RESULTS OF FACILITIES STUDY FOLLOWING MODULE B PROCESS

FOR MIDWEST ISO (MISO)

MANITOBA HYDRO TSR 500 KV OPTION 1

May 11, 2010

Submitted by
Jared Alholinna, CapX2020
Chris Ayika, PE, Xcel Energy

EXECUTIVE SUMMARY

This report contains the results of the Facilities Study performed by Great River Energy, Minnesota Power Company, Otter Tail Power Company and Xcel Energy on Midwest ISO (MISO) Project MH TSR 500 kV – Option 1 for adding 1100 MW of hydro generation from Manitoba, Canada to the upper Midwest US. The generation will interconnect via DC transmission at the Manitoba Hydro Dorsey Substation in Canada and will be connected to the MISO transmission system at the Bison and Helena Substations via a 500 kV AC transmission line. Manitoba Hydro is preparing the facilities study for the facilities north of the Canadian Border; therefore they are not a part of this study.

The customer requested completion date is December, 2017 and this study shows this date to be achievable if the agreement is executed prior to July 1, 2010. The total length of time to complete the network upgrades is estimated to be 90 months (7.5 years) from the execution of a Multiparty Facilities Construction Agreement (MPFCA). This study is contingent upon one or more earlier queued MISO facilities.

The estimate contained in the study is a ± 20% estimate according to the Module B process. Given the assumptions stated in this report, the total estimated cost for all upgrades to facilitate the Transmission Service Request (TSR) is **$1,463,690,000**. This estimate has been broken down in the **Network Upgrades** (Table 1).

Facilities Study Assumptions

These are Transmission Owners' best estimates of cost and lead-time for the project. However, there will be many factors that influence actual costs and these duration estimates, such as: construction requirements of permitting authorities to secure approvals; unexpected increases in material costs; unexpected increases or changes in labor charges; permitting authorities and required siting approvals; inclement weather and other acts of god; equipment delivery; company and non-company labor scheduling and availability; ability to schedule outages on the electric systems of the transmission owners and other electric companies; emergencies occurring on the systems of transmission owners or other electric companies; and other factors not specifically identified here.

For the purposes of this study estimate, the following assumptions have been made:

General

- The proposed 500 kV AC transmission line examined in this study will be from the U.S./Canada border to the CapX2020 Bison Substation to the CapX2020 Helena Substation with 50% series compensation located near the mid-line location of the Dorsey–Bison and Bison – Helena transmission line segments. The MISO facility study request specifically identified 500 kV terminals at the CapX2020 Bison and Helena Substations. Manitoba Hydro supplied a preliminary US/Canada border crossing location.
- All related CapX2020 transmission and substation facilities including the Bison and Helena Substations have been constructed and are in-service prior to construction initiation of the projects identified herein.
- The duration of the project identified herein is based on an aggressive routing, permitting, right-of-way and construction schedule. Delays caused by permitting procedures, land acquisition, material availability and construction labor availability can significantly impact the schedule of this project.

- Due to the projected lead times required to acquire the necessary permits and right-of-way for the proposed 500 kV transmission line, transmission line construction would need to be completed in approximately 3-1/2 years to meet the requested in-service date. To complete construction of this transmission line in the 3-1/2 year duration, it is anticipated that the transmission construction crews would consist of 174 men working 365 days per year for a total of 222,512 man-days.
- Ownership of the proposed transmission and substation facilities has not been determined at the time of this study. No financing charges have been included because the project funding mechanism has not been identified at this time. Determination of the ownership of these facilities and individual financing requirements may impact the scope, schedule and cost of project.
- Further coordination of construction, operation and maintenance of these facilities will be required with the transmission owners and Manitoba Hydro.
- All required MISO system studies have not been completed at the time of this study. This study assumes reactive support and other operational systems similar to those installed on the existing Dorsey-Forbes-Roseau-Chisago 500 kV Transmission Line.
- Sub-Synchronous Resonance (SSR) Studies have not been performed. These studies will be required to identify any special protection systems requirements.
- Thyristor controlled 50% series compensation (series capacitor bank) for the each 500 kV transmission line, Dorsey-Bison and Bison-Helena has been included in this study.
- No impacts to the transmission system facilities outside of the Bison and Helena Substations have been studied.
- The cost estimating methodology includes generalized material, labor and overheads. Availability in material and labor over the project period can significantly impact this project.
- Publicly available aerial survey and broad geotechnical information was used for this study. Variations in this information may be identified when the exact location of these facilities is determined. The exact locations may have a significant impact on the cost and construction requirements of these facilities.
- Escalation costs have been included in the substation and transmission line estimates due to the long duration required to complete this project. The escalation was calculated from the Handy-Whitman Public Utility Construction Index published by Global Insight. It is assumed that the construction sequencing of the facilities is from North to South. The calculated escalations range from 20% to 27%.

Substations

- The CapX2020 Bison and Helena Substations are installed and operating. The Bison and Helena Substation expansions are based on the CapX2020 plan at the time of this study. It is assumed that the land purchased for these two substations allows for the expansion required for the 500 kV and 345 kV installations contained herein. Costs to purchase the additional land are included in this study.
- Provisions for future 500 kV line terminals are not included in this study.
- Because exact locations for these substations are not identified at this time, generic site development requirements such as access road, site drainage, suitable grading materials and landscaping are included. The cost estimates for the foundations at the North Series Cap Bank and Bison Substation accommodate for poor soils within the Red River Valley. The exact requirements of each site may impact the scope, cost and schedule of the project.

- Typical foundation types for substation equipment like slab on grade and drilled shafts have been assumed. No piles or spread footing foundations are anticipated except where noted.
- The substation construction schedule has been developed to meet the requested in-service date with direct correlation to each substation's associated transmission line construction. Additionally, the start dates have been established to perform grading and site development during the summer and early fall months to accommodate the most ideal grading conditions. Delays in the MPFCA execution will require revision to the grading schedule.
- The relaying communications for the transmission line protection will need to be coordinated with Manitoba Hydro. This study assumes fiber optic communications via transmission line shield wire for one channel and power line carrier communications for the second channel.
- Each 500 kV series capacitor bank will be located mid-line of the Dorsey-Bison transmission line and the Bison-Helena transmission line. They will be sized for 2000 amp continuous capacity and have electrical characteristics to provide 50% compensation for their respective transmission line length. Further studies to identify the exact electrical characteristics to provide optimal power transfer will be required.
- A +/- 400 MVAR 500 kV Static VAR Compensator (SVC) has been included at the Bison Substation per direction from MISO. Further studies will be required to determine the requirements of the SVC.
- A DC reduction scheme similar to the existing Dorsey-Chisago 500 kV transmission line is required for this project. Costs for a dedicated relay panel and protection equipment has been included. The exact requirements will need to be coordinated with Manitoba Hydro.
- The substation construction estimates include a 10% contingency on labor. "Budgetary" pricing for major equipment such as series capacitors, shunt capacitors, reactors, transformers, SVC's, circuit breakers, switches, etc. were obtained. No contingency was added to these material costs. A 10% contingency was added to all other material estimates.
- Black start generation for emergency station auxiliary power has been included at all four stations.

<u>500 kV Transmission Line</u>

- Preliminary transmission line design was completed using Power Line Systems, Inc. PLS-CADD Version 10.40 software.
- Publicly available aerial survey (LIDAR) data was used to generate ground line profile. Aerial survey data was obtained from the International Water Institute and County available data. USGS survey data was used for some areas of line segment 2B.
- Survey data included only ground elevation information. No aerial obstacle (tree, existing distribution/transmission line crossing, etc.) elevation data was included. Once the transmission line route has been determined, a full aerial survey (LIDAR) will be required for final line design to verify clearances to ground and all aerial obstacles.
- Transmission line conductor shall be 3-conductor bundle 1192.5 kcmil 45/7 "Bunting" ACSR with 18 inch sub-spacing. This conductor is the same as the existing Dorsey - Chisago 500 kV transmission line.
- Transmission line shield wire shall be 7 no. 7 Alumoweld and 48 fiber OPGW. A shielding study will be required once the line route and structure type has been finalized in order to verify the shield wire is sized to meet fault current requirements.
- Four (4) structure families were evaluated for the transmission line; guyed steel lattice structures, self-supporting steel lattice structures, self-supporting tubular steel h-frame structures and self-supporting tubular monopole structures. The self-supporting steel

tubular h-frame structures were decided upon by Permitting and Land Rights and Engineering due to the relative assumed ease of permitting and land acquisition for this structure type while also considering structure costs.. Approximate structure weights and steel cost per pound were supplied by steel pole manufacturers based on similarly designed steel structures. This estimate is based on the self-supporting galvanized steel tubular h-frame structure family.

- All steel structures will be designed to NESC Grade B Construction "Heavy Loading" per NESC Section 250.
- Reliability based load cases have been included to accommodate extreme ice with concurrent wind and extreme wind loading.
- Special load cases have been included to accommodate deflection criteria, unbalanced ice loading, broken wire loading, failure containment and construction and maintenance loading.
- A high intensity wind load case has been included that simulates the wind speed of a tornado. This load case shall be applied to the structures only, not to the spans and wires.
- Failure containment structures have been spotted at intervals not exceeding ten (10) miles.
- Transposition structures will be required every 60-75 miles in order to maintain the transmission line end-to-end voltage imbalance less than 1%. Costs for transposition structures are not included in this estimate.
- Steel structures will be grounded using 1/0 copper ground wire to copperweld ground rods. Shield wire and OPGW shall be bonded to structures using #4 stranded copper. The desired ground resistance shall be 10 ohms but the maximum ground resistance shall be 25 ohms. Ground resistivity testing will be required once the line route and structure type have been finalized.
- Insulators will be porcelain or toughened glass bells for suspension (x26) and dead end (x28) applications. Coordination with Manitoba Hydro to verify same insulation levels will be required.
- Air gap will be equivalent to the number of insulators. Coordination with Manitoba Hydro to verify air gap dimensions will be required.
- Minimum clearance requirements have been defined by Section 23 of the NESC C2 2007. Clearance criteria not listed shall be applied per Section 23 of the NESC C2 2007.
- The assumed right-of-way width is 200 feet. 100 feet either side of transmission line centerline. The line will be designed to fit within the new easements.
- A geotechnical investigation (soil borings) was not completed as part of this study. A local geotechnical engineering firm was contracted for foundation recommendations based on the proposed transmission line corridor and estimated structure base reactions.
- The Red River Valley will be the hardest area for the transmission line to traverse due to the large variation in depth to firm bearing soils (80 feet to 180 feet possible).
- Three (3) foundation designs were estimated based on the geotechnical engineering recommendations.
    - Poor Soil – Located within the Red River Valley.
        - Poor soil structures shall be supported by driven pipe pile with concrete pile cap foundations.
    - Medium Soil – Located at the edges of the Red River Valley
        - Medium soil structures shall be supported by a combination of driven pipe pile with concrete pile cap and deep drilled concrete pier foundations.
    - Good Soil – Outside of the Red River Valley.

        - Good soil structures shall be supported by average drilled pier concrete pier foundations.
- The proposed 500 kV transmission line has been divided into four (4) segments. The following lists the foundation designs estimated in this study per line segment.
    - Segment 1A – US/Canada Border to the Proposed North Series Cap Bank
        - Structures located within the Red River Valley. Depth to good bearing soil ranges from 100 feet to 180 ft. All structures estimated to be on driven pipe pile with concrete pile cap foundations. It is estimated that 100% of the foundations will be driven pipe pile with concrete pile cap for this line segment.
    - Segment 1B – Proposed North Series Cap Bank to Bison Substation
        - Structures located within the Red River Valley. Depth to good bearing soils ranges from 80 feet to 140 feet. Tangent and light angle h-frame structures estimated to be on deep drilled pier foundations. Heavy angle and dead end 3-pole structures estimated to be on driven pipe pile with concrete pile cap foundations. It is estimated that 94% of the foundations will be deep drilled pier and 6% will be driven pipe pile with concrete pile cap for this line segment.
    - Segment 2A – Bison Substation to the Proposed South Series Cap Bank.
        - Structures located between the Bison Substation to Southeast of Donnelly, MN.
            - Depth to good bearing soils ranges from 80 feet to 100 feet. Tangent and light angle structures estimated to be on deep drilled pier foundations. Heavy angle and dead end structures estimated to be on driven pipe pile with concrete pile cap foundations. It is estimated that 93% of the foundations will be deep drilled pier and 7% will be driven pipe pile with concrete pile cap for this section of the line segment.
        - Structures located between Southeast of Donnelly, MN to the South Series Cap Bank.
            - Depth to good bearing soil ranges from 30 feet to 50 feet. All structures estimated to be on average depth drilled pier foundations. It is estimated that 100% of the foundations will be average depth drilled pier for this section of the line segment.
    - Segment 2B – Proposed South Series Cap Bank to the South Helena Substation
        - Structures are located in good soil conditions. Depth to good bearing soils ranges from 30 feet to 50 feet. All structures estimated to be on average depth drilled pier concrete foundations. It is estimated that 100% of the foundations will be average depth drilled pier for this line segment.
- Complete geotechnical investigation and final foundation design will be required once the line route and structure design has been finalized.
- It is anticipated that the proposed transmission line will require approximately 59,250 tons of tapered tubular steel for the proposed structures.
- It is anticipated that the proposed transmission line will require approximately 4,293 miles of 1192.5 kcmil 45/7 "Bunting" ACSR conductor.
- Transmission line construction estimates include a 10% contingency on labor and materials.
- Due to construction being completed in a compressed time frame to meet the requested in-service date, construction management costs have been included in the estimates. The

estimated construction management was assumed to be twelve (12) people required for the duration of construction.

Permitting and Land Rights

- The proposed 500 kV transmission line will be constructed within a 200 foot right-of-way.
- The estimated length of the project is approximately 477 miles.
- There will be one construction staging/laydown area every 25 miles.
- An additional 80 acres will be acquired at the future CapX2020 Bison Substation.
- An additional 40 acres will be acquired at the future CapX2020 Helena Substation.
- The locations of the future CapX2020 Helena and Bison Substations are subject to the approval of these facilities through other proceedings before the North Dakota Public Service Commission and the Minnesota Public Utilities Commission.
- Up to 40 acres will be acquired for each of the two intermediate series capacitor banks.
- The project will be constructed as concurrent construction segments or spreads, to the extent feasible, beginning in North Dakota.
- The first 48 months of the project include permitting and land rights activities leading to the start of construction along the first construction segment.
- Permitting activities within the first 48 months include strategic planning, communications, intensive agency coordination, routing, stakeholder and public involvement, field studies and surveys, preparation of permit applications, support of regulatory review processes, and legal services.
- Permitting and land rights activities will continue beyond the first 48 months. Permitting activities will continue to overlap with engineering and construction activities during the remainder of the project schedule.
- The 48-month timeline leading to start of construction along the first construction segment is largely dependent on agency concurrence regarding the anticipated permitting approach, in addition to agency reviews and approvals being completed as anticipated within the identified timeline.
- The most significant federal approval that will be required for the project is a Presidential Permit, which includes a federally led environmental impact assessment. The Presidential Permit is anticipated to be issued in no less than 2.5 years beyond submittal of the application for this permit. This permit will be required along with various other federal approvals.
- The most significant state approvals that will be required for the project, and must be obtained prior to the start of construction, include Route Permits from both the North Dakota Public Service Commission and the Minnesota Public Utilities Commission and North Dakota legislative approval. These approvals will be required along with various other state approvals, including other approvals from the two state commissions. A Certificate of Public Convenience and Necessity, Certificate of Corridor Compatibility, and Route Permit from the North Dakota Public Service Commission are anticipated to be separately approved in a two-year timeframe beyond submittal of the first application. A Certificate of Need and Route Permit from the Minnesota Public Utilities Commission are anticipated to be separately approved in less than a 2.5-year timeframe beyond submittal of the first application.
- Other federal, state, and local permit approvals not specifically identified above are anticipated to be obtained through multi-step or tiered approvals as environmental field studies and land rights activities that must be completed in advance of the submittal of

permit applications cannot be realistically completed contiguously from one end of the project to the other at one time to meet the stated in-service date.

- Environmental field surveys will be sequenced with construction segments to the extent feasible. However, surveys will be subject to timing of regulatory approvals, seasonal constraints, and permission to access property.
- Environmental field surveys are assumed to be conducted specific to areas of temporary and permanent ground disturbance.
- The estimated permitting and land rights costs do not include the following permits or compliance measures as these permits are either included within the estimated engineering costs or intentionally excluded from this estimate: National Pollutant Discharge Elimination System Permit, Stormwater Pollution Prevention Plan, environmental restoration, standard mitigation measures or best management practices implemented by construction personnel during construction; environmental monitoring and inspection during construction; local road permits such as oversize/overweight permits or driveway access permits; and compliance with air and noise quality standards during construction.
- The estimated permitting and land rights costs do not include any costs associated with compensatory mitigation or acquisition of mitigation lands.
- The estimated permitting and land rights costs do not include any potentially required pre-activity clearance surveys.
- The estimated permitting and land rights costs do not include the environmental survey of any required construction access outside of the right-of-way.
- The 48-month duration leading to start of construction along the first construction segment can only occur if there is no condemnation required for properties along this segment.
- Landowner contacts, permission to access property for natural resource and geotechnical surveys, and right-of-way acquisition will overlap with permitting activities during Phase I of the project. This assumes initiating landowner contacts in advance of an approved Route Permit in North Dakota (beginning in month 18) and following the ALJ Recommendation associated with the Route Permit in Minnesota (anticipated to be issued in month 36).
- The 48-month duration for permitting and land rights activities leading to start of construction along the first construction segment is based on current processes and procedures in both North Dakota and Minnesota.
- Minnesota's quick-take provision is assumed to be no more than 90 days.
- Right-of-way acquisition is anticipated to be completed in North Dakota in 4.5 years, based on an assumed availability of land agents. This assumes a 12-18 month duration beyond the approval of the Route Permit, which includes the potential for condemnation.
- Right-of-way acquisition in Minnesota is anticipated to be completed in Minnesota in less than 5.5 years, also based on assumed availability of land agents. This assumes a 12-24 month duration beyond the approval of the Route Permit, which includes the potential for condemnation.
- The estimated land rights cost does not include escalation of land values only labor.
- The 48-month timeline leading to start of construction along the first construction segment assumes North Dakota legislative approval will occur in 2013, in accordance with the current biennial session schedule.

These assumptions are provided in more detail, along with other assumptions, in the Permitting and Land Rights section of this Facilities Study.

A. Network Upgrades

These are additions, modifications and upgrades to the transmission to accommodate the TSR.

1) Transmission Owner Network Upgrades

The identified network upgrades consist of expansions of two (2) existing substations, two (2) new series cap station sites and approximately 477 miles of new 500 kV transmission line.

Bison Substation:

Expand the CapX2020 345-230 kV Bison Substation to accommodate two 500 kV transmission line terminals, one 500 kV +/-400 MVAR SVC, two 500 kV 300 MVAR shunt capacitor banks, one 500 kV 150 MVAR shunt reactor installed on the Dorsey transmission line, one 500 kV 225 MVAR shunt reactor installed on the Helena transmission line and one 500-345 kV 1200 MVA transformer. The 500 kV bus will be constructed in a 2000 amp, four position ring configuration with four 500 kV circuit breakers and associated bus, switches, arresters, structures, foundations, cabling and grounding. The 500 kV shunt reactors will be installed directly on the transmission line terminals. The 345 kV bus will be expanded to a 2000 amp, four row breaker-and-a-half configuration with five new 345 kV circuit breakers and associated bus, switches, structures, foundations, cabling and grounding. An additional electrical equipment enclosure will be added for the 500 kV control, protection and communication equipment. The transmission line protection will consist of an unblocking scheme over power line carrier communications for the primary relaying and a permissive scheme over fiber optic shield wire communications for the secondary relaying.

Helena Substation:

Expand the CapX2020 345 kV Helena Substation to accommodate one 500 kV transmission line terminal, one 500 kV 225 MVAR shunt reactor installed on the Bison transmission line and two 500-345 kV 1200 MVA transformers. The 500 kV bus will be constructed in a 2000 amp, three position main bus configuration with three 500 kV circuit breakers and associated bus, switches, arresters, structures, foundations, cabling and grounding. The 500 kV shunt reactors will be installed directly on the transmission line terminal. The 345 kV bus will be expanded to a 2000 amp, five row breaker-and-a-half configuration with seven new 345 kV circuit breakers and associated bus, switches, structures, foundations, cabling and grounding. An additional electrical equipment enclosure will be added for the 500 kV control, protection and communication equipment. The transmission line protection will consist of an unblocking scheme over power line carrier communications for the primary relaying and a permissive scheme over fiber optic shield wire communications for the secondary relaying.

Series Capacitor Bank Stations, North and South:

Construct two new 500 kV 2000 amp series capacitor bank stations, one located near the mid-line location of the Dorsey-Bison 500 kV transmission line and the other located near the mid-line location of the Bison-Helena 500 kV transmission line. The capacitor bank will have the electrical characteristics to provide 50% compensation for the respective transmission line length.

500 kV Transmission Line

Construct a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) TSR 500 kV Option 1 study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the mid-line location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. The proposed transmission line conductor is assumed to be 3-conductor bundle 1192.5 kcmil 45/7 "Bunting" ACSR with 18" sub-conductor spacing. The proposed transmission line shield wires are assumed to be 1 - 7no. 7 Alumoweld and 1 - 48 fiber OPGW.

It is estimated that the duration for engineering, procurement and construction will be 90 months. The estimated cost for these upgrades is **$1,463,690,000 (Table 2)**. The breakdown of the Transmission Owner's Network Upgrades is as follows:

a) Substation – Owner Network Upgrades

Bison Substation:

Bison Substation 500-345 kV expansion with two 500 kV transmission line terminals, one 500 kV +/-400 MVAR SVC, two 500 kV 300 MVAR shunt capacitor banks, one 500 kV 150 MVAR shunt reactor installed on the Dorsey transmission line, one 500 kV 225 MVAR shunt reactor installed on the Helena transmission line and one 500-345 kV 1200 MVA transformer.

Helena Substation:

Helena Substation 500-345 kV expansion with 500 kV transmission line terminal, one 500 kV 225 MVAR shunt reactor installed on the Bison transmission line and two 500-345 kV 1200 MVA transformers.

North Series Capacitor Bank Station:

Construct a new 500 kV 2000 amp series capacitor bank station located near the mid-line location of the Dorsey-Bison 500 kV transmission line. The capacitor bank will have the electrical characteristics to provide 50% compensation for the respective transmission line length.

South Series Capacitor Bank Station:

Construct a new 500 kV 2000 amp series capacitor bank station located near the mid-line location of the Bison-Helena 500 kV transmission line. The capacitor bank will have the electrical characteristics to provide 50% compensation for the respective transmission line length.

(See Substation Engineering Facilities Study section for details).

b) Transmission – Owner Network Upgrades

Construct approximately 477 miles of new 500 kV transmission line. The proposed transmission line will be from the US/Canada border to the CapX2020 Bison

Substation to the CapX2020 Helena Substation with series capacitor stations near the mid-line location of Dorsey to Bison and Bison to Helena line segments.

(See Transmission Engineering Facilities Study section for details)

c) Permitting and Land Rights – Owner Network Upgrades

A representative alignment for the proposed 500 kV transmission line was developed. The representative alignment served as the basis for estimating purposes associated with engineering and future permitting and land rights. Upon development of the representative alignment, potentially required permits and other regulatory requirements were identified, along with an estimated schedule and costs associated with satisfying these potential regulatory requirements and acquiring necessary land and easements.

An overall project schedule that accommodates the identified December 2017 in-service date has been developed. The schedule includes aggressive durations for permitting and land rights activities, but still requires extensive overlap of these activities with engineering and construction. This overlap of activities further requires that some land rights, engineering, or construction-related activities will commence in advance of having all regulatory requirements satisfied for the project as a whole. Instead, some approvals are anticipated to be obtained through what may be generally characterized as a tiered approach.

The major federal and state permits required for the 500 kV transmission line, as well as their anticipated durations of review and approval based on review of relevant projects and the various assumptions identified, are listed below.

	Administering Agency	Anticipated Start Date (or Submittal of Application)	Anticipated End Date
Presidential Permit	U.S. Department of Energy	July 2011	January 2014
Certificate of Public Convenience and Necessity	North Dakota Public Service Commission	October 2011	January 2012
Certificate of Corridor Compatibility	North Dakota Public Service Commission	January 2012	October 2012
Route Permit	North Dakota Public Service Commission	October 2012	July 2013
Legislative Approval	North Dakota Legislative Assembly	December 2012	May 2013
Certificate of Need	Minnesota Public Utilities Commission	July 2011	July 2012

Route Permit	Minnesota Public Utilities Commission	July 2012	October 2013

The permits or approvals listed above would be required in addition to other various federal, state and local approvals.

(see Permitting and Land rights Facilities Study section for details).

Table 1 - Network Upgrades

Type	Description	Cost*
Substation	Bison Substation-500- 345 kV Expansion	**$**102,400,000
	Helena Substation - 500-345 kV Expansion	$62,320,000
	North Series Capacitor Bank Station – New Station	$31,070,000
	South Series Capacitor Bank Station – New Station	$30,820,000
	Total	**$226,610,000**
Transmission	500 kV Transmission Line Segment 1A (52 mi approx.)	$159,810,000
	500 kV Transmission Line Segment 1B (112 mi approx.)	$212,940,000
	500 kV Transmission Line Segment 2A (153 mi approx.)	$266,470,000
	500 kV Transmission Line Segment 2B (160 mi approx.)	$226,440,000
	Total	**$865,660,000**
Permitting	Planning; communications; agency coordination and consultation; routing and siting; public involvement; federal, state, and local permitting; legal and other regulatory support; and environmental field studies and surveys.	**$21,000,000**
Land rights	Land acquisition for two substation expansions and two series capacitor banks; and acquisition of right-of-way, 200 feet in width, for the proposed 500 kV transmission line.	**$82,500,000**
Transmission Escalation	500 kV Transmission Line Segment 1A (52 mi approx.)	$32,270,000
	500 kV Transmission Line Segment 1B (112 mi approx.)	$49,620,000
	500 kV Transmission Line Segment 2A (153 mi approx.)	$67,390,000
	500 kV Transmission Line Segment 2B (160 mi approx.)	$60,280,000
	Total	**$209,560,000**
Substation Escalation	Bison Substation-500- 345 kV Expansion	$23,840,000
	Helena Substation - 500-345 kV Expansion	$16,520,000
	North Series Capacitor Bank Station – New Station	$6,270,000
	South Series Capacitor Bank Station – New Station	$7,880,000
	Total	**$54,510,000**
Permitting Escalation	Planning; communications; agency coordination and consultation; routing and siting; public involvement; federal, state, and local permitting; legal and other regulatory support; and environmental field studies and surveys.	**$1,750,000**
Land Rights Escalation	Land acquisition for two substation expansions and two series capacitor banks; and acquisition of right-of-way, 200 feet in width, for the proposed 500 kV transmission line.	**$2,100,000**
	TOTAL COST*	**$1,463,690,000**

*No project finance interest charges are included in the above costs.

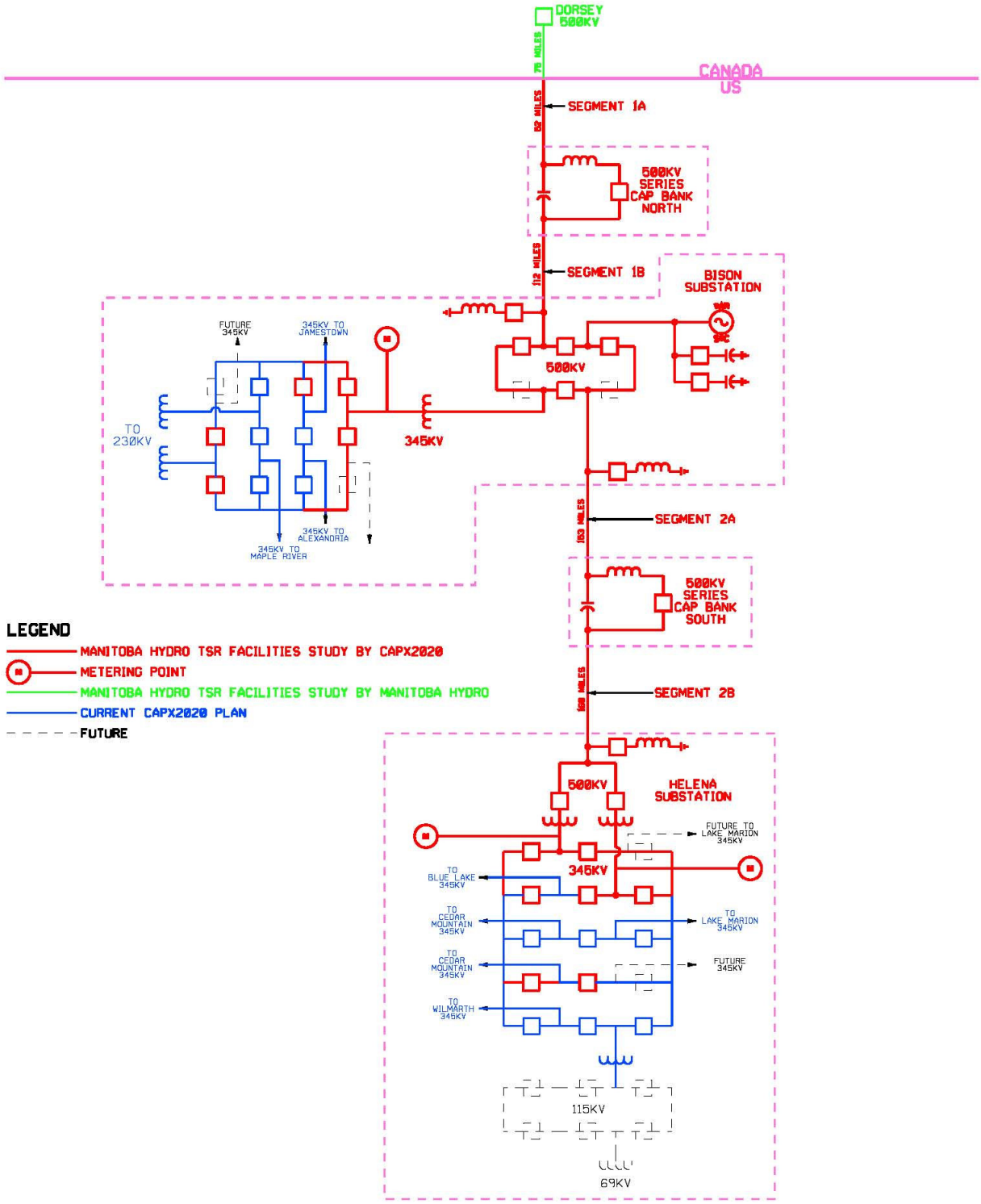
2) Stand Alone Network Upgrades

There are no stand-alone facility upgrades in this generation interconnection request.

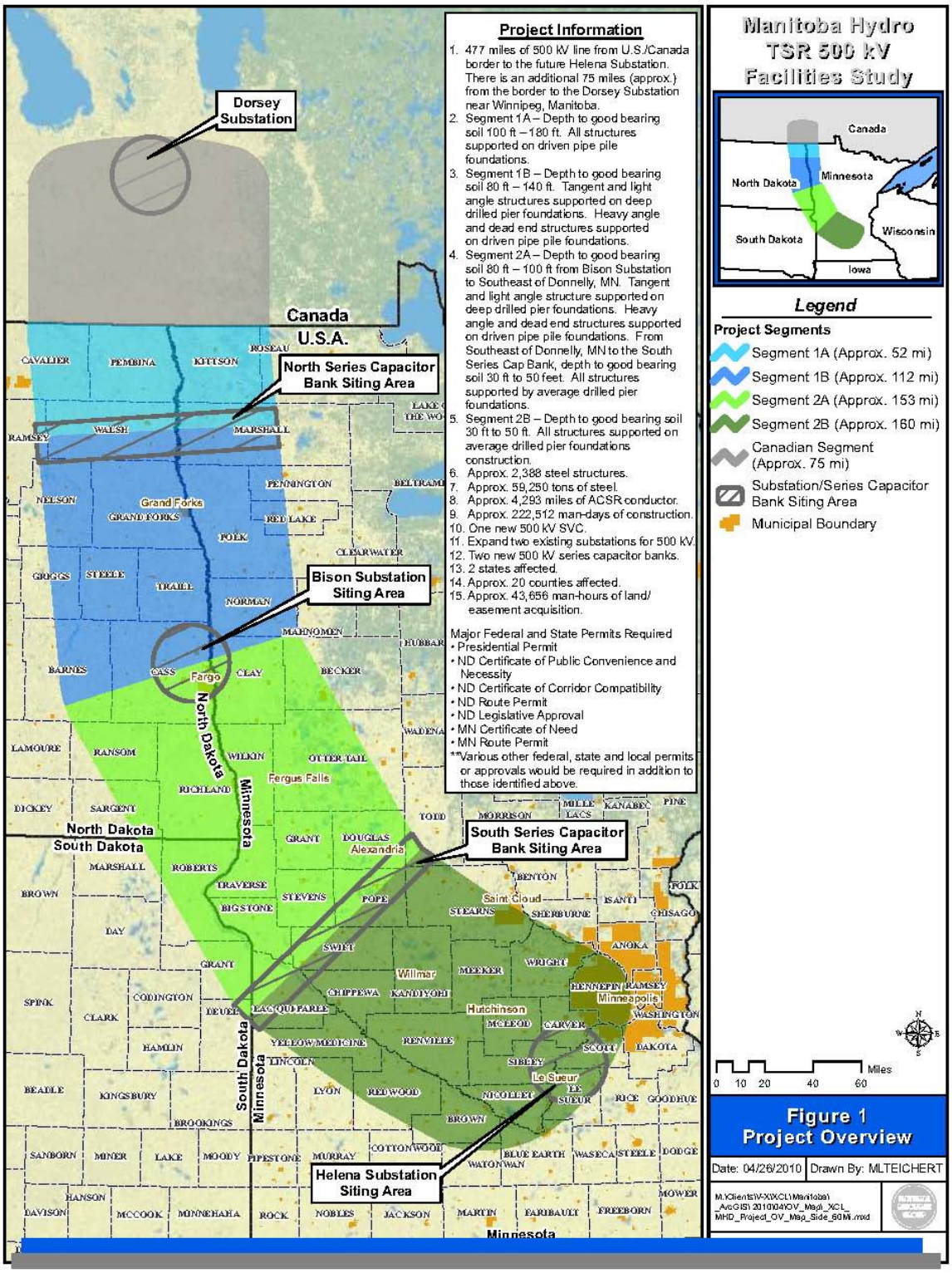
The total estimated cost for the upgrades required for the TSR Study is approximately **$1,463,690,000**. **The estimated duration to complete the required upgrades is 90 months (7.5 years) from the**

execution of the MPFCA. A proposed system One-line diagram is attached to this executive summary. The detail of the study is also attached broken down into Substation Engineering, Transmission Engineering and Land Rights.

MANITOBA HYDRO TSR 500KV FACILITIES STUDY - OPTION 1
PARTIAL SYSTEM ONE-LINE



FACILITIES STUDY MAP



Manitoba Hydro TSR 500kV Facilities Study

Transmission Owner Approval Document

Transmission Owner Representatives

GREAT RIVER ENERGY®

Devang Joshi, Transmission Engineering

Craig Poorker, Permitting and ROW

Richard Samec, Substation Engineering

Manitoba Hydro TSR 500kV Facilities Study

Transmission Owner Approval Document

Transmission Owner Representatives

Mike Klopp, Engineering

Jim Atkinson, Permitting and ROW

Manitoba Hydro TSR 500kV Facilities Study

Transmission Owner Approval Document

Transmission Owner Representatives

OTTER TAIL POWER COMPANY

Gary Eggen, Permitting and ROW

Rick Johnson, Engineering

Dean Pawlowski, Project Management

Manitoba Hydro TSR 500kV Facilities Study

Transmission Owner Approval Document

Transmission Owner Representatives

Xcel Energy®
RESPONSIBLE BY NATURE™

5/4/2010
Michael Jensen, Substation Engineering

5/5/2010
Pratap Mysore, Substation Engineering

5/4/2010
Darrin Lahr, Permitting and ROW

Pam Rasmussen, Manager Siting & Land Rights

5/4/2010
William Pim, Transmission Engineering

5/4/10
Sheldon Silberman, Manager Engineering Design Outsourcing

5/4/10
Dave Berklund, Manager Transmission Const.

5/4/10
Terry Winberg, Manager Civil Const.

SUBSTATION SECTION

RESULTS OF MANITOBA HYDRO TSR 500 KV OPTION 1 FACILITIES STUDY

SUBSTATION - DETAILS

Prepared by:

William Barnhart II, PE
HDR Engineering, Inc.

PROJECT DESIGN GUIDE

Location: North Series Capacitor Bank Station (NSC)
Project Title: MH TSR 500 kV Option 1 Facilities Study – New 500 kV Series Capacitor Bank

In-Service Date:	December 2017
Program Manager:	CapX2020
Project Manager:	Jared Alholinna, CapX2020 Chris Ayika, Xcel Energy
Prepared By:	HDR Engineering, Inc.
Estimate Type and Amount:	Facilities Study $31,070,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the midline of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. .

The following assumptions have been included in the substation portion of this study:

1. The study has been prepared for CapX2020. The ownership of the substation has not been identified at this time.

2. No special protection systems for area wide dynamic system operation have been studied at this time and no equipment for such systems are included in this study.

3. The series capacitor bank has been sized for 50% compensation of the Dorsey-Bison 500 kV transmission line based on the parameters identified within other sections of this study. The site of the series capacitor station is assumed to be as close to the "electrical center" of the transmission line as possible.

4. The exact requirements of the site including access, topography, drainage, geotechnical structure and landscaping are not identified at this time. Therefore, general assumptions have been made for this scope.

5. The estimation assumes the series capacitor bus voltage will not exceed 550kV.

Background

Several Transmission Service Requests (TSR) for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service. The study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

II. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

CIP requirements for this station are not identified at this time. The exact requirements will be identified once the ownership and operational control of the station is determined.

Facility Ratings

The substation presently meets the new facility rating requirements.

III. Right of Way

196 KSF of new land will be required.

IV. Electrical Features

Transmission Lines: Current Carrying Capacity of Affected/Tapped/New

Transmission Lines	Current Rating		
	Conductor Type	Summer (40 deg C)	Winter (0 deg C)
Dorsey-Bison 500 kV Line	3-1192.5 ACSR	4365 amps	5724 amps

The Series Capacitor Bank Station 500 kV bus and associated equipment will be rated for 2000 amps. The bank will have an emergency rating of 2500 amps.

Fault Current

The substation will be designed to 40 kA on 500 kV bus and equipment.

Preliminary Modeling in CAPE is shown in the following table:

Location \ Type of fault	Three Phase Amps
500 kV System with Dorsey-Bison Line	6,168

Electrical Removals & Relocations

No equipment will be removed or relocated for this project.

Electrical Installations (Major Equipment)

500 kV

One (1) 500 kV, 64 ohm, 768MVAR, 2000 amp series capacitor bank will be installed. The bank will consist of three insulated platforms with capacitors, movs, and reactors and associated electrical and control equipment.

Each capacitor includes a breaker for bypass. A breaker is installed on each phase to bypass the capacitor bank for maintenance.

Six (6) 500 kV, 2000A, single phase double-end-break motor-operated disconnect switches (XS7 and XS8), will be installed for breaker isolation (52/XS6).

Six (6) 500 kV, 2000A, single phase double-end-break motor-operated disconnect switches with ground switches (XS1 and XS2), will be installed for capacitor bank bypass.

Three (3) single-phase 500 kV CCVT units will be installed for Dorsey Line metering and communication between Dorsey and Bison.

Three (3) 335 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. The arresters will be mounted in the 500 kV Dorsey Line bay.

Two (2) 500 kV, 2000 A line trap and tuner will be installed on the deadend for the 500 kV Dorsey Line.

One (1) single-phase 500 kV CCVT units will be installed for Bison Line metering and communication between Dorsey and Bison.

Three (3) 335 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. The arresters will be mounted in the 500 kV Bison Line bay.

Two (2) 500 kV, 2000 A line traps and tuners will be installed on the deadend for the 500 kV Bison Line and communication between Dorsey-Bison-Helena.

The bus in each row will consist of 6 inch aluminum tube (4250 amp) in order to limit bus support structures and 2-1590 MCM aluminum stranded conductor (2400 amps) for breaker jumpers will be installed.

556.5 19 MCM aluminum stranded conductor per phase will be installed for CCVT connections.

Mobile Substation or Transformer

No Mobile Equipment will be necessary.

Electrical Equipment Enclosure (EEE)

A new 24' X 40' metal control house will be erected in the southeast corner of the new substation. The control house building will have two points of egress, one single door and one double door. The control house will have two exhaust fans, two propeller type electric unit heaters, and wall louvers. The control house will accommodate protection relay panels, AC breaker panels, DC fuse panels, terminal cabinets, 125 VDC station battery and charger, 48 VDC communication system battery and charger, telephone equipment panelboard, overhead cable tray, lights, receptacles, and other miscellaneous equipment.

AC System

The AC system will be sized to accommodate the three 500 kV single phase capacitor bank load, six 500 kV single phase gas circuit breaker motor and heater loads, twelve motor-operated disconnect heater loads, and the control building auxiliary equipment. Since there are no near term plans for adding additional equipment, the station service will be sized for the proposed installation, construction power and a small contingency factor.

The primary source for the AC station auxiliary power transformer is assumend to be 12.5 kV local distribution power. The emergency source will be a 50 KW Generator Set. The secondary voltage of the auxiliary sources will be three-phase 120/240 V.

The following equipment will be installed:

One (1) single-phase, 34,500 – 120/240 V, 50 kVA distribution transformer will be installed.

15 kV, 100 amp fused disconnects with 10E continuous elements will be installed.

DC System

A detailed DC study will be performed during the design phase of the project. The estimate provides for a 125 VDC battery with a battery charger and associated fuses and DC cabinets.

A 48 VDC battery with a battery charger and associated fuses and DC cabinets is included for the communications system equipment.

Grounding

A ground grid consisting of 4/0 copper conductor and ground rods will be installed to provide a safe and effective grounding system per IEEE standards. Soil resistivity measurements will be taken in the area where the new substation will be installed upon soil thawing and rough grading completion. Ground grid design calculations will be made at this time. Fence counterpoise grounding will be installed.

Lightning Protection

Lightning protection will be provided for the new substation to adequately protect the new 500 kV bus. The estimate includes four (4) 100' tapered tubular steel shield masts in addition to lightning masts on the 500 kV line termination structures.

Trenching & Cable

New precast trenching will be installed for all new equipment. All new control cables will be installed.

V. Civil Features

Grading & Fencing

A graded area approximately 417 feet by 470 feet will be constructed. Grading will consist of topsoil stripping and removal of all vegetation followed by subexcavation totaling 3 feet. The excavated subgrade will be compacted to form a firm base followed by the placement of approximately 2 feet of imported fill. The rough grade elevation will be established through importing, placement and compaction of a 1 foot layer of class 5 aggregate base. Prior to the in-service date, grading activity will be completed by the import and placement of a 4 inch layer of crushed rock surfacing.

Note the landscaped area is assumed to be 25% of the total graded area and for this case is limited to revegetation of surfaces beyond the edge of grade and retention pond but not exceeding the area disturbed by grading activities.

Storm Water Permit

A Storm Water Permit will be required.

Foundations & Structural

The proposed foundations include drilled piers for all galvanized steel structures and slabs-on-grade for electrical equipment (circuit breakers and power transformers) and the control house. Final foundation types and sizes will be determined once the results and recommendations of the soil boring investigation are completed.

The steel structures for the proposed substation include low profile equipment stands and bus supports and tapered tubular dead end structures to support each transmission line termination. The low profile steel structures will be tapered tubular. The tapered tubular structures will be designed and fabricated by the steel fabricator.

Civil Removals & Relocations

No civil removals or relocations will be used.

Civil Installations

The following concrete slab foundations will be installed:

Quantity	Description	Approx. Size
1	Control House	24' x 40' x 1'
1	Generator Set	5' x 10' x 1'

The following galvanized steel structures and concrete drilled pier foundations will be installed:

Steel Structures		Drilled Piers		
Qty	Description	Qty	Approximate Size	
			Diameter	Depth
36	500 kV Bus Support – 1PH	36	3'-0"	31'-0"
2	500 kV Deadend Structure	8	8'-6"	100'-0"
6	500 kV Surge Arrester Stand	6	3'-0"	21'-0"
6	500 kV Switch Stand – 2PH	24	3'-0"	21'-0"
6	500 kV CCVT Stand	6	3'-0"	20'-0"
2	Shield Pole – 100FT	2	4'-0"	32'-0"

Oil Containment

No oil containment will be required.

Electrical Equipment Enclosure (EEE) or Switchgear Building

A 24 foot by 40 foot control house will be ordered and constructed as previously outlined in this design guide.

VI. Control Features

Control Schemes

Series Capacitor Bank manufacturer will provide and install the control and protection for the bank, bypass breaker, and motor operated disconnect switches.

Primary carrier transfer trip (TT) via Pulsar TCF-10B, or equivalent, equipment will be used to communicate between Dorsey and Bison.

Secondary Tone TT via fiber optic FOCUS, or equivalent, equipment will be used to communicate between Dorsey and Bison.

DC Reduction

D.C. reduction schemes reduce the power order at Dorsey converters to prevent over loading of underlying transmission systems on loss of 500 kV paths.

D.C. power is controlled by allocator MW output setting on the D.C. bipole at the converter station. Loss of power outlet is determined by several conditions as listed below:

- Open breaker condition at local end or remote end
- Trip initiation by line relays at any end
- Bypass of capacitors.
- Loss/ reduction of power outlet at remote end. An example would be the loss of south line from Bison or bypass of series capacitor on the south line.
- Loss of reactive support for high transfers

Cross tripping of the north line may also be initiated if the power flow on the line is above a threshold as determined by load flow studies.

The degree of power order could vary from 15% reduction to 100% reduction depending on the type of disturbance.

The scheme is implemented as a fully communication scheme with two independent communication paths. The requirement of the maximum time delay permissible between the disturbance initiation and the allocator power order reduction is determined by the studies group**.**

RTU

The substation RTU will be per the transmission owner's requirements. Exact details are not identified at this time. A Multiport RTU will be installed. More than 1 SCADA circuit may be required. The SCADA protocol requirement of every utility that need access to the RTU may be different and it will decide what kind of RTU to be installed.

Local Annunciation

Local annunciation is via the station display panel.

Control Panel Locations

All Control Panels will be installed in the EEE. Space will be provided for Series Capacitor Bank manufacturer's panels.

Telephone Protection

The telephone protection equipment will includes an SNC 12-slot C-Line card shelf, a 4-port Teltone SLSS line sharing switch, and a telephone access/control box for remote communications to the relays.

Equipment Details

Removals

None.

Installations

The following new relay and control panels will be installed:

- Panel 1N, 36", Communication Panel, includes two FOCUS and two TCF-10B
- 240 VAC Cabinets
- 125 VDC Cabinets
- 48 VDC Cabinet
- Termination Cabinet

VII. Outages

None.

VIII. Material Staging Plan

All major materials will be shipped directly to the job site. Stock materials will be ordered and staged through the transmission owner's warehouse.

IX. Project and Operating Concerns

In-Service date may be impacted by transmission construction schedule as well as related substation construction schedules.

X. Related Projects

MH TSR 500 kV Option 1 – Facilities Study – Segment 1A (US/Canada Border to North Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 1B (Proposed North Series Cap Bank to proposed Bison Sub)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2A (Proposed Bison Sub to proposed South Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2B (Proposed South Series Cap Bank to proposed Helena Sub)

MH TSR 500 kV Option 1 – Facilities Study – 500-345 kV Bison Substation

MH TSR 500 kV Option 1 – Facilities Study – 500-345 kV Helena Substation

MH TSR 500 kV Option 1– Facilities Study – 500 kV South Series Cap Bank Station

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	NCB-SEr0-North Series Cap Bank
Sub./Line Name:	Series Cap Bank
WO #:	
Group Name:	
City:	
County:	
State:	ND
WO Type:	41
Op Co:	NSPM
In-service Date:	12/31/2017
Basic Scope:	NSP Sub estimating template

Estimate Information	
Est. Type	SE
Est Status:	Working
Est. Published	4/29/2010
Rev. Number:	0
Prepared By:	HDR Engineering, Inc.
Company:	Northern States Power Co - MN

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Manage	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$591,839	$0	$0	$0	$591,839
CBS3 - Civil Construction	$1,083,463	$52,200	$833,480	$50,927	$2,020,070
CBS4 - Electrical Construction	$1,406,828	$98,500	$22,167,303	$1,279,153	$24,951,784
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$127,839	$0	$0	$0	$127,839
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$3,209,969	$150,700	$23,000,784	$1,330,079	$27,691,532
Indirect Costs					
Powerplant Overheads (E&S + A&	$195,808	$0	$1,403,048	$90,328	$1,689,183
Material overheads	$0	$0	$460,016	$0	$460,016
AFUDC	$0	$0	$0	$0	$0
Contingency	$320,997	$0	$460,016	$444,234	$1,225,246
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$516,805	$0	$2,323,079	$534,561	$3,374,445
Project Total					**$31,065,977**

Print Date: 4/29/2010

Job Folder Name: NCB-SEr0-North Series Cap Bank **O&M Estimate:** $ -
Sub-Line Name: Series Cap Bank
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
JOB											
AFUDC	1	Lump Sum	Inst	Indirect	Miscelleneous	$ -	$ -	$ -	$ -	$ -	$ -
BATT 125VDC 150A WITH RACK	1	LOT	Inst	Phys	Battery	$ 6,800	$ 3,808	$ -	$ 391	$ -	$ 10,999
BATT CHRGER 125VDC 25A	1	EA	Inst	Phys	Charger	$ 3,000	$ 2,031	$ -	$ 173	$ -	$ 5,203
CAPACITOR BANK 500 kV, 768 MVAR W/ BREAKERS	1	LOT	Inst	Phys	Capacitor Bank	$ 20,000,000	$ -	$ -	$ 1,150,000	$ -	$ 21,150,000
COMM LINE TRAP 2000A	2	LOT	Inst	Cntrl	Power Line Carrier System	$ 19,670	$ 5,712	$ -	$ -	$ -	$ 25,382
Engineering & Design - Internal Labor (roll-up)	1	HR	Inst	Labor	Miscelleneous	$ -	$ 90,359	$ -	$ -	$ -	$ 90,359
GEN SET, 50KVA	1	EA	Inst	Phys	Transformer	$ 60,000	$ 2,986	$ -	$ 3,450	$ -	$ 66,436
SWITCH 500kV GROUND ATT	6	EA	Inst	Phys	Switch Gang	$ 36,000	$ 10,975	$ -	$ 2,070	$ -	$ 49,045
SWITCH MOTOR OPERATOR	12	EA	Inst	Phys	Switch Gang	$ 54,000	$ 19,038	$ -	$ 3,105	$ -	$ 76,143
CONTINGENCY	1	Lump Sum	Inst	Indirect	Miscellenous	$ 460,016	$ 320,997	$ 45,210	$ 399,024	$ -	$ 1,225,246
ESCALATION	1	Lump Sum	Inst	Indirect	Miscellenous	$ -	$ -	$ -	$ -	$ -	$ -
POWERPLANT AND MATL OVERHEADS	1	Lump Sum	Inst	Indirect	Miscellenous	$ 1,863,063	$ 195,808	$ 9,193	$ 81,135	$ -	$ 2,149,199
Permitting/Proj Management	0	HR	Inst	Labor	Land Rights (Depreciable)	$ -	$ 0	$ -	$ -	$ -	$ 0
CONTROL BUILDING 24'X40' STD SIZE F&E	1	EA	Inst	Civil	EEE	$ 58,000	$ 31,659	$ -	$ 3,335	$ -	$ 92,994
FENCE 8FT CHAIN LK W/BARB	2,432	FT	Inst	Civil	Fence & Walls	$ 52,805	$ 64,162	$ -	$ 3,036	$ -	$ 120,003
FENCE GATE DRIVE 20 FT	1	EA	Inst	Civil	Fence & Walls	$ 725	$ 66	$ -	$ 42	$ -	$ 833
Fence Silt 3'H	1,774	FT	Inst	Civil	Fence & Walls	$ 656	$ 11,701	$ -	$ 38	$ -	$ 12,395
Breaker Slab 500kV (8'x20')	6	EA	Inst	Civil	Foundations	$ 5,025	$ 24,904	$ -	$ 289	$ -	$ 30,217
Concrete Pier 4' x 16'	18	EA	Inst	Civil	Foundations	$ 19,350	$ 94,952	$ -	$ 1,113	$ -	$ 115,415
EEE Slab 24' x 40' x 1'	1	EA	Inst	Civil	Foundations	$ 4,450	$ 21,831	$ -	$ 256	$ -	$ 26,537
SITE - DETENTION POND	1	EA	Inst	Civil	Grading & Landscaping	$ 5,000	$ 7,585	$ -	$ 288	$ -	$ 12,872
SITE - EARTHWORK - COMPACTION TEST	1	EA	Inst	Civil	Grading & Landscaping	$ 150	$ -	$ -	$ 9	$ -	$ 159
SITE - GRADING	1	EA	Inst	Civil	Grading & Landscaping	$ 371,482	$ 269,788	$ -	$ 21,360	$ -	$ 662,630
500kV Bus Support Stand - 1PH (36'-6)	36	EA	Inst	Civil	Structure - Welded Tubular	$ 216,900	$ 167,100	$ -	$ 12,472	$ -	$ 396,472
500kV CCVT Stand 1PH (15')	6	EA	Inst	Civil	Structure - Welded Tubular	$ 13,650	$ 14,362	$ -	$ 785	$ -	$ 28,797
500kV Deadend Structure	2	EA	Inst	Civil	Structure - Welded Tubular	$ 925,162	$ 391,984	$ -	$ 53,197	$ -	$ 1,370,343
500kV Surge Arrester Stand 1PH	6	EA	Inst	Civil	Structure - Welded Tubular	$ 15,675	$ 15,997	$ -	$ 901	$ -	$ 32,573

Job Folder Name: NCB-SEr0-North Series Cap Bank **O&M Estimate:** $ -
Sub-Line Name: Series Cap Bank
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
500kV Switch Stand (15')	6	EA	Inst	Civil	Structure - Welded Tubular	$ 174,900	$ 94,054	$ -	$ 10,057	$ -	$ 279,011
Shield Pole 100FT	4	EA	Inst	Civil	Structure - Welded Tubular	$ 44,163	$ 36,169	$ -	$ 2,539	$ -	$ 82,872
CIVIL INSPECTION/TESTING (CONT	1	EA	Inst	Civil	Survey and Test	$ -	$ 1,080	$ -	$ -	$ -	$ 1,080
SITE - SOIL BORINGS (NEW SUB 7 BORING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 4,980	$ -	$ -	$ -	$ 4,980
SITE - SOIL GEOTECHNICAL INVESTIGATING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 6,000	$ -	$ -	$ -	$ 6,000
SITE - SOIL RESISTIVITY TESTING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 960	$ -	$ -	$ -	$ 960
SITE - SURVEY - CONST. STAKING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 1,620	$ -	$ -	$ -	$ 1,620
SITE - SURVEY (TOPO/BOUNDARY)	1	LOT	Inst	Civil	Survey and Test	$ -	$ 10,020	$ -	$ -	$ -	$ 10,020
TRENCHING AND ACCESS-MACH-36"	1,000	FT	Inst	Civil	Trenching	$ 1,000	$ 11,212	$ -	$ 58	$ -	$ 12,270
TRENCHING PRECAST 40" OPEN BOTTOM	940	FT	Inst	Civil	Trenching	$ 28,200	$ 86,178	$ -	$ 1,622	$ -	$ 115,999
TRENCHING PRECAST 40" ROAD CROSSI	60	FT	Inst	Civil	Trenching	$ 4,800	$ 9,814	$ -	$ 276	$ -	$ 14,890
. CABLE -CONT/PWR-TERM. 600V	1,176	EA	Inst	Cntrl	Cable - Control	$ 129	$ 26,340	$ -	$ 7	$ -	$ 26,477
. CABLE -CONTROL-600V 1C 12	47,430	FT	Inst	Cntrl	Cable - Control	$ 9,962	$ 106,234	$ -	$ 573	$ -	$ 116,770
. CABLE -CONTROL-600V 3C 4	440	FT	Inst	Cntrl	Cable - Control	$ 1,740	$ 986	$ -	$ 100	$ -	$ 2,825
. CABLE -CONTROL-600V 3C 6	0	FT	Inst	Cntrl	Cable - Control	$ 0	$ 0	$ -	$ 0	$ -	$ 0
. CABLE -CONTROL-600V 4C 10	5,033	FT	Inst	Cntrl	Cable - Control	$ 6,293	$ 11,272	$ -	$ 362	$ -	$ 17,927
. CABLE -CONTROL-600V 7C 10	2,310	FT	Inst	Cntrl	Cable - Control	$ 5,678	$ 5,174	$ -	$ 326	$ -	$ 11,178
. CABLE -CONTROL-600V 2PR 18	4,620	FT	Inst	Cntrl	Cable - Control	$ 3,115	$ 10,348	$ -	$ 179	$ -	$ 13,642
. CABLE -CONTROL-600V 2PR 18	4,620	FT	Inst	Cntrl	Cable - Control	$ 3,115	$ 10,348	$ -	$ 179	$ -	$ 13,642
. CABLE -CONTROL-600V 8PR 18	440	FT	Inst	Cntrl	Cable - Control	$ 691	$ 986	$ -	$ 40	$ -	$ 1,717
. CABLE -CONTROL-600V 10PR 10	5,060	FT	Inst	Cntrl	Cable - Control	$ 30,056	$ 11,333	$ -	$ 1,728	$ -	$ 43,118
FIBER OPTIC CABLE-SINGLE MODE	460	EA	Inst	Cntrl	Fiber	$ 253	$ 1,717	$ -	$ 15	$ -	$ 1,985
FIBER PATCH PANEL	1	EA	Inst	Cntrl	Fiber	$ 500	$ 560	$ -	$ 29	$ -	$ 1,089
FIBER SPLICE BOX	2	EA	Inst	Cntrl	Fiber	$ 200	$ 747	$ -	$ 12	$ -	$ 958
PANEL-COMMUNICATIONS PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 25,000	$ 5,973	$ -	$ 1,438	$ -	$ 32,410
PANEL-DC RUNBACK PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 18,500	$ 5,973	$ -	$ 1,064	$ -	$ 25,537
PANEL-FOCUS AND TCF-10B CARRIER	2	EA	Inst	Cntrl	Panels - Conventional	$ 40,000	$ 5,973	$ -	$ 2,300	$ -	$ 48,273
PANEL-PLC TERMINAL CAB LAYOUT (MATERIAL LIST & TERM BLOCK LAYOUT)	1	EA	Inst	Cntrl	Panels - Conventional	$ 12,000	$ 2,986	$ -	$ 690	$ -	$ 15,676
PANEL-QUICKPANEL DISPLAY WITH PLC, SEL-2032 COMM SW & GPS CLOCK	1	EA	Inst	Cntrl	Panels - Conventional	$ 30,000	$ 2,986	$ -	$ 1,725	$ -	$ 34,711
PANEL-TELEPHONE ACCESS CONTROL BOX AND MATERIAL LIST	1	EA	Inst	Cntrl	Panels - Conventional	$ 1,600	$ 2,986	$ -	$ 92	$ -	$ 4,678
CARRIER LINE TUNER	4	EA	Inst	Cntrl	Pilot	$ 8,000	$ 2,986	$ -	$ 460	$ -	$ 11,446
TEL 3/4" PLYWOOD PANEL	1	EA	Inst	Cntrl	Telephone	$ 50	$ 448	$ -	$ 3	$ -	$ 501
TEL POSITRON PACkAGE	1	EA	Inst	Cntrl	Telephone	$ 3,840	$ 1,493	$ -	$ 221	$ -	$ 5,554
EQUIP - BACKHOE WITH CAB	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 31,200	$ 1,794	$ -	$ 32,994

Job Folder Name: NCB-SEr0-North Series Cap Bank **O&M Estimate:** $ -
Sub-Line Name: Series Cap Bank
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
EQUIP - BOBCAT	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 30,000	$ 1,725	$ -	$ 31,725
EQUIP - CONTRACT WELDING	4	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 14,000	$ 805	$ -	$ 14,805
EQUIP - CRANE (W/OPR) - 30 TON	5	DAY	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 6,000	$ 345	$ -	$ 6,345
EQUIP - FORKLIFT (MTRL HANDLER)	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 35,200	$ 2,024	$ -	$ 37,224
EQUIP - MINI EXCAVATOR (GND WIRE INSTALL)	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 21,000	$ 1,208	$ -	$ 22,208
EQUIP - MISC (TRAILORS, TOILETS, DUMSTER, STORAGE)	10	MO	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 13,300	$ 765	$ -	$ 14,065
CONCRETE - MBL 3-MAN (MORE 100 MI)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,968	$ -	$ -	$ -	$ 2,968
Electric Construction - Mobilize (In/Out)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,986	$ -	$ -	$ -	$ 2,986
Electric Construction - Site Setup	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 5,973	$ -	$ -	$ -	$ 5,973
SITE - EARTHWORK - MOBILIZATION (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
SITE - SURFACING-MOBILIZE (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
Eng & Des - Contract - Labor Only	4,300	HR	Inst	Labor	Civil/Electrical	$ -	$ 451,500	$ -	$ -	$ -	$ 451,500
Eng SPS Study	476	HR	Inst	Labor	Civil/Electrical	$ -	$ 49,980	$ -	$ -	$ -	$ 49,980
General Foreman - Internal - Labor Only	2,640	HR	Inst	Labor	Civil/Electrical	$ -	$ 219,642	$ -	$ -	$ -	$ 219,642
TESTING-CONTROL TESTING	1,411	HR	Inst	Labor	Test	$ -	$ 103,839	$ -	$ -	$ -	$ 103,839
TESTING-PHYSICAL EPM	326	HR	Inst	Labor	Test	$ -	$ 24,000	$ -	$ -	$ -	$ 24,000
Trucking - Shipping (# Trips x HR Rnd Trip)	320	HR	Inst	Labor	Civil/Electrical	$ -	$ 21,106	$ -	$ -	$ -	$ 21,106
AC CAB 42 POS.	1	EA	Inst	Phys	AC System	$ 852	$ 523	$ -	$ 49	$ -	$ 1,424
AC PNLBRD INDOOR 120/240VAC 3PH 60HZ, 400A	1	EA	Inst	Phys	AC System	$ 1,936	$ 1,493	$ -	$ 111	$ -	$ 3,541
AUTO TRANSFER SW 400A 240V 1PH	1	EA	Inst	Phys	AC System	$ 4,445	$ 1,195	$ -	$ 256	$ -	$ 5,895
LIGHTING-HIGH VOLTAGE BAY	5	LOT	Inst	Phys	AC System	$ 2,000	$ 14,932	$ -	$ 115	$ -	$ 17,047
ARRESTER 335kV MCOV STA. PORCELAIN	6	EA	Inst	Phys	Arrester	$ 87,600	$ 4,480	$ -	$ 5,037	$ -	$ 97,117
BUS SUPPORT 550kV	36	EA	Inst	Phys	Bus Supports & Insulators	$ 27,082	$ 16,127	$ -	$ 1,557	$ -	$ 44,765
CCVT/PT SEC FUSE CAB 1 PH	6	EA	Inst	Phys	Cabinets	$ 604	$ 2,240	$ -	$ 35	$ -	$ 2,879
TERMINAL CABINET INDOOR	1	EA	Inst	Phys	Cabinets	$ 3,206	$ 2,986	$ -	$ 184	$ -	$ 6,377
CCVT 500kV MTRG HI-CAP01.5A	6	EA	Inst	Phys	CCVTs & Traps	$ 120,000	$ 20,158	$ -	$ 6,900	$ -	$ 147,058
LINE TRAP 2000A	4	EA	Inst	Phys	CCVTs & Traps	$ 79,600	$ 4,480	$ -	$ 4,577	$ -	$ 88,657
CONDUCTOR - SHIELD WIRE 3/8 " GALVANIZED E.H.S.	400	FT	Inst	Phys	Conductor & Fittings	$ 169	$ 2,986	$ -	$ 10	$ -	$ 3,165
CONDUCTOR ALUM 1590 61 STR AA	500	FT	Inst	Phys	Conductor & Fittings	$ 1,333	$ 11,946	$ -	$ 77	$ -	$ 13,355
CONDUCTOR ALUM TUBING 6 IN SCHED 40	2,500	FT	Inst	Phys	Conductor & Fittings	$ 61,250	$ 74,660	$ -	$ 3,522	$ -	$ 139,432
CONDUCTOR FITTING 345-500kV EHV	3,000	FT	Inst	Phys	Conductor & Fittings	$ 24,000	$ -	$ -	$ 1,380	$ -	$ 25,380
BATT 48VDC 50AH	1	EA	Inst	Phys	DC System	$ 3,790	$ 4,853	$ -	$ 218	$ -	$ 8,861
BATT CHRGER 48VDC 30A	1	EA	Inst	Phys	DC System	$ 2,200	$ 1,493	$ -	$ 127	$ -	$ 3,820

Job Folder Name: NCB-SEr0-North Series Cap Bank **O&M Estimate:** $ -
Sub-Line Name: Series Cap Bank
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
BATT MAIN FUSE CABINET ASSM.	1	EA	Inst	Phys	DC System	$ 345	$ 299	$ -	$ 20	$ -	$ 663
BATT MAIN FUSE CABINET ASSM.	1	EA	Inst	Phys	DC System	$ 345	$ 299	$ -	$ 20	$ -	$ 663
DC CAB 34 POSITION STL INDOOR	2	EA	Inst	Phys	DC System	$ 4,292	$ 2,986	$ -	$ 247	$ -	$ 7,525
EEE ELECT HTR 5KW & THERMOSTAT	2	EA	Inst	Phys	EEE	$ 1,514	$ 2,240	$ -	$ 87	$ -	$ 3,841
EEE FURNITURE-EQUIPMENT (NL-200904)	1	LOT	Inst	Phys	EEE	$ 1,100	$ 1,493	$ -	$ 63	$ -	$ 2,656
EEE GROUNDING 24' X 30'	1	EA	Inst	Phys	EEE	$ 155	$ 5,973	$ -	$ 9	$ -	$ 6,137
EEE LIGHTING 20X32	1	EA	Inst	Phys	EEE	$ 844	$ 8,959	$ -	$ 49	$ -	$ 9,852
GROUND CABLE ASSEMBLY ST	2	SET	Inst	Phys	Grounding	$ 2,070	$ 299	$ -	$ 119	$ -	$ 2,488
GROUND CADWELD CONNECTIONS	195,990	SFT	Inst	Phys	Grounding	$ 25,479	$ 58,531	$ -	$ 1,465	$ -	$ 85,474
GROUND GRID TEST	1	EA	Inst	Phys	Grounding	$ -	$ 1,493	$ -	$ -	$ -	$ 1,493
GROUND RODS (per grounding point)	110	EA	Inst	Phys	Grounding	$ 6,772	$ 13,633	$ -	$ 389	$ -	$ 20,794
GROUND WIRE 4/0 CU	12,000	FT	Inst	Phys	Grounding	$ 33,840	$ 223,981	$ -	$ 1,946	$ -	$ 259,767
NAMEPLATES EQUIPMENT	8	EA	Inst	Phys	Nameplates	$ 200	$ 149	$ -	$ 12	$ -	$ 361
NAMEPLATES FENCE ADDRESS	1	EA	Inst	Phys	Nameplates	$ 144	$ 37	$ -	$ 8	$ -	$ 190
NAMEPLATES FENCE WARNING	35	EA	Inst	Phys	Nameplates	$ 1,330	$ 1,307	$ -	$ 76	$ -	$ 2,713
SWITCH 500kV 2000A SPST DBL EB W INS	12	EA	Inst	Phys	Switch Gang	$ 180,000	$ 107,511	$ -	$ 10,350	$ -	$ 297,861
						$ 25,323,863	$ 3,726,774	$ 205,103	$ 1,810,238	$ -	$ 31,065,977

Substation Project Forecast

This forecast represents typical expenditures and commitments for this project based on average conditions. Adjustments to this forecast may be necessary to factor in delays or expediting efforts.

