SUBJECT AREA: **Routing, None**

REFERENCE: **MCWS MMTP IR No 1**

QUESTION:

Is the entire MMTP considered the International Power Line or only a portion of it? If it is only a portion, which portion is it? Please explain.

RESPONSE:

The MMTP includes the construction of a new international power line (the “Dorsey IPL”) as well as modifications to several existing transmission facilities that are necessary in order to accommodate the Dorsey IPL. However, the whole MMTP is not an “international power line” under the National Energy Board Act. The National Energy Board normally considers an international power line to be the portion of a transmission line between the international boundary and its closest substation. The Dorsey IPL is proposed to extend from Manitoba Hydro’s existing Dorsey Converter Station to a point on the international boundary just south of Piney, Manitoba.

SUBJECT AREA: **Routing, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

The selection of the termination point in the US is a significant factor in influencing the route of the transmission line. The EIS indicated that one of the two early options considered for termination points was the Bison Station at Fargo, North Dakota. In Section 2.5 it is indicated that Manitoba Hydro chose to eliminate the options related to a Fargo termination point based on the lack of a U.S. party willing to fund such a configuration. Please explain what factors resulted in the elimination of this routing.

RESPONSE:

Manitoba Hydro eliminated Bison Station in North Dakota as a viable termination point as Manitoba Hydro was unable to find a U.S. party that was interested in funding a U.S. transmission line that terminated at this station. Minnesota Power was not willing to provide funding for such a transmission line as Bison Station is not located in Minnesota Power’s service area and therefore would not be able to provide direct delivery of electricity to Minnesota Power’s customers. The proposed termination point is in Minnesota Power’s service area.

SUBJECT AREA: **Routing, None**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

One TAC comment from Manitoba Infrastructure expressed concern about the routing of transmission line near the intake for the Floodway.

"the inherent risks posed to the Red River Roadway Inlet Control Structure by a tower or line failure in such close proximity to the structure, and the Impacts that any disruption of service of the structure during time of flood would have upon the City of Winnipeg should operation of the structure be negatively Impacted by any such failure; and, emergency operations during periods of flood, including unforeseen circumstances".

In the Environmental Approvals Branch Summary of Comments (Oct 9th, 2016), it is noted that "Manitoba Hydro was already working with Manitoba Infrastructure to address their concerns regarding the floodway crossing near the control structure...."

Has this concern been addressed through routing and consultation with the Department?

RESPONSE:

Manitoba Hydro and Manitoba are continuing to discuss the concerns related to the crossing of the Red River near the floodway inlet and are in the process of negotiating an agreement to address the concerns.

SUBJECT AREA: **Environmental Protection, Follow-up and Monitoring, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

In Section 2.10.1, Development of Environmental Management Plans, Manitoba Hydro had indicated that construction contractors will be each asked to prepare environmental management plans. This appears to be a different approach than what MH has undertaken on other projects. Manitoba Hydro also has a stand-alone Environmental Protection Plan. This generates a series of questions.

Will there be one environmental management plan that contractors will need to comply with or an environmental management plan for each contractor? Who is the “owner” of the environmental management plans – Manitoba Hydro or the contractors?

How will Manitoba Hydro ensure all theses environmental management plans conform to the Environmental Protection Plan? How will they be different? Please explain.

RESPONSE:

The preparation of environmental management plans by the contractor as a component of the Environmental Protection Program, is consistent with Manitoba Hydro’s recent past projects. Chapter 22 of the EIS Section 22.2.1 through 22.2.6 outlines the Environmental Protection Program. All contractor developed management plans are reviewed and approved by Manitoba Hydro for conformance with the Construction Environmental Protection Plans. Chapter 22 of the EIS Section 22.2.6 pg 22-12 through 22-16 describes the different types of management plans.

SUBJECT AREA: **Community Health and Well-being, None**

REFERENCE: **Section 2.12.4.1**

QUESTION:

Section 2.12.4.1 identified the issue of the burning of slash piles in the right-of-ways. In TAC review comments it was noted that Public Health was concerned about this. Slash management wasn't identified in any of the sections of Chapter 22. Slash is identified a couple times in Chapter 22 (Section 5.2 General Mitigation Tables) (one mention of avoiding burning on permafrost soils which seems somewhat irrelevant; another about 15M away from forest stands). Given that parts of the MMTP route are located in areas of more moderate public density and that Public Health concerns may be valid can Manitoba Hydro provide some more explanation of slash pile management and specifically burning following the clearing of the PDA? More specifically:

Is the burning of slash piles a permitted activity (i.e. requiring an approval)? If so please outline requirements and conditions with respect to the burning of slash piles. If slash pile burning is not subject to a permit, what conditions does Manitoba Hydro consider appropriate for slash pile burning in southern Manitoba? Are local stakeholders notified?

RESPONSE:

Below is Manitoba Hydro's response to TAC IR MCWS /MH-I-130.

Much of this information can be found in the EIS in Chapters 18 and 22. Disposal of cleared vegetation typically involves a variety of options including piling and burning, mulching, collection and secondary use by local communities (e.g., firewood), or salvage and marketing of merchantable timber resources, if feasible. The final decision for disposal of vegetation will be determined based on the method of clearing used and the environmental licence conditions applied to the Project. From November 16 to March 31, there is no requirement for a burning permit under the *Wildfires Act* and if burning is required outside of those dates (i.e. between

April 1 and November 15) a burning permit application is made to the local Manitoba Conservation and Water Stewardship office. A copy of the burning permit must be on hand at all times while burning. All fires must be extinguished by March 31.

The process of burning involves raking timber/slash into piles using a bulldozer a safe distance from existing timber. The piles are then ignited and gas powered fans are used to spread the flames evenly. Depending on the needs of the project, burning can occur throughout the day and evening. Manitoba Hydro will minimize the extent of burning near populated areas. The burning of slash will be in accordance with the permit and the specific mitigation measures included in the Construction Environmental Protection Plan (page 5-12 of Chapter 22, Appendix A). Nearby communities would be made aware of burning activities.

SUBJECT AREA: **Infrastructure and Services, None**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

With respect to Section 2.12.8 it was indicated that there may be temporary workers camps.

Question – Will any of the workers camps be used on weekends?

RESPONSE:

Yes, camps will be used on weekends.

SUBJECT AREA: Routing, Public Engagement

REFERENCE: 3.4.9.1.2 & Chapter 5

QUESTION:

Based on a review of Section 3.4.9.1.2 and information gleaned from the routing workshop in January 2017 it appears that the Alternative Corridor Model workshop which involved identifying, ranking and weighting the various opportunities and constraints included the organizations identified on page 19 of the CEC Routing Workshop Presentation.
Was the general public (or Aboriginal people or any others) involved in any identification, ranking or weighting of opportunities and constraints? Were there other general public or Aboriginal people, groups or communities invited?

RESPONSE:

The groups that were represented in the workshops to develop the Alternate Corridor Model are listed on page 5A-3 of Appendix 5A. The general public and members of Aboriginal communities were not directly involved in the workshops. The response to SSC-IR- 037 identifies the approach to identifying attendees for the workshops, what groups were invited and what groups attended. As described on page 5-19 of the EIS, the workshops involved:

> “stakeholder groups representing the three perspectives included in the model (built, natural, technical) participated in facilitated discussions and exercises that served to define the areas of least preference, the factors, and the features under consideration in each group of factors. The stakeholder groups’ representatives that participated were technical knowledge holders that brought to the discussions their understanding of the features on the landscape and associated values/use, which made it possible for them to participate in discussions that examined the relative suitability of routing a transmission line across or in proximity to these features”

One of the lessons learned in the development of the EPRI-GTC methodology (outlined in "**A Consensus Method Finds Preferred Routing", Jesse Glasgow, 2004)):**

"*Our experience found that asking citizen stakeholders to work directly with weights and criteria among group perspectives didn't produce a viable model. Citizens tried to "game the system" in setting weights to favor their perspective, often producing unintended results. Our final approach combines the criteria and weights identified by citizen stakeholders with those identified by professionals. This process incorporates public opinion and professional experience to create a consistent model that can be used on a range of projects*."

As a result, the guidance provided to Manitoba Hydro by the Routing Consultant was that the feedback given from the general public is most effective when dealing with site specific or micro-level considerations and that the alternate corridor model is focused on developing regional or macro-level considerations. Those providing input to the corridor model need to have the required technical knowledge to understand how the factors they manage or represent interact with transmission line developments, as well as access to relevant data and information for the regional area. This needs to be complimented by an understanding of the general features present across this scale of a regional perspective, not from a single-community or micro-level perspective that may be driven by fewer or more site-specific considerations.

This is the primary rationale for why members of the public, First Nations, the MMF or elected officials were not invited to participate directly in the workshop. As noted in response to SSC-IR-037, Manitoba Hydro did invite Manitoba Aboriginal and Northern Affairs, given their broader mandate and general jurisdiction. The Association of Manitoba Municipalities was also invited to attend for similar reasons;

Feedback received through Manitoba Hydro's Public Engagement Process (Chapter 3 of the EIS) and First Nations and Metis Engagement Process (Chapter 4 of the EIS) was an important aspect of the transmission line routing and environmental assessment processes, as this feedback informed many elements of the process, including development of model criteria and weightings, mitigative segments, comparative evaluation and the environmental assessment.

SUBJECT AREA: **Routing, Public Engagement**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

In Section 3.7.2.1.4, labeled “Development of Round 2 Alternatives” three alternative segments are identified as being generated from this round of consultation.
Question – In Section 3.7.2.1.4, “Development of Round 2 Alternatives” on page 3-61, three bullet points are identified indicating public comments that led to the generation of alternative route segments. Did any of these segments end up being part of the final route? Can Manitoba Hydro point to any alternative route segments that were suggested or refined by the public that ended up being in the final preferred route?

RESPONSE:

Viable alternate route segments developed based on feedback received through the public engagement process are brought forward to be evaluated along with route segments presented during that round of engagement. Route segments that make up routes are evaluated based on their merits and they do not strictly become part of the final preferred route because they were provided by the public.

The first bullet point refers to the suggestion to parallel M602F as long as possible (Segment 201 created in response). The final route parallels M602F for over 20 km (Segment 201 became part of the final route) along the Riel to Vivian Transmission Corridor.

The second bullet refers to the suggestion to take advantage of other existing infrastructure and transmission lines (Segments 202-204 were created in response to this feedback). The final route parallels R49R for over 9 km. Segments 202 and 204 were modified further based on feedback collected through the engagement process during Round 3 that became part of the final preferred route.

The third bullet refers to feedback received in the La Broquerie/Marchand area. Participants indicated that an alternate route segment that would parallel an existing 230 kV transmission line and travel through less densely populated areas and Crown lands be developed (Segment 207 was developed to be presented during Round 2; Map 5-16). This route segment was not selected as part of the final preferred route although following Round 3, multiple alternatives were subsequently developed for consideration into the final preferred route based on feedback received.

Segments have been developed through each stage of the route selection process and some have been modified further to address ongoing feedback received. Additional segments that were suggested or refined by the public that are part of the final preferred route include:

- Segment Hybrid of 311 and 312 (Table 5-25, page 5-73):;
- Segment 331/334 (Table 5-24, page 5-63);
- Segment 353 (Table 5-24, page 5-63; Figure 5-15; 5-69);
- Segments 401/402 (Section 5.6.2, Paragraph 2 – bullet 1, page 5-94; Map 5-19 Inset 1)
- Segment 412 (Section 5.6.2, paragraph 2 – bullet 4, page 5-94; Map 5-19 inset 4)
- Segment 420 (Section 3.9.2 second paragraph; Map 5-7; Section 5.6.2, Paragraph 2 – bullet 5, page 5-94; Map 5-19 Inset 5);
- Segment 451 (Table 5-30, page 5-96; Figure 5-25, page 5-98) ;
- Segment 452 (Table 5-30, page 5-96; Figure 5-26, page 5-99);
- Segment 479 (further modified to increase separation; Table 5-30, page 5-96; Figure 5-28, page 5-101);
- Segments 409, 470, 471 (Table 5-30, page 5-96; Figure 5-102); and
- Segment 475 (further modified in discussions with landowner; Table 5-30, page 5-96; Figure 5-31, page 5-104).

SUBJECT AREA: **Project Description, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

In Section 2.4.1.1.1 Manitoba Hydro stated that 68 km of the transmission line will be in the Southern Loop Transmission Line. In Section 2.4.1.1, we were unable to find the length of transmission line in the Riel Vivian Transmission Corridor? What is the length of the proposed MMTP line that will be within the Riel Vivian Transmission Corridor?

RESPONSE:

The approximate length of the proposed 500kv D604I (Dorsey to Iron Range) transmission line within the Riel-Vivian Transmission Corridor is 24km.

SUBJECT AREA: **Property, None**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

The transmission routing exercise includes some degree of weighting and evaluation based on cost. Are the costs associated with land acquisition (i.e. easements) included in the total cost for the MMTP? Are the easement costs associated with routing the MMTP within the Southern Loop Transmission Corridor and the Real Vivian Transmission Corridor included in the overall cost?

RESPONSE:

Yes, the estimated costs associated with land acquisition are included in the total Project cost described in Chapter 2 section 2.1. This estimate includes costs associated with acquiring *new* easements for the Project. Costs associated with property rights already secured on the Southern Loop Transmission Corridor and Riel Vivian Transmission Corridor are not included in this estimate.

SUBJECT AREA: **Routing, None**

REFERENCE: **5.3.2**

QUESTION:

At the beginning of Section 5.3.2, it is explained the MMTP transmission line preliminary planning area and route planning area differ in area. The route planning area used EPRI methodology while in Section 5.3.1 to determine potential border crossing from Dorsey, a preliminary planning area was determined based on various transmission system concepts and a constraints and opportunities exercise using a list of criteria identify in Table 5-2.

It appears that this is perhaps best understood by examining Map 5-4 which shows both: the route planning area as well as several macro-corridors generated by the EPTI-GTC approach. This shows that one of the macro corridors lies outside of the Route Planning Area and is generally aligned immediately south of Winnipeg towards the US border. Is this interpretation correct?

If the EPRI-GTC approach generated a macro-corridor outside of the Preliminary Planning Area this would seem to quantitatively demonstrate that the macro corridor directly south of Winnipeg represented a viable option for further consideration (based on the criteria established during the macro corridor planning exercise). It also would seem to be counter-intuitive to the EPRI-GTC approach which indicates the macro corridors are identified before the study area is selected. Because the approach and model will select the shortest route when all factors are considered equal and that the longer a route is the more expensive it is as well as potentially disrupting more social and environmental factors one can understand why a macro corridor south of Winnipeg to the US border would have been likely generated.

Based on the information provided in Chapter 5 it appears that this macro corridor to the west of the route planning area was dropped for two reasons.

First, there appeared to be no US border crossings identified further west of Gardenton West. Is the lack of an identified US border crossing west of Gardenton West one of the reasons why this macro corridor was dropped? Did Minnesota Power not want to consider a border crossing this far west (information on the Minnesota Power website suggests that an option on the western edge of Minnesota was a consideration at one point, http://www.minnelectrans.com/documents/2015_Biennial_Report/html/Ch_3_Transmission_Studies.html)? Is there documentation that describes that the Minnesota Power was unwilling to consider border crossing options this further west? Is there information that identifies that a border crossing was not viable at the sound end of this macro corridor?

Second, in Chapter 5, Section 5.3.1 the rationale for the Western Boundary was described on page 5-14.

"The western boundary was delineated to limit the effects of transmission routing on the various towns and communities located to the south of Winnipeg. The western boundary was intended to limit transmission routing effects on development and urban development extending immediately south from Winnipeg and cumulative effects on agricultural land use with St. Vital Transmission Complex and Bipole III Transmission Projects. The area adjacent to and west of PTH #12 also has higher density rural residential development, more intense specialized agricultural land uses and developed recreational sites. The western boundary was designed to avoid these built-up areas and locations of increased human development."

While the above rationale appears to be sound can this be backed up with more rigorous evidence? For example, was population density information used to demonstrate that this area was more dense than all the other macro corridor areas? Was this an area of relatively more Class 1 agricultural land? Was Manitoba Hydro trying to avoid this area because it considered this area to already be burdened by Bi-Pole III? Was twinning the existing 230kV running south from Winnipeg to the border considered in the analysis. If so, what were the results and if not, why was it excluded. A somewhat more quantitative and detailed rationale would assist in justifying the decision.

Finally, please explain the order in which the separate planning process for the route planning area and macro corridor generation development process occurred. Did these two processes occur concurrently, semi-concurrently or did one occur before the other?

RESPONSE:

There appears to be four primary questions, as follows:

1) Did we consider another border crossing to the west that is not included in the EIS?

2) Why did we eliminate the western macro corridor from the Route Planning Area?

3) Further rationale is requested supporting why the western boundary of the route planning area was established where it is; and

4) What was the sequence of events in which these decisions were made?

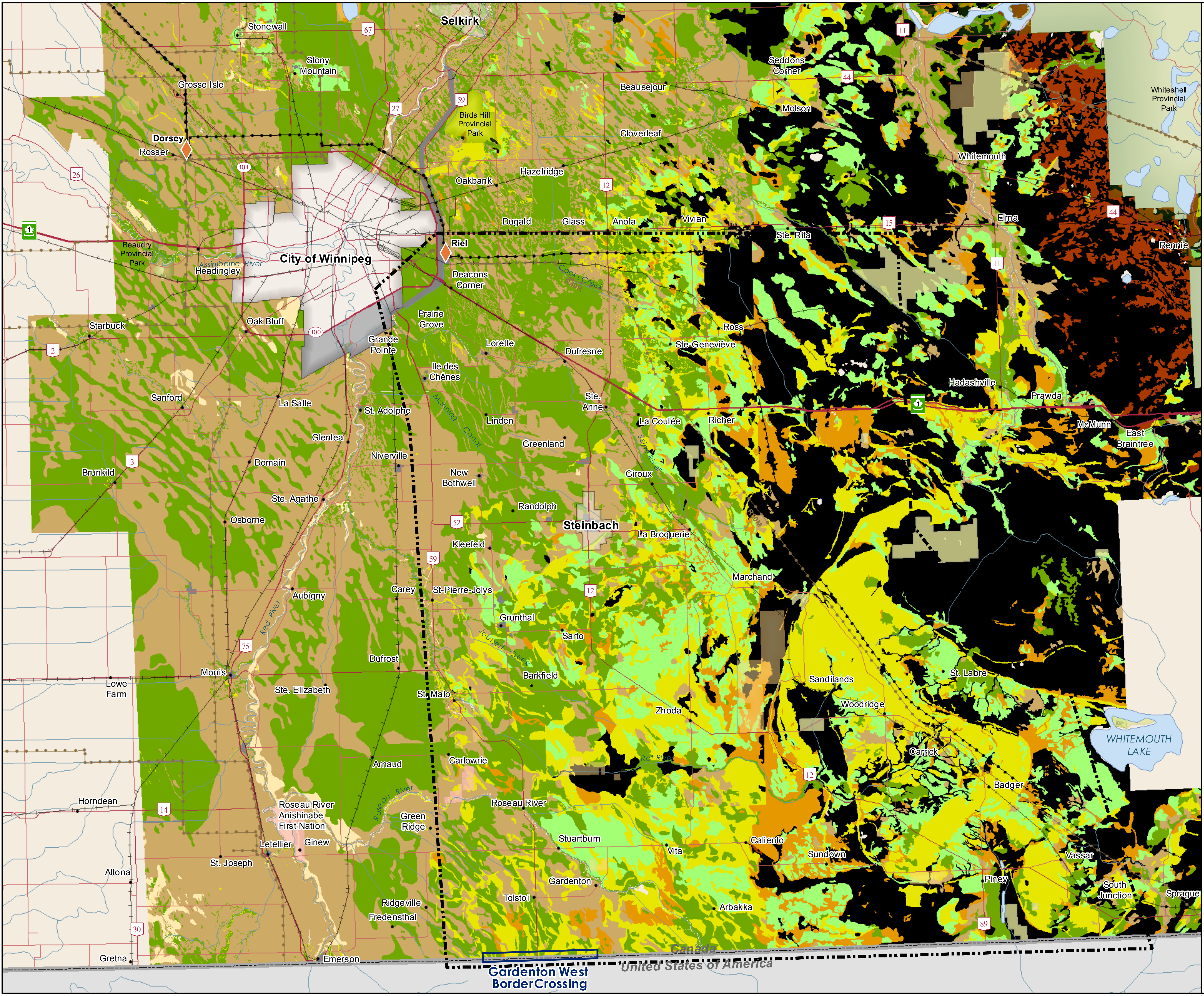
1. We did not consider an additional border crossing to the west of Gardenton West (directly south of Winnipeg).
2. In the EPRI-GTC Methodology, macro corridors are used to help define the study area for more detailed data collection. Manitoba Hydro had already completed detailed data collection in the area to the west of the Route Planning Area as a part of the St. Vital to Letellier project. On this project we determined that the Macro Corridor identified to the west, which parallels the existing Y51L transmission line, was deemed unsuitable for future consideration due to the extensive length within the Red River Floodplain, existing and expanding wind farms and residential developments adjacent to the existing ROW.
3. As noted in the question and the EIS, Chapter 5, Section 5.3.1 the rationale for the Western Boundary was described on page 5-14.

   "The western boundary was delineated to limit the effects of transmission routing on the various towns and communities located to the south of Winnipeg. The western boundary was intended to limit transmission routing effects on development and urban development extending immediately south from Winnipeg and cumulative effects on agricultural land use with St. Vital Transmission Complex and Bipole III Transmission Projects. The area adjacent to and west of PTH #12 also has higher density rural residential development, more intense specialized agricultural land uses and developed

recreational sites. The western boundary was designed to avoid these built-up areas and locations of increased human development."

As noted above, analysis conducted on the St. Vital to Letellier transmission line had contributed to the knowledge of the location and extent of high value agricultural lands and the locations and concentrations of homes and buildings in the area to the west of PTH#12. The attached maps (Map CEC-IR-11 Agricultural Capability and Map CEC-IR-11 Buildings) provide a visual representation of this information and the location of the Route Planning Area that was delineated from consideration of the macro corridors.

4. The sequence of events were:
    a. St. Vital Project and related analysis and data collection
    b. Macro Corridor for MMTP,
    c. Establishment of Route Planning Area,
    d. Identification of Alternate Corridors,
    e. Elimination of Gardenton West,
    f. Development of Alternate Routes



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

◆ Converter Station (Existing)

Infrastructure

Existing 500kV Transmission Line

Existing 230kV Transmission Line

Route Planning Area

Agricultural Capability Classification[1]

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5
- Class 6
- Class 7
- Organic
- Unclassified

Landbase

- Community
- Railway
- Trans Canada
- Provincial Highway
- Provincial Road
- First Nation Lands
- Ecological Reserve
- Wildlife Management Area
- Provincial Park
- City

Source:
1. Soil Resource Inventory, 2014. Manitoba Land Initiative.

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: March 02, 2017

N

0 5 10 Kilometres
0 5 10 Miles

1:500,000

Agricultural Capability In Route Planning Area (CEC IR 011)

Map CEC-IR-011

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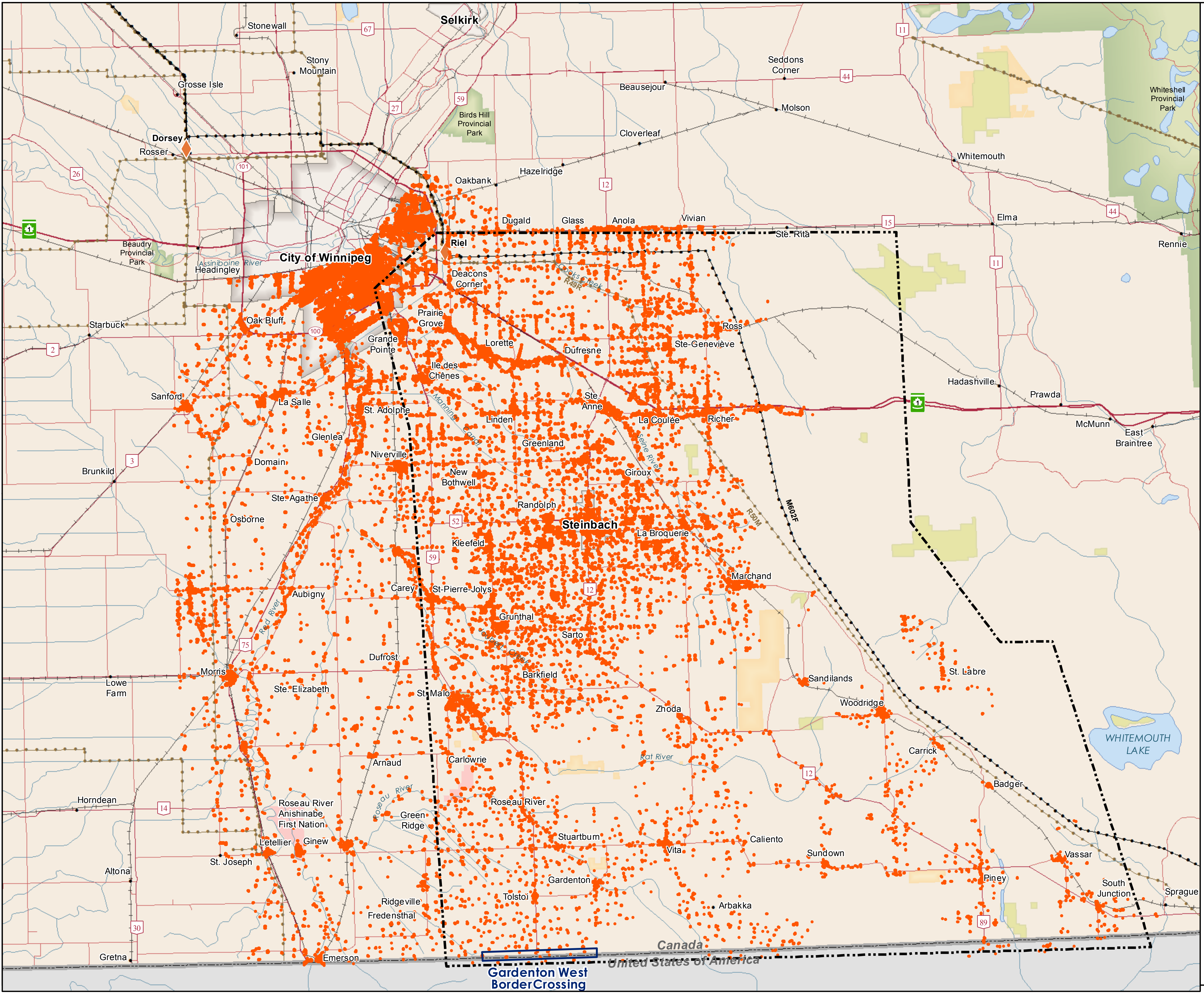

Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- ◆ Converter Station (Existing)

Infrastructure

- Existing 500kV Transmission Line
- Existing 230kV Transmission Line
- Route Planning Area
- 🟥 Buildings and Structures

Landbase

- ● Community
- Railway
- Trans Canada
- Provincial Highway
- Provincial Road
- First Nation Lands
- Ecological Reserve
- Wildlife Management Area
- Provincial Park
- City

Source:
1. Soil Resource Inventory, 2014. Manitoba Land Initiative.

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: March 02, 2017

N

0 5 10 Kilometres
0 5 10 Miles

1:500,000

Buildings and Structures In Route Planning Area (CEC IR 011)

Map CEC-IR-011

SUBJECT AREA: **Routing, None**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

Was a shortest route determined directly from Dorsey to the potential border crossing points using the land suitability index and least cost path routing process conducted? In Section 5.3.1 the origin point for the project was identified as Dorsey Converter Station. However the start point(s) for the EPRI-GTC modelling were Riel and other start points within the South Loop Transmission Corridor. Is that correct?

RESPONSE:

The project team decided early on in the process that the MMTP project would circumvent the Winnipeg area by leveraging the Southern Loop Transmission Corridor (SLTC) from Dorsey to the area around Prairie Grove. This was considered a fixed portion of the route. In order to create representative corridors, the Alternate Corridor Model was run from the Riel area and from the eastern most point of departure on the Riel – Vivian Transmission Corridor (RVTC). As the RVTC was designed to accommodate multiple transmission lines, the alternate corridor analysis process started within the SLTC and the eastern extent of this available transmission corridor.

The least cost path analysis was not conducted from Dorsey to the potential border crossing points, please see CEC-IR-073.

SUBJECT AREA: Routing, None

REFERENCE: CEC MMTP Round 1 IRs

QUESTION:

Table 5-1 on page 5-6 indicates the “Management Team” was responsible for the decisions in the development of the criteria and weight for the preference determination model. Is this the correct understanding? Could you confirm this model approach was only applied to refine the preferred route? Could you provide some more details on how it was applied? Were the specific criteria used the ones referenced in table 5.21?

RESPONSE:

Table 5-1 on page 5-6 indicates the “Management Team” was responsible for the decisions in the development of the criteria and weight for the preference determination model. Is this the correct understanding?

Yes, the Management Team noted in Table 5-1 was responsible for the decisions in the development of the criteria and weights for the preference determination model. The table below provides further detail on the management team from Table 5-1.

Table 5-1 Management Team

Name	Position	Division	Involvement
Shane Mailey	Vice President	Transmission Business Unit	Developed the criteria and weights for the preference determination model
Gerald Neufeld	Division Manager	Transmission Planning and Design	
Anthony Clark	Division Manager	Transmission Systems Operation	
Glenn Penner	Division Manager	Transmission Construction and Line Maintenance	

Could you confirm this model approach was only applied to refine the preferred route?

As discussed in section 5.2 and noted on page 5-9, the Preference Determination Model was used in all three rounds of transmission line routing.

Were the specific criteria used the ones referenced in table 5.21?

The specific criteria used in the Preference Determination Model, the criteria involved and its application are described in detail on pages 5-38 to 5-40.

Could you provide some more details on how it was applied?

The details of how the preference determination model was applied are provided in several locations of the EIS Chapter 5, including:

- Section 5.4.3.1, pages 5-38 to 5-41, pages 5-47 to 5-49, pages 5-53 to 5-55, as well as the assessment of the border crossings on pages 5-55 to 5-58.
- Section 5.5.4, pages 5-91 to 5-93
- Section 5.6.4, pages 5-117 to 5-119

Additionally further detail on the application of the model was also provided in the January 19 routing workshop and can be found on pdf pages 130 to 134 and again on page 148.The first step was to **calibrate** the Preference Determination Model with high-level evaluation criteria (please refer to SSC-IR-109 for additional details). This was done in advance of the route selection workshops, without consideration of the route finalists in order to add a layer of objectivity to the process. The Management Team was not focused on a specific set of routes, but were focused on the high-level evaluation criteria and its relative importance. It is important to distinguish the calibration workshop from the application of the model.

As detailed on page 5-39 the Preference Determination Model was **applied** in a workshop setting, incorporating the feedback of the Project Team, facilitated by members of the Routing team. The workshop and the PDM discussions make use of the cumulative knowledge and analysis on the Project, and is an opportunity for Project team members to share this knowledge (whether it is science based knowledge from field studies, community input, or technical considerations) and to weigh each route against the others with the benefit of this information, and the metrics and statistics from the Alternative Route Evaluation Model. As portions of this information is qualitative (i.e. it cannot be measured in acres, km), the discussions help the Project Team to build a shared understanding of the full scale and scope of information and then use this to develop a relative ‘rank’ for each route in the form of a score from 1-3.

SUBJECT AREA: **Routing, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

Table 5-2 was used to define the preliminary planning area to guide the potential border crossings. It was stated that the southern boundary followed the Canada – US Border. It is not clear how the four locations for border crossing box areas were determined when looking at Map 5-2 and Map 5-3. Were there specific border crossing requirements that weren't included in Chapter 5 EIS report such as physical characteristics, security, weather or technical matters?

RESPONSE:

The methodology, along with routing criteria by which potential border crossings were selected, is explained in EIS Section 5.3.1. No other physical characteristics, security, weather or other technical matters were considered by Manitoba Hydro for specific border crossing requirements.

SUBJECT AREA: **Routing, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

In Section 5.3.4 the rationale for the removal of the option utilizing the Gardenton West Border Crossing was described. The general indication is that this was done owing to the concerns in the agricultural community about going through prime agricultural area and growing rural residential areas. However, in examining Maps 5-7 (Built Environment) and 5-8 (Simple Average) this isn’t immediately obvious. We assume this is because features such as prime agricultural land are not presented separately. Which maps can better illustrate that this large area should have been eliminated as an option?
Why was a preferred route not developed in the Gardenton West Corridor and compared to the preferred routes in the other corridors using all the same criteria, prior to the border crossing discussions?

RESPONSE:

Section 5.3.4 of the EIS presents the rationale for removing the Gardenton West Border Crossing.

Both Minnesota Power and Manitoba Hydro determined that a route to Gardenton West would be infeasible as discussed in section 5.3.4. As such further evaluating options to this crossing point and engaging with the Public and through the First Nation and Metis Engagement processes was not pursued.

See attachments for CEC-IR-011 that illustrate the classes of agricultural land and the locations of buildings (including homes) and the location of the Gardenton West border crossing, in further support of the statements made in section 5.3.4.

As the business decision was made not to utilize the Gardenton West border crossing, the project team did not promote it to the next round for more detailed evaluation. This decision allowed the team to focus on route development and evaluation of options within the remaining potential areas and investigate these in more detail.

SUBJECT AREA: **Property, Routing**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

Table 5-10 the presents the Gardenton Border Crossing Preference Determination Scores and the associated rationale. Each route to that border crossing is evaluated. However, it appears to be that there is data considered in Table 5-10 that is not included in Table 5-12. For example, under Risk to Schedule "UM" there is a reference to "Route UM will require extensive private land acquisition and has the most transmission line crossings."
Where are the data that indicates the number or amount of land acquisition that is required for each route? This is referred to in Table 5-10 but doesn't appear to be in Table 5-12. On a similar issue, Class 1 Soils are also referred to in Table 5-10 as being part of the rationale but don't appear in Table 5-12. Where is that information?

RESPONSE:

The route statistics (Table 5-12, page 5-43) developed for any set of routes (see Raw and Normalized Statistics, page 5-31) are based on the Alternative Route Evaluation Model (Table 5-6, page 5-30). Route metrics and statistics are calculated for each of the criteria in the model (e.g. relocated residences, natural forests, etc.).

The information in Table 5-10 is based on the professional judgment of the attendees at the route evaluation workshop. In some cases the route statistics are used to inform the rankings and supporting rationale, as well as other additional information deemed important.

Land acquisition statements were based on the consideration of estimates of the area of private land along each route, determined using available crown land dataset(s). The consideration of the relative amount of Class 1 soils was informed by existing soil resource information obtained from the Manitoba Agricultural Interpretation Database (SoilAID); Manitoba Land Initiative 2014, which is a digital repository for provincial soil survey data in

Manitoba (covered in Chapter 15, Sections 15.3.1, page 15-15, 15.4.2, page 15-31 and presented in the soil classification Map Series 15-100).

The SoilAID data was also used to determine the Land Capability for Agriculture (Table 5A-10, page 5A-24) within the Alternate Route Evaluation Model. Additional information related to soils classifications is provided in chapter 15 of the EIS (Please refer to section 15.4.2, Table 15-5 and maps 15-100, 15-100-01 to 15-100-03).

SUBJECT AREA: **Routing, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

Minnesota Power identified Piney East as their preferred border crossing. The border crossing decision played a very significant factor in determining the final route. In contrast the discussion in section 5.4.3.3 seems very limited. Can Manitoba Hydro provide more documentation on the rationale provided by Minnesota Power?

RESPONSE:

Manitoba Hydro does not have any further documentation from the timeframe when the decision was made. The rationale provided by Minnesota Power was three-fold:

1. Piney East is in close proximity to the existing 500-kV and 230-kV lines and allows the greatest percentage of collocation in routing the Great Northern Transmission Line. Minnesota utilities are required by statute and rule to maximize the degree to which new infrastructure utilizes existing corridors.

2. The Piney East crossing allows Minnesota Power to reduce the project’s impact to agriculture.

3. Piney East is the shortest possible route on the Minnesota side of the border.

SUBJECT AREA: **Project Description, None**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

Page 5-10 indicated that there was a System Planning Report/Facility Study. Please provide the Commission with that Report.

RESPONSE:

See attachment (CEC-IR-018_Attachment) for the study that was filed with the NEB application. This study has been redacted as it contains commercially sensitive information.

Manitoba Hydro

TRANSMISSION PLANNING & DESIGN DIVISION

SYSTEM PLANNING DEPARTMENT

PRELIMINARY REPORT ON

GROUP FACILITY STUDY

MHEM 1100/750/250 MW Export/Import Firm Point to Point Group Transmission Service Requests

SPD 2013/05

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No. 38 Date: Oct. 2, 2013

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REVISIONS

No.	Prepared By	Reviewed By	Date	Comment
1.0	B. Bagen, D. Diakiw, D. Huang and M. Heron	D. Jacobson	Dec. 20, 2012	Initial report
2.0	B. Bagen, D. Diakiw, D. Huang and M. Heron	B. Bagen	Feb. 07, 2013	Draft, incorporate comments from the System Planning Project Group
3.0	B. Bagen, D. Diakiw, D. Huang and M. Heron	R. Smyrski N. Zettler	Feb. 25, 2013	Draft, include comments from Tariff and Law Departments
4.0	B. Bagen, D. Diakiw, D. Huang and M. Heron	Stakeholders	May 8, 2013	Draft, include comments from Stakeholders
5.0	B. Bagen, D. Diakiw, D. Huang and M. Heron	B. Bagen, D. Diakiw	June 18, 2013	Estimate Updates
6.0	B. Bagen, D. Diakiw, D. Huang and M. Heron	B. Bagen, D. Diakiw	Oct. 2, 2013	Preliminary Report

1.0 EXECUTIVE SUMMARY

Several Transmission Service Requests for long term firm point to point transmission service have been made by the Customer in accordance with the Manitoba Hydro (MH) Open Access Transmission Tariff (OATT). These requests seek to reserve up to 1100 MW service to permit power flow from generation in the MH Control Area to load in the northern Midwest United States (reference to Table 1 in the report), and from various sources in the northern Midwest United States to load in the MH Control Area (reference to Table 2 in the report). If these requests are approved and the Eligible Customer agrees to construct the required transmission, the service will commence on May 31, 2020.

A Group Facility study was performed to quantify the impacts of these new reservations on the Manitoba and US interconnected system performance. Steady state power flow and transient stability simulations were carried out to determine the impacts of these Transmission Service Requests. A long term transmission reliability margin (TRM) of 75 MW was used in the analysis. The primary objective of the studies described in this report is to identify the Direct Assignment Facilities and/or the Network Upgrades required for accommodating the Transmission Service Requests including costs in Manitoba and estimated time to complete the construction of the Direct Assignment Facilities and/or the Network Upgrades. A number of options were initially examined and some of them, for example, the 345 kV tie line option and alternative terminations of the new tie line at Forbes and Shannon were eliminated based on preliminary technical assessment and cost analysis. The studies described in this report will focus on the options of 500 kV and 230 kV tie lines terminating at either Fargo or Iron Range. Twenty three different evaluations were conducted to review the proposed system configurations considering the three scenarios of injection points as follows. More detailed information on the proposed options is provided in this report (Appendix A).

1. Fargo Injection:

    a. **Option W1-B:** Winnipeg (Dorsey) to Fargo (Bison) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200 MVA transformer, second circuit of double circuit Fargo (Bison) to St. Cloud (Monticello) 345 kV line, two 500/345 kV 1200 MVA transformers and two 345/230 kV 180 MVA transformers at Bison. The targeted import/export transfer increase for this option is 1100 MW.
    b. **Option W1:** Winnipeg (Dorsey) to Fargo (Bison) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200 MVA transformer, one 500/345 kV 1200 MVA transformer and two 345/230 kV 180 MVA transformers at Bison. The targeted import/export transfer increase for this option is 750 MW.

2. Iron Range Injection:

    a. **Option Y500-A/B:** Winnipeg (Dorsey) to Iron Range (Blackberry) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200

MVA transformer, double circuit Iron Range (Blackberry) to Duluth (Arrowhead) 345 kV line, two 500/345 kV 1200 MVA transformers and one 500/230 kV 900 MVA transformer at Blackberry. The targeted import/export transfer increase for this option is 1100 MW.

b. **Option Y500:** Winnipeg (Dorsey) to Iron Range (Blackberry) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200 MVA transformer, one 500/230 kV 900 MVA transformer at Blackberry. The targeted import/export transfer increase for this option is 750 MW.

3. Iron Range 230 kV Injection: Proposed facilities include Winnipeg (Riel) to Iron Range (Shannon) 230 kV line. The targeted import/export transfer increase for this option is 250 MW. This option is considered for accommodating the 250 MW request by Minnesota Power.

Based on the study results, it is found that all options evaluated in this study are technically viable with appropriate Network Upgrades for accommodating the Transmission Service Requests described previously. It should be noted that the new 500 kV MH-US tie line for the Fargo Injection may go through the Red River Valley Flood Plain. This would place greater risk on the In-Service-Date. The required Network Upgrades in addition to the proposed facilities for the options evaluated in this study are summarized in Table ES 1. The letters I, E and P respectively represent import, export and prior outage conditions in Table ES 1, for which the specific Network Upgrades are required.

Table ES 1: Network Upgrade Summary

Network Upgrades	Options				
	W1-B 1100 MW	W1 750 MW	Y500-A/B 1100 MW	Y500 750 MW	230 kV 250 MW
G82R phase shifting transformer	I,E,P	I,E	I,E,P	I,E	I
New trigger to existing HVdc reduction scheme	E, P	E	E, P	E	E
Fargo to Sheyenne 230 kV line	I, P	I			
Bison to Maple River 230 kV line	E, P	E			
Souris to Velva Tap to Mallard 115 kV line	I, P	I		I	I
Mchenry 230/115 kV transformer	I, P	I			I
Second Stone Lake 345/161 kV transformer			E, P		
Fond du lac to Thomson 115 kV line			E, P		
Blackberry 500/230 kV transformer larger than 900 MVA			I, P	E	
Blackberry to Floodwood 115 kV line				E	
Forbes to Blackberry 230 kV line			P	E	
Coon Creek - Kohlman Lake 345 kV line	I	I	I	I	
Blackberry to Nashwauk 115 kV line				E	
20 L Tap to Blackberry 115 kV line				E	
Bison 500/345 kV transformer requires overload capability greater than 1200 MVA	P				
Blackberry 500/345 kV transformer requires overload capability greater than 1200 MVA			P		
SVC/Statcom (location to be determined)	P				

No Direct Assignment Facilities are needed in Manitoba for all the options evaluated in this study. The total cost for the required Network Upgrades in Manitoba is the same for all the 500 kV options and it is estimated to be approximately $279 million (2013 overnight Canadian dollars) assuming a length of approximately 235 km (147 miles) as detailed in Table ES 2. The total cost for the required Network Upgrades in Manitoba for the 230 kV option with 250 MW/250 MW incremental export/import capability is approximately $98 million (2013 overnight Canadian dollars) assuming a length of approximately 145 km (90 miles). The total cost for the required Network Upgrades in Manitoba for the 230 kV option with 250 MW/50 MW incremental export/import capability is approximately $60 million (2013 overnight Canadian dollars). It should be noted that several risks associated with the projects are described in Section 12 and the costs associated with these risks are not included in the project cost estimates. The proposed in-service-date of all facilities is in May 31, 2020. It is considered to be an aggressive schedule and includes duration for obtaining required permits and land right activities.

Table ES 2: Summary of Estimates for Required Network Upgrades in Manitoba (500 kV Options, 2013 overnight Canadian dollar)

Item	Costs
500 kV line	$171,485,960
Dorsey Station	$23,232,384
Riel Station	$54,319,407
Glenboro South 230 kV Station	$30,399,549
Total	$279,437,300

More detailed information on Table ES 1 is provided in the following:

1. Fargo Injection:

    a. **Option W1-B:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export Transmission Service Requests of 1100 MW: Fargo to Sheyenne 230 kV line, Bison to Maple River 230 kV line, Souris to Velva Tap to Mallard 115 kV line, Mchenry 230/115 kV transformer, Coon Creek - Kohlman Lake 345 kV line, 300 MVA phase shifting transformer on line G82R, HVdc reduction for loss of the new facilities, Bison 500/345 kV transformer requires overload capability greater than 1200 MVA and a SVC/Statcom to increase R50M operational limit.

    b. **Option W1:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export Transmission Service Requests of 750 MW: Fargo to Sheyenne 230 kV line, Bison to Maple River 230 kV line, Souris to Velva Tap to Mallard 115 kV line, Mchenry 230/115 kV transformer, Coon Creek - Kohlman Lake 345 kV line, 300 MVA phase shifting transformer on line G82R and HVdc reduction for loss of the new facilities.

