

ROCHESTER PUBLIC UTILITIES

ELECTRIC SYSTEM DATA

March, 2025



Document Maintained by: Randy Anderton

Version Control

| Version | Date | Author | Change Description |
|---------|-------------------------------|-----------------------------|--|
| 1 | February, 1994 | G. Woodworth | Compiled from numerous sources |
| 2 | March, 1995 | G. Woodworth | Updated to reflect system improvements |
| 3 | May, 1999 | G. Woodworth | Updated to reflect system improvements |
| 4 | June, 2002 | G. Woodworth | Updated to reflect system improvements |
| 5 | August, 2002 | G. Woodworth | Updated to reflect system improvements |
| 6 | July, 2009 | N. Stiller | Updated for completed projects. Conformed to NERC standard FAC-008-1 |
| 7 | September, 2009 | N. Stiller | Updated for completed projects. |
| 8 | February, 2011 | N. Stiller | Updated for completed projects. |
| 9b | January, 2013 | N. Stiller | Revised transformer impedances to show $R + jX = Z$. Added substation bus equipment Updated Substation Apparatus Limits |
| 10 | October, 2013 | N. Stiller | Added line RQ12 |
| 11 | January, 2015 | N. Stiller | Corrected winding information on CC GSU2 |
| 12 | January, 2016 | N. Stiller | Added line RQ13 |
| 13 | April, 2017 | N. Stiller | Added Douglas Tr. Substation and Q5 / Q14 split |
| 14 | October, 2017 | N. Stiller | Added 13.8 kV equipment summaries. Removed duplicate line rating vs. temperature graphs. |
| 15 | April, 2018 | N. Stiller | Revised transformer data for Cascade Cr. T2 and Douglas Tr. T3. Updated IBM NGR Z data. |
| 16 | September, 2018 | N. Stiller | Added Westside Energy Station equipment |
| 17 | February, 2020 | N. Stiller | Removed all SLP generation equipment. Relocated SLS cap bank. Other general updates |
| 18 | November, 2021 | M. Boese/Ulteig Engineering | Transmission Coordination Study Updates |
| 19 | January, 2022 | W. Warren | Added Douglas Trail T3 NGR serial number |
| 20 | October, 2022 | UEI/ W. Warren | Added Marion Road Substation and Q2 / Q17 split |
| 21 | January, 2023 | W. Warren | Updated Transformer cooling data |
| 22 | August, 2024 October, 2024 | W. Warren T. Conlin | Updated Q15/Q16 Line Limits per DPC Update Updated Transformer and NGR Data from Tested Data and Cut Sheets |
| 23 | March, 2025 November, 2025 | T. Conlin | Xcel Limit adjustments on RQ12 Xcel Limit adjustments on RQ13, |

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LINE DATA LEGEND

1. The voltage listed is the nominal line to line voltage in kilovolts.
2. The positive and zero sequence susceptance given is in per unit for the total three phase line.
3. The charging current given is the charging current in amps of each phase conductor. The line parameter is calculated by multiplying the positive sequence susceptance by the base current of the line.
4. The loading capacity given is in MVA for the total three phase line.
5. Impedance values are obtained from the Aluminum Association's Aluminum Electrical Conductor Handbook, third edition, 1989. Line parameters were calculated using ASPEN Line Constants Program Version 3.1 software or CAPE Line Constants Program (beginning 2009) with conductors rated at 50°C unless noted otherwise.
6. Pos. Seq. Imp. – Positive sequence impedance of each line section and line total in ohms.
Pos. Seq. Imp. (P.U.) – Positive sequence impedance of each line section and line total in per unit on a 100 MVA base.
Zero Seq. Imp. – Zero sequence impedance of each line section and line total in ohms.
Zero Seq. Imp. (P.U.) – Zero sequence impedance of each line section and line total in per unit on a 100 MVA base.
Zero Seq. Mutual Impedance – Zero sequence mutual impedance of each double circuit line and line total in ohms.
Zero Seq. Mutual Impedance (P.U.) – Zero sequence mutual impedance of each double circuit line section and line total in per unit on a 100 MVA base.
7. Ampacity values are obtained from Southwire's Overhead Conductor Manual, first edition, first printing, 1994 and the associated Thermal Rating Program software.
8. The current carrying capacity of each overhead phase conductor is determined on the basis of:
 - a. Hot Conductor Design Temperature of the line as follows:
 - i. 25° C (77 °F) for line K1
 - ii. 75° C (167 °F) for lines Q2, Q3, Q4, Q5, Q6, Q8, and Q9
 - iii. 100° C (212 °F) for the parallel 556.5 Osprey conductors on lines Q7 and Q10.
 - iv. 132° C (270 °F) for the 954 Rail terminal drops in the deadends on lines Q7 and Q10.
 - v. 100° C (212 °F) for the 795 Drake conductors on line Q1.
 - vi. 100° C (212 °F) for the 954 Rail conductors on the Westside tap of line Q9
 - b. Ambient Temperature 80°F (26.7°C) summer normal, 32°F (0°C) winter normal
 - c. Wind speed and other factors are listed above the table on page 26 of this section.
 - d. Emergency ratings are 10% over normal ratings with the exception being Q7 and Q10. The emergency rating for these lines are based on the more restrictive of a.) 10% greater rating of 556 Osprey or, b.) 5% greater rating of the 954 Rail, since it has a higher normal hot conductor temperature. These exceptions are explained in Note 2 on page 27 of this section.
9. The current carrying capacity of lines RQ7 and RQ11 are based on conditions and methodologies determined by Southern Minnesota Municipal Power Agency (SMMMPA).

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10. The Summer current carrying capacity of line RQ12 and RQ13 are based on the following conditions determined by Xcel Energy as the entity having NERC compliance responsibility for the facility.
 - a. Air temperature is 104 deg. F
 - b. Wind speed is 2.00 ft/s
 - c. Angle between wind and conductor is 90 deg.
 - d. Conductor elevation above sea level is 1000 ft.
 - e. Conductor bearing is 90 deg.
 - f. Sun time is 12 hours (solar altitude is 67 deg. and solar azimuth is 180 deg.)
 - g. Conductor latitude is 45.0 deg.
 - h. Atmosphere is CLEAR
 - i. Day of year is 190 (corresponds to July 8 in year 2012)
 - j. Maximum conductor temperature is 392.0 deg. F

11. The Winter current carrying capacity of line RQ12 and RQ13 are based on the following conditions determined by Xcel Energy.
 - a. Air temperature is 32.00 deg. F
 - b. Wind speed is 2.00 ft/s
 - c. Angle between wind and conductor is 90 deg.
 - d. Conductor elevation above sea level is 1000 ft.
 - e. Conductor bearing is 90 deg.
 - f. Sun time is 12 hours (solar altitude is 60 deg. and solar azimuth is 180 deg.)
 - g. Conductor latitude is 45.0 deg.
 - h. Atmosphere is CLEAR
 - i. Day of year is 121 (corresponds to April 30 in year 2012)
 - j. Maximum conductor temperature is 392.0 deg. F

12. The Q7 and Q10 lines have parallel 556 ACSR Osprey conductors per phase except for the last span into the substation deadends at Crosstown and Silver Lake and the last two spans into the Cascade Creek deadend, which are 954 ACSR Rail. The low point of all these spans are located over fenced RPU substation property.

13. Line and terminal capacity curves for varying ambient temperatures for all conductor configurations and open/closed ring bus configurations are located on pages 20 through 25 of this section. Page 26 of this section contains the base data for the capacity ratings for each line along with the ambient and atmospheric assumptions based on the Southwire Thermal Rating Program. Stated line ratings account for terminal equipment limitations. Line ratings that are restricted by terminal equipment limitations are noted on the respective transmission line data page in this section.

14. [Page 27](#) is a table of line ratings effective July 1, 2002 that are used in the MISO operating guides for the Rochester area. Transmission Line Capacity vs. Ambient Temperature rating data may be used for real-time operations and near-term planning.

15. The bracketed number behind the terminal name is the MISO bus number. The format of the bus numbers were revised in 2010.

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| Station Name | Old bus number | New bus number |
|----------------|----------------|----------------|
| Bamber Valley | 63435 | 625435 |
| Cascade Creek | 63430 | 625430 |
| Chester | 63445 | 625445 |
| Crosstown | 63405 | 625405 |
| Douglas Trail | | 625450 |
| IBM | 63420 | 625420 |
| Marion Road | | |
| Northern Hills | 63415 | 625415 |
| Silver Lake | 63440 | 625440 |
| West Side | 63447 | 625447 |
| Willow Creek | 63410 | 625410 |
| Zumbro River | 63425 | 625425 |

16. Line and associated equipment ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.
17. There are three primary tangent tower structures used on the RPU transmission system. These are represented in the CAPE model as a horizontal post (triangular configuration), Davit arm single circuit (vertical configuration), and Davit arm double circuit (dual-circuit vertical configuration). Typical positive sequence parameters can be found for these configurations in the table below. The values were derived utilizing 556.5 MCM Rail 45/7 conductor. A typical structure included in the CAPE Tower Design library was utilized for these checks with 6 feet of conductor sag included. Refer to the latest CAPE model for precise data and zero-sequence impedance values.

| Tower Configuration | Positive-Sequence Resistance (Ohms/1000') | Positive-Sequence Reactance (Ohms/1000') |
|--|--|---|
| Horizontal Post (Q4 Structure) | 0.0317 | 0.1431 |
| Davit Arm Single Circuit (Q1/Q2 Structure) | 0.0317 | 0.1377 |
| Davit Arm Double Circuit (Q10 Structure) | 0.0167 | 0.0768 |

18. The current carrying capacity of lines Q15 and Q16 are based on conditions and methodologies determined by Dairyland Power Cooperative (DPC).