Work Order:
Location: Series Cap Bank
Title: NSP Sub estimating template

Costs from Estimate

		Install	Remove
Permitting and Proj. Management:	$	-	
Material:	$	24,791,000	
Transformer (with tax and OH):	$	-	
Construction Labor & Rentals:	$	2,641,000	$0
Testing Labor:	$	128,000	
E&S:	$	592,000	
Contingencies:	$	1,225,000	
Overheads:	$	1,689,000	
AFUDC:	$	-	
TNE w/o AFUDC:		$31,066,000	

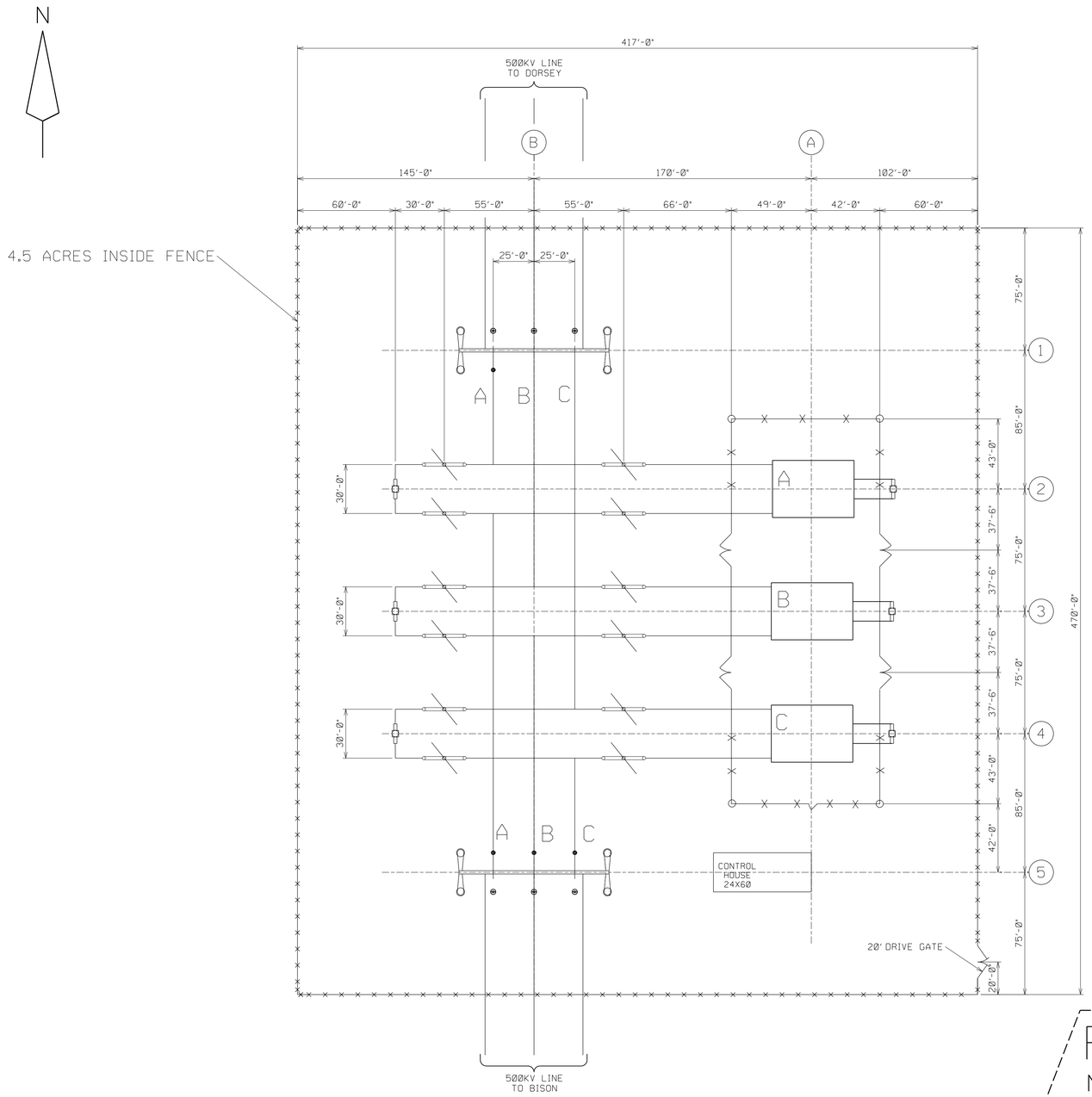
In-Service Date	**12/31/2017**
Project Start Date	**7/1/2010**
Construction Start Date	**6/1/2015**

Jul-10	$	25,700	**Apr-14**	$	25,340
Aug-10	$	25,340	**May-14**	$	2,025,340
Sep-10	$	25,340	**Jun-14**	$	25,340
Oct-10	$	25,340	**Jul-14**	$	25,340
Nov-10	$	25,340	**Aug-14**	$	25,340
Dec-10	$	25,340	**Sep-14**	$	25,340
Jan-11	$	25,340	**Oct-14**	$	25,340
Feb-11	$	25,340	**Nov-14**	$	25,340
Mar-11	$	25,340	**Dec-14**	$	25,340
Apr-11	$	25,340	**Jan-15**	$	25,340
May-11	$	25,340	**Feb-15**	$	25,340
Jun-11	$	25,340	**Mar-15**	$	25,340
Jul-11	$	25,340	**Apr-15**	$	25,340
Aug-11	$	25,340	**May-15**	$	25,340
Sep-11	$	25,340	**Jun-15**	$	243,090
Oct-11	$	25,340	**Jul-15**	$	243,090
Nov-11	$	25,340	**Aug-15**	$	243,090
Dec-11	$	25,340	**Sep-15**	$	1,243,090
Jan-12	$	25,340	**Oct-15**	$	18,331,900
Feb-12	$	25,340	**Nov-15**	$	2,847,900
Mar-12	$	25,340	**Dec-15**	$	1,647,900
Apr-12	$	25,340	**Jan-16**	$	497,900
May-12	$	25,340	**Feb-16**	$	422,900
Jun-12	$	25,340	**Mar-16**	$	349,900
Jul-12	$	25,340	**Apr-16**	$	347,900
Aug-12	$	25,340	**May-16**	$	347,900
Sep-12	$	25,340	**Jun-16**	$	347,900
Oct-12	$	25,340	**Jul-16**	$	25,340
Nov-12	$	25,340	**Aug-16**	$	25,340

Dec-12	$	25,340	**Sep-16**	$	25,340
Jan-13	$	25,340	**Oct-16**	$	25,340
Feb-13	$	25,340	**Nov-16**	$	25,340
Mar-13	$	25,340	**Dec-16**	$	25,340
Apr-13	$	25,340	**Jan-17**	$	25,340
May-13	$	25,340	**Feb-17**	$	25,340
Jun-13	$	25,340	**Mar-17**	$	25,340
Jul-13	$	25,340	**Apr-17**	$	25,340
Aug-13	$	25,340	**May-17**	$	25,340
Sep-13	$	25,340	**Jun-17**	$	25,340
Oct-13	$	25,340	**Jul-17**	$	25,340
Nov-13	$	25,340	**Aug-17**	$	25,340
Dec-13	$	25,340	**Sep-17**	$	25,340
Jan-14	$	25,340	**Oct-17**	$	25,340
Feb-14	$	25,340	**Nov-17**	$	25,340
Mar-14	$	25,340	**Dec-17**	$	25,340

	2010	**2011**	**2012**	**2013**	**Total**
TNE w/o AFUDC	$ 152,400	$ 304,080	$ 304,080	$ 304,080	**$ 31,066,000**

	2014	**2015**	**2016**	**2017**
TNE w/o AFUDC	$ 2,304,080	$ 24,926,760	$ 2,466,440	$ 304,080



PRELIMINARY
NOT FOR CONSTRUCTION

GENERAL NOTES

FOR GENERAL NOTES PRIOR TO •• CONSTRUCTION, SEE REVISION ••.

1. LOCATION OF BENCH MARK FOR GRADE ELEVATION IS N150632.82 E633564.06
   ELEVATION OF BENCH MARK IS XXXX
2. SUBSTATION ROUGH GRADE ELEVATION IS XXXX - XXXX
3. SUBSTATION AREA ENCLOSED BY FENCE AND EXTENDING 5'-0" OUTSIDE,
4. FENCE - 7'-0" HIGH STEEL CHAIN LINK FABRIC AND 1'-0" HIGH VERTICAL HEIGHT
   BARBED WIRE ON TOP, MOUNTED AT A 45° ANGLE POINTED OUTSIDE OF SUBSTATION.
   IN ACCORDANCE WITH ENG & DSGN STD ED 4.09.03.
5. SEE STRUCTURAL STEEL DRAWINGS FOR LOAD REQUIREMENTS OF EXTERNAL
   AND INTERNAL STRAINS.
6. U.G. POWER DUCTS PASS UNDER FENCE MIDWAY BETWEEN FENCE POSTS AND,
   WHERE POSSIBLE, NOT LESS THAN 2'-6" BELOW GRADE.

LEGEND

- (A) → OLD FENCE SIGN WORDED "WARNING, HAZARDOUS VOLTAGES INSIDE, KEEP OUT, CAN SHOCK BURN OR CAUSE DEATH". (THIS SIGN CAN NO LONGER BE ORDERED)
- (B) → FENCE WARNING SIGN (16-0092), PER ENG & DSGN STD ED 4.10.01. THE SIGNS ARE TO BE MOUNTED 5'-0" FROM GRADE TO TOP OF SIGN, 30'-0" - 45'-0" APART AND NO MORE THAN 15'-0" FROM THE CORNERS. ONE SIGN SHOULD BE PLACED ON THE OUTSIDE OF EACH WALK GATE. TWO SIGNS SHOULD BE MOUNTED ON EACH DRIVE GATE, ONE ON THE INSIDE AND ONE ON THE OUTSIDE. (BACK TO BACK ON THE LEFT SIDE OR DRIVERS SIDE PANEL OF THE DOUBLE GATES).
- (C) → BURIED CABLE SIGN (16-0088), PER ENG & DSGN STD ED 4.10.06. THE SIGNS ARE TO BE MOUNTED ON EACH SIDE OF FENCE FABRIC, BACK TO BACK AND APPROXIMATELY 3'-6" FROM GRADE TO TOP OF SIGNS. ORDERED BY FIELD.
- (D) → BURIED CABLE SIGN MOUNTED ON POST (16-0095), PER ENG & DSGN STD ED 4.10.06. POST AND SIGN ORDERED BY FIELD.
- (E) → SUBSTATION IDENTIFICATION SIGN PER ENG & DSGN STD ED 4.10.02 (TOP) AND ADDRESS SIGN PER ENG & DSGN STD ED 4.10.03 (BOTTOM). THE TOP SIGN MOUNTED 5'-0" FROM GRADE TO TOP OF SIGN AND LOCATED ADJACENT TO WALK OR DRIVE GATES.
- (F) → BATTERY WARNING SIGN (S7-5454), PER ENG & DSGN STD ED 4.10.04. THE SIGNS ARE TO MOUNTED ON THE OUTSIDE OF EACH CONTROL HOUSE DOOR, APPROXIMATELY 5'-0" FROM THE BOTTOM OF THE DOOR TO THE TOP OF SIGN.
- M-1 → INDICATES CONCRETE MARKERS FOR DIRECT BURIED CABLE RUNS. E & D STD. ED 4.05.04, ORDERED BY FIELD.
- INDICATES LOW BUS (21'-2")
- INDICATES PLASTIC BALARDS BY FIELD

FOR DRAWING REFERENCE AND REVISION INFORMATION SEE INDEX SHEET

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

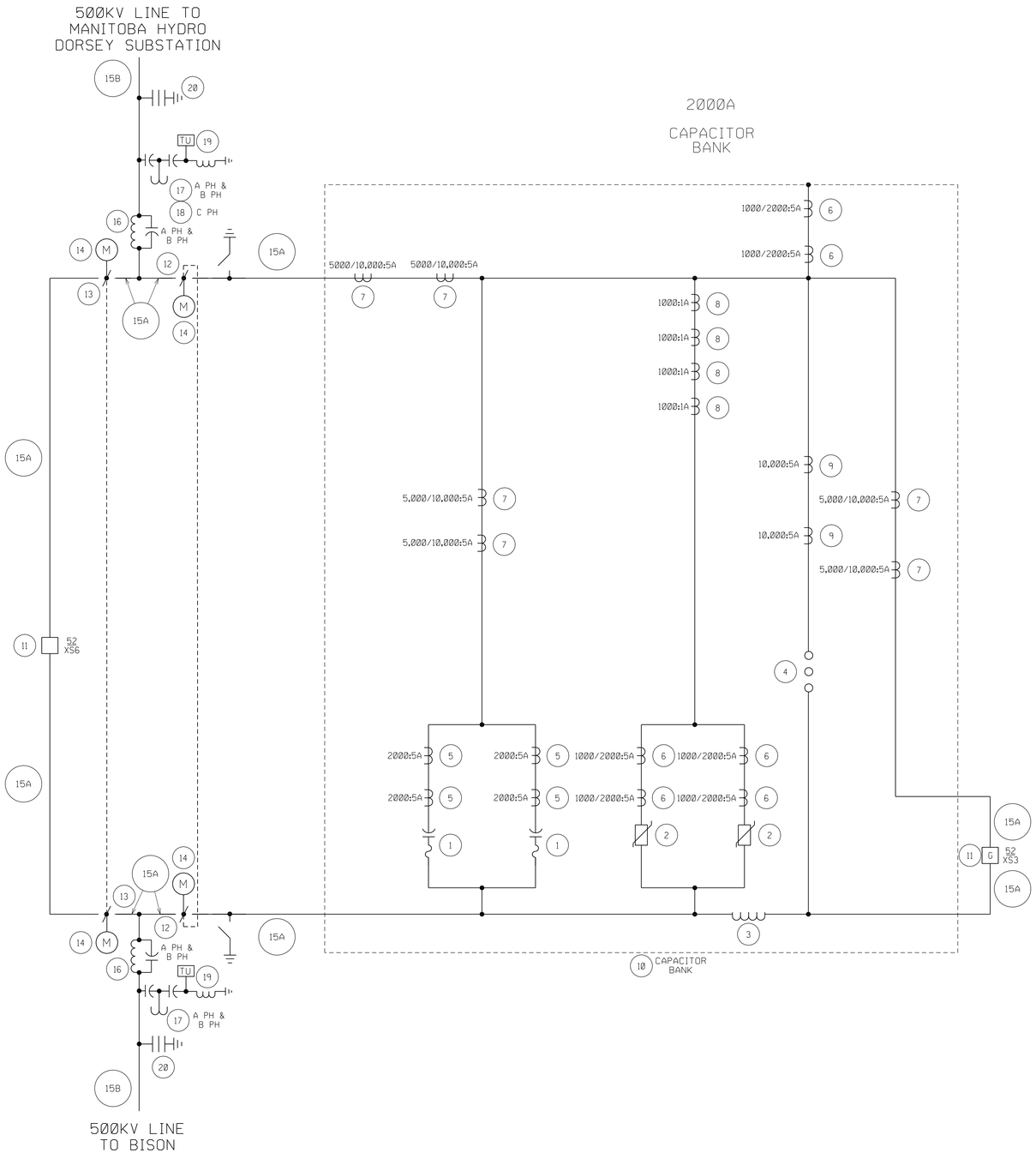
MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

NORTH 500KV SERIES CAP BANK STATION LOCATION PLAN

0 1" 2"

FILENAME	NORTH LOC PLAN.DGN
SCALE	1:40

SHEET
LOC PLAN



21 AUTOMATIC TRANSFER SWITCH
22 BATTERY
23 BATTERY CHARGER
24 STATION SERVICE
25 GEN SET

STATION AUXILIARIES LOCATED IN CONTROL HOUSE
SEE SCHEMATIC DIAGRAM

PRELIMINARY
NOT FOR CONSTRUCTION

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR 500KV FACILITIES STUDY OPTION ONE

NORTH 500KV SERIES CAP BANK STATION CIRCUIT DIAGRAM 500KV

0 1" 2"

FILENAME	NORTH CIR DIA.DGN
SCALE	NONE

SHEET **CIR DIA**

NORTH 500KV SERIES CAP BANK SUBSTATION ()

CIRCUIT DIAGRAM - LIST OF EQUIPMENT

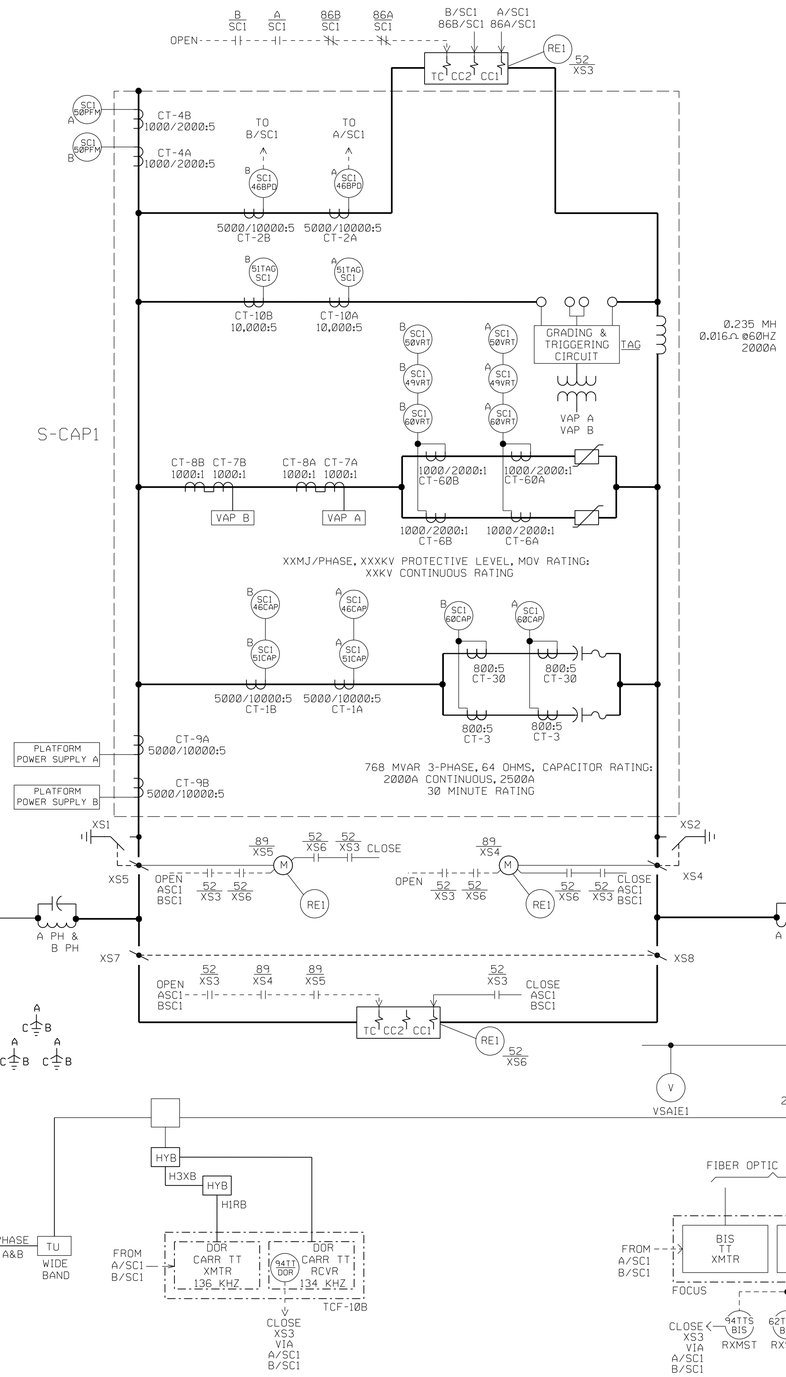
Date Created

This Map/Document is a tool to assist employees in the performance of their jobs. Your personal safety is provided for by using safety practices, procedures and equipment as described in safety training programs, manuals and SPAR's

03/17/10

REV - 0

ITEM NO.	DESCRIPTION	STANDARD DESIGNATION & NOMINAL RATING	ORDER NUMBER	DRAWING NUMBER	CURRENT REVISION INFO (Existing & unchanged items left blank)
1	1 - THREE PHASE SERIES CAPACITOR BANK, ____ CO., 768MVAR, 64 OHM (___ TWO BUSHING UNITS @ ____ KVAR, 500KV, 60 HZ, ___KV BIL, ____CO., CAT _____, CONNECTED THUS: _ UNITS SERIES PER GROUP, __ PARALLEL CONNECTED GROUPS PER SEGMENT AND _ PARALLEL CONNECTED SEGMENT PER PHASE)				
2	3 - SINGLE PHASE VARISTOR BANK, _____ CO., METAL OXIDE TYPE UNIT __ UNITS @ (__ IN PARALLEL) CONNECTED IN PARALLEL WITH (__ IN PARALLEL).				
3	3 - SINGLE PHASE REACTOR, OUTDOOR, ____ CO., DRY TYPE, AIR CORE, ___ KV BIL, ____ A, ___MH (____ OHMS @ 60 HZ)				
4	3 - SINGLE PHASE TRIGGERED AIR GAP, _____ CO., CAT _____, WITH ENCLOSURE				
5	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 2000:5A SINGLE-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
6	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 1000/2000:5A DUAL-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
7	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 5000/10000:5A DUAL-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
8	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 1000:1A SINGLE-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
9	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 10000:5A SINGLE-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
10	3 - SINGLE PHASE 500 KV INSULATED EQUIPMENT PLATFORM, _____ CO.				
11	3 - SINGLE PHASE GAS CIRCUIT BREAKER, _____ CO. TYPE _____, 550KV MAXIMUM, 40,000 AMPS INTERRUPTING CAPACITY WITHOUT CT'S	YR MFG ____, 2000 A			
12	3 - SINGLE PHASE PAIR OPERATED, SWITCH, DOUBLE END-BREAK, _____CO. TYPE _____ ,500KV, 100,000AMPS MOMENTARY WITH ONE PAIR OPERATED GROUND BLADES, _____CO., TYPE_____	___ ACCC, 2000A			
13	3 - SINGLE PHASE PAIR OPERATED, SWITCH, DOUBLE END-BREAK, _____CO. TYPE _____ ,500KV, 100000AMPS MOMENTARY	___ ACCC, 2000A			
14	1 - SWITCH OPERATING MOTOR MECHANISM, _____ CO. TYPE _____, _____VDC				
15A	BUS - ALUMINUM TUBULAR BUS	6" AL TUBE (SCHED 40)			
15B	BUS - STRANDED ALUMINUM CONDUCTOR (CODE NAME COREOPSIS)	1-1590 AAC - 61 STRAND			
16	2 - LINE TRAP, _____ CO., DRY-TYPE AIR CORE, MODEL #_____, 500GNDY/287.5KV, _____ KHZ, WIDE (OR NARROW) BAND VERTICAL MOUNTING ON 5" B.C.	EPOXY (OR NON-EPOXY), 2000A			
17	2-SINGLE-PHASE - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500GNDY/287.5KV, 1800KV BIL, _____ CO., CAT.# _____ WITH CARRIER ACCESSORIES, _____ VOLTS, _____% ACCURACY THRU _____ BURDEN				
18	1-SINGLE-PHASE - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500GNDY/287.5 KV, 1300 KV BIL, _____ CO., CAT.# _____ WITHOUT CARRIER ACCESSORIES, _____ VOLTS, _____% ACCURACY THRU _____ BURDEN				
19	2 - LINE TUNING UNIT, _____CO., MODEL #_____, WIDE BAND, _____ KHZ				
20	3 - SURGE ARRESTER, STATION CLASS, _____ CO. PORCELAIN, CAT#_____, 335KV MCOV, 500KV				
21	AUTOMATIC TRANSFER SWITCH, _____ CO., TYPE _____, 400 AMP, 120/240VAC SINGLE PHASE				
22	BATTERY, _____ CO., TYPE _____, 125 VDC, _____ AMP-HOUR RATING. BATTERY RACK IS __ TIER, __D x __W x __H				
23	BATTERY CHARGER, _____ CO., TYPE_____, ___VDC, ___ AMPS, ___VAC SINGLE PHASE SOURCE				
24	1 - SINGLE-PHASE TRANSFORMERS, _____ CO. CLASS _____, 65℃ RISE @ 1000M, SUBTRACTIVE POLARITY, 24 0/120 VOLTS				
25	1-GENSET, ____CO.				



HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

NORTH 500KV SERIES CAP BANK STATION METERING & RELAYING DIAGRAM 500KV

0 1" 2"

FILENAME	NORTH M&R.DGN
SCALE	NONE

SHEET **M&R**

5/28/2010 2:03:32 PM gstroup c:\pwworking\sea\d0400479\NORTH CAP BANK M&R.DGN

PROJECT DESIGN GUIDE

Location: Bison Substation (BIS)
Project Title: MH TSR 500 kV Option 1 Facilities Study – Upgrade Bison Substation for new 500-345 kV Substation

In-Service Date:	December 2017
Program Manager:	CapX2020
Project Manager:	Jared Alholinna, CapX2020 Chris Ayika, Xcel Energy
Prepared By:	HDR Engineering, Inc.
Estimate Type and Amount:	Facilities Study $102,400,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the midline location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. .

The following assumptions have been included in the substation portion of this study:

1. This study assumes that the CapX2020 Bison Substation has been constructed and that the 500 and 345 kV additions identified herein can be accommodated by purchasing an adjacent 80 acre parcel. The site that is selected for the Bison Substation will have the ability to acquire the required property for the expansion identified within this study.

2. The study has been prepared for CapX2020. The ownership of the substation has not been identified at this time.

3. No special protection systems for area wide dynamic system operation have been studied at this time and no equipment for such systems are included in this study.

4. The SVC and Shunt Capacitor Banks included in this study are similar to the equipment currently installed at the Forbes Substation for the existing Dorsey-Forbes-Roseau-Chisago 500 kV transmission line. Reactive support requirements have not been finalized by MISO. MISO has directed CapX2020 to include the SVC and Shunt Capacitor Banks to match the existing Forbes Substation installation.

5. The exact requirements of the site including access, topography, drainage, geotechnical structure and landscaping are not identified at this time. Therefore, general assumptions have been made for this scope. Additional costs have been included for deep drilled pier foundations that may be required due to poor soil parameters in the Red River Valley.

Background

Several Transmission Service Requests (TSR) for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service. The study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

Space will be reserved on the south 500 kV bus row for two (2) future breakers. One (1) breaker will be located west of the TR1 position and one (1) breaker will be located east of the HLN Line position.

Space will be reserved south of the new TR1 for three (3) 345 kV breakers. These will create two (2) new 345 kV line positions.

Space will be reserved east of the new TR1 345 kV position for one (1) future 345 kV breaker. This will create a new 345 kV line position.

All future equipment is shown on the attached drawings.

II. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

CIP requirements for this station are not identified at this time. The exact requirements will be identified once the ownership and operational control of the station is determined.

Facility Ratings

It is assumed that the Bison Substation constructed by CapX2020 will meet the new facility rating requirements of the transmission owner.

III. Right of Way

1,413 KSF of new land will be required north of the CapX2020 Bison Substation 345 kV Yard. It is assumed that the site that have been identified for this substation for the initial CapX2020 Bison Substation construction will allow for the expansion of the yard to accommodate the new 500 and 345 kV equipment.

IV. Electrical Features

Transmission Lines: Current Carrying Capacity of Affected/Tapped/New

Transmission Lines	Current Rating		
	Conductor Type	Summer (40 deg C)	Winter (0 deg C)
Dorsey-Bison 500 kV Line	3-1192.5 ACSR	4365 amps	5724 amps
Bison-Helena (HLN) 500 kV Line	3-1192.5 ACSR	4365 amps	5724 amps

The Bison 500 and 345 kV bus and associated equipment will be rated for 2000 amps.

Fault Current

The substation will be designed to 40 kA on 500 and 345 kV bus and equipment.

Preliminary Modeling in CAPE is shown in the following table:

Location \ Type of fault	Three Phase Amps
500 kV System at BIS with Dorsey and Helena Lines	6,168
345 kV System at BIS with Dorsey and Helena Lines	9,319

Electrical Removals & Relocations

No equipment will be removed or relocated for this project.

Electrical Installations (Major Equipment)

500 kV

Four (4) 500-345 kV, 400 MVA at 65° C top rating single phase autotransformers will be installed (TR1)(three in-service, one spare). The tertiary is rated at 34.5 kV, 70 MVA at 65° C.

Six (6) 500 kV, 2000 A, 40 kAIC, SF6 dead tank circuit breakers will be installed (52/CB2, 52/CB4, 52/CB5, 52/CB6, 52/CB7, and 52/CB8).

One (1) 500 kV, 150 MVAR Shunt Reactor will be installed on the DOR Line.

One (1) 500 kV, 225 MVAR Shunt Reactor will be installed on the HLN Line.

One (1) 500 kV, Static VAR Compensator +/- 400 MVAR will be installed.

Two (2) 500 kV, 300 MVAR Mechanically Switched Capacitors will be installed in the SVC Position.

Fifteen (15) 500 kV, 2000 A, double-end-break motor-operated disconnect switches (52/CB1-A, 52/CB2-B1, 52/CB2-B2, 52/CB3-A, 52/CB4-A, 52/CB4-B, 52/CB5-B1, 52/CB5-B2, 52/CB6-A, 52/CB6-B, 52/CB7-A, 52/CB8-A, 52/CB21-A, 52/CB22-A, and SVC-A), will be installed for breaker and SVC isolation. A switch stand for the future switch 52/CB1-B will be installed. . A switch stand for the future switch 52/CB3-B will be installed.

One (1) 500 kV, 2000 A, double-end-break motor-operated disconnect switch will be installed on a switch stand on the HV side of the 500-345 kV transformer for isolation purposes.

Three (3) single-phase 500 kV CCVT units will be installed for DOR Line protection and synchronization.

Three (3) single-phase 500 kV CCVT units will be installed for HLN Line protection.

One (1) single-phase 500 kV CCVT unit will be installed for 500 kV transformer synchronization.

One (1) single-phase 500 kV CCVT unit will be installed for 500 kV bus synchronization.

Twelve (12) 335 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. Three arresters will be mounted in each 500 kV Line position (Dorsey & HLN). Three arresters will be mounted in the 500 kV SVC position. Three arresters will be mounted in the TR1 HV position.

Two (2) 500 kV, 2000 A line traps and tuners will be installed on the deadend for the line to DOR Substation.

Two (2) 500 kV, 2000 A line traps and tuners will be installed on the deadend for the line to HLN Substation.

The bus in each row will consist of 6 inch aluminum tube (4250 amp) in order to limit bus support structures and 2-1590 MCM aluminum stranded conductor (2400 amps) for breaker jumpers will be installed.

345 kV

Five (5) 345 kV, 2000A, 40 kAIC, SF6 dead tank circuit breakers will be installed (52/CB10, 52/CB11, 52/CB14, 52/CB18, and 52/CB19).

Nine (9) 345 kV, 2000 A, double-end-break motor-operated disconnect switches (52/CB10-B1, 52/CB10-B2, 52/CB11-A, 52/CB11-B, 52/CB14-B, 52/CB19-B1, 52/CB19-B2, 52/CB18-B, and 52/CB9-A) will be installed for breaker isolation. A switch stand for the future switch 52/CB9-B will be installed. .

One (1) 345 kV, 2000 A, double-end-break motor-operated disconnect switch will be installed on a switch stand on the LV side of the 500-345 kV transformer for isolation purposes.

Three (3) 230 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. The arresters will be mounted in the TR1 LV position.

Three (3) single-phase 345 kV CCVT units will be installed on the secondary side of the 500-345 kV transformer (TR1) for revenue metering purposes.

The bus in each row will consist of 6 inch aluminum tube (4435 amp) in order to limit bus support structures and 2-1590 MCM aluminum stranded conductor (2400 amps) for breaker jumpers will be installed.

34.5 kV

Three (3) 34.5 kV, 20.125/115-69 V 175/300:1 single phase bus PTs will be installed on the TRI tertiary for relaying.

Two (2) 34.5 kV, 300 KVA, 34500-120/208 V padmount distribution transformers will be installed for station service. One (1) will be connected to the TR1 tertiary and one (1) will be connected to local distribution.

Three (3) 22 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. The arresters will be mounted in the TR1 Tertiary position.

The bus will consist of 3 inch aluminum tube (1670 amp) in order to limit bus support structures and 1590 MCM aluminum stranded conductor (1200 amps) for breaker jumpers will be installed.

Mobile Substation or Transformer

No Mobile Equipment will be necessary.

Electrical Equipment Enclosure (EEE)

A new 24' X 80' metal control house will be erected in the southeast corner of the new substation. The control house building will have two points of egress, one single door and one double door. The control house will have four exhaust fans, four propeller type electric unit heaters, and wall louvers. The control house will accommodate protection relay panels, AC breaker panels, DC fuse panels, terminal cabinets, 125 VDC station battery and charger, 48 VDC communication system battery and charger, telephone equipment panelboard, overhead cable tray, lights, receptacles, and other miscellaneous equipment.

AC System

The AC system will be sized to accommodate the three 500-345 kV single phase autotransformer fan load, thirteen 500 kV gas circuit breaker motor and heater loads, fifteen 345 kV gas circuit breaker motor and heater loads, fifty motor-operated disconnect heater loads, and the control building auxiliary equipment. The station service will be sized for the anticipated ultimate 500-345 kV layout installation, construction power and a small contingency factor.

The primary source for the AC station auxiliary power transformer will be the 34.5 kV tertiary of the 500-345 kV autotransformer, TR1. The emergency source will be local distribution power. The secondary voltage of the auxiliary sources will be three-phase 120/208 V.

Provisions for a 100 KW black start generator set has been included in this study.

DC System

A detailed DC study will be performed during the design phase of the project. The estimate provides for a 125 VDC battery with a battery charger and associated fuses and DC cabinets.

A 48 VDC battery with a battery charger and associated fuses and DC cabinets is included for the communications system equipment.

Grounding

A ground grid consisting of 4/0 copper conductor and ground rods will be installed to provide a safe and effective grounding system per IEEE standards. Soil resistivity measurements will be taken in the area where the new substation will be installed upon soil thawing and rough grading completion. Ground grid design calculations will be made at this time. Fence counterpoise grounding will be installed.

Lightning Protection

Lightning protection will be provided for the new substation to adequately protect the new 500 and 345 kV buses. The estimate includes twelve (12) 100' tapered tubular steel shield masts in addition to lightning masts on the 500 kV and 345 kV line termination structures.

Trenching & Cable

New precast trenching will be installed for all new equipment. All new control cables will be installed.

V. Civil Features

Grading & Fencing

A graded area approximately 1310 feet by 1078 feet will be constructed north of the existing Bison Substation 345 kV Yard. Grading will consist of topsoil stripping and removal of all vegetation followed by subexcavation totaling 3 feet. The excavated subgrade will be compacted to form a firm base followed by the placement of approximately 2 feet of imported fill. The rough grade elevation will be established through importing, placement and compaction of a 1 foot layer of class 5 aggregate base. Prior to the in-service date, grading activity will be completed by the import and placement of a 4 inch layer of crushed rock surfacing.

Note the landscaped area is assumed to be 25% of the total graded area and for this case is limited to revegetation of surfaces beyond the edge of grade and retention pond but not exceeding the area disturbed by grading activities.

Storm Water Permit

A Storm Water Permit will be required.

Foundations & Structural

The proposed foundations include drilled piers for all galvanized steel structures and slabs-on-grade for electrical equipment (circuit breakers and power transformers) and the control house. Final foundation types and sizes will be determined once the results and recommendations of the soil boring investigation are completed.

The steel structures for the proposed substation include low profile equipment stands and bus supports and tapered tubular dead end structures to support each transmission line termination. The low profile steel structures will be tapered tubular. The tapered tubular structures will be designed and fabricated by the steel fabricator.

Civil Removals & Relocations

No civil removals or relocations will be used.

Civil Installations

The following concrete slab foundations will be installed:

Quantity	Description	Approx. Size
1	Control House	24' x 80' x 1'
4	400 MVA Transformer Pad	45' x 65' x 3'
4	Oil Containment Basin	61' x 81' x 6'
8	500 kV Gas Circuit Breaker Slab	8' x 20' x 1'
5	345 kV Gas Circuit Breaker Slab	8' x 16' x 1'
2	Station Service Transformer Pad	5' x 5' x 1'

The following galvanized steel structures and concrete drilled pier foundations will be installed:

Steel Structures		Drilled Piers		
			Approximate Size	
Qty	Description	Qty	Diameter	Depth
54	500 kV Bus Support – 1PH	54	3'-0"	33'-0"
4	500 kV Deadend Structure	16	8'-6"	60'-0"
9	500 kV Surge Arrester Stand	9	3'-0"	21'-0"
18	500 kV Switch Stand	72	3'-0"	21'-0"
8	500 kV CCVT Stand	8	3'-0"	20'-0"
43	345 kV Bus Support – 1PH	43	3'-0"	20'-0"
1	345 kV Deadend Structure	2	8'-6"	40'-0"
11	345 kV Switch Stand	44	3'-0"	20'-0"
3	345 kV CCVT Stand	3	2'-6"	20'-0"
12	Shield Pole – 100FT	12	4'-0"	32'-0"
12	34.5 kV Bus Support – 1PH	12	3'-0"	20'-0"

Oil Containment

The transformers will contain a significant volume of oil; thus, the average risk rating for this facility is assumed to qualify the facility as a risk site. Because run-off from the facility could potentially reach navigable waters as well as create a significant plume elsewhere in the plant facility; it is recommended that the transmission owner install a cast-in-place concrete basin around each transformer.

Electrical Equipment Enclosure (EEE) or Switchgear Building

A 24 foot by 80 foot control house will be ordered and constructed as previously outlined in this design guide.

VI. Control Features

For estimating purposes, typical NSP relaying and associated communication equipment is shown.

Control Schemes

Transmission Line Protection – 500 kV Dorsey Line (DOR)

A SEL-421-3 based DCUB scheme will be used for primary relaying. A frequency shift TCF-10B, or equivalent, transmitter/receiver will be used for the primary relay pilot channel. A GE-D90+ based POTT scheme will be used for secondary relaying. A fiber optic FOCUS panel, or equivalent, transmitter/receiver will be used for the secondary relay pilot channel.

Watt/Var EMS analog values for the 500 kV DOR transmission line will be extracted from an ATAIE1 meter/transducer. The 0-1mA outputs of this transducer will be wired into the RTU.

The RTU primary relay and transfer trip On/Off control and status points will be used with the SEL relays. The RTU status points for the DOR line carrier transfer trip trouble, carrier primary relay trouble, carrier transfer trip received alarms, primary and secondary relay malfunction alarms, primary and secondary relay loss of AC will be used.

A FOCUS or equivalent transmitter/receiver for communications between HLN and DOR will be used.

Single pole tripping and reclosing will be implemented.

Transmission Line Protection – 500 kV Helena Line (HLN)

A SEL-421-3 based POTT scheme will be used for primary relaying. A frequency shift TCF-10B, or equivalent, transmitter/receiver will be used for the primary relay pilot channel. A GE-D90+ based POTT scheme will be used for secondary relaying. A fiber optic FOCUS panel, or equivalent, transmitter/receiver will be used for the secondary relay pilot channel.

Watt/Var EMS analog values for the 500 kV HLN transmission line will be extracted from an ATAIE1 meter/transducer. The 0-1mA outputs of this transducer will be wired into the RTU.

The RTU primary relay and transfer trip On/Off control and status points will be used with the SEL relays. The RTU status points for the HLN line carrier transfer trip trouble, carrier primary relay trouble, carrier transfer trip received alarms, primary and secondary relay malfunction alarms, primary and secondary relay loss of AC will be used.

Single pole tripping and reclosing will be implemented.

Transmission Breaker Protection (500 kV)

SEL-451-2 relays will be installed to provide for breaker failure protection and sync-check for the 500 kV gas circuit breakers 52/CB2, 52/CB4, 52/CB5, 52/CB6, 52/CB7, 52/CB8, 52/CB20, and 52/CB21. Breaker failure can also be provided by the line relay, but a separate breaker failure relay is assumed for estimating purposes. Remote control functionality will be provided to the EMS. Remote close will be supervised by sync/dead line/dead bus.

Local alarm and RTU status points will be added for breaker failure lockout, relay and sync malfunction, and single/dual trip coil failure alarms for the new 500 kV circuit breakers. These alarms will be generated by the SEL-451-2 relays.

Transformer Bus Protection (500 kV)

Protection of the 500 kV transformer bus will be installed and will consist of primary and secondary current differential schemes utilizing a SEL-387 as the primary relay and a G.E. B90 as the secondary relay. Transformer bus protection can be provided by transformer differential relaying, but separate bus protection is assumed for estimating purposes.

The bus differential relay may still allow through flow on the SVC position. Cross-tripping the north section if the power flow exceeds a preset value may be considered.

Local alarm and RTU status points will be added for lockout and relay malfunction. These alarms will be generated by the SEL-387 and B90 relays.

Transformer Protection (TR1)

500-345 kV TR1 protection will consist of two separate current differential and overcurrent schemes utilizing a SEL-387 as the primary relay and a G.E. T60 as the secondary relay. Separate transformer protection is assumed for estimating purposes

Local alarm and RTU status points will be added for lockout and relay malfunction. These alarms will be generated by the SEL-387 and T60 relays.

Transformer Failure Sectionalizing (TR1)

A transformer failure sectionalizing scheme will be implemented for the 500-345 kV autotransformer TR1. The scheme will work in the following manner:

- Upon detection of a transformer failure condition, the SEL-387 relay will initiate tripping of adjacent breakers. At the same time, the SEL-387 relay will initiate the opening of the transformer primary and secondary disconnect switches via the motor operators, which will isolate the failed transformer.

- Upon completion of the opening of the failed transformer's motor operated disconnect switches, the adjacent breakers will be automatically closed via their 50BF-79 SEL-451-2 relays, which will re-energize the bus.

- Remote and local control of the motor operated disconnect switches will be implemented.

Transmission Breaker Protection (345 kV)

SEL-451-2 relays will be installed to provide for breaker failure protection and sync-check for the 345 kV gas circuit breakers 52/CB10, 52/CB11, 52/CB14, 52/CB18, and 52/CB19. Separate breaker failure is assumed for estimating purposes. Remote control functionality will be provided to the EMS. Remote close will be supervised by sync/dead line/dead bus.

HMI and RTU status points will be added for breaker failure lockout relay and sync malfunction, and single/dual trip coil failure alarms for the new 345 kV circuit breakers. These alarms will be generated by the SEL-451-2 relays.

Transmission Bus Protection (345 kV)

Protection of each of the two 345 kV main buses will be installed and will consist of primary and secondary current differential schemes utilizing a SEL-487 as the primary relay and a G.E. B90 as the secondary relay. Separate bus protection is assumed for estimating purposes.

Local alarm and RTU status points will be added for lockout and relay malfunction. These alarms will be generated by the SEL-487 and B90 relays.

DC Reduction

D.C. reduction schemes reduce the power order at Dorsey converters to prevent over loading of underlying transmission systems on loss of 500 KV paths.

D.C. power is controlled by allocator MW output setting on the D.C. bipole at the converter station. Loss of power outlet is determined by several conditions as listed below:

- Open breaker condition at local end or remote end
- Trip initiation by line relays at any end
- Bypass of capacitors.
- Loss/ reduction of power outlet at remote end. An example would be the loss of south line from Bison or bypass of series capacitor on the south line.
- Loss of reactive support for high transfers

Cross tripping of the north line may also be initiated if the power flow on the line is above a threshold as determined by load flow studies.

The degree of power order could vary from 15% reduction to 100% reduction depending on the type of disturbance.

The scheme is implemented as a fully communication scheme with two independent communication paths. The requirement of the maximum time delay permissible between the disturbance initiation and the allocator power order reduction is determined by the studies group.

RTU

The substation RTU will be transmission owner's requirements. A multiport RTU will be installed. More than 1 SCADA circuit may be required. The SCADA protocol requirement of every utility that need access to the RTU may be different and it will decide what kind of RTU to be installed. Control, status, and alarm points for the new circuit breakers, motor-operated disconnect switches, and relays will be added to the RTU.

Local Annunciation

Local annunciation is via a station display panel. Alarm points will be added to the display for each of the new circuit breakers and motor operated disconnect switches.

Control Panel Locations

All Control Panels will be installed in the new EEE. Panels will be grouped by voltage rating of equipment.

Telephone protection

The telephone protection equipment will includes an SNC 12-slot C-Line card shelf, a 4-port Teltone SLSS line sharing switch, and a telephone access/control box for remote communications to the relays.

Equipment Details

Removals

None.

Installations

The following new relay and control panels will be installed:

- Panel 1N, Future 500 kV BUS 1 PRI & SEC DIFF RLY'G
- Panel 2N, 500 kV, DOR Reactor RLY'G and 500 kV 52/CB18 BKR CONT
- Panel 3N, 500 kV DOR Line PRI RLY'G & TCF-10B and 500 kV 52/CB4 BKR CONT
- Panel 4N, 500 kV DOR Line SEC RLY'G and FOCUS
- Panel 5N, 500 kV 52/CB5 BKR CONT
- Panel 6N, Bus Differential
- Panel 7N, 500 kV 52/CB6 BKR CONT
- Panel 8N, 500 kV TR1 PRI & SEC DIFF RLY'G and Future 500 kV 52/CB3 BKR CONT
- Panel 9N, 500 kV 52/CB2 BKR CONT
- Panel 10N, 500 kV HLN Line SEC RLY'G and FOCUS
- Panel 11N, 500 kV HLN Line PRI RLY'G & TCF-10B and Future 500 kV 52/CB1 BKR CONT
- Panel 12N, 500 kV, HLN Reactor RLY'G & MTR'G and 500 kV 52/CB7 BKR CONT
- Panel 13N, 500 kV BUS 2 PRI & SEC DIFF RLY'G
- Panel 1S, 345 kV BUS 1 PRI & SEC DIFF RLY'G
- Panel 2S, 345 kV TR1 PRI & SEC DIFF RLY'G and 345 kV 52/CB11 BKR CONT
- Panel 3S, 345 kV 52/CB10 BKR CONT
- Panel 4S, Future 345 kV Line PRI RLY'G & TCF-10B and 345 kV 52/CB9 BKR CONT
- Panel 5S, Future 345 kV Line SEC RLY'G & FOCUS
- Panel 6S, 345 kV 52/CB14 BKR CONT
- Panel 7S, 345 kV 52/CB19 BKR CONT
- Panel 8S, 345 kV 52/CB18 BKR CONT
- Panel 12S, Manitoba Communications Panel
- Panel 13S, HSE STA DISPLAY PANEL
- 240 VAC Cabinets
- 125 VDC Cabinets

- 48 VDC Cabinet
- Termination Cabinet

VII. Metering

Revenue metering will be installed for the 500-345 kV transformer (TR1). Bushing current transformers with metering accuracy installed on secondary bushings of the transformer will provide current input. 345 kV CCVTs will provide potential inputs.

VIII. Outages

The following outages on the 345 kV portion of the station will be required:

- Outages will be required on both of the 345 kV buses for new circuit breaker and bus installation.
- Outage on the 345 kV Jamestown transmission line for new circuit breaker installation.
- Outage on the 345-230 kV transformer for new circuit breaker and bus installation.

IX. Material Staging Plan

All major materials will be shipped directly to the job site. Stock materials will be ordered and staged through the transmission owner's warehouse.

X. Project and Operating Concerns

In-Service date may be impacted by transmission construction schedule as well as related substation construction schedules.