2. Iron Range Injection:

    a. **Option Y500-A/B:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export Transmission Service Requests of 1100 MW: second 345/161 kV 300 MVA transformer at Stone Lake, Coon Creek - Kohlman Lake 345 kV line, Fond du lac to Thomson 115 kV line, Blackberry 500/230 kV transformer capacity greater than 900 MVA, 300 MVA phase shifting transformer on line G82R, Forbes to Blackberry 230 kV line, Blackberry 500/345 kV transformer requires overload capability greater than 1200 MVA and HVdc reduction for loss of the new facilities.
    b. **Option Y500:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export Transmission Service Requests of 750 MW: Blackberry 500/230 kV transformer capacity greater than 900 MVA, Forbes to Blackberry 230 kV line, Blackberry to Floodwood 115 kV, Blackberry to Nashwauk 115 kV line, 20L Tap to Blackberry 115 kV line, Souris to Velva Tap to Mallard 115 kV line, Coon Creek - Kohlman Lake 345 kV line, 300 MVA phase shifting transformer on line G82R and HVdc reduction for loss of the new facilities.

3. Iron Range 230 kV Injection:

The following Network Upgrades in addition to the proposed facilities are needed for granting the import/export Transmission Service Request of 250 MW: Souris to Velva Tap 115 kV line, Mchenry 230/115 kV transformer, 300 MVA phase shifting transformer on line G82R and HVdc reduction for loss of the new 230 kV tie line. . For 250 MW/50 MW incremental export/import capability, the 300 MVA phase shifting transformer on line G82R is not required.

When comparing the 500 kV options with an 1100 MW of incremental MH-US transfer the following conclusions can be made:

- Power flow south from Manitoba: Increase in North Dakota export and Minnesota-Wisconsin export negatively affects the flow on the Riel – Forbes 500 kV for the Fargo injection. At the maximum simultaneous transfer simulated in this study (NDEX=2200 MW, MWEX=1600 MW), the North Dakota-Manitoba loop flow issue results in approximately 105% pre-contingency overload on the Riel – Forbes 500 kV line. This pre-contingency overload can be mitigated by controlling the power flow distributions on the US-MH interface through a phase shifting transformer added on to the line G82R.
- Power flow north to Manitoba: The performance of the Iron Range Injection is better than that of the Fargo injection in terms of the flow distribution on the two 500 kV lines and elimination of loop flow on the MH-US interface particularly at a higher NDEX level.

- With increase in North Dakota export and Minnesota-Wisconsin export, power flow is more evenly distributed on the two 500 kV lines for the Iron Range option than for the Fargo Option.
- The current Riel-Forbes 500 kV line limit of 1732 MW (2000 A) may be reached with further increase in loop flow from US to Manitoba and the Fargo injection is more prone to this limitation. This may require upgrade of the M602F series compensation at Roseau from the current rating of 2000 A to 2500 A and additional reactive support at Forbes of approximately 300 Mvar.
- Symmetric import/export capability can be achieved for all options examined in this study by appropriately controlling the flows on G82R.
- Under the prior outage of the exiting 500 kV line, the current transfer limit of 2175 MW can be kept with the addition of a phase shifting transformer on G82R and a SVC or Statcom to increase R50M operational limit for W1-B option. A SVC or Statcom is not required for Y500-A/B option to maintain 2175 MW south transfer under the same prior outage condition.

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Table of Contents

2.0 BACKGROUND

2.1 Description of the Transmission Service Requests

Several Transmission Service Requests (TSR's) for long term firm point to point transmission service as shown in Tables 1 and 2 has been made by the Customer pursuant to Section 17 of the Manitoba Hydro Open Access Transmission Tariff (MH OATT). Theses TSR's seek to reserve up to 1100 MW service to permit power flow from generation in MH Control Area to load in the northern Midwest United States, and from various sources in the northern Midwest United States to load in MH Control Area. MHEM requested that MH conduct a Group Facility Study (GFS) by executing a Group Facility Study Agreement (GFSA) dated December 21, 2009.

Table 1: MH Group TSR (Export, Total 1100 MW)

TSR	Service Type	Begin Date	End Date	Capacity (MW)	POR	POD	Source	Sink
76703206	PTP	Nov 1/14	Nov 1/24	200	MHEB	MHEB-MISO	MHEB	GRE
76703213	PTP	Jun 1/17	Jun 1/27	500	MHEB	MHEB-MISO	MHEB	WPS
76703216	PTP	Jun 1/17	Jun 1/37	250	MHEB	MHEB-MISO	MHEB	MP
76703248	PTP	Jun 1/17	Jun 1/27	50	MHEB	MHEB-MISO	MHEB	NSP
76703249	PTP	Jun 1/17	Jun 1/27	100	MHEB	MHEB-MISO	MHEB	WEC

Table 2: MH Group TSR (Import, Total 1100 MW)

TSR	Service Type	Begin Date	End Date	Capacity (MW)	POR	POD	Source	Sink
76703155	Network	Jun 1/17	Jun 1/27	500	MHEB-MISO	MHEB	WPS	MHEB
76703161	Network	Jun 1/17	Jun 1/37	250	MHEB-MISO	MHEB	MP	MHEB
76703250	Network	Nov 1/14	Nov 1/24	100	MHEB-MISO	MHEB	GRE	MHEB
76703251	Network	Nov 1/14	Nov 1/24	100	MHEB-MISO	MHEB	GRE	MHEB
76703252	Network	Jun 1/17	Jun 1/27	50	MHEB-MISO	MHEB	WEC	MHEB
76703253	Network	Jun 1/17	Jun 1/27	50	MHEB-MISO	MHEB	ALTE	MHEB
76703254	Network	Jun 1/17	Jun 1/27	50	MHEB-MISO	MHEB	ALTE	MHEB

2.2 Related Studies

An initial Group System Impact Study (GSIS) on the TSR's presented in Tables 1 and 2 was completed in June 2009 for Firm Point-to-Point Transmission Service between Control Areas of MH and northern Midwest United States in accordance with MISO OATT [1]. The study was conducted by Siemens PTI and an Ad Hoc Study Group consisting of several utilities in the northern Midwest United States and Manitoba Hydro [1]. The initial GSIS examined a few Network Upgrades options proposed by the Ad Hoc Study Group for accommodating the TSR's presented in Tables 1 and 2. The options considered include:

1) Option 1: Dorsey-Maple River 500 kV line with one 500/345 kV 1200 MVA transformer at Maple River 2)

Option 2: Dorsey-Helena 500 kV line with two 500/345 kV 1200 MVA transformers at Helena
3) Option 3: Dorsey-King 500 kV line with two 500/345 kV 1200 MVA transformers at King.

A follow-up GSIS [2] was completed in April 2010 to examine the impact of an alternative transmission plan to Option 1 proposed in the initial GSIS. The alternative scenario assumes the new 500 kV substation near Fargo at Maple River is located at the Bison substation as proposed by CapX [2]. A series of sensitivity studies has been conducted on the Bison option examined in [2] to investigate different transmission scenarios for achieving 750 MW and 1100 MW increases in transfer capability from Manitoba to US [3]. The sensitivity study also examined a 230 kV transmission option for accommodating 250 MW increase in transfer capability from Manitoba to the US [3]. The Fargo injection scenario examined in [2] and [3] is sometimes referred to as the Western Option and it has been investigated thoroughly in various studies [1-3]. Recently an Eastern injection alternative to the Fargo configuration was proposed for these TSR's presented in Tables 1 and 2. Major transmission for the Eastern injection consists of a Winnipeg, Manitoba (Dorsey substation) to Iron Range, Minnesota (Blackberry substation) 500 kV line and other facilities depending on the transfer capacity required. The Iron Range injection scenario has not been studied under MH OATT yet. This GFS examined several transmission options for both the Fargo and the Iron Range injections for accommodating up to 1100 MW transmission reservations in both southward and northward directions according to MH OATT.

An additional 230 kV scenario for accommodating the 250 MW TSR as shown in Tables 1 and 2 (MP sink/source respectively) was also investigated.

The transmission scenarios considered in this GFS are described in detail in Section 3. MH fully participated in the studies [1-3] performed by Siemens PTI and the Ad Hoc Study Group. The participation includes the development and updating of the study models, review of study results, screening and selection of the transmission alternatives and comments on the final reports. A separate individual GSIS under the MH OATT is, therefore, not needed for the TSR's presented in Tables 1 and 2. MH issued a GSIS Report on January 24, 2013 in which it determined that it would adopt the results of the MISO GSIS [1-3].

3.0 STUDY SCOPE AND OBJECTIVES

The main purpose of this GFS is to quantify the impacts of the proposed reservations as shown in Tables 1 and 2 on system performance through steady-state contingency study and transient stability simulations. The primary objective of the studies described in this report is to identify the Direct Assignment Facilities and/or the Network Upgrades required for accommodating the Transmission Service Requests including costs in Manitoba and estimated time to complete the construction of the Direct Assignment Facilities and/or the Network Upgrades. A number of transmission options have been examined including:

1. Fargo Injection:

    a. **Option W1-B:** Winnipeg (Dorsey) to Fargo (Bison) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200 MVA transformer, second circuit of double circuit Fargo (Bison) to St. Cloud (Monticello) 345 kV line, two 500/345 kV 1200 MVA transformer and two 345/230 kV 180 MVA transformers at Bison. The targeted import/export transfer increase for this option is 1100 MW .

    b. **Option W1:** Winnipeg (Dorsey) to Fargo (Bison) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200 MVA transformer, one 500/345 kV 1200 MVA transformer and two 345/230 kV 180 MVA transformers at Bison. The targeted import/export transfer increase for this option is 750 MW.

2. Iron Range Injection:

    a. **Option Y500-A/B:** Winnipeg (Dorsey) to Iron Range (Blackberry) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200 MVA transformer, double circuit Iron Range (Blackberry) to Duluth (Arrowhead) 345 kV line, two 500/345 kV 1200 MVA transformers and one 500/230 kV 900 MVA transformer at Blackberry. The targeted import/export transfer increase for this option is 1100 MW.

    b. **Option Y500:** Winnipeg (Dorsey) to Iron Range (Blackberry) 500 kV line with 60% series compensation, second Riel 500/230 kV 1200 MVA transformer, one 500/230 kV 900 MVA transformer at Blackberry. The targeted import/export transfer increase for this option is 750 MW.

3. Iron Range 230 kV Injection (Eastern): Proposed facilities include Winnipeg to Iron Range (Riel-Shannon) 230 kV line. The targeted import/export transfer increase for this option is 250 MW. This option is considered for accommodating the 250 MW request by Minnesota Power.

Schematic diagrams illustrating the connections of major facilities proposed for the above options are provided as Appendix A of this report. The scope of this GFS study is as follows:

(i) Assessment of the impacts of the group TSR shown in Tables 1 and 2 on the Manitoba and US Interconnected Transmission System considering several scenarios associated with the two injection points.
(ii) Identification of the system constraints associated with the proposed options for providing the requested service.
(iii) Estimation of costs associated with the Direct Assignment Facilities and/or Network Upgrades in Manitoba.

(iv) Estimation of the timing for construction of the Direct Assignment Facilities and/or Network Upgrades

4.0 MH-US INTERCONNECTION

An overview of MH's existing generating stations, transmission system and tie lines is provided in Appendix B. The bulk of Manitoba's power is transmitted from remote hydro electric generators in the north to the load centers in southern Manitoba over the Nelson River HVdc transmission scheme which consists of two bipolar transmission systems called Bipole I and Bipole II. Both Bipole I and Bipole II systems terminate at Dorsey Converter Station at Rosser about 26 km northwest of the City of Winnipeg, Manitoba, Canada.

The existing MH system is interconnected to the transmission systems in the US states of North Dakota and Minnesota and the Canadian provinces of Saskatchewan and Ontario. Transmission interconnections between Manitoba and the US states (MH-US interface) consist of one 500 kV line and three 230 kV lines. The Dorsey (Manitoba)-Forbes (Minnesota)-Chisago (Minnesota) 500 kV transmission line has its northern terminus at the Dorsey 500 kV bus which is connected to the Dorsey 230 kV bus through two transformers. The three 230 kV lines are L20D from Letellier (Manitoba) to Drayton (North Dakota), R50M from Richer (Manitoba) to Moranville (Minnesota) and G82R from Glenboro (Manitoba) to Rugby (North Dakota). Current total firm transfer capability on the MH-US interface is 2175 MW southward and 700 MW northward [4].

The Riel Station Reliability Project with a scheduled in-service-date (ISD) of October 2014 [5] will sectionalize the Dorsey-Forbes-Chisago 500 kV tie line at Riel but will not change the total transfer capability between MH and the US in either direction. Riel is also the proposed terminal point for MH's third HVdc bipole transmission system (Bipole III) planned to be in-service in 2017. The Bipole III system terminates at Keewatinoow converter station located in Northern Manitoba and Riel converter station located near Winnipeg in southern Manitoba. The Nelson River generating plants are connected to Bipoles I, II and III via 138 kV and 230 kV transmission which is referred to as the Manitoba Hydro Northern Collector System (MH NCS) in this report.

The studies described in this report consider a second 500 kV tie line with northern terminus at Dorsey for all 500 kV options. A new 230 kV tie-line connecting Riel 230 kV and Shannon (Minnesota) 230 kV buses were modelled for the 250 MW TSR sinking in MP as an alternative to the 500 kV options. The MH NCS generators were dispatched for scheduling the TSR's examined in this report.

5.0 STUDY METHODOLOGY AND CRITERIA

5.1 Study Methodology

A similar methodology that was used in the previous studies [1-3] was adopted in this GFS. The impacts of the proposed reservations on transmission system in Manitoba and northern Midwest United States were determined by conducting a series of steady-state power flow analyses and transient stability simulations. AC power flow analysis was performed and the incremental impact of the requested transmission services was evaluated for all transmission options considered in this GFS in steady-state analysis. Both system intact (SI) and prior outage (PO) conditions were considered for the maximum power transfer level of 1100 MW. The 500 kV line connecting Riel and Forbes (M602F) was taken out of service in prior outage case analysis. Transient stability simulations were performed for the cases representing the transmission options with the maximum transfer modeled. Transient stability simulations were performed only for system intact cases.

5.2 Study Criteria

NERC transmission planning standards (TPL) [6], MAPP Members Reliability Criteria and Study Procedures Manual [7] and the MH internal transmission service interconnection requirement (TSIR) document [8] were applied in this GFS. Steady-state pre and post- contingency bus voltages must be maintained within limits. 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. Similarly, steady-state pre- and post- contingency transmission element loadings must be maintained within limits. Transmission line and transformer loadings were compared with 100% of the PSS/E Rate B (30 minute emergency rating) following a contingency and 100% of Rate A (Continuous normal rating) for system intact conditions. Transient voltages must be within the default limits of 0.70-1.20 per unit with the exception of a few specific buses that have more stringent requirements [7].

System steady-state and dynamic performance was evaluated using the criteria described above. Bus voltages and transmission element loadings within Manitoba and northern Midwest United States were monitored. The contingency files and disturbance files used in the previous studies [1-2] were extended to include the new contingencies and faults associated with the proposed facilities for each option. North American Electric Reliability Council (NERC) Category B contingency (loss of single transmission element) and Category C contingency (common tower or breaker failure) loading above 100% Rate B are considered to require Network Upgrades.

6.0 MODEL DEVELOPMENT

6.1 Power Flow

The updated benchmark power flow model representing 2019 summer peak system conditions examined in the MISO group TSR study for Option 1 [2] was used as the starting case for this assessment. The most significant update in the MISO benchmark case includes the addition of the total Conawapa generation of 1485 MW in Manitoba. The base cases used for this study were developed by adding the proposed facilities for all of the injection scenarios as described in Section 3 to the MISO benchmark case. Prior outage cases were developed from the corresponding system intact case by taking out the

500 kV line connecting Riel and Forbes stations. A long term TRM of 75 MW was considered in the technical analysis described in this report. A summary of the power flow cases examined in this study is provided in Appendix C. Several assumptions were made in setting the base cases. These include: (1) Mesaba Generation=600 MW (2) Boswell generation=752 MW (3) G82R phase shifting transformer (PST) is set to 0 MW for south flow and 250 MW for north flow unless otherwise specified.

6.2 Transient Stability

Transient stability is investigated on the 2022 summer off-peak load flow case taken from the 2011 MRO series stability package. A summary of the power flow cases examined for stability analysis is also provided in Appendix C. A snap file containing transient stability simulation models was also taken from the 2011 MRO series stability model package. Both the load flow and stability models were updated to include all planned Conawapa generation and the proposed facilities for W1-B and Y500-A/B options at the 1100 MW incremental transfer levels for transient stability assessment in this study. The stability model used in this study is different from that used in the MISO group TSR transient stability analysis [1-2]. Their stability study was performed using a stability study package called User Interface Package (UIP) that was updated by Northern MAPP Operating Review Working Group (NMORWG) in 2009.

7.0 ANALYSIS

7.1 Steady-State Post-Disturbance Analysis

The steady-state power flow analysis was performed using the Powertech Voltage Security Assessment Tool (VSAT) which is similar to PTI’s PSS/E AC contingency calculation (ACCC) and DC Power Flow analysis (TLTG) activities [9]. VSAT can be conveniently used for assessing import or export limits between a defined source and sink. The activity identifies a study system in which generation is increased (or load is decreased) and an opposing system in which generation is decreased (or load is increased). For cases representing power flows from Manitoba to US, the source system or point of receipt (POR) is defined as the MH system and the opposing system or point of delivery (POD) is defined as several areas in northern Midwest United States including Wisconsin Public Service (WPS), Minnesota Power (MP), Great River Energy (GRE) and Alliant Energy (ALTE). Detailed information on the generators in WPS, MP, GRE and ALTE for scheduling the TSR’s can be found in [1]. The TSR’s shown in Table 1 considering the long term TRM are modeled by increasing power at Dorsey and Riel HVdc converters that are connected to the MH NCS and accordingly the outputs of appropriate generators in WPS, MP, GRE and ALTE were decreased. For cases representing power flows from US to Manitoba, the source system or POR is defined as several areas in northern Midwest United States including WPS, MP, GRE and ALTE and the opposing system or POD is defined as the MH system. The TSR’s considering the long term TRM are modeled by increasing the outputs of appropriate generators in WPS, MP, GRE and ALTE and decreasing power at Dorsey and Riel HVdc converters that are connected to the MH NCS.

All NERC Category B and Category C contingencies modeled in the MISO group TSR study for Option 1 [2] and additional contingencies associated with the proposed reservations were selected and simulated for the steady-state analysis. A summary of the steady-state simulation results is provided in Appendix D. The tables provided in Appendix D include all of the NERC Category B and Category C contingency simulation results for each transmission option at different transfer levels in approximately 50 MW increments. The steady-state results obtained for each case are briefly discussed in the following subsections.

7.1.1 System Intact Cases

Fargo Injection-Option W1-B: 1100 MW South Flow without/with PST

The base case (SI-EXPT-W-1100-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A1 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The base case (SI-EXPT-W-1100-PST-60SC) is the same as SI-EXPT-W-1100-NOPST-60SC except a phase shifting transformer was added on G82R to control the flow on the line. The total power flow from Manitoba to US is set to be 2175 MW with 0 MW flow on G82R as the starting point for both cases. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 1. It is, therefore, assumed in this study that planned projects in associated jurisdictions will mitigate these base case overload issues.

The incremental impact of the TSR’s up to 1100 MW was evaluated using VSAT by increasing the MH NCS generation and decreasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE. Table 3 presents the results obtained for 0 MW and 1100 MW increases in power transfer from MH to US on top of the base transfer level of 2175 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Tables D1 and D2 of Appendix D.

It can be concluded from the results shown in Table 3 that several Network Upgrades are needed. A new trigger to the existing HVdc power order reduction scheme is required for loss of the new 500 kV tie line to mitigate the overloads. Bison to Maple River 230 kV line upgrade may be also required if the two Bison 345/230 kV transformers are added.

Table 3: Steady State Analysis Results Summary*
(SI-EXPT-W-1100-NOPST-60SC, SI-EXPT-W-1100-PST-60SC)

Contingency	Overload Facility	Overload		Comments
		2175 MW	3275 MW	
Bison-Alex SS 345 kV line	M602F	None	102%	Wave trap ratings of Forbes and Riel in the model is less than the confirmed = 3000 Amps, Non-issue
King-Eau Claire 345 kV line	Eau Claire to Wheaton 165 kV line	101%	105%	SPS (Eau Claire to Arpin)
9L	Fond du lac to Hibbard 115 kV line	None	176%	Line upgrade MTEP11 P2549
552	Alexandria to Alex SS 115 kV line	None	102%	The upgrade of this line to 234 MVA, Page 130 in [11]
Eau Claire-Arpin 345 kV line	Petenwell to Saratoga 138 kV line	105%	125%	Lacrosse-Madison P3127 [10]
New 500 kV tie line	M602F	None	VC	New trigger to existing HVdc power order reduction scheme
Bison-Maple River 345 kV line	Bison to Maple River 230 kV line	None	102%	Line upgrade if the two Bison 345/230 kV transformers are added. These transformers are not modeled in the latest MRO series models.

*Note: The results are virtually the same for with and without PST. Only one table is, therefore, provided.

Fargo Injection-Option W1-B: 1100 MW North Flow without PST

The base case (SI-IMPT-W-1100-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A1 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The power flow from US to Manitoba is set to be 700 MW as the starting point for this case. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 2. It is, therefore, assumed that planned projects in associated jurisdictions will take care of these base case overload issues.

The incremental impact of the TSR’s up to 1100 MW was evaluated using VSAT by increasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE and decreasing the MH NCS generation. Table 4 presents the results obtained for 0 MW and 1100 MW increases in power transfer from US to MH on top of the base transfer level of 700 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Table D3 of Appendix D.

It can be concluded from the results shown in Table 4 that several Network Upgrades are needed. Upgrade of Fargo to Sheyenne 230 kV line is needed to mitigate the overload resulting from various contingencies. The overloading of Souris-Velva Tap 115 kV line due to loss of 230 kV lines Coal Creek-Stanton and Coal Creek-Mchenry-Stanton (180-2) requires line upgrade. The overloading of Mchenry transformer due to various contingencies including 180-2 needs further investigation.

Table 4: Steady State Analysis Results Summary (SI-IMPT-W-1100-NOPST-60SC)

Contingency	Overload Facility	Overload		Comments
		-700 MW	-1800 MW	
B_XEL_COON_CK-TERMINL	Coon Creek to Kohlman Lake 345 kV line	None	110%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
220 (Various)	Fargo to Sheyenne 230 kV line	108%	120%	Line upgrade
Pre-Contingency	Souris to Mallard 115 kV line	103%	108%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
180-2	Souris to Velva Tap 115 kV line	104%	118%	Line upgrade
180-2, 180-1	Mchenry 230/115 KV transformer	181%	200%	Further investigation
New 500 kV tie line	G37C	None	109%	Rating increased to 900 A by October 30, 2012. The rating in the case is 280 MVA (700 A) [12]

Fargo Injection-Option W1-B: 1100 MW North Flow with PST

The base case (SI-IMPT-W-1100-PST-60SC) is the same as SI-IMPT-W-1100-No PST-60SC except a phase shifting transformer was added to G82R with a north flow setting of 250 MW. The optimization of the setting of the phase shifter may be further investigated.

Table 5: Steady State Analysis Results Summary (SI-IMPT-W-1100-PST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		-700 MW	-1800 MW	
B_XEL_COON_CK-TERMINL	Coon Creek to Kohlman Lake 345 kV line	None	110%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
220 (Various)	Fargo to Sheyenne 230 kV line	110%	124%	Line upgrade
Pre-Contingency	Souris to Mallard 115 kV line	103%	106%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
180-2	Mchenry 230/115 KV Transformer	200%	211%	Further investigation
180-2	Rugby to RugbyBPC 115 kV	108%	113%	Mallard generation reduced by 50MW, reduce the line loading by 4%.

Based on the results shown Table 5, it can be concluded that the upgrade of Fargo to Sheyenne 230 kV line is needed for mitigating the overload due to various contingencies. The overloading of Mchenry 230/115 kV transformer due to various contingencies including 180-2 needs further investigation. The detailed simulation results are provided in Table D4 of Appendix D.

Fargo Injection-Option W1: 750 MW South Flow without PST

The base case (SI-EXPT-W-750-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A2 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The power flow from Manitoba to US is set to be 2175 MW as the starting point. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 1. It is, therefore, assumed in this study that planned projects in associated jurisdictions will take care of these base case overload issues.

The incremental impact of the TSR's up to 750 MW was evaluated using VSAT by increasing the MH NCS generation and decreasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE. Table 6 presents the results obtained for 0 MW and 750 MW increases in power transfer from MH to US on top of the base transfer level of 2175 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Table D5 of Appendix D.

Table 6: Steady State Analysis Results Summary (SI-EXPT-W-750-NOPST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		2175 MW	2925 MW	
New 500 kV tie line	M602F	None	134%	New trigger to existing HVdc power order reduction scheme
Bison 500/345 kV transformer	M602F	None	134%	New trigger to existing HVdc power order reduction scheme
King to Eau Claire 345 kV line	Eau Claire to Wheaton165 kV line	101%	105%	SPS (Eau Claire to Arpin)
Alex SS to Bison 345 kV line	M602F	None	107%	Wave trap ratings of Forbes and Riel in the model is less than the confirmed = 3000 Amps, Non-issue
Bison to Maple 345 kV line	Bison to Maple 230 kV line	None	114%	Line upgrade
Bison to Alex SS 345 kV line	Bison to Maple River 345 kV line	None	100%	Line/equipment rating increase
9L	Fond du lac to Hibbard 115 kV line	None	175%	Minnesota Power operating procedure. Page 32 in [11]
Alex SS to Waite Park 345 kV line	Alexandria to Alex SS 115 kV line	105%	120%	The upgrade of this line to 234 MVA . Page 130 in [11]
Eau Claire-Arpin 345 kV line (Various)	Petenwell to Saratoga 138 kV line	103%	125%	Lacrosse to Madison P3127 [10]

It can be concluded from the results shown in Table 6 that several Network Upgrades are needed. New trigger to existing HVdc power order reduction scheme is required for loss of the new 500 kV tie line and Bison 500/345 kV transformer to mitigate the overloads. Bison to Maple River 230 kV line upgrade may also be required if the two Bison 345/230 kV transformers are added. Overload associated with Bison to Maple River 345 kV line may be mitigated by increasing the ratings of the station equipments and/or lines.

Fargo Injection-Option W1: 750 MW South Flow with PST

The base case (SI-EXPT-W-750-PST-60SC) is the same as SI-EXPT-W-750-NOPST-60SC except that a phase shifting transformer was added to G82R with 0 MW flow setting. The incremental impact of the TSR's up to 750 MW was evaluated using VSAT by increasing the MH NCS generation and decreasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE. Table 7 presents the results obtained for 0 MW and 750 MW increases in power transfer from MH to US on top of the base transfer level of 2175 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Table D6 of Appendix D.

Table 7: Steady State Analysis Results Summary
(SI-EXPT-W-750-PST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		2175 MW	2925 MW	
New 500 kV tie line	M602F	None	139%	New trigger to existing HVdc power order reduction scheme is needed
Bison 500/345 kV transformer	M602F	None	139%	New trigger to existing HVdc power order reduction scheme
King to Eau Claire 345 kV line	Eau Claire to Wheaton 165 kV line	100%	105%	SPS (Eau Claire to Arpin)
Alex SS to Bison 345 kV line	M602F	None	106%	Wave trap ratings of Forbes and Riel in the model is less than the confirmed = 3000 Amps, Non-issue
Bison to Maple 345 kV line	Bison to Maple 230 kV line	None	113%	Line upgrade
9L	Fond du lac to Hibbard 115 kV line	None	175%	Minnesota Power operating procedure. Page 32 in [11]
Alex SS to Waite Park 345 kV line	Alexandria to Alex SS 115 kV line	105%	119%	The upgrade of this line to 234 MVA, Page 130 in [11]
Eau Claire to Arpin 345 kV line (Various)	Petenwell to Saratoga 138 kV line	103%	125%	Lacrosse to Madison P3127 [10]

Similar conclusions from the case without modelling G82R phase shifting transformer can be drawn. The only difference is that the overload of Bison to Maple River 345 kV line resulting from the loss of Bison to Alex SS 345 kV line does not show in this case. This is due to the fact that the G82R phase shifting transformer setting has changed the flow distributions on the MH-US tie lines. It should be noted that G82R PST was set to zero in this analysis. If G82R PST is set to 250 MW south, the line loadings shown in Column 3 of Table 7 will be less than those shown in Table 6.

Fargo Injection-Option W1: 750 MW North Flow without PST

The base case (SI-IMPT-W-750-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A2 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The power flow from US to Manitoba is set to be 700 MW as the starting point for this case. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 2. It is, therefore, assumed in this study that planned projects in associated jurisdictions will take care of these base case overload issues.

The incremental impact of the TSR's up to 750 MW was evaluated using VSAT by increasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE and decreasing the MH NCS generation. Table 8 presents the results obtained for 0 MW and 750 MW increases in power transfer from US to MH on top of the base transfer level of 700 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Table D7 of Appendix D.

Table 8: Steady State Analysis Results Summary (SI-IMPT-W-750-NOPST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		-700 MW	-1450 MW	
B-XEL-COON-CK-Terminal	Coon Creek to Kohlman Lake 345 kV line	None	113%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
220 (Various)	Fargo to Sheyenne 230 kV line	109%	119%	Line upgrade
Pre-Contingency	Souris to Mallard 115 kV line	103%	107%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
180-2	Souris to Velva Tap 115 kV line	104%	114%	Line upgrade
180-2 (various, 180-1)	Mchenry 230/115 kV transformer	165%	177%	Further investigation
New 500 kV/Bison 500/345 kV transformer	G37C	None	102%	Rating increased to 900 A by October 30, 2012. The rating in the case is 280 MVA (700 A) [12]

It can be concluded from the results shown in Table 8 that Network Upgrades are needed. Upgrade of Fargo to Sheyenne 230 kV line is needed to mitigate the overload resulting from various contingencies. The overloading of Souris to Velva Tap 115 kV line due to loss of 230 kV lines Coal Creek to Stanton and Coal Creek-Mchenry-Stanton (180-2) requires line upgrade. The overloading of Mchenry 230/115 kV transformer due to various contingencies including 180-1 and 180-2 needs further investigation. The overload of 230 kV line between Cornwallis and Glenboro stations can be mitigated by controlling flow on G82R.

Fargo Injection-Option W1: 750 MW North Flow with PST

The base case (SI-IMPT-W-750-PST-60SC) is the same as SI-IMPT-W-750-NOPST-60SC except a phase shifting transformer was added to G82R with a north flow setting of 250 MW. The optimization of the setting of the phase shifter may be further investigated. The detailed simulation results are provided in Table D8 of Appendix D. Similar conclusions to the previously described case without PST can be made.

Table 9: Steady State Analysis Results Summary (SI-IMPT-W-750-PST-60SC)

Contingency	**Overload Facility**	**Overload Level**		**Comments**
		-700 MW	**-1450 MW**	
B-XEL-COON-CK-Terminal	Coon Creek to Kohlman Lake 345 kV line	None	114%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
220 (Various)	Fargo to Sheyenne 230 kV line	111%	123%	Line upgrade
Pre-Contingency	Souris to Mallard 115 kV line	103%	105%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
180-2	Souris to Velva Tap 115 kV line	118%	123%	Line upgrade
180-2 (various, 180-1)	Mchenry 230/115 kV transformer	200%	208%	Further investigation
180-2	Rugby to RugbyBPC 115 kV line	108%	112%	Mallard generation reduced by 50MW, reduce the Rugby-RugbyBPC by 4%.

Iron Range Injection-Option Y500-A/B: 1100 MW South Flow without/with PST

The base case (SI-EXPT-E-1100-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A3 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The base case (SI-EXPT-E-1100-PST-60SC) is the same as SI-EXPT-E-1100-NOPST-60SC except a phase shifting transformer was added on G82R to control the flow on the line around 0 MW. The power flow from Manitoba to US is set to be 2175 MW as the starting point for both cases. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 1. It is, therefore, assumed in this study that planned projects in associated jurisdictions will take care of these base case overload issues.

Table 10: Steady State Analysis Results Summary* (SI-EXPT-E-1100-NOPST-60SC, SI-EXPT-E-1100-PST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		2175 MW	3275 MW	
New 500 kV tie line	M602F	None	148%	New trigger to existing HVdc power order reduction scheme
Blackberry 500/230 kV transformer	M602F	None	101%	G82R PST adjustment
Arrowhead to Stone Lake 345 kV line	Forbes to ChisagoN2 500 kV line and other lines	None	107%	New trigger to existing HVdc power order reduction scheme
Stone Lake to Gardner Park 345 kV line	Stone Lake 345/165 kV transformer	109%	123%	Addition of a second Stone Lake transformer
King to Eau Claire 345 kV line	Eau Claire to Wheaton 165 kV line	102%	105%	SPS (Eau Claire to Arpin)
Mesaba to Blackberry 230 kV line	Forbes to Blackberry 230 kV line	None	101%	Generation re-dispatch
Stone Lake to Gardner Park 345 kV line	Riverton to Hill City 115 kV line	None	101%	Minnesota Power operating procedure. Page 32 in [11]
9L	Fond du lac to Thomson 115 kV line	None	121%	Line upgrade MTEP11 P2549
9L	Fond du lac to Hibbard 115 kV line	128%	256%	Line upgrade MTEP11 P2549
20L	Blackberry to Nashwauk 115 kV line	None	108%	Line upgrade
Pre-Contingency	Grand Rapids to Hill City 115 kV line	None	101%	Minnesota Power operating procedure. Page 32 in [11]
Stone Lake to Gardner Park 345 kV line	Grand Rapids to Hill City 115 kV line	None	106%	Minnesota Power operating procedure. Page 32 in [11]
Eau Claire to Arpin 345 kV line	Petenwell to Saratoga 138 kV line	None	104%	Lacrosse to Madison P3127 [10]

*Note: The results are virtually the same for with and without PST. Only one table is, therefore, provided.

The incremental impact of the TSR's up to 1100 MW was evaluated using VSAT by increasing the MH NCS generation and decreasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE. Table 10 presents the results obtained for 0 MW and 1100 MW increases in power transfer from MH to US on top of the base transfer level of 2175 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Tables D9 and D10 of Appendix D.

It can be concluded from the results shown in Table 10 that several Network Upgrades are needed. New trigger to existing HVdc power order reduction scheme is required for loss of the new 500 kV tie line and Arrowhead-Stone Lake 345 kV line to mitigate the overloads. Overloading of Stone Lake 345/165 kV transformer can be mitigated by adding a second transformer at Stone Lake. Fond du lac to Thomson 115 kV needs to be upgraded.

Iron Range Injection-Option Y500-A/B: 1100 MW North Flow without/with PST

The base case (SI-IMPT-E-1100-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A3 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The base case (SI-IMPT-E-1100-PST-60SC) is the same as SI-IMPT-E-1100-NOPST-60SC except a phase shifting transformer was added on G82R to achieve 250 MW north flow on the line. The power flow from US to Manitoba is set to be 700 MW as the starting point for both cases. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 2. It is, therefore, assumed in this study that planned projects in associated jurisdictions will take care of these base case overload issues.

The incremental impact of the TSR’s up to 1100 MW was evaluated using VSAT by decreasing the MH NCS generation and increasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE. Tables 11 and 12 present the results obtained for the scenarios without and with G82R PST respectively, for 0 MW and 1100 MW increases in power transfer from US to MH on top of the base transfer level of 700 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Tables D11 and D12 of Appendix D.

Based on the results obtained for the two cases described in this section, it is recommended that the following Network Upgrades need to be completed for accommodating the increase of 1100 MW transfer capability from US to MH. The addition of a phase shifting transformer to G82R is preferred over the re-conductor of G82R as can be seen from discussions presented in Section 7.2. In addition to G82R phase shifting transformer, a transformer with larger capacity (900 MVA minimum) is required for mitigating the overload of proposed Blackberry 500/230 kV transformer. Alex SS to Alexandria 115 kV line also needs to be upgraded.

Table 11: Steady State Analysis Results Summary (SI-IMPT-E-1100-NOPST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		-700 MW	-1800 MW	
Coon Creek Terminal	Coon Creek to Kohlman 345 kV line	102%	131%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
M602F	Blackberry 500/230 kV transformer	None	112%	Increase transformer rating to 900 MVA minimum
Pre-Contingency	Souris to Mallard 115 kV line	106%	111%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
180-2	Souris to Velva Tap 115 kV line	112%	128%	Line upgrade
552	Alex SS to Alexandria 115 kV line	None	101%	Line upgrade
Pre-Contingency	G82R	None	114%	Add PST to G82R or Re-conductor G82R
180-2	Rugby to RugbyBPC 115 kV line	None	111%	Mallard generation reduced by 50MW, reduce the line loading by 4%. And/or add PST to G82R
M602F, Various	G37C	None	106%	Rating increased to 900 A by October 30, 2012. The rating in the case is 280 MVA (700 A) [12]
180-2	McHenry 230/115 kV Transformer	195%	219%	Further investigation

Table 12: Steady State Analysis Results Summary (SI-IMPT-E-1100-PST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		-700 MW	-1800 MW	
Coon Creek Terminal	Coon Creek to Kohlman 345 kV line	103%	132%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
M602F	Blackberry 500/230 kV transformer	None	115%	Increase transformer rating to 900 MVA minimum
Pre-Contingency	Souris to Mallard 115 kV line	103%	107%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
552	Alex SS to Alexandria 115 kV line	None	102%	Line upgrade
180-2	McHenry 230/115 kV Transformer	190%	201%	Further investigation

Iron Range Injection-Option Y500: 750 MW South Flow without/with PST

The base case (SI-EXPT-E-750-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A4 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The base case (SI-EXPT-E-750-PST-60SC) is the same as SI-EXPT-E-750-NOPST-60SC except a phase shifting transformer was added on G82R to achieve 0 MW flow on the line. The power flow from Manitoba to US is set to be 2175 MW as the starting point for both cases. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 1. It is, therefore, assumed in this study that planned projects in associated jurisdictions will take care of these base case overloading issues.

Table 13: Steady State Analysis Results Summary*
(SI-EXPT-E-750-NOPST-60SC, SI-EXPT-E-750-PST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		2175 MW	2925 MW	
New 500 kV tie line	M602F	None	131%	New trigger to existing HVdc power order reduction scheme
Blackberry 500/230 kV Transformer	M602F	None	131%	New trigger to existing HVdc power order reduction scheme
220 (various)	Blackberry 500/230 kV transformer	None	104%	Increase transformer rating to 900 MVA minimum
King to Eau Claire 345 kV line	Eau Claire to Wheaton165 kV line	102%	107%	SPS (Eau Claire to Arpin)
Mesaba to Blackberry CKT1 230 kV line	Mesaba to Blackberry 230 kV line (CKT 2)	None	100%	Generation re-dispatch
98L	Forbes to Blackberry 230 kV line	None	101%	Line upgrade
Pre-Contingency	Riverton to Hill City 115 kV line	106%	108%	Minnesota Power operating procedure. Page 32 in [11]
98L	Blackberry to Floodwood 115 kV line	None	104%	Line upgrade
20L (various)	Blackberry to Nashwauk 115 kV line	106%	129%	Line upgrade
Pre-Contingency	20L Tap to Blackberry 115 kV line	None	100%	Line upgrade
Pre-Contingency	Grand Rapids to Hill City 115 kV line	109%	113%	Minnesota Power operating procedure. Page 32 in [11]
565	Nary to Cass Lake 115 kV line	None	101%	Line has been upgraded to 279 MVA, Dec 5, 2012
Eau Claire to Arpin 345 kV line	Petenwell to Saratoga 138 kV line	105%	126%	Lacrosse to Madison P3127 [10]

*Note: The results are virtually the same for with and without PST. Only one table is, therefore, provided.

The incremental impact of the TSR's up to 750 MW was evaluated using VSAT by increasing the MH NCS generation and decreasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE. Table 13 presents the results obtained for 0 MW and 1100 MW increases in power transfer from MH to US on top of the base transfer level of 2175 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Tables D13 and D14 of Appendix D.

It can be concluded from the results shown in Table 13 that several Network Upgrades are needed. Overloading of M602F line due to loss of the new 500 kV tie line or the Blackberry 500/230 kV transformer requires new HVdc reduction. Five other 115 kV line upgrades in the Iron Range area identified in Table 13 may be required.

Iron Range Injection-Option Y500: 750 MW North Flow without/with PST

The base case (SI-IMPT-E-750-NOPST-60SC) for this scenario was developed by adding all of the proposed facilities as detailed in Figure A4 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The base case (SI-IMPT-E-750-PST-60SC) is the same as SI-IMPT-E-750-NOPST-60SC except a phase shifting transformer was added on G82R to achieve 250 MW north flow on the line. The power flow from US to Manitoba is set to be 700 MW as the starting point for both cases. Some base case overloads on existing facilities were found but they are not impacted by scheduling the TSRs presented in Table 2. It is, therefore, assumed in this study that planned projects in associated jurisdictions will take care of these base case overload issues.

Table 14: Steady State Analysis Results Summary
(SI-IMPT-E-750-NOPST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		-700 MW	-1450 MW	
B_XEL_COON_CK-TERMINL	Coon Creek to Kohlman 345 kV line	102%	122%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
Pre-contingency	Souris to Mallard 115 kV line	105%	109%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
180-2	Souris to Velva Tap 115 kV line	110%	121%	Line upgrade
180-2	Rugby to RugbyBPC 115 kV line	None	104%	Reducing Mallard generation by 50MW, will reduce the line loading by 4%. And/or add PST to G82R
Pre-contingency	G82R	None	106%	Add PST to G82R or re-conductor G82R
180-2, 180-1	Mchenry 230/115 kV transformer	193%	209%	Further investigation

Table 15: Steady State Analysis Results Summary (SI-IMPT-E-750-PST-60SC)

Contingency	Overload Facility	Overload Level		Comments
		-700 MW	-1450 MW	
B_XEL_COON_CK-TERMINL	Coon Creek to Kohlman 345 kV line	103%	123%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
Pre-contingency	Souris to Mallard 115 kV line	103%	105%	Reducing Mallard generation by 50 MW will reduce the loading on the line by 10%
180-2	Souris to Velva Tap 115 kV line	108%	114%	Line upgrade
180-2, 180-1	Mchenry 230/115 kV transformer	189%	198%	Further investigation

The incremental impact of the TSR's up to 750 MW was evaluated using VSAT by decreasing the MH NCS generation and increasing the outputs of appropriate generating plants in WPS, MP, GRE and ALTE. Tables 14 and 15 present the results obtained for 0 MW and 750 MW increases in power transfer from US to MH on top of the base transfer level of 700 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Tables D15 and D16 of Appendix D.

Based on the results obtained for the two cases described in this section, it is recommended that the following Network Upgrades need to be completed for accommodating the increase of 750 MW transfer capability from US to MH. The addition of phase shifting transformer to G82R is preferred over the re-conductor of G82R as can be seen from discussions presented in Section 7.2. In addition to G82R phase shifting transformer, Souris to Velva Tap 115 kV line needs to be upgraded.

Iron Range 230 kV Injection

The base cases (SI-EXPT-250-Riel-Shannon and SI-IMPT-250-Riel-Shannon) for this scenario were developed by adding all of the proposed facilities as detailed in Figure A5 in Appendix A to the benchmark case used for the MISO group TSR study for Option 1. The power flows between Manitoba and US are set to be 2175 MW and 700 MW respectively for south flow (export) and north flow (import) as the starting point. Some base case overloads on existing facilities were found but they are not impacted by scheduling the requested transmission service. It is, therefore, assumed in this study that planned projects in associated jurisdictions will take care of these base case overload issues.