LINE No. K1 – 34.4 kV Sub-Transmission

LINE NO.: K1

VOLTAGE: 34.4 KV

TERMINALS: Hydro Plant

TO: Hydro Line Substation

| | <u>LINE TOTAL</u> |
|-------------------------------|-----------------------|
| LINE MILES | 10.73 |
| MUTUAL MILES | |
| PHASE CONDUCTOR | 1/0 ACSR 6/1 Raven |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00073 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00039 |
| CHARGING AMPS | 1.2252 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 14/15 |
| WINTER NORM / EMER | 17/20 |
| LOADING CAPACITY (AMPS/PHASE) | |
| SUMMER NORM / EMER | 240/260 |
| WINTER NORM / EMER | 296/340 |
| EQUIVALENT SPACING (FT.) | 5.16 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS)* | 9.47280 + j8.40896 |
| ZERO SEQUENCE (OHMS)* | 14.5234 + j30.7212 |
| POSITIVE SEQUENCE (P.U.)* | 0.8005 + j0.7106 |
| ZERO SEQUENCE (P.U.)* | 1.2273 + j2.596 |

* This line uses resistance calculated at 25 degrees C.

LINE No. RQ7 – 161 kV, SMMPA

LINE NO.: RQ7 (Owned by SMMPA)

VOLTAGE: 161 KV

TERMINALS: Cascade Creek Substation [625430]

TO: Byron Substation [61948]

MUTUAL IMPEDANCE WITH LINE: RQ11

| | <u>Coupled Segment</u> | <u>Uncoupled Segment</u> | <u>LINE TOTAL</u> |
|-------------------------------|---------------------------|---------------------------|-------------------|
| LINE MILES | 6.40 | 3.34 | 9.74 |
| PHASE CONDUCTOR | 954 MCM ACSR 45/7 Rail | 954 MCM ACSR 45/7 Rail | |
| SHIELD CONDUCTOR | 3/8" EHS Steel | 3/8" EHS Steel | |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00974 | 0.00508 | 0.01482 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00560 | 0.00292 | 0.00852 |
| CHARGING AMPS | | | 5.3145 |
| LOADING CAPACITY (MVA) | | | |
| SUMMER NORM / EMER | 302/332 * | 302/332 * | 302/332 * |
| WINTER NORM / EMER | 396/435 * | 396/435 * | 396/435 * |
| LOADING CAPACITY (AMPS/PHASE) | | | |
| SUMMER NORM / EMER | 1083/1191 * | 1083/1191 * | 1083/1191 * |
| WINTER NORM / EMER | 1420/1560 * | 1420/1560 * | 1420/1560 * |
| EQUIVALENT SPACING (FT.) | 16.38 | 16.38 | |

IMPEDANCE DATA

| | | | |
|--------------------------|-------------------|------------------|-------------------|
| POSITIVE SEQUENCE (OHMS) | 0.6285 + j4.7026 | 0.3280 + j2.4542 | 0.9565 + j7.1568 |
| ZERO SEQUENCE (OHMS) | 2.3862 + j16.7444 | 1.2453 + j8.7385 | 3.6315 + j25.4829 |
| POSITIVE SEQUENCE (P.U.) | 0.0024 + j0.0181 | 0.0013 + j0.0095 | 0.0037 + j0.0276 |
| ZERO SEQUENCE (P.U.) | 0.0092 + j0.0646 | 0.0048 + j0.0337 | 0.0140 + j0.0983 |

MUTUAL IMPEDANCE DATA

| | |
|--------------------------|-------------------|
| ZERO SEQUENCE MUT (OHMS) | 1.7583 + j11.3421 |
| ZERO SEQUENCE MUT (P.U.) | 0.0068 + j0.0438 |

* Ratings provided by SMMPA per their ratings' methodology.

** In 2010, RQ7 was reconfigured to terminate at Byron and Cascade Creek substations after the RQ11 line was constructed to Westside substation. The Maple Leaf tap formerly connected to the RQ7 line was transferred to the RQ11 line.

LINE No. RQ11 – 161 kV, SMMPA

LINE NO.: RQ11 (Owned by SMMPA)

VOLTAGE: 161 KV

TERMINALS: Westside Substation [625436]

TO: Byron Substation [61948]
 Maple Leaf Substation [61906]

MUTUAL IMPEDANCE WITH LINE: RQ7

| | <u>Byron-ML Segment</u> | <u>ML-Westside Segment</u> | <u>LINE TOTAL</u> |
|-------------------------------|---------------------------|----------------------------|-------------------|
| LINE MILES | 4.58 | 2.40 | 6.98 |
| PHASE CONDUCTOR | 954 MCM ACSR 45/7 Rail | 954 MCM ACSR 45/7 Rail | |
| SHIELD CONDUCTOR | 3/8" EHS Steel | 3/8" EHS Steel | |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00698 | 0.00365 | 0.01063 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00425 | | 0.00425 |
| CHARGING AMPS | | | 3.8119 |
| LOADING CAPACITY (MVA) | | | |
| SUMMER NORM / EMER | 302/332 | 302/332 | 302/332 |
| WINTER NORM / EMER | 396/435 | 396/435 | 396/435 |
| LOADING CAPACITY (AMPS/PHASE) | | | |
| SUMMER NORM / EMER | 1083/1191 | 1083/1191 | 1083/1191 |
| WINTER NORM / EMER | 1420/1560 | 1420/1560 | 1420/1560 |
| EQUIVALENT SPACING (FT.) | 16.38 | 16.38 | 16.38 |

IMPEDANCE DATA

| | | | |
|--------------------------|-------------------|------------------|-------------------|
| POSITIVE SEQUENCE (OHMS) | 0.4920 + j3.3646 | 0.2618 + j1.7704 | 0.7538 + j5.1350 |
| ZERO SEQUENCE (OHMS) | 1.7497 + j11.9833 | 0.9072 + j6.2729 | 2.6569 + j18.2562 |
| POSITIVE SEQUENCE (P.U.) | 0.0019 + j0.0130 | 0.0010 + j0.0068 | 0.0029 + j0.0198 |
| ZERO SEQUENCE (P.U.) | 0.0068 + j0.0462 | 0.0035 + j0.0242 | 0.0103 + j0.0704 |

MUTUAL IMPEDANCE DATA

| | |
|--------------------------|-------------------|
| ZERO SEQUENCE MUT (OHMS) | 1.7587 + j11.3421 |
| ZERO SEQUENCE MUT (P.U.) | 0.0068 + j0.0438 |

* Ratings provided by SMMPA per their ratings methodology.

** In 2010, RQ11 was constructed to terminate at Byron and Westside substations. The Maple Leaf tap formerly connected to the RQ7 line was transferred to the RQ11 line.

LINE No. RQ12 – 161 kV, CAPX Utilities

LINE NO.: RQ12 (Owned by CAPX Utilities) Xcel designation #5310

VOLTAGE: 161 KV

TERMINALS: Northern Hills Substation [625415] TO: North Rochester Substation [601040]

MUTUAL IMPEDANCE WITH LINE: North Rochester - Byron 345 kV line

| | <u>LINE TOTAL**</u> |
|------------------------------|----------------------------|
| LINE MILES | 15.5 Overhead |
| PHASE CONDUCTOR | 795 MCM ACSS 26/7 Drake |
| SHIELD CONDUCTOR | OPGW |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.02221 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.01370 |
| CHARGING AMPS | 7.9646 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 463.2/509.5 * |
| WINTER NORM / EMER | 508.9/557.7 * |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 1661/1827 * |
| WINTER NORM / EMER | 1825/2000 * |
| EQUIVALENT SPACING (FT.) | |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 1.9544 +j11.9496 |
| ZERO SEQUENCE (OHMS) | 7.2786 +j29.6070 |
| POSITIVE SEQUENCE (P.U.) | 0.0075 + j0.0461 |
| ZERO SEQUENCE (P.U.) | 0.0281 + j0.1142 |
| <u>MUTUAL IMPEDANCE DATA</u> | |
| ZERO SEQUENCE MUT (OHMS) | 1.1373 + j2.4425 |
| ZERO SEQUENCE MUT (P.U.) | 0.0020 + j0.0044 |

* Ratings provided by Xcel Energy per their ratings methodology. Xcel uses 110% emergency ratings.

** CAPE model includes mutual coupling with adjacent Xcel Energy lines. Contact Xcel Energy for latest mutual coupling information.

LINE No. RQ13 – 161 kV, CAPX Utilities

LINE NO.: RQ13 (Owned by CAPX Utilities) Xcel designation # 5309

VOLTAGE: 161 KV

TERMINALS: Chester Substation [625445] TO: North Rochester Substation [601040]

MUTUAL IMPEDANCE WITH LINE: North Rochester - Byron 345 kV line

| | <u>LINE TOTAL**</u> |
|----------------------------------|----------------------------|
| LINE MILES | 27.54 Overhead |
| PHASE CONDUCTOR | 795 MCM ACSS 26/7 Drake |
| SHIELD CONDUCTOR | OPGW |
| POS. SEQ. SUSCEPTANCE (P.U.) | |
| ZERO SEQ. SUSCEPTANCE (P.U.) | |
| CHARGING AMPS | |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 463.7/463.7 * |
| WINTER NORM / EMER | 509.5/509.5 * |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 1663/1663 * |
| WINTER NORM / EMER | 1827/1827 * |
| EQUIVALENT SPACING (FT.) | |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 2.3484 +j18.6424 |
| ZERO SEQUENCE (OHMS) | 10.2388 +j48.4178 |
| POSITIVE SEQUENCE (P.U.) | 0.0091 + j0.0719 |
| ZERO SEQUENCE (P.U.) | 0.0395 + j0.1868 |
| <u>MUTUAL IMPEDANCE DATA</u> | |
| ZERO SEQUENCE MUT (OHMS) | 1.1373 + j2.4425 |
| ZERO SEQUENCE MUT (P.U.) | 0.0020 + j0.0044 |

* Ratings provided by Xcel Energy per their ratings methodology.