XI. Related Projects

MH TSR 500 kV Option 1 – Facilities Study – Segment 1A (US/Canada Border to North Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 1B (Proposed North Series Cap Bank to proposed Bison Sub)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2A (Proposed Bison Sub to proposed South Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2B (Proposed South Series Cap Bank to proposed Helena Sub)

MH TSR 500 kV Option 1 – Facilities Study – 500-345 kV Helena Substation

MH TSR 500 kV Option 1 – Facilities Study – 500 kV North Series Cap Bank Station

MH TSR 500 kV Option 1– Facilities Study – 500 kV South Series Cap Bank Station

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	BIS-SEr0-New Substation
Sub./Line Name:	Bison
WO #:	
Group Name:	
City:	
County:	
State:	ND
WO Type:	41
Op Co:	NSPM
In-service Date:	12/31/2017
Basic Scope:	NSP Sub estimating template

Estimate Information	
Est. Type	SE
Est Status:	Working
Est. Published	4/29/2010
Rev. Number:	0
Prepared By:	HDR Engineering, Inc.
Company:	Northern States Power Co - MN

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Mana	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$1,490,047	$0	$0	$0	$1,490,047
CBS3 - Civil Construction	$3,527,605	$59,340	$3,283,492	$192,213	$7,062,650
CBS4 - Electrical Construction	$5,316,335	$247,450	$72,914,014	$4,206,784	$82,684,583
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$419,756	$0	$0	$0	$419,756
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$10,753,743	$306,790	$76,197,506	$4,398,997	$91,657,035
Indirect Costs					
Powerplant Overheads (E&S + A	$655,978	$0	$4,648,048	$287,053	$5,591,079
Material overheads	$0	$0	$1,523,950	$0	$1,523,950
AFUDC	$0	$0	$0	$0	$0
Contingency	$1,075,374	$0	$1,142,963	$1,411,736	$3,630,073
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$1,731,353	$0	$7,314,961	$1,698,789	$10,745,102
Project Total					**$102,402,138**

Print Date: 4/29/2010

Job Folder Name: BIS-SEr0-New Substation **O&M Estimate:** $ -
Sub-Line Name: Bison Substation
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
JOB											
AFUDC	1	Lump Sum	Inst	Indirect	Miscelleneous	$ -	$ -	$ -	$ -	$ -	$ -
Engineering & Design - Internal Labor (roll-up)	1	HR	Inst	Labor	Miscelleneous	$ -	$ 240,022	$ -	$ -	$ -	$ 240,022
SWITCH GANG MOTOR OPERATOR	26	EA	Inst	Phys	Switch Gang	$ 117,000	$ 41,250	$ -	$ 6,728	$ -	$ 164,977
TRANSFORMER AUTO 500-345 400 MVA SINGLE PHASE	4	EA	Inst	Phys	Transformer	$ 18,000,000	$ -	$ -	$ 1,035,000	$ -	$ 19,035,000
TRANSFORMER INSTALLATION	4	LOT	Inst	Phys	Transformer	$ -	$ 321,936	$ -	$ -	$ -	$ 321,936
CONTINGENCY	1	Lump Sum	Inst	Indirect	Miscellenous	$ 1,142,963	$ 1,075,374	$ 92,037	$ 1,319,699	$ -	$ 3,630,073
ESCALATION	1	Lump Sum	Inst	Indirect	Miscellenous	$ -	$ -	$ -	$ -	$ -	$ -
POWERPLANT AND MATL OVERHEADS	1	Lump Sum	Inst	Indirect	Miscellenous	$ 6,171,998	$ 655,978	$ 18,714	$ 268,339	$ -	$ 7,115,029
CONTROL BUILDING 24'X80' STD SIZE F&E	1	EA	Inst	Civil	EEE	$ 89,000	$ 5,276	$ -	$ 5,118	$ -	$ 99,394
CONCRETE - FIREWALLS	2,625	SFT	Inst	Civil	Fence & Walls	$ 15,750	$ 34,627	$ -	$ 906	$ -	$ 51,282
FENCE 8FT CHAIN LK W/BARB	3,617	FT	Inst	Civil	Fence & Walls	$ 78,534	$ 95,425	$ -	$ 4,516	$ -	$ 178,474
FENCE GATE DRIVE 20 FT	4	EA	Inst	Civil	Fence & Walls	$ 2,900	$ 264	$ -	$ 167	$ -	$ 3,331
Fence Silt 3'H	3,617	FT	Inst	Civil	Fence & Walls	$ 1,338	$ 23,856	$ -	$ 77	$ -	$ 25,271
Breaker Slab 345kV (8'x16')	5	EA	Inst	Civil	Foundations	$ 2,938	$ 14,415	$ -	$ 169	$ -	$ 17,521
Breaker Slab 500kV (8'x20')	8	EA	Inst	Civil	Foundations	$ 6,700	$ 33,205	$ -	$ 385	$ -	$ 40,290
EEE Slab 24' x 80' x 1'	1	EA	Inst	Civil	Foundations	$ 8,889	$ 43,663	$ -	$ 511	$ -	$ 53,062
OIL CONTAINMENT - BASIN - >15000 GALLON	4	EA	Inst	Civil	Foundations	$ 19,350	$ 94,976	$ -	$ 1,113	$ -	$ 115,439
Station Service Padmount Pad	1	EA	Inst	Civil	Foundations	$ 135	$ 132	$ -	$ 8	$ -	$ 275
Transformer Slab 400MVA	4	EA	Inst	Civil	Foundations	$ 23,705	$ 116,319	$ -	$ 1,363	$ -	$ 141,387
SITE - DETENTION POND	4	EA	Inst	Civil	Grading & Landscaping	$ 20,000	$ 30,340	$ -	$ 1,150	$ -	$ 51,490
SITE - EARTHWORK - COMPACTION TEST	1	EA	Inst	Civil	Grading & Landscaping	$ 150	$ -	$ -	$ 9	$ -	$ 159
SITE - GRADING	1	EA	Inst	Civil	Grading & Landscaping	$ 2,299,079	$ 1,669,749	$ -	$ 132,197	$ -	$ 4,101,024
_35kV PT Stand - 3 phase	1	EA	Inst	Civil	Structure - Rolled Steel	$ 1,880	$ 2,156	$ -	$ 108	$ -	$ 4,145
34.5kV BUS SUPPORT STAND - 1PH	18	EA	Inst	Civil	Structure - Welded Tubular	$ 41,400	$ 30,243	$ -	$ 2,381	$ -	$ 74,023
345kV Bus Support Stand - 1PH (10'-0)	43	EA	Inst	Civil	Structure - Welded Tubular	$ 81,861	$ 110,168	$ -	$ 4,707	$ -	$ 196,736
500kV Bus Support Stand - 1PH (36'-6)	54	EA	Inst	Civil	Structure - Welded Tubular	$ 325,350	$ 250,650	$ -	$ 18,708	$ -	$ 594,708
500kV CCVT Stand 1PH (15')	8	EA	Inst	Civil	Structure - Welded Tubular	$ 18,200	$ 19,149	$ -	$ 1,047	$ -	$ 38,396
500kV Deadend Structure	4	EA	Inst	Civil	Structure - Welded Tubular	$ 1,850,325	$ 783,968	$ -	$ 106,394	$ -	$ 2,740,686
345kV Surge Arrester Stand 1PH	3	EA	Inst	Civil	Structure - Welded Tubular	$ 3,975	$ 5,322	$ -	$ 229	$ -	$ 9,525
500kV Surge Arrester Stand 1PH	12	EA	Inst	Civil	Structure - Welded Tubular	$ 31,350	$ 31,994	$ -	$ 1,803	$ -	$ 65,147

Job Folder Name: BIS-SEr0-New Substation **O&M Estimate:** $ -
Sub-Line Name: Bison Substation
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
345kV Switch Stand (10'-7)	10	EA	Inst	Civil	Structure - Welded Tubular	$ 147,332	$ 121,641	$ -	$ 8,472	$ -	$ 277,445
500kV Switch Stand (15')	16	EA	Inst	Civil	Structure - Welded Tubular	$ 466,400	$ 250,811	$ -	$ 26,818	$ -	$ 744,029
Shield Pole 100FT	12	EA	Inst	Civil	Structure - Welded Tubular	$ 132,489	$ 108,508	$ -	$ 7,618	$ -	$ 248,615
CIVIL INSPECTION/TESTING (CONT	1	EA	Inst	Civil	Survey and Test	$ -	$ 1,080	$ -	$ -	$ -	$ 1,080
SITE - SOIL BORINGS (NEW SUB 7 BORING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 4,980	$ -	$ -	$ -	$ 4,980
SITE - SOIL GEOTECHNICAL INVESTIGATING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 6,000	$ -	$ -	$ -	$ 6,000
SITE - SOIL RESISTIVITY TESTING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 960	$ -	$ -	$ -	$ 960
SITE - SURVEY - CONST. STAKING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 1,620	$ -	$ -	$ -	$ 1,620
SITE - SURVEY (TOPO/BOUNDARY)	1	LOT	Inst	Civil	Survey and Test	$ -	$ 10,020	$ -	$ -	$ -	$ 10,020
TRENCHING AND ACCESS-HAND-36"	400	FT	Inst	Civil	Trenching	$ 400	$ 21,897	$ -	$ 23	$ -	$ 22,320
TRENCHING AND ACCESS-MACH-36"	2,200	FT	Inst	Civil	Trenching	$ 2,200	$ 24,667	$ -	$ 127	$ -	$ 26,994
TRENCHING PRECAST 40" OPEN BOTTOM	2,520	FT	Inst	Civil	Trenching	$ 75,600	$ 231,029	$ -	$ 4,347	$ -	$ 310,976
TRENCHING PRECAST 40" ROAD CROSSI	80	FT	Inst	Civil	Trenching	$ 6,400	$ 13,086	$ -	$ 368	$ -	$ 19,854
. CABLE -CONT/PWR-TERM. 600V	4,088	EA	Inst	Cntrl	Cable - Control	$ 450	$ 91,564	$ -	$ 26	$ -	$ 92,039
. CABLE -CONTROL-600V 1C 12	213,720	FT	Inst	Cntrl	Cable - Control	$ 44,891	$ 478,693	$ -	$ 2,581	$ -	$ 526,164
. CABLE -CONTROL-600V 3C 4	6,600	FT	Inst	Cntrl	Cable - Control	$ 26,098	$ 14,783	$ -	$ 1,501	$ -	$ 42,381
. CABLE -CONTROL-600V 3C 6	1,100	FT	Inst	Cntrl	Cable - Control	$ 3,254	$ 2,464	$ -	$ 187	$ -	$ 5,905
. CABLE -CONTROL-600V 4C 10	62,783	FT	Inst	Cntrl	Cable - Control	$ 78,511	$ 140,621	$ -	$ 4,514	$ -	$ 223,647
. CABLE -CONTROL-600V 7C 10	12,650	FT	Inst	Cntrl	Cable - Control	$ 31,092	$ 28,334	$ -	$ 1,788	$ -	$ 61,213
. CABLE -CONTROL-600V 2PR 18	2,200	FT	Inst	Cntrl	Cable - Control	$ 1,483	$ 4,928	$ -	$ 85	$ -	$ 6,496
. CABLE -CONTROL-600V 2PR 18	2,200	FT	Inst	Cntrl	Cable - Control	$ 1,483	$ 4,928	$ -	$ 85	$ -	$ 6,496
. CABLE -CONTROL-600V 8PR 18	8,800	FT	Inst	Cntrl	Cable - Control	$ 13,827	$ 19,710	$ -	$ 795	$ -	$ 34,332
. CABLE -CONTROL-600V 10PR 10	9,900	FT	Inst	Cntrl	Cable - Control	$ 58,805	$ 22,174	$ -	$ 3,381	$ -	$ 84,360
FIBER OPTIC - FOCUS CHASSIS	1	EA	Inst	Cntrl	Fiber	$ 10,000	$ 1,792	$ -	$ 575	$ -	$ 12,367
FIBER OPTIC CABLE-SINGLE MODE	2,500	EA	Inst	Cntrl	Fiber	$ 1,375	$ 9,333	$ -	$ 79	$ -	$ 10,787
FIBER PATCH PANEL	1	EA	Inst	Cntrl	Fiber	$ 500	$ 560	$ -	$ 29	$ -	$ 1,089
FIBER SPLICE BOX	2	EA	Inst	Cntrl	Fiber	$ 200	$ 747	$ -	$ 12	$ -	$ 958
PANEL-345KV TRANSFORMER METERING	1	EA	Inst	Cntrl	Panels - Conventional	$ 30,000	$ 2,986	$ -	$ 1,725	$ -	$ 34,711
PANEL-COMMUNICATIONS PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 20,000	$ 5,973	$ -	$ 1,150	$ -	$ 27,123
PANEL-DC RUNBACK PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 10,000	$ 5,973	$ -	$ 575	$ -	$ 16,548
PANEL-GE-D90+ SECONDARY AND FOCUS	2	EA	Inst	Cntrl	Panels - Conventional	$ 60,000	$ 5,973	$ -	$ 3,450	$ -	$ 69,423
PANEL-PLC TERMINAL CAB LAYOUT (MATERIAL LIST & TERM BLOCK LAYOUT)	1	EA	Inst	Cntrl	Panels - Conventional	$ 12,000	$ 2,986	$ -	$ 690	$ -	$ 15,676
PANEL-QUICKPANEL DISPLAY WITH SEL-2032 COMM SW & GPS CLOCK	1	EA	Inst	Cntrl	Panels - Conventional	$ 23,000	$ 2,986	$ -	$ 1,323	$ -	$ 27,309
PANEL-SEL-387 PRI AND T-60 SEC TRANS DIFF RLY'G (500-345KV)	1	EA	Inst	Cntrl	Panels - Conventional	$ 30,000	$ 2,986	$ -	$ 1,725	$ -	$ 34,711
PANEL-SEL-387 PRIM & B-90 SEC BUS DIFFERENTIAL RLY'G	5	EA	Inst	Cntrl	Panels - Conventional	$ 115,000	$ 14,932	$ -	$ 6,613	$ -	$ 136,545
PANEL-SEL-421 PRIMARY AND TCF-10B CARRIER	2	EA	Inst	Cntrl	Panels - Conventional	$ 90,000	$ 5,973	$ -	$ 5,175	$ -	$ 101,148

Job Folder Name: BIS-SEr0-New Substation **O&M Estimate:** $ -

Sub-Line Name: Bison Substation

Scope: NSP Sub estimating template

WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
PANEL-SEL-451 BKR CONTROL	8	EA	Inst	Cntrl	Panels - Conventional	$ 96,000	$ 23,891	$ -	$ 5,520	$ -	$ 125,411
PANEL-SEL-487E REACTOR DIFF RLY'G (500KV)	2	EA	Inst	Cntrl	Panels - Conventional	$ 60,000	$ 5,973	$ -	$ 3,450	$ -	$ 69,423
PANEL-SYNCHRONIZING PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 2,000	$ 2,986	$ -	$ 115	$ -	$ 5,101
PANEL-TELEPHONE ACCESS CONTROL BOX AND MATERIAL LIST	1	EA	Inst	Cntrl	Panels - Conventional	$ 1,600	$ 2,986	$ -	$ 92	$ -	$ 4,678
TCF-10B	2	EA	Inst	Cntrl	Panels - Conventional	$ 40,000	$ 1,792	$ -	$ 2,300	$ -	$ 44,092
CARRIER LINE TUNER	4	EA	Inst	Cntrl	Pilot	$ 8,000	$ 2,986	$ -	$ 460	$ -	$ 11,446
RELAY-AUX TYPE 1(LOR, ETC.)	1	EA	Inst	Cntrl	Relay - Aux	$ 636	$ 2,986	$ -	$ 37	$ -	$ 3,659
RELAY-GE T60	2	EA	Inst	Cntrl	Relay - Microprocessor	$ 16,000	$ 1,792	$ -	$ 920	$ -	$ 18,712
TEL 3/4" PLYWOOD PANEL	1	EA	Inst	Cntrl	Telephone	$ 50	$ 448	$ -	$ 3	$ -	$ 501
TEL POSITRON PACkAGE	1	EA	Inst	Cntrl	Telephone	$ 3,840	$ 1,493	$ -	$ 221	$ -	$ 5,554
EQUIP - BACKHOE WITH CAB	68	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 53,040	$ 3,050	$ -	$ 56,090
EQUIP - BOBCAT	68	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 51,000	$ 2,933	$ -	$ 53,933
EQUIP - CONTRACT WELDING	12	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 42,000	$ 2,415	$ -	$ 44,415
EQUIP - CRANE (W/OPR) - 30 TON	60	DAY	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 72,000	$ 4,140	$ -	$ 76,140
EQUIP - FORKLIFT (MTRL HANDLER)	68	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 59,840	$ 3,441	$ -	$ 63,281
EQUIP - MINI EXCAVATOR (GND WIRE INSTALL)	12	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 6,300	$ 362	$ -	$ 6,662
EQUIP - MISC (TRAILORS, TOILETS, DUMSTER, STORAGE)	17	MO	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 22,610	$ 1,300	$ -	$ 23,910
CONCRETE - MBL 3-MAN (MORE 100 MI)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,968	$ -	$ -	$ -	$ 2,968
Electric Construction - Mobilize (In/Out)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,986	$ -	$ -	$ -	$ 2,986
Electric Construction - Site Setup	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 5,973	$ -	$ -	$ -	$ 5,973
SITE - EARTHWORK - MOBILIZATION (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
SITE - SURFACING-MOBILIZE (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
Eng & Des - Contract - Labor Only	11,429	HR	Inst	Labor	Civil/Electrical	$ -	$ 1,200,045	$ -	$ -	$ -	$ 1,200,045
Eng SPS Study	476	HR	Inst	Labor	Civil/Electrical	$ -	$ 49,980	$ -	$ -	$ -	$ 49,980
General Foreman - Internal - Labor Only	2,640	HR	Inst	Labor	Civil/Electrical	$ -	$ 219,642	$ -	$ -	$ -	$ 219,642
TESTING-CONTROL TESTING	3,966	HR	Inst	Labor	Test	$ -	$ 291,954	$ -	$ -	$ -	$ 291,954
TESTING-PHYSICAL EPM	1,736	HR	Inst	Labor	Test	$ -	$ 127,802	$ -	$ -	$ -	$ 127,802
Trucking - Shipping (# Trips x HR Rnd Trip)	320	HR	Inst	Labor	Civil/Electrical	$ -	$ 21,106	$ -	$ -	$ -	$ 21,106
AC CAB 42 POS.	2	EA	Inst	Phys	AC System	$ 1,704	$ 1,045	$ -	$ 98	$ -	$ 2,848
AC PNLBRD INDOOR 3PH 4-200 2P, 2-200 3P	1	EA	Inst	Phys	AC System	$ 1,936	$ 1,493	$ -	$ 111	$ -	$ 3,541
AC PNLBRD OUTDOOR 3PHP 1-400 3P, 2-200 2P, 2-60 2P	2	EA	Inst	Phys	AC System	$ 16,298	$ 2,986	$ -	$ 937	$ -	$ 20,221
AUTO TRANSFER SW 600A 600V 1PH	1	EA	Inst	Phys	AC System	$ 4,445	$ 1,195	$ -	$ 256	$ -	$ 5,895
LIGHTING-HIGH VOLTAGE BAY	15	LOT	Inst	Phys	AC System	$ 6,000	$ 44,796	$ -	$ 345	$ -	$ 51,141
STATION SERVICE PADMOUNT 300 kVA	1	EA	Inst	Phys	AC System	$ 8,270	$ 747	$ -	$ 476	$ -	$ 9,492
ARRESTER 22kV MCOV STA. POLYMER	3	EA	Inst	Phys	Arrester	$ 990	$ 560	$ -	$ 57	$ -	$ 1,607
ARRESTER 230kV MCOV STA. POLYMER	3	EA	Inst	Phys	Arrester	$ 21,000	$ 2,240	$ -	$ 1,208	$ -	$ 24,447
ARRESTER 335kV MCOV STA. PORCELAIN	12	EA	Inst	Phys	Arrester	$ 192,000	$ 8,959	$ -	$ 11,040	$ -	$ 211,999
BUS SUPPORT 35kV	12	EA	Inst	Phys	Bus Supports & Insulators	$ 841	$ 367	$ -	$ 48	$ -	$ 1,256

Job Folder Name: BIS-SEr0-New Substation **O&M Estimate:** $ -

Sub-Line Name: Bison Substation

Scope: NSP Sub estimating template

WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
BUS SUPPORT 345kV STD. STRENGTH	43	EA	Inst	Phys	Bus Supports & Insulators	$ 50,940	$ 16,052	$ -	$ 2,929	$ -	$ 69,921
BUS SUPPORT 550kV	54	EA	Inst	Phys	Bus Supports & Insulators	$ 86,400	$ 24,190	$ -	$ 4,968	$ -	$ 115,558
CCVT/PT SEC FUSE CAB 1 PH	8	EA	Inst	Phys	Cabinets	$ 806	$ 2,986	$ -	$ 46	$ -	$ 3,838
CCVT/PT SEC FUSE CAB 3 PH	1	EA	Inst	Phys	Cabinets	$ 293	$ 971	$ -	$ 17	$ -	$ 1,280
METERING TERM CAB OUTDOOR	1	EA	Inst	Phys	Cabinets	$ 537	$ 597	$ -	$ 31	$ -	$ 1,165
TERMINAL CABINET INDOOR	1	EA	Inst	Phys	Cabinets	$ 3,206	$ 2,986	$ -	$ 184	$ -	$ 6,377
CABLE - POWER- 600V 500MCM	450	FT	Inst	Phys	Cable - Power	$ 3,924	$ 6,719	$ -	$ 226	$ -	$ 10,869
500kV Static VAR Compensator +/- 400MVAR	1	EA	Inst	Phys	Capacitor Bank	$ 34,500,000	$ -	$ -	$ 1,983,750	$ -	$ 36,483,750
CAPACITOR BANK 500KV 300MVAR MECHANICALLY SWITCHED	2	EA	Inst	Phys	Capacitor Bank	$ 3,800,000	$ 44,796	$ -	$ 218,500	$ -	$ 4,063,296
CCVT 345kV MTRG HI-CAP0.3A	3	EA	Inst	Phys	CCVTs & Traps	$ 30,000	$ 10,079	$ -	$ 1,725	$ -	$ 41,804
CCVT 500kV MTRG HI-CAP0.3A	8	EA	Inst	Phys	CCVTs & Traps	$ 80,000	$ 26,878	$ -	$ 4,600	$ -	$ 111,478
LINE TRAP 2000A	4	EA	Inst	Phys	CCVTs & Traps	$ 79,600	$ 4,480	$ -	$ 4,577	$ -	$ 88,657
BREAKER GAS 345kV 3000A 40 kA, -40C	5	EA	Inst	Phys	Circuit Breaker	$ 2,250,000	$ 74,660	$ -	$ 129,375	$ -	$ 2,454,035
BREAKER GAS 500kV 3000A 40kA DTB W/ CT, -40C	6	EA	Inst	Phys	Circuit Breaker	$ 2,700,000	$ 156,787	$ -	$ 155,250	$ -	$ 3,012,037
CONDUCTOR - SHIELD WIRE 3/8 " GALVANIZED E.H.S.	1,600	FT	Inst	Phys	Conductor & Fittings	$ 677	$ 11,946	$ -	$ 39	$ -	$ 12,662
CONDUCTOR ALUM 1590 61 STR AA	4,700	FT	Inst	Phys	Conductor & Fittings	$ 12,530	$ 112,289	$ -	$ 720	$ -	$ 125,540
CONDUCTOR ALUM TUBING 6 IN SCHED 40	9,500	FT	Inst	Phys	Conductor & Fittings	$ 232,750	$ 283,710	$ -	$ 13,383	$ -	$ 529,843
CONDUCTOR FITTING 345-500kV EHV	14,200	FT	Inst	Phys	Conductor & Fittings	$ 113,600	$ -	$ -	$ 6,532	$ -	$ 120,132
BATT 48VDC 50AH	1	EA	Inst	Phys	DC System	$ 3,790	$ 4,853	$ -	$ 218	$ -	$ 8,861
BATT 130VDC 300AH WITH RACK	1	EA	Inst	Phys	DC System	$ 27,060	$ 6,346	$ -	$ 1,556	$ -	$ 34,962
BATT CHRGER 48VDC 30A	1	EA	Inst	Phys	DC System	$ 2,200	$ 1,493	$ -	$ 127	$ -	$ 3,820
BATT CHRGER 130VDC 50A	1	EA	Inst	Phys	DC System	$ 3,340	$ 1,493	$ -	$ 192	$ -	$ 5,025
BATT MAIN FUSE CABINET ASSM.	1	EA	Inst	Phys	DC System	$ 345	$ 299	$ -	$ 20	$ -	$ 663
BATT MAIN FUSE CABINET ASSM.	2	EA	Inst	Phys	DC System	$ 690	$ 597	$ -	$ 40	$ -	$ 1,327
DC CAB 34 POSITION STL INDOOR	1	EA	Inst	Phys	DC System	$ 2,146	$ 1,493	$ -	$ 123	$ -	$ 3,763
DC CAB 52 POSITION STL INDOOR	1	EA	Inst	Phys	DC System	$ 4,167	$ 1,792	$ -	$ 240	$ -	$ 6,199
EEE ELECT HTR 5KW & THERMOSTAT	4	EA	Inst	Phys	EEE	$ 3,028	$ 4,480	$ -	$ 174	$ -	$ 7,682
EEE FURNITURE-EQUIPMENT (NL-200904)	1	LOT	Inst	Phys	EEE	$ 1,100	$ 1,493	$ -	$ 63	$ -	$ 2,656
EEE GROUNDING 24' X 30'	3	EA	Inst	Phys	EEE	$ 465	$ 17,918	$ -	$ 27	$ -	$ 18,410
EEE LIGHTING 20X32	3	EA	Inst	Phys	EEE	$ 2,532	$ 26,878	$ -	$ 146	$ -	$ 29,555
FUSE 35kV 400A, 20kA SPST MNTG/HLD	3	EA	Inst	Phys	Fuse	$ 5,298	$ 952	$ -	$ 305	$ -	$ 6,555
GROUND CABLE ASSEMBLY ST	4	SET	Inst	Phys	Grounding	$ 4,140	$ 597	$ -	$ 238	$ -	$ 4,975
GROUND CADWELD CONNECTIONS	1,342,750	SFT	Inst	Phys	Grounding	$ 174,558	$ 401,001	$ -	$ 10,037	$ -	$ 585,596
GROUND GRID TEST	1	EA	Inst	Phys	Grounding	$ -	$ 1,493	$ -	$ -	$ -	$ 1,493
GROUND RODS (per grounding point)	700	EA	Inst	Phys	Grounding	$ 74,368	$ 86,755	$ -	$ 4,276	$ -	$ 165,400
GROUND WIRE 4/0 CU	60,000	FT	Inst	Phys	Grounding	$ 169,200	$ 1,119,906	$ -	$ 9,729	$ -	$ 1,298,835
GROUNDING HOTSTICK ST-SHEPHERDS HOOK	1	SET	Inst	Phys	Grounding	$ 518	$ 187	$ -	$ 30	$ -	$ 734
PT 35kV 1PH	3	EA	Inst	Phys	Instrument Transf.	$ 5,850	$ 2,240	$ -	$ 336	$ -	$ 8,426

Job Folder Name: BIS-SEr0-New Substation **O&M Estimate:** $ -

Sub-Line Name: Bison Substation

Scope: NSP Sub estimating template

WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
NAMEPLATES EQUIPMENT	21	EA	Inst	Phys	Nameplates	$ 525	$ 392	$ -	$ 30	$ -	$ 947
NAMEPLATES FENCE ADDRESS	1	EA	Inst	Phys	Nameplates	$ 144	$ 37	$ -	$ 8	$ -	$ 190
NAMEPLATES FENCE WARNING	75	EA	Inst	Phys	Nameplates	$ 2,850	$ 2,800	$ -	$ 164	$ -	$ 5,814
REACTOR SHUNT 500kV 150MVAR 3PH	1	EA	Inst	Phys	Reactor	$ 2,880,000	$ 156,787	$ -	$ 165,600	$ -	$ 3,202,387
REACTOR SHUNT 500kV 225MVAR 3PH	1	EA	Inst	Phys	Reactor	$ 2,880,000	$ 156,787	$ -	$ 165,600	$ -	$ 3,202,387
SWITCH 345kV 2000A TPST DBL EB	10	EA	Inst	Phys	Switch Gang	$ 250,000	$ 89,592	$ -	$ 14,375	$ -	$ 353,967
SWITCH 500kV 2000A TPST DBL EB W INS	16	EA	Inst	Phys	Switch Gang	$ 720,000	$ 143,348	$ -	$ 41,400	$ -	$ 904,748
FLD OIL FILL /drain (per5000Gal)	12	EA	Inst	Phys	Transformer	$ 12,000	$ 35,837	$ -	$ 690	$ -	$ 48,527
TRANSFORMER TEST TERMINAL LINK, 4000 AMP 4 HOLE FLAT PAD BOTH ENDS PER DWG. NQ-91802	8	EA	Inst	Phys	Transformer	$ 7,720	$ 1,493	$ -	$ 444	$ -	$ 9,657
						$ 83,512,466	$ 12,485,095	$ 417,541	$ 5,987,035	$ -	$ 102,402,138

Substation Project Forecast

This forecast represents typical expenditures and commitments for this project based on average conditions.
Adjustments to this forecast may be necessary to factor in delays or expediting efforts.

Work Order:
Location: Bison
Title: NSP Sub estimating template

Costs from Estimate

		Install	Remove
Permitting and Proj. Management:	$	-	
Material:	$	63,085,000	
Transformer (with tax and OH):	$	20,133,000	
Construction Labor & Rentals:	$	9,151,000	$0
Testing Labor:	$	420,000	
E&S:	$	1,490,000	
Contingencies:	$	3,630,000	
Overheads:	$	4,493,000	
AFUDC:	$	-	
TNE w/o AFUDC:		$102,402,000	

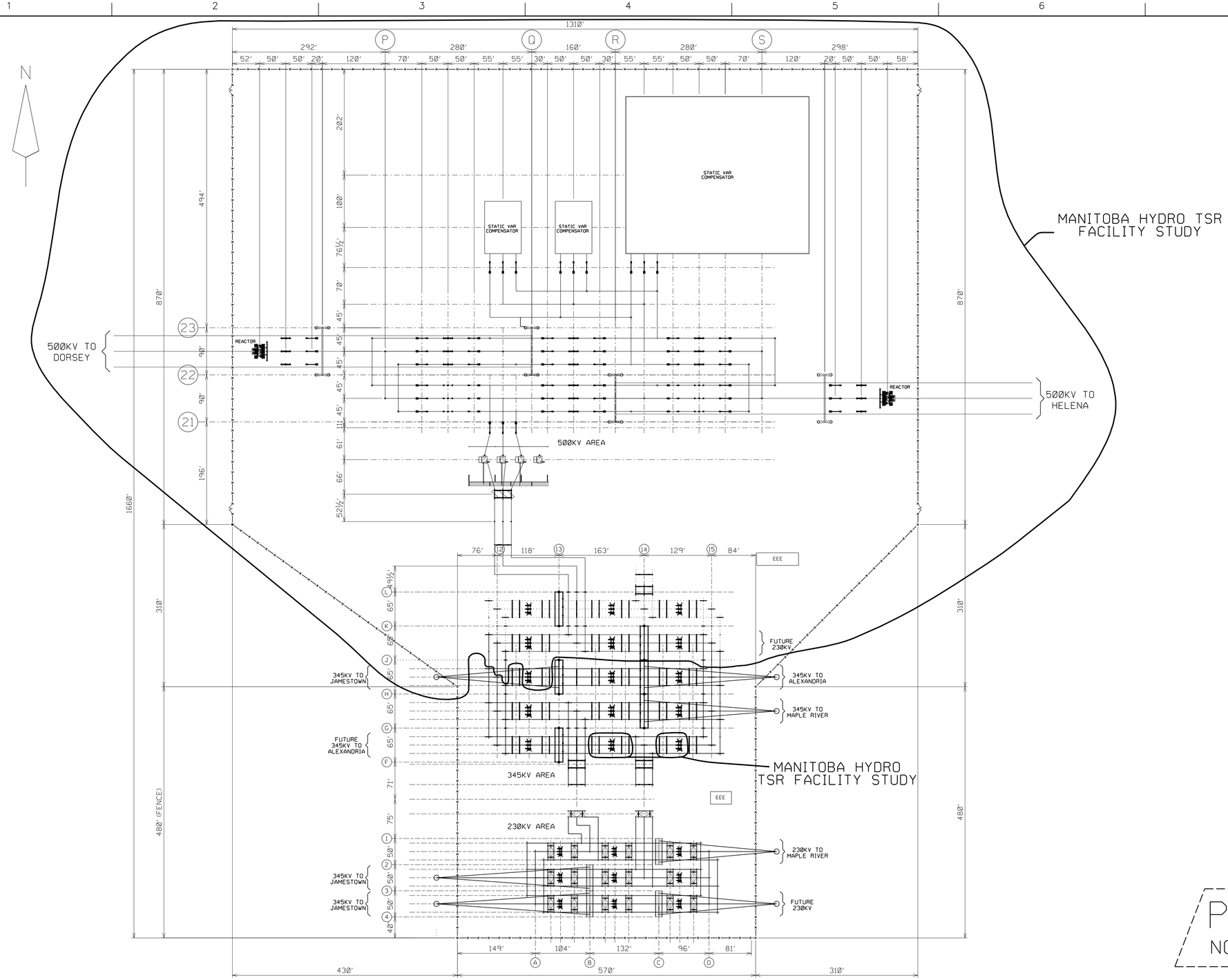
In-Service Date	**12/31/2017**
Project Start Date	**7/1/2010**
Construction Start Date	**8/3/2015**

Jul-10	$	66,280	**Apr-14**	$	66,480
Aug-10	$	66,480	**May-14**	$	66,480
Sep-10	$	66,480	**Jun-14**	$	66,480
Oct-10	$	66,480	**Jul-14**	$	66,480
Nov-10	$	66,480	**Aug-14**	$	66,480
Dec-10	$	66,480	**Sep-14**	$	66,480
Jan-11	$	66,480	**Oct-14**	$	66,480
Feb-11	$	66,480	**Nov-14**	$	66,480
Mar-11	$	66,480	**Dec-14**	$	66,480
Apr-11	$	66,480	**Jan-15**	$	66,480
May-11	$	66,480	**Feb-15**	$	66,480
Jun-11	$	66,480	**Mar-15**	$	66,480
Jul-11	$	66,480	**Apr-15**	$	66,480
Aug-11	$	66,480	**May-15**	$	66,480
Sep-11	$	66,480	**Jun-15**	$	66,480
Oct-11	$	66,480	**Jul-15**	$	66,480
Nov-11	$	66,480	**Aug-15**	$	1,395,280
Dec-11	$	66,480	**Sep-15**	$	1,395,280
Jan-12	$	66,480	**Oct-15**	$	1,395,280
Feb-12	$	66,480	**Nov-15**	$	1,395,280
Mar-12	$	66,480	**Dec-15**	$	10,542,030
Apr-12	$	66,480	**Jan-16**	$	50,570,030
May-12	$	66,480	**Feb-16**	$	10,570,030
Jun-12	$	66,480	**Mar-16**	$	10,570,030
Jul-12	$	66,480	**Apr-16**	$	1,570,030
Aug-12	$	66,480	**May-16**	$	1,235,030
Sep-12	$	66,480	**Jun-16**	$	1,070,030
Oct-12	$	66,480	**Jul-16**	$	820,030
Nov-12	$	66,480	**Aug-16**	$	820,030

Dec-12	$	66,480	**Sep-16**	$	770,030
Jan-13	$	66,480	**Oct-16**	$	670,030
Feb-13	$	66,480	**Nov-16**	$	620,030
Mar-13	$	66,480	**Dec-16**	$	595,030
Apr-13	$	66,480	**Jan-17**	$	595,030
May-13	$	66,480	**Feb-17**	$	580,030
Jun-13	$	66,480	**Mar-17**	$	570,030
Jul-13	$	66,480	**Apr-17**	$	66,480
Aug-13	$	66,480	**May-17**	$	66,480
Sep-13	$	66,480	**Jun-17**	$	66,480
Oct-13	$	66,480	**Jul-17**	$	66,480
Nov-13	$	66,480	**Aug-17**	$	66,480
Dec-13	$	66,480	**Sep-17**	$	66,480
Jan-14	$	66,480	**Oct-17**	$	66,480
Feb-14	$	66,480	**Nov-17**	$	66,480
Mar-14	$	66,480	**Dec-17**	$	66,480

	2010	**2011**	**2012**	**2013**	**Total**
TNE w/o AFUDC	$ 398,680	$ 797,760	$ 797,760	$ 797,760	**$ 102,402,000**

	2014	**2015**	**2016**	**2017**
TNE w/o AFUDC	$ 797,760	$ 16,588,510	$ 79,880,360	$ 2,343,410



PRELIMINARY
NOT FOR CONSTRUCTION

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR 500KV FACILITIES STUDY OPTION ONE

BISON SUBSTATION LOCATION PLAN

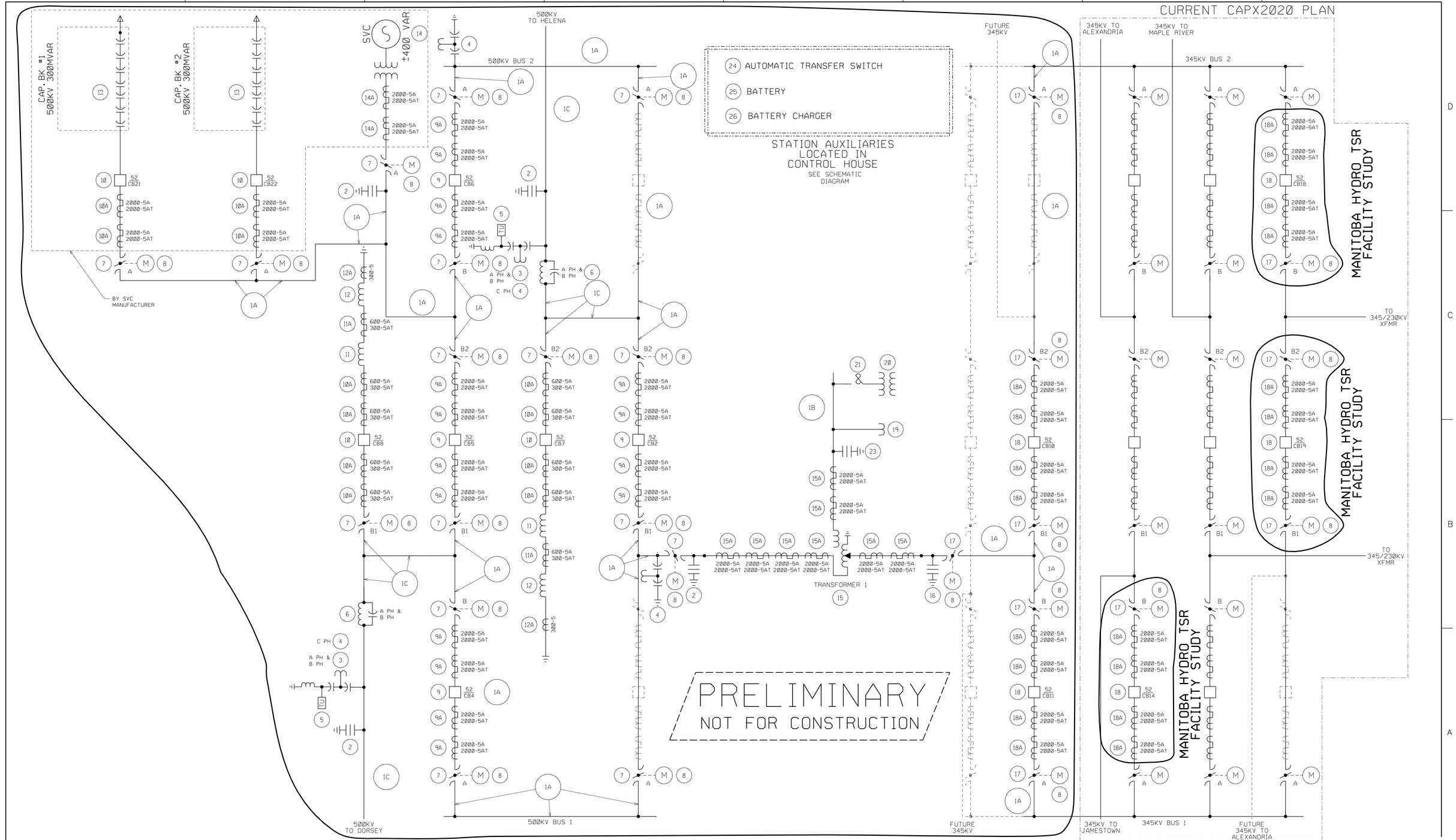
0 1" 2"

FILENAME	BISON LOC PLAN.DGN
SCALE	1:100

SHEET **LOC PLAN**

4/9/2010 1:50:46 PM gstroup c:\pwworking\east\d0381811\BISON LOC PLAN.DGN

CURRENT CAPX2020 PLAN



HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR 500KV FACILITIES STUDY OPTION ONE

BISON SUBSTATION CIRCUIT DIAGRAM

0 1" 2"

FILENAME	BISON CIR DIA.DGN
SCALE	NONE

SHEET **CIR DIA**

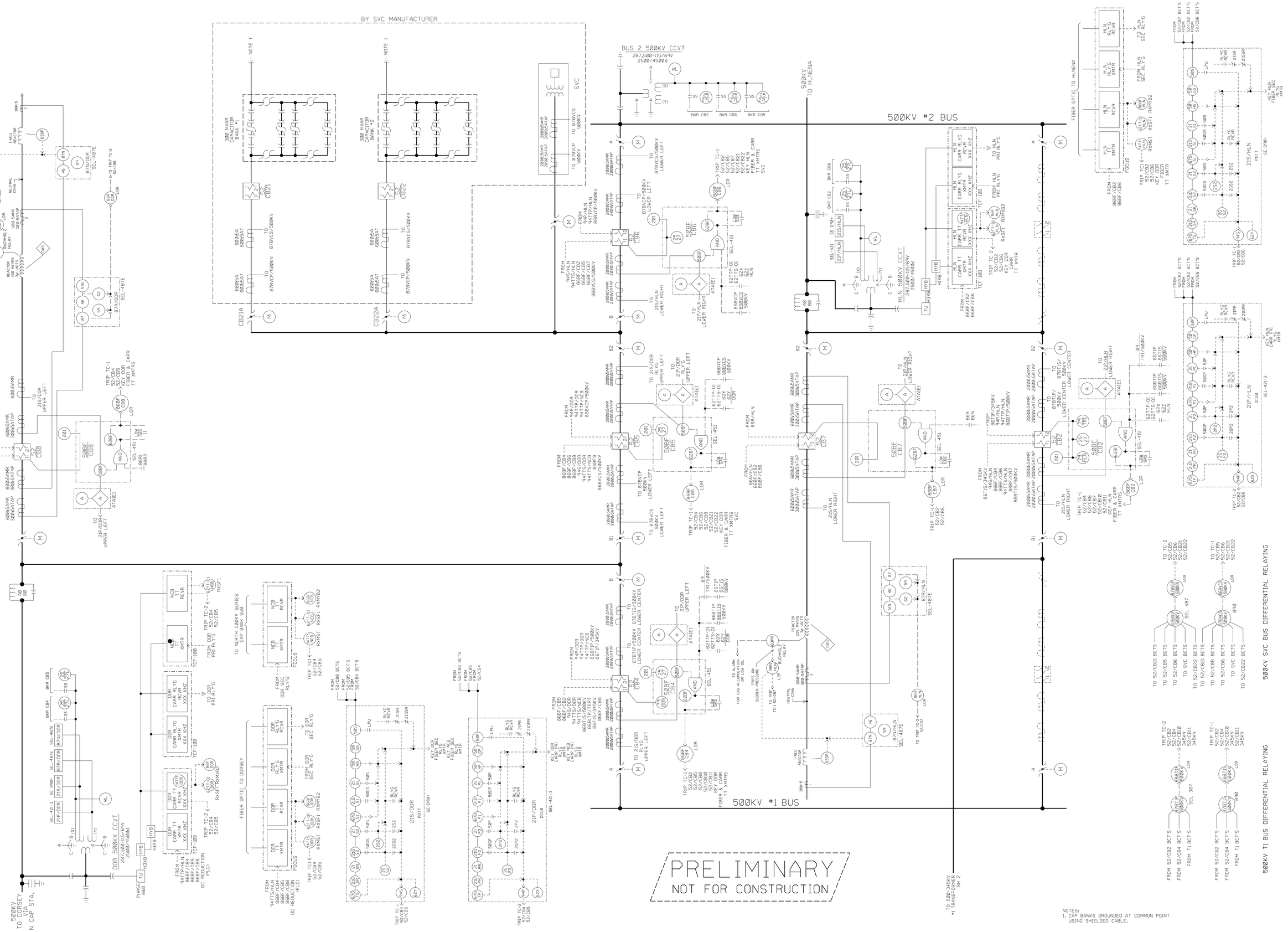
BISON SUBSTATION (BIS) | CIRCUIT DIAGRAM - LIST OF EQUIPMENT

Date Created: 03/17/10

REV - 0

This Map/Document is a tool to assist employees in the performance of their jobs. Your personal safety is provided for by using safety practices, procedures and equipment as described in safety training programs, manuals and SPAR's

ITEM NO.	DESCRIPTION	STANDARD DESIGNATION & NOMINAL RATING	ORDER NUMBER	DRAWING NUMBER	CURRENT REVISION INFO (Existing & unchanged items left blank)
1A	BUS - ALUMINUM TUBULAR BUS	6" AL TUBE (SCHED 40)			
1B	BUS - ALUMINUM TUBULAR BUS	3" AL TUBE (SCHED 40)			
1C	BUS - STRANDED ALUMINUM CONDUCTOR (CODE NAME COREOPSIS)	2-1590 AAC - 61 STRAND			
2	3 - SURGE ARRESTER, STATION CLASS, _____ CO. PORCELIAN , CAT#_____, 335KV MCOV, 500KV				
3	2 - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500 GNDY/287.5KV, 1800KV BIL, _____ CO., CAT.# _____ WITH CARRIER ACCESSORIES, 115/67 VOLTS, _____% ACCURACY THRU _____ BURDEN	EPOXY, 2000A			
4	1 - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500 GNDY/287.5KV, 1800 KV BIL, _____ CO., CAT.# _____ WITHOUT CARRIER ACCESSORIES, 125 VOLTS, _____% ACCURACY THRU _____ BURDEN	EPOXY, 2000A			
5	2 - LINE TUNING UNIT, _____ CO., MODEL #_____, WIDE BAND, _____ KHZ	D06 ACCC, 2000 A			
6	2 - LINE TRAP, _____ CO., DRY-TYPE AIR CORE, MODEL #_____, 500 GNDY/287.5KV, _____ KHZ, WIDE (OR NARROW) BAND VERTICAL MOUNTING ON CCVT OR 5" B.C.	EPOXY, 2000A			
7	1 - GROUP-OPERATED, SWITCH, DOUBLE END BREAK, _____CO. TYPE_____,500KV, 100,000AMPS MOMENTARY	YR MFG ____, 2000 A			
8	1 - SWITCH OPERATING MOTOR MECHANISM, _____ CO. TYPE _____, 125VDC				
9	1 - GAS CIRCUIT BREAKER, _____ CO. TYPE _____, 550KV MAXIMUM, 40,000 AMPS INTERRUPTING CAPACITY	YR MFG ____, 2000A			
9A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
10	1 - GAS CIRCUIT BREAKER, _____ CO. TYPE _____, 550KV MAXIMUM, 40,000 AMPS INTERRUPTING CAPACITY	YR MFG ____, 2000A			
10A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 600:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
11	1 - THREE-PHASE SHUNT REACTORS, OUTDOOR, _____ CO., 500 GNDY/288.6 KV	OIL-FILLED, 225 OR			
11A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 600:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.5			
12	1 - SINGLE-PHASE NEUTRAL GROUNDING REACTOR, OUTDOOR, _____ CO., AIR-CORE TYPE, _____ KV, _____ KVA CONTINOUS, _____ MVA FOR _____SECONDS, _____ OHMS				
12A	1 - CURRENT TRANSFORMER, _____ CO., 300:5A SINGLE-RATIO, RELAY ACCURACY CLASS C800	300MVAR @ 500 kV			
13	1-THREE PHASE CAPACITOR BANK PROVIDED BY STATIC VAR COMPENSATOR MANUFACTURE	TRF 1.0			
13A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800				
14	1 - THREE PHASE, STATIC VAR COMPENSATOR INCLUDING 500/20KV TRANSFORMER, FILTERS, CAPACITORS, ETC. 1 - PROTECTION MODULE CONSISTING OF: 3 - SINGLE PHASE , OUTDOOR POTENTIAL TRANSFORMERS, ____V, ___ CO., __KV BIL _____V, ___ KVAR, LOW VOLTAGE CAPACITORS, _ CAPACITORS PER SPLIT BUS SECTION PER PHASE	PLUS OR MINUS 400 MVAR @ 500 kV			
14A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
15	3 - SINGLE-PHASE LTC AUTO-TRANSFORMER, _____ CO. CLASS ONAN/OFAF/OFAF, 65℃ RISE @ 1000M, 500,000 GND Y/288,675-345,000 GNDY/199,186VOLTS +/- 10% LTC IN 32 - 5/8 % STEPS WITH A 400/560/700 MVA, 34,500 VOLT TERTIARY, UTC# _____	400/560/700 MVA			
15A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
16	3 - SURGE ARRESTER, STATION CLASS, _____ CO. METAL-OXIDE POLYMER, CAT#_____, 230KV MCOV, 345KV				
17	1 - GROUP-OPERATED, SWITCH, DOUBLE END BREAK, _____CO. TYPE_____,345KV, 100,000AMPS MOMENTARY	D06 ACCC, 2000 A			
18	1 - GAS CIRCUIT BREAKER, _____ CO. TYPE _____, 362KV MAXIMUM, 65,000 AMPS INTERRUPTING CAPACITY	YR MFG ____, 2000A			
18A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
19	3 - SINGLE-PHASE, OUTDOOR POTENTIAL TRANSFORMERS, TWO BUSHING, _____ CO., TYPE _____, 5000 VOLT-AMPS, 34,500 VOLTS				
20	1 - THREE-PHASE DISTRIBUTION TRANSFORMER (PAD MOUNTED), _____ CO., 300 KVA, 34,500 GNDY/19,919 VOLTS WITH THREE _____ CO. SEPARABLE LOAD-BREAK PRIMARY CABLE CONNECTORS, 35KV, 200 AMPS, 22,000 AMPS MOMENTARY				
21	3 - HOOKSTICK-OPERATED SWITCH AND FUSE COMBINATIONS _____ CO. TYPE _____, 35 KV, 600 AMPS CONTINUOUS SWITCH AND _____ CO. TYPE _____, 400 AMPS FUSE MOUNTING, CAT.# _____, STANDARD TIME-CURRENT CHARACTERISTICS," 40,000 AMPS MAXIMUM INTERRUPTING CAPACITY FOR COMBINATION	400 A FUSE ELEMENT			
22	NOT USED				
23	3 - SURGE ARRESTER, STATION CLASS, _____ CO. METAL-OXIDE POLYMER, CAT#_____, 22KV MCOV, 34.5KV				
24	AUTOMATIC TRANSFER SWITCH, _____ CO., TYPE _____, 600AMP, 120/240VAC SINGLE PHASE				
25	BATTERY, _____ CO., TYPE _____, 125VDC, 300AMP-HOUR RATING. BATTERY RACK IS __ TIER, __D x __W x __H				
26	BATTERY CHARGER, _____ CO., TYPE_____, 125VDC, 50 AMPS, ___VAC SINGLE PHASE SOURCE				



HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

BISON SUBSTATION
METERING & RELAYING DIAGRAM
500KV

0 1" 2"

FILENAME	BISON M&R.DGN
SCALE	NONE

SHEET **M&R 1 OF 2**

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BISON SUBSTATION
METERING & RELAYING DIAGRAM

SHEET	FILENAME	SCALE
M&R 2 OF 2	BISON_M&R.DGN	NONE

0 1" 2"

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

PRELIMINARY
NOT FOR CONSTRUCTION

MANITOBA HYDRO TSR FACILITY STUDY

345KV #2 BUS

345KV #1 BUS

345KV TO MAPLE RIVER

345KV TO ALEXANDRIA

345KV TO FUTURE

345KV TO JAMESTOWN

FUTURE 345KV TO ALEXANDRIA

345/230KV XMTR

500KV TO 500KV SH 1

345KV BUS #1 DIFFERENTIAL RELAYING

345KV BUS #2 DIFFERENTIAL RELAYING

T1 DIFFERENTIAL RELAYING

PROJECT MANAGER

ISSUE	DATE	DESCRIPTION	PROJECT NUMBER

HDR Engineering, Inc.

PROJECT DESIGN GUIDE

Location: South Series Capacitor Bank Station (SSC)
Project Title: MH TSR 500 kV Option 1 Facilities Study – New 500 kV Series Capacitor Bank

In-Service Date:	December 2017
Program Manager:	CapX2020
Project Manager:	Jared Alholinna, CapX2020 Chris Ayika, Xcel Energy
Prepared By:	HDR Engineering, Inc.
Estimate Type and Amount:	Facilities Study $30,820,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the midline location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. .

The following assumptions have been included in the substation portion of this study:

1. The study has been prepared for CapX2020. The ownership of the substation has not been identified at this time.

2. No special protection systems for area wide dynamic system operation have been studied at this time and no equipment for such systems are included in this study.

3. The series capacitor bank has been sized for 50% compensation of the Bison-Helena 500 kV transmission line based on the parameters identified within other sections of this study. The site of the series capacitor station is assumed to be as close to the "electrical center" of the transmission line as possible.

4. The exact requirements of the site including access, topography, drainage, geotechnical structure and landscaping are not identified at this time. Therefore, general assumptions have been made for this scope.

The estimate assumes the series capacitor bus voltage will not exceed 550kV.

Background

Several Transmission Service Requests (TSR) for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service. The study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

II. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

CIP requirements for this station are not identified at this time. The exact requirements will be identified once the ownership and operational control of the station is determined.

Facility Ratings

The substation presently meets the new facility rating requirements.

III. Right of Way

196 KSF of new land will be required.

IV. Electrical Features

	Current Rating		
Transmission Lines	**Conductor Type**	**Summer (40 deg C)**	**Winter (0 deg C)**
Bison-Helena 500 kV Line	3-1192.5 ACSR	4365 amps	5724 amps

The Series Capacitor Bank Station 500 kV bus and associated equipment will be rated for 2000 amps. The bank will have an emergency rating of 2500 amps.

Fault Current

The substation will be designed to 40 kA on 500 kV bus and equipment.

Preliminary Modeling in CAPE is shown in the following table:

Type of fault / Location	Three Phase Amps
500 kV System with Bison-Helena Line	14,757

Electrical Removals & Relocations

No equipment will be removed or relocated for this project.

Electrical Installations (Major Equipment)

500 kV

One (1) 500 kV, 64 ohm, 768MVAR, 2000 amp series capacitor bank. The bank will consist of three insulated platforms with capacitors, movs, and reactors and associated electrical and control equipment.

Six (6) 500 kV, 2000A, single phase double-end-break motor-operated disconnect switches (XS7 and XS8), will be installed for breaker isolation (52/XS6).

Six (6) 500 kV, 2000A, single phase double-end-break motor-operated disconnect switches with ground switches (XS1 and XS2), will be installed for capacitor bank bypass.

Three (3) single-phase 500 kV CCVT units will be installed for Bison Line metering and communication between Bison andHelena.

Three (3) 335 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. The arresters will be mounted in the 500 kV Bison Line bay.

Two (2) 500 kV, 2000A line traps and tuners will be installed on the deadend for the 500 kV Bison Line.

One (1) single-phase 500 kV CCVT units will be installed for Helena Line metering and communication between Bison and Helena.

Three (3) 335 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. The arresters will be mounted in the 500 kV Helena Line bay.

Two (2) 500 kV, 2000A line traps and tuners will be installed on the deadend for the 500 kV Helena Line and communication between Bison andHelena.

The bus in each row will consist of 6 inch aluminum tube (4250 amp) in order to limit bus support structures and 2-1590 MCM aluminum stranded conductor (2400 amps) for breaker jumpers will be installed.

556.5 19 MCM aluminum stranded conductor per phase will be installed for CCVT connections.

Mobile Substation or Transformer

No Mobile Equipment will be necessary.

Electrical Equipment Enclosure (EEE)

A new 24' X 40' metal control house will be erected in the southeast corner of the new substation. The control house building will have two points of egress, one single door and one double door. The control house will have two exhaust fans, two propeller type electric unit heaters, and wall louvers. The control house will accommodate protection relay panels, AC breaker panels, DC fuse panels, terminal cabinets, 125 VDC station battery and charger, telephone equipment panelboard, overhead cable tray, lights, receptacles, and other miscellaneous equipment.

AC System

The AC system will be sized to accommodate the three 500 kV single phase capacitor bank load, six 500 kV single phase gas circuit breaker motor and heater loads, twelve motor-operated disconnect heater loads, and the control building auxiliary equipment. Since there are no near term plans for adding additional equipment, the station service will be sized for the proposed installation, construction power and a small contingency factor.

The primary source for the AC station auxiliary power transformer is assumed to be 12.5 kV local distribution power. The emergency source will be a 50 KW Generator Set. The secondary voltage of the auxiliary sources will be three-phase 120/240 V.

The following equipment will be installed:

One (1) single-phase, 34,500 – 120/240 V, 50 kVA distribution transformer will be installed.

15 kV, 100 amp fused disconnects with 10E continuous elements will be installed.

DC System

A detailed DC study will be performed during the design phase of the project. The estimate provides for a 125 VDC battery with a battery charger and associated fuses and DC cabinets.

A 48 VDC battery with a battery charger and associated fuses and DC cabinets is included for the communications system equipment.

Grounding

A ground grid consisting of 4/0 copper conductor and ground rods will be installed to provide a safe and effective grounding system per IEEE standards. Soil resistivity measurements will be taken in the area where the new substation will be installed upon soil thawing and rough grading completion. Ground grid design calculations will be made at this time. Fence counterpoise grounding will be installed.

Lightning Protection

Lightning protection will be provided for the new substation to adequately protect the new 500 kV bus. The estimate includes four (4) 100' tapered tubular steel shield masts in addition to lightning masts on the 500 kV line termination structures.

Trenching & Cable

New precast trenching will be installed for all new equipment. All new control cables will be installed.

V. Civil Features

Grading & Fencing

A graded area approximately 417 feet by 470 feet will be constructed. Grading will consist of topsoil stripping and removal of all vegetation followed by subexcavation totaling 3 feet. The excavated subgrade will be compacted to form a firm base followed by the placement of approximately 2 feet of imported fill. The rough grade elevation will be established through importing, placement and compaction of a 1 foot layer of class 5 aggregate base. Prior to the in-service date, grading activity will be completed by the import and placement of a 4 inch layer of crushed rock surfacing.

Note the landscaped area is assumed to be 25% of the total graded area and for this case is limited to revegetation of surfaces beyond the edge of grade and retention pond but not exceeding the area disturbed by grading activities.

Storm Water Permit

A Storm Water Permit will be required.

Foundations & Structural

The proposed foundations include drilled piers for all galvanized steel structures and slabs-on-grade for electrical equipment (circuit breakers and power transformers) and the control house. Final foundation types and sizes will be determined once the results and recommendations of the soil boring investigation are completed.

The steel structures for the proposed substation include low profile equipment stands and bus supports and tapered tubular dead end structures to support each transmission line termination. The low profile steel structures will be tapered tubular. The tapered tubular structures will be designed and fabricated by the steel fabricator.

Civil Removals & Relocations

No civil removals or relocations will be used.

Civil Installations

The following concrete slab foundations will be installed:

Quantity	Description	Approx. Size
1	Control House	24' x 40' x 1'
1	Generator Set	5' x 10' x 1'

The following galvanized steel structures and concrete drilled pier foundations will be installed:

Steel Structures		Drilled Piers		
Qty	Description	Qty	Approximate Size	
			Diameter	Depth
36	500 kV Bus Support – 1PH	36	3'-0"	16'-6"
2	500 kV Deadend Structure	8	8'-6"	28'-0"
6	500 kV Surge Arrester Stand	6	3'-0"	10'-6"
6	500 kV Switch Stand – 2PH	24	3'-0"	10'-6"
6	500 kV CCVT Stand	6	3'-0"	10'-0"
4	Shield Pole – 100FT	2	4'-0"	16'-0"

Oil Containment

No oil containment will be required.

Electrical Equipment Enclosure (EEE) or Switchgear Building

A 24 foot by 40 foot control house will be ordered and constructed as previously outlined in this design guide.

VI. Control Features

Control Schemes

Series Capacitor Bank manufacturer will provide and install the control and protection for the bank, bypass breaker, and motor operated disconnect switches.

Primary carrier transfer trip (TT) via Pulsar TCF-10B, or equivalent, equipment will be used to communicate between Bison and Helena.

Secondary Tone TT via fiber optic FOCUS, or equivalent, equipment will be used to communicate between Bison and Helena.

DC Reduction

D.C. reduction schemes reduce the power order at Dorsey converters to prevent over loading of underlying transmission systems on loss of 500 KV paths.

D.C. power is controlled by allocator MW output setting on the D.C. bipole at the converter station. Loss of power outlet is determined by several conditions as listed below:

- Open breaker condition at local end or remote end
- Trip initiation by line relays at any end
- Bypass of capacitors.

- Loss/ reduction of power outlet at remote end. An example would be the loss of south line from Bison or bypass of series capacitor on the south line.
- Loss of reactive support for high transfers

Cross tripping of the north line may also be initiated if the power flow on the line is above a threshold as determined by load flow studies.

The degree of power order could vary from 15% reduction to 100% reduction depending on the type of disturbance.

The scheme is implemented as a fully communication scheme with two independent communication paths. The requirement of the maximum time delay permissible between the disturbance initiation and the allocator power order reduction is determined by the studies group**.**

RTU

The substation RTU will be per the transmission owner's requirements. Exact details are not identified at this time. A Multiport RTU will be installed. More than 1 SCADA circuit may be required. The SCADA protocol requirement of every utility that need access to the RTU may be different and it will decide what kind of RTU to be installed.

Local Annunciation

Local annunciation and control is via the station display panel.

Control Panel Locations

All Control Panels will be installed in the EEE. Space will be provided for Series Capacitor Bank manufacturer's panels.

Telephone Protection

The telephone protection equipment will includes an SNC 12-slot C-Line card shelf, a 4-port Teltone SLSS line sharing switch, and a telephone access/control box for remote communications to the relays.

Equipment Details

Removals

None.

Installations

The following new relay and control panels will be installed:

- Panel 1N, 36", Communication Panel, includes two FOCUS and two TCF-10B
- 240 VAC Cabinet
- 125 VDC Cabinets

- 48 VDC Cabinet
- Termination Cabinet

VII. Outages

None.

VIII. Material Staging Plan

All major materials will be shipped directly to the job site. Stock materials will be ordered and staged through the transmission owner's warehouse.

IX. Project and Operating Concerns

In-Service date may be impacted by transmission construction schedule as well as related substation construction schedules.