The incremental impact of the TSR's up to 250 MW was evaluated using VSAT for both south flow and north flow scenarios by changing the MH NCS generation and the outputs of appropriate generating plants in MP. Table 16-a presents the results obtained for 0 MW and 250 MW increases in power transfer from MH to US on top of the base transfer level of 2175 MW. Table 16-b presents the results obtained for 0 MW and 250 MW increases in power transfer from US to MH on top of the base transfer level of 700 MW. Only the worst contingency is shown for each overloaded facility. The detailed simulation results are provided in Table D17-1 and D17-2 of Appendix D respectively for both export and import cases.

It can be concluded from the results shown in Tables 16-a and 16-b that several Network Upgrades are needed. New trigger to existing HVdc power order reduction scheme is also required for loss of the new 230 kV tie line to mitigate the overloads if power flows from Manitoba to US. A phase shifting transformer is also needed for eliminating congestions on G82R line for facilitating the maximum transfer increase of 250 MW from US to Manitoba.

Table 16-a: Steady State Analysis Results Summary (SI-EXPT-250-Riel-Shannon)

Contingency	Overload Facility	Overload Level		Comments
		2175 MW	2425MW	
220, 570, Bison to AlexSS 345 kV line	M602F (Forbes to Roseau)	None	106%	Wave trap ratings of Forbes and Riel in the model is less than the confirmed = 3000 Amps, Non-issue
Pre-contingency	M602F overload	None	103%	Wave trap ratings of Forbes and Riel in the model is less than the confirmed = 3000 Amps, Non-issue
9L	Fond du lac to Hibbard 115 kV line	101%	182%	Line upgrade MTEP11 P2549
New 230 kV Tie line	M602F	None	107%	New trigger to existing HVdc power order reduction scheme

Table 16-b: Steady State Analysis Results Summary (SI-IMPT-250-Riel-Shannon)

Contingency	Overload Facility	Overload Level		Comments
		-700 MW	-950 MW	
Pre-contingency	G82R	None	101%	Add PST to G82R or Re-conductor G82R
180-2	Souris to Velva Tap 115 kV line	121%	124%	Line upgrade
180-2	Rugby to RugbyBPC 115 kV line	None	103%	Mallard generation reduced by 50MW, reduce the line loading by 4%.
180-2, 180-1	Mchenry 230/115 kV transformer	186%	190%	Further investigation

7.1.2 Prior Outage Cases

Prior outage analysis was performed only for the 1100 MW incremental export transfer scenarios for both injections (Options W1-B and Y500-A/B). For both options, prior outage cases were developed by taking out the M602F line. Comparative assessment with and without G82R phase shifting transformer was performed using the methodologies described in Section 5. The steady state simulation results are summarized in Tables 17 to 19. Detailed results are presented in Tables D18 to D21. Based on the simulation results, the following conclusions/observations can be made:

1. **Option W1-B**

    a. 2175 MW from MH to US (0 MW incremental):

    Some of the overloaded facilities in Table 17 are already addressed in Section 7.1.1 for System Intact case analysis. The following additional Network Upgrades are required for achieving 2175 MW:

    Overloading of one of the Bison 500/345 kV transformers due to the loss of the other parallel one requires the addition of a new trigger to existing HVdc power order reduction scheme or overloading capability of more than 1200 MVA for the Bison 500/345 kV transformers. R50M overload at pre-contingency can be mitigated by adjusting the G82R phase shifting transformer. The loss of F3M, however, causes R50M overload of 122% which cannot be mitigated by the adjustment of the G82R phase shifting transformer. Continuous fast reactive support would, therefore, be required to provide voltage support for mitigating the operational limit on R50M from 229 MVA to 280 MVA. Line upgrade of Forbes to Blackberry 230 kV line is also required.

    b. 2375 MW from MH to US (200 MW incremental):

    In addition to the fixes identified at 0 MW incremental (a), Overloading of Riel to Richer 230 kV line and R50M line caused by F3M contingency need line upgrades. G82R phase shifting transformer is needed to reduce loop flow on the new 500 kV tie line. Bison to Maple 345 kV line upgrade is required for eliminating overload due to loss of the Bison to AlexSS 345 kV line.

    c. 2575 MW from MH to US (400 MW incremental):

    In addition to the fixes identified at 200 MW incremental (b), Overloading of Cass County to Red River 115 kV line due to NSP-3 contingency requires line upgrade.

Table 17: Steady State Analysis Results Summary*
(PO-M602F-EXPT-W-1100-NOPST-60SC, PO-M602F-EXPT-W-1100-PST-60SC)

Contingency	**Overload Facility**	**Overload Level**			**Comments**
		2175 MW	**2375 MW**	**2575 MW**	
B_XEL_COON_CK-TERMINL , 670_1	Coon Creek to Kohlman Lake 345 kV line	121%	125%	127%	Reducing Sherco generation by 200 MW will reduce the overload by about 8%. Further investigation is needed.
Pre-contingency	New 500 kV tie line	None	101%	111%	Adjust G82R PST for south flow by 50 MW will offload the new tie line by 2%.
Bison 500/345 kV transformer	Bison 500/345 kV transformer	133%	145%	158%	New trigger to existing HVdc power order reduction scheme or provide overloading capability greater than 1200 MVA
Bison to AlexSS 345 kV line	Bison to Maple 345 kV line	None	106%	114%	Line upgrade
Pre-contingency	Bison to Maple 345 kV line	None	None	100%	Line upgrade
Bison to Maple 345 kV line	Bison to Maple 230 kV line	129%	138%	148%	Line upgrade
NSP-3	Cass County to Red River 115 kV line	None	None	106%	Line upgrade
98L	Forbes to Blackberry 230 kV line	100%	100%	102%	Line upgrade
9L	Fond du lac to Hibbard 115 kV line	None	110%	137%	Line upgrade MTEP11 P2549
20L	Blackberry to Nashwauk 115 kV line	None	105%	108%	Line upgrade
AlexSS to WaitePark 345 kV line	Alexandria to Alex SS 115 kV line	102%	106%	110%	The upgrade of this line to 234 MVA, Page 130 in [11]
800 1	Wilton to Wiltontap to Solway 115 kV line	110%	116%	120%	Generation re-dispatch at Solway
800 1	Winger to Bagley 115 kV line	None	111%	120%	Generation re-dispatch at Solway
Pre-contingency	Maple river 345/230 kV transformer	None	101%	108%	336 MVA increase to about 500 MVA
F3M (726L)	Riel to Richer 230 kV line	None	105%	111%	Line upgrade
Pre-contingency	R50M	101%	110%	117%	Conductor rating is 280 MVA, line operation limit is 229 MVA. SVC or Statcom is required to increase rating R50M to 280 MVA
F3M (726L)	R50M	122%	132%	142%	Same as above, plus G82R PST adjustment.
Eau Claire to Arpin 345 kV line	Petenwell to Saratoga 138 kV line	102%	103%	102%	Lacrosse to Madison P3127 [10]

*Note: The results are virtually the same for with and without PST. Only one table is, therefore, provided.

2. Option Y500-A/B

a. 2175 MW from MH to US (0 MW incremental):

A number of the overloaded facilities in Tables 18 and 19 are already addressed in Section 7.1.1 for System Intact case analysis. The following additional Network Upgrades are required for achieving 2175 MW:

Overloading of one of the Blackberry 500/345 kV transformers due to the loss of the other parallel one requires the addition of a new trigger to existing HVdc power order reduction scheme or overloading capability of more than 1200 MVA for the Blackberry 500/345 kV transformers. R50M and L20D overloads can be mitigated by the addition of the G82R phase shifting transformer. Line upgrade of Forbes to Blackberry 230 kV line is also needed.

b. 2375 MW from MH to US (200 MW incremental):

Pre-contingency overload of L20D can be mitigated by the addition of the G82R phase shifting transformer as well. All the other required fixes are the same as those identified in 0 MW incremental (a).

c. 2575 MW from MH to US (400 MW incremental):

Pre-contingency overload of the new 500 kV tie line and voltage collapse due to the loss of Blackberry 500/230 kV transformer can be mitigated by the addition of G82R phase shifting transformer. In addition to the fixes identified at 200 MW incremental (b), line upgrades of Fargo to Sheyenne 230 kV line and 20L Tap to Blackberry 115 kV line are required.

Table 18: Steady State Analysis Results Summary (PO-M602F-EXPT-E-1100-NOPST-60SC)

Contingency	Overload Facility	Overload Level			Comments
		2175 MW	2375 MW	2575 MW	
Arrowhead-Stone Lake 345 kV line	Blackberry 500/230 kV transformer and other facilities	126%	140%	153%	New trigger to existing HVdc power order reduction scheme
Blackberry-Arrowhead 345 kV line (Various)	Blackberry 500/230 kV transformer	None	112%	126%	Increase transformer rating to 900 MVA or greater, or add new trigger to existing HVdc power order reduction scheme
Pre-contingency	Blackberry 500/230 kV transformer	None	None	107%	Increase transformer rating to 900 MVA
Pre-contingency	New 500 kV Tie line	None	None	104%	G82R PST is required or line to be built to higher capacity
220, 220_2	Fargo to Sheyenne 230 kV line	None	None	100%	Line upgrade
Pre-contingency	Stone Lake 345/165 kV transformer	None	100%	102%	Addition of a second Stone Lake transformer
StoneLake to Gardnier Park 345 kV line	Stone Lake 345/165 kV transformer	119%	120%	123%	Addition of a second Stone Lake transformer
Mesaba to Blackberry CKT1 230 kV line	Mesaba to Blackberry 230 kV line (CKT 2)	None	102%	106%	Generation re-dispatch
Pre-contingency	Forbes to Blackberry 230 kV line	127%	133%	140%	Line upgrade
Blackberry 500/345 kV transformer	Blackberry 500/345 kV transformer 2	123%	135%	147%	New trigger to existing HVdc power order reduction scheme or provide overloading capability greater than 1200 MVA
9L	Fond du lac to Thomson 115 kV line	None	None	113%	Line upgrade MTEP11 P2549
9L	Fond du lac to Hibbard 115kV line	125%	206%	237%	Minnesota Power operating procedure. Page 32 in [11]
Pre-contingency	Blackberry to Nashwauk 115 kV line	105%	115%	119%	Line upgrade
Blackberry 500/230 kV transformer	L20D	100%	111%	124%	New trigger to existing HVdc power order reduction scheme or G82R PST is required
Pre-contingency	L20D	None	None	103%	G82R PST is required
726L, Blackberry 500/230 kV transformer	R50M	110%	117%	124%	G82R PST is required

Table 19: Steady State Analysis Results Summary (PO-M602F-EXPT-E-1100-PST-60SC)

Contingency	**Overload Facility**	**Overload Level**			**Comments**
		2175 MW	**2375 MW**	**2575 MW**	
Blackberry to Arrowhead 345 kV line (Various)	Blackberry 500/230 kV transformer	100%	116%	132%	Increase transformer rating to 900 MVA or greater, or add new trigger to existing HVdc power order reduction scheme
Arrowhead to Stone Lake 345 kV line	Blackberry 500/230 kV transformer and other facilities	129%	144%	159%	New trigger to existing HVdc power order reduction scheme
Pre-contingency	Blackberry 500/230 kV transformer	None	None	113%	Increase transformer rating to 900 MVA or greater
Pre-contingency	New 500 kV tie line series comp	None	None	102%	G82R PST adjustment by 50 MW (south) results in 2% reduction of line loading
Pre-contingency	New 500 kV tie line	None	None	108%	G82R PST adjustment by 50 MW (south) results in 2% reduction of line loading
Pre-contingency	Stone Lake 345/165 kV transformer	None	101%	103%	Addition of a second Stone Lake transformer
StoneLake to Gardnier Park 345 kV line	Stone Lake 345/165 kV transformer	120%	121%	124%	Addition of a second Stone Lake transformer
Mesaba to Blackberry CKT1 230 kV line	Mesaba to Blackberry CKT 2 230 kV line	None	103%	108%	Generation re-dispatch
Pre-contingency	Forbes to Blackberry 230 kV line	128%	135%	143%	Line upgrade
Blackberry 500/345 kV transformer	Blackberry 500/345 kV transformer 2	126%	138%	152%	New trigger to existing HVdc power order reduction scheme
9L	Fond du lac to Thomson 115 kV line	None	None	114%	Line upgrade MTEP11 P2549
9L	Fond du lac to Hibbard 115kV line	127%	207%	240%	Minnesota Power operating procedure. Page 32 in [11]
Pre-contingency	Blackberry to Nashwauk 115 kV line	106%	116%	121%	Line upgrade
Pre-contingency	20L tap to Blackberry 115 kV line	None	None	101%	Line upgrade
565	Nary to Cass Lake 115 kV line	None	None	100%	Line has been upgraded to 279 MVA, Dec 5, 2012
Blackberry 500/230 kV transformer	L20D	107%	118%	VC	New trigger to existing HVdc power order reduction scheme or G82R PST adjustment of 50 MW (south) result in 5% reduction of line loading
Pre-contingency	L20D	None	100%	113%	G82R PST adjustment of 50 MW (south) result in 5% reduction of line loading
726L (Various)	R50M	111%	119%	127%	G82R PST adjustment of 50 MW (south) result in 2.5% reduction of line loading

7.2 Impacts of North Dakota Export and Minnesota-Wisconsin Export

7.2.1 MH to US South Flow

The major interface flows assumed in the base case for the studies presented in the previous sections for the 500 kV options are shown in Table 20. It can be seen from Table 20 that the North Dakota Export (NDEX) and Minnesota-Wisconsin Export (MWEX) are approximately 1100 MW-1400 MW. It is known that change in both NDEX and MWEX have significant impact on the power flow distribution of the MH-US tie lines. This effect is sometimes referred to as the North Dakota-Manitoba loop flow issue.

Table 20: Major Interface Flows for Steady-state Contingency Analysis

Case	NDEX	MH-US	MWEX	New 500 kV	M602F	Arrowhead-Stone Lake
Option W1-B	1370	2176	1088	828	1180	498
Y500-A/B	1385	2175	1267	788	1135	742

Further studies were carried out to examine the impact of proposed alternatives on the North Dakota-Manitoba loop flow issue for the scenarios with 1100 MW and 750 MW additional MH-US transfers. The results obtained for the Fargo injection for 1100 MW and 750 MW incremental transfers from MH to US are shown respectively in Tables 21 and 22. The results obtained for the Iron Range injection for 1100 MW and 750 MW additional transfers from MH to US are shown respectively in Tables 23 and 24. It can be seen from these tables that:

1. Loop flow from North Dakota on the 500 kV tie lines increases with increase in NDEX and MWEX.
2. The flow sharing between the 500 kV lines is better for the Iron Range option.
3. The current thermal rating of 2000 A (approximately 1732 MW) on the M602F line is exceeded for the Fargo injection at higher NDEX and MWEX levels.

Table 21: Impact of NDEX and MWEX
(Option W1-B, MHEX=3275 MW, All values are in MW)

NDEX	MWEX	MH-US	L20D	G82R	R50M	New 500 kV	M602F	Arrowhead-Stone Lake
1366	1457	3274	237	-20	147	1258	1652	627
1464	1484	3277	231	-23	147	1252	1669	639
1564	1507	3278	225	-27	148	1244	1687	646
1663	1586	3278	219	-31	149	1237	1703	710
1762	1564	3278	213	-34	151	1229	1720	679
1861	1587	3279	205	-39	155	1221	1736	687
1959	1623	3279	199	-43	157	1212	1754	712
2058	1642	3278	192	-47	158	1204	1770	716
2156	1668	3277	186	-51	158	1197	1787	727
2254	1688	3278	180	-54	160	1190	1802	734

Table 22: Impact of NDEX and MWEX
(Option W1, MHEX=2925 MW, All values are in MW)

NDEX	MWEX	MH-US	L20D	G82R	R50M	New 500 kV	M602F	Arrowhead-Stone Lake
1368	1399	2926	217	-32	145	966	1629	619
1467	1426	2926	211	-35	146	956	1648	629
1567	1448	2926	205	-39	147	946	1667	637
1666	1472	2926	199	-43	148	935	1687	645
1765	1495	2926	192	-47	150	926	1706	654
1864	1528	2926	185	-51	151	914	1726	677
1962	1554	2927	179	-54	152	904	1745	688
2061	1574	2927	173	-58	154	895	1763	694
2159	1607	2926	167	-62	155	884	1783	717
2257	1636	2927	161	-66	156	874	1802	728

Table 23: Impact of NDEX and MWEX
(Option Y500-A/B, MHEX=3275 MW, All values are in MW)

NDEX	MWEX	MH-US	L20D	G82R	R50M	New 500 kV	M602F	Arrowhead-Stone Lake
1375	1453	3275	320	24	133	1184	1614	874
1475	1481	3278	311	19	134	1189	1624	886
1575	1508	3278	303	14	135	1194	1633	899
1675	1535	3279	294	9	135	1198	1643	911
1775	1561	3279	286	3	136	1202	1652	922
1875	1586	3279	277	-2	136	1206	1661	932
1974	1616	3280	267	-8	136	1213	1672	947
2074	1640	3280	259	-13	137	1217	1682	956
2173	1665	3281	250	-19	137	1221	1691	966
2272	1688	3281	242	-24	138	1224	1701	974

Table 24: Impact of NDEX and MWEX
(Option Y500, MHEX=2925 MW, All values are in MW)

NDEX	MWEX	MH-US	L20D	G82R	R50M	New 500 kV	M602F	Arrowhead-Stone Lake
1381	1395	2922	321	30	127	810	1634	612
1431	1419	2924	316	27	128	813	1640	632
1531	1445	2924	308	22	129	815	1651	640
1631	1467	2925	299	17	130	817	1662	647
1731	1490	2925	291	12	130	820	1673	655
1831	1511	2925	283	7	131	822	1684	662
1930	1537	2926	275	2	131	824	1695	672
2029	1569	2926	265	-4	132	828	1705	693
2129	1589	2927	257	-9	132	830	1716	698
2228	1610	2927	249	-14	133	832	1726	703

The pre-contingency overloading of the M602F line associated with the Fargo injection option under high NDEX and MWEX conditions can be mitigated by controlling the G82R flow through a phase shifting transformer. The study results obtained for the 1100 MW incremental transfer with the phase shifting transformer modeled are provided in Table 25. It can be seen from Table 25 that the pre-contingency overload on the M602F line can be mitigated if the flow on G82R is controlled to be at least 150 MW southward.

Table 25: Impact of G82R Phase Shifting Transformer on MH-US Tie Flow
(Option W1-B, MHEX=3275 MW, NDEX=2200 MW, All values are in MW)

PST/No PST	G82R	NDEX	MWEX	MH-US	L20D	R50M	New 500 kV	M602F	Arrowhead-Stone Lake
No PST	**-53**	**2206**	**1679**	**3278**	**183**	**160**	**1193**	**1794**	**731**
PST	1.4	2206	1680	3277	169	159	1167	1781	732
PST	50	2206	1677	3275	156	158	1143	1768	730
PST	96	2206	1676	3274	144	157	1121	1757	729
PST	147	2206	1674	3272	131	155	1096	1743	728
PST	200	2206	1672	3269	117	154	1070	1728	727
PST	255	2205	1671	3265	103	153	1043	1713	726

7.2.2 MH to US North Flow

Further studies were conducted to examine the impact of NDEX on system performance for the scenario of power flowing from the US to Manitoba. The purpose of these studies is to investigate the feasibility of achieving symmetric import/export capability for all options investigated in the studies described in this report. Figures 1 and 2 compare the impact of NDEX for Y500-A/B and W1-B options at base transfer level of 700 MW north and at the maximum transfer level of 1800 MW north respectively.

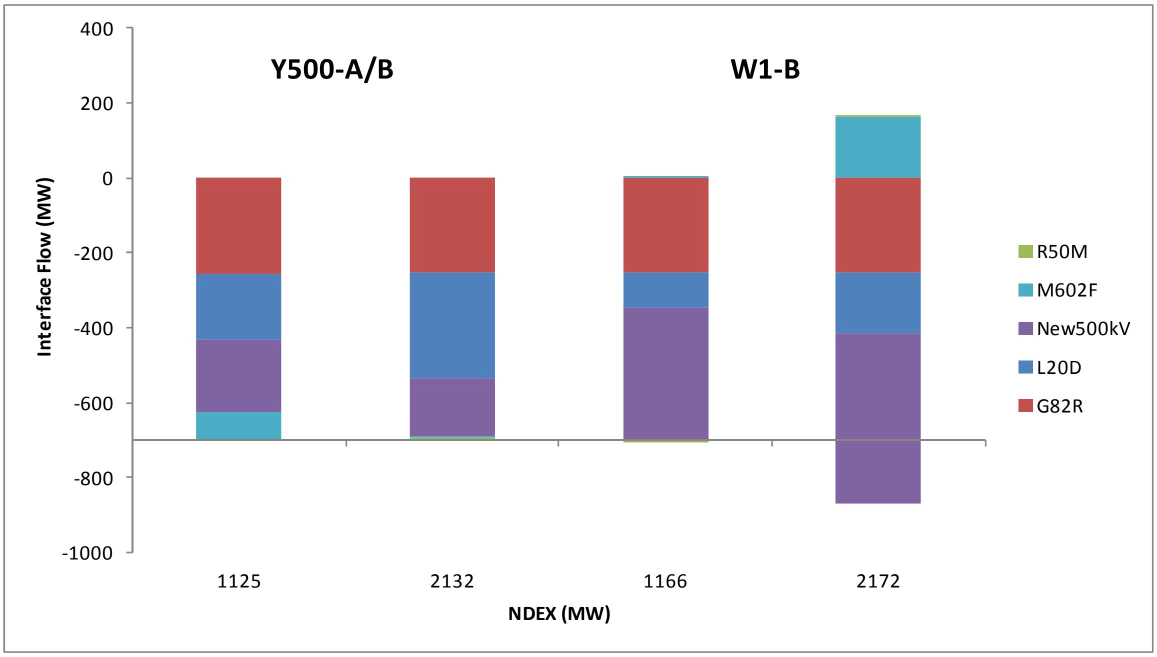


Figure 1: Comparison of the Impact of NDEX (North Flow of 700 MW)

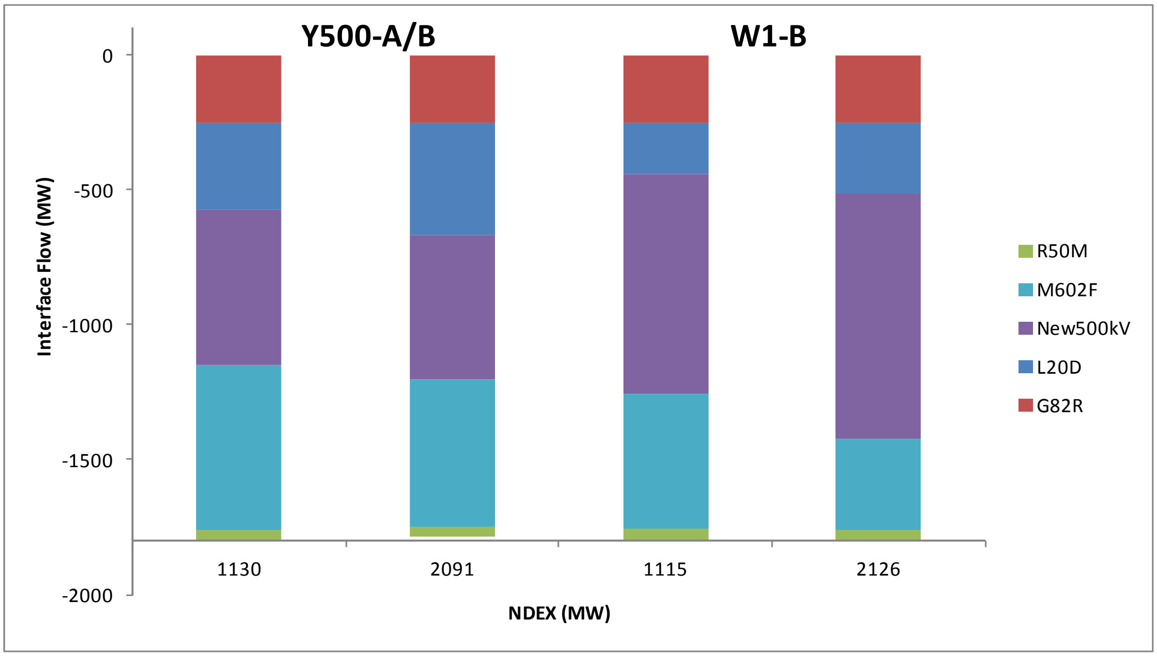


Figure 2: Comparison of the Impact of NDEX (North Flow of 1800 MW)

It can be seen from Figures 1 and 2 that the performance of the Iron Range Injection is better than that of the Fargo injection. The flow distribution on the two 500 kV lines are more even and it has relatively less loop flow on the MH-US interface for Option Y500-

A/B particularly at a higher NDEX level. Similar conclusions can be drawn by comparing Options Y500 and W1. Study results also show that symmetric import/export capability can be achieved for all options examined in this study by appropriately controlling the flows on G82R for various flow levels out of North Dakota.

7.2.3 G82R Phase-Shifting Transformer Angle

Steady-state power flow simulations were conducted to investigate the G82R PST angle required to maintain the maximum incremental Manitoba-US and US-Manitoba interchange for all the 500 kV options considered in the studies described in this report. Cases were set up for both high and low NDEX levels to examine the change in the G82R PST angle for a range of flow conditions on G82R. The results for selected G82R flow levels for both north and south flow scenarios are provided in Tables 26 and 27. It can be seen from these tables that approximately a maximum angle of 70 to 80 degrees is required for the G82R PST in order to eliminate potential transmission congestions due to the increase in NDEX. Two series PST's each with ±40 degree angle control range are, therefore, needed for the 500 kV options to provide more control flexibility over the power on G82R. It is also recommended that the power flow on G82R be controlled within the range of 0 MW to 250 MW for both north and south directions.

Table 26: G82R PST Angle Required to Maintain Maximum South flow (Degrees)

	G82R (0 MW)		G82R South (250 MW)		G82R (0 MW)		G82R South (250 MW)	
	W1-B	**W1**	**W1-B**	**W1**	**Y500-A/B**	**Y500**	**Y500-A/B**	**Y500**
High NDEX	6.14	9.09	66.74	69.55	-0.28	-0.29	60.08	60.94
Low NDEX	1.19	4.63	60.58	63.74	-7.21	-7.92	51.79	52.60

Table 27: G82R PST Angle Required to Maintain Maximum North flow (Degrees)

	G82R (0 MW)		G82R North (250 MW)		G82R (0 MW)		G82R North (250 MW)	
	W1-B	**W1**	**W1-B**	**W1**	**Y500-A/B**	**Y500**	**Y500-A/B**	**Y500**
High NDEX	62	61.16	9.21	6.06	-79.41	-74.34	-19.95	-16.04
Low NDEX	55.68	54.48	3.27	0.82	-68.71	-65.87	-11.42	-7.99

7.3 Impacts of Series Compensation

It is assumed in the previous discussions that the new 500 kV tie line has 60% series compensation. Further studies were conducted to examine the impact of the amount of the series compensation on the distribution of the power flows on the MH-US 500 kV tie lines and associated losses. Tables 28 and 29 show the results obtained for both high and lower NDEX scenarios. It can be seen from these tables that power flows are more evenly distributed on the two lines with the increase of the percentage of the series compensation and the flow sharing between the 500 kV lines is better for the Iron Range option. High percentage of series compensation is, however, prone to sub-synchronous resonance. This potential issue should be examined in detail in the future. It can also be seen from Tables 28 and 29 that losses on the 500 kV lines are virtually the same for both the Fargo and the Iron Range injections.

Table 28: Change in Flows/Losses on 500 kV Lines with Percentage of Series Compensation (NDEX=1300 MW)

Series Comp (%)	W1-B (at 3275 MW transfer)			Y500-A/B (at 3275 MW transfer)		
	M602F Flow(MW)	New Tie Flow(MW)	500 kV Losses (MW)	M602F Flow(MW)	New Tie Flow(MW)	500 kV Losses (MW)
50	1698	1184	83	1671	1101	80
60	1652	1258	84	1614	1184	82
70	1601	1345	86	1549	1279	85

Table 29: Change in Flows/Losses on 500 kV Lines with Percentage of Series Compensation (NDEX=2254 MW)

Series Comp (%)	W1-B (at 3275 MW transfer)			Y500-A/B (at 3275 MW transfer)		
	M602F Flow(MW)	New Tie Flow(MW)	500 kV Losses (MW)	M602F Flow(MW)	New Tie Flow(MW)	500 kV Losses (MW)
50	1844	1118	88	1760	1138	87
60	1802	1190	89	1701	1224	89
70	1755	1271	91	1633	1324	92

7.4 Manitoba Hydro Reactive Power Reserve

Currently, Manitoba Hydro is using a reactive reserve margin of 460 MVar at Dorsey assuming no synchronous condensers are out of service. This is translated to either 300 MVar reserve with one small synchronous condenser turned off or 160 MVar with one large synchronous condenser turned off at Dorsey. System Planning Department of Manitoba Hydro intends to maintain equal reactive reserve at both Dorsey and Riel stations after Bipole III is in service. The post Bipole III reactive reserve for Dorsey and Riel is, therefore, proposed to be no less than 900 MVar.

It was observed that the total reactive power reserve at Dorsey and Riel is approximately 1000 MVar and 1500 MVar respectively for 1100 MW and 750 MW transfer for both injections. These observations are made under the following conditions: one small synchronous condenser is off at Dorsey; 220 MVar tertiary capacitors are on at both Dorsey and Riel stations. Additional 150 MVar tertiary capacitors are, however, needed for both Dorsey and Riel stations to cater for the loss of one Riel or Dorsey transformer or other uncertainties. Variation in NDEX has minimal impact on the MH system var reserve.

7.5 Transient Stability Analysis

The transient stability analysis was performed using Siemens PTI PSS/E dynamic simulation program. The disturbances simulated in the MISO group TSR study for Option 1 [2] and the new disturbances associated with the proposed facilities were selected and tested for transient stability simulations. A brief description of each of the disturbances simulated is provided in Table 30.

Table 30: Disturbance List for Transient Stability Simulation

Disturbance	Description
ag3	4 cycle 3-phase fault at Leland Olds 345 kV, trip Leland Olds-Ft Thompson line
ag4	4 cycle 3 phase fault at Arrowhead 345 kV bus trip the Arrowhead to Stone Lake 345 kV line
ag5_BB	Iron Range Injection: 3 phase 4 cycle fault at Blackberry 345 kV bus. Disconnect the bus after fault is cleared.
ag6	Iron Range Injection: 3 phase 4 cycle fault to simulate a branch outage between Arrowhead and Stone Lake 345 kV buses.
ag7	Fargo Injection: 3 phase 4 cycle bus fault at Bison 345 kV bus. Disconnect the bus after fault is cleared.
ag8	Fargo Injection: 3 phase 4 cycle fault to simulate a branch outage between Bison and Alexandria 345 kV buses.
ag9	Iron Range Injection: trip of one Bank at Riel 500 kV Station.
ag10	Iron Range Injection: trip of 500 kV branch from Dorsey to Riel.
ag11	Iron Range Injection: trip of two banks at Riel 500 kV Station.
ag12	Iron Range Injection: trip of one bank at Dorsey 500 kV Station.
ag13	Iron Range Injection: trip of two banks at Dorsey 500 kV Station.
bas	Trip Riel-Forbes 500 kV line (M602F) with and without HVdc reduction
bjb	Trip the new 500 kV tie with and without HVdc reduction
nad	3-phase fault at Forbes on the M602F 500 kV line; trigger HVdc reduction
nmz	3-phase fault at Chisago on the Forbes F601C 500 kV line; cross trip M602F, 100% reduction, leave SVC on MP system
pas	SLG fault with breaker failure at Forbes with 602L stuck, trip M602F; trigger HVdc reduction
pcs	SLG fault at King-Eau Claire line with a breaker failure at King, trips King-ECL and ASK-CHI line, cross trip Eau Claire-Arpin
pc0	SLG fault at King- Eau Claire line with a breaker failure at King, trips King-ECL and ASK-CHI line
pct	Trip of King- Eau Claire-Arpin without a fault

The transient stability simulation results of a number of disturbances as described in Table 30 show that:

The loss of the M602F line (bas fault) without an HVdc reduction results in cascading trip of the MH-US tie lines in some extreme stressed operating conditions (MHEX=2175 MW, NDEX=2200 MW, MWEX=1600 MW, G82R=250 MW north and M602F=2200 MW) particularly with the Fargo Injection. A maximum HVdc reduction of 80% is recommended for mitigating the potential cascading trip.

1. The current Riel-Forbes 500 kV line limit of 1732 MW (2000 A) may be reached with further increase in loop flow from US to Manitoba and the Fargo injection is more prone to this limitation. This may require upgrade of the M602F series compensation at Roseau from current 2000 A to 2500 A and an additional reactive support at Forbes of approximately 300 Mvar.
2. The disturbances associated with the new tie line are simulated for scenarios with and without triggering HVdc reduction for both injections. Study results show that new trigger to the existing HVdc power order reduction scheme is needed to mitigate the overloads of facilities including the M602F line resulting from the loss of the new 500 kV tie line.
3. The out-of-step relay on the M602F line violates the 50% minimum relay margin criteria [7]. All Manitoba Hydro out-of-step relay settings need to be re-examined in detail for post new 500 kV tie line system conditions for both injections. Further studies are required to quantify these new settings, re-evaluate the current relay margin criteria or assess the need for out-of-step protection for the MH-US tie lines after the addition of the new 500 kV line.

No other stability issues were found and no transient voltage swings outside of the range or damping concerns were observed in MH or areas in northern Midwest United States for the cases examined in this report. It should, however, be noted that the damping control part of the Square Butte DC was not functioning appropriately in the MRO 2011 series stability package which is used in this study for all stability simulations. Some under-voltage issues associated with the Fargo injection options found in other studies for example Arrowhead 230 kV and Minong 161 kV bus voltages [13] were not observed in this study.

Further transient stability studies are required once the new tie line option is selected. Detailed HVdc reduction studies are also needed to quantify the required percentage of reduction to mitigate the thermal overloads and reactive concerns with the Forbes SVC. Stability simulation plots are not included in this report but are available upon request.

8.0 REQUIRED FACILTIES FOR EACH OPTION

Based on the study results, the following facilities are identified for each option:

1. Fargo Injection:
    a. **Option W1-B:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export TSR’s of 1100 MW: Fargo to Sheyenne 230 kV line, Bison to Maple River 230 kV line, Souris to Velva Tap to Mallard 115 kV line, Mchenry 230/115 kV transformer, 300 MVA phase shifting transformer on line G82R, HVdc reduction for loss of the new facilities, Bison 500/345 kV transformer requires overload capability greater than 1200 MVA and a SVC/Statcom to increase R50M operational limit.
    b. **Option W1:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export TSR’s of 750

MW: Fargo to Sheyenne 230 kV line, Bison to Maple River 230 kV line, Souris to Velva Tap to Mallard 115 kV line, Mchenry 230/115 kV transformer, phase shifting transformer on line G82R and HVdc reduction for loss of the new facilities.

2. Iron Range Injection:
   a. **Option Y500-A/B:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export TSR's of 1100 MW: second 345/161 kV 300 MVA transformer at Stone Lake, Fond du lac to Thomson 115 kV line, Blackberry 500/230 kV transformer capacity greater than 900 MVA, 300 MVA phase shifting transformer on line G82R, Forbes to Blackberry 230 kV line Blackberry 500/345 kV transformer requires overload capability greater than 1200 MVA and HVdc reduction for loss of the new facilities.
   b. **Option Y500:** The following Network Upgrades in addition to the proposed facilities are needed for granting the group import/export TSR's of 750 MW: Blackberry 500/230 kV transformer capacity greater than 900 MVA, Forbes to Blackberry 230 kV line, Blackberry to Floodwood 115 kV, Blackberry to Nashwauk 115 kV line, 20L Tap to Blackberry 115 kV line, Souris to Velva Tap to Mallard 115 kV line, phase shifting transformer on line G82R and HVdc reduction for loss of the new facilities.

3. Iron Range 230 kV Injection:

The following Network Upgrades in addition to the proposed facilities are needed for granting the import/export Transmission Service Request of 250 MW: Souris to Velva Tap 115 kV line, Mchenry 230/115 kV transformer, 300 MVA phase shifting transformer on line G82R and HVdc reduction for loss of the new 230 kV tie line. For 250 MW/50 MW incremental export/import capability, the 300 MVA phase shifting transformer on line G82R is not needed.

9.0 LINE ROUTING

Currently Manitoba Hydro is examining the potential routing of the new 500 kV line and a map showing the study areas is provided in Appendix E. The Manitoba portion of the transmission line originating from the Dorsey Station, extending south and immediately east around Winnipeg to align in close proximity to the Riel Station, located immediately east of Winnipeg. It will be contained within Manitoba Hydro's existing transmission corridor referred to as the South Loop Corridor. The South Loop Corridor is a major transmission corridor currently owned by Manitoba Hydro. It is approximately 68 km long and connects Dorsey Station to Riel Station around the south end of Winnipeg. Portions of the corridor contain existing transmission lines, and it's anticipated that the new 500 kV transmission line can also use this corridor from Dorsey Station to pass in close proximity to Riel Station. The 500 kV transmission line from Dorsey to Riel Station will be AC. There might be provision for this line to operate as a DC line as well. If so, two of the three sets of conductors used for the AC line, will be used for DC operation, if needed. Once near Riel Station it is expected to follow a general direction similar to, but with at least a 10 km separation from, the existing MH-US 500 kV line to the Canada - USA Border. At the border, the line will connect to the US portion of the transmission line, which will extend either to Bison Station near Fargo, North Dakota or Blackberry Station near Iron Range, Minnesota.

10.0 COST ESTIMATE FOR NETWORK UPGRADES IN MANITOBA

The Network Upgrades required in Manitoba for granting up to 750 MW and 1100 MW of transmission service presented in Tables 1 and 2 for all 500 kV options as shown in Figures A1 through A4 in Appendix A are the same. No direct assigned facilities and other additional Network Upgrades to the proposed facilities are needed in Manitoba. The proposed Network Upgrades for these 500 kV options in Manitoba can generally be categorized into facilities required for the construction of the 500 kV line from Dorsey to the MH-US border, facility additions associated with the termination of the new 500 kV line at Dorsey, facility additions associated with the termination of a new 230/500 kV transformer at Riel and a phase shifting transformer addition to the 230 kV G82R line at Glenboro. The estimates provided in this report include costs of facilities/equipment, labour, design, overhead, contingency and applicable interests. Capital Budget single line diagrams for Manitoba facilities are provided in Appendix G. These single line diagrams assume an earlier in-service-date of October 31, 2019 for coordinating with the construction schedule of US side facilities.

The total cost of the Manitoba portion of the new 500 kV line is estimated to be $171,485,960 (2013 overnight Canadian dollar) based on the following major assumptions:

- The 500 kV transmission option will be single circuit in design. It will be scalable to meet the 1100 MW electrical transfer with a total line length of 235 km (147 miles)
- 3 - Phase conductors: triple bundled 1192.5 MCM 45/7 aluminium conductor steel reinforced (ACSR) “Bunting” c/w spacer dampers
- 1 - Ground conductor: galvanized Size 10 (7/16”) Steel - 7 Strand Grade 1300
- 1 - 14 mm optical protection ground wire (OPGW) conductor
- Self supporting tower and footing designs to be based on the existing 500 kV US-MH tie line
- Wind & weight spans and conductor design loads to be based on the existing 500 kV US-MH tie line
- Depending on terrain conditions and environmental sensitivities, the transmission line is constructed primarily of self-supporting lattice steel structures and/or guyed lattice steel. The number of different towers required for the construction of the Manitoba portion of the new 500 kV line is given in Table H 1 in Appendix H.

The total cost of facility additions associated with the termination of the new 500 kV line at Dorsey Station is estimated to be $23,232,384 (2013 overnight Canadian dollar). The required equipment at Dorsey Station is listed in Table H 2 in Appendix H. The total cost of facility additions associated with the termination of a new 230/500 kV transformer at Riel Station is estimated to be $54,319,407 (2013 overnight Canadian dollar). The required equipment at Riel Station is listed in Table H 3 in Appendix H. The total cost of facility additions associated with the G82R phase shifting transformer is estimated to be $30,399,549 (2013 overnight Canadian dollar). The required equipment at Glenboro South 230 kV Station is listed in Table H 4 in Appendix H. The total project cost in Manitoba for the 500 kV options is estimated to be approximately $279,437,300 (2013 overnight Canadian dollar) as summarized in Table 31.

Table 31: Summary of Cost Estimates for Required Network Upgrades in Manitoba (500 kV Options, 2013 overnight Canadian dollar)

Item	Costs
500 kV line	$171,485,960
Dorsey Station	$23,232,384
Riel Station	$54,319,407
Glenboro South 230 kV Station	$30,399,549
Total	$279,437,300

For the Iron Range 230 kV Injection, no detailed estimates are available at this time. The new 230 kV line from Riel to the MH-US border is approximately 145 km (90 miles). The planning level cost estimates (±50%) for the portion of the line in Manitoba is estimated to be about $60 million. This estimate is based on a unit cost of $400, 000/km. A planning level cost estimates (±50%) for the line termination at Riel is estimated to be around $20 million. This estimate was made in reference to the Riel 230/500 kV transformer termination cost estimate as presented in Table H 3 in Appendix H. For achieving 250 MW export and 50 MW import incremental capability with the 230 kV option, total planning level Network Upgrades cost (±50%) in Manitoba is estimated to be $60 million (2013 overnight Canadian dollars). G82R PST is needed to increase the import capability of the 230 kV option to 250 MW. The cost of facility additions associated with the G82R phase shifting transformer is estimated to be $18 million. The total planning level Network Upgrades cost (±50%) in Manitoba for this option with 250 MW/250 MW import/export is estimated to be approximately $98 million (2013 overnight Canadian dollars).

11.0 CONSTRUCTION SCHEDULE

A high level schedule for the Manitoba portion of the project for both the 500 kV and the 230 kV options is provided in Appendix F. The schedule is developed in reference to experience obtained from historical actual projects implemented in Manitoba. It is considered to be an aggressive schedule for accommodating the proposed in-service-date of May 31 2020 and includes duration for obtaining required permits and land right activities. The proposed in-service-date takes into account the effective date of the Power Purchase Agreement.

12.0 RISK IDENTIFICATION

There are some risks associated with options of the project and it is MH's opinion that these risks should be identified for the Customer to consider:

1. Option W1: The proposed plan include only one 500/345 kV 1200 MVA transformer at Bison as shown in Figure A2 in Appendix A. Extended outage of this transformer could result in the curtailment of the requested 750 MW service. Addition of a second transformer bank would mitigate this risk. The cost associated with the additional transformer bank is approximately $20 million. Alternatively the risk can be mitigated by providing three 400 MVA single phase units with a spare. The cost associated with providing a 400 MVA single phase spare is approximately $5 million.
2. Option Y500: The proposed plan include one 500/230 kV 900 MVA transformer at Blackberry as shown in Figure A4 in Appendix. Minnesota Power confirmed that the proposed 900 MVA transformer at Blackberry will be three single phase units with a spare.
3. Location of the 500 kV line series compensation: The series capacitors are currently not included in the Manitoba facility estimate. If they were, a planning level estimate (±50%) is around $40 million. Detailed design studies will be undertaken to determine the optimal location (i.e. Manitoba or US location) once a facility Construction Agreement is signed.
4. Length of the Manitoba portion of the 500 kV line: Several line routings are under examination in order to minimize the total length of the 500 kV line. It is assumed that the length of the Manitoba portion of the 500 kV line is 235 km (147 miles) in this report. The actual length of the Manitoba portion may be longer due to the minimization of the total length of the 500 kV line. The associated risk cost is approximately 20% of the total line cost provided in Section 10.

13.0 CONCLUSIONS

All options evaluated in this study are technically viable with appropriate Network Upgrades and/or facility additions for accommodating the TSR's. The new 500 kV MH-US tie line for the Fargo Injection may go through the Red River Valley Flood Plain. This would place greater risk on the In-Service-Date.