** CAPE model includes mutual coupling with adjacent Xcel Energy lines. Contact Xcel Energy for latest mutual coupling information.

LINE No. Q1 – 161 kV, RPU

LINE NO.: Q1

VOLTAGE: 161 KV

TERMINALS: Silver Lake Switching Station [625440]

TO: Chester Substation (RPU) [625445]

MUTUAL IMPEDANCE WITH LINE: Q2

| | <u>Silver Lake Segment</u> | <u>Chester Segment</u> | <u>LINE TOTAL</u> |
|------------------------------|----------------------------|----------------------------|-------------------|
| LINE MILES | 1.64 | 2.86 | 4.50 |
| MUTUAL MILES | 0 | 2.86 | 2.86 |
| PHASE CONDUCTOR | 795 MCM ACSR 26/7 Drake | 795 MCM ACSR 26/7 Drake | |
| SHIELD CONDUCTOR | OPGW | OPGW | |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00248 | 0.00461 | 0.00709 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00145 | 0.00233 | 0.00378 |
| CHARGING AMPS | | | 2.5435 |
| LOADING CAPACITY (MVA) | | | |
| SUMMER NORM / EMER | 312/335 | 312/335 | 312/335 |
| WINTER NORM / EMER | 335/335 | 335/335 | 335/335 |
| LOADING CAPACITY (AMPS) | | | |
| SUMMER NORM / EMER | 1119/1201 | 1119/1201 | 1119/1201 |
| WINTER NORM / EMER | 1201/1201 | 1201/1201 | 1201/1201 |
| EQUIVALENT SPACING (FT.) | 11.44 | 13.12 | |

IMPEDANCE DATA

| | | | |
|--------------------------|------------------|------------------|------------------|
| POSITIVE SEQUENCE (OHMS) | 0.2129 + j1.2005 | 0.3711 + j1.9799 | 0.5840 + j3.1804 |
| ZERO SEQUENCE (OHMS) | 0.8521 + j3.1191 | 1.4835 + j6.1939 | 2.3356 + j9.3130 |
| POSITIVE SEQUENCE (P.U.) | 0.0008 + j0.0046 | 0.0014 + j0.0076 | 0.0023 + j0.0123 |
| ZERO SEQUENCE (P.U.) | 0.0033 + j0.0120 | 0.0057 + j0.0239 | 0.0090 + j0.0359 |

MUTUAL IMPEDANCE DATA

| | | | |
|--------------------------|--|------------------|------------------|
| ZERO SEQUENCE MUT (OHMS) | | 1.0142 + j3.8704 | 1.0142 + j3.8704 |
| ZERO SEQUENCE MUT (P.U.) | | 0.0039 + j0.0149 | 0.0039 + j0.0149 |

The Silver Lake segment is the single circuit portion of the line beginning at Silver Lake sub. The Chester segment is the double circuit portion of the line.

LINE No. Q2 – 161 kV, RPU (FUTURE)

LINE NO.: Q2

VOLTAGE: 161 KV

TERMINALS: Chester Substation (RPU) [6254XX]

TO: Marion Road Substation [6254XX]

MUTUAL IMPEDANCE WITH LINE: Q1

| | <u>LINE TOTAL</u> |
|------------------------------|-------------------------------|
| LINE MILES | 2.3 |
| PHASE CONDUCTOR | 556.5 MCM ACSR 18/1 Osprey |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00351 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00199 |
| CHARGING AMPS | 2.4921 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 198/221 |
| WINTER NORM / EMER | 250/275 |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 710/793 |
| WINTER NORM / EMER | 897/986 |
| EQUIVALENT SPACING (FT.) | 12.40 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.44763 + j1.76592 |
| ZERO SEQUENCE (OHMS) | 1.41803+ j5.22366 |
| POSITIVE SEQUENCE (P.U.) | 0.00173 + j0.00681 |
| ZERO SEQUENCE (P.U.) | 0.00547 + j0.02015 |

LINE No. Q3 – 161 kV, RPU

LINE NO.: Q3

VOLTAGE: 161 KV

TERMINALS: Willow Creek Substation [625410]

TO: Bamber Valley Substation [625435]

| | <u>LINE TOTAL</u> |
|------------------------------|-------------------------------|
| LINE MILES | 2.65 Overhead |
| PHASE CONDUCTOR | 556.5 MCM ACSR 18/1 Osprey |
| SHIELD CONDUCTOR | 3/8" EHS Steel/OPGW |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00400 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00220 |
| CHARGING AMPS | 1.4357 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 198/221 |
| WINTER NORM / EMER | 250/275 |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 710/793 |
| WINTER NORM / EMER | 897/986 |
| EQUIVALENT SPACING (FT.) | 13.195 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.4888 + j1.9575 |
| ZERO SEQUENCE (OHMS) | 1.5344 + j6.0185 |
| POSITIVE SEQUENCE (P.U.) | 0.0019 + j0.0076 |
| ZERO SEQUENCE (P.U.) | 0.0059 + j0.0232 |

LINE No. Q4 – 161 kV, RPU

LINE NO.: Q4

VOLTAGE: 161 KV

TERMINALS: Bamber Valley Substation [625435]

TO: Cascade Creek Substation [625430]

| | <u>LINE TOTAL</u> |
|------------------------------|-------------------------------|
| LINE MILES | 4.33 Overhead |
| PHASE CONDUCTOR | 556.5 MCM ACSR 18/1 Osprey |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00644 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00369 |
| CHARGING AMPS | 2.3089 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 198/221 |
| WINTER NORM / EMER | 250/275 |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 710/793 |
| WINTER NORM / EMER | 897/986 |
| EQUIVALENT SPACING (FT.) | 11.64 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.7977 + j3.2467 |
| ZERO SEQUENCE (OHMS) | 2.4589 + j10.145 |
| POSITIVE SEQUENCE (P.U.) | 0.0031 + j0.0125 |
| ZERO SEQUENCE (P.U.) | 0.0095 + j0.0391 |

LINE No. Q5 – 161 kV, RPU

LINE NO.: Q5

VOLTAGE: 161 KV

TERMINALS: Northern Hills Substation [625415]

TO: Douglas Trail Substation [625450]

| | <u>LINE TOTAL</u> |
|------------------------------|-----------------------------|
| LINE MILES | 0.94 Overhead |
| PHASE CONDUCTOR | 556 MCM ACSR 18/1 Osprey |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00137 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00081 |
| CHARGING AMPS | 0.4930 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 198/221 |
| WINTER NORM / EMER | 250/275 |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 710/793 |
| WINTER NORM / EMER | 897/986 |
| EQUIVALENT SPACING (FT.) | 11.64 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.1735 + j0.7154 |
| ZERO SEQUENCE (OHMS) | 0.5424 + j1.9874 |
| POSITIVE SEQUENCE (P.U.) | 0.0007 + j0.0028 |
| ZERO SEQUENCE (P.U.) | 0.0021 + j0.0077 |

LINE No. Q6 – 161 kV, RPU

LINE NO.: Q6

VOLTAGE: 161 KV

TERMINALS: Zumbro River Substation [625425]

TO: Chester Substation (RPU) [625445]

| | <u>LINE TOTAL</u> |
|------------------------------|-------------------------------|
| LINE MILES | 10.30 Overhead |
| PHASE CONDUCTOR | 556.5 MCM ACSR 18/1 Osprey |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.01532 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00868 |
| CHARGING AMPS | 5.4921 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 198/221 |
| WINTER NORM / EMER | 250/275 |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 710/793 |
| WINTER NORM / EMER | 897/986 |
| EQUIVALENT SPACING (FT.) | 11.64 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 1.9020 + j7.7168 |
| ZERO SEQUENCE (OHMS) | 5.9889 + j22.181 |
| POSITIVE SEQUENCE (P.U.) | 0.0073 + j0.0298 |
| ZERO SEQUENCE (P.U.) | 0.0231 + j0.0856 |

LINE No. Q7 – 161 kV, RPU

LINE NO.: Q7

VOLTAGE: 161 KV

TERMINALS: Cascade Creek Substation [625430]

TO: Crosstown Substation [625405]

| | <u>LINE TOTAL</u> |
|------------------------------|----------------------------------|
| LINE MILES | 1.215 Overhead |
| PHASE CONDUCTOR | 2-556.5 MCM ACSR 18/1* Osprey |
| SHIELD CONDUCTOR | OPGW |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00359 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00138 |
| CHARGING AMPS | 1.2858 |
| LOADING CAPACITY (MVA)* | |
| SUMMER NORM / EMER | 396/425* |
| WINTER NORM / EMER | 452/474* |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 1420/1732 |
| WINTER NORM / EMER | 1621/1732 |
| EQUIVALENT SPACING (FT.) | 11.4 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.1077 + j0.4657 |
| ZERO SEQUENCE (OHMS) | 0.5736 + j2.1692 |
| POSITIVE SEQUENCE (P.U.) | 0.0004 + j0.0018 |
| ZERO SEQUENCE (P.U.) | 0.0022 + j0.0084 |