X. Related Projects

MH TSR 500 kV Option 1 – Facilities Study – Segment 1A (US/Canada Border to North Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 1B (Proposed North Series Cap Bank to proposed Bison Sub)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2A (Proposed Bison Sub to proposed South Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2B (Proposed South Series Cap Bank to proposed Helena Sub)

MH TSR 500 kV Option 1 – Facilities Study – 500-345 kV Bison Substation

MH TSR 500 kV Option 1 – Facilities Study – 500-345 kV Helena Substation

MH TSR 500 kV Option 1– Facilities Study – 500 kV North Series Cap Bank Station

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	SCB-SEr0-New Series Cap Bank
Sub./Line Name:	Series Cap Bank
WO #:	
Group Name:	
City:	
County:	
State:	MN
WO Type:	41
Op Co:	NSPM
In-service Date:	12/31/2017
Basic Scope:	NSP Sub estimating template

Estimate Information	
Est. Type	SE
Est Status:	Working
Est. Published	4/29/2010
Rev. Number:	0
Prepared By:	HDR Engineering, Inc.
Company:	Northern States Power Co - MN

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Manage	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$591,839	$0	$0	$0	$591,839
CBS3 - Civil Construction	$1,083,463	$52,200	$619,480	$38,622	$1,793,765
CBS4 - Electrical Construction	$1,406,828	$98,500	$22,167,303	$1,279,153	$24,951,784
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$127,839	$0	$0	$0	$127,839
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$3,209,969	$150,700	$22,786,784	$1,317,774	$27,465,227
Indirect Costs					
Powerplant Overheads (E&S + A&	$195,808	$0	$1,389,994	$89,577	$1,675,379
Material overheads	$0	$0	$455,736	$0	$455,736
AFUDC	$0	$0	$0	$0	$0
Contingency	$320,997	$0	$455,736	$440,542	$1,217,275
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$516,805	$0	$2,301,465	$530,119	$3,348,389
Project Total					**$30,813,616**

Print Date: 4/29/2010

Job Folder Name: SCB-SEr0-New Series Cap Bank **O&M Estimate:** $ -
Sub-Line Name: Series Cap Bank
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
JOB											
AFUDC	1	Lump Sum	Inst	Indirect	Miscelleneous	$ -	$ -	$ -	$ -	$ -	$ -
BATT 125VDC 150A WITH RACK	1	LOT	Inst	Phys	Battery	$ 6,800	$ 3,808	$ -	$ 391	$ -	$ 10,999
BATT CHRGER 125VDC 25A	1	EA	Inst	Phys	Charger	$ 3,000	$ 2,031	$ -	$ 173	$ -	$ 5,203
CAPACITOR BANK 500 kV, 768 MVAR W/ BREAKERS	1	LOT	Inst	Phys	Capacitor Bank	$ 20,000,000	$ -	$ -	$ 1,150,000	$ -	$ 21,150,000
COMM LINE TRAP 2000A	2	LOT	Inst	Cntrl	Power Line Carrier System	$ 19,670	$ 5,712	$ -	$ -	$ -	$ 25,382
Engineering & Design - Internal Labor (roll-up)	1	HR	Inst	Labor	Miscelleneous	$ -	$ 90,359	$ -	$ -	$ -	$ 90,359
GEN SET, 50KVA	1	EA	Inst	Phys	Transformer	$ 60,000	$ 2,986	$ -	$ 3,450	$ -	$ 66,436
SWITCH 500kV GROUND ATT	6	EA	Inst	Phys	Switch Gang	$ 36,000	$ 10,975	$ -	$ 2,070	$ -	$ 49,045
SWITCH MOTOR OPERATOR	12	EA	Inst	Phys	Switch Gang	$ 54,000	$ 19,038	$ -	$ 3,105	$ -	$ 76,143
CONTINGENCY	1	Lump Sum	Inst	Indirect	Miscellenous	$ 455,736	$ 320,997	$ 45,210	$ 395,332	$ -	$ 1,217,275
ESCALATION	1	Lump Sum	Inst	Indirect	Miscellenous	$ -	$ -	$ -	$ -	$ -	$ -
POWERPLANT AND MATL OVERHEADS	1	Lump Sum	Inst	Indirect	Miscellenous	$ 1,845,729	$ 195,808	$ 9,193	$ 80,384	$ -	$ 2,131,114
Permitting/Proj Management	0	HR	Inst	Labor	Land Rights (Depreciable)	$ -	$ 0	$ -	$ -	$ -	$ 0
CONTROL BUILDING 24'X40' STD SIZE F&E	1	EA	Inst	Civil	EEE	$ 58,000	$ 31,659	$ -	$ 3,335	$ -	$ 92,994
FENCE 8FT CHAIN LK W/BARB	2,432	FT	Inst	Civil	Fence & Walls	$ 52,805	$ 64,162	$ -	$ 3,036	$ -	$ 120,003
FENCE GATE DRIVE 20 FT	1	EA	Inst	Civil	Fence & Walls	$ 725	$ 66	$ -	$ 42	$ -	$ 833
Fence Silt 3'H	1,774	FT	Inst	Civil	Fence & Walls	$ 656	$ 11,701	$ -	$ 38	$ -	$ 12,395
Breaker Slab 500kV (8'x20')	6	EA	Inst	Civil	Foundations	$ 5,025	$ 24,904	$ -	$ 289	$ -	$ 30,217
Concrete Pier 4' x 16'	18	EA	Inst	Civil	Foundations	$ 19,350	$ 94,952	$ -	$ 1,113	$ -	$ 115,415
EEE Slab 24' x 40' x 1'	1	EA	Inst	Civil	Foundations	$ 4,450	$ 21,831	$ -	$ 256	$ -	$ 26,537
SITE - DETENTION POND	1	EA	Inst	Civil	Grading & Landscaping	$ 5,000	$ 7,585	$ -	$ 288	$ -	$ 12,872
SITE - EARTHWORK - COMPACTION TEST	1	EA	Inst	Civil	Grading & Landscaping	$ 150	$ -	$ -	$ 9	$ -	$ 159
SITE - GRADING	1	EA	Inst	Civil	Grading & Landscaping	$ 371,482	$ 269,788	$ -	$ 21,360	$ -	$ 662,630
500kV Bus Support Stand - 1PH (36'-6)	36	EA	Inst	Civil	Structure - Welded Tubular	$ 197,550	$ 167,100	$ -	$ 11,359	$ -	$ 376,009
500kV CCVT Stand 1PH (15')	6	EA	Inst	Civil	Structure - Welded Tubular	$ 11,775	$ 14,362	$ -	$ 677	$ -	$ 26,814
500kV Deadend Structure	2	EA	Inst	Civil	Structure - Welded Tubular	$ 747,000	$ 391,984	$ -	$ 42,953	$ -	$ 1,181,936
500kV Surge Arrester Stand 1PH	6	EA	Inst	Civil	Structure - Welded Tubular	$ 13,612	$ 15,997	$ -	$ 783	$ -	$ 30,392

Job Folder Name: SCB-SEr0-New Series Cap Bank **O&M Estimate:** $ -
Sub-Line Name: Series Cap Bank
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
500kV Switch Stand (15')	6	EA	Inst	Civil	Structure - Welded Tubular	$ 166,650	$ 94,054	$ -	$ 9,582	$ -	$ 270,286
Shield Pole 100FT	4	EA	Inst	Civil	Structure - Welded Tubular	$ 39,863	$ 36,169	$ -	$ 2,292	$ -	$ 78,324
CIVIL INSPECTION/TESTING (CONT	1	EA	Inst	Civil	Survey and Test	$ -	$ 1,080	$ -	$ -	$ -	$ 1,080
SITE - SOIL BORINGS (NEW SUB 7 BORING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 4,980	$ -	$ -	$ -	$ 4,980
SITE - SOIL GEOTECHNICAL INVESTIGATING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 6,000	$ -	$ -	$ -	$ 6,000
SITE - SOIL RESISTIVITY TESTING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 960	$ -	$ -	$ -	$ 960
SITE - SURVEY - CONST. STAKING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 1,620	$ -	$ -	$ -	$ 1,620
SITE - SURVEY (TOPO/BOUNDARY)	1	LOT	Inst	Civil	Survey and Test	$ -	$ 10,020	$ -	$ -	$ -	$ 10,020
TRENCHING AND ACCESS-MACH-36"	1,000	FT	Inst	Civil	Trenching	$ 1,000	$ 11,212	$ -	$ 58	$ -	$ 12,270
TRENCHING PRECAST 40" OPEN BOTTOM	940	FT	Inst	Civil	Trenching	$ 28,200	$ 86,178	$ -	$ 1,622	$ -	$ 115,999
TRENCHING PRECAST 40" ROAD CROSSI	60	FT	Inst	Civil	Trenching	$ 4,800	$ 9,814	$ -	$ 276	$ -	$ 14,890
. CABLE -CONT/PWR-TERM. 600V	1,176	EA	Inst	Cntrl	Cable - Control	$ 129	$ 26,340	$ -	$ 7	$ -	$ 26,477
. CABLE -CONTROL-600V 1C 12	47,430	FT	Inst	Cntrl	Cable - Control	$ 9,962	$ 106,234	$ -	$ 573	$ -	$ 116,770
. CABLE -CONTROL-600V 3C 4	440	FT	Inst	Cntrl	Cable - Control	$ 1,740	$ 986	$ -	$ 100	$ -	$ 2,825
. CABLE -CONTROL-600V 3C 6	0	FT	Inst	Cntrl	Cable - Control	$ 0	$ 0	$ -	$ 0	$ -	$ 0
. CABLE -CONTROL-600V 4C 10	5,033	FT	Inst	Cntrl	Cable - Control	$ 6,293	$ 11,272	$ -	$ 362	$ -	$ 17,927
. CABLE -CONTROL-600V 7C 10	2,310	FT	Inst	Cntrl	Cable - Control	$ 5,678	$ 5,174	$ -	$ 326	$ -	$ 11,178
. CABLE -CONTROL-600V 2PR 18	4,620	FT	Inst	Cntrl	Cable - Control	$ 3,115	$ 10,348	$ -	$ 179	$ -	$ 13,642
. CABLE -CONTROL-600V 2PR 18	4,620	FT	Inst	Cntrl	Cable - Control	$ 3,115	$ 10,348	$ -	$ 179	$ -	$ 13,642
. CABLE -CONTROL-600V 8PR 18	440	FT	Inst	Cntrl	Cable - Control	$ 691	$ 986	$ -	$ 40	$ -	$ 1,717
. CABLE -CONTROL-600V 10PR 10	5,060	FT	Inst	Cntrl	Cable - Control	$ 30,056	$ 11,333	$ -	$ 1,728	$ -	$ 43,118
FIBER OPTIC CABLE-SINGLE MODE	460	EA	Inst	Cntrl	Fiber	$ 253	$ 1,717	$ -	$ 15	$ -	$ 1,985
FIBER PATCH PANEL	1	EA	Inst	Cntrl	Fiber	$ 500	$ 560	$ -	$ 29	$ -	$ 1,089
FIBER SPLICE BOX	2	EA	Inst	Cntrl	Fiber	$ 200	$ 747	$ -	$ 12	$ -	$ 958
PANEL-COMMUNICATIONS PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 25,000	$ 5,973	$ -	$ 1,438	$ -	$ 32,410
PANEL-DC RUNBACK PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 18,500	$ 5,973	$ -	$ 1,064	$ -	$ 25,537
PANEL-FOCUS AND TCF-10B CARRIER	2	EA	Inst	Cntrl	Panels - Conventional	$ 40,000	$ 5,973	$ -	$ 2,300	$ -	$ 48,273
PANEL-PLC TERMINAL CAB LAYOUT (MATERIAL LIST & TERM BLOCK LAYOUT)	1	EA	Inst	Cntrl	Panels - Conventional	$ 12,000	$ 2,986	$ -	$ 690	$ -	$ 15,676
PANEL-QUICKPANEL DISPLAY WITH PLC, SEL-2032 COMM SW & GPS CLOCK	1	EA	Inst	Cntrl	Panels - Conventional	$ 30,000	$ 2,986	$ -	$ 1,725	$ -	$ 34,711
PANEL-TELEPHONE ACCESS CONTROL BOX AND MATERIAL LIST	1	EA	Inst	Cntrl	Panels - Conventional	$ 1,600	$ 2,986	$ -	$ 92	$ -	$ 4,678
CARRIER LINE TUNER	4	EA	Inst	Cntrl	Pilot	$ 8,000	$ 2,986	$ -	$ 460	$ -	$ 11,446
TEL 3/4" PLYWOOD PANEL	1	EA	Inst	Cntrl	Telephone	$ 50	$ 448	$ -	$ 3	$ -	$ 501
TEL POSITRON PACkAGE	1	EA	Inst	Cntrl	Telephone	$ 3,840	$ 1,493	$ -	$ 221	$ -	$ 5,554
EQUIP - BACKHOE WITH CAB	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 31,200	$ 1,794	$ -	$ 32,994

Job Folder Name: SCB-SEr0-New Series Cap Bank **O&M Estimate:** $ -

Sub-Line Name: Series Cap Bank

Scope: NSP Sub estimating template

WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
EQUIP - BOBCAT	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 30,000	$ 1,725	$ -	$ 31,725
EQUIP - CONTRACT WELDING	4	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 14,000	$ 805	$ -	$ 14,805
EQUIP - CRANE (W/OPR) - 30 TON	5	DAY	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 6,000	$ 345	$ -	$ 6,345
EQUIP - FORKLIFT (MTRL HANDLER)	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 35,200	$ 2,024	$ -	$ 37,224
EQUIP - MINI EXCAVATOR (GND WIRE INSTALL)	40	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 21,000	$ 1,208	$ -	$ 22,208
EQUIP - MISC (TRAILORS, TOILETS, DUMSTER, STORAGE)	10	MO	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 13,300	$ 765	$ -	$ 14,065
CONCRETE - MBL 3-MAN (MORE 100 MI)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,968	$ -	$ -	$ -	$ 2,968
Electric Construction - Mobilize (In/Out)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,986	$ -	$ -	$ -	$ 2,986
Electric Construction - Site Setup	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 5,973	$ -	$ -	$ -	$ 5,973
SITE - EARTHWORK - MOBILIZATION (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
SITE - SURFACING-MOBILIZE (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
Eng & Des - Contract - Labor Only	4,300	HR	Inst	Labor	Civil/Electrical	$ -	$ 451,500	$ -	$ -	$ -	$ 451,500
Eng SPS Study	476	HR	Inst	Labor	Civil/Electrical	$ -	$ 49,980	$ -	$ -	$ -	$ 49,980
General Foreman - Internal - Labor Only	2,640	HR	Inst	Labor	Civil/Electrical	$ -	$ 219,642	$ -	$ -	$ -	$ 219,642
TESTING-CONTROL TESTING	1,411	HR	Inst	Labor	Test	$ -	$ 103,839	$ -	$ -	$ -	$ 103,839
TESTING-PHYSICAL EPM	326	HR	Inst	Labor	Test	$ -	$ 24,000	$ -	$ -	$ -	$ 24,000
Trucking - Shipping (# Trips x HR Rnd Trip)	320	HR	Inst	Labor	Civil/Electrical	$ -	$ 21,106	$ -	$ -	$ -	$ 21,106
AC CAB 42 POS.	1	EA	Inst	Phys	AC System	$ 852	$ 523	$ -	$ 49	$ -	$ 1,424
AC PNLBRD INDOOR 120/240VAC 3PH 60HZ, 400A	1	EA	Inst	Phys	AC System	$ 1,936	$ 1,493	$ -	$ 111	$ -	$ 3,541
AUTO TRANSFER SW 400A 240V 1PH	1	EA	Inst	Phys	AC System	$ 4,445	$ 1,195	$ -	$ 256	$ -	$ 5,895
LIGHTING-HIGH VOLTAGE BAY	5	LOT	Inst	Phys	AC System	$ 2,000	$ 14,932	$ -	$ 115	$ -	$ 17,047
ARRESTER 335kV MCOV STA. PORCELAIN	6	EA	Inst	Phys	Arrester	$ 87,600	$ 4,480	$ -	$ 5,037	$ -	$ 97,117
BUS SUPPORT 550kV	36	EA	Inst	Phys	Bus Supports & Insulators	$ 27,082	$ 16,127	$ -	$ 1,557	$ -	$ 44,765
CCVT/PT SEC FUSE CAB 1 PH	6	EA	Inst	Phys	Cabinets	$ 604	$ 2,240	$ -	$ 35	$ -	$ 2,879
TERMINAL CABINET INDOOR	1	EA	Inst	Phys	Cabinets	$ 3,206	$ 2,986	$ -	$ 184	$ -	$ 6,377
CCVT 500kV MTRG HI-CAP01.5A	6	EA	Inst	Phys	CCVTs & Traps	$ 120,000	$ 20,158	$ -	$ 6,900	$ -	$ 147,058
LINE TRAP 2000A	4	EA	Inst	Phys	CCVTs & Traps	$ 79,600	$ 4,480	$ -	$ 4,577	$ -	$ 88,657
CONDUCTOR - SHIELD WIRE 3/8 " GALVANIZED E.H.S.	400	FT	Inst	Phys	Conductor & Fittings	$ 169	$ 2,986	$ -	$ 10	$ -	$ 3,165
CONDUCTOR ALUM 1590 61 STR AA	500	FT	Inst	Phys	Conductor & Fittings	$ 1,333	$ 11,946	$ -	$ 77	$ -	$ 13,355
CONDUCTOR ALUM TUBING 6 IN SCHED 40	2,500	FT	Inst	Phys	Conductor & Fittings	$ 61,250	$ 74,660	$ -	$ 3,522	$ -	$ 139,432
CONDUCTOR FITTING 345-500kV EHV	3,000	FT	Inst	Phys	Conductor & Fittings	$ 24,000	$ -	$ -	$ 1,380	$ -	$ 25,380
BATT 48VDC 50AH	1	EA	Inst	Phys	DC System	$ 3,790	$ 4,853	$ -	$ 218	$ -	$ 8,861
BATT CHRGER 48VDC 30A	1	EA	Inst	Phys	DC System	$ 2,200	$ 1,493	$ -	$ 127	$ -	$ 3,820

Job Folder Name: SCB-SEr0-New Series Cap Bank **O&M Estimate:** $ -
Sub-Line Name: Series Cap Bank
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
BATT MAIN FUSE CABINET ASSM.	1	EA	Inst	Phys	DC System	$ 345	$ 299	$ -	$ 20	$ -	$ 663
BATT MAIN FUSE CABINET ASSM.	1	EA	Inst	Phys	DC System	$ 345	$ 299	$ -	$ 20	$ -	$ 663
DC CAB 34 POSITION STL INDOOR	2	EA	Inst	Phys	DC System	$ 4,292	$ 2,986	$ -	$ 247	$ -	$ 7,525
EEE ELECT HTR 5KW & THERMOSTAT	2	EA	Inst	Phys	EEE	$ 1,514	$ 2,240	$ -	$ 87	$ -	$ 3,841
EEE FURNITURE-EQUIPMENT (NL-200904)	1	LOT	Inst	Phys	EEE	$ 1,100	$ 1,493	$ -	$ 63	$ -	$ 2,656
EEE GROUNDING 24' X 30'	1	EA	Inst	Phys	EEE	$ 155	$ 5,973	$ -	$ 9	$ -	$ 6,137
EEE LIGHTING 20X32	1	EA	Inst	Phys	EEE	$ 844	$ 8,959	$ -	$ 49	$ -	$ 9,852
GROUND CABLE ASSEMBLY ST	2	SET	Inst	Phys	Grounding	$ 2,070	$ 299	$ -	$ 119	$ -	$ 2,488
GROUND CADWELD CONNECTIONS	195,990	SFT	Inst	Phys	Grounding	$ 25,479	$ 58,531	$ -	$ 1,465	$ -	$ 85,474
GROUND GRID TEST	1	EA	Inst	Phys	Grounding	$ -	$ 1,493	$ -	$ -	$ -	$ 1,493
GROUND RODS (per grounding point)	110	EA	Inst	Phys	Grounding	$ 6,772	$ 13,633	$ -	$ 389	$ -	$ 20,794
GROUND WIRE 4/0 CU	12,000	FT	Inst	Phys	Grounding	$ 33,840	$ 223,981	$ -	$ 1,946	$ -	$ 259,767
NAMEPLATES EQUIPMENT	8	EA	Inst	Phys	Nameplates	$ 200	$ 149	$ -	$ 12	$ -	$ 361
NAMEPLATES FENCE ADDRESS	1	EA	Inst	Phys	Nameplates	$ 144	$ 37	$ -	$ 8	$ -	$ 190
NAMEPLATES FENCE WARNING	35	EA	Inst	Phys	Nameplates	$ 1,330	$ 1,307	$ -	$ 76	$ -	$ 2,713
SWITCH 500kV 2000A SPST DBL EB W INS	12	EA	Inst	Phys	Switch Gang	$ 180,000	$ 107,511	$ -	$ 10,350	$ -	$ 297,861
						$ 25,088,249	$ 3,726,774	$ 205,103	$ 1,793,491	$ -	$ 30,813,616

Substation Project Forecast

This forecast represents typical expenditures and commitments for this project based on average conditions.
Adjustments to this forecast may be necessary to factor in delays or expediting efforts.

Work Order:
Location: Series Cap Bank
Title: NSP Sub estimating template

Costs from Estimate

		Install	Remove
Permitting and Proj. Management:	$	-	
Material:	$	24,560,000	
Transformer (with tax and OH):	$	-	
Construction Labor & Rentals:	$	2,641,000	$0
Testing Labor:	$	128,000	
E&S:	$	592,000	
Contingencies:	$	1,217,000	
Overheads:	$	1,675,000	
AFUDC:	$	-	
TNE w/o AFUDC:		$30,813,000	

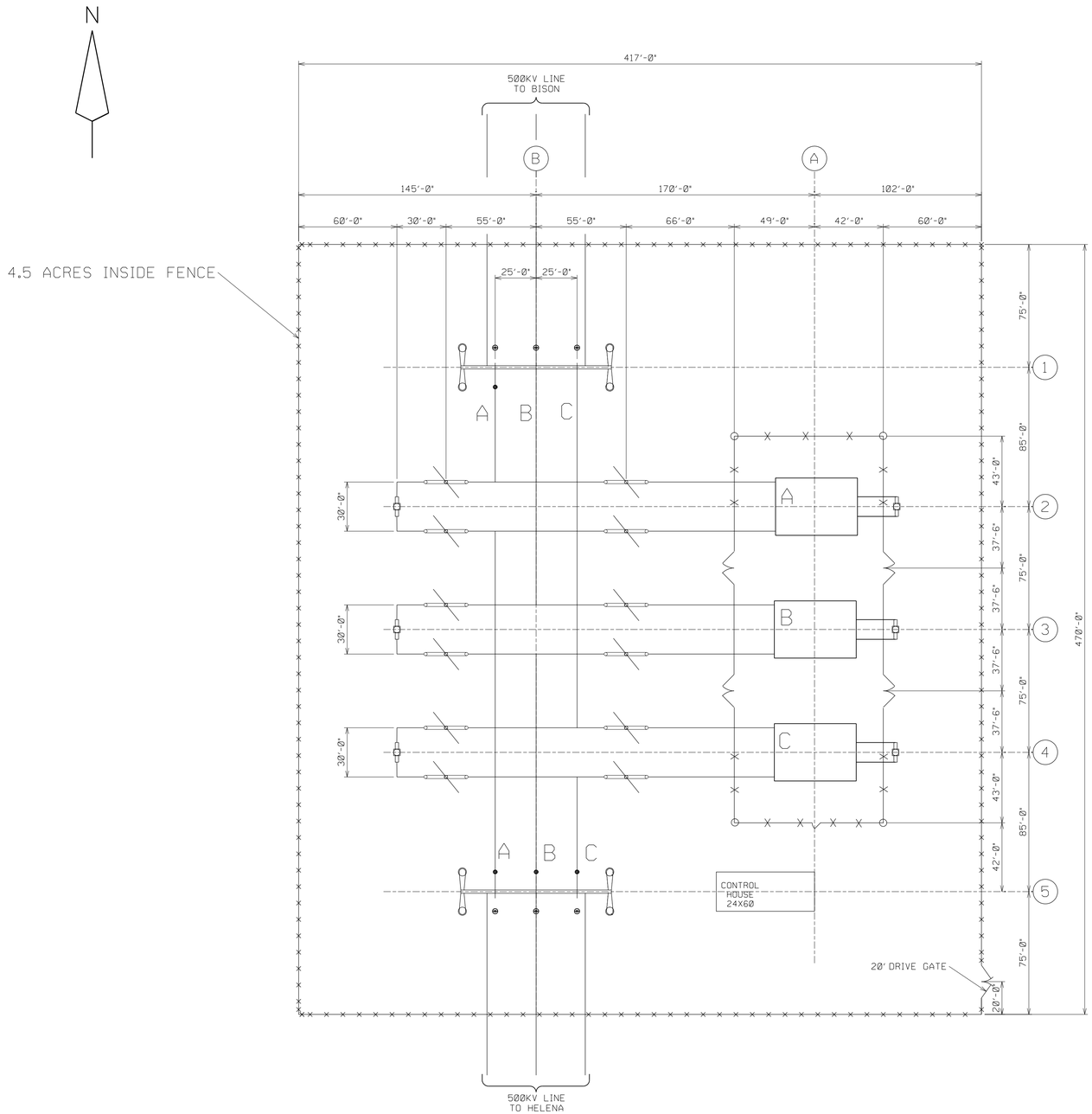
In-Service Date	**12/31/2017**
Project Start Date	**7/1/2010**
Construction Start Date	**6/1/2015**

Jul-10	$	25,130	**Apr-14**	$	25,190
Aug-10	$	25,190	**May-14**	$	25,190
Sep-10	$	25,190	**Jun-14**	$	25,190
Oct-10	$	25,190	**Jul-14**	$	25,190
Nov-10	$	25,190	**Aug-14**	$	25,190
Dec-10	$	25,190	**Sep-14**	$	25,190
Jan-11	$	25,190	**Oct-14**	$	25,190
Feb-11	$	25,190	**Nov-14**	$	25,190
Mar-11	$	25,190	**Dec-14**	$	25,190
Apr-11	$	25,190	**Jan-15**	$	25,190
May-11	$	25,190	**Feb-15**	$	25,190
Jun-11	$	25,190	**Mar-15**	$	25,190
Jul-11	$	25,190	**Apr-15**	$	25,190
Aug-11	$	25,190	**May-15**	$	2,025,190
Sep-11	$	25,190	**Jun-15**	$	25,190
Oct-11	$	25,190	**Jul-15**	$	25,190
Nov-11	$	25,190	**Aug-15**	$	25,190
Dec-11	$	25,190	**Sep-15**	$	25,190
Jan-12	$	25,190	**Oct-15**	$	25,190
Feb-12	$	25,190	**Nov-15**	$	25,190
Mar-12	$	25,190	**Dec-15**	$	25,190
Apr-12	$	25,190	**Jan-16**	$	25,190
May-12	$	25,190	**Feb-16**	$	25,190
Jun-12	$	25,190	**Mar-16**	$	25,190
Jul-12	$	25,190	**Apr-16**	$	25,190
Aug-12	$	25,190	**May-16**	$	25,190
Sep-12	$	25,190	**Jun-16**	$	186,940
Oct-12	$	25,190	**Jul-16**	$	186,940
Nov-12	$	25,190	**Aug-16**	$	186,940

Dec-12	$	25,190	**Sep-16**	$	1,186,940
Jan-13	$	25,190	**Oct-16**	$	19,031,740
Feb-13	$	25,190	**Nov-16**	$	2,347,740
Mar-13	$	25,190	**Dec-16**	$	1,347,740
Apr-13	$	25,190	**Jan-17**	$	597,740
May-13	$	25,190	**Feb-17**	$	397,740
Jun-13	$	25,190	**Mar-17**	$	359,740
Jul-13	$	25,190	**Apr-17**	$	347,740
Aug-13	$	25,190	**May-17**	$	347,740
Sep-13	$	25,190	**Jun-17**	$	347,750
Oct-13	$	25,190	**Jul-17**	$	25,190
Nov-13	$	25,190	**Aug-17**	$	25,190
Dec-13	$	25,190	**Sep-17**	$	25,190
Jan-14	$	25,190	**Oct-17**	$	25,190
Feb-14	$	25,190	**Nov-17**	$	25,190
Mar-14	$	25,190	**Dec-17**	$	25,190

	2010	**2011**	**2012**	**2013**	**Total**
TNE w/o AFUDC	$ 151,080	$ 302,280	$ 302,280	$ 302,280	**$ 30,813,000**

	2014	**2015**	**2016**	**2017**
TNE w/o AFUDC	$ 302,280	$ 2,302,280	$ 24,600,930	$ 2,549,590



GENERAL NOTES

FOR GENERAL NOTES PRIOR TO •• CONSTRUCTION, SEE REVISION ••.

1. LOCATION OF BENCH MARK FOR GRADE ELEVATION IS N150632.82 E633564.06
   ELEVATION OF BENCH MARK IS XXXX
2. SUBSTATION ROUGH GRADE ELEVATION IS XXXX - XXXX
3. SUBSTATION AREA ENCLOSED BY FENCE AND EXTENDING 5'-0" OUTSIDE.
4. FENCE - 7'-0" HIGH STEEL CHAIN LINK FABRIC AND 1'-0" HIGH VERTICAL HEIGHT BARBED WIRE ON TOP, MOUNTED AT A 45° ANGLE POINTED OUTSIDE OF SUBSTATION. IN ACCORDANCE WITH ENG & DSGN STD ED 4.09.03.
5. SEE STRUCTURAL STEEL DRAWINGS FOR LOAD REQUIREMENTS OF EXTERNAL AND INTERNAL STRAINS.
6. U.G. POWER DUCTS PASS UNDER FENCE MIDWAY BETWEEN FENCE POSTS AND, WHERE POSSIBLE, NOT LESS THAN 2'-6" BELOW GRADE.

LEGEND

- [A] → OLD FENCE SIGN WORDED "WARNING, HAZARDOUS VOLTAGES INSIDE, KEEP OUT, CAN SHOCK BURN OR CAUSE DEATH". (THIS SIGN CAN NO LONGER BE ORDERED)
- [B] → FENCE WARNING SIGN (16-0092), PER ENG & DSGN STD ED 4.10.01. THE SIGNS ARE TO BE MOUNTED 5'-0" FROM GRADE TO TOP OF SIGN, 30-0" - 45'-0" APART AND NO MORE THAN 15'-0" FROM THE CORNERS. ONE SIGN SHOULD BE PLACED ON THE OUTSIDE OF EACH WALK GATE. TWO SIGNS SHOULD BE MOUNTED ON EACH DRIVE GATE, ONE ON THE INSIDE AND ONE ON THE OUTSIDE. (BACK TO BACK ON THE LEFT SIDE OR DRIVERS SIDE PANEL OF THE DOUBLE GATES).
- [C] → BURIED CABLE SIGN (16-0088), PER ENG & DSGN STD ED 4.10.06. THE SIGNS ARE TO BE MOUNTED ON EACH SIDE OF FENCE FABRIC, BACK TO BACK AND APPROXIMATELY 3'-6" FROM GRADE TO TOP OF SIGNS. ORDERED BY FIELD.
- [D] → BURIED CABLE SIGN MOUNTED ON POST (16-0095), PER ENG & DSGN STD ED 4.10.06. POST AND SIGN ORDERED BY FIELD.
- [E] → SUBSTATION IDENTIFICATION SIGN PER ENG & DSGN STD ED 4.10.02 (TOP) AND ADDRESS SIGN PER ENG & DSGN STD ED 4.10.03 (BOTTOM). THE TOP SIGN MOUNTED 5'-0" FROM GRADE TO TOP OF SIGN AND LOCATED ADJACENT TO WALK OR DRIVE GATES.
- [F] → BATTERY WARNING SIGN (S7-5454), PER ENG & DSGN STD ED 4.10.04. THE SIGNS ARE TO MOUNTED ON THE OUTSIDE OF EACH CONTROL HOUSE DOOR, APPROXIMATELY 5'-0" FROM THE BOTTOM OF THE DOOR TO THE TOP OF SIGN.
- [M-1] → INDICATES CONCRETE MARKERS FOR DIRECT BURIED CABLE RUNS. E & D STD. ED 4.05.04, ORDERED BY FIELD.
- ——— INDICATES LOW BUS (21'-2")
- ◆ INDICATES PLASTIC BALARDS BY FIELD

FOR DRAWING REFERENCE AND REVISION INFORMATION SEE INDEX SHEET

PRELIMINARY
NOT FOR CONSTRUCTION

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

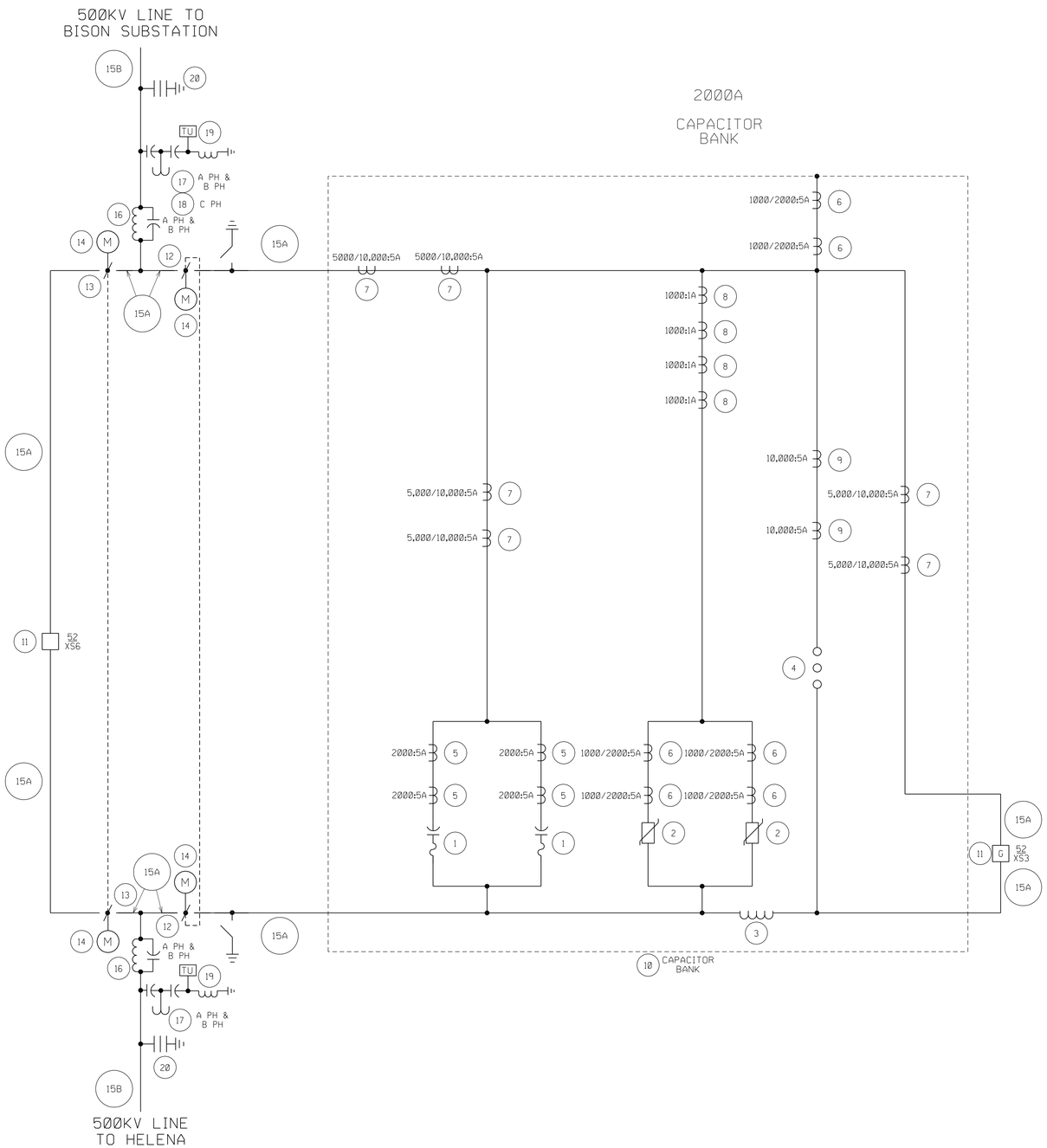
MANITOBA HYDRO TSR 500KV FACILITIES STUDY OPTION ONE

SOUTH 500KV SERIES CAP BANK STATION LOCATION PLAN

0 1" 2"

FILENAME	SOUTH LOC PLAN.DGN
SCALE	1:40

SHEET
LOC PLAN



21 AUTOMATIC TRANSFER SWITCH

22 BATTERY

23 BATTERY CHARGER

24 STATION SERVICE

25 GEN SET

STATION AUXILIARIES LOCATED IN CONTROL HOUSE

SEE SCHEMATIC DIAGRAM

PRELIMINARY

NOT FOR CONSTRUCTION

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

SOUTH 500KV SERIES CAP BANK STATION
CIRCUIT DIAGRAM
500KV

0 1" 2"

FILENAME	SOUTH CIR DIA.DGN
SCALE	NONE

SHEET **CIR DIA**

SOUTH 500KV SERIES CAP BANK SUBSTATION ()

CIRCUIT DIAGRAM - LIST OF EQUIPMENT

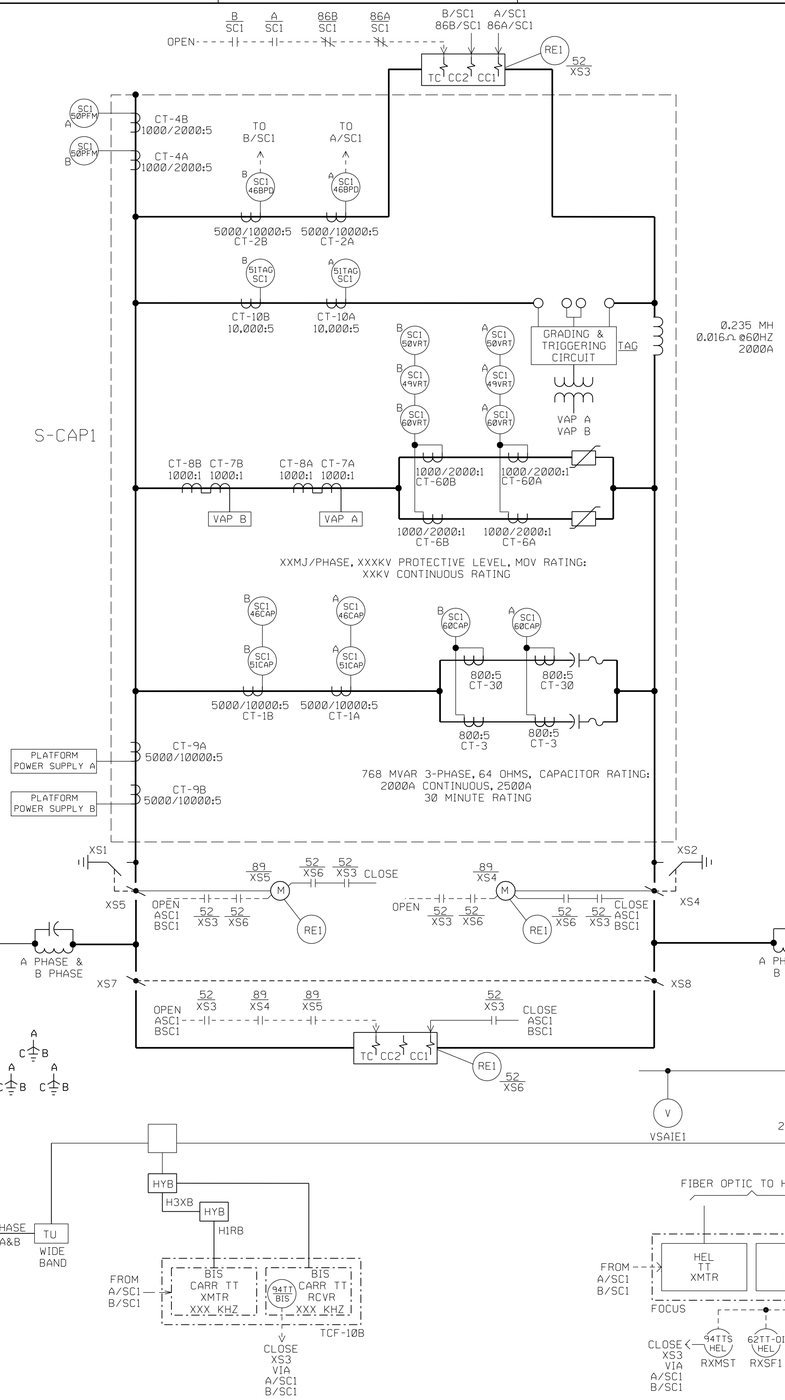
Date Created

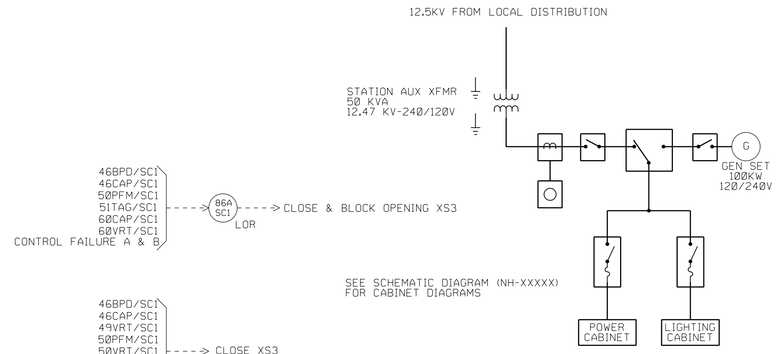
03/17/10

REV - 0

This Map/Document is a tool to assist employees in the performance of their jobs. Your personal safety is provided for by using safety practices, procedures and equipment as described in safety training programs, manuals and SPAR's

ITEM NO.	DESCRIPTION	STANDARD DESIGNATION & NOMINAL RATING	ORDER NUMBER	DRAWING NUMBER	CURRENT REVISION INFO (Existing & unchanged items left blank)
1	DESCRIPTION	STANDARD DESIGNATION & NOMINAL RATING			
2	1 - THREE PHASE SERIES CAPACITOR BANK, ____ CO., 768MVAR, 64 OHM (___ TWO BUSHING UNITS @ ____ KVAR, 500KV, 60 HZ, ___KV BIL, ____CO., CAT _____, CONNECTED THUS: _ UNITS SERIES PER GROUP, __ PARALLEL CONNECTED GROUPS PER SEGMENT AND _ PARALLEL CONNECTED SEGMENT PER PHASE)				
3	3 - SINGLE PHASE REACTOR, OUTDOOR, ____ CO., DRY TYPE, AIR CORE, ___ KV BIL, ____ A, ___MH (____ OHMS @ 60 HZ)				
4	3 - SINGLE PHASE TRIGGERED AIR GAP, _____ CO., CAT _____, WITH ENCLOSURE				
5	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 2000:5A SINGLE-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
6	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 1000/2000:5A DUAL-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
7	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 5000/10000:5A DUAL-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
8	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 1000:1A SINGLE-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
9	3 - OUTDOOR CURRENT TRANSFORMERS, _____ CO. TYPE _____, _____KV, 10000:5A SINGLE-RATIO, RELAY TYPE, ACCURACY CLASS ____	TRF1.0			
10	3 - SINGLE PHASE 500 KV INSULATED EQUIPMENT PLATFORM, _____ CO.				
11	3 - SINGLE PHASE GAS CIRCUIT BREAKER, _____CO. TYPE _____, 550KV MAXIMUM, 40,000 AMPS INTERRUPTING CAPACITY WITHOUT CT'S	YR MFG ____, 2000 A			
12	3 - SINGLE PHASE PAIR OPERATED, SWITCH, DOUBLE END-BREAK, _____CO. TYPE _____ ,500KV, 100,000AMPS MOMENTARY WITH ONE PAIR OPERATED GROUND BLADES, _____CO., TYPE_____	___ ACCC, 2000A			
13	3 - SINGLE PHASE PAIR OPERATED, SWITCH, DOUBLE END-BREAK, _____CO. TYPE _____ ,500KV, 100000AMPS MOMENTARY	___ ACCC, 2000A			
14	1 - SWITCH OPERATING MOTOR MECHANISM, _____ CO. TYPE _____, _____VDC				
15A	BUS - ALUMINUM TUBULAR BUS	6" AL TUBE (SCHED 40)			
15B	BUS - STRANDED ALUMINUM CONDUCTOR (CODE NAME COREOPSIS)	2-1590 AAC - 61 STRAND			
16	2 - LINE TRAP, _____ CO., DRY-TYPE AIR CORE, MODEL #_____, 500GNDY/287.5KV, _____ KHZ, WIDE (OR NARROW) BAND VERTICAL MOUNTING ON 5" B.C.	EPOXY (OR NON-EPOXY), 2000A			
17	2-SINGLE-PHASE - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500GNDY/287.5KV, 1800KV BIL, _____ CO., CAT.# _____ WITH CARRIER ACCESSORIES, _____ VOLTS, _____% ACCURACY THRU _____ BURDEN				
18	1-SINGLE-PHASE - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500GNDY/287.5 KV, 1300 KV BIL, _____ CO., CAT.# _____ WITHOUT CARRIER ACCESSORIES, _____ VOLTS, _____% ACCURACY THRU _____ BURDEN				
19	2 - LINE TUNING UNIT, _____ CO., MODEL #_____, WIDE BAND, _____ KHZ				
20	3 - SURGE ARRESTER, STATION CLASS, _____ CO. PORCELAIN, CAT#_____, 335KV MCOV, 500KV				
21	AUTOMATIC TRANSFER SWITCH, _____ CO., TYPE _____, 400 AMP, 120/240VAC SINGLE PHASE				
22	BATTERY, _____ CO., TYPE _____, 125 VDC, _____ AMP-HOUR RATING. BATTERY RACK IS __ TIER, __D x __W x __H				
23	BATTERY CHARGER, _____ CO., TYPE_____, ___VDC, ___ AMPS, ___VAC SINGLE PHASE SOURCE				
24	1 - SINGLE-PHASE TRANSFORMERS, _____ CO. CLASS _____, 65℃ RISE @ 1000M, SUBTRACTIVE POLARITY, 24 0/120 VOLTS				
25	1-GENSET, ____CO.				





46BPD/SC1
46CAP/SC1
50PFM/SC1
51TAG/SC1
60CAP/SC1
60VRT/SC1
CONTROL FAILURE A & B
86A SC1 LOR
-> CLOSE & BLOCK OPENING XS3

46BPD/SC1
46CAP/SC1
49VRT/SC1
50PFM/SC1
50VRT/SC1
51CAP/SC1
51TAG/SC1
60CAP/SC1
60VRT/SC1
(CARR)94TT/HEL
(CARR)94TT/BIS
(TONE)94TT/HEL
(TONE)94TT/BIS
-> CLOSE XS3

NOTES:

46BPD/SC1
46CAP/SC1
50PFM/SC1
51TAG/SC1
60CAP/SC1
60VRT/SC1
CONTROL FAILURE A & B
86B SC1 LOR
-> CLOSE & BLOCK OPENING XS3

46BPD/SC1
46CAP/SC1
49VRT/SC1
50PFM/SC1
50VRT/SC1
51CAP/SC1
51TAG/SC1
60CAP/SC1
60VRT/SC1
(CARR)94TT/HEL
(CARR)94TT/BIS
(TONE)94TT/HEL
(TONE)94TT/BIS
-> CLOSE XS3

LINE TRIP "A" -> 94A SC1

LINE TRIP "B" -> 94B SC1

DEVICE LEGEND

FUNCTIONS OF PLC

- 46BPD - BREAKER POLE DISAGREEMENT
- 46CAP - CAPACITOR BANK PHASE UNBALANCE
- 49VRT - VARISTOR OVERTEMPERATURE
- 50PFM - PLATFORM FAULT OVERCURRENT
- 50VRT - FAST VARISTOR BYPASS INSTATANEOUS OVERCURRENT
- 51CAP - CAPACITOR TIME OVERCURRENT
- 60CAP - CAPACITOR UNBALANCE
- 60VRT - VARISTOR UNBALANCE

- 86A - CONTROL A, BYPASS LOCKOUT
- 86B - CONTROL B, BYPASS LOCKOUT
- 94A - CONTROL A, LINE TRIP
- 94B - CONTROL B, LINE TRIP

A - PROGRAMMABLE LOGIC CONTROLLER (PLC) A
B - PROGRAMMABLE LOGIC CONTROLLER (PLC) B

SC1 - SERIES CAPACITOR #1

REFERENCE DRAWINGS:

CIRCUIT DIAGRAM _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

SCHEMATIC DIAGRAM _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

PRELIMINARY
NOT FOR CONSTRUCTION

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

SOUTH 500KV SERIES CAP BANK STATION
METERING & RELAYING DIAGRAM
500KV

0 1" 2"

FILENAME	SOUTH M&R.DGN
SCALE	NONE

SHEET **M&R**

PROJECT DESIGN GUIDE

Location: Helena Substation (HLN)
Project Title: MH TSR 500 kV Option 1 Facilities Study – Upgrade Helena Substation for new 500-345 kV Substation

In-Service Date:	December 2017
Program Manager:	CapX2020
Project Manager:	Jared Alholinna, CapX2020 Chris Ayika, Xcel Energy
Prepared By:	HDR Engineering, Inc.
Estimate Type and Amount:	Facilities Study $62,320,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the midline location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. .

The following assumptions have been included in the substation portion of this study:

1. This study assumes that the CapX2020 Helena Substation has been constructed and that the 500 and 345 kV additions identified herein can be accommodated by purchasing an adjacent 40 acre parcel. The site that is selected for the Helena Substation will have the ability to acquire the required property for the expansion identified within this study.

2. The study has been prepared for CapX2020. The ownership of the substation has not been identified at this time.

3. No special protection systems for area wide dynamic system operation have been studied at this time and no equipment for such systems are included in this study.

4. Two 1200MVA, 500-345 kV transformers are included as directed by MISO. Confirmation of this requirement will be obtained in a later in the project.

5. The exact requirements of the site including access, topography, drainage, geotechnical structure and landscaping are not identified at this time. Therefore, general assumptions have been made for this scope.

Background

Several Transmission Service Requests (TSR) for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service. The study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

Space will be reserved on the west side of the 500 kV yard. This space is for one (1) breaker per row and future 500 kV Bus 1 for a breaker and a half layout.

Space will be reserved on the south 500 kV bus for three (3) future breakers. One (1) breaker will be located west of the TR2 position and two (2) breakers will be located east of the TR2 position.

Space will be reserved east of the new 345 kV 52/CB8 breaker for one (1) breaker.

All future work is shown on attached drawings.

II. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

CIP requirements for this station are not identified at this time. The exact requirements will be identified once the ownership and operational control of the station is determined.

Facility Ratings

The substation presently meets the new facility rating requirements.

III. Right of Way

523 KSF of new land will be required north of the existing Helena Substation 345 kV Yard. It is assumed that the site that have been identified for this substation for the initial CapX2020 Helena Substation construction will allow for the expansion of the yard to accommodate the new 500 and 345 kV equipment.

IV. Electrical Features

Transmission Lines: Current Carrying Capacity of Affected/Tapped/New

	Current Rating		
Transmission Lines	**Conductor Type**	**Summer (40 deg C)**	**Winter (0 deg C)**
Bison-Helena 500 kV Line	3-1192.5 ACSR	4365 amps	5724 amps

The Helena 500 and 345 kV bus and associated equipment will be rated for 2000 amps.

Fault Current

The substation will be designed to 40 kA on 500 and 345 kV bus and equipment.

Preliminary Modeling in CAPE is shown in the following table:

Location \ **Type of fault**	**Three Phase Amps**
500 kV System at HLN with Bison Line	14,757
345 kV System at HLN with Bison Line	25,124

Electrical Removals & Relocations

No equipment will be removed or relocated for this project. Rewiring of existing 345 kV breakers will be required.

Electrical Installations (Major Equipment)

500 kV

Seven (7) 500-345 kV, 400 MVA at 65° C top rating single phase autotransformers will be installed (TR1 and TR2)(six in-service, one spare).

Three (3) 500 kV, 2000A, 40 kAIC, SF6 dead tank circuit breakers will be installed (52/CB5, 52/CB6 and 52/CB13).

One (1) 500 kV, 225 MVAR Shunt Reactor will be installed on the BIS Line.

Eight (8) 500 kV, 2000 A, double-end-break motor-operated disconnect switches (52/CB2-B2, 52/CB3-A, 52/CB4-B, 52/CB5-B1, 52/CB5-B2, 52/CB6-A, 52/CB6-B, and 52/CB13-A) will be installed for breaker isolation. A switch stand for the future switch in the TR2 row west of breaker 52/CB3 will be installed.

Two (2) 500 kV, 2000 A, double-end-break motor-operated disconnect switch will be installed on a switch stand on the HV side of each 500-345 kV transformers (TR1 & TR2) for isolation purposes.

Three (3) single-phase 500 kV CCVT units will be installed for BIS Line protection.

Two (2) single-phase 500 kV CCVT units will be installed for 500 kV transformer synchronization.

Nine (9) 335 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. Three arresters will be mounted in the BIS 500 kV Line position. Three arresters will be mounted in the TR1 500 kV position. Three arresters will be mounted in the TR2 500 position.

One (1) 500 kV, 2000 A line trap and tuner will be installed on the deadend for the line to BIS Substation.

The bus in each row will consist of 6 inch aluminum tube (4250 amp) in order to limit bus support structures and 2-1590 MCM aluminum stranded conductor (2400 amps) for breaker jumpers will be installed.

345 kV

Seven (7) 345 kV, 2000 A, 40 kAIC, SF6 dead tank circuit breakers will be installed (52/CB7, 52/CB8, 52/CB10, 52/CB11, 52/CB12, 52/CB17 and 52/CB18).

Thirteen (13) 345 kV, 2000 A, double-end-break motor-operated disconnect switches (52/CB7-A, 52/CB7-B, 52/CB8-B1, 52/CB8-B2. 52/CB9-A, 52/CB10-B, 52/CB11-B1, 52/CB11-B2, 52/CB12-A, 52/CB12-B, 52/CB17-B, 52/CB18-B1, and 52/CB18-B2) will be installed for breaker isolation. A switch stand for the future switch 52/CB9-B will be installed.

Two (2) 345 kV, 2000 A, double-end-break motor-operated disconnect switches will be installed on switch stands on the LV side of each 500-345 kV transformers (TR1 & TR2) for isolation purposes.

Two (2) single-phase 345 kV CCVT units will be installed for 345 kV bus synchronization.

Six (6) single-phase 345 kV CCVT units will be installed for transformer metering. Three (3) on the secondary side of each 500-345 kV transformer (TR1 & TR2).

Six (6) 230 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. Three arresters will be mounted in the TR1 345 kV position. Three arresters will be mounted in the TR2 345 kV position.

The bus in each row will consist of 6 inch aluminum tube (4250 amp) in order to limit bus support structures and 2-1590 MCM aluminum stranded conductor (2400 amps) for breaker jumpers will be installed.

34.5 kV

Six (6) 34.5 kV, 20.125/115-69V 175/300:1 single phase bus PTs will be installed on the TRI tertiary for relaying. Three (3) will be connected to each autotransformer (TR1 and TR2).

Two (2) 34.5 kV, 300 KVA, 34500-120/208 V padmount distribution transformers will be installed for station service. One (1) will be connected to the TR1 tertiary and one (1) will be connected to the TR2 tertiary.

Six (6) 22 kV MCOV station-class surge arresters will be installed for lightning and switching surge protection. Three arresters will be mounted in the TR1 34.5k V position. Three arresters will be mounted in the TR2 34.5 kV position.

The bus will consist of 3 inch aluminum tube (1670 amp) in order to limit bus support structures and 1590 MCM aluminum stranded conductor (1200 amps) for transformer jumpers will be installed.

<u>Mobile Substation or Transformer</u>

No Mobile Equipment will be necessary.

Electrical Equipment Enclosure (EEE)

A new 24' X 80' metal control house for the 500 kV yard will be erected in the southeast corner of the new substation. The control house building will have two points of egress, one single door and one double door. The control house will have four exhaust fans, four propeller type electric unit heaters, and wall louvers. The control house will accommodate protection relay panels, AC breaker panels, DC fuse panels, terminal cabinets, 125 VDC station battery and charger, 48 VDC communication system battery and charger, telephone equipment panelboard, overhead cable tray, lights, receptacles, and other miscellaneous equipment.

AC System

The AC system will be sized to accommodate the six 500-345 kV autotransformer fan load, seven 500 kV gas circuit breaker motor and heater loads, eight 345 kV gas circuit breaker motor and heater loads, thirty-one motor-operated disconnect heater loads, and the control building auxiliary equipment. The station service will be sized for the anticipated ultimate 500-345 kV layout installation, construction power and a small contingency factor.

The primary source for the AC station auxiliary power transformer will be the 34.5 kV tertiary of the 500-345 kV autotransformer, TR1. The emergency source will be the 34.5 kV tertiary of the 500-345 kV autotransformer, TR2. The secondary voltage of the auxiliary sources will be three-phase 120/208 V.

Provisions for a 100 KW black start generator set has been included in this study.

DC System

A detailed DC study will be performed during the design phase of the project. The estimate provides for a 125 VDC battery with a battery charger and associated fuses and DC cabinets.

A 48 VDC battery with a battery charger and associated fuses and DC cabinets is included for the communications system equipment.

Grounding

A ground grid consisting of 4/0 copper conductor and ground rods will be installed to provide a safe and effective grounding system per IEEE standards. Soil resistivity measurements will be taken in the area where the new substation will be installed upon soil thawing and rough grading completion. Ground grid design calculations will be made at this time. Fence counterpoise grounding will be installed.

Lightning Protection

Lightning protection will be provided for the new substation to adequately protect the new 500 and 345 kV buses. The estimate includes fifteen (15) 100' tapered tubular steel shield masts in addition to lightning masts on the 500 kV and 345 kV line termination structures.

Trenching & Cable

New precast trenching will be installed for all new equipment. All new control cables will be installed.

V. Civil Features

Grading & Fencing

A graded area approximately 1150 feet by 515 feet will be constructed north of the existing Helena Substation 345 kV Yard. Grading will consist of topsoil stripping and removal of all vegetation followed by subexcavation totaling 3 feet. The excavated subgrade will be compacted to form a firm base followed by the placement of approximately 2 feet of imported fill. The rough grade elevation will be established through importing, placement and compaction of a 1 foot layer of class 5 aggregate base. Prior to the in-service date, grading activity will be completed by the import and placement of a 4 inch layer of crushed rock surfacing.

Note the landscaped area is assumed to be 25% of the total graded area and for this case is limited to revegetation of surfaces beyond the edge of grade and retention pond but not exceeding the area disturbed by grading activities.

Storm Water Permit

A Storm Water Permit will be required.

Foundations & Structural

The proposed foundations include drilled piers for all galvanized steel structures and slabs-on-grade for electrical equipment (circuit breakers and power transformers) and the control house. Final foundation types and sizes will be determined once the results and recommendations of the soil boring investigation are completed.

The steel structures for the proposed substation include low profile equipment stands and bus supports and tapered tubular dead end structures to support each transmission line termination. The low profile steel structures will be tapered tubular. The tapered tubular structures will be designed and fabricated by the steel fabricator.

Civil Removals & Relocations

No civil removals or relocations will be used.

Civil Installations

The following concrete slab foundations will be installed:

Quantity	Description	Approx. Size
1	Control House	24' x 80' x 1'
7	400 MVA Transformer Pad	45' x 65' x 3'
7	Oil Containment Basin	61' x 81' x 6'
3	500 kV Gas Circuit Breaker Slab	8' x 20' x 1'
7	345 kV Gas Circuit Breaker Slab	8' x 16' x 1'
2	Station Service Transformer Pad	5' x 5' x 1'

The following galvanized steel structures and concrete drilled pier foundations will be installed:

Steel Structures		Drilled Piers		
Qty	Description	Qty	Approximate Size	
			Diameter	Depth
54	500 kV Bus Support – 1PH	54	3'-0"	16'-6"
2	500 kV Deadend Structure	8	8'-6"	28'-0"
3	500 kV Surge Arrester Stand	3	3'-0"	10'-6"
11	500 kV Switch Stand	44	3'-0"	10'-6"
5	500 kV CCVT Stand	5	3'-0"	10'-0"
43	345 kV Bus Support – 1PH	43	3'-0"	10'-0"
1	345 kV Deadend Structure	2	8'-6"	20'-0"
16	345 kV Switch Stand	64	3'-0"	10'-0"
5	345 kV CCVT Stand	5	2'-6"	10'-0"
15	Shield Pole – 100FT	15	4'-0"	16'-0"
33	34.5 kV Bus Support – 1PH	33	3'-0"	10'-0"

Oil Containment

The transformers will contain a significant volume of oil; thus, the average risk rating for this facility is assumed to qualify the facility as a risk site. Because run-off from the facility could potentially reach navigable waters as well as create a significant plume elsewhere in the plant facility; it is recommended that the transmission owner install a cast-in-place concrete basin around each transformer.

Electrical Equipment Enclosure (EEE) or Switchgear Building

A 24 foot by 80 foot control house will be ordered and constructed as previously outlined in this design guide.

VI. Control Features

For estimating purposes, typical NSP relaying and associated communication equipment is shown.

Control Schemes

Transmission Line Protection – 500 kV Bison Line (BIS)

A SEL-421-3 based DCUB scheme will be used for primary relaying. A frequency shift TCF-10B, or equivalent, transmitter/receiver for the primary relay pilot channel. A GE-D90+ based POTT scheme will be used for secondary relaying. A fiber optic FOCUS panel, or equivalent, transmitter/receiver will be used for the secondary relay pilot channel.

Watt/Var EMS analog values for the 500 kV BIS transmission line will be extracted from an ATAIE1 meter/transducer. The 0-1mA outputs of this transducer will be wired into the RTU.

The RTU primary relay and transfer trip On/Off control and status points will be used with the SEL relays. The RTU status points for the BIS line carrier transfer trip trouble, carrier primary relay trouble, carrier transfer trip received alarms, primary and secondary relay malfunction alarms, primary and secondary relay loss of AC will be used.

Single pole tripping and reclosing will be implemented.

Transmission Breaker Protection (500 kV)

SEL-451-2 relays will be installed to provide for breaker failure protection and sync-check for the 500 kV gas circuit breakers 52/CB5, 52/CB6, and 52/CB13. Breaker failure can also be provided by the line relay, but a separate breaker failure relay is assumed for estimating purposes. Remote control functionality will be provided to the EMS. Remote close will be supervised by sync/dead line/dead bus.

Local alarm and RTU status points will be added for breaker failure lockout, relay and sync malfunction, and single/dual trip coil failure alarms for the new 500 kV circuit breakers. These alarms will be generated by the SEL-451-2 relays.

Transformer Bus Protection (500 kV)

Protection of the 500 kV transformer bus will be installed and will consist of primary and secondary current differential schemes utilizing a SEL-387 as the primary relay and a G.E. B90 as the secondary relay. Transformer bus protection can be provided by transformer differential relaying, but separate bus protection relay is assumed for estimating purposes.

Local alarm and RTU status points will be added for lockout and relay malfunction. These alarms will be generated by the SEL-387 relays.

Transformer Protection (TR1)

500-345 kV TR1 protection will consist of two separate current differential and overcurrent schemes utilizing a SEL-387 as the primary relay and a G.E. T60 as the secondary relay. Separate transformer protection relay is assumed for estimating purposes

Local alarm and RTU status points will be added for lockout and relay malfunction. These alarms will be generated by the SEL-387 and T60 relays.

Transformer Protection (TR2)

500-345 kV TR2 protection will consist of two separate current differential and overcurrent schemes utilizing a SEL-387 as the primary relay and a G.E. T60 as the secondary relay. Separate transformer protection relay is assumed for estimating purposes.

Local alarm and RTU status points will be added for lockout and relay malfunction. These alarms will be generated by the SEL-387 and T60 relays.

Transformer Failure Sectionalizing (500 kV)

A transformer failure sectionalizing scheme will be implemented for the 500-345 kV autotransformers TR1 and TR2. The scheme will work in the following manner:

- Upon detection of a transformer failure condition, the SEL-387 relay will initiate tripping of adjacent breakers. At the same time, the SEL-387 relay will initiate the opening of the failed transformer's primary and secondary disconnect switches via the motor operators, which will isolate the failed transformer.

- Upon completion of the opening of the failed transformer's motor operated disconnect switches, the adjacent breakers will be automatically closed via their 50BF-79 SEL-451-2 relays.

- Remote and local control of the motor operated disconnect switches will be implemented.

Transformer Breaker Protection (345 kV)

SEL-451-2 relays will be installed to provide for breaker failure protection and sync-check for the 345 kV gas circuit breakers 52/CB7, 52/CB8, 52/CB10, 52/CB11, 52/CB12, 52/CB17, and 52/CB18. Separate breaker failure relay is assumed for estimating purposes. Remote control functionality will be provided to the EMS. Remote close will be supervised by sync/dead line/dead bus.

Local alarm and RTU status points will be added for breaker failure lockout, relay and sync malfunction, and single/dual trip coil failure alarms for the new 345 kV circuit breakers. These alarms will be generated by the SEL-451-2 relays.

Transmission Bus Protection (345 kV)

Protection of each of the 345 kV main buses will be installed and will consist of primary and secondary current differential schemes utilizing a SEL-487 as the primary relay and a G.E. B90 as the secondary relay. Separate bus protection relay is assumed for estimating purposes.

Local alarm and RTU status points will be added for lockout and relay malfunction. These alarms will be generated by the SEL-487 relays.

DC Reduction

D.C. reduction schemes reduce the power order at Dorsey converters to prevent over loading of underlying transmission systems on loss of 500 kV paths.

D.C. power is controlled by allocator MW output setting on the D.C. bipole at the converter station. Loss of power outlet is determined by several conditions as listed below:

- Open breaker condition at local end or remote end
- Trip initiation by line relays at any end
- Bypass of capacitors.
- Loss/ reduction of power outlet at remote end. An example would be the loss of south line from Bison or bypass of series capacitor on the south line.
- Loss of reactive support for high transfers

Cross tripping of the north line may also be initiated if the power flow on the line is above a threshold as determined by load flow studies.

The degree of power order could vary from 15% reduction to 100% reduction depending on the type of disturbance.

The scheme is implemented as a fully communication scheme with two independent communication paths. The requirement of the maximum time delay permissible between the disturbance initiation and the allocator power order reduction is determined by the studies group.

RTU

The substation RTU will be transmission owner's requirements. A Multiport RTU will be installed. More than 1 SCADA circuit may be required. The SCADA protocol requirement of every utility that needs access to the RTU may be different and it will decide what kind of RTU to be installed. Control, status, and alarm points for the new circuit breakers, motor-operated disconnect switches, and relays will be added to the RTU.

Local Annunciation

Local annunciation is via a station display panel. Alarm points will be added to the existing display for each of the new circuit breakers and motor operated disconnect switches.

Control Panel Locations

All Control Panels will be installed in the new EEE. Panels will be grouped by voltage rating of equipment.

Telephone protection

The telephone protection equipment will includes an SNC 12-slot C-Line card shelf, a 4-port Teltone SLSS line sharing switch, and a telephone access/control box for remote communications to the relays.

Equipment Details

Removals

None.