When comparing the 500 kV options with an 1100 MW of incremental MH-US transfer the following conclusions can be made:

- Power flow south from Manitoba: Increase in North Dakota export and Minnesota-Wisconsin export negatively affects the flow on the Riel – Forbes 500 kV for the Fargo injection. At the maximum simultaneous transfer simulated in this study (NDEX=2200 MW, MWEX=1600 MW), the North Dakota-Manitoba loop flow issue results in approximately 105% pre-contingency overload on the Riel – Forbes 500 kV line. This pre-contingency overload can be mitigated by controlling the power flow distributions on the US-MH interface through a phase shifting transformer added on to the line G82R.

- Power flow north to Manitoba: The performance of the Iron Range Injection is better than that of the Fargo injection in terms of the flow distribution on the two 500 kV lines and elimination of loop flow on the MH-US interface particularly at a higher NDEX level.
- With increase in North Dakota export and Minnesota-Wisconsin export, power flow is more evenly distributed on the two 500 kV lines for the Iron Range option than for the Fargo Option.
- The current Riel-Forbes 500 kV line limit of 1732 MW (2000 A) may be reached with further increase in loop flow from US to Manitoba and the Fargo injection is more prone to this limitation. This may require upgrade of the M602F series compensation at Roseau from the current rating of 2000 A to 2500 A and additional reactive support at Forbes of approximately 300 Mvar.
- Symmetric import/export capability can be achieved for all options examined in this study by appropriately controlling the flows on G82R.
- Under the prior outage of the exiting 500 kV line, the current transfer limit of 2175 MW can be kept with the addition of a phase shifting transformer on G82R and a SVC or Statcom to increase R50M operational limit for W1-B option. A SVC or Statcom is not required for Y500-A/B option to maintain 2175 MW south transfer under the same prior outage condition.

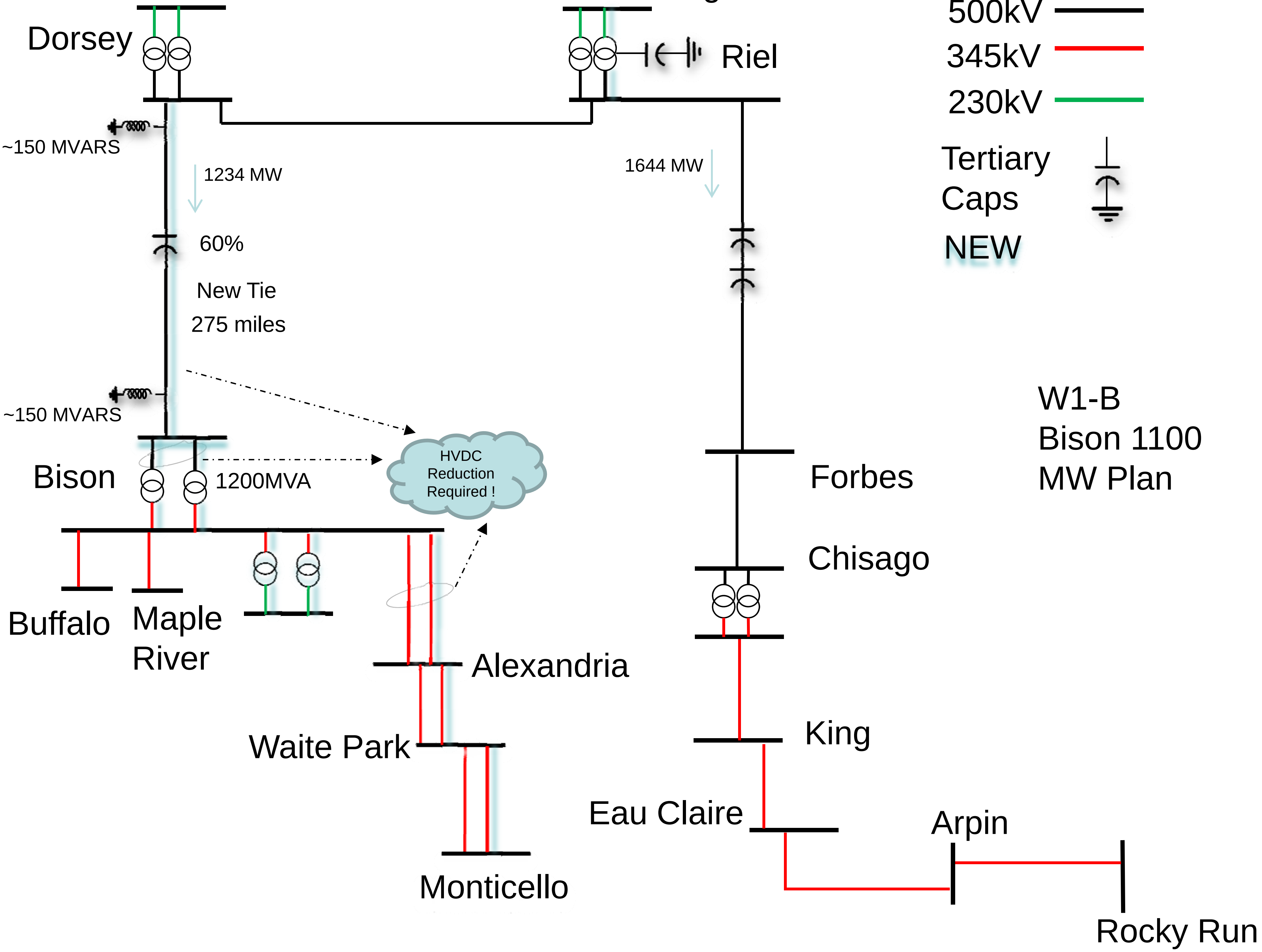
No Direct Assignment Facilities are needed in Manitoba for all the options evaluated in this study. The total cost for the required Network Upgrades in Manitoba is the same for all the 500 kV options and it is estimated to be approximately $279 million (2013 overnight Canadian dollars) assuming a length of approximately 235 km (147 miles). For achieving 250 MW export and 50 MW import incremental capability with the 230 kV option, the total planning level Network Upgrades cost (±50%) is estimated to be $60 million (2013 overnight Canadian dollars) in Manitoba. G82R PST is needed to increase the import capability of the 230 kV option to 250 MW. The cost of facility additions associated with the G82R phase shifting transformer is estimated to be $18 million. The total planning level Network Upgrades cost (±50%) in Manitoba for this option with 250 MW/250 MW import/export is estimated to be approximately $98 million (2013 overnight Canadian dollars). It should be noted that several risks associated with the projects are described in Section 12 and the costs associated with these risks are not included in the project cost estimates.

REFERENCES

[1] Douglas R. Brown, Hari Singh, Lengcheng Huang, “MHEB Group TSR System Impact Study”, Siemens PTI Report R164-08, June, 2009.
[2] Douglas R. Brown and Patrick Jehring, “MHEB Group TSR System Impact Study Transmission Option 1”, Siemens PTI Report R30-10, April, 2010.
[3] MISO Transmission Access Planning, “MH-US TSR Sensitivity Analyses”, September, 2012.
[4] Manitoba Hydro OATT website: http://oasis.midwestiso.org/documents/mheb/ops_guide.html
[5] Manitoba Hydro, “Long-Term Development Plan-2011 for Manitoba Hydro’s Electrical Transmission System”, available on-line: http://oasis.midwestiso.org/documents/mheb/Long%20Term%20Development%20Plan%20June%208,%202011.pdf
[6] NERC website: http://www.nerc.com/page.php?cid=2|20
[7] MAPP Planning Standards Development Working Group, “MAPP Members Reliability Criteria and Study Procedures Manual”, February 2009.
[8] MH Document, “Transmission System Interconnection Upgrades”.
[9] Powertechs-DSA PowerTools^{TM} website: http://www.dsapowertools.com/
[10] MTEP 12, “MISO Transmission Expansion Plan 2012”, 2012.
[11] Minnesota Transmission Assessment & Compliance Team, “MN TACT Region Third Annual 2012 Transmission Assessment for Period of 2012 to 2022”, August, 2012.
[12] Manitoba Hydro, “St. Joseph 300 MW Wind Farm”, December 2009, available at Manitoba Hydro OASIS website: http://oasis.midwestiso.org/documents/Mheb/St_Joseph_IFS-final-Dec_18-stmp.pdf
[13] George Sweezy, “Dorsey-Iron Range 500 kV Project Preliminary Stability Analysis Draft Report”, December 2012, Available at MISO OASIS website: https://oasis.midwestiso.org/documents/miso/Dorsey%20-%20Iron%20Range%20500%20kV%20Project%20Preliminary%20Stability%20Analysis%20-%20Draft%20Report%20-%2012-5-2012.pdf

Appendix A
Simplified Diagrams of Proposed Facilities of Different Options

Figure A1


Dorsey
Riel
500kV
345kV
230kV
Tertiary Caps
NEW
~150 MVARS
1234 MW
60%
New Tie
275 miles
1644 MW
~150 MVARS
Bison
1200MVA
HVDC Reduction Required !
W1-B
Bison 1100 MW Plan
Forbes
Chisago
Buffalo
Maple River
Alexandria
King
Waite Park
Eau Claire
Arpin
Monticello
Rocky Run

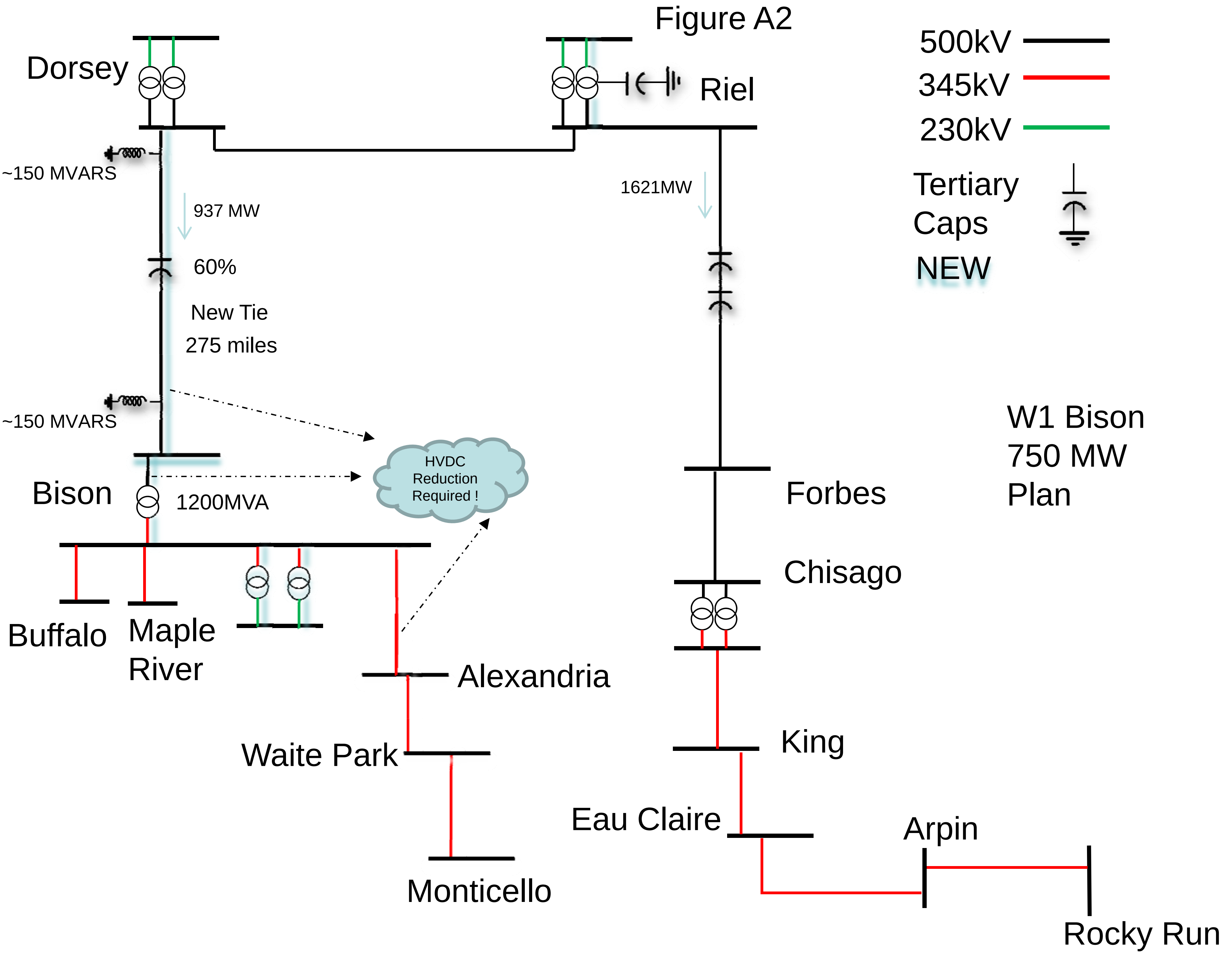
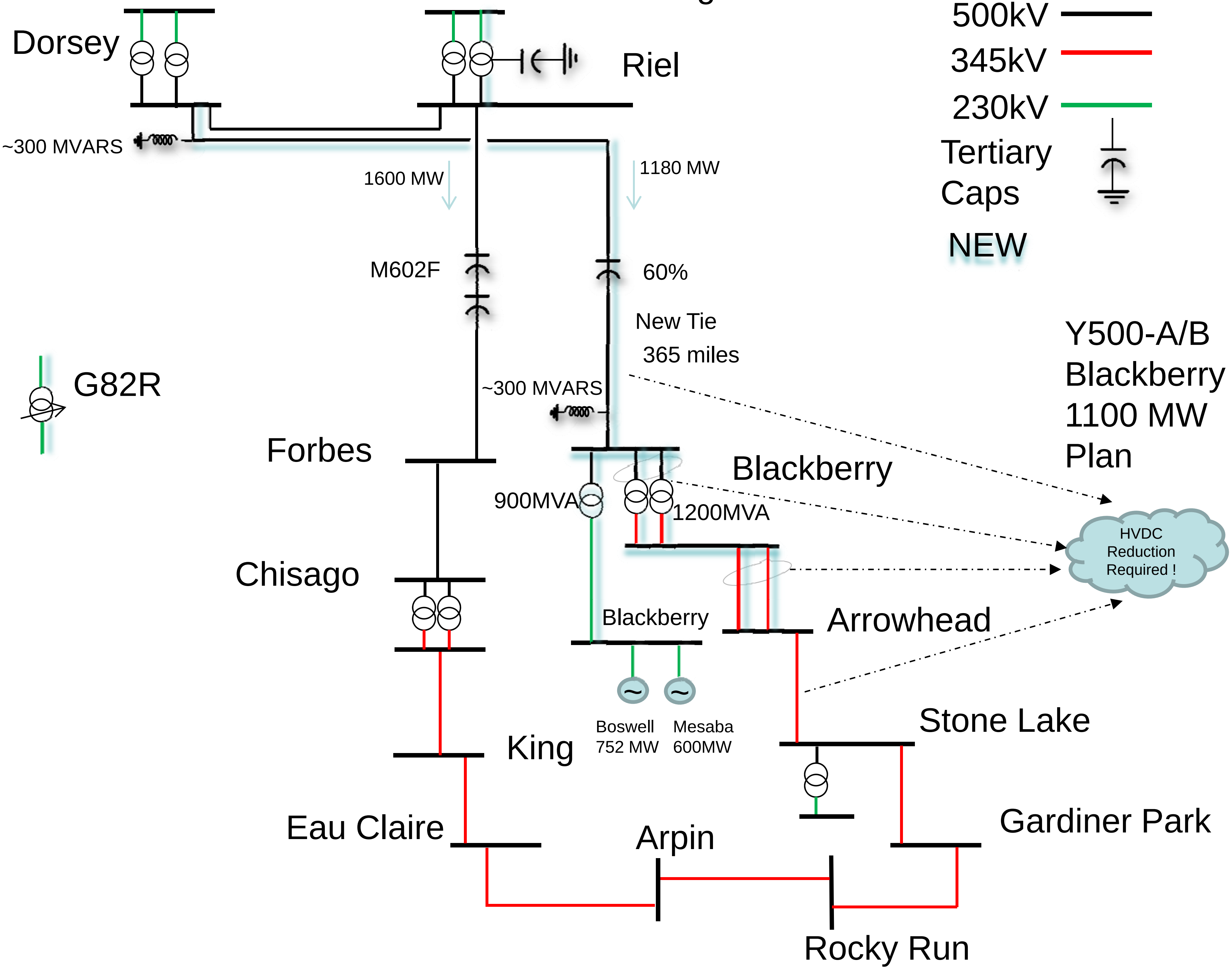


Figure A2
500kV
345kV
230kV
Tertiary Caps
NEW
Dorsey
Riel
~150 MVARS
937 MW
60%
New Tie
275 miles
~150 MVARS
1621MW
HVDC Reduction Required !
Bison
1200MVA
Forbes
Chisago
W1 Bison
750 MW
Plan
Buffalo
Maple River
Alexandria
Waite Park
Monticello
King
Eau Claire
Arpin
Rocky Run

Figure A3



500kV
345kV
230kV
Tertiary Caps
NEW
Dorsey
Riel
~300 MVARS
1600 MW
1180 MW
M602F
60%
New Tie
365 miles
Y500-A/B
Blackberry
1100 MW
Plan
G82R
~300 MVARS
Forbes
Blackberry
900MVA
1200MVA
HVDC Reduction Required !
Chisago
Blackberry
Arrowhead
Boswell
752 MW
Mesaba
600MW
King
Stone Lake
Eau Claire
Arpin
Gardiner Park
Rocky Run

Figure A4

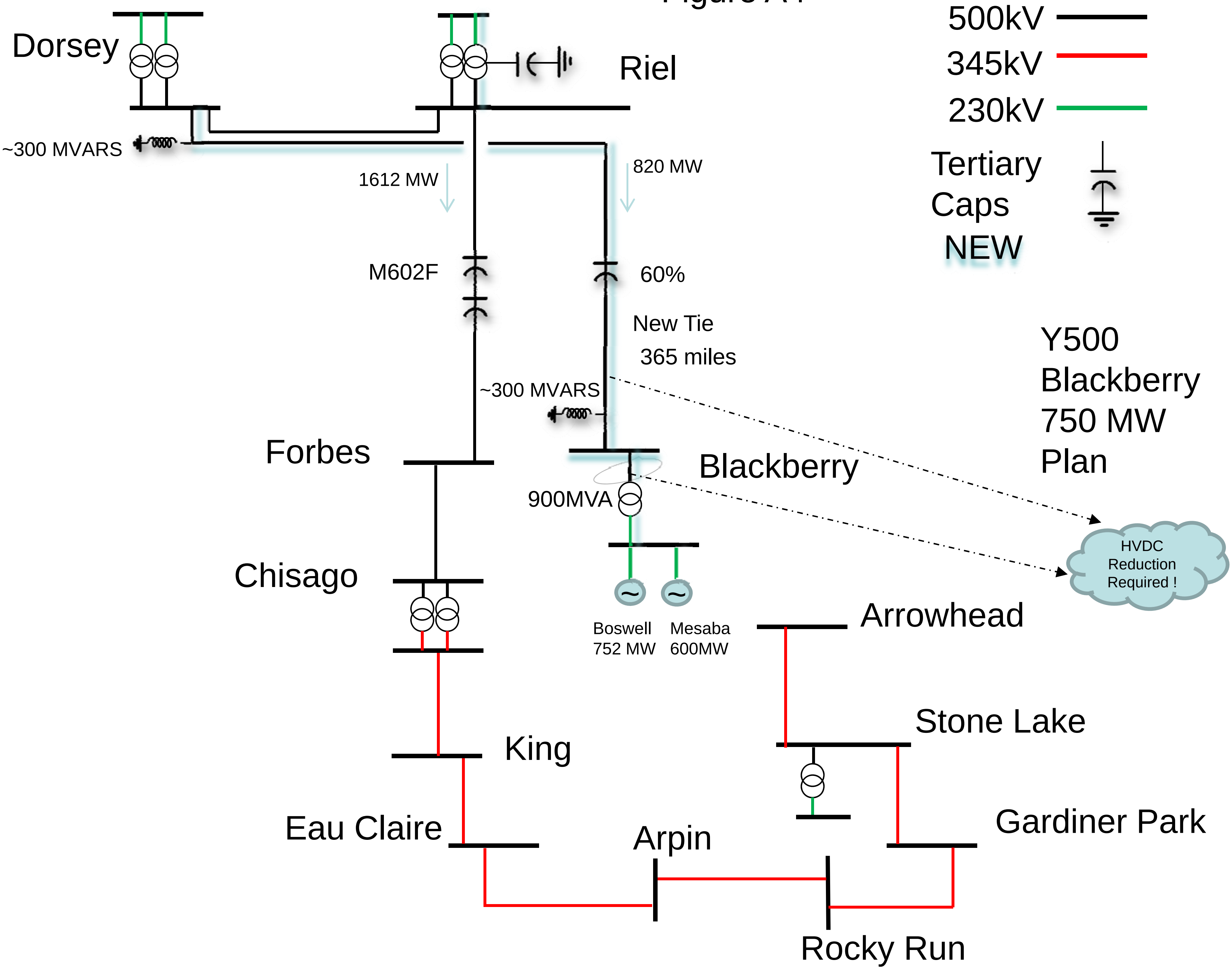
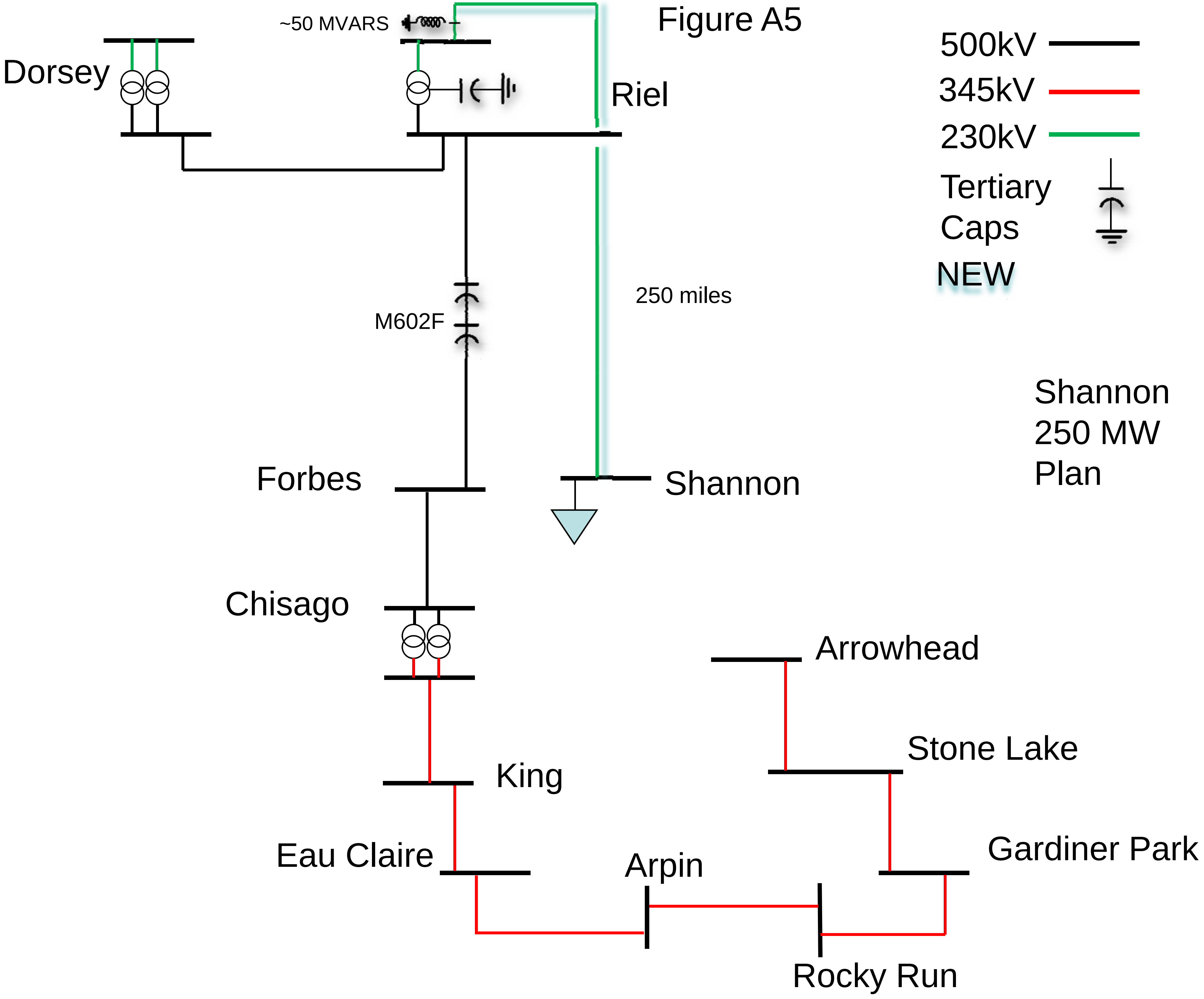
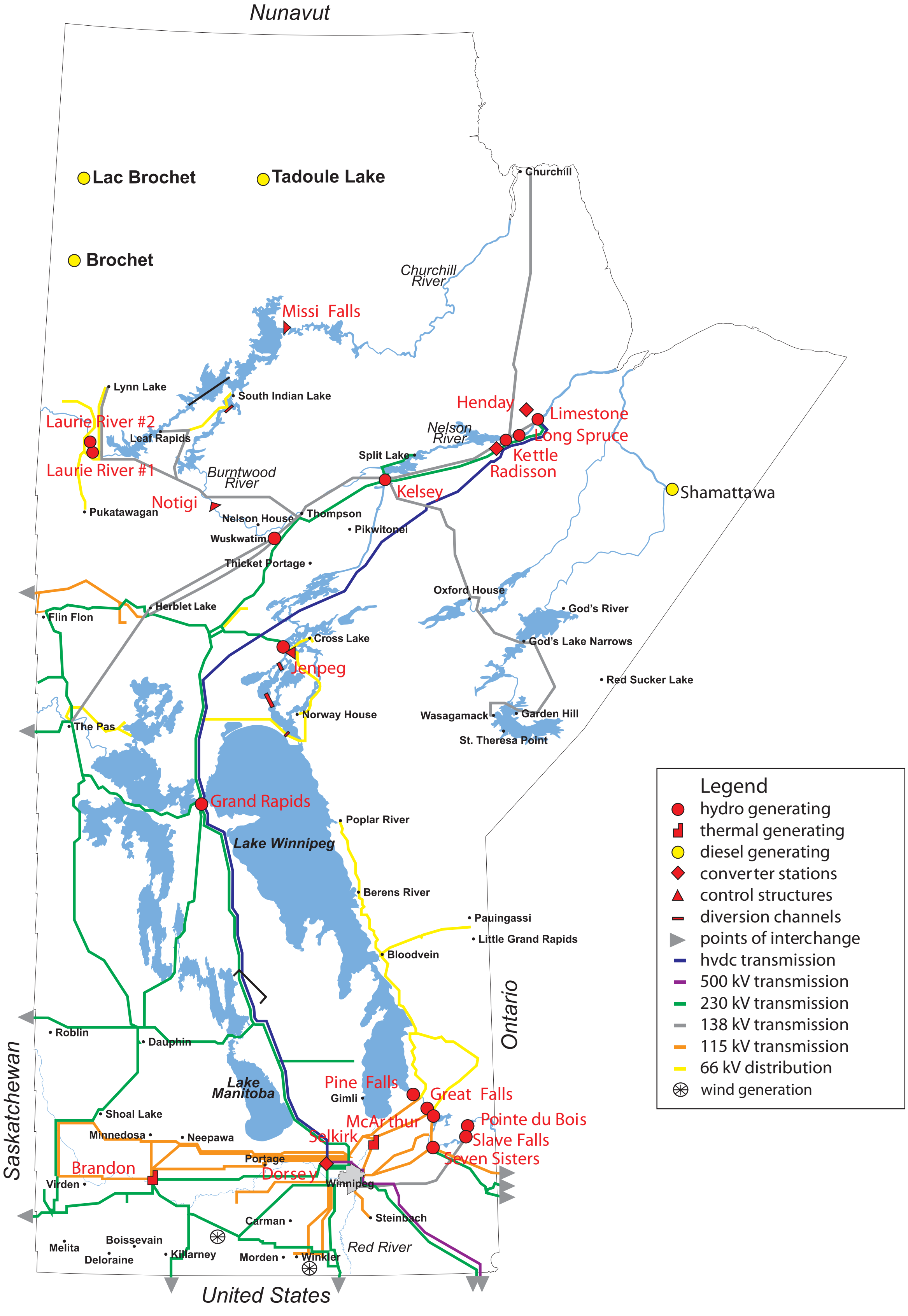

500kV
345kV
230kV
Tertiary
Caps
NEW
Dorsey
Riel
~300 MVARS
1612 MW
820 MW
M602F
60%
New Tie
365 miles
~300 MVARS
Forbes
Blackberry
900MVA
Y500
Blackberry
750 MW
Plan
HVDC
Reduction
Required !
Chisago
Boswell
752 MW
Mesaba
600MW
Arrowhead
Stone Lake
King
Eau Claire
Arpin
Gardiner Park
Rocky Run

Figure A5


~50 MVARS
Dorsey
Riel
500kV
345kV
230kV
Tertiary Caps
NEW
M602F
250 miles
Shannon 250 MW Plan
Forbes
Shannon
Chisago
Arrowhead
Stone Lake
King
Gardiner Park
Eau Claire
Arpin
Rocky Run

Appendix B
An overview of Existing Manitoba Hydro Bulk Electric System

Manitoba Hydro's Existing Generating Stations and Transmission System



Appendix C
Summary of Power Flow and Dynamics Cases

Steady State Loadflow Summary Created On : Fri Dec 14 10:36:25 201

Tie Line Flow (MW)

Case Name	MH->US	MH->SPC 230kV	MH->SPC 115kV	MH->SPC Net	MH->ONT	B10T (S)	S. Ont->US	F3M(S)	E-W Ties West	P19W	MWSI	MWEX	NDEX
PO-M602F-EXPT-E-1100-NOPST-60SC	2163.74	61.20	-60.83	0.37	0.13	164.94	2.88	151.20	14.42	98.13	566.53	1271.80	1416.82
PO-M602F-EXPT-E-1100-PST-60SC	2164.75	61.27	-60.83	0.44	-0.05	165.18	3.07	150.81	14.21	98.20	567.28	1275.53	1368.38
PO-M602F-EXPT-W-1100-NOPST-60SC	2166.02	61.05	-60.83	0.22	1.56	164.97	1.05	154.06	16.25	98.22	646.60	988.33	1337.11
PO-M602F-SI-EXPT-W-1100-PST-60SC	2167.67	61.11	-60.83	0.28	-0.07	165.04	3.39	150.71	13.98	98.23	646.45	987.77	1328.61
SI-EXPT-E-1100-NOPST-60SC	2174.57	61.01	-60.83	0.17	0.00	165.07	3.13	150.88	14.11	98.33	659.14	1267.32	1336.20
SI-EXPT-E-1100-PST-60SC	2173.36	61.15	-60.83	0.32	0.35	165.04	2.79	151.43	14.40	98.26	657.15	1263.19	1382.34
SI-EXPT-E-750-NOPST-60SC	2172.59	61.16	-60.83	0.33	0.01	165.17	3.03	150.96	14.24	98.29	738.90	1101.63	1355.24
SI-EXPT-E-750-PST-60SC	2172.46	60.94	-60.83	0.11	-0.18	164.84	2.93	150.86	14.31	98.26	733.09	1093.72	1382.58
SI-EXPT-W-1100-NOPST-60SC	2176.84	60.77	-60.83	-0.06	0.09	164.94	2.68	150.98	14.60	98.39	731.56	1088.12	1299.13
SI-EXPT-W-1100-PST-60SC	2175.46	60.97	-60.83	0.14	0.02	164.87	2.67	150.97	14.62	98.28	728.02	1084.69	1375.67
SI-EXPT-W-750-NOPST-60SC	2174.76	61.32	-60.83	0.49	1.20	165.48	3.84	150.98	13.44	98.38	717.34	1087.12	1302.56
SI-EXPT-W-750-PST-60SC	2174.93	61.06	-60.83	0.23	0.01	164.97	2.59	150.96	14.68	98.28	714.43	1084.55	1374.40
SI-IMPT-E-1100-NOPST-60SC	-702.68	72.12	-60.83	11.29	3.61	2.79	9.07	150.17	9.01	40.28	232.74	706.73	891.23
SI-IMPT-E-1100-PST-60SC	-704.60	72.19	-60.83	11.35	3.68	3.00	9.08	150.23	9.01	40.23	231.15	702.62	937.69
SI-IMPT-E-750-NOPST-60SC	-696.47	69.41	-60.83	8.58	-0.09	0.01	4.34	150.60	13.50	40.31	264.53	652.74	897.41
SI-IMPT-E-750-PST-60SC	-698.05	69.30	-60.83	8.47	-0.08	0.03	4.32	150.60	13.49	40.28	262.71	650.24	936.61
SI-IMPT-W-1100-0MW-PST-60SC	-708.82	55.82	-60.83	-5.01	-0.01	-0.12	3.80	150.83	14.04	40.23	238.62	668.88	1157.09
SI-IMPT-W-1100-NOPST-60SC	-700.14	55.72	-60.83	-5.11	0.03	-0.07	3.75	150.89	14.07	40.61	256.34	685.62	895.92
SI-IMPT-W-1100-PST-60SC	-702.56	56.51	-60.83	-4.31	0.23	1.02	3.98	150.89	13.85	40.60	255.87	685.16	906.08
SI-IMPT-W-750-NOPST-60SC	-698.48	54.58	-60.83	-6.25	-0.46	-1.25	3.23	150.86	14.58	40.63	256.30	684.99	893.39
SI-IMPT-W-750-PST-60SC	-700.88	55.37	-60.83	-5.46	-0.26	-0.17	3.46	150.86	14.36	40.62	255.85	684.55	903.57

PGEN (MW)

Case Name	MHDC (MW)	Kelsey	Wuskwatim	Jenpeg	Grand Rapids	Selkirk	Brandon	Pine Falls	Great Falls	McArthur Falls	Seven Sisters	Slave Falls	Pointe du bois	ST Leon	ST Joseph	Winnipeg River
PO-M602F-EXPT-E-1100-NOPST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
PO-M602F-EXPT-E-1100-PST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
PO-M602F-EXPT-W-1100-NOPST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
PO-M602F-SI-EXPT-W-1100-PST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-E-1100-NOPST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-E-1100-PST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-E-750-NOPST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-E-750-PST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-W-1100-NOPST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-W-1100-PST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-W-750-NOPST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-EXPT-W-750-PST-60SC	3732.00	315.00	222.90	136.00	332.19	145.00	269.60	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-E-1100-NOPST-60SC	1520.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-E-1100-PST-60SC	1520.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-E-750-NOPST-60SC	1520.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-E-750-PST-60SC	1520.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-W-1100-0MW-PST-60SC	1502.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-W-1100-NOPST-60SC	1502.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-W-1100-PST-60SC	1502.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-W-750-NOPST-60SC	1502.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05
SI-IMPT-W-750-PST-60SC	1502.00	225.00	148.60	90.67	266.89	0.00	0.00	103.68	136.78	56.19	165.40	68.00	120.00	19.80	60.00	650.05

MVar	Cushion					QGen				
Case Name	Dorsey	Riel	Grand Rapids	Ponton	Birchtree	Dorsey	Riel	Grand Rapids	Ponton	Birchtree
PO-M602F-EXPT-E-1100-NOPST-60SC	1104.92	1155.96	77.40	70.10	61.52	595.08	-155.96	87.80	79.90	33.48
PO-M602F-EXPT-E-1100-PST-60SC	1082.13	1143.86	76.95	70.09	61.55	617.87	-143.86	88.25	79.91	33.45
PO-M602F-EXPT-W-1100-NOPST-60SC	1128.06	1079.45	77.51	70.12	61.56	571.94	-79.45	87.69	79.88	33.44
PO-M602F-SI-EXPT-W-1100-PST-60SC	1115.49	1075.94	77.01	70.09	61.56	584.51	-75.94	88.19	79.91	33.44
SI-EXPT-E-1100-NOPST-60SC	1376.12	1224.52	76.84	70.09	61.60	323.88	-224.52	88.36	79.91	33.40
SI-EXPT-E-1100-PST-60SC	1375.03	1231.34	76.84	70.09	61.57	324.97	-231.34	88.36	79.91	33.43
SI-EXPT-E-750-NOPST-60SC	1423.99	1134.20	76.97	70.10	61.59	276.01	-134.20	88.23	79.90	33.41
SI-EXPT-E-750-PST-60SC	1419.43	1138.51	76.81	70.08	61.57	280.57	-138.51	88.39	79.92	33.43
SI-EXPT-W-1100-NOPST-60SC	1385.49	1169.59	76.83	70.10	61.62	314.51	-169.59	88.37	79.90	33.38
SI-EXPT-W-1100-PST-60SC	1387.65	1177.97	77.10	70.10	61.58	312.35	-177.97	88.10	79.90	33.42
SI-EXPT-W-750-NOPST-60SC	1366.25	1139.64	76.93	70.10	61.62	333.75	-139.64	88.27	79.90	33.38
SI-EXPT-W-750-PST-60SC	1367.34	1147.92	77.10	70.10	61.58	332.66	-147.92	88.10	79.90	33.42
SI-IMPT-E-1100-NOPST-60SC	1728.16	1119.31	139.34	124.78	95.94	-28.16	-119.31	-15.44	25.22	-0.94
SI-IMPT-E-1100-PST-60SC	1770.41	1118.84	142.45	124.95	95.99	-70.41	-118.84	-18.55	25.05	-0.99
SI-IMPT-E-750-NOPST-60SC	1707.37	1109.45	139.32	124.79	95.95	-7.37	-109.45	-15.42	25.21	-0.95
SI-IMPT-E-750-PST-60SC	1749.29	1109.17	142.43	124.96	96.00	-49.29	-109.17	-18.53	25.04	-1.00
SI-IMPT-W-1100-0MW-PST-60SC	1751.52	1273.85	145.81	124.37	95.79	-51.52	-273.85	-21.91	25.63	-0.79
SI-IMPT-W-1100-NOPST-60SC	1743.72	1291.07	140.75	124.22	95.80	-43.72	-291.07	-16.85	25.78	-0.80
SI-IMPT-W-1100-PST-60SC	1802.93	1293.54	147.23	124.59	95.93	-102.93	-293.54	-23.33	25.41	-0.93
SI-IMPT-W-750-NOPST-60SC	1727.80	1282.24	140.70	124.22	95.81	-27.80	-282.24	-16.80	25.78	-0.81
SI-IMPT-W-750-PST-60SC	1787.59	1284.70	147.21	124.59	95.94	-87.59	-284.70	-23.31	25.41	-0.94

Load (MW)	Area	Zones				
Case Name	667	1646	1647	1648	1649	1650
PO-M602F-EXPT-E-1100-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
PO-M602F-EXPT-E-1100-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
PO-M602F-EXPT-W-1100-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
PO-M602F-SI-EXPT-W-1100-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-E-1100-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-E-1100-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-E-750-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-E-750-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-W-1100-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-W-1100-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-W-750-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-EXPT-W-750-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-E-1100-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-E-1100-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-E-750-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-E-750-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-W-1100-0MW-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-W-1100-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-W-1100-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-W-750-NOPST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50
SI-IMPT-W-750-PST-60SC	3576.90	888.90	1337.18	545.66	72.66	732.50

Dynamic Summary Created On :

Tie Line Flow (MW)

Case Name	MH->US	MH->SPC 230kV	MH->SPC 115kV	MH->SPC Net	MH->ONT	B10T (S)	S. Ont->US	F3M(S)	E-W Ties West	P19W	MWSI	MWEX	NDEX
MRO-2011Series-FINAL-2022SO-DYN-Bison-1100extra-transfer-allconawapa	3278	54	-54	0	0	165	1	147	-143	67	671	861	218
MRO-2011Series-FINAL-2022SO-DYN-New-tieline-1100extra-transfer-allconawapa	3274	54	-54	-1	0	165	-1	151	-141	67	638	1069	299
Bison-MHEX3275-MWEX1600-NDEX2200-D602F220	3275	54	-54	0	1	166	-1	151	-141	68	1438	1600	2205
Blackberry-MHEX3275-MWEX1600-NDEX2200-D602F220	3275	52	-54	-2	0	164	-1	151	-140	68	1106	1600	2201

Case Name	MHDC (MW)	Kelsey	Wuskwatim	Jenpeg	Grand Rapids	Selkirk	Brandon	Pine Falls	Great Falls	McArthur Falls	Seven Sisters	Slave Falls	Pointe du bois	ST Leon	ST Joseph	Winnipeg River
MRO-2011Series-FINAL-2022SO-DYN-Bison-1100extra-transfer-allconawapa	4116	251	200	168	480	0	0	89	135	56	165	68	78	48	66	591
MRO-2011Series-FINAL-2022SO-DYN-New-tieline-1100extra-transfer-allconawapa	4116	251	200	168	480	0	0	89	135	56	165	68	78	48	66	591
Bison-MHEX3275-MWEX1600-NDEX2200-D602F220	4112	251	200	168	480	0	0	89	135	56	165	68	78	48	66	591
Blackberry-MHEX3275-MWEX1600-NDEX2200-D602F220	4106	251	200	168	480	0	0	89	135	56	165	68	78	48	66	591

MVar	Cushion					QGen				
Case Name	Dorsey	Riel	Grand Rapids	Ponton	Birchtree	Dorsey	Riel	Grand Rapids	Ponton	Birchtree
MRO-2011Series-FINAL-2022SO-DYN-Bison-1100extra-transfer-allconawapa	1187	273	143	151	98	513	727	22	-1	-3
MRO-2011Series-FINAL-2022SO-DYN-New-tieline-1100extra-transfer-allconawapa	1184	394	142	151	98	516	606	23	-1	-3
Bison-MHEX3275-MWEX1600-NDEX2200-D602F220	1124	0	138	151	98	576	1000	27	-1	-3
Blackberry-MHEX3275-MWEX1600-NDEX2200-D602F220	1255	686	139	151	99	445	314	26	-1	-4

Load (MW)	Area	Zones				
Case Name	667	1646	1647	1648	1649	1650
MRO-2011Series-FINAL-2022SO-DYN-Bison-1100extra-transfer-allconawapa	2497	584	847	283	45	739
MRO-2011Series-FINAL-2022SO-DYN-New-tieline-1100extra-transfer-allconawapa	2497	584	847	283	45	739
Bison-MHEX3275-MWEX1600-NDEX2200-D602F220	2497	584	847	283	45	739
Blackberry-MHEX3275-MWEX1600-NDEX2200-D602F220	2497	584	847	283	45	739

Appendix D
Steady State Simulation Results (Overloads)