* See Note 8 & 9 in Legend page 1

LINE No. Q8 – 161 kV, RPU

LINE NO.: Q8

VOLTAGE: 161 KV

TERMINALS: Cascade Creek Substation [625430]

TO: IBM Substation [625420]

| | <u>LINE TOTAL</u> |
|------------------------------|-------------------------------|
| LINE MILES | 2.10 Overhead |
| PHASE CONDUCTOR | 556.5 MCM ACSR 18/1 Osprey |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00320 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00171 |
| CHARGING AMPS | 1.1463 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 198/221 |
| WINTER NORM / EMER | 250/275 |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 710/793 |
| WINTER NORM / EMER | 897/986 |
| EQUIVALENT SPACING (FT.) | 11.64 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.3869 + j1.5348 |
| ZERO SEQUENCE (OHMS) | 1.2252 + j4.6524 |
| POSITIVE SEQUENCE (P.U.) | 0.0015 + j0.0059 |
| ZERO SEQUENCE (P.U.) | 0.0047 + j0.0179 |

LINE No. Q9 – 161 kV, RPU

LINE NO.: Q9

VOLTAGE: 161 KV

TERMINALS: IBM Substation [625420]

TO: Northern Hills Substation [625415]
Westside Substation [625436]

| | <u>IBM – Tap Segment</u> | <u>NH – Tap Segment</u> | <u>Westside – Tap Segment</u> | <u>LINE TOTAL</u> |
|------------------------------|------------------------------|-----------------------------|-----------------------------------|-----------------------|
| LINE MILES | 1.27 Overhead | 1.57 Overhead | 1.83 Overhead | 4.67 |
| PHASE CONDUCTOR | 954 MCM ACSR 45/7 Rail | 954 MCM ACSR 45/7 Rail | 954 MCM ACSR 45/7 Rail | |
| SHIELD CONDUCTOR | OPGW | 3/8" EHS Steel | OPGW | |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00195 | 0.00241 | 0.00281 | 0.00718 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00112 | 0.00138 | 0.00162 | 0.00411 |
| CHARGING AMPS | | | | 2.5748 |
| LOADING CAPACITY (MVA) | | | | |
| SUMMER NORM / EMER | 278/305 | 278/305 | 342/376 | |
| WINTER NORM / EMER | 351/386 | 351/386 | 399/439 | |
| LOADING CAPACITY (AMPS) | | | | |
| SUMMER NORM / EMER | 997/1094 | 997/1094 | 1225/1348 | |
| WINTER NORM / EMER | 1258/1383 | 1258/1383 | 1430/1573 | |
| EQUIVALENT SPACING (FT.) | 15.45 | 15.45 | 14.67 | |
| <u>IMPEDANCE DATA</u> | | | | |
| POSITIVE SEQUENCE (OHMS) | 0.1394 + j0.9183 | 0.1722 + j1.1366 | 0.2010 + j1.3220 | 0.5126 + j3.3769 |
| ZERO SEQUENCE (OHMS) | 0.6346 + 2.5873 | 0.7843 + j3.3391 | 0.9147 + j3.5915 | 2.3336 + j9.5179 |
| POSITIVE SEQUENCE (P.U.) | 0.0005 + j0.0035 | 0.0007 + j0.0044 | 0.0008 + j0.0051 | 0.0020 + j0.0130 |
| ZERO SEQUENCE (P.U.) | 0.0025 + j0.0100 | 0.0030 + j0.0129 | 0.0035 + j0.0139 | 0.0090 + j0.0367 |

* The Westside tap is constructed at 212 deg. F. NESC sag limit. The Northern Hills to IBM original line is constructed at the 167 degree F. NESC sag limit.

LINE No. Q10 – 161 kV, RPU

LINE NO.: Q10

VOLTAGE: 161 KV

TERMINALS: Crosstown Substation [625405]

TO: Silver Lake Substation [625440]

| | <u>LINE TOTAL</u> |
|------------------------------|--------------------------------|
| LINE MILES | 0.36 Overhead |
| MUTUAL MILES | |
| PHASE CONDUCTOR | 2-556 MCM ACSR 18/1* Osprey |
| SHIELD CONDUCTOR | OPGW |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00100 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00039 |
| CHARGING AMPS | 0.36 |
| LOADING CAPACITY (MVA)* | |
| SUMMER NORM / EMER | 396/425* |
| WINTER NORM / EMER | 452/474* |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 1420/1732 |
| WINTER NORM / EMER | 1621/1732 |
| EQUIVALENT SPACING (FT.) | 15.1 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.0318 + j0.1461 |
| ZERO SEQUENCE (OHMS) | 0.1699 + j0.7822 |
| POSITIVE SEQUENCE (P.U.) | 0.0001 + j0.0006 |
| ZERO SEQUENCE (P.U.) | 0.0007 + j0.0030 |

* See Note 8 & 9 in Legend

LINE No. Q14 – 161 kV, RPU

LINE NO.: Q14

VOLTAGE: 161 KV

TERMINALS: Douglas Trail Substation [625450]

TO: Zumbro River Substation [625425]

| | <u>LINE TOTAL</u> |
|------------------------------|-----------------------------|
| LINE MILES | 3.233 Overhead |
| PHASE CONDUCTOR | 556 MCM ACSR 18/1 Osprey |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00476 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00261 |
| CHARGING AMPS | 1.7072 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 198/221 |
| WINTER NORM / EMER | 250/275 |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 710/793 |
| WINTER NORM / EMER | 897/986 |
| EQUIVALENT SPACING (FT.) | 11.64 |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.5949 + j2.4421 |
| ZERO SEQUENCE (OHMS) | 1.8474 + j8.4085 |
| POSITIVE SEQUENCE (P.U.) | 0.0023 + j0.0094 |
| ZERO SEQUENCE (P.U.) | 0.0071 + j0.0324 |

LINE No. Q15 – 161 kV, DPC

LINE NO.: DPC Q15 (Owned by DPC up to 1922QA15)

VOLTAGE: 161 KV

TERMINALS: RPU's Chester Substation [625445]

TO: DPC's Rochester Substation [69547]

| | <u>LINE TOTAL</u> |
|------------------------------|--------------------------------|
| LINE MILES | 0.042 (Approximately 222 feet) |
| MUTUAL MILES | |
| PHASE CONDUCTOR | 795 MCM ACSS |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00007 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00005 |
| CHARGING AMPS | 0.0251 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 334.6/377.4* |
| WINTER NORM / EMER | 405.8/450.9* |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 1200/1353.4* |
| WINTER NORM / EMER | 1455.2/1616.9* |
| EQUIVALENT SPACING (FT.) | N/A |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00473 + j0.03157 |
| ZERO SEQUENCE (OHMS) | 0.02653 + j0.10459 |
| POSITIVE SEQUENCE (P.U.) | 0.00002 + j0.00012 |
| ZERO SEQUENCE (P.U.) | 0.00010 + j0.00040 |

Commented [WW5]: To be verified with DPC

* Ratings provided by Xcel Energy per their ratings methodology.

LINE No. Q16 – 161 kV, DPC

LINE NO.: DPC Q16 (Owned by DPC up to 822QA15)

VOLTAGE: 161 KV

TERMINALS: RPU's Chester Substation [625445] TO: DPC's Rochester Substation [69547]

| | LINE TOTAL |
|------------------------------|-----------------------------------|
| LINE MILES | 0.078 (Approximately 413 feet) |
| PHASE CONDUCTOR | 954 MCM ACSR 45/7 Rail |
| SHIELD CONDUCTOR | 3/8" EHS Steel |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00012 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00008 |
| CHARGING AMPS | 0.0430 |
| LOADING CAPACITY (MVA) | |
| SUMMER NORM / EMER | 299.7/329.7* |
| WINTER NORM / EMER | 389.2/428.2* |
| LOADING CAPACITY (AMPS) | |
| SUMMER NORM / EMER | 1074.7/1182.3* |
| WINTER NORM / EMER | 1395.7/1535.5* |
| EQUIVALENT SPACING (FT.) | N/A |
| <u>IMPEDANCE DATA</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00861 + j0.05744 |
| ZERO SEQUENCE (OHMS) | 0.04828 + j0.19030 |
| POSITIVE SEQUENCE (P.U.) | 0.00003 + j0.00022 |
| ZERO SEQUENCE (P.U.) | 0.00019 + j0.00073 |

* Ratings provided by Xcel Energy per their ratings methodology.