Installations

The following new relay and control panels will be installed:

- Panel 1N, Future 500 kV BUS 1 PRI & SEC DIFF RLY'G
- Panel 2N, 500 kV TR1 PRI & SEC DIFF RLY'G and Future 500 kV 52/CB4 BKR CONT
- Panel 3N, 500 kV 52/CB5 BKR CONT
- Panel 4N, 500 kV BIS Line SEC RLY'G and FOCUS
- Panel 5N, 500 kV BIS Line PRI RLY'G & TCF-10B and 500 kV 52/CB13 BKR CONT
- Panel 6N, 500 kV, BIS Reactor RLY'G and 500 kV 52/CB18 BKR CONT
- Panel 7N, 500 kV, Future Reactor RLY'G and 500 kV 52/CB18 BKR CONT
- Panel 8N, 500 kV Future Line PRI RLY'G & TCF-10B and 500 kV 52/CB19 BKR CONT
- Panel 9N, 500 kV Future Line SEC RLY'G and FOCUS
- Panel 10N, 500 kV 52/CB2 BKR CONT
- Panel 11N, 500 kV TR2 PRI & SEC DIFF RLY'G and Future 500 kV 52/CB3 BKR CONT
- Panel 12N, 500 kV BUS 2 PRI & SEC DIFF RLY'G
- Panel 1S, 345 kV BUS 1 PRI & SEC DIFF RLY'G
- Panel 2S, 345 kV TR1 PRI & SEC DIFF RLY'G and 345 kV 52/CB7 BKR CONT
- Panel 3S, 345 kV 52/CB8 BKR CONT
- Panel 4S, Future 345 kV Line PRI RLY'G & TCF-10B and 345 kV 52/CB9 BKR CONT
- Panel 5S, Future 345 kV Line SEC RLY'G & FOCUS
- Panel 6S, 345 kV 52/CB10 BKR CONT
- Panel 7S, 345 kV 52/CB11 BKR CONT
- Panel 8S, 345 kV TR1 PRI & SEC DIFF RLY'G and 345 kV 52/CB12 BKR CONT
- Panel 9S, 345 kV 52/CB17 BKR CONT
- Panel 10S, 345 kV 52/CB18 BKR CONT
- Panel 12S, Manitoba Communications Panel
- Panel 13S, HSE STA DISPLAY PANEL
- 240 VAC Cabinets
- 125 VDC Cabinets
- 48 VDC Cabinet
- Termination Cabinet

VII. Metering

Revenue metering will be installed for each 500-345 kV transformer (TR1 & TR2). Bushing current transformers with metering accuracy installed on secondary bushings of each transformer will provide current input. 345 kV CCVTs will provide potential input.

VIII. Outages

The following outages on the 345 kV portion of the station will be required:

- Outage on the Blue Lake 345 kV transmission line for new circuit breaker, 500-345 kV transformer and bus installation.

- Outage on the Cedar Mountain 345 kV transmission line for new circuit breaker and bus installation.

- Outage on both 345 kV main buses for new circuit breaker and bus installation.

IX. Material Staging Plan

All major materials will be shipped directly to the job site. Stock materials will be ordered and staged through the transmission owner's warehouse.

X. Project and Operating Concerns

In-Service date may be impacted by transmission construction schedule as well as related substation construction schedules.

XI. Related Projects

MH TSR 500 kV Option 1 – Facilities Study – Segment 1A (US/Canada Border to North Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 1B (Proposed North Series Cap Bank to proposed Bison Sub)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2A (Proposed Bison Sub to proposed South Series Cap Bank)

MH TSR 500 kV Option 1 – Facilities Study – Segment 2B (Proposed South Series Cap Bank to proposed Helena Sub)

MH TSR 500 kV Option 1 – Facilities Study – 500-345 kV Bison Substation

MH TSR 500 kV Option 1 – Facilities Study – 500 kV North Series Cap Bank Station

MH TSR 500 kV Option 1– Facilities Study – 500 kV South Series Cap Bank Station

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	HLN-SEro-New Substation
Sub./Line Name:	Helena
WO #:	
Group Name:	
City:	
County:	
State:	MN
WO Type:	41
Op Co:	NSPM
In-service Date:	12/31/2017
Basic Scope:	NSP Sub estimating template

Estimate Information	
Est. Type	SE
Est Status:	Working
Est. Published	4/29/2010
Rev. Number:	0
Prepared By:	HDR Engineering, Inc.
Company:	Northern States Power Co - MN

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Mana	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$1,171,908	$0	$0	$0	$1,171,908
CBS3 - Civil Construction	$2,314,752	$53,100	$1,469,155	$104,274	$3,941,282
CBS4 - Electrical Construction	$3,822,936	$200,270	$43,003,797	$2,959,479	$49,986,482
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$496,706	$0	$0	$0	$496,706
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$7,806,303	$253,370	$44,472,952	$3,063,753	$55,596,378
Indirect Costs					
Powerplant Overheads (E&S + A	$476,184	$0	$2,712,850	$202,345	$3,391,379
Material overheads	$0	$0	$889,459	$0	$889,459
AFUDC	$0	$0	$0	$0	$0
Contingency	$780,630	$0	$667,094	$995,137	$2,442,861
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$1,256,815	$0	$4,269,403	$1,197,481	$6,723,700
Project Total					**$62,320,077**

Print Date: 4/29/2010

Job Folder Name: HLN-SEro-New Substation **O&M Estimate:** $ -
Sub-Line Name: Helena Substation
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
JOB											
AFUDC	1	Lump Sum	Inst	Indirect	Miscelleneous	$ -	$ -	$ -	$ -	$ -	$ -
Engineering & Design - Internal Labor (roll-up)	1	HR	Inst	Labor	Miscelleneous	$ -	$ 187,008	$ -	$ -	$ -	$ 187,008
SWITCH GANG MOTOR OPERATOR	25	EA	Inst	Phys	Switch Gang	$ 112,500	$ 39,663	$ -	$ 7,706	$ -	$ 159,870
TRANSFORMER AUTO 500-345 400 MVA SINGLE PHASE	7	EA	Inst	Phys	Transformer	$ 31,500,000	$ -	$ -	$ 2,157,750	$ -	$ 33,657,750
TRANSFORMER INSTALLATION	7	LOT	Inst	Phys	Transformer	$ -	$ 563,387	$ -	$ -	$ -	$ 563,387
CONTINGENCY	1	Lump Sum	Inst	Indirect	Miscellenous	$ 667,094	$ 780,630	$ 76,011	$ 919,126	$ -	$ 2,442,861
ESCALATION	1	Lump Sum	Inst	Indirect	Miscellenous	$ -	$ -	$ -	$ -	$ -	$ -
POWERPLANT AND MATL OVERHEADS	1	Lump Sum	Inst	Indirect	Miscellenous	$ 3,602,309	$ 476,184	$ 15,456	$ 186,889	$ -	$ 4,280,838
Permitting/Proj Management	0	HR	Inst	Labor	Land Rights (Depreciable)	$ -	$ 0	$ -	$ -	$ -	$ 0
Eng & Des - Contract - Labor Only	8,904	HR	Inst	Labor	Civil/Electrical	$ -	$ 934,920	$ -	$ -	$ -	$ 934,920
CONTROL BUILDING 24'X80' STD SIZE F&E	1	EA	Inst	Civil	EEE	$ 89,000	$ 5,276	$ -	$ 6,097	$ -	$ 100,373
FENCE 8FT CHAIN LK W/BARB	2,400	FT	Inst	Civil	Fence & Walls	$ 52,110	$ 63,317	$ -	$ 3,570	$ -	$ 118,997
FENCE GATE DRIVE 20 FT	4	EA	Inst	Civil	Fence & Walls	$ 2,900	$ 264	$ -	$ 199	$ -	$ 3,362
Fence Silt 3'H	2,400	FT	Inst	Civil	Fence & Walls	$ 888	$ 15,829	$ -	$ 61	$ -	$ 16,778
Breaker Slab 345kV (8'x16')	7	EA	Inst	Civil	Foundations	$ 4,113	$ 20,180	$ -	$ 282	$ -	$ 24,575
Breaker Slab 500kV (8'x20')	3	EA	Inst	Civil	Foundations	$ 2,513	$ 12,452	$ -	$ 172	$ -	$ 15,136
EEE Slab 24' x 80' x 1'	1	EA	Inst	Civil	Foundations	$ 8,889	$ 43,663	$ -	$ 609	$ -	$ 53,160
OIL CONTAINMENT - BASIN - >15000 GALLON	1	EA	Inst	Civil	Foundations	$ 4,838	$ 23,744	$ -	$ 331	$ -	$ 28,913
Station Service Padmount Pad	2	EA	Inst	Civil	Foundations	$ 270	$ 264	$ -	$ 18	$ -	$ 552
Transformer Slab 400MVA	7	EA	Inst	Civil	Foundations	$ 41,484	$ 203,559	$ -	$ 2,842	$ -	$ 247,884
SITE - DETENTION POND	4	EA	Inst	Civil	Grading & Landscaping	$ 20,000	$ 30,340	$ -	$ 1,370	$ -	$ 51,710
SITE - EARTHWORK - COMPACTION TEST	1	EA	Inst	Civil	Grading & Landscaping	$ 150	$ -	$ -	$ 10	$ -	$ 160
SITE - GRADING	1	EA	Inst	Civil	Grading & Landscaping	$ 1,000,746	$ 726,805	$ -	$ 68,551	$ -	$ 1,796,102
34.5 kV Switch Structure (high)	2	EA	Inst	Civil	Structure - Rolled Steel	$ 5,576	$ 8,210	$ -	$ 382	$ -	$ 14,168
_35kV PT Stand - 3 phase	2	EA	Inst	Civil	Structure - Rolled Steel	$ 3,261	$ 4,312	$ -	$ 223	$ -	$ 7,797
34.5kV BUS SUPPORT STAND - 1PH	33	EA	Inst	Civil	Structure - Welded Tubular	$ 69,712	$ 55,445	$ -	$ 4,775	$ -	$ 129,933
345kV Bus Support Stand - 1PH (10'-0)	69	EA	Inst	Civil	Structure - Welded Tubular	$ 106,225	$ 176,781	$ -	$ 7,276	$ -	$ 290,282
500kV Bus Support Stand - 1PH (36'-6)	46	EA	Inst	Civil	Structure - Welded Tubular	$ 252,425	$ 213,517	$ -	$ 17,291	$ -	$ 483,233
345kV CCVT Stand 1PH (8'-5)	5	EA	Inst	Civil	Structure - Welded Tubular	$ 9,197	$ 9,907	$ -	$ 630	$ -	$ 19,735

Job Folder Name: HLN-SEro-New Substation **O&M Estimate:** $ -
Sub-Line Name: Helena Substation
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
500kV CCVT Stand 1PH (15')	5	EA	Inst	Civil	Structure - Welded Tubular	$ 9,812	$ 11,968	$ -	$ 672	$ -	$ 22,453
500kV Deadend Structure	2	EA	Inst	Civil	Structure - Welded Tubular	$ 774,250	$ 391,984	$ -	$ 53,036	$ -	$ 1,219,270
345kV Surge Arrester Stand 1PH	6	EA	Inst	Civil	Structure - Welded Tubular	$ 6,450	$ 10,644	$ -	$ 442	$ -	$ 17,535
500kV Surge Arrester Stand 1PH	9	EA	Inst	Civil	Structure - Welded Tubular	$ 20,419	$ 23,996	$ -	$ 1,399	$ -	$ 45,813
345kV Switch Stand (10'-7)	16	EA	Inst	Civil	Structure - Welded Tubular	$ 212,532	$ 194,626	$ -	$ 14,558	$ -	$ 421,717
500kV Switch Stand (15')	11	EA	Inst	Civil	Structure - Welded Tubular	$ 305,525	$ 172,432	$ -	$ 20,928	$ -	$ 498,886
Shield Pole 100FT	10	EA	Inst	Civil	Structure - Welded Tubular	$ 99,657	$ 90,423	$ -	$ 6,827	$ -	$ 196,907
CIVIL INSPECTION/TESTING (CONT	1	EA	Inst	Civil	Survey and Test	$ -	$ 1,080	$ -	$ -	$ -	$ 1,080
SITE - SOIL GEOTECHNICAL INVESTIGATING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 6,000	$ -	$ -	$ -	$ 6,000
SITE - SOIL RESISTIVITY TESTING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 960	$ -	$ -	$ -	$ 960
SITE - SURVEY - CONST. STAKING	1	LOT	Inst	Civil	Survey and Test	$ -	$ 1,620	$ -	$ -	$ -	$ 1,620
SITE - SURVEY (TOPO/BOUNDARY)	1	LOT	Inst	Civil	Survey and Test	$ -	$ 10,020	$ -	$ -	$ -	$ 10,020
TRENCHING AND ACCESS-HAND-36"	500	FT	Inst	Civil	Trenching	$ 500	$ 27,372	$ -	$ 34	$ -	$ 27,906
TRENCHING AND ACCESS-MACH-36"	1,600	FT	Inst	Civil	Trenching	$ 1,600	$ 17,940	$ -	$ 110	$ -	$ 19,650
TRENCHING PRECAST 40" OPEN BOTTOM	2,040	FT	Inst	Civil	Trenching	$ 61,200	$ 187,024	$ -	$ 4,192	$ -	$ 252,416
TRENCHING PRECAST 40" ROAD CROSSI	60	FT	Inst	Civil	Trenching	$ 4,800	$ 9,814	$ -	$ 329	$ -	$ 14,943
. CABLE -CONT/PWR-TERM. 600V	2,556	EA	Inst	Cntrl	Cable - Control	$ 281	$ 57,250	$ -	$ 19	$ -	$ 57,550
. CABLE -CONTROL-600V 1C 12	105,240	FT	Inst	Cntrl	Cable - Control	$ 22,105	$ 235,718	$ -	$ 1,514	$ -	$ 259,337
. CABLE -CONTROL-600V 3C 4	7,040	FT	Inst	Cntrl	Cable - Control	$ 27,838	$ 15,768	$ -	$ 1,907	$ -	$ 45,513
. CABLE -CONTROL-600V 3C 6	770	FT	Inst	Cntrl	Cable - Control	$ 2,278	$ 1,725	$ -	$ 156	$ -	$ 4,159
. CABLE -CONTROL-600V 4C 10	61,380	FT	Inst	Cntrl	Cable - Control	$ 76,757	$ 137,480	$ -	$ 5,258	$ -	$ 219,495
. CABLE -CONTROL-600V 7C 10	3,575	FT	Inst	Cntrl	Cable - Control	$ 8,787	$ 8,007	$ -	$ 602	$ -	$ 17,396
. CABLE -CONTROL-600V 2PR 18	6,050	FT	Inst	Cntrl	Cable - Control	$ 4,079	$ 13,551	$ -	$ 279	$ -	$ 17,910
. CABLE -CONTROL-600V 8PR 18	8,580	FT	Inst	Cntrl	Cable - Control	$ 13,481	$ 19,218	$ -	$ 923	$ -	$ 33,622
. CABLE -CONTROL-600V 10PR 10	13,860	FT	Inst	Cntrl	Cable - Control	$ 82,327	$ 31,044	$ -	$ 5,639	$ -	$ 119,010
FIBER OPTIC - FOCUS CHASSIS	1	EA	Inst	Cntrl	Fiber	$ 10,000	$ 1,792	$ -	$ 685	$ -	$ 12,477
FIBER OPTIC CABLE-SINGLE MODE	1,000	FT	Inst	Cntrl	Fiber	$ 550	$ 3,733	$ -	$ 38	$ -	$ 4,321
FIBER PATCH PANEL	1	EA	Inst	Cntrl	Fiber	$ 500	$ 560	$ -	$ 34	$ -	$ 1,094
FIBER SPLICE BOX (FEEDER)	1	EA	Inst	Cntrl	Fiber	$ 100	$ 373	$ -	$ 7	$ -	$ 480
PANEL-345KV TRANSFORMER METERING	2	EA	Inst	Cntrl	Panels - Conventional	$ 60,000	$ 5,973	$ -	$ 4,110	$ -	$ 70,083
PANEL-COMMUNICATIONS PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 25,000	$ 5,973	$ -	$ 1,713	$ -	$ 32,685
PANEL-DC RUNBACK PANEL	1	EA	Inst	Cntrl	Panels - Conventional	$ 18,500	$ 5,973	$ -	$ 1,267	$ -	$ 25,740
PANEL-GE-D90+ SECONDARY AND FOCUS	1	EA	Inst	Cntrl	Panels - Conventional	$ 30,000	$ 2,986	$ -	$ 2,055	$ -	$ 35,041
PANEL-PLC TERMINAL CAB LAYOUT (MATERIAL LIST & TERM BLOCK LAYOUT)	1	EA	Inst	Cntrl	Panels - Conventional	$ 12,000	$ 2,986	$ -	$ 822	$ -	$ 15,808

Job Folder Name: HLN-SEro-New Substation **O&M Estimate:** $ -
Sub-Line Name: Helena Substation
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
PANEL-QUICKPANEL DISPLAY WITH PLC, SEL-2032 COMM SW & GPS CLOCK	1	EA	Inst	Cntrl	Panels - Conventional	$ 30,000	$ 2,986	$ -	$ 2,055	$ -	$ 35,041
345KV)	2	EA	Inst	Cntrl	Panels - Conventional	$ 60,000	$ 5,973	$ -	$ 4,110	$ -	$ 70,083
PANEL-SEL-387 PRIM & B-90 SEC BUS DIFFERENTIAL RLY'G	2	EA	Inst	Cntrl	Panels - Conventional	$ 46,000	$ 5,973	$ -	$ 3,151	$ -	$ 55,124
PANEL-SEL-421 PRIMARY AND TCF-10B CARRIER	1	EA	Inst	Cntrl	Panels - Conventional	$ 45,000	$ 2,986	$ -	$ 3,083	$ -	$ 51,069
PANEL-SEL-451 BKR CONTROL	4	EA	Inst	Cntrl	Panels - Conventional	$ 48,000	$ 11,946	$ -	$ 3,288	$ -	$ 63,234
PANEL-SEL-487E REACTOR DIFF RLY'G (500KV)	1	EA	Inst	Cntrl	Panels - Conventional	$ 30,000	$ 2,986	$ -	$ 2,055	$ -	$ 35,041
PANEL-SYNCHRONIZING PANEL	2	EA	Inst	Cntrl	Panels - Conventional	$ 4,000	$ 5,973	$ -	$ 274	$ -	$ 10,247
PANEL-TELEPHONE ACCESS CONTROL BOX AND MATERIAL LIST	1	EA	Inst	Cntrl	Panels - Conventional	$ 1,600	$ 2,986	$ -	$ 110	$ -	$ 4,696
TCF-10B	1	EA	Inst	Cntrl	Panels - Conventional	$ 20,000	$ 896	$ -	$ 1,370	$ -	$ 22,266
CARRIER LINE TUNER	2	EA	Inst	Cntrl	Pilot	$ 4,000	$ 1,493	$ -	$ 274	$ -	$ 5,767
RELAY-AUX TYPE 1(LOR, ETC.)	1	EA	Inst	Cntrl	Relay - Aux	$ 636	$ 2,986	$ -	$ 44	$ -	$ 3,666
RELAY-GE T60	1	EA	Inst	Cntrl	Relay - Microprocessor	$ 8,000	$ 896	$ -	$ 548	$ -	$ 9,444
TEL 3/4" PLYWOOD PANEL	1	EA	Inst	Cntrl	Telephone	$ 50	$ 448	$ -	$ 3	$ -	$ 501
TEL POSITRON PACkAGE	1	EA	Inst	Cntrl	Telephone	$ 3,840	$ 1,493	$ -	$ 263	$ -	$ 5,596
EQUIP - BACKHOE WITH CAB	25	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 19,500	$ 1,336	$ -	$ 20,836
EQUIP - BOBCAT	64	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 48,000	$ 3,288	$ -	$ 51,288
EQUIP - CONTRACT WELDING	8	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 28,000	$ 1,918	$ -	$ 29,918
EQUIP - CRANE (W/OPR) - 30 TON	40	DAY	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 48,000	$ 3,288	$ -	$ 51,288
EQUIP - FORKLIFT (MTRL HANDLER)	64	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 56,320	$ 3,858	$ -	$ 60,178
EQUIP - MINI EXCAVATOR (GND WIRE INSTALL)	64	WK	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 33,600	$ 2,302	$ -	$ 35,902
EQUIP - MISC (TRAILORS, TOILETS, DUMSTER, STORAGE)	15	MO	Inst	Equip. & Mobilization	Equip	$ -	$ -	$ 19,950	$ 1,367	$ -	$ 21,317
CONCRETE - MBL 3-MAN (MORE 100 MI)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,968	$ -	$ -	$ -	$ 2,968
Electric Construction - Mobilize (In/Out)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 2,986	$ -	$ -	$ -	$ 2,986
Electric Construction - Site Setup	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 5,973	$ -	$ -	$ -	$ 5,973
SITE - EARTHWORK - MOBILIZATION (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
SITE - SURFACING-MOBILIZE (IN/OUT)	1	EA	Inst	Equip. & Mobilization	Mobilization	$ -	$ 1,649	$ -	$ -	$ -	$ 1,649
Eng SPS Study	476	HR	Inst	Labor	Civil/Electrical	$ -	$ 49,980	$ -	$ -	$ -	$ 49,980
General Foreman - Internal - Labor Only	2,640	HR	Inst	Labor	Civil/Electrical	$ -	$ 219,642	$ -	$ -	$ -	$ 219,642
TESTING-CONTROL TESTING	4,863	HR	Inst	Labor	Test	$ -	$ 358,008	$ -	$ -	$ -	$ 358,008
TESTING-PHYSICAL EPM	1,884	HR	Inst	Labor	Test	$ -	$ 138,698	$ -	$ -	$ -	$ 138,698
Trucking - Shipping (# Trips x HR Rnd Trip)	320	HR	Inst	Labor	Civil/Electrical	$ -	$ 21,106	$ -	$ -	$ -	$ 21,106
AC CAB 42 POS.	1	EA	Inst	Phys	AC System	$ 852	$ 523	$ -	$ 58	$ -	$ 1,433
AC PNLBRD INDOOR 3PH 4-200 2P, 2-200 3P	1	EA	Inst	Phys	AC System	$ 1,936	$ 1,493	$ -	$ 133	$ -	$ 3,562
AC PNLBRD OUTDOOR 3PHP 1-400 3P, 2-200 2P, 2-60 2P	2	EA	Inst	Phys	AC System	$ 16,298	$ 2,986	$ -	$ 1,116	$ -	$ 20,400
AUTO TRANSFER SW 600A 600V 1PH	1	EA	Inst	Phys	AC System	$ 4,445	$ 1,195	$ -	$ 304	$ -	$ 5,944
LIGHTING-HIGH VOLTAGE BAY	15	LOT	Inst	Phys	AC System	$ 6,000	$ 44,796	$ -	$ 411	$ -	$ 51,207
STATION SERVICE PADMOUNT 300 kVA	2	EA	Inst	Phys	AC System	$ 16,540	$ 1,493	$ -	$ 1,133	$ -	$ 19,166

Job Folder Name: HLN-SEro-New Substation **O&M Estimate:** $ -
Sub-Line Name: Helena Substation
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
ARRESTER 22kV MCOV STA. POLYMER	6	EA	Inst	Phys	Arrester	$ 1,980	$ 1,120	$ -	$ 136	$ -	$ 3,236
ARRESTER 230kV MCOV STA. POLYMER	6	EA	Inst	Phys	Arrester	$ 42,000	$ 4,480	$ -	$ 2,877	$ -	$ 49,357
ARRESTER 335kV MCOV STA. PORCELAIN	9	EA	Inst	Phys	Arrester	$ 144,000	$ 6,719	$ -	$ 9,864	$ -	$ 160,583
BUS SUPPORT 35kV	33	EA	Inst	Phys	Bus Supports & Insulators	$ 2,312	$ 1,010	$ -	$ 158	$ -	$ 3,481
BUS SUPPORT 345kV STD. STRENGTH	69	EA	Inst	Phys	Bus Supports & Insulators	$ 81,740	$ 25,758	$ -	$ 5,599	$ -	$ 113,097
BUS SUPPORT 550kV	46	EA	Inst	Phys	Bus Supports & Insulators	$ 73,600	$ 20,606	$ -	$ 5,042	$ -	$ 99,248
CCVT/PT SEC FUSE CAB 1 PH	7	EA	Inst	Phys	Cabinets	$ 705	$ 2,613	$ -	$ 48	$ -	$ 3,366
CCVT/PT SEC FUSE CAB 3 PH	2	EA	Inst	Phys	Cabinets	$ 586	$ 1,941	$ -	$ 40	$ -	$ 2,567
METERING TERM CAB OUTDOOR	2	EA	Inst	Phys	Cabinets	$ 1,074	$ 1,195	$ -	$ 74	$ -	$ 2,342
TERMINAL CABINET INDOOR	1	EA	Inst	Phys	Cabinets	$ 3,206	$ 2,986	$ -	$ 220	$ -	$ 6,413
CABLE - POWER- 600V 500MCM	120	FT	Inst	Phys	Cable - Power	$ 1,046	$ 1,792	$ -	$ 72	$ -	$ 2,910
CCVT 345kV 0.3% w/o Carrier	2	EA	Inst	Phys	CCVTs & Traps	$ 19,600	$ 6,719	$ -	$ 1,343	$ -	$ 27,662
CCVT 345kV MTRG HI-CAP0.3A	3	EA	Inst	Phys	CCVTs & Traps	$ 30,000	$ 10,079	$ -	$ 2,055	$ -	$ 42,134
CCVT 500kV MTRG HI-CAP0.3A	5	EA	Inst	Phys	CCVTs & Traps	$ 50,000	$ 16,799	$ -	$ 3,425	$ -	$ 70,224
LINE TRAP 2000A	2	EA	Inst	Phys	CCVTs & Traps	$ 39,800	$ 2,240	$ -	$ 2,726	$ -	$ 44,766
BREAKER GAS 345kV 3000A 40 kA, -40C	7	EA	Inst	Phys	Circuit Breaker	$ 3,150,000	$ 104,525	$ -	$ 215,775	$ -	$ 3,470,300
BREAKER GAS 500kV 3000A 40kA DTB W/ CT, -40C	3	EA	Inst	Phys	Circuit Breaker	$ 1,350,000	$ 78,393	$ -	$ 92,475	$ -	$ 1,520,868
CONDUCTOR - SHIELD WIRE 3/8 " GALVANIZED E.H.S.	800	FT	Inst	Phys	Conductor & Fittings	$ 339	$ 5,973	$ -	$ 23	$ -	$ 6,335
CONDUCTOR ALUM 1590 61 STR AA	2,400	FT	Inst	Phys	Conductor & Fittings	$ 6,398	$ 57,339	$ -	$ 438	$ -	$ 64,176
CONDUCTOR ALUM TUBING 6 IN SCHED 40	10,500	FT	Inst	Phys	Conductor & Fittings	$ 257,250	$ 313,574	$ -	$ 17,622	$ -	$ 588,445
CONDUCTOR FITTING 345-500kV EHV	12,900	FT	Inst	Phys	Conductor & Fittings	$ 103,200	$ -	$ -	$ 7,069	$ -	$ 110,269
BATT 48VDC 50AH	1	EA	Inst	Phys	DC System	$ 3,790	$ 4,853	$ -	$ 260	$ -	$ 8,903
BATT 130VDC 300AH WITH RACK	1	EA	Inst	Phys	DC System	$ 27,060	$ 6,346	$ -	$ 1,854	$ -	$ 35,260
BATT CHRGER 48VDC 30A	1	EA	Inst	Phys	DC System	$ 2,200	$ 1,493	$ -	$ 151	$ -	$ 3,844
BATT CHRGER 130VDC 50A	1	EA	Inst	Phys	DC System	$ 3,340	$ 1,493	$ -	$ 229	$ -	$ 5,062
BATT MAIN FUSE CABINET ASSM.	2	EA	Inst	Phys	DC System	$ 690	$ 597	$ -	$ 47	$ -	$ 1,335
DC CAB 34 POSITION STL INDOOR	1	EA	Inst	Phys	DC System	$ 2,146	$ 1,493	$ -	$ 147	$ -	$ 3,786
DC CAB 52 POSITION STL INDOOR	1	EA	Inst	Phys	DC System	$ 4,167	$ 1,792	$ -	$ 285	$ -	$ 6,245
EEE ELECT HTR 5KW & THERMOSTAT	4	EA	Inst	Phys	EEE	$ 3,028	$ 4,480	$ -	$ 207	$ -	$ 7,716
EEE FURNITURE-EQUIPMENT (NL-200904)	1	LOT	Inst	Phys	EEE	$ 1,100	$ 1,493	$ -	$ 75	$ -	$ 2,669
EEE GROUNDING 24' X 30'	3	EA	Inst	Phys	EEE	$ 465	$ 17,918	$ -	$ 32	$ -	$ 18,415
EEE LIGHTING 20X32	3	EA	Inst	Phys	EEE	$ 2,532	$ 26,878	$ -	$ 173	$ -	$ 29,583
FUSE 35kV 400A, 20kA SPST MNTG/HLD	3	EA	Inst	Phys	Fuse	$ 5,298	$ 952	$ -	$ 363	$ -	$ 6,613
GROUND CABLE ASSEMBLY ST	4	SET	Inst	Phys	Grounding	$ 4,140	$ 597	$ -	$ 284	$ -	$ 5,021
GROUND CADWELD CONNECTIONS	522,981	SFT	Inst	Phys	Grounding	$ 67,988	$ 156,184	$ -	$ 4,657	$ -	$ 228,829
GROUND GRID TEST	1	EA	Inst	Phys	Grounding	$ -	$ 1,493	$ -	$ -	$ -	$ 1,493
GROUND RODS (per grounding point)	325	EA	Inst	Phys	Grounding	$ 20,007	$ 40,279	$ -	$ 1,370	$ -	$ 61,657

Job Folder Name: HLN-SEro-New Substation **O&M Estimate:** $ -
Sub-Line Name: Helena Substation
Scope: NSP Sub estimating template
WO #:

Description	Qty	Unit of Measure	Inst/ Rem	Work Group	Cost Item Group	Materials Total Cost	Labor Total Cost	Rented Equipment Total Cost	Fees Total Cost	Subcontract Total Cost	Total Cost
GROUND WIRE 4/0 CU	25,000	FT	Inst	Phys	Grounding	$ 70,500	$ 466,628	$ -	$ 4,829	$ -	$ 541,957
GROUNDING HOTSTICK ST-SHEPHERDS HOOK	1	SET	Inst	Phys	Grounding	$ 518	$ 187	$ -	$ 35	$ -	$ 740
PT 35kV 1PH	6	EA	Inst	Phys	Instrument Transf.	$ 11,700	$ 4,480	$ -	$ 801	$ -	$ 16,981
NAMEPLATES EQUIPMENT	16	EA	Inst	Phys	Nameplates	$ 400	$ 299	$ -	$ 27	$ -	$ 726
NAMEPLATES FENCE ADDRESS	1	EA	Inst	Phys	Nameplates	$ 144	$ 37	$ -	$ 10	$ -	$ 191
NAMEPLATES FENCE WARNING	48	EA	Inst	Phys	Nameplates	$ 1,824	$ 1,792	$ -	$ 125	$ -	$ 3,741
REACTOR SHUNT 500kV 225MVAR 3PH	1	EA	Inst	Phys	Reactor	$ 2,900,000	$ 156,787	$ -	$ 198,650	$ -	$ 3,255,437
SWITCH 34.5kV SPST 600A	3	EA	Inst	Phys	Switch - Hookstick	$ 1,245	$ 560	$ -	$ 85	$ -	$ 1,890
SWITCH 345kV 2000A TPST DBL EB	15	EA	Inst	Phys	Switch Gang	$ 375,000	$ 134,389	$ -	$ 25,688	$ -	$ 535,076
SWITCH 500kV 2000A TPST DBL EB W INS	10	EA	Inst	Phys	Switch Gang	$ 45,000	$ 89,592	$ -	$ 3,083	$ -	$ 137,675
FLD OIL FILL /drain (per5000Gal)	21	EA	Inst	Phys	Transformer	$ 21,000	$ 62,715	$ -	$ 1,439	$ -	$ 85,153
TRANSFORMER TEST TERMINAL LINK, 4000 AMP 4 HOLE FLAT PAD BOTH ENDS PER DWG. NQ-91802	14	EA	Inst	Phys	Transformer	$ 13,510	$ 2,613	$ -	$ 925	$ -	$ 17,049
						$ 48,742,355	$ 9,063,118	$ 344,837	$ 4,169,768	$ -	$ 62,320,077

Substation Project Forecast

This forecast represents typical expenditures and commitments for this project based on average conditions.
Adjustments to this forecast may be necessary to factor in delays or expediting efforts.

Work Order:
Location: Helena
Title: NSP Sub estimating template

Costs from Estimate

		Install	Remove
Permitting and Proj. Management:	$	-	
Material:	$	14,768,000	
Transformer (with tax and OH):	$	35,579,000	
Construction Labor & Rentals:	$	6,391,000	$0
Testing Labor:	$	497,000	
E&S:	$	1,172,000	
Contingencies:	$	2,443,000	
Overheads:	$	1,470,000	
AFUDC:	$	-	
TNE w/o AFUDC:		$62,320,000	

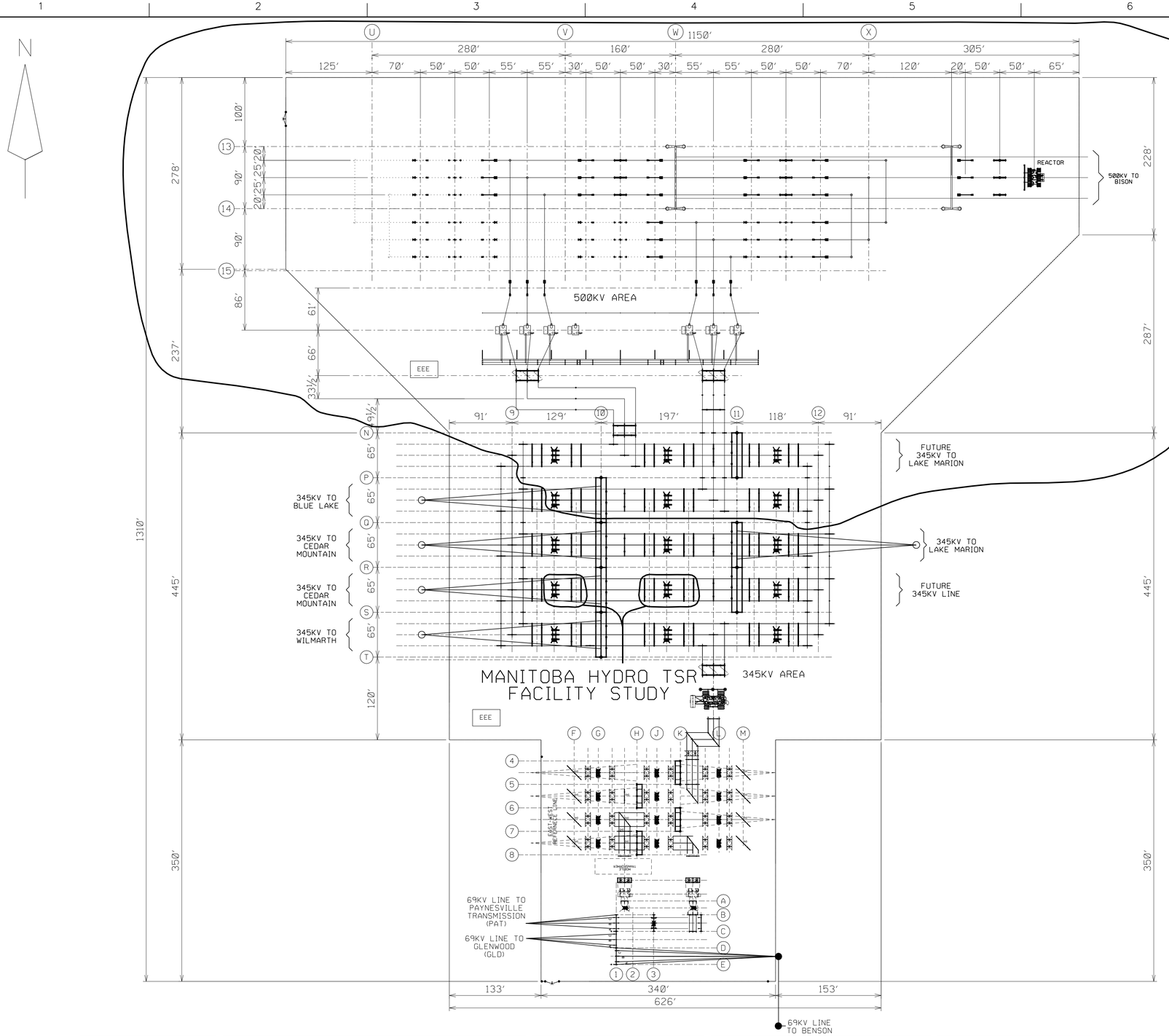
In-Service Date	**12/31/2017**
Project Start Date	**7/1/2010**
Construction Start Date	**8/1/2016**

Jul-10	$	29,050	**Apr-14**	$	29,360
Aug-10	$	29,360	**May-14**	$	29,360
Sep-10	$	29,360	**Jun-14**	$	29,360
Oct-10	$	29,360	**Jul-14**	$	29,360
Nov-10	$	29,360	**Aug-14**	$	29,360
Dec-10	$	29,360	**Sep-14**	$	29,360
Jan-11	$	29,360	**Oct-14**	$	29,360
Feb-11	$	29,360	**Nov-14**	$	29,360
Mar-11	$	29,360	**Dec-14**	$	29,360
Apr-11	$	29,360	**Jan-15**	$	29,360
May-11	$	29,360	**Feb-15**	$	29,360
Jun-11	$	29,360	**Mar-15**	$	29,360
Jul-11	$	29,360	**Apr-15**	$	29,360
Aug-11	$	29,360	**May-15**	$	29,360
Sep-11	$	29,360	**Jun-15**	$	29,360
Oct-11	$	29,360	**Jul-15**	$	29,360
Nov-11	$	29,360	**Aug-15**	$	29,360
Dec-11	$	29,360	**Sep-15**	$	29,360
Jan-12	$	29,360	**Oct-15**	$	29,360
Feb-12	$	29,360	**Nov-15**	$	29,360
Mar-12	$	29,360	**Dec-15**	$	29,360
Apr-12	$	29,360	**Jan-16**	$	29,360
May-12	$	29,360	**Feb-16**	$	29,360
Jun-12	$	29,360	**Mar-16**	$	29,360
Jul-12	$	29,360	**Apr-16**	$	29,360
Aug-12	$	29,360	**May-16**	$	29,360
Sep-12	$	29,360	**Jun-16**	$	29,360
Oct-12	$	29,360	**Jul-16**	$	412,360
Nov-12	$	29,360	**Aug-16**	$	804,470

Dec-12	$	29,360	**Sep-16**	$	2,304,470
Jan-13	$	29,360	**Oct-16**	$	20,804,470
Feb-13	$	29,360	**Nov-16**	$	20,421,470
Mar-13	$	29,360	**Dec-16**	$	5,462,890
Apr-13	$	29,360	**Jan-17**	$	2,962,890
May-13	$	29,360	**Feb-17**	$	1,462,890
Jun-13	$	29,360	**Mar-17**	$	1,062,890
Jul-13	$	29,360	**Apr-17**	$	712,890
Aug-13	$	29,360	**May-17**	$	562,890
Sep-13	$	29,360	**Jun-17**	$	487,890
Oct-13	$	29,360	**Jul-17**	$	470,890
Nov-13	$	29,360	**Aug-17**	$	462,890
Dec-13	$	29,360	**Sep-17**	$	462,890
Jan-14	$	29,360	**Oct-17**	$	462,890
Feb-14	$	29,360	**Nov-17**	$	462,890
Mar-14	$	29,360	**Dec-17**	$	421,470

	2010	**2011**	**2012**	**2013**	**Total**
TNE w/o AFUDC	$ 175,850	$ 352,320	$ 352,320	$ 352,320	**$ 62,320,000**

	2014	**2015**	**2016**	**2017**
TNE w/o AFUDC	$ 352,320	$ 352,320	$ 50,386,290	$ 9,996,260



PRELIMINARY
NOT FOR CONSTRUCTION

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

HELENA SUBSTATION
LOCATION PLAN

0 1" 2"

FILENAME	HELENA LOC PLAN.DGN
SCALE	NONE

SHEET
LOC PLAN

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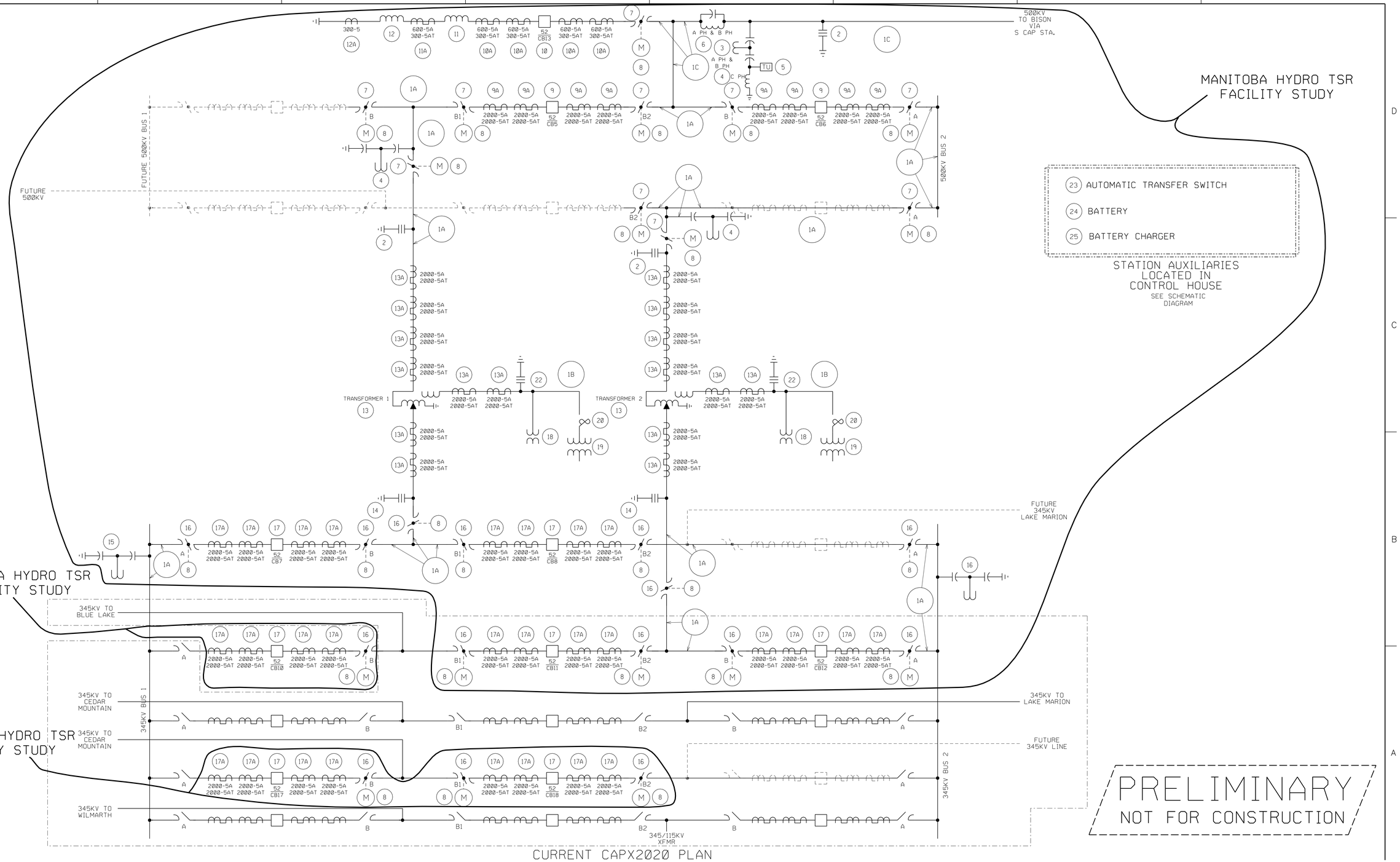

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER

PROJECT NUMBER

CAPX2020

**MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE**

**HELENA SUBSTATION
CIRCUIT DIAGRAM
500KV**

0 1" 2"

FILENAME	HELENA CIR DIA.DGN
SCALE	NONE

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HELENA SUBSTATION (HEL) | CIRCUIT DIAGRAM - LIST OF EQUIPMENT

Date Created: 03/17/10

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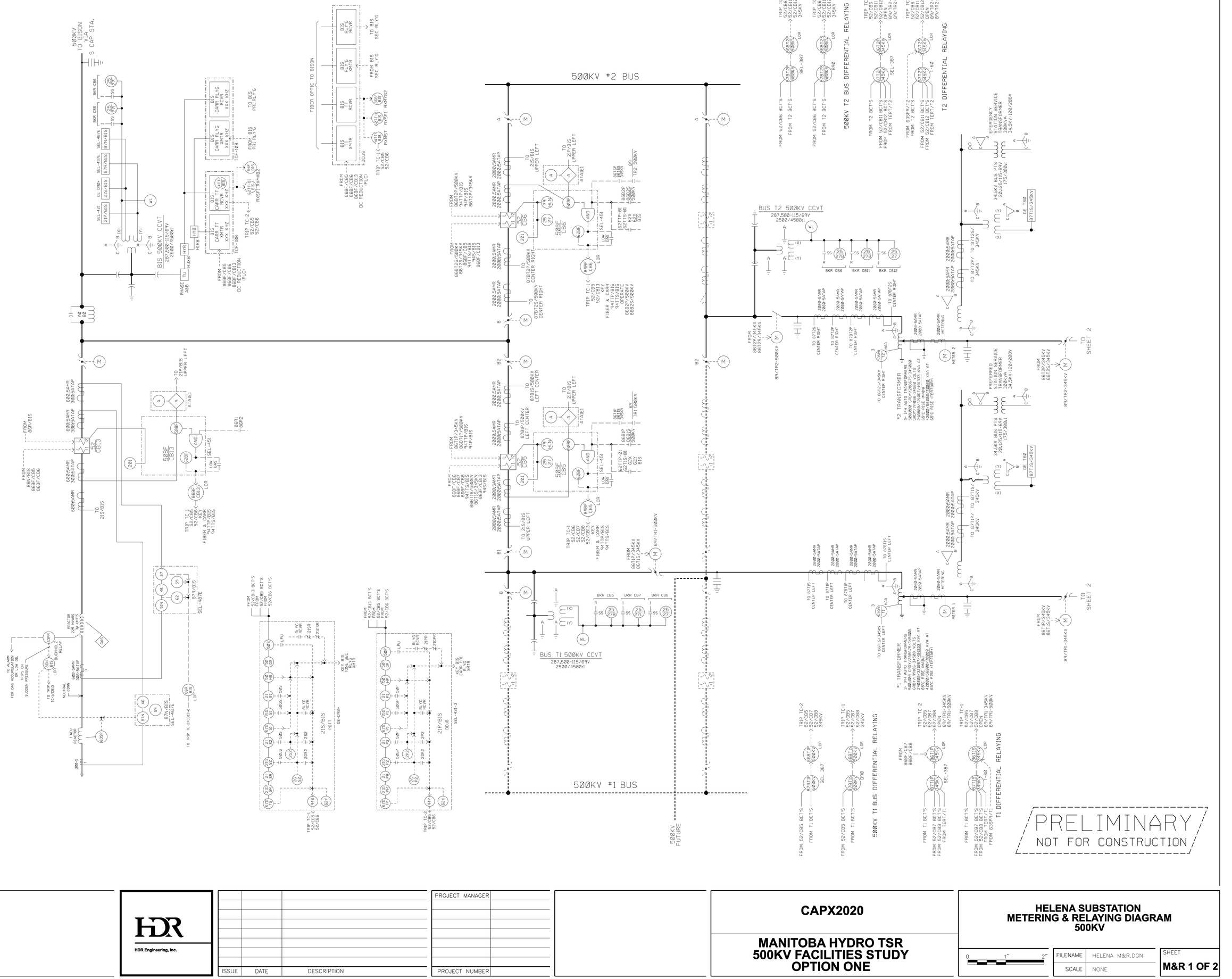
This Map/Document is a tool to assist employees in the performance of their jobs. Your personal safety is provided for by using safety practices, procedures and equipment as described in safety training programs, manuals and SPAR's

ITEM NO.	DESCRIPTION	STANDARD DESIGNATION & NOMINAL RATING	ORDER NUMBER	DRAWING NUMBER	CURRENT REVISION INFO (Existing & unchanged items left blank)
1A	BUS - ALUMINUM TUBULAR BUS	6" AL TUBE (SCHED 40)			
1B	BUS - ALUMINUM TUBULAR BUS	3" AL TUBE (SCHED 40)			
1C	BUS - STRANDED ALUMINUM CONDUCTOR (CODE NAME COREOPSIS)	2-1590 AAC - 61 STRAND			
2	3 - SURGE ARRESTER, STATION CLASS, _____ CO. PORCELIAN, CAT#_____, 335KV MCOV, 500KV				
3	2 - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500 GNDY/287.5KV, 1800KV BIL, _____ CO., CAT.# _____ WITH CARRIER ACCESSORIES, 115/67 VOLTS, _____% ACCURACY THRU _____ BURDEN	EPOXY, 2000A			
4	1 - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 500 GNDY/287.5KV, 1800 KV BIL, _____ CO., CAT.# _____ WITHOUT CARRIER ACCESSORIES, 125 VOLTS, _____% ACCURACY THRU _____ BURDEN	EPOXY, 2000A			
5	2 - LINE TUNING UNIT, _____ CO., MODEL #_____, WIDE BAND, _____ KHZ	D06 ACCC, 2000 A			
6	2 - LINE TRAP, _____ CO., DRY-TYPE AIR CORE, MODEL #_____, 500 GNDY/287.5KV, _____ KHZ, WIDE (OR NARROW) BAND VERTICAL MOUNTING ON 5" B.C.	EPOXY, 2000A			
7	1 - GROUP-OPERATED, SWITCH, DOUBLE END BREAK, _____CO. TYPE_____,500KV, 100,000AMPS MOMENTARY	YR MFG ____, 2000 A			
8	1 - SWITCH OPERATING MOTOR MECHANISM, _____ CO. TYPE _____, 125VDC				
9	1 - GAS CIRCUIT BREAKER, _____ CO. TYPE _____, 550KV MAXIMUM, 40,000 AMPS INTERRUPTING CAPACITY	YR MFG ____, 2000A			
9A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
10	1 - GAS CIRCUIT BREAKER, _____ CO. TYPE _____, 550KV MAXIMUM, 40,000 AMPS INTERRUPTING CAPACITY	YR MFG ____, 2000A			
10A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 600:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
11	1 - THREE-PHASE SHUNT REACTORS, OUTDOOR, _____ CO., 500 GNDY/288.6 KV	OIL-FILLED, 225MVAR			
11A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 600:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.5			
12	1 - SINGLE-PHASE NEUTRAL GROUNDING REACTOR, OUTDOOR, _____ CO., AIR-CORE TYPE, _____ KV, _____ KVA CONTINOUS, _____ MVA FOR _____SECONDS, _____ OHMS				
12A	1 - CURRENT TRANSFORMER, _____ CO., 300:5A SINGLE-RATIO, RELAY ACCURACY CLASS C800	300MVAR @ 500 kV			
13	3 - SINGLE-PHASE LTC AUTO-TRANSFORMER, _____ CO. CLASS ONAN/OFAF/OFAF, 65℃ RISE @ 1000M, 500,000 GND Y/288,675-345,000 GNDY/199,186VOLTS +/- 10% LTC IN 32 - 5/8 % STEPS WITH A 400/560/700 MVA, 34,500 VOLT TERTIARY, UTC# _____	400/560/700 MVA			
13A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
14	3 - SURGE ARRESTER, STATION CLASS, _____ CO. METAL-OXIDE POLYMER, CAT#_____, 230KV MCOV, 345KV	D06 ACCC, 2000 A			
15	1 - COUPLING CAPACITOR VOLTAGE TRANSFORMER (CCVT), 345KV, 1300KV BIL, _____ CO., CAT.# _____ WITHOUT CARRIER ACCESSORIES, _____ VOLTS, _____% ACCURACY THRU _____ BURDEN				
16	1 - GROUP-OPERATED, SWITCH, DOUBLE END BREAK, _____CO. TYPE_____,345KV, 100,000AMPS MOMENTARY	D06 ACCC, 2000 A			
17	1 - GAS CIRCUIT BREAKER, _____ CO. TYPE _____, 362KV MAXIMUM, 40,000 AMPS INTERRUPTING CAPACITY	YR MFG ____, 2000A			
17A	3 - BUSHING CURRENT TRANSFORMERS, _____ CO., 3000:5A MULTI-RATIO RELAYING TYPE, ACCURACY CLASS C800	TRF 1.0			
18	3 - SINGLE-PHASE, OUTDOOR POTENTIAL TRANSFORMERS, TWO BUSHING, _____ CO., TYPE _____, 5000 VOLT-AMPS, 34,500 VOLTS				
19	1 - THREE-PHASE DISTRIBUTION TRANSFORMER (PAD MOUNTED), _____ CO., 300 KVA, 34,500 GNDY-120/208 VOLTS WITH THREE _____ CO. SEPARABLE LOAD-BREAK PRIMARY CABLE CONNECTORS, 35KV, 200 AMPS, 22,000 AMPS MOMENTARY				
20	3 - HOOKSTICK-OPERATED SWITCH AND FUSE COMBINATIONS _____ CO. TYPE _____, 35 KV, 600 AMPS CONTINUOUS SWITCH AND _____ CO. TYPE _____, 400 AMPS FUSE MOUNTING, CAT.# _____, STANDARD TIME-CURRENT CHARACTERISTICS," 40,000 AMPS MAXIMUM INTERRUPTING CAPACITY FOR COMBINATION	400 A FUSE ELEMENT			
21	NOT USED				
22	3 - SURGE ARRESTER, STATION CLASS, _____ CO. METAL-OXIDE POLYMER, CAT#_____, 22KV MCOV, 34.5KV				
23	AUTOMATIC TRANSFER SWITCH, _____ CO., TYPE _____, 600AMP, 120/240VAC SINGLE PHASE				
24	BATTERY, _____ CO., TYPE _____, 125VDC, 300AMP-HOUR RATING. BATTERY RACK IS __ TIER, __D x __W x __H				
25	BATTERY CHARGER, _____ CO., TYPE_____, 125VDC, 50 AMPS, ___VAC SINGLE PHASE SOURCE				



HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

HELENA SUBSTATION
METERING & RELAYING DIAGRAM
500KV

0 1" 2"

FILENAME	HELENA M&R.DGN
SCALE	NONE

SHEET
M&R 1 OF 2

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PRELIMINARY
NOT FOR CONSTRUCTION

CAPX2020

MANITOBA HYDRO TSR
500KV FACILITIES STUDY
OPTION ONE

HELENA SUBSTATION
METERING & RELAYING DIAGRAM
345KV

SHEET **M&R 2 OF 2**
FILENAME HELENA M&R.DGN
SCALE NONE
0 1" 2"

PROJECT MANAGER | PROJECT NUMBER

ISSUE	DATE	DESCRIPTION

HDR
HDR Engineering, Inc.

345KV BUS #1 DIFFERENTIAL RELAYING
CEDAR MOUNTAIN LINE RELAYING (EXISTING)
BLUE LAKE LINE RELAYING (EXISTING)
MANITOBA HYDRO TSR FACILITY STUDY

345KV BUS #2 DIFFERENTIAL RELAYING
MANITOBA HYDRO TSR FACILITY STUDY

TO EXISTING 345KV BUS
345/115KV XFMR
345KV TO WILMARTH
345KV TO CEDAR MOUNTAIN
345KV TO LAKE MARION
345KV TO BLUE LAKE
FUTURE 345KV LINE
TO SHEET 1

345KV #2 BUS
345KV #1 BUS
BUS 2 345KV CCVT 287,500-115/69V 2500/4500:1
BUS 1 345KV CCVT 287,500-115/69V 2500/4500:1

TRANSMISSION LINE SECTION

RESULTS OF MANITOBA HYDRO TSR 500 KV OPTION 1 FACILITIES STUDY

500kV TRANSMISSION LINE - DETAILS

Prepared by:

Nick Schneider
HDR Engineering, Inc.

PROJECT DESIGN GUIDE

Location: 500 kV, Canada/North Dakota border to Helena South Substation

Project Title: MH TSR 500 kV Option 1 Facilities Study – Segment 1A - U.S./Canada border to the proposed North Series Cap Bank.

In-Service Date:	December, 2017
Program Manager:	CapX2020
Project Manager:	Chris Ayika (Xcel Energy) Jared Alholinna (CapX2020)
Prepared By:	HDR Engineering, Inc.
Estimate Type (Appropriation or Engineering) and Amount:	Facilities Study $ 159,810,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the mid-line location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. The proposed 500 kV transmission line will be constructed using self-supporting steel h-frame tangent and light angle structures and self-supporting steel 3-pole heavy angle and deadend structures. Structures will be installed on driven pipe pile with concrete pile cap and concrete drilled pier foundations.

This estimate is for Line Segment 1A – U.S./Canada border to the proposed North Series Cap Bank. (Approximately 52 miles)

The following items are attached:

- Proposed System One-line Diagram – *See Facilities Study Executive Summary.*
- Area Map – *See Permitting and Land Rights section of Facilities Study.*
- Proposed Structure Family Drawings.
- Proposed Project Schedule – *See Facilities Study Executive Summary.*

Background

Several Transmission Service Requests (TSR) for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service. The study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

The scope of this estimate is limited to the requirements associated with the MISO request. No other considerations have been identified at this time.

II. General Technical Requirements

- Transmission line conductor shall be 3-conductor bundle 1192.5 kcmil 45/7 "Bunting" ACSR with 18 inch sub-spacing.
- Transmission line shield wire shall be 7 no. 7 Alumoweld and 48 fiber OPGW. A shielding study will be required once the line route and structure type has been finalized in order to verify the shield wire is sized to meet fault current requirements.
- The following maximum tension limits shall be applied. Shield wire tension shall be based on 80% of the conductor tension at 60 degrees final.

Weather Case				Tension Limit	
Wind (psf)	**Radial Ice (inches)**	**Temp (°F)**	**Condition**	**NESC Limit 261H1a,b**	**Project Specific Limit**
4	0.5	0	Initial	60% RBS	40% RBS
0	0	0	Final	--	25% RBS
0	0	0	Initial	--	33% RBS
0	0	60	Initial	35% RBS	--
0	0	60	Final	25% RBS	--
0	0	-20	Initial	--	20% RBS for ACSR

- All steel structures will be designed to NESC Grade B Construction "Heavy Loading" per NESC Section 250.

Required NESC Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
1	4	0.5	0	I	1.5	2.5/1.65	1.65	NESC Heavy Grade B k= 0.3 Structural Shape Factor=1.0 See Note 2
2a	6.4	0.5	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2b	6.4	0.75	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2c	6.4	1.0	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
3	21	0	60	I	1.1	1.1	1.1	NESC Extreme Wind See Notes 1,3,7

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Case 1 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms and braces.

Note 3: Load Cases 2 and 3 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 4: Refer to NESC Figure 250-3 for applicable ice and wind loads.

Note 5: Ice is assumed to weigh 57 lbs/ft³.

Note 6: For the Manitoba Hydro 500 kV project, the vertical load factor shall be 1.1.

Note 7: For the Manitoba Hydro 500 kV project, all load factors shall be 1.1.

- Additional load cases shall be included for additional line reliability.

Reliability-Based Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
4a	6.4	0.75	0	F	1.0	1.0	1.0	ASCE 7-05, 0.5 in 50-year return Ice Load Zone(load case 2a): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4b	6.4	1.125	0	F	1.0	1.0	1.0	ASCE 7-05, 0.75 in 50-year return Ice Load Zone(load case 2b): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4c	6.4	1.5	0	F	1.0	1.0	1.0	ASCE 7-05, 1.0 in 50-year return Ice Load Zone(load case 2c): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
5	WL x 1.3	0	60	I	1.0	1.0	1.0	Extreme Wind Loading: 200-Year Return Period See Notes 1, 2 and 4

Note 1: WL = Wind Load adjusted for the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 4 and 5 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 3: Ice is assumed to weigh 57 lbs/ft³.

Note 4: The 50-year return period Extreme Wind Load is multiplied by 1.3 to convert to a 200-year return period load (ANSI/ASCE Standard 7-05). The extreme wind loading of special wind regions (as verified by regional studies and utility experience) shall be used if the loads are greater than those specified in Load Case 3.

- Special load cases shall be included to accommodate deflection criteria, unbalanced ice loading, broken wire loading, failure containment and construction and maintenance loading.

Special Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
6	2	0	40	I	1.0	1.0	1.0	Deflection Condition, Structure shape factor=1.0, Not for switch structures See Note 1
7	4	0.5	0	I	1.1	1.1	1.1	Broken Wire (Phase), Structure shape factor=1.0 See Notes 2, 3, and 6
8	0	0.25	32	I	1.1	1.1	1.1	Unbalanced Ice See Notes 3, 4, and 6
9	4	0.5	0	I	1.1	1.1	1.1	Failure Containment Structure See Notes 5 and 6
10	2	0	-20	I	1.5	1.5	1.5	Construction load with wire caught in block or tensioning at structure See Note 6

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: The longitudinal load shall be applied at any one shield wire or one conductor (phase) position.

Note 3: For suspension type attachments, the conductor tension for the Broken Wire or Unbalanced Ice load shall be multiplied by 0.70 to account for the benefit of insulator swing. The Broken Wire or Unbalanced Ice load at the shield wire position shall not be reduced as there is minimal insulator (hardware) swing. For arms with both a shield wire and conductor attachment, the one load creating the most severe condition shall be applied, not both.

Note 4: The differential tensions shall be calculated for 0.25 inch equivalent radial ice load on all conductors and shield wires on one side of the structure with no ice on the other side.

Note 5: This load case is only used on structures designated as Failure Containment structures. This load case shall be applied simultaneously at all wire positions on one side of the structure assuming no tension in the opposite direction.

Note 6: Load Cases 7 through 10 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 7: Ice is assumed to weigh 57 lbs/ft³.

- A high intensity wind load case shall be included that simulates the wind speed of a tornado. This load case shall be applied to the structures only, not to the spans and wires.