Table D1

SI-EXPT-W-1100-NOPST-60SC-

🟪 Existing D.C. reduction

🟧 Proposed D.C. reduction

Overload %

🟩 Base case issue

VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
New 500	601001,601013,1 M602F	x	100.5	102.8	105.1	107.4	109.7	111.8	114.1	116.4	118.9	121	123.4	125.7	128	130.7	133.3	135.8	138.3	141.2	144.2	147.2	150.5	VC
SINGLE-042	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.9	102.1	103.4
Bison-AlexSS 345	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.1	102.3
001	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	102
003	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.8
B2_XEL_ROSEAUMP-MORNVL	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	102
SINGLE-040	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8
NSP - 3	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
New 500	601001,601017,1 Forbes to ChisagoN2 500kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	102.6	104.7	VC
New 500	601012,601013,1 M602F SC	x	x	x	x	x	x	x	x	x	101.4	103.2	105.2	107.2	109.1	111.3	113.5	115.6	117.7	120.1	122.6	125.1	127.9	VC
M602F	601060,601062,1	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	103.6	105.8	108.5	111.2	VC				
M602F	601060,601067,1 Bison 500/345 xfmr	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	VC				
M602F	601060,601067,2 Bison 500/345 xfmr	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	VC				
M602F	601061,601062,1 New Tie SC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	102.9	105.5	108.2	VC				
M602F	601061,667500,1 New Tie	x	x	x	x	x	x	x	x	x	x	x	x	x	100	102.3	104.5	107.1	109.8	VC				
M602F	601067,657792,1 Bison to Maple River 345 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.6	102.6	104.6	106.4	108.6	111	VC				
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	100.7	100.6	100.6	100.5	100.5	100.5	100.5	100.5	100.5	101.4	102.3	103	103.9	104.8	105.6	105.7	105.6	105.5	105.5	105.4	105.3	105.3	105.2
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	x	x	100.3	101	101.8	102.5	102.6	102.6	102.5	102.5	102.4	102.3	102.3	102.2
Bison to Maple 345	602050,657754,1 Bison to Maple 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.1	102
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	104.6	104.5	104.5	104.5	104.5	104.5	104.8	105.2	105.7	105.9	106	106.2	106.5	106.6	106.9	106.8	106.7	106.6	106.5	106.4	106.3	106.2	106
B_XEL_S_FARIB-S38-LOONLK	603001,619605,1 Wfarib to Airtech 115kv	102	102	102	102	102	102	102	102.1	102.6	102.8	103.1	103.5	103.8	104	104.3	104.2	104.1	104	104	103.9	103.8	103.7	103.6
180 2	603022,603023,1	111.5	111.1	110.9	110.6	110.5	110.2	109.7	109.1	108.8	108.2	107.8	107.3	106.9	106.3	106.1	105.6	105.3	104.8	104.3	104	103.5	103	102.7
9L	608666,608676,1 Fondulac to Hibbard 118kv	x	x	x	148.5	148.6	161.1	175.5	175.1	175.4	175.8	174.9	174.1	173.5	173	172.4	172.6	173	173.5	174.2	174.6	175	175.4	176
128L	608696,608698,1	103.6	103.6	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.8	103.8	103.8	103.8	103.9
42L	608696,608698,1	123.2	123.2	123.3	123.3	123.3	123.3	123.3	123.3	123.3	123.3	123.3	123.4	123.4	123.4	123.4	123.4	123.5	123.5	123.5	123.5	123.5	123.5	123.5
128L	608696,608699,1	104.5	104.5	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.7	104.7	104.7	104.7	104.8	104.8
42L	608696,608699,1	124.1	124.1	124.2	124.2	124.2	124.2	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.4	124.4	124.4	124.4	124.4	124.4	124.4	124.4
42L	608698,608699,1	115.2	115.2	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.4	115.4	115.4	115.4	115.4
42L	608698,608700,1	113.6	113.6	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.8	113.7	113.8	113.8	113.8	113.8	113.8	113.9	113.9	113.9	113.9	113.9	113.9	113.9
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
180 2	615347,615349,1	100.6	100.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
B_XEL_FIBROMIN-BENSON	620218,652555,1 MoroTap to Morris 115kv	108.6	108.7	108.9	109.1	109.2	109.4	109.8	110.2	110.6	110.9	111.3	111.6	112	112.3	112.6	112.9	113.3	113.6	114	114.3	114.7	115	115.4
552	620222,658050,1 Alexandria to AlexSS 115 kV	x	x	x	x	100	100.7	100.8	101	101.2	101.3	101.5	101.7	101.9	102.1	102.2	102.2	102.1	102	101.9	101.9	101.9	101.8	101.8
M602F	657754,620189,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.9	VC				
M602F	657754,620190,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.9	VC				
SINGLE-046	657756,657791,1	113.9	113.6	113.3	113	112.7	112.4	111.8	111.1	110.5	110	109.4	108.9	108.3	107.7	107.1	106.7	106.3	105.8	105.4	105	104.5	104	103.6
M602F	657792,620189,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	102.4	104.7	VC				
M602F	657792,620190,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	102.4	104.7	VC				
~~DSY BK51~~	~~667035,669102,52 Dorsey Bank~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~100.9~~	~~102.4~~	~~103.9~~	~~105.5~~	~~107~~	~~108.8~~	~~110.3~~
M602F	667041,667046,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.9	102.4	104.4	106.6	VC				
DSY BK51	667500,667035,52 Dorsey Bank	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	101.6	103.2	104.8	106.4	108	109.2	110.6
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	104.5	104.6	104.6	105	105.1	105.6	105.5	105.4	105	108.3	112.3	115.7	119.3	122.8	126.1	126.6	126.3	126	125.7	125.4	125.2	124.9	124.6
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	101.6	101.6	101.7	102.1	102.3	102.7	102.6	102.4	102.1	105.4	109.4	112.9	116.4	120	123.3	123.8	123.5	123.2	122.9	122.6	122.4	122.1	121.8
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	100.3	100.2	100.1	x	103.4	108.1	112.1	116	119.9	123.7	124.2	123.9	123.6	123.3	122.9	122.6	122.3	122
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	102	106	109.5	113	116.4	119.8	120.3	120	119.8	119.5	119.4	119.1	118.8	118.6
WPS-ARP1E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	101.4	105.2	109.1	112.9	116.7	117.4	117	116.7	116.5	116.1	115.9	115.6	115.3
B_XEL_KING-EAU_CLA	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.9	101.3	101.1	100.9	100.7	100.5	100.3	100.1	x
New 500	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.5	102.9	105.7	108.4	111	114	VC
New 500	M602F	x	x	x	x	x	x	x	x	102	104.1	105.9	107.9	110	111.9	114.2	116.5	118.6	120.8	123.3	125.8	128.5	131.3	VC
M602F	R50M	x	x	101.5	104.2	106.8	109.4	111.4	113.3	115.3	117.4	119.7	121.7	124.1	126.4	129.3	131.5	134.4	137.5	VC				
34L		VC																						
007		VC																						
230		VC																						
860		VC																						
230_2		VC																						
B_XEL_T_CRNRS-HYDROLN-WIEN		VC																						

Table D2

SI-EXPT-W-1100-PST-60SC-

🟪 Existing D.C. reduction

🟧 Proposed D.C. reduction

Overload %

🟩 Base case issue

VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
New 500	601001,601013,1 M602F	x	101.3	103.8	106.3	108.8	111.2	113.6	116.2	118.8	121.3	124.1	126.8	129.5	132.2	135	138.2	141.3	144.8	148.3	152	VC		
SINGLE-042	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	101.8	103
Bison-AlexSS 345	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.9
001	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.6
003	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	101.4
B2_XEL_ROSEAUMP-MORNVLL	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.6
SINGLE-040	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3
New 500	601001,601017,1 Forbes to ChisagoN2 500kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	102.9	105.3	VC		
New 500	601012,601013,1 M602F SC	x	x	x	x	x	x	x	x	101.4	103.4	105.7	108.1	110.3	112.5	114.9	117.6	120.1	123.1	126	129.2	VC		
M602F	601060,601062,1	x	x	x	x	x	x	x	x	x	x	x	x	101.7	104.2	106.7	109.4	112.6	VC					
M602F	601060,601067,1 Bison 500/345 xfmr	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.6	VC					
M602F	601060,601067,2 Bison 500/345 xfmr	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.6	VC					
M602F	601061,601062,1 New Tie SC	x	x	x	x	x	x	x	x	x	x	x	x	x	101.4	103.9	106.5	109.6	VC					
M602F	601061,667500,1 New Tie	x	x	x	x	x	x	x	x	x	x	x	x	100.6	103	105.5	108.1	111.2	VC					
M602F	601067,657792,1 Bison to Maple River 345 kV	x	x	x	x	x	x	x	x	x	x	x	100.9	103	105.2	107.5	109.8	112.6	VC					
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	100.6	100.6	100.5	100.5	100.5	100.4	100.4	100.4	100.5	101.3	102.2	103	103.8	104.7	105.5	105.6	105.6	105.5	105.4	105.4	105.3	105.2	105.2
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	x	x	100.2	101	101.7	102.5	102.6	102.5	102.5	102.4	102.4	102.3	102.3	102.2
Bison to Maple 345	602050,657754,1 Bison to Maple 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.2
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	104.4	104.4	104.4	104.4	104.4	104.4	104.7	105.1	105.6	105.8	106	106.2	106.4	106.6	106.8	106.7	106.6	106.6	106.4	106.3	106.2	106.1	106
B_XEL_S_FARIB-S38-LOONLK-E	603001,619605,1 Wfarib to Airtech 115kv	101.9	101.9	101.9	102	101.9	102.2	102	102	102.5	102.8	103	103.5	103.7	104	104.2	104.2	104.1	104	103.9	103.8	103.7	103.7	103.6
180 2	603022,603023,1	109.2	109.2	109.1	108.9	108.9	108.7	108.4	108.1	107.9	107.7	107.4	107.1	106.9	106.7	106.6	106.3	106.1	105.8	105.8	105.6	105.3	105.1	105.1
9L	608666,608676,1 Fondulac to Hibbard 118kv	x	x	x	148	148.1	160.6	174.7	174.6	175	175.3	174.4	173.8	173.2	172.6	172	172.2	172.7	173.2	173.9	174.4	174.6	175.1	175.7
128L	608696,608698,1	103.6	103.6	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.8	103.8	103.8	103.8	103.9
42L	608696,608698,1	123.2	123.2	123.3	123.3	123.3	123.3	123.3	123.3	123.3	123.3	123.3	123.4	123.4	123.4	123.4	123.4	123.4	123.5	123.5	123.5	123.5	123.5	123.5
128L	608696,608699,1	104.5	104.5	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.7	104.7	104.7	104.7	104.8
42L	608696,608699,1	124.1	124.1	124.2	124.2	124.2	124.2	124.2	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.4	124.4	124.4	124.4	124.4	124.4	124.4
42L	608698,608699,1	115.2	115.2	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.4	115.4	115.4	115.4
42L	608698,608700,1	113.6	113.6	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.7	113.8	113.8	113.8	113.8	113.8	113.9	113.9	113.9	113.9	113.9	113.9	113.9
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
B_XEL_FIBROMIN-BENSON	620218,652555,1 MoroTap to Morris 115kv	108.6	108.8	108.9	109.1	109.2	109.4	109.8	110.2	110.6	110.9	111.3	111.6	112	112.2	112.6	112.9	113.2	113.6	114	114.3	114.7	115	115.3
552	620222,658050,1 Alexandria to AlexSS 115 kV	x	x	x	x	x	100.4	100.5	100.7	100.9	101.1	101.3	101.5	101.7	101.8	102	102	101.9	101.9	101.8	101.7	101.7	101.7	101.7
M602F	657754,620189,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	103.4	VC					
M602F	657754,620190,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	103.4	VC					
SINGLE-046	657756,657791,1	117.3	116.9	116.4	116.1	115.7	115.3	114.6	113.7	112.9	112.3	111.6	110.9	110.2	109.5	108.8	108.2	107.7	107.1	106.6	106	105.4	104.8	104.2
M602F	657792,620189,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.4	103.5	106.1	VC					
M602F	657792,620190,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.4	103.5	106.1	VC					
M602F	667041,667046,1	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	102.4	104.5	106.6	VC					
DSY BK51	667500,667035,52	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	102.1	103.8	105.5	107.2	108.8	110
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	104.4	104.4	104.5	105	105.1	105.5	105.4	105.3	104.9	108.2	112.2	115.7	119.2	122.7	126.1	126.5	126.2	126	125.7	125.4	125.1	124.8	124.5
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	101.5	101.6	101.6	102	102.2	102.6	102.5	102.3	102	105.3	109.3	112.9	116.4	119.9	123.3	123.7	123.5	123.2	122.9	122.6	122.4	122.1	121.7
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	100.1	100.1	x	x	103.3	108	112	115.9	119.8	123.6	124.1	123.8	123.5	123.2	122.9	122.6	122.2	121.9
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	102	106	109.5	112.9	116.4	119.7	120.3	120	119.7	119.5	119.3	119	118.8	118.5
WPS-ARP1E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	101.3	105.2	109	112.9	116.6	117.2	117	116.7	116.4	116.1	115.8	115.5	115.3
B_XEL_KING-EAU_CLA	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.9	101.2	101.1	100.9	100.6	100.5	100.3	100.1	x
New 500	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	101.6	104.7	108.2	111.5	115.2	118.6	122.6	VC		
M602F	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	VC					
New 500	M602F	x	x	x	x	x	x	x	101.8	104	106.1	108.5	110.9	113.2	115.5	117.9	120.7	123.3	126.4	129.4	132.6	VC		
M602F	R50M	x	x	102.1	104.5	107.2	110	112.2	114.1	116.5	119	121.2	123.6	126.2	128.8	131.5	134.5	137.6	VC					
34L		VC																						
007		VC																						
230		VC																						
860		VC																						
230_2		VC																						
B_XEL_T_CRNRS-HYDROLN-WIEN		VC																						

Table D3

SI-IMPT-W-1100-NOPST-60SC-

Overload %

▨ Existing D.C. reduction
▨ Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 kV	x	x	x	x	x	x	x	x	x	x	101.1	102.9	104.7	106.3	107.9	109.2	109.6	110	110.5	110.6	110.4	110.1	109.5
220	602006,652435,1 Fargo to Sheynne 230 kV	107.6	108.3	109	109.6	110.3	110.9	111.2	111.7	112.1	112.5	112.9	113.4	113.8	114.3	114.7	115.2	115.9	116.6	117.4	118.1	118.8	119.4	120.1
220_2	602006,652435,1 Fargo to Sheynne 230 kV	107.6	108.3	109	109.7	110.3	110.9	111.2	111.6	112.1	112.5	112.9	113.4	113.8	114.3	114.7	115.2	115.9	116.7	117.4	118.1	118.7	119.4	120.1
Bison to Buffalo 345	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	100.2	100.7	101	101.4	101.9	102.4	102.9	103.4	103.9	104.3	104.9	105.4	106.2	106.9	107.7	108.4	109.2	109.9	110.5
610 2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	100.2	100.6	100.9	101.4	101.8	102.5	103.2	103.8	104.5	105.1	105.7	106.3
200	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	100.8	101.5	102.2	102.8	103.4	104	104.6	105.2
200_2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	100.8	101.5	102.2	102.8	103.4	104	104.6	105.2
G82R	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.1	101.8	102.5
610 1	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2	100.9	101.5	102.1
Bison to Buffalo 345	603018,620204,1 Fargo to Sheynne 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	100.3	100.5	100.8	101.3	101.6
Pre Contingency	**603022,603023,1 Souir to Mallard 115 kV**	**103.1**	**103.3**	**103.4**	**103.6**	**103.9**	**104**	**104.4**	**104.5**	**104.9**	**105**	**105.4**	**105.5**	**105.9**	**106**	**106.4**	**106.6**	**107**	**107.2**	**107.6**	**107.8**	**108.2**	**108.5**	**108.4**
180 2	603022,605634,1 Souris to Velva Tap 115 kV	104	104.7	105.4	106.1	106.7	107.4	107.8	108.4	109	109.5	110.1	110.7	111.3	111.9	112.4	113	113.7	114.5	115.1	115.8	116.4	117.1	117.8
B_XEL_LKMARN-KEK_NSP	603170,616922,1 WillP to ApplV 115 kV	109	109.2	109.4	109.7	109.9	110.1	110.1	110	109.8	109.7	109.6	109.4	109.3	109.2	109	108.7	107.3	106.6	105.8	106.7	108.8	110.6	110.9
500	603177,616004,1	106.8	107.1	107.4	107.7	107.9	108.2	108.3	108.4	108.5	108.6	108.7	108.8	108.9	109	109.1	109.3	109.6	109.9	110.1	110.4	110.7	111	111.3
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	122.9	122.9	122.9	123	122.9	123	122.9	122.9	122.9	123	123	123	123	123	123	123	123	123	123	123	123.1	123.1	123.1
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	123.8	123.8	123.8	123.8	123.8	123.8	123.8	123.8	123.8	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9	124	124	124	124
42L	608698,608699,1	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1
42L	608698,608700,1	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.5	113.5
42L	608700,608701,1	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6
39L	608702,608704,1	102.7	102.8	103	103.1	103.3	103.6	104	104.1	104.2	104.2	104.3	104.4	104.4	104.5	104.6	104.7	104.7	104.8	104.9	105	105.1	105.2	105.4
180 1	615347,615349,1 Mchenry Transformer	117.4	117.8	118	118.4	118.7	119.1	119.4	119.8	120.1	120.8	121.1	121.7	122.1	122.6	122.9	123.6	123.9	124.7	125.1	125.4	125.8	126.2	126.5
180 2	615347,615349,1 Mchenry Transformer	180.8	181.7	182.7	183.5	184.5	185.3	186	186.7	187.5	188.2	189	189.8	190.6	191.3	192.2	192.9	193.9	194.9	195.8	196.8	197.7	198.6	199.6
180 1	615348,615347,1 Mchenry Transformer	106.7	107	107.2	107.6	107.8	108.2	108.5	108.8	109.1	109.7	110	110.6	110.9	111.3	111.7	112.3	112.6	113.3	113.6	114	114.3	114.6	115
180 2	615348,615347,1 Mchenry Transformer	164.3	165.1	166	166.8	167.6	168.4	169	169.7	170.4	171.1	171.8	172.5	173.2	173.9	174.6	175.3	176.2	177.1	178	178.8	179.7	180.5	181.4
B2_XEL_WILLPIP-S35-JOHNCAK115.0	615440,616929,1 LKMARN to KENRICK 115 kV	104.6	104.8	105.1	105.3	105.5	105.7	105.7	105.6	105.4	105.3	105.2	105.1	105	104.9	104.8	104.5	103.5	103	102.5	102.5	102.9	103.3	103.4
B2_XEL_WILLPIP-S35-JOHNCAK115.0	616925,616929,1	x	100	100.3	100.5	100.7	100.9	100.9	100.7	100.6	100.5	100.4	100.3	100.2	100	x	x	x	x	x	x	x	x	x
New 500	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.8	102.8	103.9	105	106.1	107.1	108	108.7
220	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	100.5
220_2	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.5
34L		**VC**																						
007		**VC**																						
L20D		**VC**																						
230		**VC**																						
860		**VC**																						
230_2		**VC**																						
B_XEL_BLK_DOG-PILOTKB		**VC**																						

Table D4

SI-IMPT-W-1100-PST-60SC-

🟪 Existing D.C. reduction

🟧 Proposed D.C. reduction

Overload %

🟩 Base case issue

VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 kV	x	x	x	x	x	x	x	x	x	x	101.3	103	104.8	106.5	108.1	109.5	109.9	110.4	110.8	110.9	110.7	110.5	109.8
220	602006,652435,1 Fargo to Sheynne 230 kV	109.8	110.6	111.4	112.2	112.9	113.6	113.9	114.5	114.9	115.5	116	116.5	117.1	117.6	118.1	118.7	119.4	120.2	121.1	121.8	122.6	123.3	124.1
220_2	602006,652435,1 Fargo to Sheynne 230 kV	109.8	110.6	111.4	112.2	112.9	113.6	113.9	114.4	115	115.5	116	116.5	117	117.6	118.1	118.7	119.4	120.3	121.1	121.8	122.6	123.3	124.1
610 2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	100.1	100.6	101.1	101.6	102	102.6	103.1	103.5	104.3	105.1	105.7	106.5	107.2	107.8	108.6
200	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	100.3	100.8	101.2	101.7	102.3	102.9	103.7	104.5	105.1	105.8	106.4	107.1
200_2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	100.3	100.8	101.2	101.7	102.3	102.9	103.7	104.5	105.1	105.8	106.4	107.1
610 1	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.3	102	102.8	103.5	104.3
G82R	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.4	102.1
M602F	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	101.8
L20D	603018,620204,1 Fargo to Sheynne 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
Pre Contingency	**603022,603023,1 Souir to Mallard 115 kV**	**102.7**	**102.8**	**103**	**103**	**103.1**	**103.2**	**103.5**	**103.4**	**103.7**	**103.7**	**104**	**104**	**104.3**	**104.2**	**104.6**	**104.6**	**104.9**	**104.9**	**105.2**	**105.3**	**105.5**	**105.8**	**105.9**
180 2	603022,605634,1	117.5	117.6	117.8	118	118.4	118.5	119.2	119.3	119.9	119.9	120.6	120.6	121.2	121.3	122	122.2	122.8	123.3	123.6	124.2	124.5	125	125.5
B_XEL_LKMARN-KEK_NSP	603170,616922,1	109	109.2	109.5	109.7	109.9	110.1	110.1	110	109.8	109.7	109.6	109.4	109.3	109.2	109.1	108.7	107.4	106.6	105.9	106.8	108.9	110.7	110.9
500	603177,616004,1	106.8	107.1	107.4	107.7	107.9	108.2	108.3	108.4	108.5	108.6	108.7	108.9	109	109.1	109.3	109.4	109.7	110	110.2	110.5	110.9	111.1	111.4
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	122.9	122.9	122.9	123	122.9	123	122.9	122.9	122.9	123	123	123	123	123	123	123	123	123	123.1	123.1	123.1	123.1	123.1
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	123.8	123.8	123.8	123.8	123.8	123.8	123.8	123.8	123.8	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9	124	124	124	124	124
42L	608698,608699,1	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1
42L	608698,608700,1	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.5	113.5	113.5
42L	608700,608701,1	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.5	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6
39L	608702,608704,1	102.7	102.8	103	103.1	103.3	103.6	104	104.1	104.2	104.2	104.3	104.4	104.5	104.6	104.6	104.7	104.8	104.9	105	105.1	105.2	105.3	105.4
180 1	615347,615349,1 Mchenry Transformer	119	119.2	119.1	119.1	119.4	119.5	119.8	119.8	120	120.1	120.5	120.5	120.8	120.9	121.2	121.3	121.5	121.6	122	122	122.4	122.5	122.7
180 2	615347,615349,1 Mchenry Transformer	200	200.3	200.7	201.1	201.6	201.9	202.6	202.9	203.2	203.7	204.2	204.7	205.3	205.7	206.1	206.5	207.3	207.9	208.7	209.1	209.9	210.2	210.9
180 1	615348,615347,1 Mchenry Transformer	108.1	108.2	108.2	108.2	108.4	108.5	108.8	108.9	109.1	109.1	109.4	109.5	109.7	109.8	110.1	110.2	110.4	110.5	110.8	110.8	111.2	111.3	111.5
180 2	615348,615347,1 Mchenry Transformer	181.8	182.1	182.4	182.8	183.2	183.5	184.1	184.4	184.7	185.2	185.6	186.1	186.6	186.9	187.4	187.7	188.4	188.9	189.7	190.1	190.8	191	191.7
B2_XEL_WILLPIP-S35-JOHNCAI	615440,616929,1	104.6	104.9	105.1	105.3	105.6	105.7	105.7	105.6	105.5	105.4	105.3	105.1	105	104.9	104.8	104.6	103.6	103	102.6	102.6	103	103.4	103.6
B2_XEL_WILLPIP-S35-JOHNCAI	616925,616929,1	x	100	100.3	100.5	100.7	100.9	100.9	100.8	100.7	100.5	100.4	100.3	100.2	100.1	100	x	x	x	x	x	x	x	x
180 2	652452,659264,1 Rugby to RogbyBPC 115 kV	108.2	108.3	108.5	108.6	108.8	108.9	109.4	109.5	109.6	109.8	110	110.2	110.4	110.6	110.8	110.9	111.3	111.5	111.9	112.1	112.4	112.7	112.8
34L		**VC**																						
007		**VC**																						
230		**VC**																						
860		**VC**																						
230_2		**VC**																						
B_XEL_BLK_DOG-PILOTKB		**VC**																						
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**																						

Table D5

Overload %

SI-EXPT-W-750-NOPST-60SC-

🟪 Existing D.C. reduction 🟧 Proposed D.C. reduction 🟩 Base case issue VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
New 500	601001,601013,1 M602F	x	101.2	103.8	106.1	108.3	110.7	112.8	115.1	117.5	119.5	122.1	124.4	126.7	129.3	132	134.4
Bison 500-345BK	601001,601013,1 M602F	x	101	103.6	105.9	108.2	110.5	112.9	115.2	117.3	119.4	122.2	124.4	126.9	129.3	132	134.4
Bison-AlexSS 345	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	100.3	102	103.7	105.3	106.8
AlexSS-WaitePark 345	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	102.3
SINGLE-042	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	102.3
001	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8
003	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6
B2_XEL_ROSEAUMP-MORNVLL-RICH223	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8
New 500	601012,601013,1 M602F SC	x	x	x	x	x	x	x	x	100.3	101.9	104.1	106	108	110.1	112.4	114.4
Bison 500-345BK	601012,601013,1 M602F SC	x	x	x	x	x	x	x	x	100.1	101.9	104.2	106.1	108.1	110.2	112.4	114.4
M602F	601060,601067,1 Bison 500/345 xfmr	133	136.2	139.6	143.2	146.7	150.5	154.4	158.2	162.4	166.7	**VC**	x	x	x	x	x
M602F	601067,657792,1 Bison to Maple River 345 kV	104.7	106.7	108.8	111.1	113.4	116	118.4	120.9	123.6	126.5	**VC**	x	x	x	x	x
Bison-Alex SS 345	601067,657792,1 Bison to Maple River 345 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	100.5	100.5	100.4	100.4	100.3	100.3	100.3	100.3	100.3	101.2	102	102.8	103.6	104.4	105.2	105.3
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	x	x	100.1	100.8	101.5	102.3	102.3
Bison to Maple 345	602050,657754,1 Bison to Maple 230 kV	x	x	x	x	100.2	101.4	102.8	104.1	105.3	106.6	107.8	109.2	110.5	111.8	113.2	114.4
220	602050,657754,1 Bison to Maple 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4
220_2	602050,657754,1 Bison to Maple 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	104	104	104	104	103.9	103.9	104.2	104.6	105.1	105.3	105.4	105.6	105.8	106	106.2	106.2
B_XEL_S_FARIB-S38-LOONLK-EASTWD	603001,619605,1 Wfarib to Airtech 115kv	101.6	101.6	101.8	101.8	101.8	101.8	101.6	101.6	102.1	102.4	102.8	103	103.3	103.5	103.8	103.7
180 2	603022,603023,1	110.2	110	109.7	109.2	109.1	108.8	108.4	107.7	107.2	106.7	106.1	105.9	105.3	104.8	104.2	103.7
9L	608666,608676,1 Fondulac to Hibbard 118kv	x	x	x	150.2	150.4	162.5	177.5	177.3	177.6	177.6	177	176.4	175.8	175.3	174.6	174.8
128L	608696,608698,1	103.6	103.6	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.8	103.8	103.8	103.8
42L	608696,608698,1	123.2	123.2	123.3	123.3	123.3	123.3	123.4	123.4	123.4	123.4	123.4	123.5	123.5	123.5	123.5	123.5
128L	608696,608699,1	104.5	104.5	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.7	104.7	104.7	104.8
42L	608696,608699,1	124.1	124.1	124.2	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.4	124.4	124.4	124.4	124.4	124.4
42L	608698,608699,1	115.2	115.2	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.4	115.4
42L	608698,608700,1	113.6	113.6	113.7	113.7	113.7	113.8	113.8	113.8	113.8	113.8	113.8	113.9	113.9	113.9	113.9	113.9
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
B_XEL_FIBROMIN-BENSON	620218,652555,1 MoroTap to Morris 115kv	111.5	111.7	111.9	112.1	112.2	112.5	112.9	113.4	113.8	114.2	114.6	115	115.5	115.9	116.4	116.9
AlexSS-WaitePark 345	620222,658050,1 Alexandria to AlexSS 115 kV	104.8	105.6	106.3	107.3	108.3	109.3	110.1	111.1	112.1	113	114.1	115.2	116.2	117.3	118.4	119.7
M602F	620329,657750,1	x	x	x	x	x	x	x	100.1	103	105.8	**VC**					
M602F	657750,657754,1	x	x	x	x	x	x	x	100.2	103.2	106	**VC**					
M602F	657754,620189,1	x	x	x	102	104.1	106.5	108.7	111	113.4	116.1	**VC**					
M602F	657754,620190,1	x	x	x	102	104.1	106.5	108.7	111	113.4	116.1	**VC**					
SINGLE-046	657756,657791,1	109.4	109.1	108.7	108.4	108.1	107.8	107.1	106.3	105.6	105	104.4	103.7	103.1	102.4	101.8	101.1
M602F	657792,620189,1	x	100.6	102.6	104.7	107	109.3	111.6	114	116.5	119.2	**VC**					
M602F	657792,620190,1	x	100.6	102.6	104.7	107	109.3	111.6	114	116.5	119.2	**VC**					
M602F	667041,667046,1	x	x	x	x	x	x	101.7	103.4	105.4	107.7	**VC**					
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	103.3	103.3	103.3	103.8	103.9	104.3	104.2	104	103.6	106.9	110.9	114.2	117.8	121.3	124.6	125
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	100.4	100.5	100.6	101	101	101.5	101.3	101.2	100.8	104	108	111.3	115	118.4	121.9	122.3
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	101.9	106.6	110.3	114.3	118.3	122	122.6
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	100.8	104.7	108	111.6	115.2	118.6	119
WPS-ARP1E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	103.6	107.6	111.5	115.3	115.8
B_XEL_KING-EAU_CLA	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2
New 500	M602F	x	x	x	x	x	x	x	100.8	102.9	104.6	106.8	108.8	110.8	113	115.3	117.4
Bison 500-345BK	M602F	x	x	x	x	x	x	x	100.9	102.7	104.5	106.9	108.9	110.9	113.1	115.4	117.5
M602F	R50M	111.7	114.8	118.1	121.2	124.1	127.6	130.4	132.9	135.8	139.1	**VC**					
34L		**VC**															
007		**VC**															
230		**VC**															
860		**VC**															
230_2		**VC**															
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**															

Table D6

SI-EXPT-W-750-PST-60SC

Overload %

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
New 500	601001,601013,1 M602F	x	101.8	104.5	107	109.5	111.9	114.4	117	119.5	122.2	124.7	127.4	130.2	133.2	136.1	139
Bison 500-345BK	601001,601013,1 M602F	x	101.7	104.3	106.8	109.3	111.9	114.4	117	119.4	122.2	124.7	127.3	130.2	132.9	136.1	139
Bison-AlexSS 345	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	101.2	102.9	104.6	106.2
SINGLE-042	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	101.7
AlexSS-WaitePark 345	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.6
001	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
B2_XEL_ROSEAUMP-MORNVLL-RICI	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
New 500	601012,601013,1 M602F Series Comp	x	x	x	x	x	x	x	x	101.9	104.1	106.3	108.5	110.9	113.4	115.8	118.3
Bison 500-345BK	601012,601013,1 M602F Series Comp	x	x	x	x	x	x	x	x	101.9	104.2	106.3	108.5	110.9	113.1	115.8	118.2
M602F	601067,657792,1 Bison to Maple River 345 kV	105.8	108	110.4	112.8	115.5	118.4	121.1	124.1	127	VC						
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	100.4	100.4	100.4	100.3	100.3	100.2	100.2	100.3	100.3	101.1	102	102.8	103.6	104.4	105.2	105.3
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	x	x	100.1	100.8	101.5	102.2	102.3
Bison to Maple 345	602050,657754,1 Bison to Maple river 230 kV	x	x	x	x	x	x	100.9	102.3	103.5	104.9	106.2	107.7	109	110.6	111.9	113.4
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	103.9	103.9	103.9	103.9	103.8	103.8	104.1	104.5	105	105.2	105.3	105.5	105.7	105.9	106.1	106.2
B_XEL_S_FARIB-S38-LOONLK-EAST\	603001,619605,1 Wfarib to Airtech 115kv	101.8	101.8	101.8	101.8	101.8	101.8	101.6	101.6	102.1	102.6	102.8	103	103.3	103.5	103.8	103.7
180 2	603022,603023,1	108.2	108.2	108.1	108	107.9	107.8	107.5	107.1	106.9	106.7	106.3	106.2	105.9	105.4	105.2	104.9
9L	608666,608676,1 Fondulac to Hibbard 115 kV	x	x	x	149.8	149.9	162.7	177.1	177.4	177.1	177.4	176.6	176.1	175.5	175.1	174.3	174.6
128L	608696,608698,1	103.6	103.6	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.8	103.8	103.8
42L	608696,608698,1	123.2	123.2	123.3	123.3	123.3	123.3	123.4	123.4	123.4	123.4	123.4	123.4	123.5	123.5	123.5	123.5
128L	608696,608699,1	104.5	104.5	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.6	104.7	104.7	104.7	104.7
42L	608696,608699,1	124.1	124.2	124.2	124.2	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.4	124.4	124.4	124.4	124.4
42L	608698,608699,1	115.2	115.2	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.4	115.4
42L	608698,608700,1	113.6	113.6	113.7	113.7	113.7	113.8	113.8	113.8	113.8	113.8	113.8	113.9	113.9	113.9	113.9	113.9
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.6
B_XEL_FIBROMIN-BENSON	620218,652555,1	111.5	111.7	111.9	112.1	112.2	112.4	112.9	113.4	113.8	114.2	114.6	115	115.4	115.9	116.4	116.8
AlexSS-WaitePark 345	620222,658050,1 AlexSS to Alexandria 115 kV	104.5	105.3	106	107	108	108.9	109.9	110.8	111.8	112.8	113.8	114.9	116	117.1	118.1	119.4
M602F	620329,657750,1 Fronter to Wahptn 230 kV	x	x	x	x	x	x	x	102.5	105.4	VC						
M602F	657750,657754,1	x	x	x	x	x	x	x	102.7	105.5	VC						
M602F	657754,620189,1	x	x	101.4	103.6	106.1	108.7	111.2	113.9	116.6	VC						
M602F	657754,620190,1	x	x	101.4	103.6	106.1	108.7	111.2	113.9	116.6	VC						
SINGLE-046	657756,657791,1	112.5	112.1	111.6	111.1	110.7	110.3	109.5	108.6	107.7	107	106.2	105.4	104.6	103.8	103	102.3
M602F	657792,620189,1	x	101.9	104.1	106.4	108.9	111.6	114.2	117	119.7	VC						
M602F	657792,620190,1	x	101.9	104.1	106.4	108.9	111.6	114.2	117	119.7	VC						
M602F	667041,667046,1	x	x	x	x	x	101.1	103.1	105.2	107.3	VC						
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	103.2	103.3	103.3	103.8	103.8	104.3	104.2	104	103.5	106.9	110.8	114.2	117.8	121.2	124.5	125
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	100.3	100.4	100.5	100.9	101	101.4	101.3	101.1	100.7	103.9	108	111.3	115	118.5	121.9	122.2
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	101.8	106.5	110.3	114.3	118.2	121.9	122.4
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	100.7	104.6	108	111.5	115.1	118.5	119
WPS-ARP1E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	103.5	107.5	111.4	115.2	115.7
B_XEL_KING-EAU_CLA	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2
New 500	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	102.4	105.4
Bison 500-345BK	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	102.3	105.3
New 500	M602F	x	x	x	x	x	x	100.2	102.5	104.6	106.9	109.1	111.3	113.8	116.4	118.9	121.4
Bison 500-345BK	M602F	x	x	x	x	x	x	100.2	102.5	104.5	106.9	109.1	111.3	113.8	116.1	118.9	121.3
M602F	R50M	112.6	116.2	119.7	122.4	126.1	129.6	132.4	135.6	138.6	VC						
34L		VC															
007		VC															
230		VC															
860		VC															
230_2		VC															
B_XEL_T_CRNRS-HYDROLN-WIEN		VC															

Table D7

Overload %

SI-IMPT-W-750-NOPST-60SC-

🟪 Existing D.C. reduction 🟧 Proposed D.C. reduction 🟩 Base case issue VC Voltage collapse

Congtigency	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 kV	x	x	x	x	x	x	x	x	x	101.8	103.9	105.9	108	109.9	111.7	113.3
220	602006,652435,1 Fargo to Sheynne 230 kV	108.5	109.4	110.2	111.1	111.8	112.6	113	113.7	114.3	115	115.6	116.3	117	117.6	118.3	119
220_2	602006,652435,1 Fargo to Sheynne 230 kV	108.5	109.3	110.2	111	111.9	112.6	113	113.7	114.4	115	115.6	116.3	116.9	117.6	118.3	119
610 2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	100.1	100.7	101.4	102.2	102.9
200	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	101
200_2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101
Pre Contingency	**603022,603023,1 Souris to Mallard 115 kV**	**103.1**	**103.3**	**103.4**	**103.8**	**103.9**	**104.4**	**104.5**	**104.9**	**105**	**105.5**	**105.6**	**106**	**106.2**	**106.6**	**106.8**	**107.2**
180 2	603022,605634,1 Souris to Velva Tap 115 kV	104.4	105.2	105.9	106.6	107.3	108	108.5	109.1	109.7	110.4	111	111.7	112.3	113	113.7	114.4
B_XEL_LKMARN-KEK_NSP	603170,616922,1	108.9	109.2	109.4	109.6	109.8	110	110	109.8	109.7	109.5	109.4	109.2	109	108.9	108.8	108.4
500	603177,616004,1	107.2	107.5	107.8	108.1	108.4	108.7	108.8	108.9	109	109.2	109.3	109.5	109.7	109.8	110	110.1
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	122.9	122.9	123	122.9	122.9	123	122.9	123	123	123	123	123	123	123	123	123
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	123.8	123.8	123.8	123.8	123.8	123.9	123.8	123.8	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9
42L	608698,608699,1	115	115	115	115	115	115	115	115	115	115	115	115	115	115.1	115.1	115.1
42L	608698,608700,1	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.4	113.4	113.4	113.4	113.4	113.4	113.4
42L	608700,608701,1	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6
39L	608702,608704,1	102.7	102.8	103	103.2	103.4	103.6	104	104.1	104.2	104.3	104.4	104.5	104.6	104.7	104.7	104.8
180 1	615347,615349,1 McHenry Transformer	117.4	117.8	118	118.5	119	119.3	119.7	120.1	120.8	121.2	121.7	122.1	122.8	123.1	123.8	124.2
180 2	615347,615349,1 McHenry Transformer	181.5	182.4	183.4	184.4	185.3	186.2	186.8	187.7	188.5	189.3	190.2	191.1	191.9	192.8	193.8	194.8
180 1	615348,615347,1 McHenry Transformer	106.7	107	107.2	107.6	108.1	108.4	108.8	109.1	109.8	110.1	110.6	111	111.6	111.8	112.5	112.9
180 2	615348,615347,1 McHenry Transformer	164.9	165.8	166.6	167.6	168.4	169.2	169.8	170.6	171.3	172.1	172.8	173.7	174.4	175.3	176.1	177
B2_XEL_WILLPIP-S35-JOHNCAK115.0	615440,616929,1	104.6	104.8	105.1	105.3	105.5	105.6	105.6	105.4	105.3	105.2	105	104.9	104.7	104.6	104.5	104.2
B2_XEL_WILLPIP-S35-JOHNCAK115.0	616925,616929,1	x	100	100.3	100.5	100.7	100.8	100.8	100.6	100.5	100.3	100.2	100	x	x	x	x
New 500	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.9	102
Bison 500-345BK	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.9	102
34L		**VC**															
007		**VC**															
230		**VC**															
860		**VC**															
230_2		**VC**															
B_XEL_BLK_DOG-PILOTKB		**VC**															
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**															

Table D8

Overload %

SI-IMPT-W-750-PST-60SC-

🟪 Existing D.C. reduction 🟧 Proposed D.C. reduction 🟩 Base case issue **VC** Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 kV	x	x	x	x	x	x	x	x	x	102	104.1	106.1	108.2	110.1	111.9	113.6
220	602006,652435,1 Fargo to Sheynne 230 kV	110.8	111.8	112.7	113.7	114.5	115.4	115.9	116.7	117.4	118.2	118.9	119.6	120.4	121.1	121.9	122.7
220_2	602006,652435,1 Fargo to Sheynne 230 kV	110.8	111.7	112.8	113.7	114.6	115.4	115.9	116.7	117.4	118.1	118.9	119.6	120.4	121.1	121.9	122.7
610 2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	100.2	100.9	101.6	102.3	103	103.8	104.6
200	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.4	101	101.7	102.5
200_2	602006,652435,1 Fargo to Sheynne 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.4	101	101.8	102.5
Pre Contingency	**603022,603023,1 Souris to Mallard 115 kV**	**102.7**	**102.8**	**102.9**	**102.9**	**103.2**	**103.2**	**103.5**	**103.5**	**103.9**	**103.9**	**104.2**	**104.2**	**104.5**	**104.5**	**104.8**	**105**
180 2	603022,605634,1 Souris to Velva Tap 115 kV	117.6	117.8	118	118.2	118.8	118.9	119.6	119.9	120.5	120.7	121.3	121.7	122.1	122.4	122.8	123.3
B_XEL_LKMARN-KEK_NSP	603170,616922,1	109	109.2	109.4	109.6	109.8	110	110	109.8	109.7	109.5	109.4	109.2	109.1	109	108.8	108.4
500	603177,616004,1	107.2	107.5	107.8	108.1	108.4	108.7	108.8	109	109.1	109.2	109.4	109.5	109.7	109.9	110	110.2
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	122.9	122.9	123	122.9	123	123	122.9	123	123	123	123	123	123	123	123	123
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	123.8	123.8	123.8	123.8	123.9	123.9	123.8	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9	123.9
42L	608698,608699,1	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115.1	115.1
42L	608698,608700,1	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.4	113.4	113.4	113.4	113.4	113.4	113.4
42L	608700,608701,1	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6	102.6
39L	608702,608704,1	102.7	102.9	103	103.2	103.4	103.6	104.1	104.2	104.3	104.3	104.4	104.5	104.6	104.7	104.7	104.8
180 1	615347,615349,1 McHenry Transformer	118.9	118.7	118.9	119	119.3	119.4	119.7	119.9	120.1	120.2	120.6	120.7	120.9	121	121.4	121.5
180 2	615347,615349,1 McHenry Transformer	200.3	200.7	201.1	201.5	202.2	202.4	203.3	203.4	204.1	204.8	205.2	205.8	206.3	207	207.6	208.3
180 1	615348,615347,1 McHenry Transformer	108	107.9	108	108.1	108.4	108.5	108.8	108.9	109.1	109.2	109.5	109.6	109.9	110	110.3	110.4
180 2	615348,615347,1 McHenry Transformer	182.1	182.4	182.8	183.1	183.7	184	184.8	184.9	185.5	186.1	186.5	187	187.5	188.2	188.7	189.3
B2_XEL_WILLPIP-S35-JOHNCAK115.0	615440,616929,1	104.6	104.9	105.1	105.3	105.5	105.7	105.6	105.5	105.4	105.2	105.1	104.9	104.8	104.7	104.6	104.3
B2_XEL_WILLPIP-S35-JOHNCAK115.0	616925,616929,1	x	100	100.3	100.5	100.7	100.8	100.8	100.7	100.5	100.4	100.3	100.1	100	x	x	x
180 2	652452,659264,1 Rugby to RogbyBPC 115 kV	108.4	108.6	108.8	108.9	109.1	109.1	109.8	109.7	110.1	110.3	110.5	110.8	110.9	111.3	111.5	111.8
34L		**VC**															
007		**VC**															
230		**VC**															
860		**VC**															
230_2		**VC**															
B_XEL_BLK_DOG-PILOTKB		**VC**															
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**															