LINE No. Q17 – 161 kV, RPU (FUTURE)

LINE NO.: Q17

VOLTAGE: 161 KV

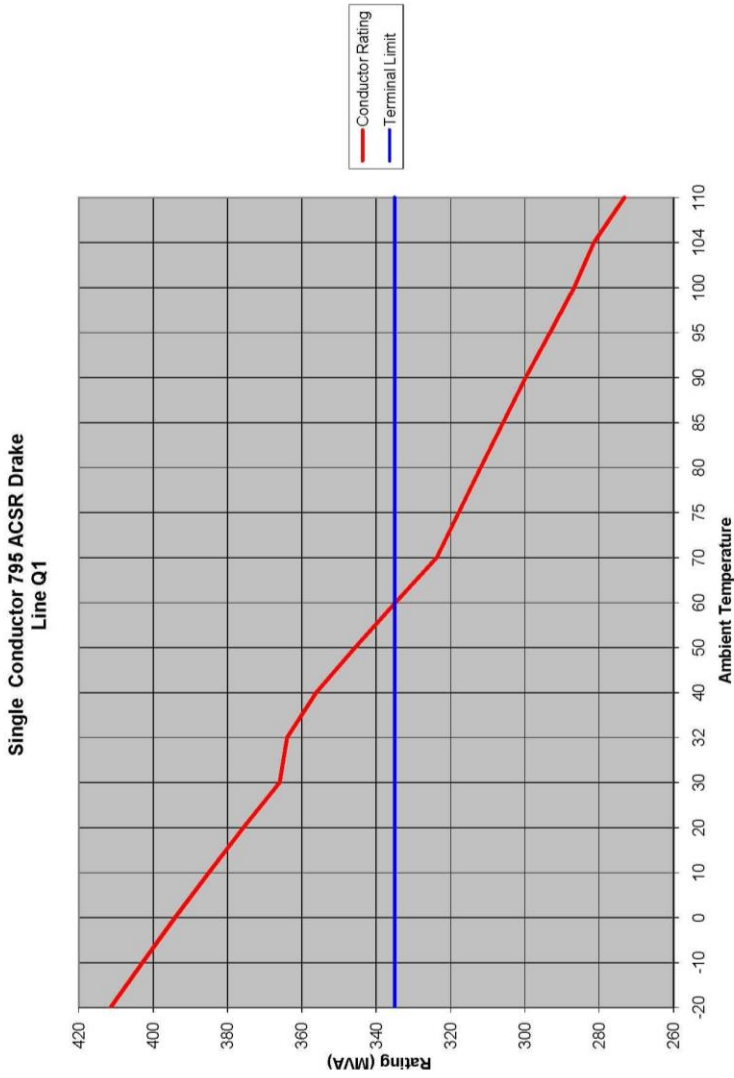
TERMINALS: Willow Creek Substation [625410]

TO: Chester Substation (RPU) [6254XX]

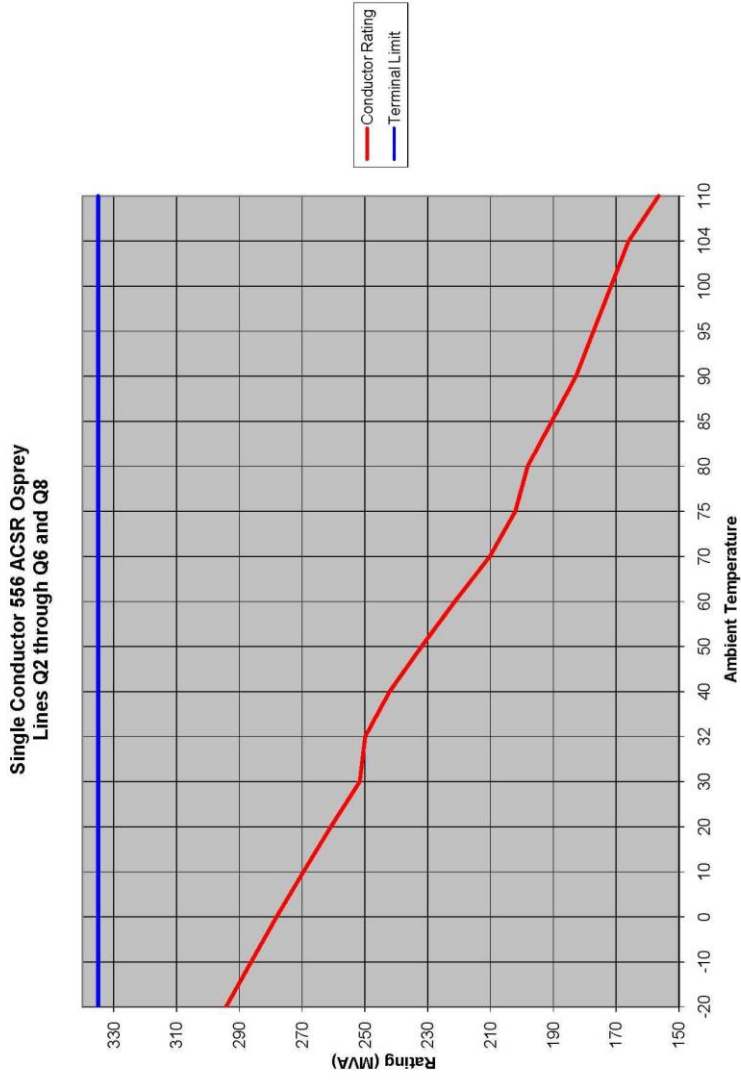
MUTUAL IMPEDANCE WITH LINE: Q1

| | <u>Coupled Segment</u> | <u>Uncoupled Segment</u> | <u>LINE TOTAL</u> |
|----------------------------------|-------------------------------|-------------------------------|-----------------------|
| LINE MILES | 2.86 | 1.53 | 4.39 |
| MUTUAL MILES | 2.86 | 0 | 2.86 |
| PHASE CONDUCTOR | 556.5 MCM ACSR 18/1 Osprey | 556.5 MCM ACSR 18/1 Osprey | |
| SHIELD CONDUCTOR | OPGW | OPGW | |
| POS. SEQ. SUSCEPTANCE (P.U.) | 0.00463 | 0.00112 | 0.00696 |
| ZERO SEQ. SUSCEPTANCE (P.U.) | 0.00280 | 0.00131 | 0.00411 |
| CHARGING AMPS | | | 4.9416 |
| LOADING CAPACITY (MVA) | | | |
| SUMMER NORM / EMER | 198/221 | 198/221 | 198/221 |
| WINTER NORM / EMER | 250/275 | 250/275 | 250/275 |
| LOADING CAPACITY (AMPS) | | | |
| SUMMER NORM / EMER | 710793 | 710793 | 710793 |
| WINTER NORM / EMER | 897/986 | 897/986 | 897/986 |
| EQUIVALENT SPACING (FT.) | 11.44 | 12.40 | |
| <u>IMPEDANCE DATA</u> | | | |
| POSITIVE SEQUENCE (OHMS) | 0.3707 + j1.9784 | 0.2819 + j1.1180 | 0.6526 + j3.0964 |
| ZERO SEQUENCE (OHMS) | 1.3828 + j6.1468 | 0.9040 + j3.5801 | 2.2868 + j9.7269 |
| POSITIVE SEQUENCE (P.U.) | 0.0014 + j0.0076 | 0.0011 + j0.0044 | 0.0025 + j0.0120 |
| ZERO SEQUENCE (P.U.) | 0.0053 + j0.0237 | 0.0035 + j0.0138 | 0.0088 + j0.0375 |
| <u>MUTUAL IMPEDANCE DATA</u> | | | |
| ZERO SEQUENCE MUT (OHMS) | 1.0142 + j3.8704 | | 1.0142 + j3.8704 |
| ZERO SEQUENCE MUT (P.U.) | 0.0039 + j0.0149 | | 0.0039 + j0.0149 |