High Intensity Wind Load Cases

LC	Weather Case					Load Factors			Comments / Description
	Transv. Wind (PSF)	Long. Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
11a	53.8	0.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, Perpendicular to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11b	38.0	38.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, At 45° to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11c	0	53.8	0	60	I	1.0	1.0	1.0	High Intensity Wind, In-line with line/structure, Structure shape factor=1.0, See Notes 1 and 2

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 11a, 11b, and 11c shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

- Structures shall be designed to the following load case combinations.

Load Cases per Structure Type

LC (see Note 1)	Structure Types				
	Tangent 0° to 2°	**Small Angle 2° to 15°**	**Medium Angle 15° to 30°**	**Non-terminal Deadend 0° to 90°**	**Terminal Deadend 0° to 90°**
1	X	X	X	X	X
1 Wires 1 Side (See Note 2)					X
2a, 2b, 2c (See Note 3)	X	X	X	X	X
3	X	X	X	X	X
4a, 4b, 4c (See Note 4)	X	X	X	X	X
5	X	X	X	X	X
6	X	X	X	X	X
7	X	X	X	X	
8	X	X	X	X	
9				X	
10 (See Note 5)	X	X	X	X	
11a, 11b, 11c (See Note 6)	X	X	X	X	X

Note 1: All Load Cases are with intact conductors and shield wires, unless otherwise noted.

Note 2: Terminal wire loads shall be applied to one side of structure only. Utility responsible for design of that structure shall also determine applicable design wind and weight spans.

Note 3: For application of Load Case 2a, 2b, or 2c, see Required NESC Load Cases Table.

Note 4: For application of Load Case 4a, 4b, or 4c, see Reliability Based Load Cases Table.

Note 5: For tangent, small angle, and medium angle structures, this Load Case shall only apply at one phase or shield wire position, which ever results in the most severe loading acting on the structure, and/or support arm. For non-terminal deadend structure, this Load Case shall apply to all phases and shield wire positions.

Note 6: Load Cases 11a, 11b, and 11c all pertain to the direction of high intensity wind loads as they apply across the structure only. These loads shall not be applied to the supporting spans of conductor and shield wire.

- Failure containment structures shall be spotted at intervals not exceeding ten (10) miles.
- Transposition structures may be required every 60-75 miles in order to maintain the transmission line end-to-end voltage imbalance less than 1%.

- Insulators shall be porcelain or toughened glass bells for suspension and dead end applications. Coordination with Manitoba Hydro to verify same insulation levels will be required. The following lists the proposed insulation levels in terms of number of porcelain or toughened glass bells.

Structure Type	Line Angle	500 kV
		Steel
Tangent	0° to 2°	26
Small Angle	2° to 15°	26
Medium Angle	15° to 30°	28
Deadend Terminal & Non-terminal	0° to 90°	28

- Air gap shall be equivalent to the number of insulators. Coordination with Manitoba Hydro to verify air gap dimensions will be required. The minimum air gap distances shall be as follows.

Design Air Gap Clearances

Air Gap	
	500 kV
Load Case	Steel
No Wind, No Ice, 60° Final (NESC 441)	152"
6# Wind, No Ice, 60° Final	106"
High Wind (21#, No Ice, 120° Final)	44"

- Minimum clearance requirements shall be defined by Section 23 of the NESC C2 2007. Clearance criteria not listed shall be applied per Section 23 of the NESC C2 2007. The following minimum clearances shall be applied for line design.

General Clearances

Clearance Category:	500 kV		Comments
	Design	NESC	
Basic Ground Clearance	38'0"	28'4"	Roads, streets, all land traversed by vehicles, agricultural land, forests, pedestrian only access
State Highways, County Roads	38'0"	28'4"	
Interstate Highway	39'0"	28'4"	
Railroads	39'0"	36'4"	Individual railroads may require additional clearance above tracks.

Minimum clearances between adjacent lines (based on NESC 233 B-1)

Horizontal Clearances Between Adjacent Lines			
Line Sizes	NESC Electrical Clearance	Clearance Envelope	Distance Between Line, Conductors
500-500	25.4'	21.7'	47.1'
500-345	21.8'	21.7'	43.5'
500-230	19.5'	21.7'	41.2'
500-161	18.1'	21.7'	39.8'
500-115	17.2'	21.7'	38.9'
500-69	16.2'	21.7'	37.9'

Minimum vertical clearances between lines on same structures (based on NESC 235)

Same Utility	
kV	**500**
34.5	12.3’
69	13.0’
115	14.0’
161	14.9’
230	16.3’
345	18.6’
500	21.7’

Different Utility	
kV	**500**
34.5	14.3’
69	15.0’
115	16.0’
161	16.9’
230	18.3’
345	20.6’
500	23.7’

Minimum vertical clearance between crossing lines.

Source	**500 kV**	
	NESC	**Design**
34.5 kV	11’4”	13.8’
69 kV	12’0”	14.5’
115 kV	12’11”	15.4’
161 kV	13’11”	16.4’
230 kV	15’3”	17.8’
345 kV	17’7”	20.1’
500 kV	20’6”	23.0’

- The assumed right-of-way width shall be 200 feet. 100 feet either side of transmission line centerline. The line shall be designed to fit within the new easements. The minimum clearance to be maintained from the conductor to the edge of right-of-way shall be as follows.

	500 kV (ft)
Load Case 1	17.4
Load Case 2	17.4
Load Case 3	3.7

Load Case 1	0 PSF Wind, No Ice, -20°F, Initial (NESC 234 A.1.)
Load Case 2	6 PSF Wind, No Ice, 120°F, Final (MH and MN TOs Standards)
Load Case 3	Wind Load From Extreme High Wind Load Case, No Ice, 60°F,Final

III. Right of Way

The new right-of-way shall be 100' on either side of transmission line center line with a total width of 200'. Land owner agreements will be required for access to the transmission line right-of-way. Any construction damages to private landowner property will be negotiated with the landowner.

IV. Specific Design Features (Major Equipment to be Installed)

Two hundred fifty five (255) self-supporting steel 0-2° tangent h-frame structures on driven pipe pile with concrete pile cap foundations will be installed.

Three (3) self-supporting steel 2-15° light angle h-frame structures on driven pipe pile with concrete pile cap foundations will be installed.

Five (5) self-supporting steel 0-45° terminal deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Four (4) self-supporting steel 45-90° terminal deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Fifty two (52) miles of 3-phase triple bundled 1192.5 kcmil 45/7 ACSR "Bunting" conductor will be installed.

Fifty two (52) miles of 7 no. 7 Alumoweld shield wire will be installed.

Fifty two (52) miles of 48 fiber OPGW shield wire will be installed.

Thirteen (13) OPGW shield wire splice boxes will be installed.

Removals & Relocations

No removal required.

Grounding of Structures

Steel structures to be grounded using 1/0 copper ground wire and copperweld ground rods. Shield wire will be bonded to structure using #4 stranded copper.

Desired ground resistance is 10 ohms but maximum ground resistance shall be 25 ohms. Ground resistivity testing will be required once the line route is finalized.

Lightning Protection

A 7 no. 7 Alumoweld and 48 fiber OPGW will be installed to meet fault current requirements.

V. Civil Features

Access, Grading, Fencing and Culvert Work

Access road grading will be required for access to right-of-way. Once the transmission line route is finalized, access roads will be designed. These costs are not included in the estimate.

Storm Water Permit

A storm water permit will be required. Once the line route is finalized, a specific SWPPP will be completed and submitted to the required agencies.

Foundations & Structural

Five hundred forty three (543) driven pipe pile with concrete pile cap foundations will be required.

VI. Outages

Outages to existing transmission and distribution facilities will be required during stringing construction. Once the route is finalized and construction schedule set, coordination with these facilities will begin.

VII. Project and Operating Concerns

Close coordination with Manitoba Hydro will be required to create an overall design, construction, and permitting timeline for this project.

VIII. Related Projects

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 1B (Proposed North Series Cap Bank to proposed Bison Sub)

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 2A (Proposed Bison Sub to proposed South Series Cap Bank)

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 2B (Proposed South Series Cap Bank to proposed Helena Sub)

WO# TBD – 500 kV Bison Substation Facilities Study

WO# TBD – 500 kV Helena South Substation Facilities Study

WO# TBD – 500 kV North Series Cap Bank

WO# TBD – 500 kV South Series Cap Bank

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	MH 500kV TSR - FaSt1 - Line Segment 1A
Sub./Line Name:	
WO #:	
Group Name:	
City:	
County:	
State:	ND
WO Type:	21
Op Co:	NSPM
In-service Date:	12/31/2017
Basic Scope:	

Estimate Information	
Est. Type	
Est Status:	Finalized
Est. Published	3/8/2010
Rev. Number:	
Prepared By:	HDR Engineering
Company:	

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Manageme	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$1,055,983	$0	$0	$970,725	$2,026,708
CBS3 - Civil Construction	$25,170,373	$19,253,506	$45,354,793	$4,565,020	$94,343,692
CBS4 - Electrical Construction	$12,325,980	$3,459,829	$26,322,214	$1,526,688	$43,634,711
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$0	$0	$0	$0	$0
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$38,552,336	$22,713,335	$71,677,007	$7,062,434	$140,005,112
Indirect Costs					
Powerplant Overheads (E&S + A&G)	$3,142,015	$1,851,137	$3,122,786	$417,893	$8,533,831
Material overheads	$0	$0	$766,328	$0	$766,328
AFUDC	$0	$0	$0	$0	$0
Contingency	$4,144,376	$2,237,264	$4,119,012	$0	$10,500,652
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$7,286,391	$4,088,400	$8,008,126	$417,893	$19,800,810
Project Total					**$159,805,922**

Print Date: 4/30/2010

Description	Qty	Unit of Measure	Unit Cost	Total Cost	Materials Total Cost	Labor Total Cost
JOB						
ESCALATION	1	Lump Sum		$0.00	$0.00	$0.00
AFUDC	1	Lump Sum		$0.00	$0.00	$0.00
CONTINGENCY	1	Lump Sum		$10,500,651.56	$4,119,011.96	$4,144,376.10
POWERPLANT AND MATL OVERHEADS	1	Lump Sum		$9,300,158.51	$3,889,113.61	$3,142,015.37
TOTAL USED FOR FORECAST	1	LOT		$2,026,708.29	$0.00	$1,055,983.29
TANGENT 0-2 - MATERIAL & STEEL	255	Each	$80,474.48	$20,520,992.30	$19,396,022.97	$0.00
LIGHT ANGLE 2-15 - MATERIAL & STEEL	3	Each	$88,370.12	$265,110.36	$250,576.90	$0.00
RUNNING ANGLE 15-30 - MATERIAL - STEEL	0	Each		$0.00	$0.00	$0.00
DEADEND 0-45 - MATERIAL - STEEL	5	Each	$355,492.11	$1,777,460.54	$1,680,019.41	$0.00
DEADEND 45-90 - MATERIAL - STEEL	4	Each	$388,766.21	$1,555,064.83	$1,469,815.53	$0.00
TANGENT 0-2 - LABOR (8 MEN/8 HR/2.5 CREW DAYS)	255	Each	$22,547.95	$5,749,727.67	$0.00	$3,558,502.15
LIGHT ANGLE 2 - 15 - LABOR (8 MEN/8 HR/ 2.7 CREW DAYS)	3	Each	$23,160.08	$69,480.23	$0.00	$42,635.27
RUNNING ANGLE 15 - 30 - LABOR (8 MEN/8 HR/6.6 CREW DAYS)	0	Each		$0.00	$0.00	$0.03
DEADEND 0 - 45 - LABOR (8 MEN/8 HR/ 6.9 CREW DAYS)	5	Each	$62,280.96	$311,404.80	$0.00	$194,587.47
DEADEND 45 - 90 - LABOR (8 MEN/8 HR/7.5 CREW DAYS)	4	Each	$68,702.04	$274,808.16	$0.00	$171,790.85
MATTING FOR CIVIL (PER FOUNDATION - POOR SOIL)	543	Each	$1,541.69	$837,139.09	$0.00	$650,811.72
INTERNAL-CIVIL RESTORATION CREW-3 MEN/1DAY/10 HR PLUS EQUIPMENT	52	Mile	$2,822.88	$146,789.92	$0.00	$132,116.47
FOUNDATION DRIVEN PILE FOUNDATION MATERIALS	543	Each	$88,370.85	$47,985,370.60	$45,354,792.63	$0.00
FOUNDATION DEEP DRILLED PIER FOUNDATION MATERIALS	0	Each		$0.00	$0.00	$0.00
FOUNDATION TYPICAL DRILLED PIER FOUNDATION MATERIALS	0	Each		$0.00	$0.00	$0.00
CIVIL CONSTRUCTION DRIVEN PILE FOUNDATION LABOR (8 MEN/8 HR/9.5 CREW DAYS)	543	Each	$79,512.82	$43,175,458.77	$0.00	$22,806,901.97
CIVIL CONSTRUCTION DEEP DRILLED PIER FOUNDATION LABOR (8 MEN/8 HR/5.5 CREW DAYS)	0	Each		$0.00	$0.00	$0.00
CIVIL CONSTRUCTION TYPICAL PIER FOUNDATION LABOR (8 MEN/8 HR/.75 CREW DAYS)	0	Each		$0.00	$0.00	$0.00
CONDUCTOR - 1192.5 KCMIL 45/7	2,508,500	FT	$1.06	$2,653,993.00	$2,508,500.00	$0.00
7 no 7 ALUMOWELD	278,800	FT	$0.57	$158,197.05	$149,524.62	$0.00
OPGW- 48 FIBER SINGLE MODE	281,300	FT	$3.17	$892,846.20	$843,900.00	$0.00
FIBER OPTIC SPLICE BOX FOR 48 FIBER	13	EA	$1,941.43	$25,238.59	$23,855.00	$0.00
LABOR FOR FIBER OPTIC SPLICE INSTALL	13	Each	$16,192.22	$210,498.91	$0.00	$184,029.96
STRINGING-CONDUCTOR-WEEKLY INTERNAL OH LABOR CREW-30 MEN/4 DAYS/10 HR DAYS	52	Mile	$105,858.86	$5,504,660.59	$0.00	$5,000,814.00
RIGHT OF WAY PREP	52	Mile	$15,000.00	$780,000.00	$0.00	$586,355.19
MOB/DEMOB - CIVIL CREWS	1	EA		$1,418,933.90	$0.00	$994,187.52
MOB/DEMOBD - LINE CREWS	1	EA		$628,576.57	$0.00	$367,009.19
CONSTRUCTION MANAGEMENT 12 MEN/1DAY/10HR DAYS	304	DAY	$9,988.98	$3,036,651.29	$0.00	$2,806,610.69
				$159,805,921.80	**$79,685,132.66**	**$45,838,727.23**

Name of project / estimate	MH TSR 500KV Facilities Study - Segment 1A
Lead Engineer	HDR Engineering Inc.
Project Manager	Chris Ayika, Jared Alholinna
Creation Date of Estimate	4/9/2010
In-Service Date of Project	12/31/2017
Total Cost (no escalation & no AFUDC)	159,805,922

Estimate spend schedule:

	Approx Cost	Start date	End date
Engineering Design Window	2,026,708	7/1/2010	12/31/2017
Material Delivery Window	79,685,133	3/3/2014	8/31/2014
Construction & Commission Window	78,094,081	7/1/2014	1/31/2015
	159,805,922		

Detailed Project Spend Forecast

	Approx Cost	Start date	End date
Engineering Design Window	2,026,708	7/1/2010	12/31/2017
Procurement Delivery Window	79,685,133	3/3/2014	8/31/2014
Construction & Commission Window	78,094,081	7/1/2014	1/31/2015
Total	159,805,922		

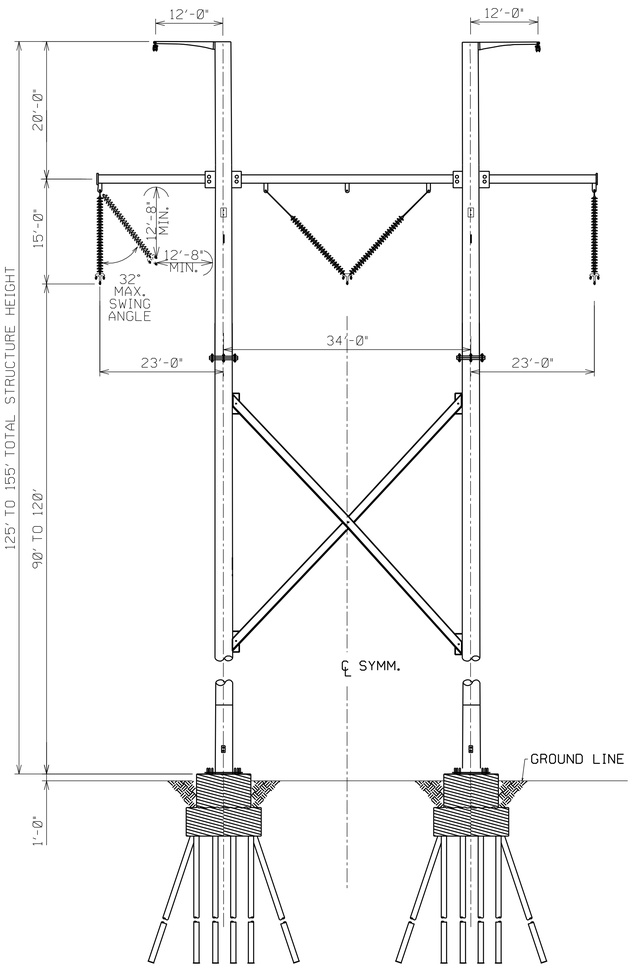
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Jul-10	**Aug-10**	**Sep-10**	**Oct-10**	**Nov-10**	**Dec-10**	**Jan-11**	**Feb-11**	**Mar-11**	**Apr-11**	**May-11**	**Jun-11**	**Jul-11**	**Aug-11**	**Sep-11**	**Oct-11**	**Nov-11**	**Dec-11**	**Jan-12**	**Feb-12**	**Mar-12**	**Apr-12**	**May-12**	**Jun-12**	**Jul-12**	**Aug-12**	**Sep-12**	**Oct-12**	**Nov-12**	**Dec-12**	**Jan-13**
Engineering Design Window	5058	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	15200	15200	15200	15200	20267
Procurement Delivery Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	5058	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	5067	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	15200	15200	15200	15200	20267

	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
	Feb-13	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	**Jul-13**	**Aug-13**	**Sep-13**	**Oct-13**	**Nov-13**	**Dec-13**	**Jan-14**	**Feb-14**	**Mar-14**	**Apr-14**	**May-14**	**Jun-14**	**Jul-14**	**Aug-14**	**Sep-14**	**Oct-14**	**Nov-14**	**Dec-14**	**Jan-15**	**Feb-15**	**Mar-15**	**Apr-15**	**May-15**	**Jun-15**	**Jul-15**	**Aug-15**
Engineering Design Window	20267	20267	20267	20267	20267	25334	25334	30401	30401	101335	101335	101335	101335	101335	101335	101335	101335	81068	60801	40534	40534	20267	20267	20267	20267	20267	20267	20267	20267	20267	20267
Procurement Delivery Window	0	0	0	0	0	0	0	0	0	0	0	0	0	13280856	13280856	13280856	13280856	13280856	13280856	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11156297	11156297	11156297	11156297	11156297	11156297	11156297	0	0	0	0	0	0	0
Total	20267	20267	20267	20267	20267	25334	25334	30401	30401	101335	101335	101335	101335	13382191	13382191	13382191	13382191	24518221	24497954	11196831	11196831	11176564	11176564	11176564	20267	20267	20267	20267	20267	20267	20267

	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
	Sep-15	**Oct-15**	**Nov-15**	**Dec-15**	**Jan-16**	**Feb-16**	**Mar-16**	**Apr-16**	**May-16**	**Jun-16**	**Jul-16**	**Aug-16**	**Sep-16**	**Oct-16**	**Nov-16**	**Dec-16**	**Jan-17**	**Feb-17**	**Mar-17**	**Apr-17**	**May-17**	**Jun-17**	**Jul-17**	**Aug-17**	**Sep-17**	**Oct-17**	**Nov-17**	**Dec-17**	**Jan-18**	**Feb-18**	**Mar-18**
Engineering Design Window	20267	20267	15200	15200	15200	15200	15200	15200	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	5067	5067	5067	5067	5067	0	0	0
Procurement Delivery Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	20267	20267	15200	15200	15200	15200	15200	15200	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	10134	5067	5067	5067	5067	5067	0	0	0

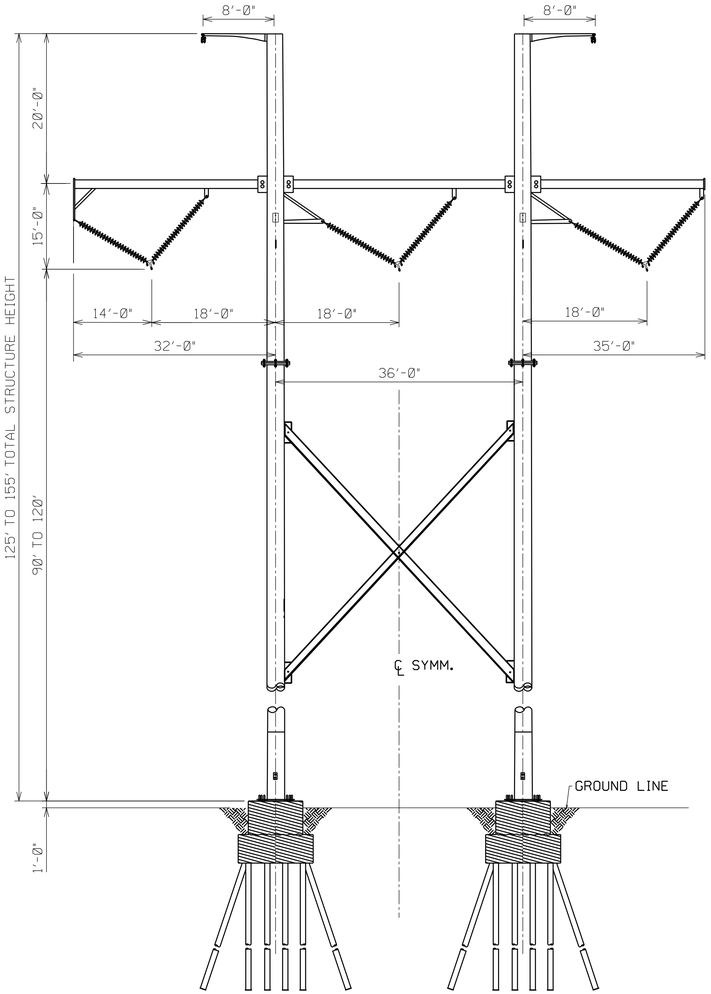
NOTES:

1. SHIELDING ANGLE IS ESTIMATED TO BE NO GREATER THAN 20° FOR AT-REST CONDITIONS.
2. DESIGN WIND & WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.



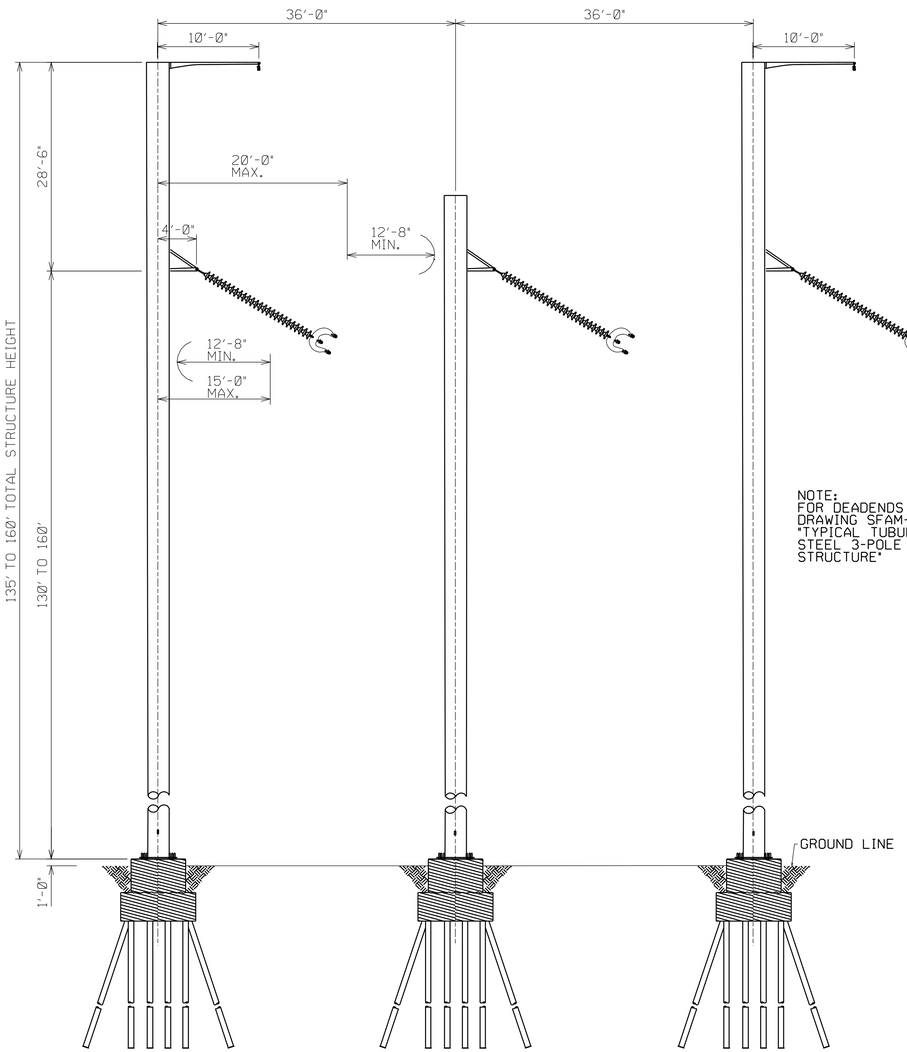
0°-2° TANGENT SUSPENSION

WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



2-15° ANGLE SUSPENSION

WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



NOTE:
FOR DEADENDS SEE DRAWING SFAM-2, "TYPICAL TUBULAR STEEL 3-POLE DEADEND STRUCTURE"

15°-30° RUNNING ANGLE SUSPENSION

WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER

PROJECT NUMBER

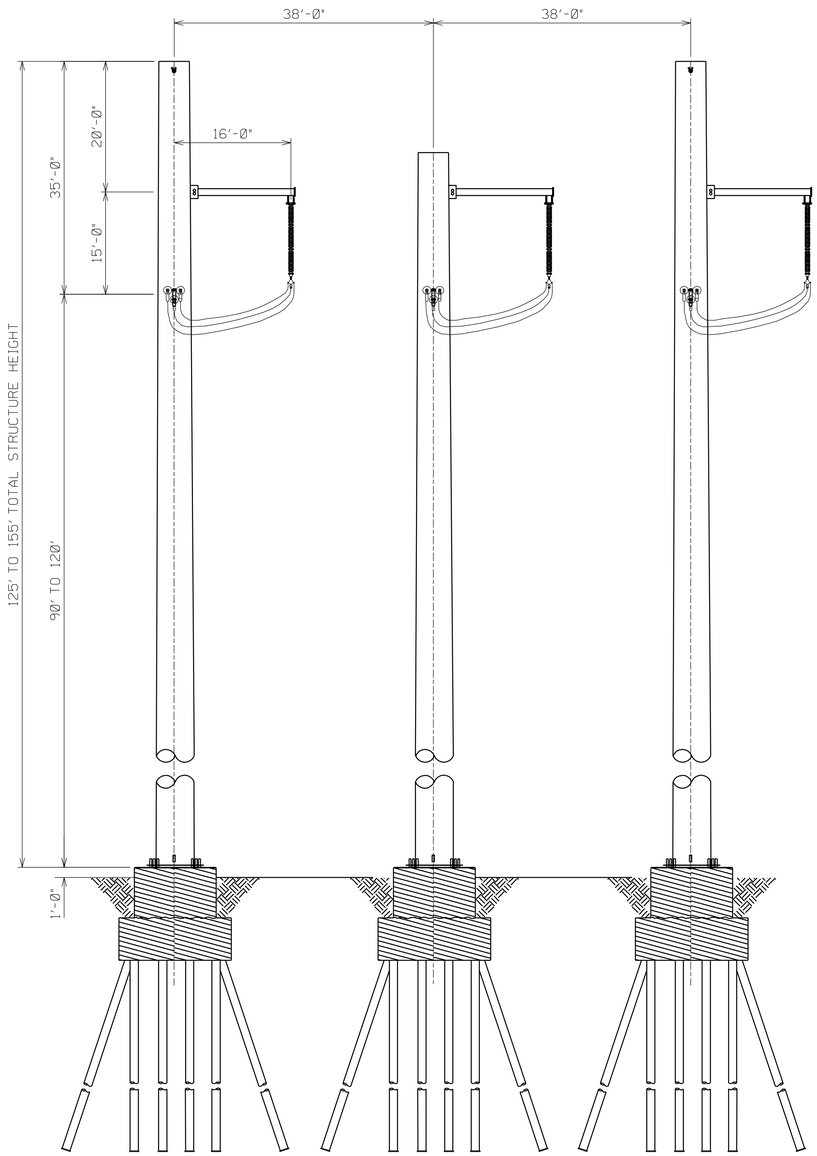
CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

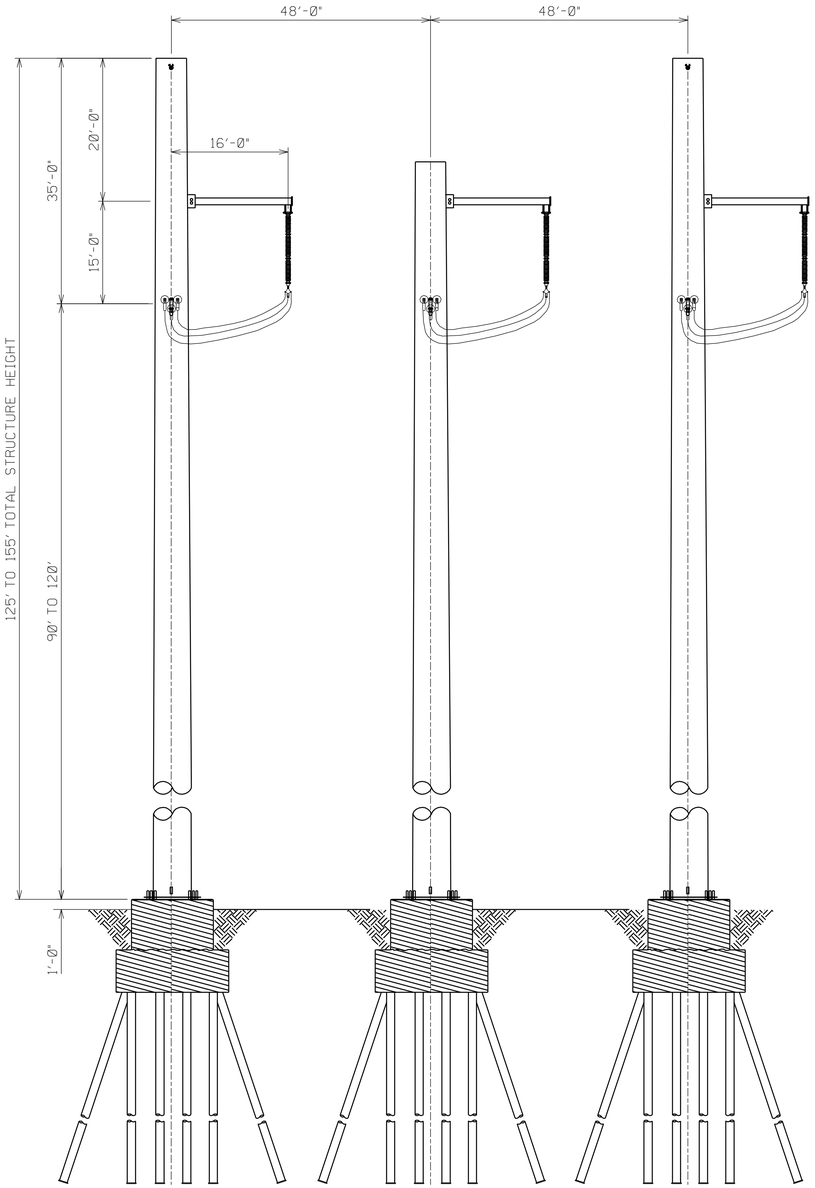
EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME
STRUCTURE FAMILY

FILENAME	SFAM1A-1
SCALE	NONE

SHEET **SFAM-1**



0° - 45° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



45° - 90° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

NOTES:

1. SHIELDING ANGLE AT DEADENDS IS 0°.
2. DESIGN WIND AND WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME
STRUCTURE FAMILY

FILENAME	SFAM1A-2
SCALE	NONE

SHEET **SFAM-2**

PROJECT DESIGN GUIDE

Location: 500 kV, Canada/North Dakota border to Helena South Substation

Project Title: MH TSR 500 kV Option 1 Facilities Study – Segment 1B – Proposed North Cap Bank to proposed Bison Substation near Fargo ND.

In-Service Date:	December, 2017
Program Manager:	CapX2020
Project Manager:	Chris Ayika (Xcel Energy) Jared Alholinna (CapX2020)
Prepared By:	HDR Engineering, Inc.
Estimate Type (Appropriation or Engineering) and Amount:	Facilities Study $212,940,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the mid-line location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. The proposed 500 kV transmission line will be constructed using self-supporting steel h-frame tangent and light angle structures and self-supporting steel 3-pole heavy angle and deadend structures. Structures will be installed on driven pipe pile with concrete pile cap and concrete drilled pier foundations.

This estimate is for Line Segment 1B – Proposed North Series Cap Bank proposed Bison Substation near Fargo ND. (Approximately 112 miles)

The following items are attached:

- Proposed System One-line Diagram – ***See Facilities Study Executive Summary.***
- Area Map – ***See Permitting and Land Rights section of Facilities Study.***
- Proposed Structure Family Drawings.
- Proposed Project Schedule – ***See Facilities Study Executive Summary.***

Background

Several requests for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service, the study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

The scope of this estimate is limited to the requirements associated with the MISO request. No other considerations have been identified at this time.

II. General Technical Requirements

- Transmission line conductor shall be 3-conductor bundle 1192.5 kcmil 45/7 "Bunting" ACSR with 18 inch sub-spacing.
- Transmission line shield wire shall be 7 no. 7 Alumoweld and 48 fiber OPGW. A shielding study will be required once the line route and structure type has been finalized in order to verify the shield wire is sized to meet fault current requirements.
- The following maximum tension limits shall be applied. Shield wire tension shall be based on 80% of the conductor tension at 60 degrees final.

Weather Case				Tension Limit	
Wind (psf)	**Radial Ice (inches)**	**Temp (°F)**	**Condition**	**NESC Limit 261H1a,b**	**Project Specific Limit**
4	0.5	0	Initial	60% RBS	40% RBS
0	0	0	Final	--	25% RBS
0	0	0	Initial	--	33% RBS
0	0	60	Initial	35% RBS	--
0	0	60	Final	25% RBS	--
0	0	-20	Initial	--	20% RBS for ACSR

- All steel structures will be designed to NESC Grade B Construction "Heavy Loading" per NESC Section 250.

Required NESC Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
1	4	0.5	0	I	1.5	2.5/1.65	1.65	NESC Heavy Grade B k= 0.3 Structural Shape Factor=1.0 See Note 2
2a	6.4	0.5	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2b	6.4	0.75	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2c	6.4	1.0	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
3	21	0	60	I	1.1	1.1	1.1	NESC Extreme Wind See Notes 1,3,7

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Case 1 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms and braces.

Note 3: Load Cases 2 and 3 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 4: Refer to NESC Figure 250-3 for applicable ice and wind loads.

Note 5: Ice is assumed to weigh 57 lbs/ft³.

Note 6: For the Manitoba Hydro 500 kV project, the vertical load factor shall be 1.1.

Note 7: For the Manitoba Hydro 500 kV project, all load factors shall be 1.1.

- Additional load cases shall be included for additional line reliability.

Reliability-Based Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
4a	6.4	0.75	0	F	1.0	1.0	1.0	ASCE 7-05, 0.5 in 50-year return Ice Load Zone(load case 2a): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4b	6.4	1.125	0	F	1.0	1.0	1.0	ASCE 7-05, 0.75 in 50-year return Ice Load Zone(load case 2b): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4c	6.4	1.5	0	F	1.0	1.0	1.0	ASCE 7-05, 1.0 in 50-year return Ice Load Zone(load case 2c): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
5	WL x 1.3	0	60	I	1.0	1.0	1.0	Extreme Wind Loading: 200-Year Return Period See Notes 1, 2 and 4

Note 1: WL = Wind Load adjusted for the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 4 and 5 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 3: Ice is assumed to weigh 57 lbs/ft³.

Note 4: The 50-year return period Extreme Wind Load is multiplied by 1.3 to convert to a 200-year return period load (ANSI/ASCE Standard 7-05). The extreme wind loading of special wind regions (as verified by regional studies and utility experience) shall be used if the loads are greater than those specified in Load Case 3.

- Special load cases shall be included to accommodate deflection criteria, unbalanced ice loading, broken wire loading, failure containment and construction and maintenance loading.

Special Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
6	2	0	40	I	1.0	1.0	1.0	Deflection Condition, Structure shape factor=1.0, Not for switch structures See Note 1
7	4	0.5	0	I	1.1	1.1	1.1	Broken Wire (Phase), Structure shape factor=1.0 See Notes 2, 3, and 6
8	0	0.25	32	I	1.1	1.1	1.1	Unbalanced Ice See Notes 3, 4, and 6
9	4	0.5	0	I	1.1	1.1	1.1	Failure Containment Structure See Notes 5 and 6
10	2	0	-20	I	1.5	1.5	1.5	Construction load with wire caught in block or tensioning at structure See Note 6

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: The longitudinal load shall be applied at any one shield wire or one conductor (phase) position.

Note 3: For suspension type attachments, the conductor tension for the Broken Wire or Unbalanced Ice load shall be multiplied by 0.70 to account for the benefit of insulator swing. The Broken Wire or Unbalanced Ice load at the shield wire position shall not be reduced as there is minimal insulator (hardware) swing. For arms with both a shield wire and conductor attachment, the one load creating the most severe condition shall be applied, not both.

Note 4: The differential tensions shall be calculated for 0.25 inch equivalent radial ice load on all conductors and shield wires on one side of the structure with no ice on the other side.

Note 5: This load case is only used on structures designated as Failure Containment structures. This load case shall be applied simultaneously at all wire positions on one side of the structure assuming no tension in the opposite direction.

Note 6: Load Cases 7 through 10 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 7: Ice is assumed to weigh 57 lbs/ft³.

- A high intensity wind load case shall be included that simulates the wind speed of a tornado. This load case shall be applied to the structures only, not to the spans and wires.

High Intensity Wind Load Cases

LC	Weather Case					Load Factors			Comments / Description
	Transv. Wind (PSF)	Long. Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
11a	53.8	0.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, Perpendicular to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11b	38.0	38.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, At 45° to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11c	0	53.8	0	60	I	1.0	1.0	1.0	High Intensity Wind, In-line with line/structure, Structure shape factor=1.0, See Notes 1 and 2

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 11a, 11b, and 11c shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

- Structures shall be designed to the following load case combinations.

Load Cases per Structure Type

LC (see Note 1)	Structure Types				
	Tangent 0° to 2°	**Small Angle 2° to 15°**	**Medium Angle 15° to 30°**	**Non-terminal Deadend 0° to 90°**	**Terminal Deadend 0° to 90°**
1	X	X	X	X	X
1 Wires 1 Side (See Note 2)					X
2a, 2b, 2c (See Note 3)	X	X	X	X	X
3	X	X	X	X	X
4a, 4b, 4c (See Note 4)	X	X	X	X	X
5	X	X	X	X	X
6	X	X	X	X	X
7	X	X	X	X	
8	X	X	X	X	
9				X	
10 (See Note 5)	X	X	X	X	
11a, 11b, 11c (See Note 6)	X	X	X	X	X

Note 1: All Load Cases are with intact conductors and shield wires, unless otherwise noted.

Note 2: Terminal wire loads shall be applied to one side of structure only. Utility responsible for design of that structure shall also determine applicable design wind and weight spans.

Note 3: For application of Load Case 2a, 2b, or 2c, see Required NESC Load Cases Table.

Note 4: For application of Load Case 4a, 4b, or 4c, see Reliability Based Load Cases Table.

Note 5: For tangent, small angle, and medium angle structures, this Load Case shall only apply at one phase or shield wire position, which ever results in the most severe loading acting on the structure, and/or support arm. For non-terminal deadend structure, this Load Case shall apply to all phases and shield wire positions.

Note 6: Load Cases 11a, 11b, and 11c all pertain to the direction of high intensity wind loads as they apply across the structure only. These loads shall not be applied to the supporting spans of conductor and shield wire.

- Failure containment structures shall be spotted at intervals not exceeding ten (10) miles.
- Transposition structures may be required every 60-75 miles in order to maintain the transmission line end-to-end voltage imbalance less than 1%.

- Insulators shall be porcelain or toughened glass bells for suspension and dead end applications. Coordination with Manitoba Hydro to verify same insulation levels will be required. The following lists the proposed insulation levels in terms of number of porcelain or toughened glass bells.

Structure Type	Line Angle	500 kV
		Steel
Tangent	0° to 2°	26
Small Angle	2° to 15°	26
Medium Angle	15° to 30°	28
Deadend Terminal & Non-terminal	0° to 90°	28

- Air gap shall be equivalent to the number of insulators. Coordination with Manitoba Hydro to verify air gap dimensions will be required. The minimum air gap distances shall be as follows.

Design Air Gap Clearances

Air Gap	
	500 kV
Load Case	Steel
No Wind, No Ice, 60° Final (NESC 441)	152"
6# Wind, No Ice, 60° Final	106"
High Wind (21#, No Ice, 120° Final)	44"

- Minimum clearance requirements shall be defined by Section 23 of the NESC C2 2007. Clearance criteria not listed shall be applied per Section 23 of the NESC C2 2007. The following minimum clearances shall be applied for line design.

General Clearances

Clearance Category:	500 kV		Comments
	Design	NESC	
Basic Ground Clearance	38'0"	28'4"	Roads, streets, all land traversed by vehicles, agricultural land, forests, pedestrian only access
State Highways, County Roads	38'0"	28'4"	
Interstate Highway	39'0"	28'4"	
Railroads	39'0"	36'4"	Individual railroads may require additional clearance above tracks.

Minimum clearances between adjacent lines (based on NESC 233 B-1)

Horizontal Clearances Between Adjacent Lines			
Line Sizes	NESC Electrical Clearance	Clearance Envelope	Distance Between Line, Conductors
500-500	25.4'	21.7'	47.1'
500-345	21.8'	21.7'	43.5'
500-230	19.5'	21.7'	41.2'
500-161	18.1'	21.7'	39.8'
500-115	17.2'	21.7'	38.9'
500-69	16.2'	21.7'	37.9'

Minimum vertical clearances between lines on same structures (based on NESC 235)

Same Utility	
kV	**500**
34.5	12.3’
69	13.0’
115	14.0’
161	14.9’
230	16.3’
345	18.6’
500	21.7’

Different Utility	
kV	**500**
34.5	14.3’
69	15.0’
115	16.0’
161	16.9’
230	18.3’
345	20.6’
500	23.7’

Minimum vertical clearance between crossing lines.

Source	**500 kV**	
	NESC	**Design**
34.5 kV	11’4”	13.8’
69 kV	12’0”	14.5’
115 kV	12’11”	15.4’
161 kV	13’11”	16.4’
230 kV	15’3”	17.8’
345 kV	17’7”	20.1’
500 kV	20’6”	23.0’

- The assumed right-of-way width shall be 200 feet. 100 feet either side of transmission line centerline. The line shall be designed to fit within the new easements. The minimum clearance to be maintained from the conductor to the edge of right-of-way shall be as follows.

	500 kV (ft)
Load Case 1	17.4
Load Case 2	17.4
Load Case 3	3.7

Load Case 1	0 PSF Wind, No Ice, -20°F, Initial (NESC 234 A.1.)
Load Case 2	6 PSF Wind, No Ice, 120°F, Final (MH and MN TOs Standards)
Load Case 3	Wind Load From Extreme High Wind Load Case, No Ice, 60°F,Final

III. Right of Way

The new right-of-way shall be 100' on either side of transmission line center line with a total width of 200'. Land owner agreements will be required for access to the transmission line right-of-way. Any construction damages to private landowner property will be negotiated with the landowner.

IV. Specific Design Features (Major Equipment to be Installed)

Five hundred thirty three (533) self-supporting steel 0-2° tangent h-frame structures on drilled pier foundations will be installed.

Seven (7) self-supporting steel 2-15° light angle h-frame structures on drilled pier foundations will be installed.

One (1) 15-30° running angle 3-pole structure on driven pipe pile with concrete pile cap foundations will be installed.

Ten (10) self-supporting steel 0-45° terminal deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Two (2) self-supporting steel 0-45° deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Seven (7) self-supporting steel 45-90° terminal deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Three (3) self-supporting steel 45-90° deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

One hundred twelve (112) miles of 3-phase triple bundled 1192.5 kcmil 45/7 ACSR "Bunting" conductor will be installed.

One hundred twelve (112) miles of 7 no. 7 Alumoweld shield wire will be installed.

One hundred twelve (112) miles of 48 fiber OPGW shield wire will be installed.

Thirty one (31) OPGW shield wire splice boxes will be installed.

Removals & Relocations

No removal required.

Grounding of Structures

Steel structures to be grounded using 1/0 copper ground wire and copperweld ground rods. Shield wire will be bonded to structure using #4 stranded copper.

Desired ground resistance is 10 ohms but maximum ground resistance shall be 25 ohms. Ground resistivity testing will be required once the line route is finalized.

Lightning Protection

A 7 no. 7 Alumoweld and 48 fiber OPGW will be installed to meet fault current requirements.

V. Civil Features

Access, Grading, Fencing and Culvert Work

Access road grading will be required for access to right-of-way. Once the transmission line route is finalized, access roads will be designed. These costs are not included in the estimate.

Storm Water Permit

A storm water permit will be required. Once the line route is finalized, a specific SWPPP will be completed and submitted to the required agencies.

Foundations & Structural

Sixty nine (69) driven pipe pile with concrete pile cap foundations will be required.

One thousand eighty (1080) drilled pier foundations will be required.

VI. Outages

Outages to existing transmission and distribution facilities will be required during stringing construction. Once the route is finalized and construction schedule set, coordination with these facilities will begin.

VII. Project and Operating Concerns

Close coordination with Manitoba Hydro will be required to create an overall design, construction, and permitting timeline for this project.

VIII. Related Projects

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 1A (Canada/North Dakota border to Proposed North Series Cap Bank)

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 2A (Proposed Bison Sub to proposed South Series Cap Bank)

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 2B (Proposed South Series Cap Bank to proposed Helena South Sub)

WO# TBD – 500 kV Bison Substation Facilities Study

WO# TBD – 500 kV Helena South Substation Facilities Study

WO# TBD – 500 kV North Series Cap Bank

WO# TBD – 500 kV South Series Cap Bank

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	MH 500kV TSR - FaSt1 - Line Segment 1B
Sub./Line Name:	
WO #:	
Group Name:	
City:	
County:	
State:	ND
WO Type:	21
Op Co:	NSPM
In-service Date:	
Basic Scope:	

Estimate Information	
Est. Type	
Est Status:	Finalized
Est. Published	3/8/2010
Rev. Number:	
Prepared By:	HDR Engineering
Company:	

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Manageme	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$1,236,163	$0	$0	$1,931,685	$3,167,848
CBS3 - Civil Construction	$31,792,527	$24,371,306	$25,431,678	$4,050,058	$85,645,569
CBS4 - Electrical Construction	$23,159,682	$7,680,980	$56,622,539	$3,284,107	$90,747,309
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$0	$0	$0	$0	$0
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$56,188,372	$32,052,286	$82,054,217	$9,265,850	$179,560,725
Indirect Costs					
Powerplant Overheads (E&S + A&G)	$4,579,352	$2,612,261	$6,341,924	$735,128	$14,268,666
Material overheads	$0	$0	$1,556,300	$0	$1,556,300
AFUDC	$0	$0	$0	$0	$0
Contingency	$6,040,250	$3,141,124	$8,365,115	$0	$17,546,489
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$10,619,602	$5,753,385	$16,263,340	$735,128	$33,371,456
Project Total					**$212,932,181**

Print Date: 4/30/2010

Description	Qty	Unit of Measure	Unit Cost	Total Cost	Materials Total Cost	Labor Total Cost
JOB						
ESCALATION	1	Lump Sum		$0.00	$0.00	$0.00
AFUDC	1	Lump Sum		$0.00	$0.00	$0.00
CONTINGENCY	1	Lump Sum		$17,546,488.97	$8,365,114.94	$6,040,250.00
POWERPLANT AND MATL OVERHEADS	1	Lump Sum		$15,824,966.56	$7,898,224.80	$4,579,352.32
TOTAL USED FOR FORECAST	1	LOT		$3,167,848.29	$0.00	$1,236,163.29
TANGENT 0-2 - MATERIAL & STEEL	533	Each	$80,474.48	$42,892,897.63	$40,541,491.14	$0.00
LIGHT ANGLE 2-15 - MATERIAL & STEEL	7	Each	$88,370.12	$618,590.84	$584,679.43	$0.00
RUNNING ANGLE 15-30 - MATERIAL - STEEL	1	Each		$313,216.09	$296,045.45	$0.00
DEADEND 0-45 - MATERIAL - STEEL	12	Each	$355,492.11	$4,265,905.29	$4,032,046.59	$0.00
DEADEND 45-90 - MATERIAL - STEEL	10	Each	$388,766.21	$3,887,662.07	$3,674,538.82	$0.00
TANGENT 0-2 - LABOR (8 MEN/8 HR/2.5 CREW DAYS)	533	Each	$23,386.51	$12,465,008.71	$0.00	$7,437,967.24
LIGHT ANGLE 2 - 15 - LABOR (8 MEN/8 HR/ 2.7 CREW DAYS)	7	Each	$23,978.12	$167,846.82	$0.00	$99,482.29
RUNNING ANGLE 15 - 30 - LABOR (8 MEN/8 HR/6.6 CREW DAYS)	1	Each		$67,025.61	$0.00	$41,098.01
DEADEND 0 - 45 - LABOR (8 MEN/8 HR/ 6.9 CREW DAYS)	12	Each	$64,586.99	$775,043.88	$0.00	$467,009.93
DEADEND 45 - 90 - LABOR (8 MEN/8 HR/7.5 CREW DAYS)	10	Each	$71,217.71	$712,177.10	$0.00	$429,477.12
MATTING FOR CIVIL (PER FOUNDATION - POOR SOIL)	69	Each	$1,541.69	$106,376.79	$0.00	$82,699.83
INTERNAL-CIVIL RESTORATION CREW-3 MEN/1DAY/10 HR PLUS EQUIPMENT	112	Mile	$2,822.88	$316,332.28	$0.00	$284,711.00
FOUNDATION DRIVEN PILE FOUNDATION MATERIALS	69	Each	$88,370.85	$6,097,588.53	$5,763,316.19	$0.00
FOUNDATION DEEP DRILLED PIER FOUNDATION MATERIALS	1,080	Each	$19,267.71	$20,809,126.66	$19,668,361.68	$0.00
FOUNDATION TYPICAL DRILLED PIER FOUNDATION MATERIALS	0	Each		$0.00	$0.00	$0.00
CIVIL CONSTRUCTION DRIVEN PILE FOUNDATION LABOR (8 MEN/8 HR/9.5 CREW DAYS)	69	Each	$79,512.82	$5,486,384.26	$0.00	$2,898,114.62
CIVIL CONSTRUCTION DEEP DRILLED PIER FOUNDATION LABOR (8 MEN/8 HR/5.5 CREW DAYS)	1,080	Each	$46,046.23	$49,729,925.63	$0.00	$26,269,218.00
CIVIL CONSTRUCTION TYPICAL PIER FOUNDATION LABOR (8 MEN/8 HR/.75 CREW DAYS)	0	Each		$0.00	$0.00	$0.34
CONDUCTOR - 1192.5 KCMIL 45/7	5,325,865	FT	$1.06	$5,634,765.17	$5,325,865.00	$0.00
7 no 7 ALUMOWELD	591,691	FT	$0.57	$335,738.06	$317,332.76	$0.00
OPGW- 48 FIBER SINGLE MODE	597,885	FT	$3.17	$1,897,686.99	$1,793,655.00	$0.00
FIBER OPTIC SPLICE BOX FOR 48 FIBER	31	EA	$1,941.43	$60,184.33	$56,885.00	$0.00
LABOR FOR FIBER OPTIC SPLICE INSTALL	31	Each	$17,310.30	$536,619.27	$0.00	$438,840.66
STRINGING-CONDUCTOR-WEEKLY INTERNAL OH LABOR CREW-30 MEN/4 DAYS/10 HR DAYS	112	Mile	$108,095.01	$12,113,126.54	$0.00	$10,776,754.17
RIGHT OF WAY PREP	112	Mile	$15,000.00	$1,680,900.00	$0.00	$1,263,595.44
MOB/DEMOB - CIVIL CREWS	1	EA		$1,418,933.90	$0.00	$994,187.52
MOB/DEMOBD - LINE CREWS	1	EA		$647,515.37	$0.00	$367,009.19
CONSTRUCTION MANAGEMENT 12 MEN/1DAY/10HR DAYS	336	DAY	$9,988.98	$3,356,298.79	$0.00	$3,102,043.39
				$212,932,180.90	**$98,317,556.82**	**$66,807,974.38**

Name of project / estimate	MH TSR 500KV Facilities Study - Segment 1B
Lead Engineer	HDR Engineering Inc.
Project Manager	Chris Ayika, Jared Alholinna
Creation Date of Estimate	4/9/2010
In-Service Date of Project	12/31/2017
Total Cost (no escalation & no AFUDC)	212,932,181

Estimate spend schedule:

	Approx Cost	Start date	End date
Engineering Design Window	3,167,848	7/1/2010	12/31/2017
Material Delivery Window	98,317,557	11/1/2014	7/31/2015
Construction & Commission Window	111,446,776	2/1/2015	12/31/2015
	212,932,181		

Detailed Project Spend Forecast

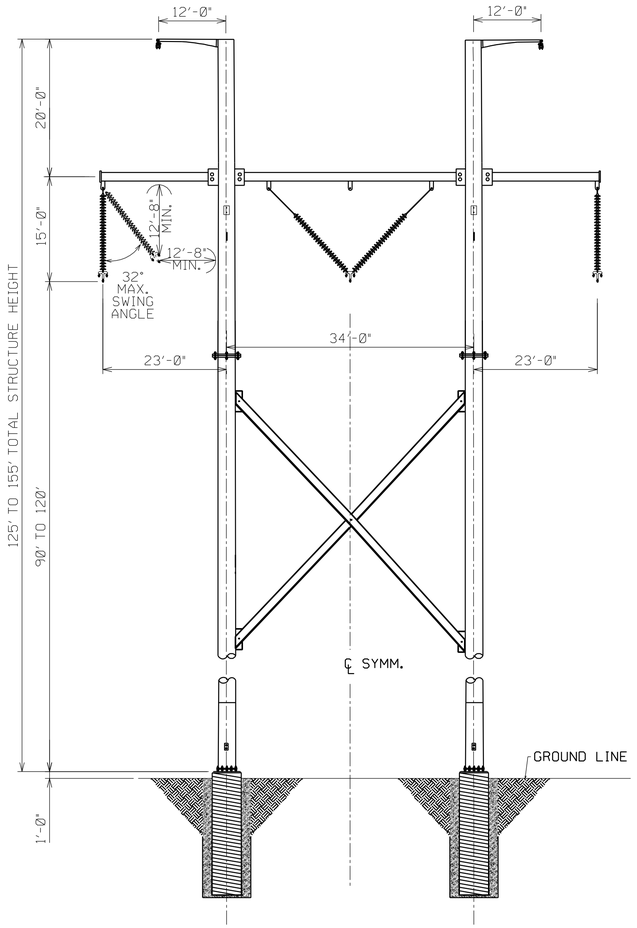
	Approx Cost	Start date	End date	1 Jul-10	2 Aug-10	3 Sep-10	4 Oct-10	5 Nov-10	6 Dec-10	7 Jan-11	8 Feb-11	9 Mar-11	10 Apr-11	11 May-11	12 Jun-11	13 Jul-11	14 Aug-11	15 Sep-11	16 Oct-11	17 Nov-11	18 Dec-11	19 Jan-12	20 Feb-12	21 Mar-12	22 Apr-12	23 May-12	24 Jun-12	25 Jul-12	26 Aug-12	27 Sep-12	28 Oct-12	29 Nov-12	30 Dec-12	31 Jan-13
Engineering Design Window	3,167,848	7/1/2010	12/31/2017	7925	7924	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	23759	23759	23759	23759	31678
Procurement Delivery Window	98,317,557	11/1/2014	7/31/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	111,446,776	2/1/2015	12/31/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	212,932,181			7925	7924	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	7920	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	23759	23759	23759	23759	31678

	32 Feb-13	33 Mar-13	34 Apr-13	35 May-13	36 Jun-13	37 Jul-13	38 Aug-13	39 Sep-13	40 Oct-13	41 Nov-13	42 Dec-13	43 Jan-14	44 Feb-14	45 Mar-14	46 Apr-14	47 May-14	48 Jun-14	49 Jul-14	50 Aug-14	51 Sep-14	52 Oct-14	53 Nov-14	54 Dec-14	55 Jan-15	56 Feb-15	57 Mar-15	58 Apr-15	59 May-15	60 Jun-15	61 Jul-15	62 Aug-15
Engineering Design Window	31678	31678	31678	31678	31678	39598	39598	47518	47518	158392	158392	158392	158392	158392	158392	158392	158392	126714	95035	63357	63357	31678	31678	31678	31678	31678	31678	31678	31678	31678	31678
Procurement Delivery Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10924173	10924173	10924173	10924173	10924173	10924173	10924173	10924173	10924173	0
Construction & Commission Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10131525	10131525	10131525	10131525	10131525	10131525	10131525
Total	31678	31678	31678	31678	31678	39598	39598	47518	47518	158392	158392	158392	158392	158392	158392	158392	158392	126714	95035	63357	63357	10955851	10955851	10955851	21087376	21087376	21087376	21087376	21087376	21087376	10163203

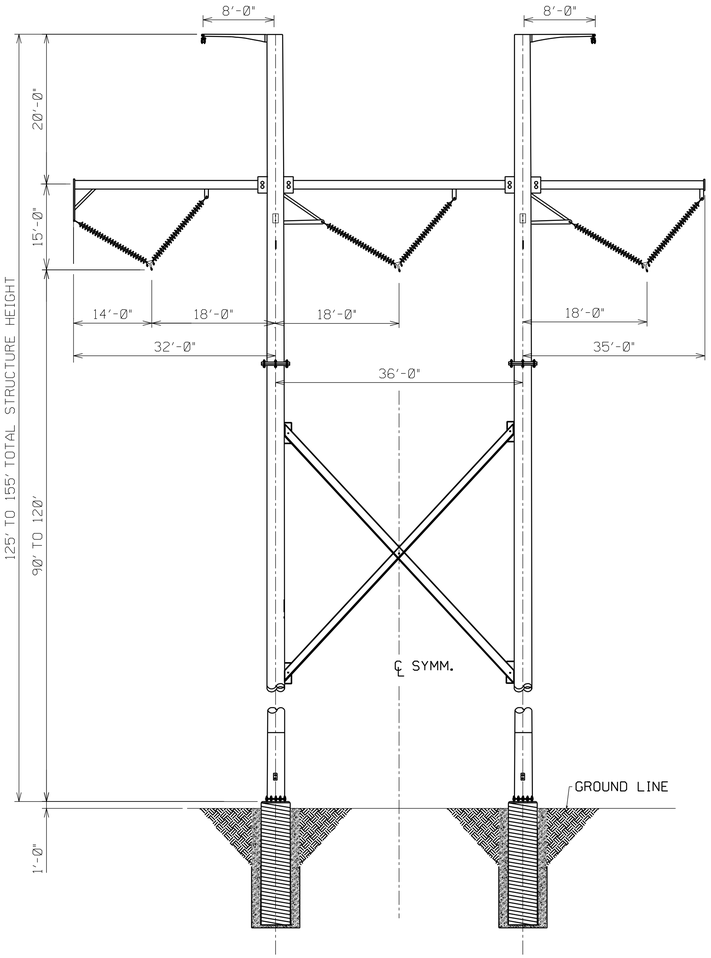
	63 Sep-15	64 Oct-15	65 Nov-15	66 Dec-15	67 Jan-16	68 Feb-16	69 Mar-16	70 Apr-16	71 May-16	72 Jun-16	73 Jul-16	74 Aug-16	75 Sep-16	76 Oct-16	77 Nov-16	78 Dec-16	79 Jan-17	80 Feb-17	81 Mar-17	82 Apr-17	83 May-17	84 Jun-17	85 Jul-17	86 Aug-17	87 Sep-17	88 Oct-17	89 Nov-17	90 Dec-17	91 Jan-18	92 Feb-18	93 Mar-18
Engineering Design Window	31678	31678	23759	23759	23759	23759	23759	23759	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	7920	7920	7920	7920	7920	0	0	0
Procurement Delivery Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	10131525	10131525	10131525	10131525	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	10163203	10163203	10155284	10155284	23759	23759	23759	23759	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	15839	7920	7920	7920	7920	7920	0	0	0

NOTES:

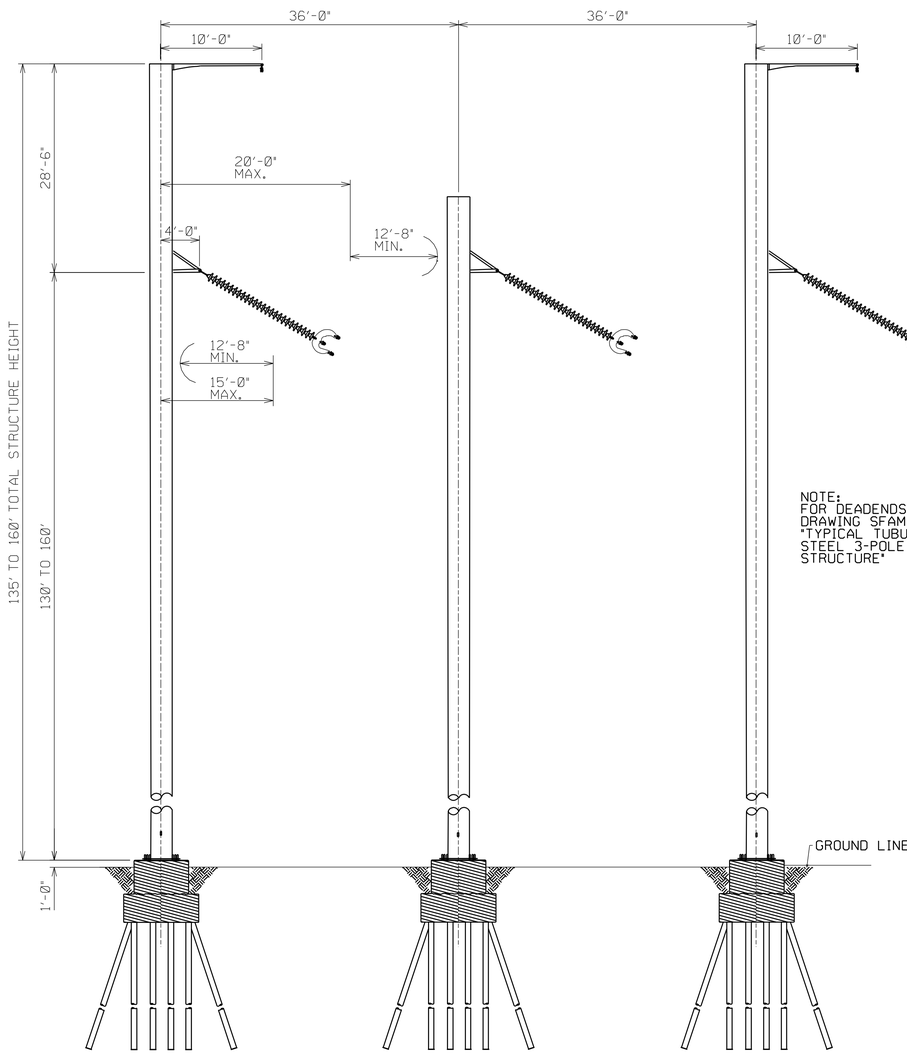
1. SHIELDING ANGLE IS ESTIMATED TO BE NO GREATER THAN 20° FOR AT-REST CONDITIONS.
2. DESIGN WIND & WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.