Table D9

Overload %

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

SI-EXPT-E-1100-NOPST-60SC-

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
New 500 D-Black	601001,601013,1 M602F	x	x	100.2	102.3	104.4	106.6	108.7	110.5	112.8	114.8	116.9	119.3	121.5	123.6	125.9	128.4	130.5	132.9	135.6	138.3	140.9	143.9	147
Blackberry 345/230 BK	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.5
Arrowhead-StoneLake 345	601001,601017,1 Forbes to ChisagoN2 500kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2	101.8	103.3	104.9	106.4
New 500 D-Black	601012,601013,1 M602F SC	x	x	x	x	x	x	x	x	x	x	x	101.8	103.6	105.4	107.3	109.4	111.2	113.2	115.5	117.7	119.9	122.5	125
B3_XEL_CHIS_CO110.0-34.5_9	601016,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	101.7	103.5	105.2
B3_XEL_CHIS_CO110.0-34.5_10	601016,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.5	103.4	105
B3_XEL_CHIS_CO110.0-34.5_9	601018,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.5	102.3	103.9
B3_XEL_CHIS_CO110.0-34.5_10	601018,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101	102.9	104.5
M602F	601035,608625,3 Blackberry 345/230 xfmr	x	x	x	x	x	x	101.6	104.7	107.4	110.8	113.9	117.7	120.7	124.8	128.8	132.8	136.4	140.3	140.7	**VC**			
M602F	601061,601062,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	103.4	106.5	**VC**			
M602F	601062,608635,1	x	x	x	x	x	x	x	x	x	x	x	x	x	101.7	103.7	105.8	107.7	110.1	113.4	**VC**			
StoneLake-GardnierPark 345	602017,699450,1 Stone Lake 345/161 Xfmr	109.3	109.4	109.4	109.8	109.6	110	110.5	111.1	111.8	112.7	113.6	114.6	115.5	116.5	117.4	118.1	118.6	119.2	119.9	120.8	121.4	122.4	122.9
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	101.5	101.5	101.4	101.4	101.3	101.3	101.3	101.3	101.3	102.1	103	103.8	104.5	105.3	106.1	106.2	106.1	106	105.9	105.7	105.6	105.5	105.4
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	x	100.8	101.5	102.2	102.8	103.4	103.6	103.5	103.4	103.3	103.2	103.1	103.1	103
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	103.4	103.4	103.3	103.3	103.3	103.3	103.6	104	104.4	104.6	104.8	105	105.1	105.3	105.5	105.5	105.3	105.2	105.1	105	104.8	104.7	104.6
B_XEL_S_FARIB-S38-LOONLK-EA	603001,619605,1 Wfarib to Airtech 115kv	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.6	100.8	101	101.2	101.4	101.6	101.9	101.8	101.7	101.6	101.5	101.4	101.2	101.1	101
180 2	603022,603023,1	108.4	108.2	108.2	107.8	107.6	107.2	106.6	106.1	105.5	104.9	104.6	104	103.4	102.8	102.3	101.7	101.2	100.7	100	x	x	x	x
Arrowhead-StoneLake 345	603140,603141,1 Ironriver to Inopump 115 kV	105.6	105.2	104.7	102.9	102.5	100.7	101.2	102.3	103.5	105.9	108.6	111	113.3	115.7	118.1	119.3	120.1	121	121.9	121.8	122.6	122.7	123.6
Arrowhead-StoneLake 345	603142,680386,1 Bayfront to Pilsen 115 kV	100.9	100.6	100.1	x	x	x	x	x	x	101.2	103.9	106.3	108.6	111	113.4	114.6	115.4	116.3	117.2	117.1	117.9	118	118.9
B_XEL_LKMARN-KEK_NSP	603170,616922,1 Willpip to Applevalley 115kv	100.2	100.2	100.2	100.3	100.3	100.3	100.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	100.3
M602F	608624,608625,1 Forbes to Blackberry 230 kV	115.1	117.5	119.8	121	121.1	122.1	123.8	125.5	127.4	129.3	131.1	133.2	135.2	137.5	139.7	142.2	144.5	147	149.2	**VC**			
Mesaba-Blackberry	608624,608625,1 Forbes to Blackberry 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2	100.6
Arrowhead-StoneLake 345	608653,618002,1 Riverton to Hillcity 115kv	100.6	x	x	x	x	x	x	x	x	x	x	x	x	x	101.1	102.8	104.4	106.1	107.9	109.7	111.3	113.2	115
9L	608666,608676,1 Fondulac to Hibbard 115kv	128.7	127.7	131.8	209.5	209.9	224.2	239.2	240.4	241.5	241.8	242.1	242.6	242.9	243.3	243.8	244.8	246.3	247.7	249.2	251.2	252.5	254.2	255.8
9L	608665,608666,1 Fondulac to Thompson 115 kV	x	x	x	100.3	100.4	107.1	113.9	114.4	114.9	115	115.1	115.4	115.5	115.7	115.9	116.3	117	117.6	118.4	119.3	119.8	120.6	121.4
StoneLake-GardnierPark 345	608665,608666,1 Fondulac to Thompson 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.4	100.8	101	101.5	102.1	102.7	103.3	104.4	105	106.1	106.6
Arrowhead-StoneLake 345	608653,618002,1 Riverton to Hillcity 115kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	100.9	100.8	101.5	101.6	102.3
StoneLake-GardnierPark 345	608653,618002,1 Riverton to Hillcity 115kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	102.2
Arrowhead-StoneLake 345	608683,608684,1 Stn WI to Stn MN 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2	101.1	101.7	102.4	103.1	102.9	103.6	103.7	104.3
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.7	103.7	103.7	103.7	103.8	103.8	103.8
42L	608696,608698,1	123	123.1	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.3	123.3	123.3	123.4	123.4	123.5	123.5	123.5	123.5
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.6	104.6	104.6	104.7	104.7	104.7	104.8
42L	608696,608699,1	123.9	124	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.2	124.2	124.2	124.3	124.3	124.4	124.4	124.4	124.4	124.4
42L	608698,608699,1	115.1	115.1	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.5	115.5
42L	608698,608700,1	113.4	113.5	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.7	113.7	113.7	113.8	113.9	113.9	113.9	113.9	113.9
42L	608700,608701,1	102.6	102.6	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
M602F	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	102.4	103	105.4	106.6	107.5	108.5	109.4	110.4	111.3	112.4	113.4	114.7	115.8	117.1	118.3	119.6	120.5	**VC**			
20L	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	102.1	102.3	102.6	102.8	103.1	103.2	103.4	103.6	103.8	104.1	104.4	104.8	105.2	105.6	106.1	106.6	107	107.5
M602F	608739,608781,1 20l Tap to Blackberry 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2	101.4	102.4	**VC**			
Arrowhead-StoneLake 345	608740,618002,1 GrRapids to Hillcity 115kv	103.9	103.3	102.7	102.6	x	x	x	x	x	x	x	100.8	101.9	103.2	104.5	106.1	107.7	109.4	111.2	113	114.7	116.5	118.3
StoneLake-GardnierPark 345	608740,618002,1 GrRapids to Hillcity 115kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	102.2	103.9	105.5
Pre Contingency	**608740,618002,1 GrRapids to Hillcity 115k**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.5**
B_XEL_FIBROMIN-BENSON	620218,652555,1 MoroTap to Morris 115kv	101.7	101.8	101.8	101.9	101.8	101.9	102.1	102.3	102.5	102.7	102.9	103.1	103.2	103.5	103.6	103.8	104	104.2	104.5	104.6	104.8	105	105.2
SINGLE-046	657756,657791,1	124.6	124.7	124.7	124.7	124.8	124.8	124.6	124.3	124.1	123.9	123.7	123.5	123.3	123.1	122.9	122.9	122.8	122.8	122.7	122.7	122.7	122.6	122.6
DSY BK51	667035,669102,52	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	102.2	103.5
DSY BK51	667500,667035,52	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.5	103	104.4
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	103.4	106.8	107.1	106.7	106.3	106	105.7	105.2	104.9	104.4
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	101	104.5	105	104.6	104	103.8	103.3	102.9	102.7	102.3
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	103.2	103.6	103.1	102.8	102.4	101.9	101.4	101.2	100.6
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.1	101.4	101	100.6	100.4	100.1	x	x	x
M602F	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	103.2	105.6	107.8	110.4	112.7	**VC**			
New 500 D-Black	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	104	106.8
New 500 D-Black	M602F	x	x	x	x	x	x	x	x	x	100.6	102.5	104.5	106.4	108.2	110.1	112.3	114.1	116.2	118.5	120.8	123.1	125.7	128.3
M602F	R50M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	102.5	104.1	106.1	108.1	**VC**			
34L		**VC**																						
007		**VC**																						
230		**VC**																						
860		**VC**																						
230_2		**VC**																						
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**																						

Table D10

SI-EXPT-E-1100-PST-60SC-

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
Overload %
🟩 Base case issue
VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
New 500 D-Black	601001,601013,1 M602F	x	x	x	100.9	103	105.3	107.5	109.4	111.7	114	116.4	118.8	121.1	123.4	125.8	128.4	130.7	133.3	136.2	139.1	141.9	145.4	148.4
Blackberry 345/230 BK	601001,601013,1 M602F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.1
Arrowhead-StoneLake 345	601001,601017,1 Forbes to ChisagoN2 500kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	102	103.6	105.3	107
New 500 D-Black	601012,601013,1 M602F SC	x	x	x	x	x	x	x	x	x	x	x	101.4	103.3	105.2	107.2	109.4	111.3	113.6	116	118.4	120.7	123.7	126.2
B3_XEL_CHIS_CO110.0-34.5_9	601016,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.2	102	103.9	105.7
B3_XEL_CHIS_CO110.0-34.5_10	601016,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	101.8	103.8	105.5
Arrowhead-StoneLake 345	601018,601021,1 Chisago to Kolman Lk 345 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3
B3_XEL_CHIS_CO110.0-34.5_9	601018,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	102.7	104.5
B3_XEL_CHIS_CO110.0-34.5_10	601018,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.3	103.2	105
M602F	601035,608625,3 Blackberry 345/230 xfmr	x	x	x	x	x	x	100.1	103.2	106.6	109.8	113.2	117.1	120.4	124.8	129	133.3	137.3	141.6	**VC**				
M602F	601061,601062,1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.5	103.9	**VC**				
M602F	601062,608635,1	x	x	x	x	x	x	x	x	x	x	x	x	x	101.7	103.8	106	108.1	110.6	**VC**				
StoneLake-GardnierPark 345	602017,699450,1 Stone Lake 345/161 Xfmr	108.8	108.9	108.9	109.3	109.1	109.5	110.1	110.7	111.4	112.3	113.3	114.3	115.2	116.2	117.2	117.9	118.5	119.1	120.2	120.8	121.7	122.4	123.3
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	101.4	101.4	101.4	101.3	101.3	101.2	101.2	101.2	101.3	102.1	103	103.8	104.5	105.3	106	106.2	106	105.9	105.9	105.8	105.6	105.5	105.4
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	x	100.8	101.5	102.2	102.8	103.4	103.6	103.5	103.4	103.3	103.2	103.1	103.1	103
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	103.3	103.3	103.3	103.2	103.2	103.2	103.5	103.9	104.4	104.6	104.7	104.9	105.1	105.3	105.5	105.5	105.3	105.2	105.1	105	104.9	104.8	104.6
B_XEL_S_FARIB-S38-LOONLK-EASTW	603001,619605,1 Wfarib to Airtech 115kv	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.6	100.8	101	101.2	101.4	101.6	101.8	101.8	101.7	101.6	101.5	101.4	101.2	101.1	101
180 2	603022,603023,1	104.9	104.7	104.6	104.1	104	104.1	103.8	103.5	103.2	103	102.7	102.5	102.3	102	102	101.8	101.6	101.4	101.1	100.9	100.8	100.6	100.4
Arrowhead-StoneLake 345	603140,603141,1 Ironriver to Inopump 115 kV	105.3	104.9	104.3	102.5	102.1	100.4	101	102	103.3	105.8	108.6	111	113.3	115.8	118.2	119.5	120.4	121.3	121.4	122.3	122.3	123.4	123.4
Arrowhead-StoneLake 345	603142,680386,1 Bayfront to Pilsen 115 kV	100.6	100.2	x	x	x	x	x	x	x	101.1	103.9	106.3	108.6	111.1	113.5	114.8	115.7	116.6	116.7	117.6	117.6	118.7	118.8
B_XEL_LKMARN-KEK_NSP	603170,616922,1 Willpip to Applevalley 115kv	100.3	100.3	100.3	100.3	100.3	100.3	100.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	100.3
Mesaba-Blackberry	608622,608625,2 Mesaba to Blackberry circuit 2 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	100.7
M602F	608624,608625,1 Forbes to Blackberry 230 kV	114.3	116.6	119	120	120.1	121.2	123	124.9	126.9	128.9	130.7	132.9	135	137.4	139.8	142.4	144.9	147.6	**VC**				
Arrowhead-StoneLake 345	608632,608684,1 Dahlbrg to Stinson 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.3	101.9	102.6	102.7	103.4	103.4	104.2	104.2
Arrowhead-StoneLake 345	608653,618002,1 Riverton to Hillcity 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	102.6	104.4	106.1	108.2	110	111.8	113.9	115.8
StoneLake-GardnierPark 345	608653,618002,1 Riverton to Hillcity 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	102.9
9L	608665,608666,1 Fondulac to Thompson 115 kV	x	x	x	x	x	106.6	113.3	113.9	114.4	114.7	114.8	115.1	115.2	115.5	115.7	116.2	116.8	117.6	118.5	119.3	120	120.7	121.6
9L	608666,608676,1 Fondulac to Hibbard 115 kV	127.3	126	130.1	208.3	208.7	223.2	237.9	239.1	240.5	241	241.4	241.9	242.3	242.9	243.4	244.5	246	247.6	249.6	251.3	253	254.6	256.4
StoneLake-GardnierPark 345	608666,608676,1 Fondulac to Hibbard 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	100.7	101.2	101.9	102.5	103.8	104.4	105.4	106.1	107.3
Arrowhead-StoneLake 345	608683,608684,1 Stn WI to Stn MN 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	100.5	101.3	101.3	102.2	102.2
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.7	103.7	103.7	103.7	103.8	103.8	103.8
42L	608696,608698,1	123	123.1	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.3	123.3	123.3	123.4	123.4	123.5	123.5	123.5	123.5
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.6	104.6	104.6	104.7	104.7	104.7	104.8
42L	608696,608699,1	123.9	124	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.2	124.2	124.2	124.3	124.3	124.4	124.4	124.4	124.4	124.4
42L	608698,608699,1	115.1	115.1	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.5	115.5
42L	608698,608700,1	113.4	113.5	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.7	113.7	113.7	113.8	113.9	113.9	113.9	113.9	113.9
42L	608700,608701,1	102.6	102.6	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
39L	608702,608704,1	102	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
M602F	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	101.9	102.5	104.9	106.1	107	108.1	109.1	110.2	111.1	112.3	113.3	114.6	115.8	117.2	118.5	119.8	**VC**				
20L	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	102	102.2	102.4	102.7	103	103.1	103.3	103.5	103.8	104	104.4	104.8	105.2	105.7	106.2	106.7	107.1	107.6
M602F	608739,608781,1 20l Tap to Blackberry 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	101.6	**VC**				
Arrowhead-StoneLake 345	608740,618002,1 GrRapids to Hillcity 115kv	102.5	101.9	101.3	101.2	x	x	x	x	x	x	x	100.1	101.4	102.8	104.2	105.9	107.7	109.5	111.5	113.3	115.1	117.2	119.1
StoneLake-GardnierPark 345	608740,618002,1 GrRapids to Hillcity 115kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101	102.7	104.5	106.3
Pre Contingency	**608740,618002,1 GrRapids to Hillcity 115kv**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**101.1**
B_XEL_FIBROMIN-BENSON	620218,652555,1 MoroTap to Morris 115kv	102	102.1	102.1	102.2	102.1	102.1	102.3	102.5	102.7	102.9	103.1	103.2	103.4	103.5	103.7	103.9	104	104.2	104.4	104.6	104.8	105	105.2
SINGLE-046	657756,657791,1	126.7	126.7	126.8	126.7	126.8	126.6	126.2	125.7	125.3	125	124.7	124.3	124	123.6	123.3	123.1	122.8	122.6	122.4	122.1	121.9	121.7	121.5
DSY BK51	667500,667035,52	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.9	103.5	105
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	103.3	106.8	107.1	106.7	106.3	106.1	105.7	105.2	104.8	104.4
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	101	104.4	105	104.5	104	103.8	103.3	102.9	102.8	102.4
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	103.2	103.6	103.1	102.8	102.5	101.9	101.6	101.1	100.7
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101	101.4	101	100.5	100.4	100.2	x	x	x
M602F	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	103.4	106.2	108.7	111.6	**VC**				
New 500 D-Black	L20D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	103.1	106.6	109.5
New 500 D-Black	M602F	x	x	x	x	x	x	x	x	x	x	101.9	104	106.1	108	110.1	112.3	114.3	116.5	119.1	121.5	123.9	127	129.6
M602F	R50M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	102.7	104.5	106.5	**VC**				
34L		**VC**																						
007		**VC**																						
230		**VC**																						
860		**VC**																						
230_2		**VC**																						
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**																						

Table D11

Overload %

🟪 Existing D.C. reduction

🟧 Proposed D.C. reduction

🟩 Base case issue

VC Voltage collapse

SI-IMPT-E-1100-NOPST-60SC-

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 kV	101.9	103.4	103.9	104.2	104.4	104.5	104.6	104.7	104.9	107.2	109.7	112.1	114.5	116.9	119.4	121.7	124	126.3	127.5	128.5	129.5	130.4	130.8
M602F	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	103.4	106.2	109	111.7
220	602006,652435,1	102.9	102.7	102.7	102.8	102.9	103	103.1	103.2	103	102.9	102.7	102.5	102.4	102.2	102.1	102	101.8	101.7	101.8	101.9	102.2	102.3	102.4
220_2	602006,652435,1	102.9	102.7	102.7	102.8	102.9	103	103.1	103.2	103	102.9	102.7	102.5	102.4	102.2	102.1	102	101.8	101.7	101.8	101.9	102.2	102.3	102.4
Pre Contingency	**603022,603023,1 Souir to Mallard 115 kV**	**105.6**	**105.7**	**105.8**	**106**	**106.1**	**106.6**	**106.9**	**107.2**	**107.2**	**107.7**	**107.9**	**108.2**	**108.3**	**108.6**	**108.9**	**109.2**	**109.5**	**109.8**	**110.1**	**110.4**	**110.8**	**111.1**	**111.4**
180 2	603022,605634,1 Souris to Velva Tap 115 kV	111.8	112.2	112.6	113.1	113.6	114.5	115.1	115.8	116.1	117	117.7	118.5	119.2	119.8	120.6	121.4	122.3	123.3	124.2	125.1	126.1	127.1	128
B_XEL_LKMARN-KEK_NSP	603170,616922,1 WillP to ApplV 115 kV	109.5	109.4	109.6	109.8	110	110.2	110.4	110.6	110.6	110.5	110.3	110.1	110	109.8	109.6	109.5	109.3	109.2	107.8	106.9	106.2	106.1	108.1
500	603177,616004,1	106.5	106.5	106.7	106.9	107.1	107.3	107.5	107.7	107.7	107.7	107.7	107.7	107.7	107.8	107.8	107.8	107.8	107.9	108	108.1	108.3	108.5	108.7
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.4	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	124	124	124	124	124	124	124	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1
42L	608698,608699,1	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2
42L	608698,608700,1	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.6	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
39L	608702,608704,1	105.5	105.6	105.7	105.7	105.8	105.9	106	106.1	106.6	106.7	106.7	106.8	106.9	106.9	107	107.1	107.2	107.2	107.3	107.4	107.5	107.5	107.6
180 1	615347,615349,1 McHenry Transformer	125.5	125.9	126.3	126.8	127.3	128.1	128.5	129.1	129.4	129.8	130	130.4	130.7	130.9	131.2	131.6	131.9	132.2	132.5	132.9	133.4	133.8	134.3
180 2	615347,615349,1 McHenry Transformer	194.9	195.5	196.3	197.1	198	199.1	200	200.9	201.5	202.6	203.6	204.6	205.6	206.6	207.7	208.9	210.2	211.7	213	214.4	215.9	217.3	218.7
180 1	615348,615347,1 McHenry Transformer	114	114.4	114.8	115.2	115.6	116.3	116.8	117.3	117.6	117.9	118.1	118.5	118.7	119	119.2	119.6	119.9	120.1	120.4	120.8	121.3	121.6	122
180 2	615348,615347,1 McHenry Transformer	177.1	177.6	178.4	179.1	179.9	180.9	181.8	182.6	183.2	184.2	185	186	186.9	187.8	188.8	189.9	191	192.4	193.6	194.8	196.2	197.6	198.8
B2_XEL_WILLPIP-S35-JOHNCAK115.	615440,616929,1 LKMARN to KENRICK 115 kV	105.8	105.7	105.9	106.2	106.5	106.7	106.9	107.1	107.2	107	106.9	106.8	106.7	106.6	106.5	106.4	106.2	106.2	105.2	104.6	104.1	103.8	104.2
B2_XEL_WILLPIP-S35-JOHNCAK115.	616925,616929,1	101	100.9	101.1	101.4	101.7	101.9	102.1	102.3	102.3	102.2	102.1	102	101.8	101.7	101.6	101.5	101.4	101.4	100.4	x	x	x	x
552	620222,658050,1 AlexSS to Alexander 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	100.6	101
Pre Contingency	**620379,920081,1 Rugby to G904Tap (G82R)**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.1**	**101.2**	**102.3**	**103.3**
180 2	652452,659264,1 Rugby to Rugbcpc 115 kV	x	x	x	x	x	x	x	x	x	x	x	100.8	101.6	102.4	103.3	104.1	105	106.1	107	107.9	109	110	110.9
180 2	657756,657791,1	114.8	114.8	115.1	115.3	115.6	115.9	116.2	116.4	116.5	116.7	116.8	117	117.2	117.3	117.5	117.7	117.8	118	118.2	118.5	118.8	119	119.3
SINGLE-046	657756,657791,1	150.5	150.4	150.5	150.7	150.9	151.1	151.3	151.4	151.4	151.4	151.4	151.4	151.4	151.4	151.4	151.5	151.5	151.5	151.6	151.8	152	152.1	152.2
Pre Contingency	**667052,920081,1 G82R**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.5**	**101.6**	**102.6**	**103.7**	**104.8**	**105.8**	**106.9**	**108.1**	**109.1**	**110.2**	**111.4**	**112.5**	**113.5**
M602F	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	101.1	102.2	103.3	104.3	105.3
New 500 D-Black	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	101.7	102.6	103.6	104.6	105.5
250	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	100.8	101.5	102.3	103	103.7
220	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	100.9	101.6	102.3
220_2	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	100.9	101.6	102.2
Blackberry 345/230 BK	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	101.2	102
STVITAL-LETELIER	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	100.8
STVITAL-LAV	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	100.8
100	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7
100_2	G37C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7
34L		**VC**																						
007		**VC**																						
230		**VC**																						
860		**VC**																						
230_2		**VC**																						
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**																						

Table D12

SI-IMPT-E-1100-PST-60SC-

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
Overload %
🟩 Base case issue
VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 k	102.6	104.2	104.7	105	105.2	105.4	105.5	105.5	105.9	108.2	110.7	113.2	115.6	118.1	120.6	123	125.3	127.6	128.8	129.9	130.9	131.8	132.3
M602F	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.4	104.1	107	109.5	112.2	115.4
220	602006,652435,1	104.5	104.2	104.3	104.4	104.5	104.7	104.9	105	105	104.9	104.8	104.7	104.6	104.6	104.6	104.5	104.5	104.4	104.6	104.8	105.1	105.3	105.5
220_2	602006,652435,1	104.5	104.2	104.3	104.4	104.5	104.8	104.9	105	104.9	104.9	104.8	104.7	104.6	104.6	104.6	104.5	104.5	104.4	104.6	104.8	105	105.3	105.5
Pre Contingency	**603022,603023,1 Souir to Mallard 115 kV**	**103.3**	**103.4**	**103.5**	**103.6**	**103.7**	**104**	**104.1**	**104.4**	**104.4**	**104.4**	**104.6**	**104.7**	**104.9**	**105**	**105.2**	**105.3**	**105.4**	**105.6**	**105.8**	**105.9**	**106.1**	**106.3**	**106.5**
180 2	603022,605634,1 Souris to Velva Tap 115 kV	108.8	109.1	109.5	110	110.4	110.9	111.3	111.9	111.9	112.2	112.6	112.9	113.3	113.5	113.9	114.2	114.5	114.9	115.2	115.6	116	116.4	116.8
B_XEL_LKMARN-KEK_NSP	603170,616922,1 WillP to ApplV 115 kV	109.5	109.5	109.6	109.8	110.1	110.3	110.5	110.6	110.7	110.5	110.4	110.2	110	109.9	109.7	109.6	109.4	109.3	107.9	107	106.3	106.2	108.3
500	603177,616004,1	106.6	106.6	106.8	107	107.2	107.4	107.6	107.7	107.7	107.7	107.8	107.8	107.8	107.8	107.9	107.9	107.9	107.9	108	108.2	108.4	108.5	108.7
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.1	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	124	124	124	124	124	124	124	124	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1
42L	608698,608699,1	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2
42L	608698,608700,1	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.5	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6
42L	608700,608701,1	102.6	102.5	102.6	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
39L	608702,608704,1	105.5	105.6	105.7	105.8	105.9	106	106.1	106.2	106.6	106.7	106.8	106.8	106.9	107	107.1	107.2	107.2	107.3	107.4	107.5	107.4	107.5	107.6
180 1	615347,615349,1 McHenry Transformer	122.4	122.6	122.8	123	123.2	123.5	123.6	123.9	123.9	124.1	124.1	124.1	124.3	124.4	124.4	124.5	124.5	124.8	125	125.2	125.5	125.6	125.9
180 2	615347,615349,1 McHenry Transformer	190.2	190.8	191.6	192.4	193.2	193.7	194.2	195.2	195.1	195.6	196	196.4	196.9	197.2	197.7	198.2	198.5	199.1	199.4	199.9	200.4	200.9	201.3
180 1	615348,615347,1 McHenry Transformer	111.2	111.4	111.6	111.8	111.9	112.2	112.3	112.6	112.5	112.7	112.8	112.8	112.9	113	113	113.1	113.1	113.3	113.6	113.8	114	114.1	114.4
180 2	615348,615347,1 McHenry Transformer	172.9	173.4	174.1	174.8	175.5	176.1	176.5	177.4	177.3	177.7	178.2	178.5	178.9	179.2	179.7	180.1	180.4	180.9	181.2	181.7	182.2	182.5	183
B2_XEL_WILLPIP-S35-JOHNCAK115.0	615440,616929,1	105.9	105.8	106.1	106.4	106.6	106.9	107.1	107.3	107.4	107.2	107.1	107	106.9	106.8	106.7	106.6	106.5	106.4	105.4	104.9	104.4	104.1	104.5
B2_XEL_WILLPIP-S35-JOHNCAK115.0	616925,616929,1	101.1	101	101.2	101.5	101.8	102.1	102.3	102.5	102.5	102.4	102.3	102.2	102.1	102	101.9	101.8	101.7	101.6	100.6	100.1	x	x	x
552	620222,658050,1 AlexSS to Alexander 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4	100.8	101.2	101.7
180 2	657756,657791,1	114.9	115	115.2	115.5	115.8	116.2	116.4	116.7	116.8	117	117.2	117.3	117.5	117.7	117.9	118.1	118.2	118.4	118.6	118.8	119.1	119.3	119.6
SINGLE-046	657756,657791,1	152.4	152.4	152.5	152.7	152.9	153.3	153.6	153.8	154	154.1	154.3	154.4	154.6	154.8	155	155.1	155.3	155.4	155.7	156	156.3	156.6	156.9
34L		**VC**																						
007		**VC**																						
230		**VC**																						
860		**VC**																						
230_2		**VC**																						
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**																						

SI-EXPT-E-750-NOPST-60SC-

Overload %

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
New 500 D-Black	601001,601013,1 M602F	x	x	101.2	103.3	105.5	107.6	109.6	111.7	113.7	116	118.1	120.3	122.6	125	127.3	129.7
Blackberry 500-345BK	601001,601013,1 M602F	x	x	101.3	103.3	105.3	107.4	109.6	111.6	113.7	115.8	118.2	120.4	122.6	124.9	127.4	129.6
Blackberry 345/230 BK	601001,601013,1 M602F	x	x	101.2	103.3	105.3	107.4	109.6	111.6	113.7	115.8	118.2	120.4	122.6	124.9	127.4	129.6
New 500 D-Black	601012,601013,1 M602F Series Comp	x	x	x	x	x	x	x	x	x	x	100.8	102.6	104.6	106.5	108.4	110.5
Blackberry 500-345BK	601012,601013,1 M602F Series Comp	x	x	x	x	x	x	x	x	x	x	100.8	102.7	104.5	106.4	108.6	110.3
Blackberry 345/230 BK	601012,601013,1 M602F Series Comp	x	x	x	x	x	x	x	x	x	x	100.8	102.7	104.5	106.4	108.6	110.4
B3_XEL_CHIS_CO110.0-34.5_9	601016,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	100.5	102	103.8	105.5
B3_XEL_CHIS_CO110.0-34.5_10	601016,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.9	103.6	105.4
B3_XEL_CHIS_CO110.0-34.5_9	601018,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	x	100.8	102.6	104.3
B3_XEL_CHIS_CO110.0-34.5_10	601018,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	x	101.3	103.1	104.8
M602F	601035,608625,3 Blackberry 345/230 kV BK	165.6	169.6	174	178.2	182.9	187.4	VC									
D-RIEL	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	100.6	102.7	104.6	106.4	108.3
SINGLE-042	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	101.3	103	105.2	107.2
001	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	102.7	104.7
003	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	102.5	104.5
B2_XEL_ROSEAUMP-MORNVLL-RICH22	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	102.7	104.7
726L	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	101.6
SINGLE-040	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	103.1
SINGLE-031	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	102	104
220	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.9	103.8
220_2	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.9	103.8
STVITAL-LETELIER	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4
STVITAL-LAV	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4
Bison-AlexSS 345	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6
540	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
G82R	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
NSP - 4	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
100	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
250	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
570 1	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.1
575	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
865	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
866	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
99	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.4
100_2	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
B3_XEL_CHIS_CO110.0-34.5_9	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
B3_XEL_CHIS_CO110.0-34.5_10	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100
B_XEL_CHIS_CO-KOLMNLK	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.5
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	102.2	102.2	102.2	102.1	102.1	102	102	102	102	102.8	103.7	104.4	105.2	106	106.7	106.9
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	100.2	101	101.6	102.3	103	103.7	103.7
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	104.3	104.3	104.3	104.3	104.2	104.2	104.5	104.9	105.4	105.6	105.7	105.9	106.1	106.3	106.5	106.5
B_XEL_S_FARIB-S38-LOONLK-EASTWD	603001,619605,1 Wfarib to Airtech 115kv	101.4	101.4	101.4	101.4	101.4	101.3	101.4	101.3	101.9	102.1	102.3	102.5	102.8	103	103.5	103.5
180 2	603022,603023,1	105.3	105.2	104.9	104.7	104.2	104	103	102.5	101.7	101.1	100.5	x	x	x	x	x
Arrowhead-StoneLake 345	603140,603141,1 Ironriver to Inopump 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	102.4	103.4
Mesaba-Blackberry	608622,608625,2 Mesab to Blackberry cct2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	100.4
M602F	608624,608625,1 Forbes to blackberry 230 kV	164.6	167.6	170.9	172.9	173.1	175	VC									
98L	608624,608625,1 Forbes to blackberry 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.4
620	608624,608625,1 Forbes to blackberry 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.4
M602F	608635,601035,1	110.4	113	116	118.8	121.9	124.9	VC									
Pre Contingency	**608653,618002,1 Riverton to Hillcity 118kv**	**105.5**	**104.9**	**104.3**	**104.3**	**x**	**x**	**x**	**x**	**x**	**x**	**100.8**	**102.1**	**103.4**	**104.7**	**106.1**	**107.8**
98L	608663,608739,1 Blackberry to Fldwood 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.2	101.5	102.7	103.7
620	608663,608739,1 Blackberry to Fldwood 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.2	101.5	102.8	103.7
9L	608666,608676,1	107.6	106	109.7	176.8	177.3	192.2	206	206.8	207.4	207.4	206.8	206.5	206.2	205.9	206.4	207.4
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.7	103.7	103.7	103.7	103.8	103.8	103.8	103.9	103.9	103.9	103.9
42L	608696,608698,1	123.1	123.2	123.3	123.3	123.3	123.4	123.4	123.5	123.5	123.5	123.5	123.5	123.5	123.6	123.6	123.7
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.6	104.6	104.6	104.7	104.7	104.7	104.8	104.8	104.8	104.8	104.8
42L	608696,608699,1	124	124.1	124.2	124.2	124.2	124.3	124.3	124.4	124.4	124.4	124.4	124.4	124.5	124.5	124.6	124.6
42L	608698,608699,1	115.1	115.2	115.3	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.5	115.5	115.5	115.5	115.6	115.6
42L	608698,608700,1	113.5	113.6	113.7	113.7	113.7	113.8	113.8	113.9	113.9	113.9	113.9	113.9	114	114	114.1	114.1
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.6	102.5	102.6	102.6	102.6	102.6
M602F	608737,608739,1 Blackberry to Nashwak 115 kV	123.7	127.4	131	132.2	134.7	136.4	VC									
20L	608737,608739,1 Blackberry to Nashwak 115 kV	105.9	108.6	111.3	112	120.8	123.4	123.9	124.4	125.1	125.5	126.2	126.8	127.5	128.2	128.9	129.4
98L	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	x	x	x	x	x	100.5	101.1	101.8	102.3	102.9	103.4
620	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	x	x	x	x	x	100.5	101.1	101.8	102.3	102.9	103.4
MNsteel-Blackberry	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.4	100.8	101.2	101.5
M602F	608739,608781,1 20L Tap to blackberry 115 kV	x	x	x	x	101	106.5	VC									
Pre Contingency	**608739,608781,1 20L Tap to blackberry 115 kV**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.4**
M602F	608740,608781,1 Hill City to 20L Tap 115 kV	x	x	x	x	x	102.2	VC									
Pre Contingency	**608740,618002,1 GrRapids to Hillcity 115kv**	**109.3**	**108.7**	**108.1**	**108.1**	**x**	**x**	**x**	**100.7**	**102.2**	**103.3**	**104.6**	**105.9**	**107.2**	**108.4**	**109.9**	**111.5**
B_XEL_FIBROMIN-BENSON	620218,652555,1	103.5	103.6	103.6	103.7	103.7	103.7	104	104.2	104.5	104.7	104.9	105.1	105.4	105.6	105.9	106.1
565	620247,657710,1 Nary to CassLk 115kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.5	101.2
SINGLE-046	657756,657791,1	123	123.1	123.1	123.1	123.1	123.2	122.8	122.6	122.3	122.1	121.9	121.6	121.4	121.2	120.9	120.8
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	104.6	104.6	104.7	105	105	105.3	105.1	104.8	104.3	107.6	111.8	115	118.4	121.8	125.2	125.5
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	101.4	101.4	101.5	101.8	101.8	102	101.9	101.6	101.1	104.4	108.6	111.8	115.2	118.6	122.1	122.4
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	102.6	107.4	111	114.8	118.7	122.5	123
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	101.3	105.3	108.6	111.9	115.2	118.7	119.1
WPS-ARP1E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	101	104.5	108.3	112.1	116	116.3
B_XEL_KING-EAU_CLA	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
M602F	L20D	x	x	x	x	x	100.8	VC									
New 500 D-Black	M602F	x	x	x	x	x	x	x	x	x	101.6	103.4	105.3	107.3	109.3	111.3	113.4
Blackberry 500-345BK	M602F	x	x	x	x	x	x	x	x	x	101.4	103.5	105.4	107.2	109.2	111.4	113.3
Blackberry 345/230 BK	M602F	x	x	x	x	x	x	x	x	x	101.4	103.4	105.4	107.2	109.2	111.4	113.3

Table D14

Overload %

SI-EXPT-E-750-PST-60SC-

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
New 500 D-Black	601001,601013,1 M602F	x	x	100.3	102.5	104.7	107	109	111.4	113.6	116	118.3	120.6	123.2	125.7	128.2	130.9
Blackberry 500-230BK	601001,601013,1 M602F	x	x	100.3	102.5	104.8	106.8	109	111.3	113.7	115.8	118.3	120.7	123.1	125.6	128.1	130.8
New 500 D-Black	601012,601013,1 M602F Series Comp	x	x	x	x	x	x	x	x	x	x	100.9	102.8	105	107.1	109.2	111.5
Blackberry 500-230BK	601012,601013,1 M602F Series Comp	x	x	x	x	x	x	x	x	x	x	100.9	102.9	104.9	107.1	109.1	111.4
B3_XEL_CHIS_CO110.0-34.5_9	601016,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	100.9	102.6	104.5	106.4
B3_XEL_CHIS_CO110.0-34.5_10	601016,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	100.8	102.4	104.3	106.2
B3_XEL_CHIS_CO110.0-34.5_9	601018,605586,10	x	x	x	x	x	x	x	x	x	x	x	x	x	101.4	103.3	105.1
B3_XEL_CHIS_CO110.0-34.5_10	601018,605587,9	x	x	x	x	x	x	x	x	x	x	x	x	100.3	101.9	103.8	105.7
001	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	101	103.3	105.5
003	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	100.7	103.1	105.3
220	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	102.3	104.4
220_2	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	100	102.3	104.4
726L	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.5	102.4
Pre Contingency	**601035,608625,3 Blackberry 345/230 kV BK**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.1**
M602F	601035,608625,3 Blackberry 345/230 kV BK	164.5	168.5	172.7	177.2	182.2	186.9	**VC**									
D-RIEL	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	100.6	102.9	105.1	106.9	109.1
SINGLE-042	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	101.2	103.4	105.7	108
SINGLE-031	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	100.3	102.7	105
B2_XEL_ROSEAUMP-MORNVLL-RIC	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	101	103.3	105.5
SINGLE-040	601035,608625,3 Blackberry 345/230 kV BK	x	x	x	x	x	x	x	x	x	x	x	x	x	x	101.7	103.9
King-EuClaire 345	602021,602030,1 EuClaire to Wht 165kv	101	101	100.9	100.8	100.8	100.7	100.8	100.8	100.8	101.6	102.6	103.2	104.1	104.9	105.7	105.8
B_XEL_KING-EAU_CLA	602021,602030,1 EuClaire to Wht 165kv	x	x	x	x	x	x	x	x	x	x	x	100.5	101.3	102	102.6	102.7
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	104.3	104.3	104.2	104.2	104.2	104.2	104.5	104.9	105.4	105.6	105.7	105.9	106.2	106.3	106.6	106.5
B_XEL_S_FARIB-S38-LOONLK-EAST	603001,619605,1 Wfarib to Airtech 115kv	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.9	102.1	102.3	102.6	102.8	103	103.5	103.5
180 2	603022,603023,1	103.2	103	102.8	102.4	102.3	102.3	102.2	101.8	101.5	101.3	101	100.7	100.5	100	x	x
Mesaba-Blackberry	608622,608625,2 Mesab to Blackberry cct2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1	100.5
M602F	608624,608625,1 Forbes to blackberry 230 kV	164.2	167.2	170.3	172.5	172.9	174.9	**VC**									
98L	608624,608625,1 Forbes to blackberry 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.5
620	608624,608625,1 Forbes to blackberry 230 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.5
M602F	608635,601035,1	109.7	112.3	115.1	118.2	121.5	124.6	**VC**									
Pre Contingency	**608653,618002,1 Riverton to Hillcity 118kv**	**104.7**	**104.1**	**103.5**	**103.6**	**x**	**x**	**x**	**x**	**x**	**x**	**101**	**102.4**	**103.8**	**105.3**	**106.9**	**108.8**
98L	608663,608739,1 Blackberry to Fldwood 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	102.5	103.6
620	608663,608739,1 Blackberry to Fldwood 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	101.2	102.5	103.6
9L	608665,608666,1 Fondulac to Thompson 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.1
9L	608666,608676,1	107.3	105.9	109.1	177	177.4	192.4	206.4	207.2	207.8	208	207.6	207.3	207.1	206.9	207.5	208.7
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.7	103.7	103.7	103.8	103.8	103.9	103.9	103.9	103.9	103.9
42L	608696,608698,1	123.1	123.2	123.3	123.3	123.3	123.3	123.4	123.4	123.5	123.5	123.5	123.5	123.5	123.6	123.6	123.7
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.6	104.6	104.6	104.7	104.7	104.7	104.8	104.8	104.8	104.8	104.8
42L	608696,608699,1	124	124.1	124.2	124.2	124.2	124.3	124.3	124.4	124.4	124.4	124.4	124.4	124.5	124.5	124.6	124.7
42L	608698,608699,1	115.1	115.2	115.3	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.5	115.5	115.5	115.5	115.6	115.6
42L	608698,608700,1	113.5	113.6	113.7	113.7	113.7	113.7	113.8	113.9	113.9	113.9	113.9	113.9	114	114	114	114.1
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.6	102.6	102.6
M602F	608737,608739,1 Blackberry to Nashwak 115 kV	123.5	127.1	130.7	132	134.6	136.3	**VC**									
20L	608737,608739,1 Blackberry to Nashwak 115 kV	105.8	108.5	111.2	112	120.7	123.4	123.8	124.4	125.1	125.6	126.3	126.9	127.7	128.3	129	129.6
98L	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	x	x	x	x	x	100.5	101.1	101.8	102.3	102.9	103.5
620	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	x	x	x	x	x	100.5	101.1	101.8	102.3	102.9	103.5
MNsteel-Blackberry	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	100.5	100.9	101.2	101.6
M602F	608739,608781,1 20L Tap to blackberry 115 kV	x	x	x	x	100.9	106.4	**VC**									
M602F	608739,608781,1 20L Tap to blackberry 115 kV	x	x	x	x	x	102.2	**VC**									
Pre Contingency	**608739,608781,1 20L Tap to blackberry 115 kV**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.1**	**100.7**
D-Riel2	608739,608781,1 20L Tap to blackberry 115 kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	102.3
Pre Contingency	**608740,618002,1 GrRapids to Hillcity 115kv**	**108.5**	**107.9**	**107.3**	**107.4**	**x**	**x**	**x**	**100.4**	**102**	**103.4**	**104.8**	**106.2**	**107.6**	**109.1**	**110.7**	**112.5**
B_XEL_FIBROMIN-BENSON	620218,652555,1	103.7	103.8	103.8	103.9	103.8	103.9	104.1	104.3	104.6	104.7	105	105.2	105.4	105.6	105.8	106
565	620247,657710,1 Nary to CassLk 115kV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100.6	101.4
SINGLE-046	657756,657791,1	124.2	124.2	124.2	124.2	124.1	124	123.6	123	122.6	122.2	121.8	121.3	120.9	120.4	120	119.6
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	104	104.1	104.1	104.5	104.5	104.8	104.6	104.3	103.8	107.1	111.1	114.5	117.9	121.4	124.9	125.3
ATC-ARPG3	699240,699808,1 Petenwel to Sar 138kv	100.9	100.9	101	101.2	101.3	101.5	101.4	101.1	100.7	103.9	107.9	111.3	114.8	118.2	121.7	122.1
WPS-ARP2E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	102	106.7	110.5	114.4	118.3	122.2	122.5
ATC-ARPG2	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	100.6	104.5	107.9	111.3	114.8	118.3	118.7
WPS-ARP1E	699240,699808,1 Petenwel to Sar 138kv	x	x	x	x	x	x	x	x	x	x	x	103.6	107.5	111.4	115.3	115.7
New 500 D-Black	M602F	x	x	x	x	x	x	x	x	x	101.6	103.5	105.5	107.8	110	112.1	114.4
Blackberry 500-345BK	M602F	x	x	x	x	x	x	x	x	x	101.4	103.6	105.6	107.7	109.9	112	114.3
Blackberry 345/230 BK	M602F	x	x	x	x	x	x	x	x	x	101.4	103.6	105.7	107.7	109.9	112	114.3
34L		**VC**															
007		**VC**															
230		**VC**															
860		**VC**															
230_2		**VC**															
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**															