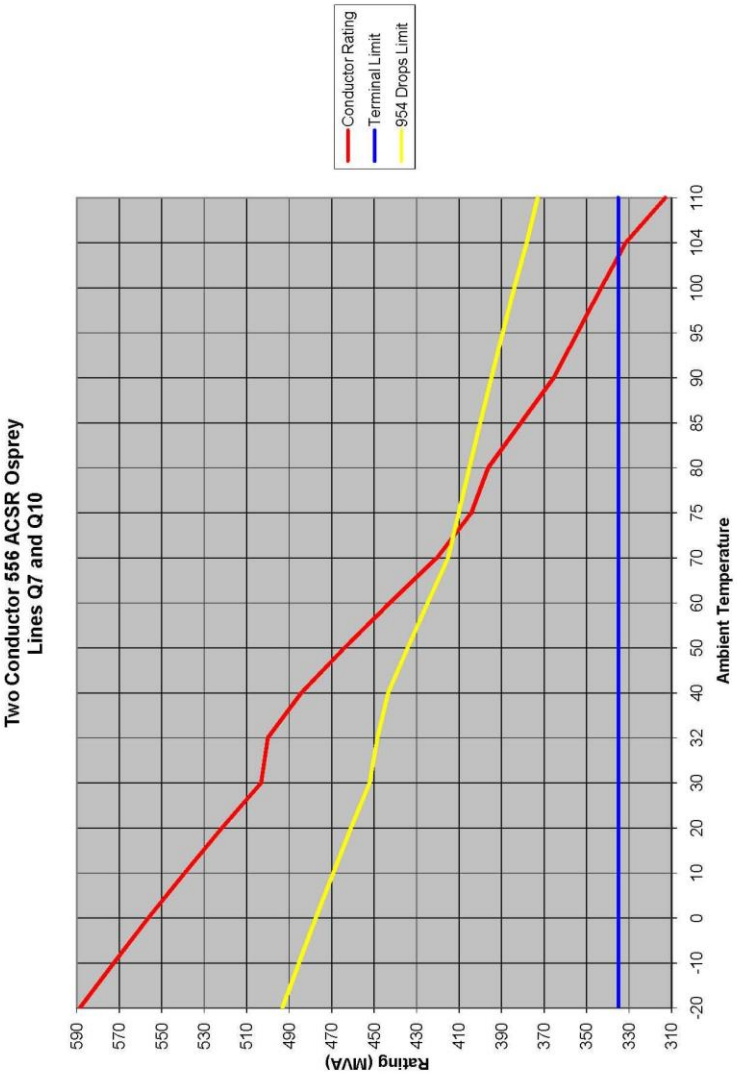
Line Q1 Rating vs. Temperature graph



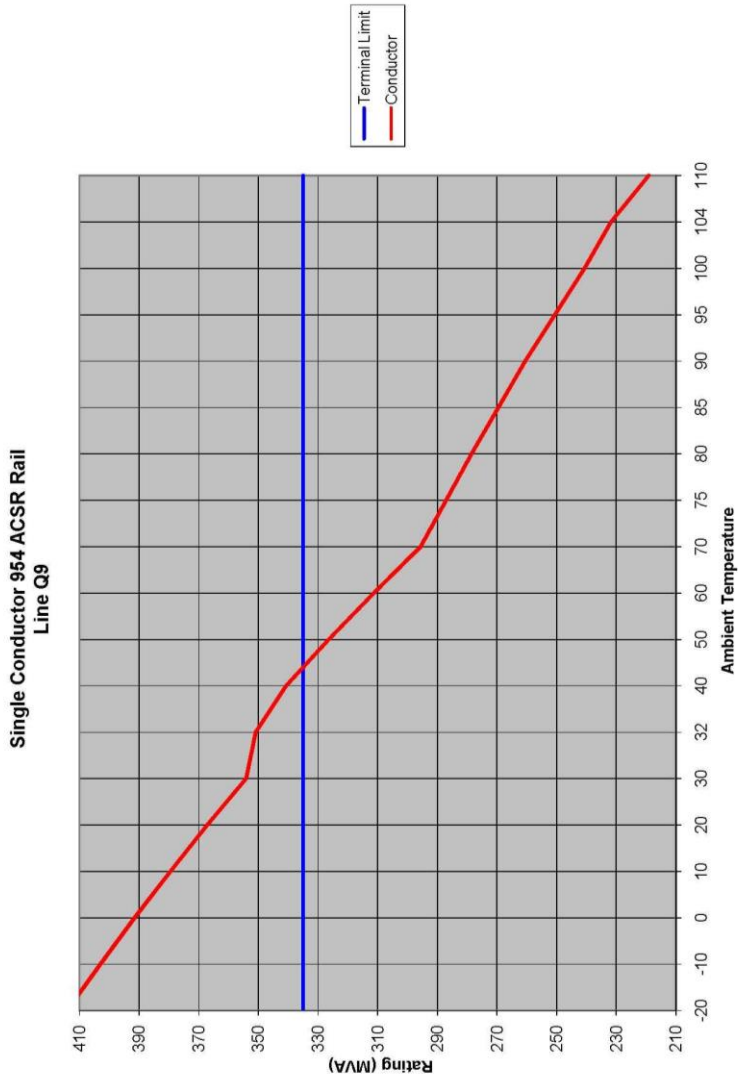
Lines Q2 thru Q6 & Q8 Ratings vs. Temperature graphs



Lines Q7 & Q10 Ratings vs. Temperature graphs



Line Q9 Rating (167 F° design) vs. Temperature graph



Transmission Line Capacity vs. Ambient Temperature Rating Data

TRANSMISSION LINE CAPACITY VERSUS AMBIENT TEMPERATURE RATING DATA

Assumptions

- Wind Speed - 2 ft/sec
- Wind to Conductor Angle - 90 degrees
- Elevation above Sea Level - 1100 ft
- East to West Line
- Latitude 44 degrees
- Sun time 14:00 hours
- Industrial Atmosphere
- Emissivity - 0.5
- Solar Absorptivity - 0.5

| AMBIENT TEMP DEG F | 167 Deg F Design 566.5 Osprey | | 212 Deg F Design 756 Drake | | 167 Deg F Design 954 Rail | | 212 Deg F Design 954 Rail | | 270 Deg F Design 954 Rail | | 167 Deg F Design 2 X 566.5 Osprey | | AMBIENT TEMP DEG F | |
|--------------------------|----------------------------------|-----|-------------------------------|-----|------------------------------|-----|------------------------------|-----|------------------------------|-----|--------------------------------------|-----|--------------------------|-------|
| | AMPS | MVA | AMPS | MVA | AMPS | MVA | AMPS | MVA | AMPS | MVA | AMPS | MVA | DEG F | DEG C |
| -20 | 1055 | 294 | 1475 | 411 | 1485 | 414 | 1616 | 451 | 1769 | 493 | 2110 | 568 | -20 | -28.9 |
| -10 | 1026 | 286 | 1445 | 403 | 1445 | 403 | 1582 | 441 | 1740 | 485 | 2053 | 572 | -10 | -23.3 |
| 0 | 997 | 278 | 1413 | 394 | 1404 | 391 | 1548 | 432 | 1712 | 477 | 1995 | 566 | 0 | -17.8 |
| 10 | 967 | 270 | 1380 | 385 | 1361 | 379 | 1512 | 422 | 1682 | 469 | 1933 | 559 | 10 | -12.2 |
| 20 | 935 | 261 | 1347 | 376 | 1316 | 367 | 1476 | 412 | 1652 | 461 | 1871 | 552 | 20 | -6.7 |
| 30 | 902 | 252 | 1312 | 366 | 1270 | 354 | 1437 | 401 | 1621 | 452 | 1804 | 503 | 30 | -1.1 |
| 32 | 896 | 250 | 1305 | 364 | 1258 | 351 | 1430 | 399 | 1608 | 448 | 1793 | 500 | 32 | 0.0 |
| 40 | 868 | 242 | 1277 | 356 | 1222 | 341 | 1399 | 390 | 1590 | 443 | 1736 | 484 | 40 | 4.4 |
| 50 | 832 | 232 | 1239 | 346 | 1170 | 326 | 1358 | 379 | 1557 | 434 | 1664 | 464 | 50 | 10.0 |
| 60 | 794 | 221 | 1201 | 335 | 1116 | 311 | 1315 | 367 | 1523 | 425 | 1587 | 443 | 60 | 15.6 |
| 70 | 754 | 210 | 1161 | 324 | 1060 | 296 | 1271 | 354 | 1489 | 415 | 1507 | 420 | 70 | 21.1 |
| 75 | 725 | 202 | 1140 | 318 | 1029 | 287 | 1248 | 348 | 1471 | 410 | 1449 | 404 | 75 | 23.9 |
| 80 | 697 | 198 | 1118 | 312 | 999 | 278 | 1225 | 342 | 1453 | 405 | 1421 | 396 | 80 | 26.7 |
| 85 | 683 | 190 | 1097 | 306 | 966 | 269 | 1202 | 335 | 1434 | 400 | 1366 | 381 | 85 | 29.4 |
| 90 | 655 | 183 | 1075 | 300 | 934 | 260 | 1177 | 328 | 1416 | 395 | 1310 | 365 | 90 | 32.2 |
| 95 | 635 | 177 | 1051 | 293 | 898 | 251 | 1152 | 321 | 1396 | 389 | 1270 | 354 | 95 | 35.0 |
| 100 | 615 | 172 | 1028 | 287 | 863 | 241 | 1126 | 314 | 1377 | 384 | 1230 | 343 | 100 | 37.8 |
| 104 | 595 | 166 | 1009 | 281 | 831 | 232 | 1105 | 308 | 1356 | 378 | 1189 | 332 | 104 | 40.0 |
| 110 | 561 | 156 | 980 | 273 | 786 | 219 | 1073 | 299 | 1338 | 373 | 1122 | 313 | 110 | 43.3 |

RPU Line Ratings Compliant With the Local Area Operating Guide
Effective July 1, 2002

| | SUMMER ambient T 75 deg. F. or below | 4 hour SUMMER SHORT TERM EMERGENCY 75 deg. F. or below | SUMMER OFF-PEAK ambient T 80 deg. F. | 4 hour SUMMER OFF-PEAK EMERGENCY 80 deg. F. | SUMMER PEAK ambient T 100 deg. F. | 4 hour SUMMER PEAK EMERGENCY 100 deg. F. | WINTER ambient T 32 deg. F. or below | 4 hour WINTER SHORT TERM EMERGENCY 32 deg. F. or below |
|--------|---|---|---|---|--|--|---|---|
| Q1 ** | 318 | 350/335 | 312 | 34/335 | 287 | 316 | 368/335 | 403/335 |
| Q2 | 202 | 222 | 188 | 221 | 172 | 188 | 250 | 275 |
| Q3 | 202 | 222 | 188 | 221 | 172 | 188 | 250 | 275 |
| Q4 | 202 | 222 | 188 | 221 | 172 | 188 | 250 | 275 |
| Q5 | 202 | 222 | 188 | 221 | 172 | 188 | 250 | 275 |
| Q6 | 202 | 222 | 188 | 221 | 172 | 188 | 250 | 275 |
| Q7 *** | 405/335 | 445/335 | 396/335 | 425/335 | 343/335 | 377/335 | 452/335 | 474/335 |
| Q8 | 202 | 222 | 188 | 221 | 172 | 188 | 250 | 275 |
| Q9 | 287 | 316 | 278 | 305 | 241 | 285 | 335 | 335 |
| Q10 * | 405/335 | 445/335 | 396/335 | 425/335 | 343/335 | 377/335 | 452/335 | 474/335 |

FACILITY/ambient temperature (F)

- Q1 ** Silver Lake - DPC Rochester **
- Q2 Willow Creek - DPC Rochester
- Q3 Cascade Creek - Zumbro Valley
- Q4 Cascade Creek - Zumbro Valley
- Q5 Northern Hills - Zumbro River
- Q6 Zumbro River - DPC Rochester
- Q7 *** Cascade Creek - Crosstown *
- Q8 Cascade Cr. - IBM
- Q9 IBM - Northern Hills
- Q10 * Crosstown - Silver Lake *

Notes:

- * If two ratings are listed, as in 368/335, 368 MVA is the line rating with the ring bus at both ends of the line closed and 335 MVA is the line rating with the ring bus at either end of the line open.
- ** A rating of 335 MVA is due to 1200 amp terminal equipment installations.
- 1. The 4 hour emergency ratings for all lines except Q7 and Q10 are based on:
 - a. The ambient temperature listed.
 - b. The design hot conductor temperature for the line.
- 2. The 4 hour emergency ratings Q7 and Q10 are based on the following:
 - a. The ambient temperature listed.
 - b. The 556 ACSR is rated at a hot conductor temperature of 132 deg. C / 167 deg. F.
 - c. The 554 ACSR is rated at a hot conductor temperature of 75 deg. C / 167 deg. F.
 - d. There are five spans of 954 ACSR on the two lines. All are within substation property.
 - e. The emergency ratings are based on the more limiting of:
 - 1. The 556 ACSR rating plus 1.0% or
 - 2. The 954 ACSR rating plus 5%

Substation Apparatus Limits

SUBSTATION APPARATUS LIMITS

Revised 10/2022

| Substation (Abbreviation) | Wave Trap Cont. Rating | * Bus Tube and Jumper Sizes, Cont. Rating & Config. | Disconnect Cont. Rating | Breaker Cont. Rating | "In-Line" Transformer Cont. Rating | Lowest Cont. Rating of CT | MVA Limit for Primary Relay | MVA Limit for Secondary Relay | MVA Limit for Bus Relay | Other Limits |
|--------------------------------------|---|--|---|---|------------------------------------|--|---|---|---|--|
| Bamber Valley (BV) | NA | 3.5" Sch 40 Alum (2)436 AAC Limit = 353 MVA | 5 - 1200 A Limit = 335 MVA | 2 - 1200 A Limit = 335 MVA | NA | Line Q3: 1000 CT x 1.5 RF Limit = 418 MVA | Line Q3: 311L @ 1000S CT Limit = 836 MVA | Line Q3: SEL 311C @ 1200S CT Limit = 1004 MVA | Bus D#1 Limit = 669 MVA | NA |
| Cascade Cr. (CC) | 1600 A limit to Byron | 4" Sch 40 Alum (2)795 ACSR Limit = 419 / 838 MVA | 12 - 1200 A Limit = 335 / 670 MVA | 101Q87 - 2000 A 910Q87 - 2000 A 910Q87 - 2000 A BT2Q87 - 2000 A B14Q87 - 2000 A Limit = 558 / 1116 MVA | NA | Line Q4: 1200 CT x 1.5 RF Limit = 502 MVA | Line Q4: SEL 321 @ 1200S CT Limit = 1004 MVA | Line Q4: SEL 311C @ 1200S CT Limit = 1004 MVA | Bus D#1 & 2 Limit = 1004 MVA | Line Q7: 954 ACSR terminal line drops at 270 deg. F, 75 deg F ambient Limit = 230 MVA |
| Chester (CH) | NA | 4" Sch 40 Alum (2)568 ACSR Limit = 528 / 1056 MVA | 12 - 2000 A Limit = 558 / 1116 MVA | 850B16 - 2000 A 820B16 - 2000 A 620B16 - 2000 A 650B16 - 2000 A Limit = 558 / 1116 MVA | NA | Line Q2: 1200 CT x 2.0 RF Limit = 669 MVA | Line Q2: 311L @ 1200S CT Limit = 1004 MVA | Line Q2: SEL 311C @ 1200S CT Limit = 1004 MVA | NA | Line R013 metering CT 1500 CT x 2.0 RF Limit = 836 MVA |
| Crossham (CR) | NA | 3" Sch 40 Alum (2)436 AAC Limit = 353 / 706 MVA | 8 - 1200 A Limit = 335 / 670 MVA | 4 - 1200 A Limit = 335 / 670 MVA | NA | Line Q10: 1200 CT x 2.0 RF Limit = 669 MVA | Line Q10: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q10: SEL 311C @ 1200S CT Limit = 1004 MVA | 15KV Bus 1 D#1 SBD 15KV Bus 2 D#1 SBD Limit = 669 MVA | Line Q7 & Q10: 954 ACSR terminal line drops at 270 deg. F, 75 deg F ambient Limit = 230 MVA |
| Douglas Trail (DT) | NA | 4" Sch 40 Alum (2)1590 AAC Limit = 616 MVA | 5 - 2000A Limit = 558MVA | 5 - 2000A Limit = 558MVA | NA | Line Q1: 1200 CT x 2.0 RF Limit = 669 MVA | Line Q1: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q1: SEL 311C @ 1200S CT Limit = 1004 MVA | NA | Line Q3 and Q14: 954 ACSR terminal Line Drops Limit = 227 MVA |
| International Business Machines (IB) | NA | 4" Sch 40 Alum (2)436 AAC Limit = 353 MVA | 4 - 1200 A 2 - 2000 A Limit = 558 MVA | 2 - 2000 A Limit = 558 MVA | NA | Line Q9: 1000 CT x 2.0 RF Limit = 669 MVA | Line Q9: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q9: SEL 311C @ 1200S CT Limit = 1004 MVA | Bus D#1 Limit = 1004 MVA | NA |
| Marion Rd (MR) | NA | 4" Sch 40 Alum (2)1590 AAC Limit = 616 MVA | 5 - 2000A Limit = 558MVA | 5 - 2000A Limit = 558MVA | NA | Line Q2: 1000 CT x 2.0 RF Limit = 558 MVA | Line Q2: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q2: SEL 311C @ 1200S CT Limit = 1004 MVA | NA | Line Q2 and Q17: 954 ACSR Terminal Line Drops Limit = 227 MVA |
| N. Hills (NH) | NA | 4" Sch 40 Alum (2)436 AAC Limit = 353 / 706 MVA | 9 - 2000 A Limit = 558 MVA | 4 - 2000 A Limit = 558 MVA | NA | Line Q6: 1000 CT x 2.0 RF Limit = 558 MVA | Line Q6: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q6: SEL 311C @ 1200S CT Limit = 1004 MVA | Bus D#1 & 2 Limit = 1004 MVA | NA |
| Silver Lake (SL) | NA | 3" Sch 40 Alum (2)436 AAC Limit = 353 / 706 MVA | 12 - 1200 A Limit = 335 / 670 MVA | 6 - 1200 A Limit = 335 / 670 MVA | NA | Line Q10: 1200 CT x 2.0 RF Limit = 669 MVA | Line Q10: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q10: SEL 311C @ 1200S CT Limit = 1004 MVA | Transf D#3 & 4 Limit = 669 MVA | Line Q10: 954 ACSR terminal line drops at 270 deg. F, 75 deg F ambient Limit = 230 MVA |
| Westside (WS) | 2000 A limit to Byron / Maple Leaf Limit = 558 MVA | 4" Sch 40 Alum (2)1590 AAC Limit = 616 MVA | 4 - 2000 A Limit = 558 MVA | 2 - 2000 A Limit = 558 MVA | NA | Line Q9: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q9: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q9: SEL 311C @ 1200S CT Limit = 1004 MVA | Bus D#1 Limit = 1004 MVA | Line R011 metering CT 1500 CT x 2.0 RF Limit = 836 MVA |
| Willow Creek (WC) | NA | 3" Sch 40 Alum (2)436 AAC Limit = 353 MVA | 5 - 1200 A Limit = 558 MVA | 1 - 2000 A Limit = 558 MVA | NA | 1000 CT x 1.5 RF Limit = 418 MVA | Line Q3: 311L @ 1000S CT Limit = 836 MVA | Line Q2: SEL 311C @ 1200S CT Limit = 1004 MVA | Bus D#1 Limit = 669 MVA | NA |
| Zumbro River (ZR) | NA | 4" Sch 40 Alum (2)436 AAC Limit = 353 MVA | 2 - 1200 A Limit = 335 MVA | 1 - 2000 A Limit = 558 MVA | NA | 1000 CT x 2.0 RF Limit = 558 MVA | Line Q6: SEL 311L @ 1200S CT Limit = 1004 MVA | Line Q6: SEL 311C @ 1200S CT Limit = 1004 MVA | NA | NA |

* Bus tube ratings per NEMA CC1-1984, 30 deg. C rise over 40 deg. C ambient, no wind, end 30
 ** Flexible bus conductor rating per Southwest, Conductor temperature of 75°C, ambient temperature 25°C, emissivity 0.5, wind 2 ft/sec. in sun.
 † Bus tube ratings are listed, as in 332 / 664 MVA. 332 is the rating with any part of the ring bus open - 664 is the rating with the ring bus closed.
 ‡ Relay limits shown are based on rated secondary AC input current limits.

GENERATION DATA

LEGEND

1. All electric generators at Silver Lake Plant were decommissioned December, 2016. Data for these retired machines has been deleted. Refer to version 16 or prior of the System Data Book for machine information if needed.
2. Type and rating data for reactors and resistors used as neutral current limiting devices for generating units can be found in the section marked Generator Resistor, Reactor, & Bus Duct Data. Impedances of these devices are not included in the generator impedance data.
3. Impedance data given as % on a machine base is the actual impedance data obtained from the generator test report. These values are test results with the generator nameplate maximum MVA rating used as an MVA base.
4. The impedance data given as P.U. on 100 MVA base is the actual impedance data obtained from the generator test report adjusted to a uniform system base of 100 MVA and expressed in per unit.
5. The inertia constant H is expressed in kilowatt-seconds/kilo volt-amperes and is computed as follows:

$$H = \frac{0.231 (WK^2) (RPM)^2 (10^{-6})}{kVA}$$

Where

| | | |
|-----------------|---|---|
| WK ² | = | Moment of inertia in lb.-ft ² |
| RPM | = | Turbine speed in revolutions per minute |
| kVA | = | Generator nameplate rating in kilo volt-amperes |

6. The Maximum VAR OUTPUT and Maximum VAR INTAKE are the reactive limits of the machine. (Care must be taken to not exceed the MVA rating of the machine.)
7. Generator and associated equipment ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.