0°-2° TANGENT SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



2-15° ANGLE SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



NOTE:
FOR DEADENDS SEE DRAWING SFAM-2, "TYPICAL TUBULAR STEEL 3-POLE DEADEND STRUCTURE"

15°-30° RUNNING ANGLE SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER

PROJECT NUMBER

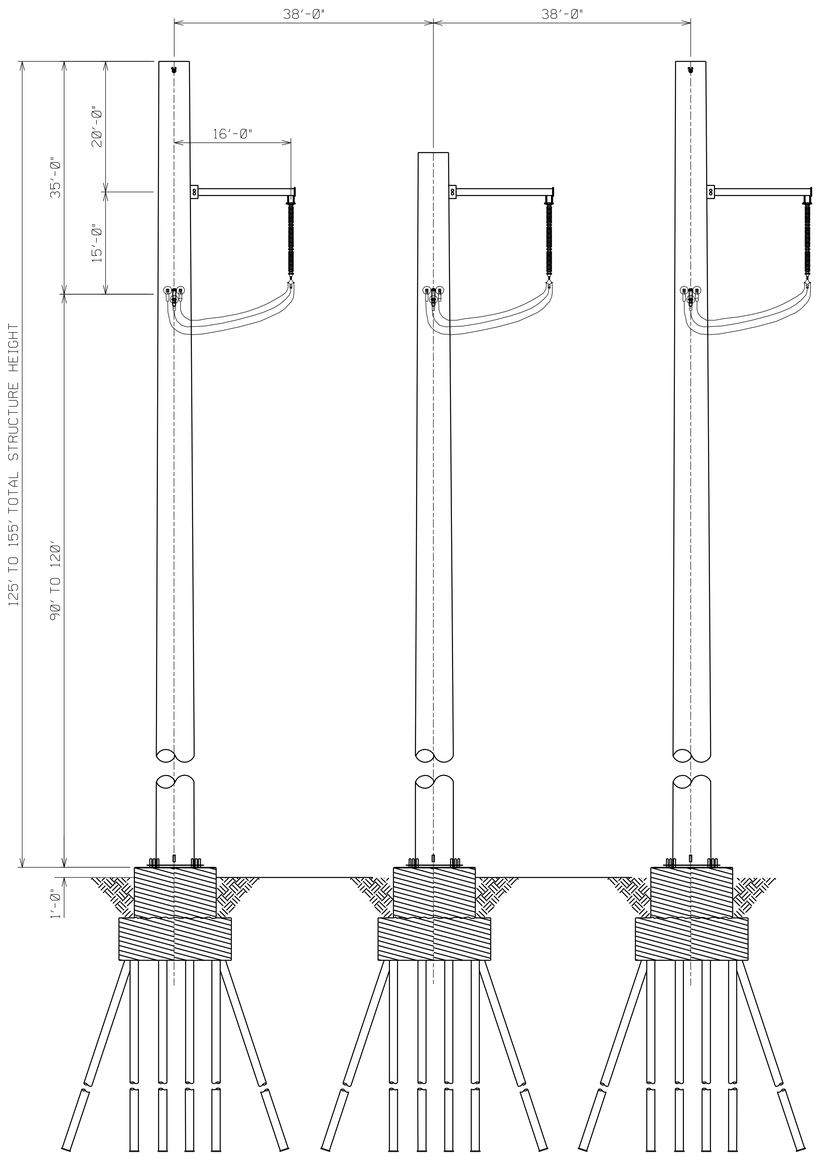
CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

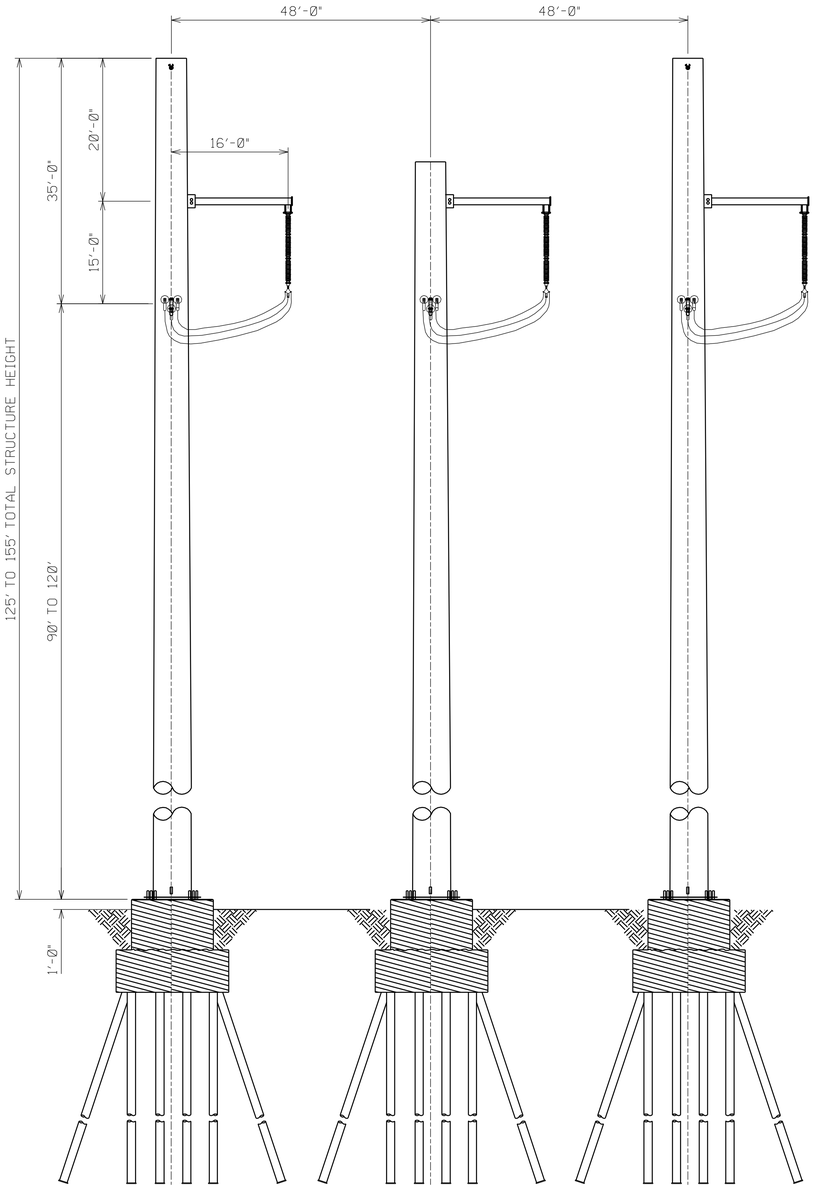
EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME STRUCTURE FAMILY

FILENAME	SFAM1B_2A-1
SCALE	NONE

SHEET
SFAM-1



0° - 45° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



45° - 90° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

NOTES:

1. SHIELDING ANGLE AT DEADENDS IS 0°.
2. DESIGN WIND AND WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME
STRUCTURE FAMILY

FILENAME	SFAM1B_2A-2
SCALE	NONE

SHEET
SFAM-2

PROJECT DESIGN GUIDE

Location: 500 kV, Canada/North Dakota border to Helena South Substation

Project Title: MH TSR 500 kV Option 1 Facilities Study – Segment 2A –Bison Substation to the proposed South Series Cap Bank.

In-Service Date:	December, 2017
Program Manager:	CapX2020
Project Manager:	Chris Ayika (Xcel Energy) Jared Alholinna (CapX2020)
Prepared By:	HDR Engineering, Inc.
Estimate Type (Appropriation or Engineering) and Amount:	Facilities Study $266,470,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the mid-line location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. The proposed 500 kV transmission line will be constructed using self-supporting steel h-frame tangent and light angle structures and self-supporting steel 3-pole heavy angle and deadend structures. Structures will be installed on driven pipe pile with concrete pile cap and concrete drilled pier foundations.

This estimate is for Line Segment 2A- Bison Substation to the proposed South Series Cap Bank. (Approximately 153 miles)

The following items are attached:

- Proposed System One-line Diagram – ***See Facilities Study Executive Summary.***
- Area Map – ***See Permitting and Land Rights section of Facilities Study.***
- Proposed Structure Family Drawings.
- Proposed Project Schedule – ***See Facilities Study Executive Summary.***

Background

Several requests for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service, the study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

The scope of this estimate is limited to the requirements associated with the MISO request. No other considerations have been identified at this time.

II. General Technical Requirements

- Transmission line conductor shall be 3-conductor bundle 1192.5 kcmil 45/7 "Bunting" ACSR with 18 inch sub-spacing.
- Transmission line shield wire shall be 7 no. 7 Alumoweld and 48 fiber OPGW. A shielding study will be required once the line route and structure type has been finalized in order to verify the shield wire is sized to meet fault current requirements.
- The following maximum tension limits shall be applied. Shield wire tension shall be based on 80% of the conductor tension at 60 degrees final.

Weather Case				Tension Limit	
Wind (psf)	**Radial Ice (inches)**	**Temp (°F)**	**Condition**	**NESC Limit 261H1a,b**	**Project Specific Limit**
4	0.5	0	Initial	60% RBS	40% RBS
0	0	0	Final	--	25% RBS
0	0	0	Initial	--	33% RBS
0	0	60	Initial	35% RBS	--
0	0	60	Final	25% RBS	--
0	0	-20	Initial	--	20% RBS for ACSR

- All steel structures will be designed to NESC Grade B Construction "Heavy Loading" per NESC Section 250.

Required NESC Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
1	4	0.5	0	I	1.5	2.5/1.65	1.65	NESC Heavy Grade B k= 0.3 Structural Shape Factor=1.0 See Note 2
2a	6.4	0.5	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2b	6.4	0.75	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2c	6.4	1.0	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
3	21	0	60	I	1.1	1.1	1.1	NESC Extreme Wind See Notes 1,3,7

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Case 1 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms and braces.

Note 3: Load Cases 2 and 3 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 4: Refer to NESC Figure 250-3 for applicable ice and wind loads.

Note 5: Ice is assumed to weigh 57 lbs/ft³.

Note 6: For the Manitoba Hydro 500 kV project, the vertical load factor shall be 1.1.

Note 7: For the Manitoba Hydro 500 kV project, all load factors shall be 1.1.

- Additional load cases shall be included for additional line reliability.

Reliability-Based Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
4a	6.4	0.75	0	F	1.0	1.0	1.0	ASCE 7-05, 0.5 in 50-year return Ice Load Zone(load case 2a): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4b	6.4	1.125	0	F	1.0	1.0	1.0	ASCE 7-05, 0.75 in 50-year return Ice Load Zone(load case 2b): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4c	6.4	1.5	0	F	1.0	1.0	1.0	ASCE 7-05, 1.0 in 50-year return Ice Load Zone(load case 2c): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
5	WL x 1.3	0	60	I	1.0	1.0	1.0	Extreme Wind Loading: 200-Year Return Period See Notes 1, 2 and 4

Note 1: WL = Wind Load adjusted for the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 4 and 5 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 3: Ice is assumed to weigh 57 lbs/ft³.

Note 4: The 50-year return period Extreme Wind Load is multiplied by 1.3 to convert to a 200-year return period load (ANSI/ASCE Standard 7-05). The extreme wind loading of special wind regions (as verified by regional studies and utility experience) shall be used if the loads are greater than those specified in Load Case 3.

- Special load cases shall be included to accommodate deflection criteria, unbalanced ice loading, broken wire loading, failure containment and construction and maintenance loading.

Special Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
6	2	0	40	I	1.0	1.0	1.0	Deflection Condition, Structure shape factor=1.0, Not for switch structures See Note 1
7	4	0.5	0	I	1.1	1.1	1.1	Broken Wire (Phase), Structure shape factor=1.0 See Notes 2, 3, and 6
8	0	0.25	32	I	1.1	1.1	1.1	Unbalanced Ice See Notes 3, 4, and 6
9	4	0.5	0	I	1.1	1.1	1.1	Failure Containment Structure See Notes 5 and 6
10	2	0	-20	I	1.5	1.5	1.5	Construction load with wire caught in block or tensioning at structure See Note 6

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: The longitudinal load shall be applied at any one shield wire or one conductor (phase) position.

Note 3: For suspension type attachments, the conductor tension for the Broken Wire or Unbalanced Ice load shall be multiplied by 0.70 to account for the benefit of insulator swing. The Broken Wire or Unbalanced Ice load at the shield wire position shall not be reduced as there is minimal insulator (hardware) swing. For arms with both a shield wire and conductor attachment, the one load creating the most severe condition shall be applied, not both.

Note 4: The differential tensions shall be calculated for 0.25 inch equivalent radial ice load on all conductors and shield wires on one side of the structure with no ice on the other side.

Note 5: This load case is only used on structures designated as Failure Containment structures. This load case shall be applied simultaneously at all wire positions on one side of the structure assuming no tension in the opposite direction.

Note 6: Load Cases 7 through 10 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 7: Ice is assumed to weigh 57 lbs/ft³.

- A high intensity wind load case shall be included that simulates the wind speed of a tornado. This load case shall be applied to the structures only, not to the spans and wires.

High Intensity Wind Load Cases

LC	Weather Case					Load Factors			Comments / Description
	Transv. Wind (PSF)	Long. Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
11a	53.8	0.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, Perpendicular to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11b	38.0	38.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, At 45° to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11c	0	53.8	0	60	I	1.0	1.0	1.0	High Intensity Wind, In-line with line/structure, Structure shape factor=1.0, See Notes 1 and 2

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 11a, 11b, and 11c shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

- Structures shall be designed to the following load case combinations.

Load Cases per Structure Type

LC (see Note 1)	Structure Types				
	Tangent 0° to 2°	**Small Angle 2° to 15°**	**Medium Angle 15° to 30°**	**Non-terminal Deadend 0° to 90°**	**Terminal Deadend 0° to 90°**
1	X	X	X	X	X
1 Wires 1 Side (See Note 2)					X
2a, 2b, 2c (See Note 3)	X	X	X	X	X
3	X	X	X	X	X
4a, 4b, 4c (See Note 4)	X	X	X	X	X
5	X	X	X	X	X
6	X	X	X	X	X
7	X	X	X	X	
8	X	X	X	X	
9				X	
10 (See Note 5)	X	X	X	X	
11a, 11b, 11c (See Note 6)	X	X	X	X	X

Note 1: All Load Cases are with intact conductors and shield wires, unless otherwise noted.

Note 2: Terminal wire loads shall be applied to one side of structure only. Utility responsible for design of that structure shall also determine applicable design wind and weight spans.

Note 3: For application of Load Case 2a, 2b, or 2c, see Required NESC Load Cases Table.

Note 4: For application of Load Case 4a, 4b, or 4c, see Reliability Based Load Cases Table.

Note 5: For tangent, small angle, and medium angle structures, this Load Case shall only apply at one phase or shield wire position, which ever results in the most severe loading acting on the structure, and/or support arm. For non-terminal deadend structure, this Load Case shall apply to all phases and shield wire positions.

Note 6: Load Cases 11a, 11b, and 11c all pertain to the direction of high intensity wind loads as they apply across the structure only. These loads shall not be applied to the supporting spans of conductor and shield wire.

- Failure containment structures shall be spotted at intervals not exceeding ten (10) miles.
- Transposition structures may be required every 60-75 miles in order to maintain the transmission line end-to-end voltage imbalance less than 1%.

- Insulators shall be porcelain or toughened glass bells for suspension and dead end applications. Coordination with Manitoba Hydro to verify same insulation levels will be required. The following lists the proposed insulation levels in terms of number of porcelain or toughened glass bells.

Structure Type	Line Angle	500 kV
		Steel
Tangent	0° to 2°	26
Small Angle	2° to 15°	26
Medium Angle	15° to 30°	28
Deadend Terminal & Non-terminal	0° to 90°	28

- Air gap shall be equivalent to the number of insulators. Coordination with Manitoba Hydro to verify air gap dimensions will be required. The minimum air gap distances shall be as follows.

Design Air Gap Clearances

Air Gap	
	500 kV
Load Case	Steel
No Wind, No Ice, 60° Final (NESC 441)	152"
6# Wind, No Ice, 60° Final	106"
High Wind (21#, No Ice, 120° Final)	44"

- Minimum clearance requirements shall be defined by Section 23 of the NESC C2 2007. Clearance criteria not listed shall be applied per Section 23 of the NESC C2 2007. The following minimum clearances shall be applied for line design.

General Clearances

Clearance Category:	500 kV		Comments
	Design	NESC	
Basic Ground Clearance	38'0"	28'4"	Roads, streets, all land traversed by vehicles, agricultural land, forests, pedestrian only access
State Highways, County Roads	38'0"	28'4"	
Interstate Highway	39'0"	28'4"	
Railroads	39'0"	36'4"	Individual railroads may require additional clearance above tracks.

Minimum clearances between adjacent lines (based on NESC 233 B-1)

Horizontal Clearances Between Adjacent Lines			
Line Sizes	NESC Electrical Clearance	Clearance Envelope	Distance Between Line, Conductors
500-500	25.4'	21.7'	47.1'
500-345	21.8'	21.7'	43.5'
500-230	19.5'	21.7'	41.2'
500-161	18.1'	21.7'	39.8'
500-115	17.2'	21.7'	38.9'
500-69	16.2'	21.7'	37.9'

Minimum vertical clearances between lines on same structures (based on NESC 235)

Same Utility	
kV	**500**
34.5	12.3’
69	13.0’
115	14.0’
161	14.9’
230	16.3’
345	18.6’
500	21.7’

Different Utility	
kV	**500**
34.5	14.3’
69	15.0’
115	16.0’
161	16.9’
230	18.3’
345	20.6’
500	23.7’

Minimum vertical clearance between crossing lines.

Source	**500 kV**	
	NESC	**Design**
34.5 kV	11’4”	13.8’
69 kV	12’0”	14.5’
115 kV	12’11”	15.4’
161 kV	13’11”	16.4’
230 kV	15’3”	17.8’
345 kV	17’7”	20.1’
500 kV	20’6”	23.0’

- The assumed right-of-way width shall be 200 feet. 100 feet either side of transmission line centerline. The line shall be designed to fit within the new easements. The minimum clearance to be maintained from the conductor to the edge of right-of-way shall be as follows.

	500 kV (ft)
Load Case 1	17.4
Load Case 2	17.4
Load Case 3	3.7

Load Case 1	0 PSF Wind, No Ice, -20°F, Initial (NESC 234 A.1.)
Load Case 2	6 PSF Wind, No Ice, 120°F, Final (MH and MN TOs Standards)
Load Case 3	Wind Load From Extreme High Wind Load Case, No Ice, 60°F,Final

III. Right of Way

The new right-of-way shall be 100' on either side of transmission line center line with a total width of 200'. Land owner agreements will be required for access to the transmission line right-of-way. Any construction damages to private landowner property will be negotiated with the landowner.

IV. Specific Design Features (Major Equipment to be Installed)

Four (4) self-supporting steel 15-30° running angle 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Seven (7) self-supporting steel 0-45° terminal deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Three (3) self-supporting steel 0-45° deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Seven (7) self-supporting steel 45-90° terminal deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Six (6) self-supporting steel 45-90° deadend 3-pole structures on driven pipe pile with concrete pile cap foundations will be installed.

Six hundred seventy six (676) self-supporting steel 0-2° tangent h-frame structures on drilled pier foundations will be installed.

Ten (10) self-supporting steel 2-15° light angle h-frame structures on drilled pier foundations will be installed.

Two (2) self-supporting steel 15-30° running angle 3-pole structures on drilled pier foundations will be installed.

Four (4) self-supporting steel 0-45° terminal deadend 3-pole structures on drilled pier foundations will be installed.

Five (5) self-supporting steel 45-90° terminal deadend 3-pole structures on drilled pier foundations will be installed.

One hundred fifty three (153) miles of 3-phase triple bundled 1192.5 kcmil 45/7 ACSR "Bunting" conductor will be installed.

One hundred fifty three (153) miles of 7 no. 7 Alumoweld shield wire will be installed.

One hundred fifty three (153) miles of 48 fiber OPGW shield wire will be installed.

Thirty nine (39) OPGW shield wire splice boxes will be installed.

Removals & Relocations

No removal required.

Grounding of Structures

Steel structures to be grounded using 1/0 copper ground wire and copperweld ground rods. Shield wire will be bonded to structure using #4 stranded copper.

Desired ground resistance is 10 ohms but maximum ground resistance shall be 25 ohms. Ground resistivity testing will be required once the line route is finalized.

Lightning Protection

A 7 no. 7 Alumoweld and 48 fiber OPGW will be installed to meet fault current requirements.

V. Civil Features

Access, Grading, Fencing and Culvert Work

Access road grading will be required for access to right-of-way. Once the transmission line route is finalized, access roads will be designed. These costs are not included in the estimate.

Storm Water Permit

A storm water permit will be required. Once the line route is finalized, a specific SWPPP will be completed and submitted to the required agencies.

Foundations & Structural

Eighty one (81) driven pipe pile with concrete pile cap foundations will be required.

One thousand four hundred five (1405) drilled pier foundations will be required.

VI. Outages

Outages to existing transmission and distribution facilities will be required during stringing construction. Once the route is finalized and construction schedule set, coordination with these facilities will begin.

VII. Project and Operating Concerns

Close coordination with Manitoba Hydro will be required to create an overall design, construction and permitting timeline for this project.

VIII. Related Projects

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 1A (U.S./Canada border to the proposed North Series Cap Bank.)

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 1B (Proposed North Series Cap Bank to proposed Bison Sub)

WO# TBD – MH 500 kV TSR – Facilities Study – Segment 2B (Proposed South Series Cap Bank to proposed Helena South Sub)

WO# TBD – 500 kV Bison Substation Facilities Study

WO# TBD – 500 kV Helena South Substation Facilities Study

WO# TBD – 500 kV North Series Cap Bank

WO# TBD – 500 kV South Series Cap Bank

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	MH 500kV TSR - FaSt1 - Line Segment 2A
Sub./Line Name:	
WO #:	
Group Name:	
City:	
County:	
State:	MN
WO Type:	21
Op Co:	NSPM
In-service Date:	12/31/2017
Basic Scope:	

Estimate Information	
Est. Type	
Est Status:	Finalized
Est. Published	3/8/2010
Rev. Number:	
Prepared By:	HDR Engineering
Company:	

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Manageme	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$1,359,000	$0	$0	$2,586,725	$3,945,725
CBS3 - Civil Construction	$35,919,302	$26,219,408	$31,457,709	$5,321,397	$98,917,817
CBS4 - Electrical Construction	$30,659,948	$10,043,919	$75,573,991	$5,441,327	$121,719,185
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$0	$0	$0	$0	$0
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$67,938,250	$36,263,327	$107,031,700	$13,349,450	$224,582,726
Indirect Costs					
Powerplant Overheads (E&S + A&G)	$5,536,967	$2,955,461	$8,317,503	$1,058,778	$17,868,710
Material overheads	$0	$0	$2,041,105	$0	$2,041,105
AFUDC	$0	$0	$0	$0	$0
Contingency	$7,303,362	$3,698,859	$10,970,940	$0	$21,973,161
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$12,840,329	$6,654,320	$21,329,548	$1,058,778	$41,882,976
Project Total					**$266,465,703**

Print Date: 4/30/2010

Description	Qty	Unit of Measure	Unit Cost	Total Cost	Materials Total Cost	Labor Total Cost
JOB						
ESCALATION	1	Lump Sum		$0.00	$0.00	$0.00
AFUDC	1	Lump Sum		$0.00	$0.00	$0.00
CONTINGENCY	1	Lump Sum		$21,973,161.06	$10,970,939.87	$7,303,361.89
POWERPLANT AND MATL OVERHEADS	1	Lump Sum		$19,909,815.20	$10,358,608.34	$5,536,967.38
TOTAL USED FOR FORECAST	1	LOT		$3,945,725.00	$0.00	$1,359,000.00
TANGENT 0-2 - MATERIAL & STEEL	676	Each	$81,539.36	$55,120,606.88	$51,418,476.57	$0.00
LIGHT ANGLE 2-15 - MATERIAL & STEEL	10	Each	$89,539.48	$895,394.79	$835,256.33	$0.00
RUNNING ANGLE 15-30 - MATERIAL - STEEL	6	Each	$317,360.72	$1,904,164.34	$1,776,272.70	$0.00
DEADEND 0-45 - MATERIAL - STEEL	14	Each	$360,196.16	$5,042,746.26	$4,704,054.35	$0.00
DEADEND 45-90 - MATERIAL - STEEL	18	Each	$393,910.56	$7,090,390.11	$6,614,169.88	$0.00
TANGENT 0-2 - LABOR (8 MEN/8 HR/2.5 CREW DAYS)	676	Each	$23,386.51	$15,809,279.34	$0.00	$9,433,519.43
LIGHT ANGLE 2 - 15 - LABOR (8 MEN/8 HR/ 2.7 CREW DAYS)	10	Each	$23,978.12	$239,781.17	$0.00	$142,117.56
RUNNING ANGLE 15 - 30 - LABOR (8 MEN/8 HR/6.6 CREW DAYS)	6	Each	$67,025.61	$402,153.68	$0.00	$246,588.09
DEADEND 0 - 45 - LABOR (8 MEN/8 HR/ 6.9 CREW DAYS)	14	Each	$64,586.99	$904,217.85	$0.00	$544,844.92
DEADEND 45 - 90 - LABOR (8 MEN/8 HR/7.5 CREW DAYS)	18	Each	$71,217.71	$1,281,918.77	$0.00	$773,058.82
MATTING FOR CIVIL (PER FOUNDATION - POOR SOIL)	81	Each	$1,541.69	$124,877.10	$0.00	$97,082.41
INTERNAL-CIVIL RESTORATION CREW-3 MEN/1DAY/10 HR PLUS EQUIPMENT	153	Mile	$2,822.88	$431,901.11	$0.00	$388,727.32
FOUNDATION DRIVEN PILE FOUNDATION MATERIALS	81	Each	$89,540.22	$7,252,757.56	$6,765,632.05	$0.00
FOUNDATION DEEP DRILLED PIER FOUNDATION MATERIALS	1,128	Each	$19,522.67	$22,021,571.89	$20,542,511.09	$0.00
FOUNDATION TYPICAL DRILLED PIER FOUNDATION MATERIALS	277	Each	$16,058.97	$4,448,334.85	$4,149,566.09	$0.00
CIVIL CONSTRUCTION DRIVEN PILE FOUNDATION LABOR (8 MEN/8 HR/9.5 CREW DAYS)	81	Each	$79,512.82	$6,440,538.05	$0.00	$3,402,134.55
CIVIL CONSTRUCTION DEEP DRILLED PIER FOUNDATION LABOR (8 MEN/8 HR/5.5 CREW DAYS)	1,128	Each	$46,046.23	$51,940,144.54	$0.00	$27,436,738.80
CIVIL CONSTRUCTION TYPICAL PIER FOUNDATION LABOR (8 MEN/8 HR/.75 CREW DAYS)	277	Each	$4,764.47	$1,319,757.63	$0.00	$955,067.62
CONDUCTOR - 1192.5 KCMIL 45/7	7,272,500	FT	$1.07	$7,796,120.00	$7,272,500.00	$0.00
7 no 7 ALUMOWELD	808,100	FT	$0.57	$464,600.67	$433,396.15	$0.00
OPGW- 48 FIBER SINGLE MODE	816,100	FT	$3.22	$2,624,577.60	$2,448,300.00	$0.00
FIBER OPTIC SPLICE BOX FOR 48 FIBER	39	EA	$1,967.12	$76,717.68	$71,565.00	$0.00
LABOR FOR FIBER OPTIC SPLICE INSTALL	39	Each	$17,310.30	$675,101.67	$0.00	$552,089.87
STRINGING-CONDUCTOR-WEEKLY INTERNAL OH LABOR CREW-30 MEN/4 DAYS/10 HR DAYS	153	Mile	$108,095.01	$16,538,536.15	$0.00	$14,713,933.50
RIGHT OF WAY PREP	153	Mile	$23,000.00	$3,519,000.00	$0.00	$2,645,364.01
MOB/DEMOB - CIVIL CREWS	1	EA		$1,418,933.90	$0.00	$994,187.52
MOB/DEMOBD - LINE CREWS	1	EA		$647,515.37	$0.00	$367,009.19
CONSTRUCTION MANAGEMENT 12 MEN/1DAY/10HR DAYS	421	DAY	$9,988.98	$4,205,362.47	$0.00	$3,886,786.51
				$266,465,702.70	**$128,361,248.43**	**$80,778,579.38**

Name of project / estimate	MH TSR 500KV Facilities Study - Segment 2A
Lead Engineer	HDR Engineering Inc.
Project Manager	Chris Ayika, Jared Alholinna
Creation Date of Estimate	4/9/2010
In-Service Date of Project	12/31/2017
Total Cost (no escalation & no AFUDC)	266,465,703

Estimate spend schedule:

	Approx Cost	Start date	End date
Engineering Design Window	3,945,725	7/1/2010	12/31/2017
Material Delivery Window	128,361,248	6/1/2015	5/31/2016
Construction & Commission Window	134,158,730	1/1/2016	2/28/2017
	266,465,703		

Detailed Project Spend Forecast

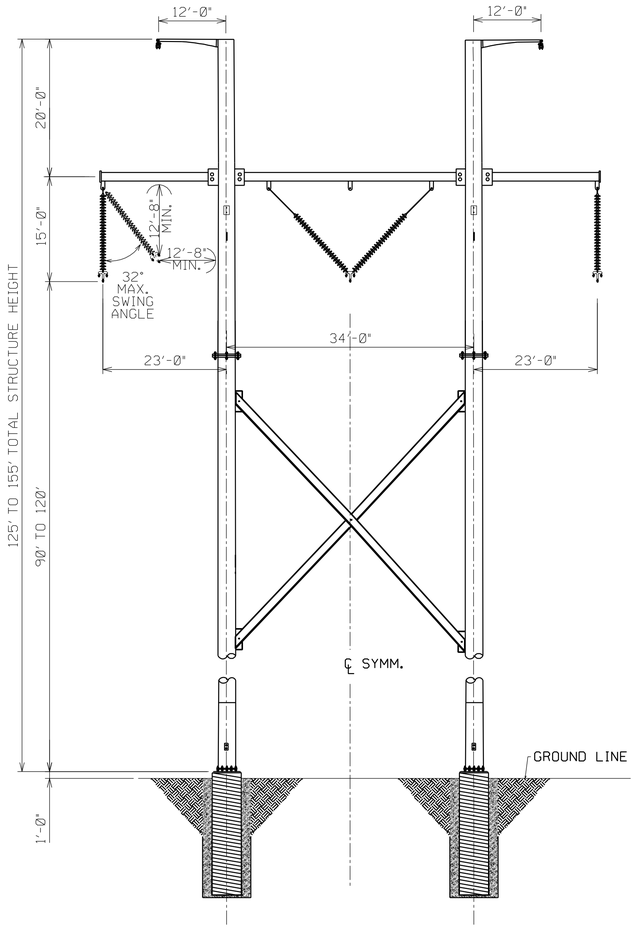
	Approx Cost	Start date	End date	1 Jul-10	2 Aug-10	3 Sep-10	4 Oct-10	5 Nov-10	6 Dec-10	7 Jan-11	8 Feb-11	9 Mar-11	10 Apr-11	11 May-11	12 Jun-11	13 Jul-11	14 Aug-11	15 Sep-11	16 Oct-11	17 Nov-11	18 Dec-11	19 Jan-12	20 Feb-12	21 Mar-12	22 Apr-12	23 May-12	24 Jun-12	25 Jul-12	26 Aug-12	27 Sep-12	28 Oct-12	29 Nov-12	30 Dec-12	31 Jan-13
Engineering Design Window	3,945,725	7/1/2010	12/31/2017	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	29593	29593	29593	29593	39457
Procurement Delivery Window	128,361,248	6/1/2015	5/31/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	134,158,730	1/1/2016	2/28/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	266,465,703			9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	29593	29593	29593	29593	39457

	32 Feb-13	33 Mar-13	34 Apr-13	35 May-13	36 Jun-13	37 Jul-13	38 Aug-13	39 Sep-13	40 Oct-13	41 Nov-13	42 Dec-13	43 Jan-14	44 Feb-14	45 Mar-14	46 Apr-14	47 May-14	48 Jun-14	49 Jul-14	50 Aug-14	51 Sep-14	52 Oct-14	53 Nov-14	54 Dec-14	55 Jan-15	56 Feb-15	57 Mar-15	58 Apr-15	59 May-15	60 Jun-15	61 Jul-15	62 Aug-15
Engineering Design Window	39457	39457	39457	39457	39457	49322	49322	59186	59186	197286	197286	197286	197286	197286	197286	197286	197286	157829	118372	78915	78915	39457	39457	39457	39457	39457	39457	39457	39457	39457	39457	39457
Procurement Delivery Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10696771	10696771	10696771	10696771	10696771
Construction & Commission Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	39457	39457	39457	39457	39457	49322	49322	59186	59186	197286	197286	197286	197286	197286	197286	197286	197286	157829	118372	78915	78915	39457	39457	39457	39457	39457	39457	39457	10736228	10736228	10736228	10736228	10736228

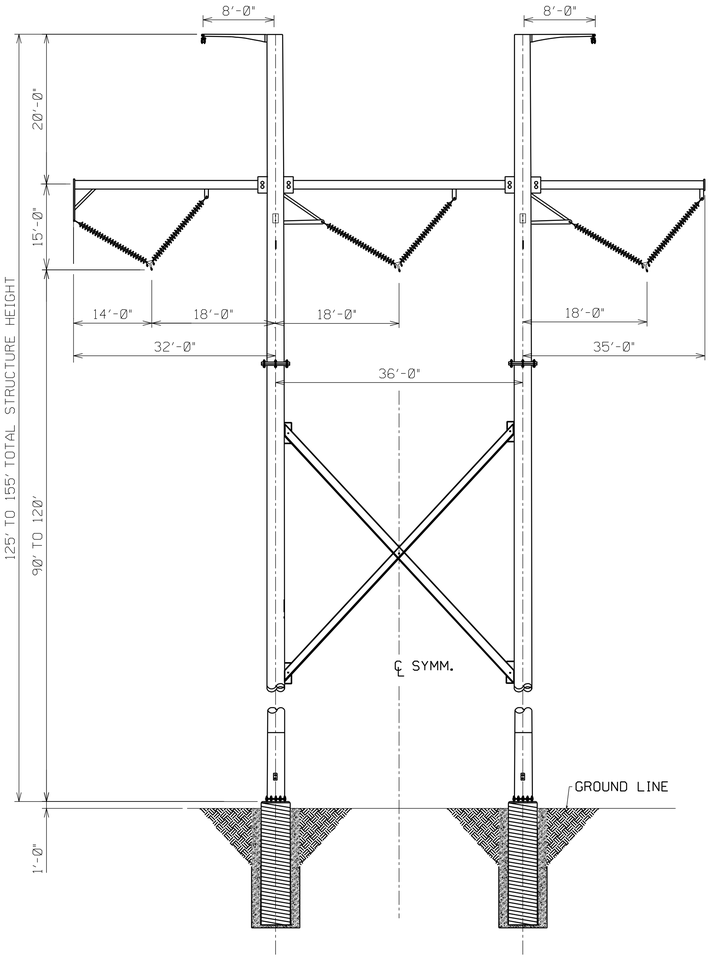
	63 Sep-15	64 Oct-15	65 Nov-15	66 Dec-15	67 Jan-16	68 Feb-16	69 Mar-16	70 Apr-16	71 May-16	72 Jun-16	73 Jul-16	74 Aug-16	75 Sep-16	76 Oct-16	77 Nov-16	78 Dec-16	79 Jan-17	80 Feb-17	81 Mar-17	82 Apr-17	83 May-17	84 Jun-17	85 Jul-17	86 Aug-17	87 Sep-17	88 Oct-17	89 Nov-17	90 Dec-17	91 Jan-18	92 Feb-18	93 Mar-18
Engineering Design Window	39457	39457	29593	29593	29593	29593	29593	29593	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	9864	9864	9864	9864	9864	0	0	0
Procurement Delivery Window	10696771	10696771	10696771	10696771	10696771	10696771	10696771	10696771	10696771	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	0	0	0	0	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	10736228	10736228	10726364	10726364	20309130	20309130	20309130	20309130	20299266	9602495	9602495	9602495	9602495	9602495	9602495	9602495	9602495	9602495	19729	19729	19729	19729	19729	9864	9864	9864	9864	9864	0	0	0

NOTES:

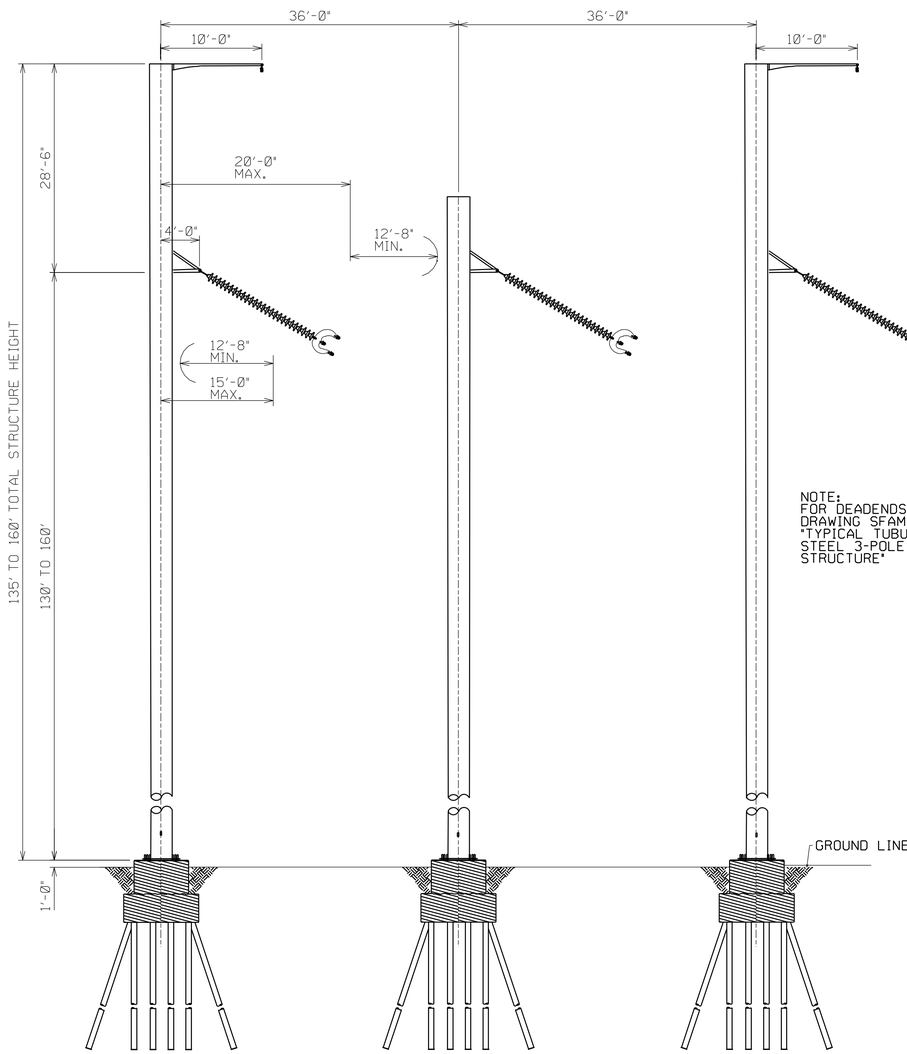
1. SHIELDING ANGLE IS ESTIMATED TO BE NO GREATER THAN 20° FOR AT-REST CONDITIONS.
2. DESIGN WIND & WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.



0°-2° TANGENT SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



2-15° ANGLE SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



NOTE:
FOR DEADENDS SEE DRAWING SFAM-2, "TYPICAL TUBULAR STEEL 3-POLE DEADEND STRUCTURE"

15°-30° RUNNING ANGLE SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER

PROJECT NUMBER

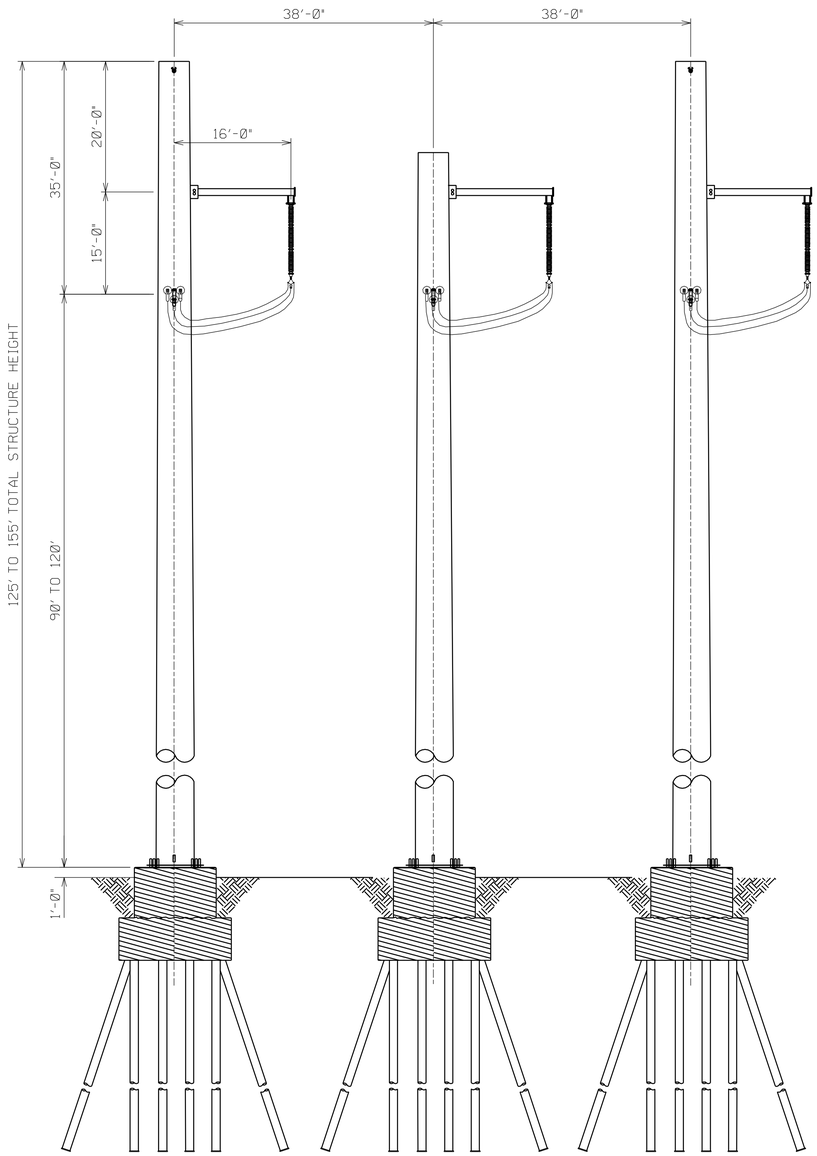
CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

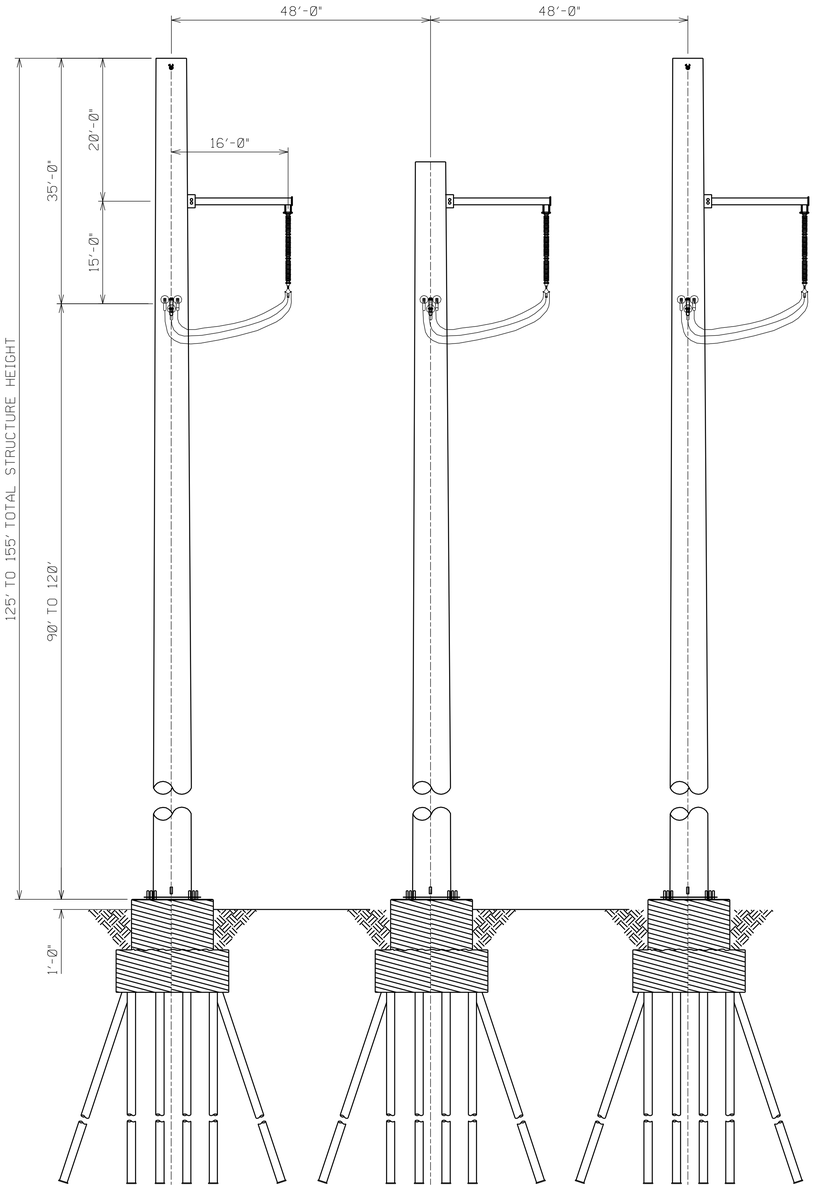
EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME STRUCTURE FAMILY

FILENAME	SFAM1B_2A-1
SCALE	NONE

SHEET
SFAM-1



0° - 45° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



45° - 90° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

NOTES:

1. SHIELDING ANGLE AT DEADENDS IS 0°.
2. DESIGN WIND AND WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME
STRUCTURE FAMILY

FILENAME	SFAM1B_2A-2
SCALE	NONE

SHEET
SFAM-2

PROJECT DESIGN GUIDE

Location: 500 kV, Canada/North Dakota border to Helena South Substation

Project Title: MH TSR 500 kV Option 1 Facilities Study – Segment 2B – Proposed South Series Cap Bank to the proposed Helena South Substation.

In-Service Date:	December, 2017
Program Manager:	CapX2020
Project Manager:	Chris Ayika (Xcel Energy) Jared Alholinna (CapX2020)
Prepared By:	HDR Engineering, Inc.
Estimate Type (Appropriation or Engineering) and Amount:	Facilities Study $226,440,000

I. Project Purpose & Scope

Midwest ISO (MISO) is requesting a facilities study for a new 500 kV transmission line as part of the upgrades proposed for the Manitoba Hydro (MH) group TSR study. The proposed CapX2020 Transmission Owner portion of the 500 kV transmission line will be from the U.S./Canada border to the proposed Bison Substation in the Fargo, North Dakota area to the proposed Helena Substation in Minnesota with 50% series compensation near the mid-line location of the Dorsey – Bison and Bison – Helena line segments (Option 1). The proposed 500 kV transmission line is approximately 552 total miles in length of which 477 miles would be located in North Dakota and Minnesota. The proposed 500 kV transmission line will be constructed using self-supporting steel h-frame tangent and light angle structures and self-supporting steel 3-pole heavy angle and deadend structures. Structures will be installed on driven pipe pile with concrete pile cap and concrete drilled pier foundations.

This estimate is for Line Segment 2B – South Series Cap Bank to the Helena South Substation. (Approximately 160 miles)

The following items are attached:

- Proposed System One-line Diagram – ***See Facilities Study Executive Summary.***
- Area Map – ***See Permitting and Land Rights section of Facilities Study.***
- Proposed Structure Family Drawings.
- Proposed Project Schedule – ***See Facilities Study Executive Summary.***

Background

Several requests for long term transmission service have been made under the Midwest ISO (MISO) open access transmission and energy markets tariff. The requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the U.S. for the proposed transmission service, the study will encompass upgrades for the MH TSR study specifically A000.

Future Considerations

The scope of this estimate is limited to the requirements associated with the MISO request. No other considerations have been identified at this time.

II. General Technical Requirements

- Transmission line conductor shall be 3-conductor bundle 1192.5 kcmil 45/7 "Bunting" ACSR with 18 inch sub-spacing.
- Transmission line shield wire shall be 7 no. 7 Alumoweld and 48 fiber OPGW. A shielding study will be required once the line route and structure type has been finalized in order to verify the shield wire is sized to meet fault current requirements.
- The following maximum tension limits shall be applied. Shield wire tension shall be based on 80% of the conductor tension at 60 degrees final.

Weather Case				Tension Limit	
Wind (psf)	**Radial Ice (inches)**	**Temp (°F)**	**Condition**	**NESC Limit 261H1a,b**	**Project Specific Limit**
4	0.5	0	Initial	60% RBS	40% RBS
0	0	0	Final	--	25% RBS
0	0	0	Initial	--	33% RBS
0	0	60	Initial	35% RBS	--
0	0	60	Final	25% RBS	--
0	0	-20	Initial	--	20% RBS for ACSR

- All steel structures will be designed to NESC Grade B Construction "Heavy Loading" per NESC Section 250.

Required NESC Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
1	4	0.5	0	I	1.5	2.5/1.65	1.65	NESC Heavy Grade B k= 0.3 Structural Shape Factor=1.0 See Note 2
2a	6.4	0.5	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2b	6.4	0.75	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
2c	6.4	1.0	15	F	1.1	1.0	1.0	NESC: Extreme Ice with Concurrent Wind Loading See Note 3,4,6
3	21	0	60	I	1.1	1.1	1.1	NESC Extreme Wind See Notes 1,3,7

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Case 1 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms and braces.

Note 3: Load Cases 2 and 3 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 4: Refer to NESC Figure 250-3 for applicable ice and wind loads.

Note 5: Ice is assumed to weigh 57 lbs/ft³.

Note 6: For the Manitoba Hydro 500 kV project, the vertical load factor shall be 1.1.

Note 7: For the Manitoba Hydro 500 kV project, all load factors shall be 1.1.

- Additional load cases shall be included for additional line reliability.

Reliability-Based Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
4a	6.4	0.75	0	F	1.0	1.0	1.0	ASCE 7-05, 0.5 in 50-year return Ice Load Zone(load case 2a): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4b	6.4	1.125	0	F	1.0	1.0	1.0	ASCE 7-05, 0.75 in 50-year return Ice Load Zone(load case 2b): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
4c	6.4	1.5	0	F	1.0	1.0	1.0	ASCE 7-05, 1.0 in 50-year return Ice Load Zone(load case 2c): 200-Year Return Period Extreme Radial Ice w/ Concurrent Wind Structure shape factor = 1.0 See Note 2
5	WL x 1.3	0	60	I	1.0	1.0	1.0	Extreme Wind Loading: 200-Year Return Period See Notes 1, 2 and 4

Note 1: WL = Wind Load adjusted for the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 4 and 5 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 3: Ice is assumed to weigh 57 lbs/ft³.

Note 4: The 50-year return period Extreme Wind Load is multiplied by 1.3 to convert to a 200-year return period load (ANSI/ASCE Standard 7-05). The extreme wind loading of special wind regions (as verified by regional studies and utility experience) shall be used if the loads are greater than those specified in Load Case 3.

- Special load cases shall be included to accommodate deflection criteria, unbalanced ice loading, broken wire loading, failure containment and construction and maintenance loading.

Special Load Cases

LC	Weather Case				Load Factors			Comments / Description
	Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
6	2	0	40	I	1.0	1.0	1.0	Deflection Condition, Structure shape factor=1.0, Not for switch structures See Note 1
7	4	0.5	0	I	1.1	1.1	1.1	Broken Wire (Phase), Structure shape factor=1.0 See Notes 2, 3, and 6
8	0	0.25	32	I	1.1	1.1	1.1	Unbalanced Ice See Notes 3, 4, and 6
9	4	0.5	0	I	1.1	1.1	1.1	Failure Containment Structure See Notes 5 and 6
10	2	0	-20	I	1.5	1.5	1.5	Construction load with wire caught in block or tensioning at structure See Note 6

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: The longitudinal load shall be applied at any one shield wire or one conductor (phase) position.

Note 3: For suspension type attachments, the conductor tension for the Broken Wire or Unbalanced Ice load shall be multiplied by 0.70 to account for the benefit of insulator swing. The Broken Wire or Unbalanced Ice load at the shield wire position shall not be reduced as there is minimal insulator (hardware) swing. For arms with both a shield wire and conductor attachment, the one load creating the most severe condition shall be applied, not both.

Note 4: The differential tensions shall be calculated for 0.25 inch equivalent radial ice load on all conductors and shield wires on one side of the structure with no ice on the other side.

Note 5: This load case is only used on structures designated as Failure Containment structures. This load case shall be applied simultaneously at all wire positions on one side of the structure assuming no tension in the opposite direction.

Note 6: Load Cases 7 through 10 shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

Note 7: Ice is assumed to weigh 57 lbs/ft³.

- A high intensity wind load case shall be included that simulates the wind speed of a tornado. This load case shall be applied to the structures only, not to the spans and wires.

High Intensity Wind Load Cases

LC	Weather Case					Load Factors			Comments / Description
	Transv. Wind (PSF)	Long. Wind (PSF)	Ice (IN)	Temp (°F)	F/I	Vert.	Transv.	Long.	
11a	53.8	0.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, Perpendicular to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11b	38.0	38.0	0	60	I	1.0	1.0	1.0	High Intensity Wind, At 45° to line/structure, Structure shape factor=1.0, See Notes 1 and 2
11c	0	53.8	0	60	I	1.0	1.0	1.0	High Intensity Wind, In-line with line/structure, Structure shape factor=1.0, See Notes 1 and 2

Note 1: Wind Load must be adjusted to accommodate the Velocity Pressure Exposure Coefficient and Gust Response Factor per NESC 250 C. The shape factor and importance factor shall be taken as 1.0.

Note 2: Load Cases 11a, 11b, and 11c shall have a Strength Factor of 1.0 applied to metal structures, poles, crossarms, and braces.

- Structures shall be designed to the following load case combinations.

Load Cases per Structure Type

LC (see Note 1)	Structure Types				
	Tangent 0° to 2°	**Small Angle 2° to 15°**	**Medium Angle 15° to 30°**	**Non-terminal Deadend 0° to 90°**	**Terminal Deadend 0° to 90°**
1	X	X	X	X	X
1 Wires 1 Side (See Note 2)					X
2a, 2b, 2c (See Note 3)	X	X	X	X	X
3	X	X	X	X	X
4a, 4b, 4c (See Note 4)	X	X	X	X	X
5	X	X	X	X	X
6	X	X	X	X	X
7	X	X	X	X	
8	X	X	X	X	
9				X	
10 (See Note 5)	X	X	X	X	
11a, 11b, 11c (See Note 6)	X	X	X	X	X

Note 1: All Load Cases are with intact conductors and shield wires, unless otherwise noted.

Note 2: Terminal wire loads shall be applied to one side of structure only. Utility responsible for design of that structure shall also determine applicable design wind and weight spans.

Note 3: For application of Load Case 2a, 2b, or 2c, see Required NESC Load Cases Table.

Note 4: For application of Load Case 4a, 4b, or 4c, see Reliability Based Load Cases Table.

Note 5: For tangent, small angle, and medium angle structures, this Load Case shall only apply at one phase or shield wire position, which ever results in the most severe loading acting on the structure, and/or support arm. For non-terminal deadend structure, this Load Case shall apply to all phases and shield wire positions.

Note 6: Load Cases 11a, 11b, and 11c all pertain to the direction of high intensity wind loads as they apply across the structure only. These loads shall not be applied to the supporting spans of conductor and shield wire.

- Failure containment structures shall be spotted at intervals not exceeding ten (10) miles.
- Transposition structures may be required every 60-75 miles in order to maintain the transmission line end-to-end voltage imbalance less than 1%.

- Insulators shall be porcelain or toughened glass bells for suspension and dead end applications. Coordination with Manitoba Hydro to verify same insulation levels will be required. The following lists the proposed insulation levels in terms of number of porcelain or toughened glass bells.

Structure Type	Line Angle	500 kV
		Steel
Tangent	0° to 2°	26
Small Angle	2° to 15°	26
Medium Angle	15° to 30°	28
Deadend Terminal & Non-terminal	0° to 90°	28

- Air gap shall be equivalent to the number of insulators. Coordination with Manitoba Hydro to verify air gap dimensions will be required. The minimum air gap distances shall be as follows.

Design Air Gap Clearances

Air Gap	
	500 kV
Load Case	Steel
No Wind, No Ice, 60° Final (NESC 441)	152"
6# Wind, No Ice, 60° Final	106"
High Wind (21#, No Ice, 120° Final)	44"

- Minimum clearance requirements shall be defined by Section 23 of the NESC C2 2007. Clearance criteria not listed shall be applied per Section 23 of the NESC C2 2007. The following minimum clearances shall be applied for line design.

General Clearances

Clearance Category:	500 kV		Comments
	Design	NESC	
Basic Ground Clearance	38'0"	28'4"	Roads, streets, all land traversed by vehicles, agricultural land, forests, pedestrian only access
State Highways, County Roads	38'0"	28'4"	
Interstate Highway	39'0"	28'4"	
Railroads	39'0"	36'4"	Individual railroads may require additional clearance above tracks.

Minimum clearances between adjacent lines (based on NESC 233 B-1)

Horizontal Clearances Between Adjacent Lines			
Line Sizes	NESC Electrical Clearance	Clearance Envelope	Distance Between Line, Conductors
500-500	25.4'	21.7'	47.1'
500-345	21.8'	21.7'	43.5'
500-230	19.5'	21.7'	41.2'
500-161	18.1'	21.7'	39.8'
500-115	17.2'	21.7'	38.9'
500-69	16.2'	21.7'	37.9'

Minimum vertical clearances between lines on same structures (based on NESC 235)

Same Utility	
kV	**500**
34.5	12.3’
69	13.0’
115	14.0’
161	14.9’
230	16.3’
345	18.6’
500	21.7’

Different Utility	
kV	**500**
34.5	14.3’
69	15.0’
115	16.0’
161	16.9’
230	18.3’
345	20.6’
500	23.7’

Minimum vertical clearance between crossing lines.

Source	**500 kV**	
	NESC	**Design**
34.5 kV	11’4”	13.8’
69 kV	12’0”	14.5’
115 kV	12’11”	15.4’
161 kV	13’11”	16.4’
230 kV	15’3”	17.8’
345 kV	17’7”	20.1’
500 kV	20’6”	23.0’

- The assumed right-of-way width shall be 200 feet. 100 feet either side of transmission line centerline. The line shall be designed to fit within the new easements. The minimum clearance to be maintained from the conductor to the edge of right-of-way shall be as follows.