Table D15

Overload %

SI-IMPT-E-750-NOPST-60SC-

🟪 Existing D.C. reduction 🟧 Proposed D.C. reduction 🟩 Base case issue VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 kV	102.2	103.7	104.2	104.5	104.7	104.8	104.9	104.9	105.1	107.5	109.9	112.4	114.8	117.3	119.7	122
220	602006,652435,1	102	101.8	101.8	102	102.1	102.3	102.4	102.5	102.4	102.2	102.1	101.9	101.8	101.7	101.6	101.4
220_2	602006,652435,1	102	101.8	101.8	102	102.1	102.3	102.4	102.5	102.4	102.2	102.1	101.9	101.8	101.7	101.5	101.4
Pre Contingency	**603022,603023,1 Souir to Mallard 115 kV**	**104.7**	**104.8**	**105**	**105.3**	**105.7**	**106.1**	**106.5**	**106.8**	**107.1**	**107.4**	**107.7**	**108**	**108.2**	**108.5**	**108.8**	**109.1**
180 2	603022,605634,1 Souris to Velva tap 115 kV	110.2	110.6	111.1	111.9	112.8	113.5	114.4	115.2	115.8	116.5	117.3	118.1	118.9	119.7	120.5	121.3
B_XEL_LKMARN-KEK_NSP	603170,616922,1	109	108.9	109.1	109.3	109.6	109.8	110	110.3	110.4	110.2	110	109.9	109.7	109.6	109.4	109.3
500	603177,616004,1	106	106	106.2	106.4	106.7	106.9	107.1	107.3	107.4	107.4	107.4	107.5	107.5	107.5	107.6	107.6
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1
42L	608698,608699,1	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2
42L	608698,608700,1	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
39L	608702,608704,1	103.3	103.5	103.7	103.9	104.1	104.3	104.4	104.6	105.1	105.3	105.5	105.6	105.8	105.9	106.1	106.2
180 1	615347,615349,1 Mchenry transformer	124.3	124.5	125	125.8	126.5	127.2	128	128.5	129.1	129.4	129.8	130.1	130.4	130.7	131.2	131.5
180 2	615347,615349,1 Mchenry transformer	192.8	193.6	194.5	195.6	196.8	197.8	199	200.2	201	202	203	204.3	205.3	206.4	207.5	208.8
180 1	615348,615347,1 Mchenry transformer	112.9	113.1	113.6	114.3	114.9	115.5	116.2	116.8	117.3	117.6	118	118.2	118.5	118.8	119.2	119.5
180 2	615348,615347,1 Mchenry transformer	175.2	175.9	176.7	177.7	178.9	179.8	180.8	181.9	182.7	183.6	184.5	185.7	186.6	187.6	188.6	189.7
B2_XEL_WILLPIP-S35-JOHNCAK	615440,616929,1	105.4	105.3	105.5	105.8	106.1	106.4	106.6	106.8	106.9	106.8	106.7	106.6	106.5	106.4	106.3	106.2
B2_XEL_WILLPIP-S35-JOHNCAK	616925,616929,1	100.5	100.5	100.7	101	101.3	101.5	101.8	102	102.1	102	101.9	101.8	101.7	101.6	101.5	101.4
180 2	652452,659264,1 Rugbcpc to Rugby 115 kV	x	x	x	x	x	x	x	x	x	x	x	100.6	101.5	102.4	103.2	104.1
180 2	657756,657791,1	113.9	114	114.2	114.6	115	115.3	115.6	116	116.1	116.3	116.4	116.7	116.8	117.1	117.2	117.4
SINGLE-046	657756,657791,1	149.7	149.7	149.8	150.1	150.3	150.6	150.8	151	151	151	151	151.1	151.1	151.1	151.1	151.2
Pre Contingency	**667052,920081,1 G82R**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.1**	**101.4**	**102.4**	**103.6**	**104.8**	**105.8**
34L		**VC**															
007		**VC**															
230		**VC**															
860		**VC**															
230_2		**VC**															
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**															

Table D16

Overload %

SI-IMPT-E-750-PST-60SC-

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

Congtingecy	Facility	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
B_XEL_COON_CK-TERMINL	601019,601021,1 Coon Ck to Kolmin Lake 345 kV	102.8	104.3	104.8	105.1	105.4	105.6	105.8	105.8	106.1	108.5	111	113.4	115.9	118.4	120.9	123.3
220	602006,652435,1	103.3	103.1	103.1	103.4	103.7	103.9	104.1	104.3	104.3	104.2	104.2	104.1	104.1	104	104	104
220_2	602006,652435,1	103.4	103.1	103.1	103.4	103.7	103.9	104.1	104.3	104.3	104.2	104.2	104.1	104.1	104	104	104
Pre Contingency	**603022,603023,1 Souir to Mallard 115 kV**	**102.8**	**102.9**	**103**	**103.3**	**103.5**	**103.6**	**103.8**	**104**	**104.1**	**104.3**	**104.5**	**104.6**	**104.8**	**104.9**	**105.1**	**105.2**
180 2	603022,605634,1 Souris to Velva tap 115 kV	107.9	108.3	108.7	109.5	109.9	110.3	110.8	111.2	111.5	111.9	112.3	112.7	113	113.4	113.7	114.1
B_XEL_LKMARN-KEK_NSP	603170,616922,1	109.1	109	109.1	109.4	109.7	109.9	110.1	110.3	110.4	110.3	110.1	110	109.8	109.7	109.5	109.4
500	603177,616004,1 Kerhot to Maynard 115 kV	106.1	106.1	106.3	106.5	106.7	106.9	107.2	107.4	107.4	107.4	107.5	107.5	107.6	107.6	107.6	107.7
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1
42L	608698,608699,1	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2	115.2
42L	608698,608700,1	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6	113.6
42L	608700,608701,1	102.6	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5	102.5
39L	608702,608704,1	103.4	103.6	103.8	103.9	104.1	104.4	104.5	104.6	105.2	105.4	105.6	105.7	105.9	106	106.2	106.3
180 1	615347,615349,1 Mchenry transformer	122	122.2	122.4	122.8	122.9	123.1	123.3	123.6	123.6	123.8	124	124.1	124.1	124.2	124.2	124.4
180 2	615347,615349,1 Mchenry transformer	189.4	190	190.9	192	192.4	192.9	193.6	194.2	194.6	195.1	195.7	196.3	196.7	197.1	197.5	198.1
180 1	615348,615347,1 Mchenry transformer	110.8	111	111.2	111.6	111.7	111.8	112	112.2	112.3	112.5	112.6	112.7	112.7	112.9	112.9	113
180 2	615348,615347,1 Mchenry transformer	172.1	172.7	173.4	174.5	174.9	175.3	175.9	176.5	176.9	177.3	177.8	178.4	178.7	179.2	179.5	180
B2_XEL_WILLPIP-S35-JOHNCAK115	615440,616929,1	105.5	105.4	105.6	106	106.3	106.5	106.8	107	107.1	107	106.9	106.8	106.7	106.6	106.5	106.5
B2_XEL_WILLPIP-S35-JOHNCAK115	616925,616929,1	100.7	100.6	100.8	101.1	101.5	101.7	102	102.2	102.3	102.2	102.1	102	101.9	101.8	101.7	101.7
180 2	657756,657791,1	114.1	114.1	114.4	114.8	115.2	115.5	115.9	116.2	116.4	116.6	116.8	117	117.2	117.4	117.6	117.8
SINGLE-046	657756,657791,1	151.4	151.3	151.5	151.8	152.3	152.6	153	153.3	153.5	153.7	153.9	154.1	154.3	154.5	154.6	154.9
34L		**VC**															
007		**VC**															
230		**VC**															
860		**VC**															
230_2		**VC**															
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**															

Table D17-1

Overload %

🟪 Existing D.C. reduction
🟧 Proposed D
🟩 Base case issue
VC Voltage col

SI-EXPT-250-Riel-Shannon

Congtingecy	Facility	0	50	100	150	200	250
SINGLE-042	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	101.8	104	106.1	108.2	110.4
001	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	102.1	104.3	106.6	108.8
003	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	102.2	104.4	106.6	108.8
SINGLE-040	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	100.6	102.7	105.1	107.3
SINGLE-031	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	101.2	103.3	105.6	107.8
220	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	100.1	102.1	104.1	106.1
220_2	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	100.1	102.1	104.1	106.1
B2_XEL_ROSEAUMP-MORNVLL-RICH2230	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	102.1	104.3	106.6	108.8
Bison-AlexSS 345	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	x	100.8	102.8	104.7
570 1	601001,601013,1, FORBES 2 500. to ROSEAUS2 500.	x	x	x	100.4	102.4	104.5
Pre Contingency	**601001,601013,1, FORBES 2 500. to ROSEAUS2 500.**	**x**	**x**	**x**	**x**	**100.8**	**102.7**
King-EuClaire 345	602021,602030,1, EAU CLA5 161. to WHT 14 5 161.	100.9	100.8	100.8	100.7	100.7	100.7
B_XEL_LKMARN-KEK_NSP	603001,619605,1, W FARIB7 115. to GRE-AIRTECH7115.	104.3	104.2	104.2	104.2	104.2	104.1
B_XEL_S_FARIB-S38-LOONLK-EASTWD	603001,619605,1, W FARIB7 115. to GRE-AIRTECH7115.	101.3	101.3	101.3	101.3	101.3	101.2
180 2	603022,603023,1, SOURIS 7 115. to MALLARD7 115.	101.6	100.9	100.5	x	x	x
9L	608666,608676,1, FONDULAC 115. to HIBBARD7 115.	101.2	x	x	161.8	181.2	181.6
128L	608696,608698,1, TAC HBR6 138. to HOYT LK6 138.	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1, TAC HBR6 138. to HOYT LK6 138.	123.1	123.1	123.2	123.3	123.3	123.3
128L	608696,608699,1, TAC HBR6 138. to DUNKARD6 138.	104.5	104.5	104.5	104.5	104.5	104.6
42L	608696,608699,1, TAC HBR6 138. to DUNKARD6 138.	124	124.1	124.2	124.2	124.2	124.2
42L	608698,608699,1, HOYT LK6 138. to DUNKARD6 138.	115.1	115.1	115.2	115.3	115.3	115.3
42L	608698,608700,1, HOYT LK6 138. to 43L TAP6 138.	113.5	113.5	113.7	113.7	113.7	113.7
42L	608700,608701,1, 43L TAP6 138. to LASKIN 6 138.	102.6	102.5	102.5	102.5	102.5	102.5
B_XEL_FIBROMIN-BENSON	620218,652555,1, MOROTP 7 115. to MORRIS 7 115.	103.3	103.4	103.4	103.5	103.4	103.4
Pre Contingency	**620270,924981,P1, LADISH 7 115. to G645 115.**	**165.1**	**165.1**	**165.1**	**165.1**	**165**	**165**
SINGLE-046	657756,657791,1, SQBUTTE4 230. to CENTER 3 345.	124.8	124.8	124.8	124.9	125	125.1
EuClaire-Arpin 345	699240,699808,1, SAR 138 138. to PETENWEL 138.	102.2	102.2	102.2	102.5	102.7	102.7
M602F		**VC**	x	x	x	x	x
34L		**VC**	x	x	x	x	x
007		**VC**	x	x	x	x	x
230		**VC**	x	x	x	x	x
860		**VC**	x	x	x	x	x
230_2		**VC**	x	x	x	x	x
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**	x	x	x	x	x

Table D17-2

Overload %

🟪	Existing D.C. reduction	🟧	Proposed D.C. reduction
🟩	Base case issue	VC	Voltage collapse

SI-IMPT-250-Riel-Shannon

Congtingecy	Facility	0	50	100	150	200	250
220	602006,652435,1, SHEYNNE4 230. to FARGO 4 230.	108.5	107.9	107.4	107	107	107
220_2	602006,652435,1, SHEYNNE4 230. to FARGO 4 230.	108.5	107.9	107.4	107	107	107
Pre Contingency	**603022,603023,1, SOURIS 7 115. to MALLARD7 115.**	**111.2**	**111.3**	**111.3**	**111.4**	**111.4**	**111.6**
180 2	603022,605634,1, SOURIS 7 115. to VELVA TAP 115.	121.4	121.6	122	122.5	123.1	123.7
B_XEL_LKMARN-KEK_NSP	603170,616922,1, WILLPIP7 115. to GRE-APPVLTW7115.	112.2	112.2	112.2	112	112.3	112.6
500	603177,616004,1, MAYNARD7 115. to GRE-KERKHOT7115.	109.5	109.4	109.4	109.4	109.6	109.8
128L	608696,608698,1, TAC HBR6 138. to HOYT LK6 138.	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1, TAC HBR6 138. to HOYT LK6 138.	122.9	122.9	122.9	122.9	122.9	122.9
128L	608696,608699,1, TAC HBR6 138. to DUNKARD6 138.	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1, TAC HBR6 138. to DUNKARD6 138.	123.8	123.8	123.8	123.8	123.8	123.8
42L	608698,608699,1, HOYT LK6 138. to DUNKARD6 138.	115	115	115	115	115	115
42L	608698,608700,1, HOYT LK6 138. to 43L TAP6 138.	113.3	113.3	113.3	113.3	113.3	113.3
42L	608700,608701,1, 43L TAP6 138. to LASKIN 6 138.	102.6	102.6	102.6	102.6	102.6	102.6
39L	608702,608704,1, LASKIN 7 115. to 34L TAP7 115.	104.3	104.2	104.2	104.4	104.6	104.8
180 1	615347,615349,1, GRE-MCHENRY4230. to and 615348	132	132.3	132.6	133.2	133.6	133.8
180 2	615347,615349,1, GRE-MCHENRY4230. to and 615348	204.9	205.4	206.2	207.1	208.2	209.3
180 1	615348,615347,1, GRE-MCHENRY7115. to and 615349	119.9	120.2	120.5	121	121.4	121.6
180 2	615348,615347,1, GRE-MCHENRY7115. to and 615349	186.2	186.7	187.4	188.2	189.2	190.2
B2_XEL_WILLPIP-S35-JOHNCAK115.0	615440,616929,1, GRE-LKMARN 7115. to GRE-KENRICK7115.	109.8	109.8	109.8	109.7	110	110.3
B2_XEL_WILLPIP-S35-JOHNCAK115.0	616925,616929,1, GRE-DKTAHGT7115. to GRE-KENRICK7115.	105	105	105	104.9	105.2	105.5
Pre Contingency	**620270,924981,P1, LADISH 7 115. to G645 115.**	**165.1**	**165.1**	**165.1**	**165**	**165.1**	**165.1**
180 2	652452,659264,1, RUGBY 7 115. to RUGBCPC7 115.	x	x	x	100.8	101.7	102.5
180 2	657756,657791,1, SQBUTTE4 230. to CENTER 3 345.	120.3	120.2	120.2	120.3	120.5	120.8
SINGLE-046	657756,657791,1, SQBUTTE4 230. to CENTER 3 345.	157.1	157	156.7	156.6	156.7	156.8
Pre Contingency	**657791,661016,1, CENTER 3 345. to COYOTE 3 345.**	**100.1**	**100.1**	**100.1**	**100.1**	**100.2**	**100.3**
Pre Contingency	**667052,920081,1, GLENBOR4 230. to G904_TAP 230.**	**x**	**x**	**x**	**x**	**x**	**101.1**
007		**VC**	x	x	x	x	x
230		**VC**	x	x	x	x	x
860		**VC**	x	x	x	x	x
230_2		**VC**	x	x	x	x	x
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**	x	x	x	x	x

Table D18

Overload %

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

PO-M602F-EXPT-W-1100-NOPST-60SC

Congtingecy	Facility	0	50	100	150	200	250	300	350	400
B_XEL_COON_CK-TERMINL	601019,601021,1, COON CK3 345. to KOLMNLK3 345.	120.7	121.9	123	123.8	124.6	125.5	125.8	126.2	126.7
Pre Contingency	**601060,601062,1, BISON 500. to DBCOMPS 500.**	**x**	**x**	**x**	**x**	**101.4**	**103.8**	**106.1**	**108.4**	**110.7**
Bison 500-345BK	601060,601067,2, BISON 500. to BISON 3 345.	132.6	135.5	138.3	141.7	144.9	148.2	151.5	154.8	158.3
Pre Contingency	**601061,601062,1, DBCOMPN 500. to DBCOMPS 500.**	**x**	**x**	**x**	**x**	**x**	**101.3**	**103.5**	**105.7**	**107.9**
Pre Contingency	**601061,667500,1, DBCOMPN 500. to DORSEY 2 500.**	**x**	**x**	**x**	**x**	**100.8**	**103.1**	**105.4**	**107.6**	**109.8**
Bison-AlexSS 345	601067,657792,1, BISON 3 345. to MAPLE R3 345.	x	x	101.5	103.4	105.5	107.5	109.6	111.6	113.7
L20D	601067,657792,1, BISON 3 345. to MAPLE R3 345.	x	x	x	x	100.6	102.6	104.6	106.6	108.7
SINGLE-042	601067,657792,1, BISON 3 345. to MAPLE R3 345.	x	x	x	x	x	x	x	100.8	102.7
Pre Contingency	**601067,657792,1, BISON 3 345. to MAPLE R3 345**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.4**
220	602050,657754,1, BISON 4 230. to MAPLE R4 230.	116.3	118.8	121.5	124.2	127.4	130.2	133.4	136.3	139.4
220_2	602050,657754,1, BISON 4 230. to MAPLE R4 230.	116.4	118.8	121.5	124.2	127.4	130.1	133.4	136.3	139.4
Bison to Maple 345	602050,657754,1, BISON 4 230. to MAPLE R4 230.	128.6	130.8	133.2	135.5	138.1	140.6	143.3	145.5	148.1
B_XEL_LKMARN-KEK_NSP	603001,619605,1, W FARIB7 115. to GRE-AIRTECH7115.	102.8	102.7	102.6	102.5	102.4	102.2	102.5	102.8	103.2
B_XEL_S_FARIB-S38-LOONLK-E	603001,619605,1, W FARIB7 115. to GRE-AIRTECH7115.	101.6	101.5	101.5	101.4	101.4	101.3	101.3	101.3	101.7
NSP - 3	603019,603021,1, CASS CO7 115. to REDRIVR7 115.	x	x	x	x	x	x	100.4	102.4	106.3
98L	608624,608625,1, FORBES 4 230. to BLCKBRY4 230.	100.3	101.3	102.2	102.5	100.1	x	100.4	101	101.5
9L	608666,608676,1, FONDULAC 115. to HIBBARD7 115.	x	x	x	112	110.2	124.2	137.5	137.3	137.3
128L	608696,608698,1, TAC HBR6 138. to HOYT LK6 138.	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1, TAC HBR6 138. to HOYT LK6 138.	123	123	123.1	123.2	123.2	123.2	123.2	123.2	123.3
128L	608696,608699,1, TAC HBR6 138. to DUNKARD6 138.	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1, TAC HBR6 138. to DUNKARD6 138.	123.9	123.9	124	124.1	124.1	124.1	124.1	124.2	124.2
42L	608698,608699,1, HOYT LK6 138. to DUNKARD6 138.	115	115.1	115.1	115.2	115.2	115.2	115.2	115.2	115.3
42L	608698,608700,1, HOYT LK6 138. to 43L TAP6 138.	113.4	113.4	113.5	113.5	113.6	113.6	113.6	113.6	113.7
42L	608700,608701,1, 43L TAP6 138. to LASKIN 6 138.	102.6	102.6	102.5	102.5	102.5	102.5	102.5	102.5	102.5
20L	608737,608739,1, NASHWAK7 115. to BLCKBRY7 115.	x	x	x	x	105.3	107.4	107.5	107.7	107.8
AlexSS-WaitePark 345	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	101.5	102.5	103.5	104.6	105.9	107.1	107.9	108.7	109.6
552	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	114.2	115.4	116.2	117.2	118.5	119.7	120.3	120.8	121.4
553	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	101.1	101.8	102.5	103.3	104.3	105.2	105.8	106.4	106.9
865	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	103.9	104.8	105.7	106.8	108	109.1	109.8	110.4	111
NSP - 3	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	x	100.2	101.2	102.2	103.4	104.5	105.3	106.2	107.1
866	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	x	x	x	100.3	101.4	102.3	102.9	103.4	103.9
610 1	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	x	x	x	x	100.8	101.8	102.5	103.1	103.7
Bison to Maple 345	620222,658050,1, ALEXAND7 115. to ALEXSS 7 115.	x	x	x	x	x	x	x	100.2	100.9
800 1	620238,620239,1, WINGER 7 115. to BAGLEY 7 115.	x	100.6	103.5	106.8	110.7	114	116.2	118	120.4
800 1	620245,620281,1, WILTON 7 115. to WILT TAP 115.	107.7	109.2	110.8	112.3	114.1	115.6	116.7	117.2	118.1
800 1	620281,620285,1, WILT TAP 115. to SOLWAY 7 115.	109.9	111.4	113	114.5	116.4	117.8	118.9	119.5	120.4
Pre Contingency	**657754,620189,1, MAPLE R4 230. to MAPLER1Y 345**	**x**	**x**	**x**	**x**	**x**	**x**	**101.3**	**103.1**	**104.7**
Pre Contingency	**657754,620190,1, MAPLE R4 230. to MAPLER2Y 345**	**x**	**x**	**x**	**x**	**x**	**x**	**101.3**	**103.1**	**104.7**
Pre Contingency	**657792,620189,1, MAPLE R3 345. to MAPLER1Y 345**	**x**	**x**	**x**	**x**	**100.5**	**102.4**	**104.1**	**105.9**	**107.6**
Pre Contingency	**657792,620190,1, MAPLE R3 345. to MAPLER2Y 345**	**x**	**x**	**x**	**x**	**100.5**	**102.4**	**104.1**	**105.9**	**107.6**
726L	667041,667046,1, RIEL 4 230. to RICHER 4 230.	x	x	101.4	103	105	106.9	108.4	109.6	111.1
EuClaire-Arpin 345	699240,699808,1, SAR 138 138. to PETENWEL 138.	102.4	102.3	102.2	102.6	102.5	102.7	102.4	102.1	101.6
Pre Contingency	R50M	101	103.1	105.5	107.2	109.7	112.4	113.9	115.8	117.4
New 500		**VC**								
34L		**VC**								
007		**VC**								
230		**VC**								
860		**VC**								
230_2		**VC**								
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**								

Table D19

Overload %

🟪 Existing D.C. reduction

🟧 Proposed D.C. reduction

🟩 Base case issue

VC Voltage collapse

PO-M602F-EXPT-W-1100-PST-60SC

Congtingecy	Facility	0	50	100	150	200	250	300	350	400
B_XEL_COON_CK-TERMINL	601019,601021,1 Kolmin Lk to Coon Creek 345 kV	120.7	121.9	123	123.8	124.6	125.5	125.8	126.2	126.7
Pre Contingency	**601060,601062,1 New Tie**	**x**	**x**	**x**	**x**	**101.4**	**103.8**	**106.1**	**108.4**	**110.7**
Bison 500-345BK	601060,601067,2 Bison 500/345 Xfmr 2	132.6	135.5	138.3	141.7	144.9	148.2	151.5	154.8	158.3
Pre Contingency	**601061,601062,1 New Tie SC**	**x**	**x**	**x**	**x**	**x**	**101.3**	**103.5**	**105.7**	**107.9**
Pre Contingency	**601061,667500,1 New Tie**	**x**	**x**	**x**	**x**	**100.8**	**103.1**	**105.4**	**107.6**	**109.8**
Bison-AlexSS 345	601067,657792,1 Bison to Maple River 345 kV	x	x	101.5	103.4	105.5	107.5	109.6	111.6	113.7
L20D	601067,657792,1 Bison to Maple River 345 kV	x	x	x	x	100.6	102.6	104.6	106.6	108.7
SINGLE-042	601067,657792,1 Bison to Maple River 345 kV	x	x	x	x	x	x	x	100.8	102.7
Pre Contingency	**601067,657792,1 Bison to Maple River 345 kV**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.4**
220	602050,657754,1 Bison to Maple 230 kV	116.3	118.8	121.5	124.2	127.4	130.2	133.4	136.3	139.4
220_2	602050,657754,1 Bison to Maple 230 kV	116.4	118.8	121.5	124.2	127.4	130.1	133.4	136.3	139.4
Bison to Maple 345	602050,657754,1 Bison to Maple 230 kV	128.6	130.8	133.2	135.5	138.1	140.6	143.3	145.5	148.1
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Wfarib to Airtech 115kv	102.8	102.7	102.6	102.5	102.4	102.2	102.5	102.8	103.2
B_XEL_S_FARIB-S38-LOONLK-EAST	603001,619605,1 Wfarib to Airtech 115kv	101.6	101.5	101.5	101.4	101.4	101.3	101.3	101.3	101.7
NSP - 3	603019,603021,1 Red River to Cass Co. 115 kV	x	x	x	x	x	x	100.4	102.4	106.3
98L	608624,608625,1 Blackberry to Forbes 230 kV	100.3	101.3	102.2	102.5	100.1	x	100.4	101	101.5
9L	608666,608676,1 Fondulac to Hibbard 115kv	x	x	x	112	110.2	124.2	137.5	137.3	137.3
128L	608696,608698,1	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6
42L	608696,608698,1	123	123	123.1	123.2	123.2	123.2	123.2	123.2	123.3
128L	608696,608699,1	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5	104.5
42L	608696,608699,1	123.9	123.9	124	124.1	124.1	124.1	124.1	124.2	124.2
42L	608698,608699,1	115	115.1	115.1	115.2	115.2	115.2	115.2	115.2	115.3
42L	608698,608700,1	113.4	113.4	113.5	113.5	113.6	113.6	113.6	113.6	113.7
42L	608700,608701,1	102.6	102.6	102.5	102.5	102.5	102.5	102.5	102.5	102.5
20L	608737,608739,1 Blackberry to Nashwak 115 kV	x	x	x	x	105.3	107.4	107.5	107.7	107.8
Bison to Buffalo 345	620198,620358,1 Buffalo 345 Xfmr	114	113.9	113.8	113.8	113.9	113.8	113.7	113.5	113.3
Bison to Buffalo 345	620203,620204,1 Fargo to Maple 115 kV	112.9	112.7	112.5	112.3	112.2	112.3	112	111.8	111.5
B_XEL_FIBROMIN-BENSON	620218,652555,1 MoroTap to Morris 115kv	119.8	120.2	120.7	121.1	121.5	121.9	122.5	123.2	123.8
AlexSS-WaitePark 345	620222,658050,1 Alexandria to AlexSS 115 kV	101.5	102.5	103.5	104.6	105.9	107.1	107.9	108.7	109.6
552	620222,658050,1 Alexandria to AlexSS 115 kV	114.2	115.4	116.2	117.2	118.5	119.7	120.3	120.8	121.4
553	620222,658050,1 Alexandria to AlexSS 115 kV	101.1	101.8	102.5	103.3	104.3	105.2	105.8	106.4	106.9
865	620222,658050,1 Alexandria to AlexSS 115 kV	103.9	104.8	105.7	106.8	108	109.1	109.8	110.4	111
NSP - 3	620222,658050,1 Alexandria to AlexSS 115 kV	x	100.2	101.2	102.2	103.4	104.5	105.3	106.2	107.1
866	620222,658050,1 Alexandria to AlexSS 115 kV	x	x	x	100.3	101.4	102.3	102.9	103.4	103.9
610 1	620222,658050,1 Alexandria to AlexSS 115 kV	x	x	x	x	100.8	101.8	102.5	103.1	103.7
Bison to Maple 345	620222,658050,1 Alexandria to AlexSS 115 kV	x	x	x	x	x	x	x	100.2	100.9
800 1	620238,620239,1 Bagley to Winger 115 kV	x	100.6	103.5	106.8	110.7	114	116.2	118	120.4
800 1	620245,620281,1 Wilton to Wilton tap 115 kV	107.7	109.2	110.8	112.3	114.1	115.6	116.7	117.2	118.1
Bison to Buffalo 345	620258,620198,1 Buffalo 345/115 xfmr	105.1	104.9	104.9	104.9	104.9	104.9	104.7	104.5	104.4
800 1	620281,620285,1 Solway to Wilton Tap 115 kV	109.9	111.4	113	114.5	116.4	117.8	118.9	119.5	120.4
Pre Contingency	**657754,620189,1 Maple River 345/230 Xfmr**	**x**	**x**	**x**	**x**	**x**	**x**	**101.3**	**103.1**	**104.7**
Pre Contingency	**657754,620190,1 Maple River 345/230 Xfmr 2**	**x**	**x**	**x**	**x**	**x**	**x**	**101.3**	**103.1**	**104.7**
Pre Contingency	**657792,620189,1 Maple River 345 Xfmr**	**x**	**x**	**x**	**x**	**100.5**	**102.4**	**104.1**	**105.9**	**107.6**
Pre Contingency	**657792,620190,1 Maple River 345 Xfmr**	**x**	**x**	**x**	**x**	**100.5**	**102.4**	**104.1**	**105.9**	**107.6**
726L	667041,667046,1 Riel to Richer 230 kV	x	x	101.4	103	105	106.9	108.4	109.6	111.1
EuClaire-Arpin 345	699240,699808,1 Petenwel to Sar 138kv	102.4	102.3	102.2	102.6	102.5	102.7	102.4	102.1	101.6
Pre Contingency	**R50M**	**101**	**103.1**	**105.5**	**107.2**	**109.7**	**112.4**	**113.9**	**115.8**	**117.4**
New 500		**VC**								
34L		**VC**								
007		**VC**								
230		**VC**								
860		**VC**								
230_2		**VC**								
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**								

Table D20

Overload %

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

PO-M602F-EXPT-E-1100-NOPST-60SC

Congtingecy	Facility	0	50	100	150	200	250	300	350	400
001	151203,608784,1 F3M Ontario	106.5	107.9	109.2	110.1	111.3	112.4	111.5	112.2	111.4
003	151203,608784,1 F3M Ontario	103.1	104.5	105.8	106.7	107.9	108.9	108.1	108.8	108.1
SINGLE-040	151203,608784,1 F3M Ontario	100.1	101.4	102.8	103.6	104.6	105.6	104.9	105.4	104.7
B2_XEL_ROSEAUMP-MORNVLL-RICH22	151203,608784,1 F3M Ontario	106.5	107.8	109.2	110.1	111.3	112.3	111.5	112.2	111.4
Arrowhead-StoneLake 345	601035,608625,3 Blackberry 345/230 Xfmr	125.8	129	132.4	135.2	139.5	142.8	146.2	149.4	152.8
Blackberry-Arrowhead 345	601035,608625,3 Blackberry 345/230 Xfmr	x	100.6	104.1	107.4	112	115.8	119.1	122.5	126.2
SINGLE-042	601035,608625,3 Blackberry 345/230 Xfmr	x	100.8	104.7	108.3	113.3	117.3	120.5	124.3	128
StoneLake-GardnierPark 345	601035,608625,3 Blackberry 345/230 Xfmr	x	x	101.1	103.9	108.1	111.5	114.9	117.9	121.3
001	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	102.7	107.5	111.6	115.4	118.6	122.4
003	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	102.4	107.2	111.2	115.1	118.3	122.1
SINGLE-040	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	100.5	104.8	108.8	112.7	115.8	119.6
B2_XEL_ROSEAUMP-MORNVLL-RICH22	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	102.7	107.5	111.5	115.4	118.6	122.4
SINGLE-031	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	103.5	107.6	111.5	114.8	118.7
220	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	101.7	105.2	108.8	112.3	115.4
220_2	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	101.8	105.2	108.8	112.3	115.4
Bison-AlexSS 345	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	x	100	103.2	106.6	110.1
726L	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	x	101.2	104.3	107.8	111.2
G82R	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	x	100.8	104.2	108	111.8
570 1	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	x	100.4	103.6	107.1	110.5
Pre Contingency	**601035,608625,3 Blackberry 345/230 Xfmr**	**x**	**x**	**x**	**x**	**x**	**x**	**100.6**	**103.7**	**107.1**
Pre Contingency	**601061,667500,1 New Tie**	**x**	**x**	**x**	**x**		**x**	**100.2**	**102**	**104**
Pre Contingency	**601062,608635,1 New Tie**	**x**	**x**	**x**	**x**	**x**	**x**	**100.5**	**102.3**	**104.4**
220	602006,652435,1 Fargo to Sheyenne 230 kV	x	x	x	x	x	x	x	x	100.2
220_2	602006,652435,1 Fargo to Sheyenne 230 kV	x	x	x	x	x	x	x	x	100.2
StoneLake-GardnierPark 345	602017,699450,1 Stonelake 345/165 Xfmr	119.1	119.2	119.5	119.9	119.9	120.2	121	121.8	122.6
Pre Contingency	**602017,699450,1 Stonelake 345/165 Xfmr**	**x**	**x**	**x**	**100.2**	**100.2**	**101**	**101.4**	**101.9**	**102.4**
Blackberry 345/230 BK	602017,699450,1 Stonelake 345/165Xfmr	x	x	x	x	x	x	x	x	100.7
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Airtech to W Farib 115 kV	101.5	101.5	101.4	101.3	101.2	101.2	101.4	101.8	102.1
Arrowhead-StoneLake 345	603140,603141,1 Inopump to Ironriver 115 kV	113.4	112.9	112.4	110.5	110.1	108.2	108.7	109.7	110.8
Arrowhead-StoneLake 345	603142,680386,1 Pilsn to Bayfrnt 115 kV	108.9	108.4	107.9	106	105.6	103.7	104.2	105.2	106.3
B_XEL_LKMARN-KEK_NSP	603170,616922,1 Willpip to ApplV 115 kV	101.6	101.6	101.7	101.7	101.8	101.9	101.7	101.5	101.2
Mesaba-Blackberry	608622,608625,2 Mesaba to blackberry cct 2	x	x	100.4	101	101.7	102.7	103.4	104.4	105.7
Pre Contingency	**608624,608625,1 Forbes to Blackberry 230 kV**	**127.1**	**129.7**	**132.3**	**133.2**	**133.2**	**134.1**	**135.8**	**137.6**	**139.7**
Blackberry 500-345BK	608635,601035,2 Blackberry 500-345BK2	123	125.6	128.6	131.6	134.8	137.8	140.8	143.7	146.7
Arrowhead-StoneLake 345	608653,618002,1 Riverton to hillcity 115 kV	108.4	107.8	107.4	107.2	x	x	x	100.2	101.4
9L	608665,608666,1 Fondulac to Thomson 115 kV	x	x	x	x	x	105.1	112	112.4	112.9
9L	608666,608676,1 Fondulac to Hibbard 115kv	125.2	124.3	129	205.1	205.5	219.9	235.2	236.3	237.3
Blackberry 345/230 BK	608666,608676,1 Fondulac to Hibbard 118kv	x	x	x	101.6	103.8	103.3	107.9	109.2	110.5
128L	608696,608698,1	103.6	103.7	103.8	103.8	103.8	103.8	103.9	103.9	103.9
42L	608696,608698,1	123.3	123.4	123.5	123.5	123.5	123.5	123.5	123.6	123.7
128L	608696,608699,1	104.5	104.6	104.7	104.7	104.8	104.8	104.8	104.8	104.8
42L	608696,608699,1	124.2	124.3	124.4	124.4	124.4	124.4	124.5	124.5	124.7
42L	608698,608699,1	115.3	115.3	115.5	115.5	115.5	115.5	115.5	115.5	115.6
42L	608698,608700,1	113.7	113.8	113.9	113.9	113.9	113.9	113.9	114	114.1
42L	608700,608701,1	102.5	102.5	102.6	102.6	102.5	102.5	102.6	102.6	102.6
Pre Contingency	**608737,608739,1 Nashwauk to Blackberry 115 kV**	**105**	**108.5**	**111.9**	**112.4**	**114.9**	**116**	**117**	**118**	**119.2**
Arrowhead-StoneLake 345	608739,608781,1 20L Tap to Blackberry 115 kV	x	x	x	x	x	100.8	101.8	102.7	103.8
Arrowhead-StoneLake 345	608740,608781,1 Grand Rapids to 20L Tap 115 kV	x	x	x	x	x	x	x	x	100.8
001	608740,608781,1 Grand Rapids to 20L Tap 115 kV	x	x	x	x	x	x	x	x	100.6
Arrowhead-StoneLake 345	608740,618002,1 Grand Rapids to Hill City 115 kV	111.8	111.2	110.8	110.6	103.1	101	102.2	103.7	104.8
B_XEL_FIBROMIN-BENSON	620218,652555,1	106	106.1	106.2	106.3	106.4	106.5	106.8	107.1	107.4
SINGLE-031	620255,657705,1	x	x	x	x	x	x	100.7	102.7	105
SINGLE-031	657714,920075,1	x	x	x	x	x	x	101.5	104	106.7
SINGLE-046	657756,657791,1	124.5	124.6	124.5	124.5	124.6	124.5	124.2	123.8	123.6
Blackberry 345/230 BK	L20D	100.4	102.8	105.7	108	110.5	112.9	116.2	119.9	124.4
Pre Contingency	**L20D**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.6**	**103**
Blackberry 345/230 BK	R50M	102.1	104.8	107.8	110	112.5	114.7	118	120.7	124.7
726L	R50M	109.6	111.6	113.7	115.5	117.2	119.1	120.6	122.2	123.9
Blackberry 500-345BK	R50M	x	x	x	x	x	x	x	x	100.8
New 500 D-Black		**VC**								
34L		**VC**								
007		**VC**								
230		**VC**								
860		**VC**								
230_2		**VC**								
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**								

Table D21

Overload %

🟪 Existing D.C. reduction
🟧 Proposed D.C. reduction
🟩 Base case issue
VC Voltage collapse

PO-M602F-EXPT-E-1100-PST-60SC

Congtingecy	Facility	0	50	100	150	200	250	300	350	400
001	151203,608784,1 F3M Ontario	106.7	108.2	109.5	110.6	111.7	111.8	112.7	112	111.8
003	151203,608784,1 F3M Ontario	103.5	104.9	106.1	107.2	108.4	108.5	109.3	108.6	108.4
SINGLE-040	151203,608784,1 F3M Ontario	100.3	101.7	103.1	103.9	105.2	105.3	105.9	105.3	105.2
B2_XEL_ROSEAUMP-MORNVLL-RICH2230	151203,608784,1 F3M Ontario	106.8	108.2	109.6	110.6	111.8	111.9	112.7	111.9	111.7
Blackberry-Arrowhead 345	601035,608625,3 Blackberry 345/230 Xfmr	100.3	103.8	107.8	111.5	116.3	120.3	124.1	128.5	132.3
Arrowhead-StoneLake 345	601035,608625,3 Blackberry 345/230 Xfmr	129.1	132.4	136	139.2	143.7	147.4	151	155.3	159.4
SINGLE-042	601035,608625,3 Blackberry 345/230 Xfmr	100.5	104.2	108.7	112.6	117.8	121.9	126	130.1	134.8
StoneLake-GardnierPark 345	601035,608625,3 Blackberry 345/230 Xfmr	x	100.9	104.6	107.6	112.3	115.9	119.4	123.6	127.7
001	601035,608625,3 Blackberry 345/230 Xfmr	x	x	103.2	107	112.1	116.8	120.3	124.9	129.2
003	601035,608625,3 Blackberry 345/230 Xfmr	x	x	103	106.8	111.9	116.6	120	124.7	129
SINGLE-040	601035,608625,3 Blackberry 345/230 Xfmr	x	x	101	104.3	109.5	114	117.4	122.1	126.6
SINGLE-031	601035,608625,3 Blackberry 345/230 Xfmr	x	x	100.3	103.6	108.9	113.6	117.3	122.3	126.7
B2_XEL_ROSEAUMP-MORNVLL-RICH2230	601035,608625,3 Blackberry 345/230 Xfmr	x	x	103.2	107	112.2	116.8	120.3	125	129.2
220	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	100.6	105.1	109.4	113.2	117	121.3
220_2	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	100.7	105.2	109.4	113.1	117	121.3
STVITAL-LETELIER	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	100.2	104.1	107.8	112.1	115.7
STVITAL-LAV	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	100.2	104.1	107.7	112.1	115.7
Bison-AlexSS 345	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	100.4	104.2	107.8	112.1	115.8
726L	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	101.8	105.5	109.2	113.5	117
570 1	601035,608625,3 Blackberry 345/230 Xfmr	x	x	x	x	100.9	104.8	108.6	112.8	116.5
Pre Contingency	**601035,608625,3 Blackberry 345/230 Xfmr**	**x**	**x**	**x**	**x**	**x**	**101.4**	**105.1**	**109.3**	**113.2**
Pre Contingency	**601061,601062,1 Series comp new tie**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**101.8**
Pre Contingency	**601061,667500,1 New Tie**	**x**	**x**	**x**	**x**	**x**	**100.6**	**102.7**	**105.2**	**107.6**
Pre Contingency	**601062,608635,1 New Tie**	**x**	**x**	**x**	**x**	**x**	**100.9**	**103.1**	**105.6**	**108.1**
StoneLake-GardnierPark 345	602017,699450,1 Stonelake 345/165 Xfmr	119.9	120.1	120.4	120.8	120.8	121.3	122	122.9	123.9
Pre Contingency	**602017,699450,1 Stonelake 345/161 Xfmr**	**x**	**x**	**x**	**100.7**	**100.8**	**101.6**	**102.1**	**102.6**	**103.1**
Blackberry 345/230 BK	602017,699450,1 Stonelake 345/161 Xfmr	x	x	x	x	x	x	100.2	101.3	x
B_XEL_LKMARN-KEK_NSP	603001,619605,1 Airtech to W Farib 115 kV	101.6	101.5	101.4	101.4	101.3	101.2	101.5	101.8	102.2
Arrowhead-StoneLake 345	603140,603141,1 Inopump to Ironriver 115 kV	113.9	113.5	113	111.1	110.7	109	109.6	110.6	111.8
Arrowhead-StoneLake 345	603142,680386,1 Pilsn to Bayfrnt 115 kV	109.4	109	108.4	106.6	106.2	104.5	105.1	106.2	107.3
B_XEL_LKMARN-KEK_NSP	603170,616922,1 Willpip to ApplV 115 kV	101.5	101.6	101.6	101.7	101.8	101.8	101.6	101.4	101.2
Mesaba-Blackberry	608622,608625,2 Mesaba to blackberry cct 2	x	100.4	101.1	101.9	102.8	103.6	104.8	106.3	107.7
Pre Contingency	**608624,608625,1 Forbes to Blackberry 230 kV**	**128.4**	**131.1**	**133.8**	**134.8**	**134.9**	**136**	**137.7**	**140.2**	**142.6**
Blackberry 500-345BK	608635,601035,2 Blackberry 500-345BK2	125.6	128.5	131.7	134.9	138.1	141.7	144.9	148.4	152
Arrowhead-StoneLake 345	608653,618002,1 Riverton to hillcity 115 kV	110.3	109.8	109.4	109.3	101.8	100	101.3	103	104.5
9L	608665,608666,1 Fondulac to Thompson 115 kV	x	x	x	x	x	106.3	112.9	113.5	114.1
9L	608666,608676,1 Fondulac to Hibbard 118kv	127.4	126.5	131.4	206.8	207.3	222.8	237.3	238.5	240
Blackberry 345/230 BK	608666,608676,1 Fondulac to Hibbard 118kv	x	x	x	103.3	105.7	105.2	110.4	112.5	x
128L	608696,608698,1	103.7	103.7	103.8	103.9	103.9	103.9	103.9	103.9	104
42L	608696,608698,1	123.3	123.4	123.5	123.5	123.5	123.5	123.6	123.8	124
128L	608696,608699,1	104.6	104.6	104.8	104.8	104.8	104.8	104.8	104.8	105
42L	608696,608699,1	124.2	124.3	124.4	124.4	124.4	124.5	124.6	124.7	124.9
42L	608698,608699,1	115.3	115.3	115.5	115.5	115.5	115.5	115.5	115.7	115.8
42L	608698,608700,1	113.7	113.8	113.9	113.9	113.9	113.9	114	114.2	114.4
42L	608700,608701,1	102.5	102.5	102.5	102.5	102.5	102.5	102.6	102.6	102.6
39L	608702,608704,1	101.7	x	x	x	x	x	x	x	x
Pre Contingency	**608737,608739,1 Nashwak to Blackberry 115 kV**	**105.7**	**109.2**	**112.6**	**113.2**	**115.8**	**117.2**	**118.1**	**119.5**	**120.8**
Arrowhead-StoneLake 345	608739,608781,1 20L Tap to Blackberry 115 kV	x	x	x	x	x	102.2	103.3	104.6	105.9
Pre Contingency	**608739,608781,1 20L Tap to Blackberry 115 kV**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**100.1**	**101.4**
Arrowhead-StoneLake 345	608740,608781,1 Grand Rapids to 20L Tap 115 kV	x	x	x	x	x	x	100.3	101.7	103.1
Arrowhead-StoneLake 345	608740,618002,1 Grand Rapids to Hill City 115 kV	113.7	113.2	112.7	112.7	105.2	103.5	104.8	106.4	107.9
B_XEL_FIBROMIN-BENSON	620218,652555,1	105.8	105.9	106	106.1	106.1	106.2	106.5	106.8	107.1
565	620247,657710,1 Nary to CassLk 115kV	x	x	x	x	x	x	x	x	100.1
SINGLE-031	620255,657705,1	x	x	x	x	101.4	103.7	106.1	109.3	111.9
SINGLE-031	620255,920075,1	x	x	x	x	x	x	x	x	102.5
SINGLE-031	657714,920075,1	x	x	x	100.4	102.7	105.5	108.3	112.1	115.3
SINGLE-046	657756,657791,1	121.9	121.9	121.6	121.5	121.3	121	120.5	119.7	119.1
Blackberry 345/230 BK	L20D	106.6	109.4	112.3	114.8	117.7	121	126.5	133.5	**VC**
Pre Contingency	**L20D**	**x**	**x**	**x**	**x**	**100.4**	**102.6**	**105.4**	**109.1**	**112.6**
Blackberry 345/230 BK	R50M	104.8	107.8	110.7	112.8	115.5	118.6	122.5	128.1	**VC**
726L	R50M	110.9	113	115.4	117.1	119.2	121	122.7	124.7	126.5
Blackberry 500-345BK	R50M	x	x	x	x	x	x	x	101.5	104
SINGLE-031	R50M	x	x	x	x	x	x	x	101	103.4
D-REIL	R50M	x	x	x	x	x	x	x	x	101.7
MNsteel-Blackberry	R50M	x	x	x	x	x	x	x	x	100.9
Arrowhead-StoneLake 345	R50M	x	x	x	x	x	x	x	x	100.7
220	R50M	x	x	x	x	x	x	x	x	100.7
220_2	R50M	x	x	x	x	x	x	x	x	100.7
New 500 D-Black		**VC**								
34L		**VC**								
007		**VC**								
230		**VC**								
860		**VC**								
230_2		**VC**								
B_XEL_T_CRNRS-HYDROLN-WIEN		**VC**								

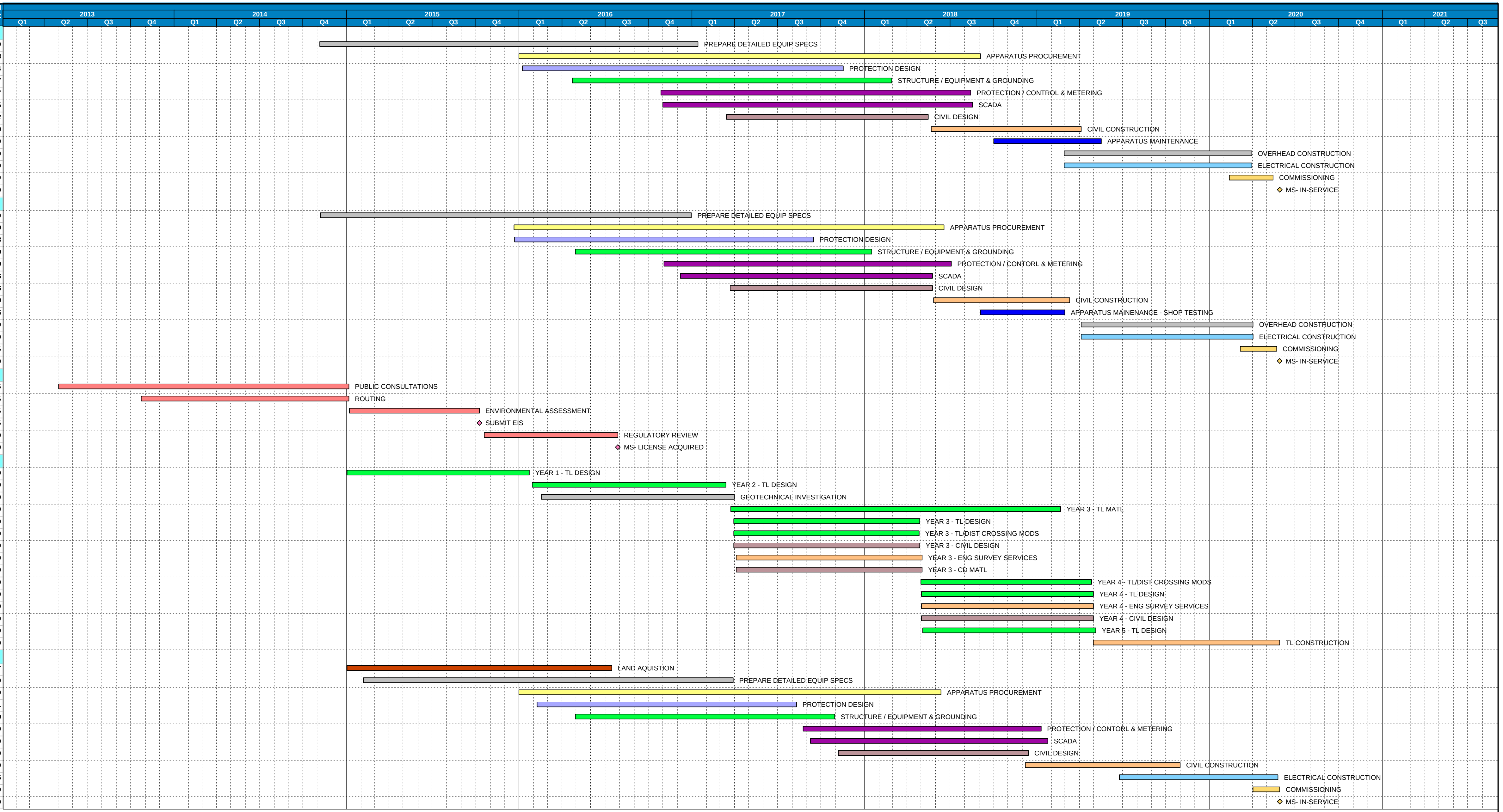
Appendix E

Map of Potential New Tie Line Corridors

REDACTED

Appendix F
Proposed Project Construction Schedule

Activity ID	Activity Name	Orig Dur	Rem Dur	Start	Finish	Resp Area	Total Float
Riel 500 or 230kV Stn - Transformer							
1400	PREPARE DETAILED EQUIP SPECS	510	510	2014-11-05	2017-01-13*	SPL	0
0020	APPARATUS PROCUREMENT	641	641	2015-12-31*	2018-09-03	AQC	453
0030	PROTECTION DESIGN	435	435	2016-01-08*	2017-11-17	PD	654
0040	STRUCTURE / EQUIPMENT & GRO...	435	435	2016-04-22*	2018-02-28	SEG	587
0060	PROTECTION / CONTROL & METER...	435	435	2016-10-27*	2018-08-14	ACE	467
0070	SCADA	435	435	2016-10-31*	2018-08-17	ACEC	465
0050	CIVIL DESIGN	283	283	2017-03-15*	2018-05-15	CD2	532
0090	CIVIL CONSTRUCTION	229	229	2018-05-22*	2019-04-05	CC	299
0120	APPARATUS MAINTENANCE	165	165	2018-10-01*	2019-05-17	AM	0
0110	OVERHEAD CONSTRUCTION	284	284	2019-02-28*	2020-03-31	SOHC	0
0130	ELECTRICAL CONSTRUCTION	284	284	2019-02-28*	2020-03-31	EC	0
0140	COMMISSIONING	68	68	2020-02-12*	2020-05-15	CM	9
1420	MS- IN-SERVICE	0	0		2020-05-29*	CM	0
Dorsey 500 kV Station - Terminate Tie Line							
1260	PREPARE DETAILED EQUIP SPECS	500	500	2014-11-06	2016-12-30*	SPL	0
0020	APPARATUS PROCUREMENT	591	591	2015-12-21*	2018-06-18	AQC	509
0030	PROTECTION DESIGN	400	400	2015-12-23*	2017-09-15	PD	698
0040	STRUCTURE / EQUIPMENT & GRO...	400	400	2016-04-29*	2018-01-16	SEG	619
0060	PROTECTION / CONTORL & METER...	400	400	2016-11-02*	2018-07-03	ACE	499
0070	SCADA	350	350	2016-12-08*	2018-05-24	ACEC	526
0050	CIVIL DESIGN	284	284	2017-03-23*	2018-05-24	CD2	526
0080	CIVIL CONSTRUCTION	206	206	2018-05-28*	2019-03-11	CC	319
0100	APPARATUS MAINENANCE - SHOP ...	130	130	2018-09-03*	2019-03-01	AM	325
0090	OVERHEAD CONSTRUCTION	260	260	2019-04-05	2020-04-02*	SOHC	0
0110	ELECTRICAL CONSTRUCTION	260	260	2019-04-05	2020-04-02*	EC	0
0120	COMMISSIONING	56	56	2020-03-06*	2020-05-22	CM	5
1430	MS- IN-SERVICE	0	0		2020-05-29*	CM	0
MH-US 500 or 230kV Facilities-Lic.& Env							
2561	PUBLIC CONSULTATIONS	400	400	2013-05-01*	2015-01-06	LEA	5
2571	ROUTING	280	280	2013-10-23*	2015-01-06	LEA	5
2581	ENVIRONMENTAL ASSESSMENT	180	180	2015-01-07*	2015-10-09	LEA	5
2601	SUBMIT EIS	0	0		2015-10-09	LEA	5
2591	REGULATORY REVIEW	180	180	2015-10-19*	2016-07-28	LEA	0
2611	MS- LICENSE ACQUIRED	0	0		2016-07-28*	LEA	0
MH-USA 500 or 230kV Transmission Line							
0020	YEAR 1 - TL DESIGN	248	248	2015-01-02*	2016-01-22	TL1	0
0030	YEAR 2 - TL DESIGN	260	260	2016-01-29*	2017-03-14	TL1	0
0100	GEOTECHNICAL INVESTIGATION	261	261	2016-02-17*	2017-03-31	GD	0
0050	YEAR 3 - TL MATL	477	477	2017-03-24*	2019-02-20	TL1	0
0040	YEAR 3 - TL DESIGN	261	261	2017-03-30*	2018-04-27	TL1	0
0060	YEAR 3 - TL/DIST CROSSING MODS	260	260	2017-03-30*	2018-04-26	TL1	0
0150	YEAR 3 - CIVIL DESIGN	261	261	2017-03-30*	2018-04-27	CD2	0
0130	YEAR 3 - ENG SURVEY SERVICES	261	261	2017-04-05*	2018-05-03	ESS	0
0170	YEAR 3 - CD MATL	261	261	2017-04-05*	2018-05-03	CD2	0
0080	YEAR 4 - TL/DIST CROSSING MODS	260	260	2018-04-30*	2019-04-26	TL1	0
0070	YEAR 4 - TL DESIGN	260	260	2018-05-02*	2019-04-30	TL1	0
0140	YEAR 4 - ENG SURVEY SERVICES	260	260	2018-05-02*	2019-04-30	ESS	0
0160	YEAR 4 - CIVIL DESIGN	260	260	2018-05-02*	2019-04-30	CD2	0
0090	YEAR 5 - TL DESIGN	261	261	2018-05-04*	2019-05-06	TL1	0
0110	TL CONSTRUCTION	283	283	2019-05-01*	2020-05-29	TC	0
Glenboro Line G82R Phase Shifter - 230 kV							
0090	LAND AQUISTION	360	360	2015-01-02*	2016-07-15	PY	967
1260	PREPARE DETAILED EQUIP SPECS	500	500	2015-02-05	2017-03-29*	SPL	0
0020	APPARATUS PROCUREMENT	581	581	2015-12-31*	2018-06-11	AQC	0
0030	PROTECTION DESIGN	350	350	2016-02-08*	2017-08-09	PD	451
0040	STRUCTURE / EQUIPMENT & GRO...	350	350	2016-04-29*	2017-10-30	SEG	399
0060	PROTECTION / CONTORL & METER...	350	350	2017-08-24*	2019-01-10	ACE	0
0070	SCADA	350	350	2017-09-08*	2019-01-24	ACEC	0
0050	CIVIL DESIGN	284	284	2017-11-06*	2018-12-13	CD2	0
0080	CIVIL CONSTRUCTION	235	235	2018-12-07*	2019-10-31	CC	0
0110	ELECTRICAL CONSTRUCTION	240	240	2019-06-25*	2020-05-25	EC	15
0120	COMMISSIONING	40	40	2020-04-03	2020-05-28*	CM	0
1430	MS- IN-SERVICE	0	0		2020-05-29*	CM	0



Manitoba Hydro

⬜ Early bar
🟪 ACE Bar
🟨 AQC Bar
🟦 AM Bar
🟧 CC, TC Bar
🟫 CD Bar
🟨 CM Bar
🟩 Comms Bar
🟦 EC, OHC/UGC Bar
🟩 ECM Bar
🟪 HS Bar
🟥 LEA Bar
🟦 MD Bar
🟪 PD Bar
🟥 PY Bar
🟩 SEG...
⬜ SP Bar
🟨 SYS...

MH-US 500 OR 230KV NEW TIE LINE CONSTRUCTION SCHEDULE (MANITOBA PORTION)

2013-02-07
Transmission Projects Dept
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Date	Revision	Checked	Approved

Appendix G
Capital Budget Single Line Diagrams

REDACTED

Appendix H
List of Required Facility Additions in Manitoba

Table H 1: Towers Required for the Manitoba Portion of the New 500 kV Line

Tower Description	Quantity
A-501-1 + 7.5m Ext	158
A-501-1 + 9m Ext	230
A-501-1 + 10.5m Ext	9
B-501-1 + 6m Ext	3
C-500-1	7
E-500-1	14
F-500-1	10

Table H2: Equipment Required at Dorsey Station for the 500 kV Options

Item	Quantity
500 kV Single Phase Circuit Breakers	6
500 kV Current Transformers	6
300 MVAr Single Phase Reactors	4
500 kV 3 Pole VB Disconnects	6
500 kV Lightning Arrestors	6
500 kV 3 Pole Ground Switches	2
500 kV Filter Capacitor Coupling CVTs	6
138 kV VB Disconnect Switch	1
Wave Traps	3
500 kV Single Phase Potential Transformers	6
138 kV Ground Switch	1
138 kV Lightning Arrestors	3
40 MVAr Single Phase Neutral Reactor	1
69 kV 3 Phase CB Disconnect Switch	1
72.5 kV Circuit Breakers	3
69 kV Current Transformers	3
72 kV Lightning Arrestors	3
46 kV 36.7 MVAr Capacitor Banks	2
69 kV 1 mH Single Phase Reactors	6

Table H3: Equipment Required at Riel Station for the 500 kV Options

Item	Quantity
400 MVA Single Phase Auto-Transformers	4
500 kV Single Phase Circuit Breakers	6
500 kV Current Transformers	6
500 kV 3 Pole VB Disconnects	6
500 kV 3 Pole Ground Switch	1
500 kV Lightning Arrestors	6
500 kV Single Phase Potential Transformers	6
230 kV CB Disconnect Switch	1
230 kV Lightning Arrestors	3
230 kV Single Phase Potential Transformer	1
46 kV 36.7 MVAr Capacitor Banks	6
72.5 kV Lightning Arrestors	9
69 kV 3 Phase CB Disconnect Switches	2
72.5 kV Circuit Breakers	2
69 kV Current Transformers	6
69 kV 1 mH Single Phase Reactors	12
230 kV Circuit Breakers	3
230 kV Current Transformers	3

Table H4: Equipment Required at Glenboro South Station for the G82R PST

Item	Quantity***
300 MVA Phase Shifting Transformer	1
230 kV Lightning Arrestors	6
230 kV CB Disconnect Switch	3
230 kV Current Transformers	3

***** Note:** for the 500 kV options, the quantity of facility will be doubled

SUBJECT AREA: **Routing, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

On page 5-26 Manitoba Hydro indicated that System Planners requested a 10 km buffer between existing 500 kV transmission lines in order to reduce risks to the system. Can Manitoba Hydro identify what specific risks system planners would be concerned with?
Page 5-89 engineering perspective relates primarily to weather which is consistent across the routes. A weather study was conducted to refine the final route. On page 5A – 28, for Round 2 and round 3 route evaluation, the previous 10 km buffer separation distance from the exiting 500 kV transmission line routing constraint to address system reliability was re-evaluated based on community feedback and new information from the weather study and Minnesota Power Great Northern Transmission Line which included an option that paralleled the existing M602F 500 kV Line. Can Manitoba Hydro provide some details on what was involved in the study and did the study impact on routing? If so how?

RESPONSE:

The 10 km buffer was requested by the System Planners to improve the overall reliability of the two 500-kV AC circuits during extreme weather events. The separation distance was intended to reduce the risk of an outage on both of the 500-kV AC circuits when extreme weather events (i.e. tornadoes) were forecast in the local area (see related IR responses SSC-IR-061, SSC-IR-062 and SSC-IR-063).

The weather study completed for the Manitoba-Minnesota Transmission Project included an investigation on the probability of tornadoes impacting two parallel transmission lines of various separation distances. A Monte Carlo approach was taken to simulate the occurrence of tornadoes of strength ranging from F0 (weakest) to F5 (most intense) based on the probability of occurrence of tornadoes in southern Manitoba, probability of direction of travel, and the track length characteristics and relative frequency of each F scale. As the line length decreases, the annual probability of occurrence decreases roughly proportionally for small line separations, and decreases more than proportionally for longer separations.

The weather study indicated a higher probability of tornadoes to track in an east-west direction compared to a north-south direction. This lower risk as well as corridor access and proximity to Winnipeg allowed for reducing separation between 500-kV transmission lines within the Riel-Vivian Transmission Corridor.

SUBJECT AREA: Routing, None

REFERENCE: CEC MMTP Round 1 IRs - Part 1

QUESTION:

At the January 2017 Routing Workshop the CEC inquired about how certain route statistic values were calculated. So for example on Table 5.7 there are a number of values calculated and there is no explanation as to the formula used to arrive at these values. The values we are asking about are:

- Current Agricultural Land Use (Value);
- Land Capability for Agriculture (value);
- Intactness
- Seasonal Construction and Maintenance Restrictions
- Index of Proximity to Existing 500 kV lines

Can Manitoba Hydro provide a definition for each of the above and the formulas used in calculating them?

Please provide any other associated information.

RESPONSE:

Definitions and formulas for the above are provided in Table 5A-10, pages 5A-24 and 5A-25. Attempted clarification is provided below.

Current Agricultural Land Use refers to the current use of the land based on the Manitoba Land Classification Dataset. The number of acres of annual cropland crossed by a route (length x ROW width) was multiplied by 2.7. The number of acres of hay land was multiplied by 1. The resulting value is based on the number of acres of agricultural land with a slight “weight” given to annual cropland over hay land.

Land Capability for Agriculture refers to the ability of a piece of land to be used for agriculture. The Manitoba Soils Dataset was used to determine this. The number of acres of Class 1-3 soils within the right-of-way crossed by a route was multiplied by 2. The number of acres within the right-of-way of Class 4-5 was multiplied by 1. The resulting value is based on the number of acres of Class 1-5 soils, with a slight "weight" given to Class 1-3 soils. The higher the value, the more "land capable for agriculture" is crossed.

Intactness gives value to large intact natural habitat areas. Using Forest Resource Inventory data and a defined set of disturbance datasets (High 400m buffer = highways and rail lines, Low 200m buffer = municipal roads, transmission lines, cart tracks and pipelines), intact natural habitat (grassland, wetland, natural forest) polygons equal to or greater than 200 hectares are considered intact habitat. The value provided refers to the number of acres of intact habitat within the proposed right-of-way by a route. Higher values indicate more intact habitat being fragmented.

Seasonal Construction and Maintenance Restrictions refers to the potential difficulty in constructing or maintaining the line based on land use / land cover type. The number of acres of wetlands, forest and agricultural land within the right-of way are multiplied by 50% (0.50), 25% (0.25) and 25% (0.25) respectively, then added together to get a value where the lower the value, the better the construction and maintenance activities can be performed.

Index of Proximity to Existing 500kV Lines refers to the distance of the proposed routes to existing 500kV lines. High values (less preferred for routing) are given to points close to existing lines with values decreasing with increased distance. This value was determined by first converting the study area into a grid of 5m x 5m cells. Each cell was assigned a value, with the value being determined by the distance to the existing 500kv line. The values of the cells that corresponded to the right-of-way of each Route were then summed, and the resulting figure determined the value for the metric. Higher values indicate closer overall proximity and therefore lower system reliability.

SUBJECT AREA: **Traditional Land and Resource Use, None**

REFERENCE: **Chapter 11, Table 11-1**

QUESTION:

According to Table 11-1, Brokenhead Ojibway Nation, Long Plain First Nation, Swan Lake First Nation and Roseau River Anishinabe First Nation all took part in ATK studies and interviews but are not mentioned as completed studies on page 11-2. Can Manitoba Hydro explain this?
On page 11-6 it is indicated that: "Six First Nations have submitted self-directed Project-specific TLU studies: Black River First Nation, Long Plain First Nation, Swan Lake First Nation, Roseau River Anishinabe First Nation, Peguis First Nation and Sagkeeng First Nation." It is also mentioned that discussions have occurred on studies to be undertaken by the Sandy Bay Ojibway First Nation and the Manitoba Metis Federation. Can Manitoba Hydro provide an overall status report on each of the TK studies?

RESPONSE:

Table 11-1 provided the status of First Nation and Metis engagement at the time of filing. Not all communities listed in Table 11-1 decided to undertake a study at the time the EIS was submitted. Since filing the EIS, Manitoba Hydro has continued to offer communities opportunities for engagement on the project. An updated status table is provided below.

Who	Began discussions about conducting TLU Study	Started TLU study	Submitted final report
ATKS Management Team	April 2014	July 2014	May 2015
Dakota Plains Wahpeton First Nation	May 2014	October 2014	September 2016
Dakota Tipi First Nation	April 2014	August 2015	Pending
Manitoba Metis Federation	November 2013	January 2016	Pending
Peguis First Nation	October 2013	September 2014	June 2015
Roseau River Anishinabe First Nation	August 2013	September 2014	July 2015
Sagkeeng First Nation	December 2013	February 2015	March 2016

During the meeting with Brokenhead Ojibway Nation on May 7, 2015, representatives indicated they would like to have a community information session for the Project and the community would decide how to proceed after the session. A community session has not occurred to date; however, Manitoba Hydro continues to provide opportunities for the community to engage in the project and has continued to share project information the project planning progressed. More detailed information on engagement with Brokenhead Ojibway Nation, can be found in Table 4A -6 in the EIS.

Meetings with Sandy Bay Ojibway First Nation have not occurred to date. Manitoba Hydro continues to share project information with the community and provides opportunities for the community to engage in the project. More detailed information on engagement with Sandy Bay Ojibway First Nation, can be found in Table 4A-12 in the EIS.

SUBJECT AREA: **Traditional Land and Resource Use, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

In Chapter 11, Assessment of Potential Environmental Effects on Traditional Land and Resource Use, Manitoba Hydro on page 11-64 makes the following statement with respect to determination of significance:

"There are generally accepted thresholds for TLRU, which makes determining the significance of effects on TLRU challenging."

The sentence appears to be illogical because if there are accepted thresholds it should be relatively easy to determine the significance of effects. Was the statement accurate? If is was, please identify what these accepted thresholds are?

RESPONSE:

This statement in the EIS was incorrect and was corrected as part of an errata submission dated April 29, 2016. The statement should read, "There are no generally accepted thresholds for TLRU, which makes determining the significance of effects on TLRU challenging."

SUBJECT AREA: **Employment and Economy, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

On page 14-46, it is noted that: “Manitoba Hydro expects that the firm export contracts it has signed with five utilities will have a total value of approximately $10.1 billion after 2015”. The reference to this point was a Winnipeg Free Press article from 2015. For the record, could Manitoba Hydro confirm this information based on its own internal calculations and reporting?

RESPONSE:

In Hydro’s view, the question is out of scope of the CEC Hearing. However, on a “without prejudice” basis, see below which is an excerpt from Manitoba Hydro’s response to PUB/MH I-64a during the 2014/15 & 2015/16 General Rate Application for confirmation of this amount.

Table #4 MH Export Contracts After 2015 – Total Revenue

Customer	Contract Name	Status	Capacity Revenue	Energy Revenue	Total Revenue
Minnesota Power	MP 250	Signed			
	MP Energy Exchange	Signed			
	MP 50	Signed			
	MP 133	Signed			
Northern States Power	NSP125	Signed			
	NSP 375/325 SPS	Signed			
	NSP 350 Div. Exchge	Signed			
Wisconsin Public Service	WPS 100 Product A	Signed			
	WPS 100 Product B	Signed			
	WPS 108	Signed			
	WPS 308	Signed			
Great River Energy	GRE Div. Exchange	Signed			
SaskPower	SaskPower 25	Signed			
Total			$1,239M	$8,970M	$10,122M

SUBJECT AREA: **Agriculture, None**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

Section 15.3 describes sources of information and methods of assessment undertaken to assess the potential effects of the Project on agriculture. Sources appear to be largely through desktop review of publicly available information, and through representative agricultural groups and government agencies. Section 15.3.1.4 notes field studies were conducted as follows:

"Systematic observations were made by Stantec staff (windshield surveys) in the RAA for preliminary alternative routes evaluation.

Systematic observations were made by Manitoba Hydro staff (windshield surveys) in the RAA to confirm the locations of agricultural buildings." (p. 15-18)

Further information on the types of observations made would be useful. Were there attempts made to confirm or classify agricultural types of operations based on visible agricultural infrastructure? Was there a standard survey form that Manitoba Hydro utilized when assessing such operations in the field?

RESPONSE:

Stantec staff completed agricultural windshield surveys in the RAA on October 9, 2013, to gain a better understanding of the project area as part of preliminary alternative routes evaluation and not to confirm or classify agricultural operations. Notes were taken during this survey, however a standard form was not used or developed for this data collection as the nature of the data collection did not necessitate one.

The identification of livestock operations was primarily conducted via "desktop" means as outlined in Section 15.4.4. Specific livestock operation location-data were obtained from industry associations representing hog, dairy and broiler chicken and broiler-breeder operations. However, industry associations representing beef, egg and turkey producers did not provide livestock operation location data for member confidentiality reasons. Manitoba Beef Producers and Manitoba Turkey Producers provided numbers of operations by RM or town while Manitoba Agriculture, Food and Rural Development (MAFRD) provided numbers of beekeeping operations by RM. Following their review of the Final Preferred Route, Manitoba Beef Producers broadly indicated that the New ROW will traverse some cattle producers' operations (Cousins 2015, pers. comm.).

Additional information on livestock operation locations was gathered through the public engagement process (PEP) and key person interviews (KPIs) to further strengthen the confidence in the identification of livestock operations. During the PEP, some landowners provided the legal land locations of their livestock operations.

The data sources described above were supplemented with a review and interpretation of the geospatial buildings inventory database developed by Manitoba Hydro, which was validated through windshield surveys, and review and interpretation of aerial imagery by the assessment team to identify and characterize livestock operations, particularly for those operation types for which location data were not available. Manitoba Hydro's windshield survey protocol started with the development of a buildings inventory database class by digitizing building locations from various sources of building information and digital imagery. Manitoba Hydro validated the buildings inventory by conducting windshield surveys using ESRI ArcGIS Collector and tablet technology. Where accessible all public roads were traveled within the route planning area to validate locations and inventory newly constructed visible buildings.

Windshield surveys undertaken by Manitoba Hydro during the route selection process and additional desktop review was considered sufficient for the assessment of effects on livestock operations. The windshield survey identified agricultural buildings/operations, and information provided by industry stakeholders on livestock location by type and additional desktop review including aerial imagery analysis provided current information on type and intensity of livestock operations. This information was adequate to assess effects of the Project on livestock operations to support the EIS. Therefore, additional field surveys were not conducted because they would not have resulted in additional information that would have influenced the outcomes of the assessment. Effects and mitigations were identified at an appropriate scale and in consideration of the types of livestock operations identified within the local assessment area.

As indicated in Section 15.4.4.5, Manitoba Hydro will continue communicating with affected landowners to identify types of operations as necessary throughout the planning process. Through these discussions, Manitoba Hydro, may identify additional site-specific mitigation measures based on identified effects on individual operations. As indicated in section 15.10, additional discussions are planned to be held with landowners regarding avoidance of specific features (e.g., manure application drag hose infrastructure), including through tower location spotting.

References:

Cousins, Maureen. 2015. Policy Analyst. Manitoba Beef Producers, Winnipeg, Manitoba. Email correspondence regarding feedback on Final Preferred Route for Manitoba-Minnesota Transmission Project with Wara Chiyoka, Soil Scientist, Stantec Consulting Ltd., Winnipeg, MB, February 17, 2015.

SUBJECT AREA: **Agriculture, Infrastructure and Services**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

It appears that there is no geospatial data in Manitoba on fields that have drainage infrastructure. Is that correct?
Section 15.5.3.1.1 notes interference with or damage to tile drainage infrastructure as a potential concern. As this can be a potentially costly issue for agricultural operators to correct, does Manitoba Hydro have in place information to identify fields with drainage infrastructure prior to construction? How would this be handled?

RESPONSE:

There was no publicly-available information about tile drainage infrastructure locations found by the study team during the assessment of effects on agriculture. Information for permitted tile drainage projects was requested from Manitoba Conservation and Water Stewardship's (MCWS; now Manitoba Sustainable Development) Drainage and Water Control Licensing department, but no feedback was received as of the EIS filing date (Reimer 2015, pers. comm.).

If present in the project development area (PDA), tile drainage systems could be damaged during construction, primarily as a result of tower foundation installation and heavy equipment movement.

Throughout Round 3 of the public engagement process, agriculture related questions were asked of landowners potentially affected and those within one mile of the proposed transmission line. When information regarding whether a landowner has tile drainage was provided, it was documented on the landowner documentation form completed with a Manitoba Hydro representative at public events. Communication and discussions continue with potentially affected landowners, further information collected can be incorporated into the Construction Environmental Protection Plans.

Specific mitigation to reduce the potential for damage to tile drainage systems could include tower location spotting developed in cooperation with landowners (who would be required to help identify specific tile line locations in relation to the project).

If damage occurs to a landowner's tile drainage system as a result of the project, compensation may be provided under Manitoba Hydro's Manitoba-Minnesota Transmission Project Landowner Compensation Program (found in Appendix 15C).

As discussed in section 15-9 (p. 15-104), the Environmental Monitoring Plan will be used to evaluate the success of post-construction land rehabilitation. This will include landowners confirming the success of repairs to tile drainage systems damaged by construction activities.

SUBJECT AREA: **Agriculture, Public Engagement**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

Section 15.2 identifies spatial and temporal boundaries used for the agricultural assessment. The boundaries identified are appropriate, including the use of 1 km buffer for the boundaries of the LAA and the inclusion of full municipal boundaries as part of the RAA noting socio-economic relationship of communities potentially affected by the Project. Were any agricultural community groups or rural organizations beyond those agricultural industries represented identified and/or engaged with on the LAA boundary? If not, why was this the case? Were any concerns expressed about this?

Section 15.3.1.3 identifies organizations the study team selected to represent the interests of the broad agricultural industry within the RAA. How were representative associations identified? Were there other types of agriculture or agricultural groups with less broad representation that were not selected (e.g. specialty seed producers, other livestock types) and if so why were they not included?

RESPONSE:

The rationale for the Local Assessment Area (LAA) which was used to assess project effects on agriculture is provided in Section 15.2.1. The LAA included all components of the Project Development Area (PDA) and consisted of a 1-km buffer from the ROW centerline for the transmission line and a 1-km buffer around all station footprints. These LAA areas cover an area that generally encompasses the basic field management unit most commonly used within the RAA – the quarter section; a land area of 800 m x 800 m. By extending beyond the quarter section dimensions, the 1-km buffer used for the LAA is conservative - a scenario that favored the capturing of the likely extent of potential Project interactions with agriculture. Based on review of past similar projects' assessment boundaries as well as the assessment team's understanding of agricultural management units within the Project area, the engagement of stakeholders on the LAA boundary was not considered necessary. The assessment team is not aware of any concerns raised because of this.

Through its comprehensive public engagement process (PEP), Manitoba Hydro engaged with many groups that had interest in the Project. These groups are outlined in Appendix 5A and others have been added as the PEP progressed. The following agricultural groups were invited to participate in the PEP process.

- Hylife and subsidiary companies
- Maple Leaf
- Keystone Agricultural Producers (KAP)
- Manitoba Aerial Applicators Association (MAAA)
- Beef Producers of Manitoba
- Manitoba Agriculture, Food, and Rural Development (MAFRD)
- Organic Producers Association of Manitoba (OPAM)
- Bipole III Coalition

Landowner Information Centres were established during Round 3 of the public engagement program to facilitate meetings with potentially affected landowners. The purpose of these meetings was to collect detailed property information from potentially affected landowners and those located within one mile of the preferred route, in a one-on-one setting, to inform the environmental assessment and route determination processes, including agricultural-specific information to support the assessment.

The study team requested information on locations of livestock operations from the following producer representative organizations and kept informed through the PEP

    - Manitoba Pork Council
    - Dairy Farmers of Manitoba
    - Manitoba Beef Producers
    - Chicken Producers of Manitoba
    - Manitoba Egg Producers

  - Manitoba Bee Keepers Association, and
  - Manitoba Turkey Producers;
- Locations of the following livestock operations from MAFRD to supplement data from producer representative organizations
  - Beef
  - Turkey
  - Bee keeping, and
  - Bison
- Locations of organic operations from the Organic Producers Association of Manitoba; and
- Locations of fruit farms from the Prairie Fruit Growers Association.

The study team received livestock operations location information from organizations representing hog, dairy, and broiler chicken and broiler-breeder operations (i.e., Manitoba Pork Council, Dairy Farmers of Manitoba, and Chicken Producers of Manitoba, respectively). Manitoba Beef Producers, Manitoba Egg Farmers, and Manitoba Turkey Producers as well as MAFRD did not provide livestock operation location data for confidentiality reasons. The latter three provided information on the number of egg, turkey, and apiary operations by RM or town. The Prairie Fruit Growers Association did not have location information of their members' operations by RM and redirected the study team to the organization's website which shows locations of and directions to the farms (Thiessen 2014, pers. comm.). The Organic Producers Association of Manitoba indicated not having members in the Project area (Rogalsky-Tapp 2014, pers. comm.).

Using a combination of desktop review of past Manitoba Hydro project stakeholder groups, Project-wide PEP preliminary findings and internet search, producer representative groups with known or potential for members in the Project area were identified by the study team and contacted for key person interviews (KPIs). The KPIs focused on the collection of information related to current and future agricultural activities and information required to define and evaluate Project effects on agriculture and supplement other baseline information. Agricultural

KPIs were undertaken with seven organizations deemed to represent the broad agricultural industry interests within the regional assessment area (Section 15.3.1.3 – Volume 3, Chapter 15)

Manitoba Hydro understood that it may not be possible to capture all potentially interested groups while undertaking the preliminary stakeholder group identification process. To capture those potentially overlooked, Manitoba Hydro used notification methods as outlined in Section 3.4.3 and welcomed any interested individual or group to contact Manitoba Hydro.

References:

Rogalsky-Tapp, Linda. 2014. Administrative Assistant. Organic Producers Association of Manitoba (OPAM), Miniota, Manitoba. Email correspondence confirming the absence of OPAM members in the Manitoba-Minnesota Transmission Project area with Wara Chiyoka, Soil Scientist, Stantec Consulting Ltd., Winnipeg, MB, December, 22, 2014.

Thiessen, Waldo. 2014. Executive Director. Prairie Fruit Growers Association, Altona, Manitoba. Email correspondence regarding the locations of fruit-growing operations in the project area for the Manitoba-Minnesota Transmission Project with Wara Chiyoka, Soil Scientist, Stantec Consulting Ltd., Winnipeg, MB, October, 23, 2014.

SUBJECT AREA: **Vegetation and Wetlands, None**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

Manitoba Hydro noted proposed amendments to The Noxious Weeds Act in Section 15.1.1.3 and the current absence of legislation specifically governing clubroot and other soil-borne diseases. It is noted that the proposed changes to the Act will provide for some mitigation with respect to biosecurity (i.e., in terms of cleaning of equipment travelling through agricultural fields). If the Act is not passed or is not passed in time prior to the commencement of MMTP will Manitoba Hydro adopt such mitigation to address the possible effects anyways?

RESPONSE:

Manitoba Hydro has an Agricultural Biosecurity Standard Operating Procedure (SOP) which exceeds current Manitoba legislation and leads the construction and utility industry in setting the benchmark for biosecurity practices in Manitoba. The SOP can be found in the EIS with the most current version available under “Additional materials” on this page https://www.hydro.mb.ca/projects/mb_mn_transmission/document_library.shtml.

SUBJECT AREA: **Agriculture, None**

REFERENCE: **CEC MMTP Round 1 IRs - Part 1**

QUESTION:

Section 15.4.4.2 discusses mentions of concerns with respect to liquid manure spreading but little discussion is included. How might Project activities impede/affect manure spreading activities? Can appropriate mitigation measures be identified to address this concern?

RESPONSE:

The Project has the potential to affect manure application and spreading activities. Mitigation measures have been identified to reduce the potential for these effects.

Construction activities have the potential to interact with manure application and spreading by limiting the field area available for application or reducing access to field areas that require traversing the ROW. Interference with liquid manure application systems, including surface drag hoses, and potential disturbance or damage to other associated infrastructure by construction activities could also occur (Section 15.5.3.1.1; p. 15-74).

As discussed in section 15.5.3.1.2 (p. 15-81), there are up to 20 hog and dairy operations within the LAA that produce liquid manure waste that may be applied by draglines on surrounding fields. The potential for interference with maneuvering liquid manure application drag line systems is greater than with more simplistic solid manure spreading or liquid manure application using tank-based injection equipment. During Project operations, the presence of towers may affect the use of equipment including maneuvering liquid manure application drag line systems, controlling the direction of application and maintaining efficient fieldwork patterns (Section 15.5.3.1.2).

Such limitations may increase equipment maneuvering requirements and increase the time and labour needed for manure application and spreading. However, a study undertaken by PAMI

(2015) indicates that there would likely be no changes in dragline practices with straight-line transmission line configurations other than reduced footprints associated with the tower footprints. For diagonal transmission line configurations, two different application starting points would be required as well as additional time and labour to maneuver around towers (PAMI 2015; see Figure 3-6, below).

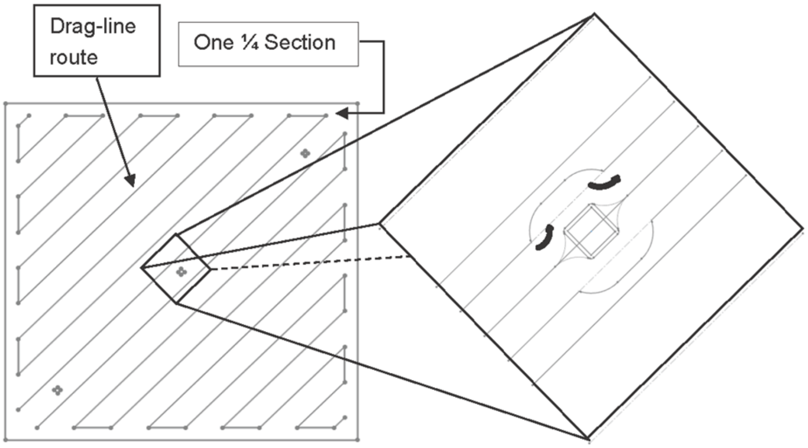

Figure 3-6. Route taken with a dragline manure injector for Scenario 3 (field divided) with close-up of 30ft implement pass of a steel tower.

Manitoba Hydro will use self-supporting towers in agricultural areas that will reduce the infrastructure footprint, thus limiting effects on agricultural activities. As discussed in Section 15.3.2.1 (p. 15-85), prior to construction, if landowners identify the location of manure application draglines, they will be considered when tower siting, where possible, to reduce effects. Ongoing, planned communication between Manitoba Hydro, contractors and landowners will help identify concerns related to manure spreading and application specific to individual operations and can provide the information necessary to further reduce the potential for effects related to interactions with the Project.

The effects of the project on manure application and spreading are anticipated to occur irregularly and be of short-term in duration if they occur.

Compensation provided according to the Manitoba-Minnesota Transmission Project Landowner Compensation (see Appendix 15C) includes Structure Impact Compensation, which covers losses of land permanently removed from production and additional time required to maneuver farm machinery around Project structures.

SUBJECT AREA: **Agriculture, Livestock operations**

REFERENCE: **CEC MMTP Round 1 IRs**

QUESTION:

Section 15.4.4 notes data collection on livestock operations was undertaken via desktop review and through the PEP. Were surveys to identify/confirm farm operations undertaken? If not please explain why. This could also have assisted in confirming desktop data interpretation as Table 15-14 notes a high proportion of Unclassified operations within both existing and new ROW.

RESPONSE:

Please refer to the response for CEC-IR-026.

In addition, the data sources described were supplemented with a review and interpretation of the geospatial buildings inventory database developed by Manitoba Hydro, including validation through windshield surveys (Manitoba Hydro 2014a). Additionally, aerial imagery (Google Earth imagery, Google Street View and aerial photos accessed from MLI [2009, 2010, 2011]) interpretation conducted by the assessment team was used to identify and characterize livestock operations, particularly for those operation types for which location data were not available. This included assessing such visual indicators as building types, presence of lagoons and manure storage, and land use/ground patterns (e.g., livestock trails).

Additional surveys or data collection were not conducted beyond those activities documented above and in Chapter 15 and the Socio-Economic Technical Data Report. The level of information obtained through desktop review was considered sufficient for the assessment of effects on livestock operations. Additional field surveys would not have influenced the conclusions of the assessment. Effects and mitigations were identified at an appropriate scale and in consideration of the types of livestock operations identified within the local assessment area. Desktop characterization of the unclassified operations (see Section 15.4.4.5; p. 15-51) resulted in conclusions that these operations are likely or might be cattle or feedlots, hog, equine or chicken operations, or, in some cases, unlikely to be livestock operations or active livestock operations. The unclassified operations likely to represent some type of livestock production were expected to be associated with types of operations considered in the environmental baseline and effects assessment for agriculture. Knowing the operation type would not have resulted in a change in the assessment as the effects to these operation types have already been considered and assessed.

SUBJECT AREA: **Agriculture, Organic/specialty operations**

REFERENCE: **MMTP CEC Round 1 IRs**

QUESTION:

Specialty agricultural operations such as organic production are noted in Section 15.4.5. Will proximity of these operations to Project activities potentially impede future organic production or potential for certification? The same question applies to other specialty operations (Section 15.4.5.1.2).

RESPONSE:

The Organic Producers of Manitoba (OPAM) do not have registered organic producers within the 11 Rural Municipalities (RMs) that are traversed by the project, and there were no lands identified as actively under organic production by landowners during the public engagement process. However, at meetings in La Broquerie, one landowner indicated organic orchid development as a potential land use while another landowner expressed a desire to make their land organic.

Per the OPAM website (http://www.opam-mb.com/Certification.html), and in line with the National Standard of Canada on organic production systems (Government of Canada 2015), a 36-month period without use of prohibited inputs (e.g., fertilizer, herbicide, etc.) should be fulfilled for land transitioning to organic production in pursuit of organic certification. According to certification requirements provided by OPAM, there are none that relate to the presence of, or proximity to, transmission line developments. The Standard also requires a buffer zone of at least 8 m or other physical barrier to minimize the physical movement of prohibited substances onto organic lands from adjacent areas.

As per Manitoba Hydro’s Landowner Compensation Policy (Appendix 15c) landowners are responsible for weed control within their agricultural lands traversed by the ROW, and can select appropriate control methods at their discretion. It is Manitoba Hydro’s standard practice to notify landowners along the ROW of vegetation management activities, including the use of herbicides. Manitoba Hydro will continue to work with identified organic producers to take their operations and the National Standard into consideration when developing integrated vegetation management strategies on the ROW. No impediments to organic production or certification are expected.

The following specialty operations were identified as partially or wholly occurring within the LAA but outside of the project development area (PDA):

- one aquafarm east of PTH 12 in the RM of Springfield
- one aquafarm which also produces fruit and vegetables in the RM of Ste Anne, and
- one fruit farm producing berries in the RM of La Broquerie located 100-400 m away from an alternative route segment.

There are no known active specialty operations within the PDA, and this precludes the potential for permanent loss of land from current specialty operations. Future specialty operations as described above can be designed to be compatible with a transmission line ROW. Manitoba Hydro, when requested by landowners, will provide applicable guidance on a case by case basis to assist in the development of compatible specialty operations.

References:

Government of Canada. 2015. National Standard of Canada – Organic production systems; General principles and management standards. CAN/CGSB-32.310-2015