	500 kV (ft)
Load Case 1	17.4
Load Case 2	17.4
Load Case 3	3.7

Load Case 1	0 PSF Wind, No Ice, -20°F, Initial (NESC 234 A.1.)
Load Case 2	6 PSF Wind, No Ice, 120°F, Final (MH and MN TOs Standards)
Load Case 3	Wind Load From Extreme High Wind Load Case, No Ice, 60°F,Final

III. Right of Way

The new right-of-way shall be 100' on either side of transmission line center line with a total width of 200'. Land owner agreements will be required for access to the transmission line right-of-way. Any construction damages to private landowner property will be negotiated with the landowner.

IV. Specific Design Features (Major Equipment to be Installed)

Seven hundred eighteen (718) self-supporting steel 0-2° tangent h-frame structures on drilled pier foundations will be installed.

Fifty (50) self supporting steel 2-15° light angle h-frame structures on drilled pier foundations will be installed.

Sixteen (16) self-supporting steel 15-30° running angle 3-pole structures on drilled pier foundations will be installed.

Three (3) self-supporting steel 0-45° terminal deadend 3-pole structures on drilled pier foundations will be installed.

Twelve (12) self-supporting steel 0-45° deadend 3-pole structures on drilled pier foundations will be installed.

Twenty four (24) self-supporting steel 45-90° terminal deadend 3-pole structures on drilled pier foundations will be installed.

Eleven (11) self-supporting steel 45-90° deadend 3-pole structures on drilled pier foundations will be installed.

One hundred sixty (160) miles of 3-phase of triple bundled 1192.5 kcmil 45/7 ACSR "Bunting" conductor will be installed.

One hundred sixty (160) miles of 7 no. 7 Alumoweld shield wire will be installed.

One hundred sixty (160) miles of 48 fiber OPGW shield wire will be installed.

Forty (40) OPGW shield wire splice boxes will be installed.

Removals & Relocations

No removal required.

Grounding of Structures

Steel structures to be grounded using 1/0 copper ground wire and copperweld ground rods. Shield wire will be bonded to structure using #4 stranded copper.

Desired ground resistance is 10 ohms but maximum ground resistance shall be 25 ohms. Ground resistivity testing will be required once the line route is finalized.

Lightning Protection

A 7 no. 7 Alumoweld and 48 fiber OPGW will be installed to meet fault current requirements.

V. Civil Features

Access, Grading, Fencing and Culvert Work

Access road grading will be required for access to right-of-way. Once the transmission line route is finalized, access roads will be designed. These costs are not included in the estimate.

Storm Water Permit

A storm water permit will be required. Once the line route is finalized, a specific SWPPP will be completed and submitted to the required agencies.

Foundations & Structural

One thousand seven hundred thirty four (1734) drilled pier foundations will be required.

VI. Outages

Outages to existing transmission and distribution facilities will be required during stringing construction. Once the route is finalized and construction schedule set, coordination with these facilities will begin.

VII. Project and Operating Concerns

Close coordination with Manitoba Hydro will be required to create an overall design, construction and permitting timeline for this project.

VIII. Related Projects

WO# TBD-MH 500 kV TSR – Facilities Study – Segment 1A (U.S./Canada border to the proposed North Series Cap Bank)

WO# TBD-MH 500 kV TSR – Facilities Study – Segment 1B (Proposed North Series Cap Bank to proposed Bison Sub)

WO# TBD-MH 500 kV TSR – Facilities Study – Segment 2A (Proposed Bison Sub to proposed South Series Cap Bank)

WO# TBD-500 kV Bison Substation Facilities Study

WO# TBD-500 kV Helena South Substation Facilities Study

WO# TBD-500 kV North Series Cap Bank

WO# TBD-500 kV South Series Cap Bank

Xcel Energy
Project Estimate Summary

Project Information	
Job Folder Name	MH 500kV TSR - FaSt1 - Line Segment 2A
Sub./Line Name:	
WO #:	
Group Name:	
City:	
County:	
State:	MN
WO Type:	21
Op Co:	NSPM
In-service Date:	12/31/2017
Basic Scope:	

Estimate Information	
Est. Type	
Est Status:	Finalized
Est. Published	3/8/2010
Rev. Number:	
Prepared By:	HDR Engineering
Company:	

Estimate Summary

WBS Costs	Labor	Equipment	Material	Other	Total
CBS1 - Permitting/Project Manageme	$0	$0	$0	$0	$0
CBS2 - Engineering/Design	$1,359,000	$0	$0	$2,586,725	$3,945,725
CBS3 - Civil Construction	$35,919,302	$26,219,408	$31,457,709	$5,321,397	$98,917,817
CBS4 - Electrical Construction	$30,659,948	$10,043,919	$75,573,991	$5,441,327	$121,719,185
CBS5 - Construction Remove	$0	$0	$0	$0	$0
CBS6 - Commissioning	$0	$0	$0	$0	$0
CBS7 - CIAC and Other	$0	$0	$0	$0	$0
Direct Cost Subtotal	$67,938,250	$36,263,327	$107,031,700	$13,349,450	$224,582,726
Indirect Costs					
Powerplant Overheads (E&S + A&G)	$5,536,967	$2,955,461	$8,317,503	$1,058,778	$17,868,710
Material overheads	$0	$0	$2,041,105	$0	$2,041,105
AFUDC	$0	$0	$0	$0	$0
Contingency	$7,303,362	$3,698,859	$10,970,940	$0	$21,973,161
Escalation	$0	$0	$0	$0	$0
Indirect Cost Subtotal	$12,840,329	$6,654,320	$21,329,548	$1,058,778	$41,882,976
Project Total					**$266,465,703**

Print Date: 4/30/2010

Description	Qty	Unit of Measure	Unit Cost	Total Cost	Materials Total Cost	Labor Total Cost
JOB						
ESCALATION	1	Lump Sum		$0.00	$0.00	$0.00
AFUDC	1	Lump Sum		$0.00	$0.00	$0.00
CONTINGENCY	1	Lump Sum		$21,973,161.06	$10,970,939.87	$7,303,361.89
POWERPLANT AND MATL OVERHEADS	1	Lump Sum		$19,909,815.20	$10,358,608.34	$5,536,967.38
TOTAL USED FOR FORECAST	1	LOT		$3,945,725.00	$0.00	$1,359,000.00
TANGENT 0-2 - MATERIAL & STEEL	676	Each	$81,539.36	$55,120,606.88	$51,418,476.57	$0.00
LIGHT ANGLE 2-15 - MATERIAL & STEEL	10	Each	$89,539.48	$895,394.79	$835,256.33	$0.00
RUNNING ANGLE 15-30 - MATERIAL - STEEL	6	Each	$317,360.72	$1,904,164.34	$1,776,272.70	$0.00
DEADEND 0-45 - MATERIAL - STEEL	14	Each	$360,196.16	$5,042,746.26	$4,704,054.35	$0.00
DEADEND 45-90 - MATERIAL - STEEL	18	Each	$393,910.56	$7,090,390.11	$6,614,169.88	$0.00
TANGENT 0-2 - LABOR (8 MEN/8 HR/2.5 CREW DAYS)	676	Each	$23,386.51	$15,809,279.34	$0.00	$9,433,519.43
LIGHT ANGLE 2 - 15 - LABOR (8 MEN/8 HR/ 2.7 CREW DAYS)	10	Each	$23,978.12	$239,781.17	$0.00	$142,117.56
RUNNING ANGLE 15 - 30 - LABOR (8 MEN/8 HR/6.6 CREW DAYS)	6	Each	$67,025.61	$402,153.68	$0.00	$246,588.09
DEADEND 0 - 45 - LABOR (8 MEN/8 HR/ 6.9 CREW DAYS)	14	Each	$64,586.99	$904,217.85	$0.00	$544,844.92
DEADEND 45 - 90 - LABOR (8 MEN/8 HR/7.5 CREW DAYS)	18	Each	$71,217.71	$1,281,918.77	$0.00	$773,058.82
MATTING FOR CIVIL (PER FOUNDATION - POOR SOIL)	81	Each	$1,541.69	$124,877.10	$0.00	$97,082.41
INTERNAL-CIVIL RESTORATION CREW-3 MEN/1DAY/10 HR PLUS EQUIPMENT	153	Mile	$2,822.88	$431,901.11	$0.00	$388,727.32
FOUNDATION DRIVEN PILE FOUNDATION MATERIALS	81	Each	$89,540.22	$7,252,757.56	$6,765,632.05	$0.00
FOUNDATION DEEP DRILLED PIER FOUNDATION MATERIALS	1,128	Each	$19,522.67	$22,021,571.89	$20,542,511.09	$0.00
FOUNDATION TYPICAL DRILLED PIER FOUNDATION MATERIALS	277	Each	$16,058.97	$4,448,334.85	$4,149,566.09	$0.00
CIVIL CONSTRUCTION DRIVEN PILE FOUNDATION LABOR (8 MEN/8 HR/9.5 CREW DAYS)	81	Each	$79,512.82	$6,440,538.05	$0.00	$3,402,134.55
CIVIL CONSTRUCTION DEEP DRILLED PIER FOUNDATION LABOR (8 MEN/8 HR/5.5 CREW DAYS)	1,128	Each	$46,046.23	$51,940,144.54	$0.00	$27,436,738.80
CIVIL CONSTRUCTION TYPICAL PIER FOUNDATION LABOR (8 MEN/8 HR/.75 CREW DAYS)	277	Each	$4,764.47	$1,319,757.63	$0.00	$955,067.62
CONDUCTOR - 1192.5 KCMIL 45/7	7,272,500	FT	$1.07	$7,796,120.00	$7,272,500.00	$0.00
7 no 7 ALUMOWELD	808,100	FT	$0.57	$464,600.67	$433,396.15	$0.00
OPGW- 48 FIBER SINGLE MODE	816,100	FT	$3.22	$2,624,577.60	$2,448,300.00	$0.00
FIBER OPTIC SPLICE BOX FOR 48 FIBER	39	EA	$1,967.12	$76,717.68	$71,565.00	$0.00
LABOR FOR FIBER OPTIC SPLICE INSTALL	39	Each	$17,310.30	$675,101.67	$0.00	$552,089.87
STRINGING-CONDUCTOR-WEEKLY INTERNAL OH LABOR CREW-30 MEN/4 DAYS/10 HR DAYS	153	Mile	$108,095.01	$16,538,536.15	$0.00	$14,713,933.50
RIGHT OF WAY PREP	153	Mile	$23,000.00	$3,519,000.00	$0.00	$2,645,364.01
MOB/DEMOB - CIVIL CREWS	1	EA		$1,418,933.90	$0.00	$994,187.52
MOB/DEMOBD - LINE CREWS	1	EA		$647,515.37	$0.00	$367,009.19
CONSTRUCTION MANAGEMENT 12 MEN/1DAY/10HR DAYS	421	DAY	$9,988.98	$4,205,362.47	$0.00	$3,886,786.51
				$266,465,702.70	**$128,361,248.43**	**$80,778,579.38**

Name of project / estimate	MH TSR 500KV Facilities Study - Segment 2A
Lead Engineer	HDR Engineering Inc.
Project Manager	Chris Ayika, Jared Alholinna
Creation Date of Estimate	4/9/2010
In-Service Date of Project	12/31/2017
Total Cost (no escalation & no AFUDC)	266,465,703

Estimate spend schedule:

	Approx Cost	Start date	End date
Engineering Design Window	3,945,725	7/1/2010	12/31/2017
Material Delivery Window	128,361,248	6/1/2015	5/31/2016
Construction & Commission Window	134,158,730	1/1/2016	2/28/2017
	266,465,703		

Detailed Project Spend Forecast

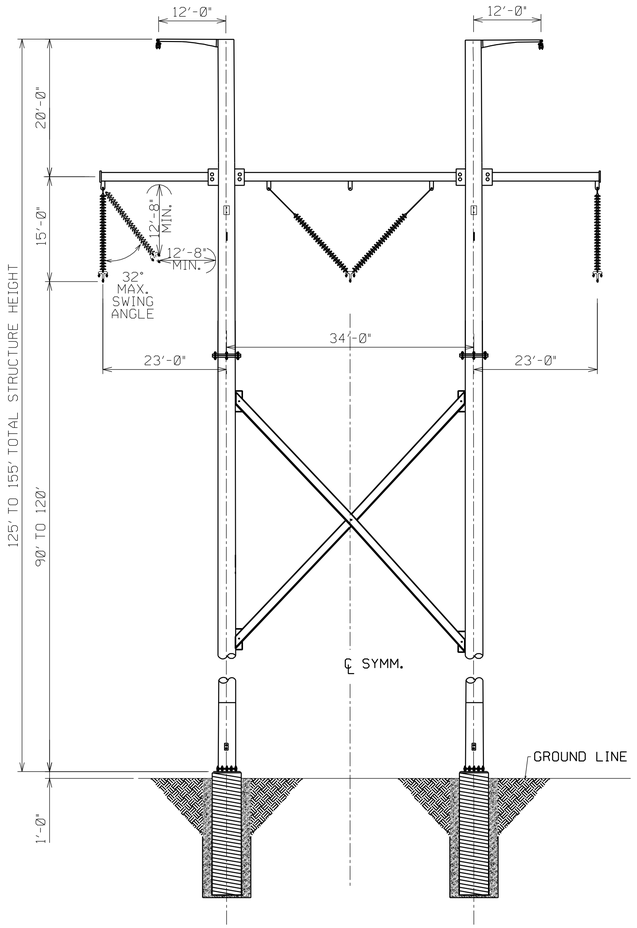
	Approx Cost	Start date	End date	1 Jul-10	2 Aug-10	3 Sep-10	4 Oct-10	5 Nov-10	6 Dec-10	7 Jan-11	8 Feb-11	9 Mar-11	10 Apr-11	11 May-11	12 Jun-11	13 Jul-11	14 Aug-11	15 Sep-11	16 Oct-11	17 Nov-11	18 Dec-11	19 Jan-12	20 Feb-12	21 Mar-12	22 Apr-12	23 May-12	24 Jun-12	25 Jul-12	26 Aug-12	27 Sep-12	28 Oct-12	29 Nov-12	30 Dec-12	31 Jan-13
Engineering Design Window	3,945,725	7/1/2010	12/31/2017	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	29593	29593	29593	29593	39457
Procurement Delivery Window	128,361,248	6/1/2015	5/31/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	134,158,730	1/1/2016	2/28/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	266,465,703			9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	9864	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	29593	29593	29593	29593	39457

	32 Feb-13	33 Mar-13	34 Apr-13	35 May-13	36 Jun-13	37 Jul-13	38 Aug-13	39 Sep-13	40 Oct-13	41 Nov-13	42 Dec-13	43 Jan-14	44 Feb-14	45 Mar-14	46 Apr-14	47 May-14	48 Jun-14	49 Jul-14	50 Aug-14	51 Sep-14	52 Oct-14	53 Nov-14	54 Dec-14	55 Jan-15	56 Feb-15	57 Mar-15	58 Apr-15	59 May-15	60 Jun-15	61 Jul-15	62 Aug-15
Engineering Design Window	39457	39457	39457	39457	39457	49322	49322	59186	59186	197286	197286	197286	197286	197286	197286	197286	197286	157829	118372	78915	78915	39457	39457	39457	39457	39457	39457	39457	39457	39457	39457	39457
Procurement Delivery Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10696771	10696771	10696771	10696771	10696771
Construction & Commission Window	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	39457	39457	39457	39457	39457	49322	49322	59186	59186	197286	197286	197286	197286	197286	197286	197286	197286	157829	118372	78915	78915	39457	39457	39457	39457	39457	39457	39457	10736228	10736228	10736228	10736228	10736228

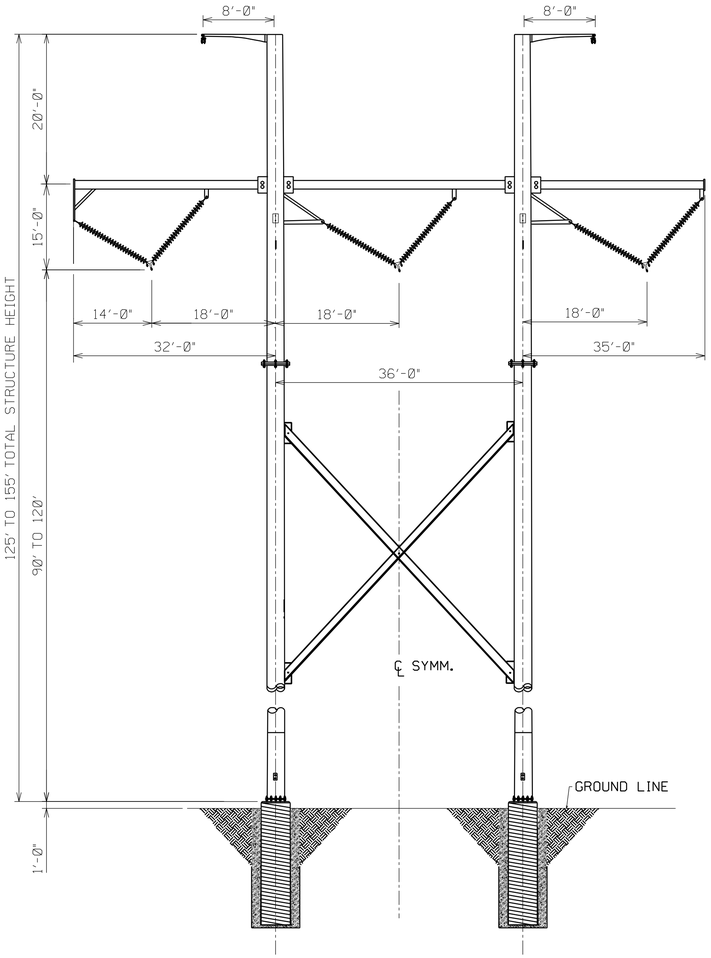
	63 Sep-15	64 Oct-15	65 Nov-15	66 Dec-15	67 Jan-16	68 Feb-16	69 Mar-16	70 Apr-16	71 May-16	72 Jun-16	73 Jul-16	74 Aug-16	75 Sep-16	76 Oct-16	77 Nov-16	78 Dec-16	79 Jan-17	80 Feb-17	81 Mar-17	82 Apr-17	83 May-17	84 Jun-17	85 Jul-17	86 Aug-17	87 Sep-17	88 Oct-17	89 Nov-17	90 Dec-17	91 Jan-18	92 Feb-18	93 Mar-18
Engineering Design Window	39457	39457	29593	29593	29593	29593	29593	29593	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	19729	9864	9864	9864	9864	9864	0	0	0
Procurement Delivery Window	10696771	10696771	10696771	10696771	10696771	10696771	10696771	10696771	10696771	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction & Commission Window	0	0	0	0	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	9582766	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	10736228	10736228	10726364	10726364	20309130	20309130	20309130	20309130	20299266	9602495	9602495	9602495	9602495	9602495	9602495	9602495	9602495	9602495	19729	19729	19729	19729	19729	9864	9864	9864	9864	9864	0	0	0

NOTES:

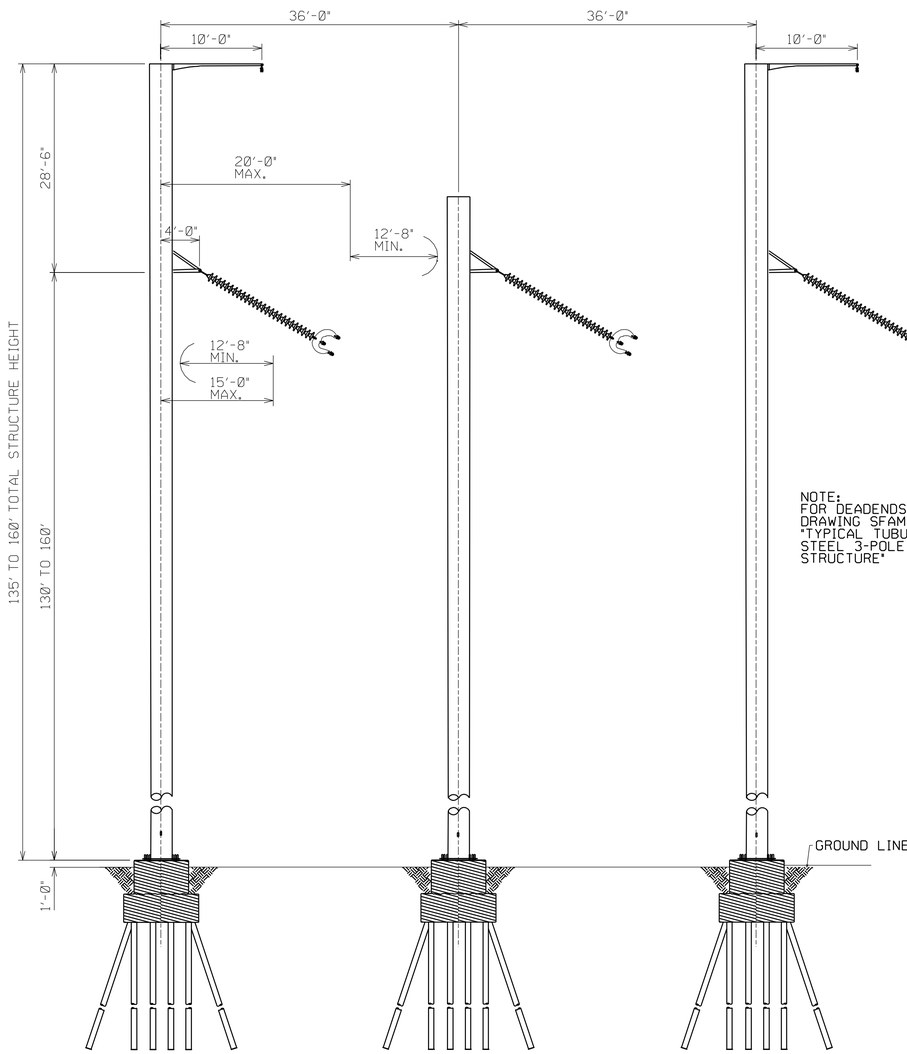
1. SHIELDING ANGLE IS ESTIMATED TO BE NO GREATER THAN 20° FOR AT-REST CONDITIONS.
2. DESIGN WIND & WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.



0°-2° TANGENT SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



2-15° ANGLE SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



NOTE:
FOR DEADENDS SEE DRAWING SFAM-2, "TYPICAL TUBULAR STEEL 3-POLE DEADEND STRUCTURE"

15°-30° RUNNING ANGLE SUSPENSION
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER

PROJECT NUMBER

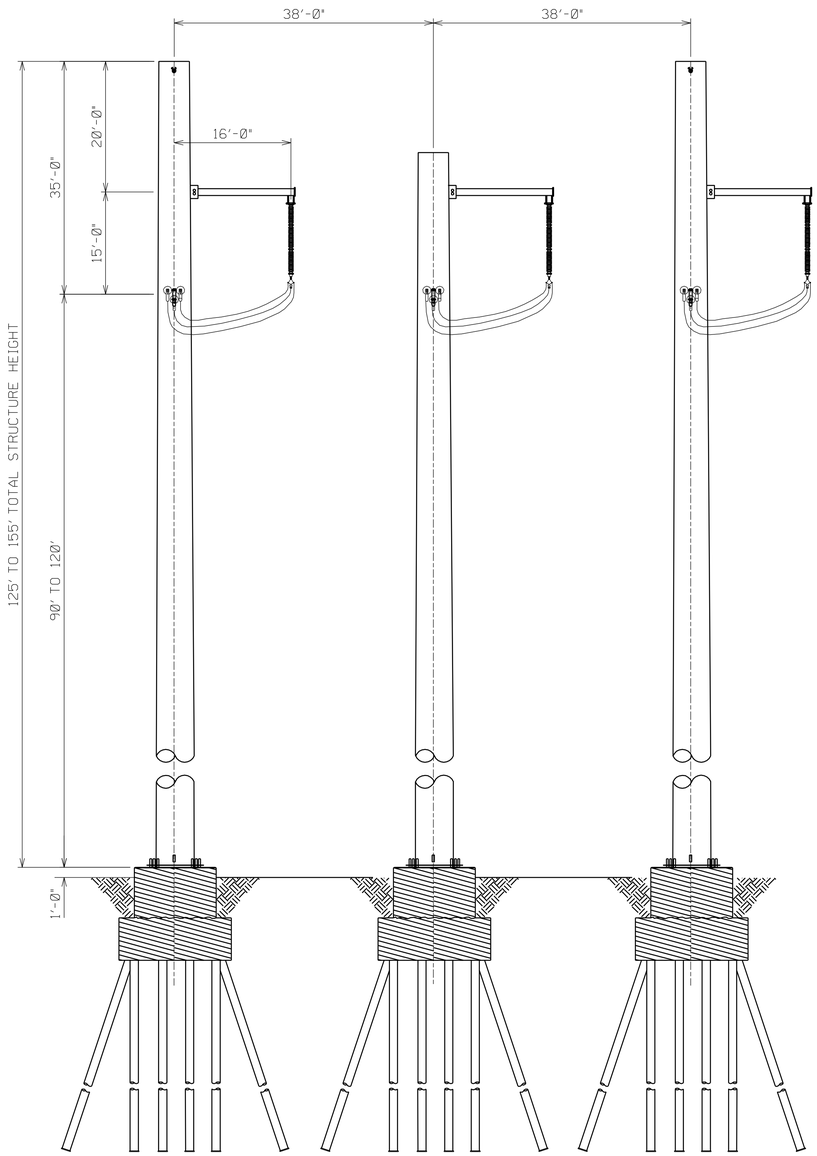
CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

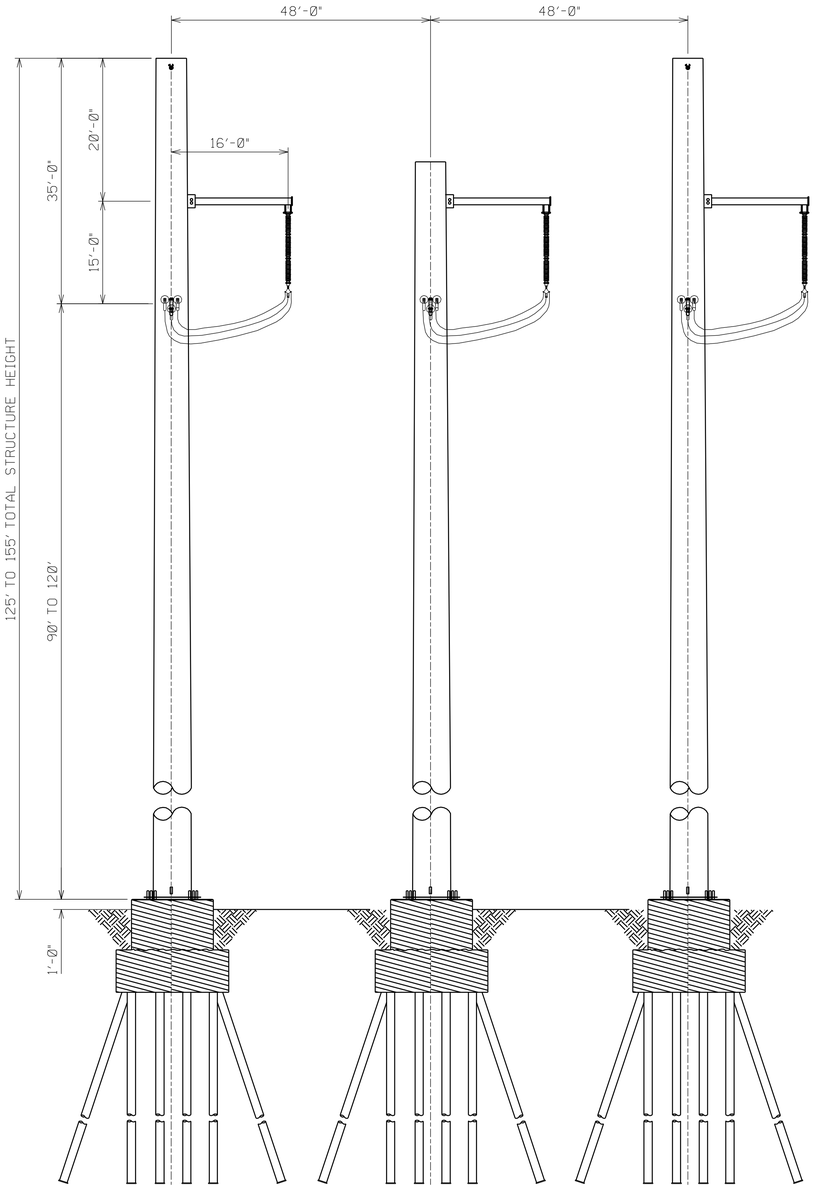
EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME STRUCTURE FAMILY

FILENAME	SFAM1B_2A-1
SCALE	NONE

SHEET
SFAM-1



0° - 45° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT



45° - 90° DEADEND
WIND SPAN: 1200 FT
WEIGHT SPAN: 1500 FT

NOTES:

1. SHIELDING ANGLE AT DEADENDS IS 0°.
2. DESIGN WIND AND WEIGHT SPANS NOTED UNDER EACH STRUCTURE TYPE.
3. STRUCTURE HEIGHT RANGES BASED ON MEETING DESIGN GROUND CLEARANCE OF 38'-0" FOR 3-BUNDLE 1192.5 KCM 45/7 ACSR "BUNTING" UNDER DESIGN TENSION REQUIREMENTS. FOR MORE INFORMATION SEE DESIGN CRITERIA DOCUMENT.

HDR Engineering, Inc.

ISSUE	DATE	DESCRIPTION
–	–	–

PROJECT MANAGER	
PROJECT NUMBER	

CAPX2020

MH TSR 500KV
OPTION 1
FACILITIES STUDY

EXHIBIT DRAWING
TYPICAL TUBULAR STEEL H-FRAME
STRUCTURE FAMILY

FILENAME	SFAM1B_2A-2
SCALE	NONE

SHEET
SFAM-2

PERMITTING AND LAND RIGHTS SECTION

RESULTS OF MANITOBA HYDRO TSR 500 kV OPTION 1 FACILITIES STUDY

PERMITTING AND LAND RIGHTS – DETAILS

Prepared by: _____

Donell Murphy
Natural Resource Group, LLC

On behalf of: Great River Energy
Minnesota Power
Otter Tail Power
Xcel Energy
Natural Resource Group, LLC

PERMITTING AND LAND RIGHTS STUDY OBJECTIVES

The primary objective of the permitting and land rights study was to identify a representative alignment for the proposed 500 kV transmission line. The representative alignment served as the basis for estimating purposes for the Facilities Study, as it relates to both engineering and future permitting and land rights activities. Upon development of the representative alignment, potentially required permits and other regulatory requirements were identified, along with an estimated schedule and costs associated with satisfying these potential regulatory requirements and acquiring necessary land and easements.

INTRODUCTION

The routing of any new high voltage electrical transmission line across a landscape generally involves the potential for displacement of property or property uses and the potential for impacts to the human and natural environment. However, the evaluation of these potential impacts is based in part on a collective assessment of trade-offs, interpretations, and qualifications associated with affected land uses; perceptions or values of affected stakeholders, landowners, or other members of the general public; physical impediments; legal or regulatory obstacles; and other environmental considerations. The identification and evaluation of the representative corridor was conducted using available information appropriate for the scope of the Study, industry practices, and recent relevant project experience. More specifically, the representative corridor was studied in accordance with applicable regulatory requirements and guidelines as identified in both Minnesota and North Dakota applicable statutes, rules, and local zoning ordinances. These regulations or guidelines identify the evaluation of the potential to parallel existing rights-of-way and other linear features, such as property or field lines, while also reducing the potential for environmental impacts. Additionally, consideration was given to avoiding the crossing of areas of which an overhead transmission facility cannot be permitted and large scale residential displacement. The results of this feasibility review are provided within this section. An overall summary is followed by more detailed discussions of permitting and land rights and their associated estimated costs, estimated timelines or schedules, and other considerations.

The interstate transmission facility that is the subject of this Facilities Study will require a number of regulatory approvals administered by various affected agencies. Some of these regulatory requirements involve lengthy review and approval durations, while some involve prolonged pre-application processes or activities. Inherent in the regulatory review process is the potential for unanticipated regulatory requirements which create certain project risks. These risks could manifest themselves in a number of ways, for example unforeseen route modifications, costly mitigation measures, and/or project delays. The assumptions in this Study do not include the potential financial or other burdens associated with these unknown risks and have not been quantified as part of this effort.

PERMITTING AND LAND RIGHTS SUMMARY

Facilities Study ID: Manitoba Hydro TSR 500 kV Facilities Study, Option 1 (Dorsey – Helena)

Description: New 500 kV Transmission Line from U.S./Canada Border (south of Dorsey Substation) to Future CapX2020 Helena Substation

Project Description

Voltage	500 kV
Estimated Length	477 miles
Proposed Substation Facility	No
Substation Expansion	Yes. Proposed modifications at future CapX2020 Bison and Helena Substations.
Other Facilities	Yes. Proposed intermediate series capacitor banks between substation interconnections.
Map Reference	See Figure 1 in the Executive Summary

Project Estimate

Major Permitting Requirements

- Presidential Permit
- Minnesota Certificate of Need
- Minnesota Route Permit
- North Dakota Certificate of Public Convenience and Necessity
- North Dakota Certificate of Corridor Compatibility
- North Dakota Route Permit
- North Dakota Legislative Approval

Estimated Permitting Timeline/Schedule **At least 48 months**

Key Permitting Timeline/Schedule Assumptions

- A December 2017 in-service date is desired.
- Month 0 is assumed to be July 2010.
- The project will be constructed as concurrent construction segments or spreads, to the extent feasible, beginning in North Dakota.
- The first 48 months of the project include permitting and land rights activities leading to the start of construction along the first construction segment.
- Permitting activities within the first 48 months include strategic planning, communications, intensive

agency coordination, routing, stakeholder and public involvement, field studies and surveys, preparation of permit applications, support of regulatory review processes, and legal services.

- Permitting activities will continue beyond the first 48 months. Permitting activities will continue to overlap with engineering and construction activities during the remainder of the project schedule.
- The 48-month timeline leading to start of construction along the first construction segment is largely dependent on agency concurrence regarding the anticipated permitting approach, in addition to agency reviews and approvals being completed as anticipated within the identified timeline.
- Strategic planning, intensive agency coordination, stakeholder and public involvement, routing, field studies to support routing, and preparation of the Presidential Permit, Minnesota Certificate of Need (MN CON), and North Dakota Advanced Determination of Prudence (ND ADP) applications are anticipated to be completed during months 0 through 12. The ND ADP is not a required approval.
- The Presidential Permit, MN CON, and ND ADP applications are anticipated to be submitted in month 12.
- The North Dakota Certificate of Public Convenience and Necessity (ND CPCN) application is anticipated to be submitted in month 15.
- The North Dakota Certificate of Corridor Compatibility (ND CCC) application is anticipated to be submitted in month 18. This assumes the ND CPCN has been approved.
- The Minnesota Route Permit (MN RP) application is anticipated to be submitted in month 24. This assumes the MN CON has been approved.
- The North Dakota Route Permit (ND RP) application is anticipated to be submitted in month 27. This assumes the ND CCC has been approved.
- The Administrative Law Judge (ALJ) Recommendation associated with the MN RP is anticipated to be issued in month 36.
- The ND RP is anticipated to be approved in month 36.
- The final order associated with the MN RP is anticipated to be issued in month 39, followed by a notice to proceed in month 40.
- The Presidential Permit is anticipated to be approved in month 42.
- The 48-month timeline leading to start of construction along the first construction segment assumes North Dakota legislative approval will occur in 2013, in accordance with the current biennial session schedule.
- Construction cannot commence without a notice to proceed from either state commission following Route Permit approval and approval of any other required permits. Additionally, construction is assumed to start following approval of the Presidential Permit.
- Intensive environmental field surveys associated with no less than the first construction segment will

be completed no later than month 40. Permission to access private property for areas to be surveyed is assumed to be completed prior to the commencement of these surveys.

- Environmental field surveys will be sequenced with the identified construction segments to the extent feasible. However, surveys will be subject to timing of regulatory approvals, seasonal constraints, and permission to access property.
- Environmental field surveys are assumed to be conducted specific to areas of temporary and permanent ground disturbance.
- Other permit applications, such as the assumed permit to be issued by the U.S. Army Corps of Engineers for impacts to jurisdictional wetlands and waters associated with the first construction segment, are anticipated to be submitted no later than month 42. This assumes approval of other required permits associated with the first construction segment no later than month 48.
- All required permits in addition to the Presidential Permit, ND ADP, ND CPCN, ND CCC, ND RP, MN CON, and MN RP are assumed will be obtained through multi-step approvals as environmental field studies and land rights activities that must be completed in advance of the submittal of permit applications cannot be realistically completed contiguously from one end of the project to the other at one time and still meet a December 2017 in-service date.

Estimated Permitting Cost **$22,750,000**

Key Permitting Cost Assumptions

- A 2017 in-service date is desired.
- Month 0 is assumed to be July 2010.
- The project will be constructed as concurrent construction segments or spreads, to the extent feasible, beginning in North Dakota.
- The estimated cost does not include the following permits or compliance measures as these permits are either included within the estimated engineering costs or intentionally excluded from this estimate: National Pollutant Discharge Elimination System Permit, Stormwater Pollution Prevention Plan, environmental restoration, standard mitigation measures or best management practices implemented by construction personnel during construction; environmental monitoring and inspection during construction; local road permits such as oversize/overweight permits or driveway access permits; and compliance with air and noise quality standards during construction.
- The estimated cost does not include any costs associated with compensatory mitigation or acquisition of mitigation lands.
- The estimated cost does not include any potentially required pre-activity clearance surveys.
- The estimated cost includes permitting activities to be completed in advance of the start of construction and during construction.

- Environmental field surveys will be sequenced with the identified construction segments to the extent feasible. Permission to access private property will be completed in advance of commencing environmental field surveys.
- Environmental field surveys are assumed to be conducted specific to areas of temporary and permanent ground disturbance.
- The estimated cost does not include the survey of any required construction access outside of the right-of-way.

Right-of-Way Requirements: Fee/Easement/License

Estimated Right-of-Way Timeline/Schedule: **No less than 30 months and assumed completion in 64 months**

Key Right-of-Way Timeline/Schedule Assumptions

- A 2017 in-service date is desired.
- Month 0 is assumed to be July 2010.
- The project will be constructed as concurrent construction segments or spreads, to the extent feasible, beginning in North Dakota.
- The locations of the future CapX2020 Helena and Bison Substations are subject to the approval of these facilities through other proceedings before the North Dakota Public Service Commission and the Minnesota Public Utilities Commission.
- The first 48 months of the project include permitting and land rights activities leading to the start of construction along the first construction segment. This 48-month duration leading to start of construction along the first construction segment can only occur if there is no condemnation required for properties along this segment. This 48-month duration also assumes land rights activities associated with the first construction segment, and any additional areas, will commence in month 18 and continue through month 48, resulting in the identified minimum 30-month duration.
- Landowner contacts, permission to access property for natural resource and geotechnical surveys, and right-of-way acquisition will overlap with permitting activities during the first 48 months of the project. This assumes initiating landowner contacts in advance of an approved ND RP (beginning in month 18) and following the ALJ Recommendation associated with the MN RP (anticipated to be issued in month 36).
- The 48-month duration for permitting and land rights activities leading to start of construction along the first construction segment is based on current processes and procedures in both North Dakota and Minnesota.
- Actual right-of-way acquisition associated with the first construction segment is anticipated to

commence in North Dakota in month 24.

- Right-of-way acquisition is anticipated to commence in Minnesota no sooner than month 39.
- Land rights activities will continue beyond the first 48 months. Right-of-way acquisition will continue to overlap with engineering and construction activities during the remainder of the project schedule.
- Minnesota's quick-take provision is assumed to be no more than 90 days.
- Right-of-way acquisition is anticipated to be completed in North Dakota in month 54, based on an assumed availability of land agents. This assumes a 12-18 month duration beyond the approval of the Route Permit, which includes the potential for condemnation.
- Right-of-way acquisition in Minnesota is anticipated to be completed in Minnesota in month 64, also based on assumed availability of land agents. This assumes a 12-24 month duration beyond the approval of the Route Permit, which includes the potential for condemnation.

Estimated Right-of-Way Cost **$84,600,000**

Key Right-of-Way Cost Assumptions

- A 2017 in-service date is desired.
- Month 0 is assumed to be July 2010.
- The project will be constructed as concurrent construction segments, to the extent feasible, beginning in North Dakota.
- The proposed 500 kV transmission line will be constructed within a 200-foot right-of-way.
- The estimated length of the project is approximately 477 miles.
- There will be one staging/laydown area every 25 miles.
- An additional 80 acres will be acquired at the future CapX2020 Bison Substation.
- An additional 40 acres will be acquired at the future CapX2020 Helena Substation.
- The locations of the future CapX2020 Bison and Helena Substations are subject to the approval of these facilities through other proceedings before the North Dakota Public Service Commission and the Minnesota Public Utilities Commission.
- Up to 40 acres will be acquired for each intermediate series capacitor bank.
- The 48-month duration for permitting and land rights activities leading to start of construction along the first construction segment is based on current processes and procedures in both North Dakota and Minnesota.
- The estimated right-of-way cost was based on a collective assessment of: land and easement acquisition and costs associated with securing any required construction access both within and outside of the right-of-way (including an estimated value by type of land use or land cover and land agent costs); land agent costs and permit fees associated with road and railroad crossings; costs

associated with damage to crops during construction; and costs associated with other considerations such as the potential for condemnation or residential displacement.

- The estimated cost for right-of-way acquisition does not include escalation of land values.

DEVELOPMENT OF REPRESENTATIVE CORRIDOR

In general, identifying the representative corridor involved the identification of a potential border crossing area followed by the delineation of the Study area, identification and categorization of routing criteria, identification of at least three geographically diverse potential alignments for comparison purposes, and selection of a representative alignment. The selected representative alignment can best be described as a conceptual, but relatively plausible alignment extending between the U.S./Canada border and the future CapX2020 Helena Substation. The representative alignment was identified only for the purpose of establishing a basis for the required engineering and right-of-way assessments. Also included with development of the representative alignment was the identification of potential intermediate series capacitor bank sites. The representative corridor, as depicted on Figure 1 in the Executive Summary, encompasses the representative alignment but is not specifically based on this alignment. While this Study largely makes reference to the representative alignment since this alignment was used for estimating purposes, this alignment is only conceptual in nature and assumed to be generally representative of other alignments that could be identified within the overall representative corridor. The representative corridor, as depicted on Figure 1 in the Executive Summary, is not to be considered as a formal, delineated study area.

Based on coordination with representatives of Manitoba Hydro, a border crossing area was identified. This area, approximately 10 miles wide, is located along the U.S./Canada border due south of the Dorsey Substation, which is located northwest of Winnipeg, Manitoba. The Study area was then delineated by encompassing an area 50 miles wide on either side of a straight line between the border crossing area and the future CapX2020 Bison Substation, to be located west of Fargo, North Dakota, and the future Helena Substation to be located east of Le Sueur, Minnesota. The portion of the project between the U.S./Canada border and the future CapX2020 Bison Substation is also referred to as Project Segment 1. The portion of the project between the future CapX2020 Bison Substation and the future CapX2020 Helena Substation is also referred to as Project Segment 2. The border crossing area and CapX2020 Bison and Helena Substations were considered relatively fixed termini for the purposes of the Study. An intermediate series capacitor bank will be constructed as close to the "electric middle" of each segment as possible. Potential sites for the two series capacitor banks were identified, as described further below.

The identified routing criteria were based on applicable regulatory requirements and guidelines as identified in both Minnesota and North Dakota applicable statutes, rules, and local zoning ordinances, in addition to criteria typically taken into consideration for the routing of transmission facilities. The criteria were then grouped into 'Highly Sensitive Areas', 'Moderately Sensitive Areas', and 'Low Sensitivity Areas' categories.

Highly Sensitive Areas include areas across which an overhead transmission line cannot be permitted. Examples of Highly Sensitive Areas include state scientific and natural areas, state and national parks, federally owned waterfowl production areas, and state archaeological sites. Moderately Sensitive Areas include areas across which an overhead transmission line crossing could be permitted in accordance with what are typically lengthier agency reviews and an increased level of public scrutiny. Based on relevant project experience, Moderately Sensitive Areas will likely be of primary concern to potentially affected stakeholders (e.g. local jurisdictions) or landowners. Examples of Moderately Sensitive Areas include existing residential uses, local zoning ordinances and setback requirements, federal and state lands or easements, and center pivot irrigation uses. Low Sensitivity Areas are those remaining areas that, similar to the Highly and Moderately Sensitive Areas, will still have to be taken into account with regard to potential impacts, constructability, and any required licensing or permitting procedures resulting from impacts. Examples of Low Sensitivity Areas include general agricultural uses, wetlands, forested or wooded areas, and floodplains.

Use of the terms 'sensitive' or 'sensitivity' does not imply that these areas should or can be avoided, except in the case of Highly Sensitive Areas. Further, Low Sensitivity Areas were no less considered than Highly Sensitive or Moderately Sensitive Areas. The routing criteria were categorized only for the purposes of readily assessing where concentrations of areas occur across which the proposed 500 kV transmission line would be

explicitly prohibited, or where areas occur across which the proposed line would be a permitted use although typically subject to greater scrutiny by affected agencies, landowners, or other interested parties. Highly Sensitive Areas were mapped in red, Moderately Sensitive Areas in orange, and Low Sensitivity Areas in yellow. This facilitated quick visual recognition of areas obviously constrained by Highly Sensitive and Moderately Sensitive Areas across the regional landscape, and areas otherwise still constrained but with relatively less potential resistance or fewer obstructions. Identifying and categorizing the routing criteria served as a fundamental basis of the approach to developing a conceptual but conceivably plausible representative alignment.

Data and information associated with the identified criteria and appropriate for the scope of the Study was collected. This data and information mostly included the collection of geospatial data from local, state, and federal agencies; data repositories; or other data sources and included only readily available or accessible data. This data was supplemented by the inclusion of other data such as existing electrical and transportation infrastructure, other linear facilities, and parcel boundaries, in addition to data generated through aerial photo-interpretation. Data and information considered appropriate for the scope of the Study included readily available or accessible federal and state, and in some instances county, level information. Data and information not considered appropriate for the scope of the Study included information such as local land use plans or zoning districts and any data not considered readily available or accessible within a reasonable timeframe relative to the overall Study schedule.

Following data collection and review of the occurrence of high concentrations of Highly Sensitive Areas and areas of increased density of Moderately Sensitive or Low Sensitivity Areas, potential pathways mostly outside of these areas were identified. These potential pathways also took into account the presence of existing linear features that could be paralleled.

Paralleling roads is typically considered advantageous when routing transmission lines; however, this presents challenges in some locations. For example, local governments in North Dakota often have setback requirements from roadways. These setbacks can negate benefits resulting from right-of-way sharing and require the placement of the proposed line in a location that likely conflicts with existing homes and other structures. In general, in most agricultural settings, existing residences occur along roads. Placing the proposed 500 kV line and its associated right-of-way along road rights-of-way may result in transmission structures being located between road rights-of-way and existing homes along these rights-of-way more frequently than if the proposed line were located along property, section, or field lines. Immediate physical proximity would be combined with and may elevate any other perceptions or concerns held by the affected homeowner. Specific to North Dakota, placing a transmission line within 500 feet of an existing home requires a waiver from that homeowner.

The advantages and disadvantages of paralleling existing transportation corridors, utility corridors, and property or field lines, combined with a review of the various categories of sensitive areas occurring along these linear features, were considered in identifying at least three geographically diverse potential alignments within the identified potential pathways. These alignments were refined by reducing the number of angle structures, where practical, and evaluated in comparison to one another. The alignment having a shorter distance while also having a reduced number of angle structures, reduced number of road, railroad, or facility crossings, and a lesser perceived potential for impact was selected as the representative alignment. A representative corridor encompassing the representative alignment but not specifically based on this alignment was then identified, as depicted on Figure 1 in the Executive Summary. While this Study largely makes reference to the representative alignment since this alignment was used for estimating purposes, this alignment is only conceptual in nature and assumed to be generally representative of other alignments that could be identified within the overall representative corridor. The representative corridor, as depicted on Figure 1 in the Executive Summary, is not to be considered as a formal, delineated study area.

In addition to developing the representative alignment, two potential intermediate series capacitor bank sites were also identified. The locations of these potential sites along the representative alignment were selected based predominantly on proximity to the "electric middle" of Segments 1 and 2 respectively, proximity to existing transportation access, and proximity to existing homes. The potential locations of these series capacitor bank sites are also depicted on Figure 1 in the Executive Summary.

PERMITTING REQUIREMENTS

Potential federal, state, and local regulatory requirements associated with the representative alignment are identified below. The regulatory requirements identified are associated with construction of the proposed 500 kV transmission line, series capacitor banks, substation modifications, construction access roads, temporary access outside of the proposed right-of-way, staging and laydown areas, and any other areas of ground disturbance. Permits, approvals, or compliance directly associated with construction activities and typically obtained by construction personnel, such as a National Pollutant Discharge Elimination System permit and Stormwater Pollution Prevention Plan, are not included in the permitting and land rights review of regulatory requirements and development of an associated schedule and cost. Permits, approvals, or compliance excluded from the permitting and land rights review of regulatory requirements – although included in the engineering section of this Study – include the following:

- National Pollutant Discharge Elimination System Permit
- Stormwater Pollution Prevention Plan
- Environmental restoration;
- Standard mitigation measures or best management practices implemented by construction personnel during construction;
- Environmental monitoring and inspection during construction;
- Local road permits such as oversize/overweight permits or driveway access permits; and
- Compliance with air and noise quality standards during construction.

An overall project schedule that accommodates the identified December 2017 in-service date has been developed. The schedule, provided in the Executive Summary, includes aggressive durations for permitting and land rights activities, but still requires extensive overlap of these activities with engineering and construction. This overlap of activities further requires that some land rights, engineering, or construction-related activities will commence in advance of having all regulatory requirements satisfied for the project as a whole. Instead, some approvals are anticipated to be obtained through what may be generally characterized as a tiered approach.

The major federal and state permits required for the 500 kV transmission line, as well as their anticipated durations of review and approval based on review of relevant projects and the various assumptions identified, are listed below.

	Administering Agency	Anticipated Start Date (or Submittal of Application)	Anticipated End Date
Presidential Permit	U.S. Department of Energy	July 2011	January 2014
Certificate of Public Convenience and Necessity	North Dakota Public Service Commission	October 2011	January 2012
Certificate of Corridor Compatibility	North Dakota Public Service Commission	January 2012	October 2012

	Administering Agency	Anticipated Start Date (or Submittal of Application)	Anticipated End Date
Route Permit	North Dakota Public Service Commission	October 2012	July 2013
Legislative Approval	North Dakota Legislative Assembly	December 2012	May 2013
Certificate of Need	Minnesota Public Utilities Commission	July 2011	July 2012
Route Permit	Minnesota Public Utilities Commission	July 2012	October 2013

The permits or approvals listed above would be required in addition to other various federal, state and local approvals.

Federal Permits, Approvals, or Compliance

As identified above, a number of federal permits are likely to be required, along with consultation with other federal agencies, for the project. The project will be constructed as concurrent construction segments, to the extent feasible. As a result of this approach to construction, some federal permits or consultations will be obtained or completed in a multi-step or tiered approach. This will require an early emphasis on intensive agency coordination during the planning stage of the project and ongoing permitting activities during construction. Construction is assumed to start following approval of the Presidential Permit. Potentially required federal permits and approvals include, but may not be limited to:

- U.S. Department of Energy: Presidential Permit, Lead Agency for environmental review in accordance with the National Environmental Policy Act (assumed Environmental Impact Statement)
- Section 106 of the National Historic Preservation Act; U.S. Department of Energy to serve as Lead Agency (a Programmatic Agreement between the Lead Agency, interested tribes, and the Applicants is anticipated)
- U.S. Army Corps of Engineers: Permits under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act;
- U.S. Fish and Wildlife Service: Consultations under Section 7 of the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act;
- Federal Aviation Administration: Notice of Proposed Construction; and
- Department of Homeland Security: Consultation and Concurrence (international border crossing).

Other required federal authorizations that have been delegated to state permitting agencies (such as Section 401 Water Quality Certification) are addressed in the applicable state permitting discussion below.

State Permits, Approvals, or Compliance

Each of the two states crossed by the proposed 500 kV transmission line will potentially require the following environmental reviews and authorizations, prior to the start of construction of the project. The project will be constructed as concurrent construction segments, to the extent feasible, beginning in North Dakota. As a result of this approach to construction, some state permits or consultations will be obtained or completed

through multi-step review and approval processes as environmental field studies and land rights activities that must be completed in advance of the submittal of permit applications cannot be realistically completed contiguously from one end of the project to the other at one time and still meet a December 2017 in-service date. This will require an early emphasis on intensive agency coordination during the planning stage of the project and ongoing permitting activities during construction. State siting or licensing authorizations such as those required from the Minnesota Public Utilities Commission and the North Dakota Public Service Commission is included in the list below. No construction can commence until notices to proceed have been issued by both state commissions. An Advanced Determination of Prudence may be sought in North Dakota, although this determination is not a required approval. Potentially required state permits and approvals include, but may not be limited to:

- Certificate of Need (MN);
- Certificate of Public Convenience and Necessity (ND);
- Certificate of Corridor Compatibility (ND);
- Route Permit (MN and ND);
- Approval by Legislative Assembly (ND);
- Section 401 Water Quality Certification;
- License to cross public lands and waters (MN);
- Construction dewatering permits (MN and ND);
- State protected species consultations (MN and ND);
- State Historic Preservation Office consultations (MN and ND);
- Utility Permit for encroachment of or crossing state highway right-of-way (MN); and
- Utility Occupancy Permit for encroachment of or crossing state highway right-of-way (ND).

Local Permits, Approvals, or Compliance

Local permits and approvals potentially required prior to the start of construction of the project include, but may not be limited to:

- Local road right-of-way encroachment and crossing permits (MN and ND);
- Wetland Conservation Act compliance for construction access roads (MN);
- Compliance with local setback requirements, Conditional Use Permits, Variances, or Waivers (ND); and
- Water resource and watershed district consultations/permits/approvals (MN and ND).

Estimated Permitting Timeline/Schedule and Associated Assumptions

An aggressive permitting and land rights schedule has been developed for the project, given the general size and scope of the project and consideration of permitting requirements, to achieve the desired 2017 in-service date. The project will be constructed as concurrent construction segments, to the extent feasible, beginning in North Dakota. The first 48 months of the project includes permitting and land rights activities leading to the start of construction along the first construction segment. Permitting activities during the first 48 months include strategic planning, communications, intensive agency coordination, routing, stakeholder and public involvement, field studies and surveys, preparation of permit applications, support of regulatory review processes, and legal services.

As a result of construction sequencing necessary to achieve the desired in-service date, permitting activities will continue beyond the first 48 months. Permitting activities will continue to overlap with engineering and construction activities during the remainder of the project schedule. The schedule assumes, in general,

significant overlap of permitting, land rights, engineering, and construction activities during various stages of project development.

The 48-month timeline leading to start of construction along the first construction segment is largely dependent on agency concurrence with regard to the anticipated permitting approach, in addition to agency reviews and approvals being completed as anticipated within the identified timeline. The overall estimated project schedule is included in the Executive Summary.

Strategic planning, intensive agency coordination, stakeholder and public involvement, routing, field studies to support routing, and preparation of major federal and state permit applications are anticipated to be completed in months 0 through 27. Planning, agency coordination, stakeholder and public involvement, routing, and field studies to support routing are anticipated to be completed during months 0 to 8. Preparation of the Presidential Permit, MN CON, and ND ADP applications are anticipated to be completed during months 8 through 12. The Presidential Permit, MN CON, and ND ADP applications are anticipated to be submitted in month 12. The ND CPCN application is anticipated to be submitted in month 15. The ND CCC application is anticipated to be submitted in month 18. This assumes the ND CPCN has been approved. The MN RP application is anticipated to be submitted in month 24. This assumes the MN CON has been approved (anticipated 12-month duration for review and approval). The ND RP application is anticipated to be submitted in month 27. This assumes the ND CCC has been approved (anticipated 9-month duration for review and approval). The ALJ Recommendation associated with the MN RP is anticipated to be issued in month 36. The ND RP is anticipated to be approved in month 36 (anticipated 9-month duration for review and approval). The final order associated with the MN RP is anticipated to be issued in month 39 (anticipated 15-month duration for review and approval), followed by a notice to proceed in month 40. The Presidential Permit is anticipated to be approved in month 42 (anticipated 30-month duration for review and approval). The 48-month timeline leading to start of construction along the first construction segment assumes North Dakota legislative approval will occur in 2013, in accordance with the current biennial session schedule. Other permit applications, such as the assumed permit to be issued by the U.S. Army Corps of Engineers for impacts to jurisdictional wetlands and waters associated with the first construction segment, are anticipated to be submitted no later than month 42. This assumes approval of other required permits associated with the first construction segment no later than month 48. Construction cannot commence without approval of the Presidential Permit, a notice to proceed from either state commission following Route Permit approval, and approval of any other required permits.

Intensive environmental field surveys associated with no less than the first construction segment will be completed no later than month 40. Permission to access private property for areas to be surveyed is assumed to be completed prior to the commencement of these surveys. Environmental field surveys will be sequenced with the identified construction segments to the extent feasible. However, surveys will be subject to timing of regulatory approvals, seasonal constraints, and permission to access property. Surveys are assumed to be conducted specific to areas of temporary and permanent ground disturbance.

Estimated Permitting Cost and Associated Assumptions

As previously identified, the regulatory requirements identified are associated with construction of the proposed 500 kV transmission line, series capacitor banks, substation modifications, construction access roads, temporary access outside of the proposed right-of-way, staging and laydown areas, and any other areas of ground disturbance. However, specific miles of construction access and any other areas of ground disturbance are unknown at this time. As identified above, permits, approvals, or compliance directly associated with construction activities and typically obtained or implemented by construction personnel are not included in the permitting and land rights review of regulatory requirements and development of an associated schedule and cost.

The estimated cost for completing permitting activities, which extends from project kick-off to obtaining final required permits for construction, is $22,750,000 (2017 dollars). Other permitting-related considerations excluded from this estimate include costs associated with environmental surveys of temporary construction access outside of the right-of-way, any pre-activity clearance surveys, and costs associated with compensatory mitigation or acquisition of mitigation lands. Environmental field surveys will be sequenced with the identified construction segments to the extent feasible. Permission to access private property will be completed in advance of commencing environmental field surveys. Environmental field surveys are assumed to be conducted specific to areas of temporary and permanent ground disturbance.

RIGHT-OF-WAY REQUIREMENTS

The proposed 500 kV transmission line will be constructed within a 200-foot right-of-way. The estimated length of the project is approximately 477 miles. There will be one staging/laydown area every 25 miles. An additional 80 acres will be acquired at the future CapX2020 Bison Substation. An additional 40 acres will be acquired at the future CapX2020 Helena Substation. Up to 40 acres will be acquired for each intermediate series capacitor bank.

Estimated Right-of-Way Timeline/Schedule and Associated Assumptions

An aggressive schedule has been developed for the project, given the general size and scope of the project and consideration of permitting requirements, to achieve the desired 2017 in-service date. The schedule assumes, in general, significant overlap of permitting, land rights, engineering, and construction activities during various stages of project development. The overall estimated project schedule is included the Executive Summary.

The project will be constructed as concurrent construction segments, to the extent feasible, beginning in North Dakota. The first 48 months of the project includes permitting and land rights activities leading to the start of construction along the first construction segment. This 48-month duration leading to start of construction along the first construction segment can only occur if there is no condemnation required for properties along this segment. This also assumes land rights activities associated with the first construction segment, and any additional areas, will commence in month 18 and continue through month 48, resulting in the identified 30-month duration. However, it should be noted that pending legislation in Minnesota would result in added time and cost to the land and easement acquisition process. This 48-month duration for permitting and land rights activities leading to start of construction along the first construction segment is based on current processes and procedures in both North Dakota and Minnesota.

Landowner contacts, permission to access property for natural resource and geotechnical surveys, and right-of-way acquisition will overlap with permitting activities during the first 48 months of the project. This assumes initiating landowner contacts in advance of an approved ND RP (beginning in month 18) and following the ALJ Recommendation associated with the MN RP (anticipated to be issued in month 36). Actual right-of-way acquisition associated with the first construction segment is anticipated to commence in North Dakota in month 24. Right-of-way acquisition is anticipated to commence in Minnesota no sooner than month 39. Minnesota's quick-take provision is assumed to be no more than 90 days. Right-of-way acquisition, which typically requires that aerial photography, final engineering and design, and preliminary construction access plans have been provided, will continue to overlap with engineering and construction activities during the remainder of the project schedule. Right-of-way acquisition is anticipated to be completed in North Dakota in month 54, based on an assumed availability of land agents. This assumes a 12-18 month duration which includes the potential for condemnation. Right-of-way acquisition in Minnesota is anticipated to be completed in Minnesota in month 64, also based on assumed availability of land agents. This assumes a 12-24 month duration which includes the potential for condemnation. An estimated 43,656 man-hours will be required for land/easement acquisition.

Estimated Right-of-Way Cost and Associated Assumptions

The estimated cost for right-of-way acquisition is $84,600,000 (2017 dollars). The duration for land rights activities is based on current processes and procedures in both North Dakota and Minnesota. The estimated right-of-way cost was based on a collective assessment of land and easement acquisition and costs associated with securing any required construction access both within and outside of the right-of-way (including an estimated value by type of land use or land cover and land agent costs); land agent costs and permit fees associated with road and railroad crossings; costs associated with damage to crops during construction; and costs associated with other considerations such as the potential for condemnation or residential displacement. The estimated cost for right-of-way acquisition does not include escalation of land values.