CASCADE CREEK UNIT #1

GENERATOR NO.: 1

LOCATION: Cascade Creek Substation

FUEL SOURCE: No. 2 Oil or Natural Gas

MANUFACTURER: Westinghouse

YEAR OF MANUFACTURE: 1975

SERIAL NO.: 17A2182 (Turbine) / 83P350 (Generator)

PRIME MOVER: Gas Turbine

VOLTAGE/CONNECTION: 13.800 / Wye

PHASE/FREQ./SPEED: 3 Phase / 60 cycle / 3,600 RPM

MVA RATING: (MAX./ MIN.) 39.222 MVA @ 0.90 pf, 35,300 MW /

GROUNDING IMPEDANCE: (TYPE/RATING) Neutral Reactor / See Reactor Data

GENERATOR COOLANT: Air

IMPEDANCE DATA

| (P.U. ON MACHINE BASE) | | (P.U. ON 100 MVA BASE) | |
|------------------------------------|---------|------------------------------------|--------|
| SYNCHRONOUS REACTANCE (X_d) | 2.048 | SYNCHRONOUS REACTANCE (X_d) | 5.2224 |
| TRANSIENT REACTANCE (X'_d) | 0.314 * | TRANSIENT REACTANCE (X'_d) | 0.8007 |
| SUBTRANSIENT REACTANCE (X''_d) | 0.161 | SUBTRANSIENT REACTANCE (X''_d) | 0.4106 |
| NEG. SEQUENCE REACTANCE (X_2) | 0.161 | NEG. SEQUENCE REACTANCE (X_2) | 0.4106 |
| ZERO SEQUENCE REACTANCE (X_0) | 0.056 | ZERO SEQUENCE REACTANCE (X_0) | 0.1482 |

INERTIA CONSTANT (H) = 1.92 KW-Sec/KVA *
 $WK^2 = 76,000$ (Turbine) + 22,600 (Generator) + 755 (Exciter) + 7,900 (Gear)

| | | | | |
|--------------------------|----------|----------|--------------------------|------|
| Maximum MW OUTPUT (Pmax) | 27.0 Sum | 40.0 Win | Minimum MW OUTPUT (Pmin) | 5.0 |
| Maximum MVAR OUTPUT | | 17.1 | Maximum MVAR INTAKE | -8.5 |

* Comparison of RPU generation data (shown here) and data requested from Westinghouse Corp. show slight discrepancies in the X'_d impedance value and major discrepancies in the inertia constant value H. Westinghouse reported $X'_d = 0.276$, $H = 8.1860$. A better approximation of H was developed in 2002 (shown here).

CASCADE CREEK UNIT #2

GENERATOR NO.: 2
 LOCATION: Cascade Creek Substation
 FUEL SOURCE: No. 2 Oil or Natural Gas
 MANUFACTURER: Pratt & Whitney / Brush
 YEAR OF MANUFACTURE: 2001
 SERIAL NO.: 905043.010
 PRIME MOVER: Gas Turbine
 VOLTAGE/CONNECTION: 13.800 / Wye
 PHASE/FREQ./SPEED: 3 Phase / 60 cycle / 3,600 RPM
 MVA RATING: (MAX./ MIN.) 71.176 @ 0.85 pf /
 GROUNDING IMPEDANCE: Neutral Resistor / Dist. Trans. w/secondary resistor
 (TYPE/RATING)
 GENERATOR COOLANT: Air

IMPEDANCE DATA

| (P.U. ON MACHINE BASE) | | (P.U. ON 100 MVA BASE) | |
|------------------------------------|--------|------------------------------------|--------|
| SYNCHRONOUS REACTANCE (X_d) | 2.283 | SYNCHRONOUS REACTANCE (X_d) | 3.2075 |
| TRANSIENT REACTANCE (X'_d) | 0.2166 | TRANSIENT REACTANCE (X'_d) | 0.3043 |
| SUBTRANSIENT REACTANCE (X''_d) | 0.1492 | SUBTRANSIENT REACTANCE (X''_d) | 0.2096 |
| NEG. SEQUENCE REACTANCE (X_2) | 0.1718 | NEG. SEQUENCE REACTANCE (X_2) | 0.2414 |
| ZERO SEQUENCE REACTANCE (X_0) | 0.0913 | ZERO SEQUENCE REACTANCE (X_0) | 0.1283 |

INERTIA CONSTANT (H) 1.79 KW-Sec/KVA

| | | | |
|--------------------------|------|--------------------------|-------|
| Maximum MW OUTPUT (Pmax) | 49.9 | Minimum MW OUTPUT (Pmin) | 3.0 |
| Maximum MVAR OUTPUT | 37.5 | Maximum MVAR INTAKE | -18.7 |

HYDRO PLANT UNIT #1

| | |
|---------------------------------------|------------------------------|
| GENERATOR NO.: | 1 |
| LOCATION: | Hydro Plant |
| FUEL SOURCE: | Water |
| MANUFACTURER: | General Electric |
| YEAR OF MANUFACTURE: | 1915-1919 Rebuilt 1984 |
| SERIAL NO.: | 1352999 |
| PRIME MOVER: | Francis Turbine |
| VOLTAGE/CONNECTION: | 2300 / Delta |
| PHASE/FREQ./SPEED: | 3 Phase / 60 Cycle / 225 RPM |
| MVA RATING: (MAX./ MIN.) | 1.487 @ 0.95 pf / |
| GROUNDING IMPEDANCE: (TYPE/RATING) | Ungrounded / |
| GENERATOR COOLANT: | Air |

IMPEDANCE DATA

| | (P.U. ON MACHINE BASE) | | (P.U. ON 100 MVA BASE) |
|------------------------------------|------------------------|------------------------------------|------------------------|
| SYNCHRONOUS REACTANCE (X_d) | 1.50 | SYNCHRONOUS REACTANCE (X_d) | 100.874 |
| TRANSIENT REACTANCE (X'_d) | 0.40 | TRANSIENT REACTANCE (X'_d) | 26.899 |
| SUBTRANSIENT REACTANCE (X''_d) | 0.40 | SUBTRANSIENT REACTANCE (X''_d) | 26.899 |
| NEG. SEQUENCE REACTANCE (X_2) | 0.56 | NEG. SEQUENCE REACTANCE (X_2) | 37.659 |
| ZERO SEQUENCE REACTANCE (X_0) | 0.07 | ZERO SEQUENCE REACTANCE (X_0) | 4.707 |
| Maximum MW OUTPUT (Pmax) | 1.2 | Minimum MW OUTPUT (Pmin) | 0.7 |
| Maximum MVAR OUTPUT | 0.46 | Maximum MVAR INTAKE | -0.23 |

HYDRO PLANT UNIT #2

| | |
|---------------------------------------|------------------------------|
| GENERATOR NO.: | 2 |
| LOCATION: | Hydro Plant |
| FUEL SOURCE: | Water |
| MANUFACTURER: | General Electric |
| YEAR OF MANUFACTURE: | 1915-1919 Rebuilt 1984 |
| SERIAL NO.: | 1353000 |
| PRIME MOVER: | Francis Turbine |
| VOLTAGE/CONNECTION: | 2300 / Delta |
| PHASE/FREQ./SPEED: | 3 Phase / 60 Cycle / 225 RPM |
| MVA RATING: (MAX./ MIN.) | 1.487 @ 0.95 pf / |
| GROUNDING IMPEDANCE: (TYPE/RATING) | Ungrounded / |
| GENERATOR COOLANT: | Air |

IMPEDANCE DATA

| | (P.U. ON MACHINE BASE) | | (P.U. ON 100 MVA BASE) |
|------------------------------------|------------------------|------------------------------------|------------------------|
| SYNCHRONOUS REACTANCE (X_d) | 1.50 | SYNCHRONOUS REACTANCE (X_d) | 100.874 |
| TRANSIENT REACTANCE (X'_d) | 0.40 | TRANSIENT REACTANCE (X'_d) | 26.899 |
| SUBTRANSIENT REACTANCE (X''_d) | 0.40 | SUBTRANSIENT REACTANCE (X''_d) | 26.899 |
| NEG. SEQUENCE REACTANCE (X_2) | 0.56 | NEG. SEQUENCE REACTANCE (X_2) | 37.659 |
| ZERO SEQUENCE REACTANCE (X_0) | 0.07 | ZERO SEQUENCE REACTANCE (X_0) | 4.707 |
| Maximum MW OUTPUT (Pmax) | 1.2 | Minimum MW OUTPUT (Pmin) | 0.7 |
| Maximum MVAR OUTPUT | 0.46 | Maximum MVAR INTAKE | -0.23 |

IBM PLANT GEN-SET #1

| | | | |
|---------------------------------------|--------------------|---|---------------------|
| GENERATOR NO.: | IBM Genset No. 1 | | |
| LOCATION: | IBM Plant Bldg. 20 | | |
| FUEL SOURCE: | Diesel | | |
| MANUFACTURER: | Caterpillar | | |
| YEAR OF MANUFACTURE: | 2006 | | |
| SERIAL NO.: | GZS00145 | | |
| PRIME MOVER: | Diesel Engine | | |
| VOLTAGE/CONNECTION: | 480/277 | / | Wye |
| PHASE/FREQ./SPEED: | 3 Phase | / | 60 Cycle / 1800 RPM |
| MVA RATING: (MAX./ MIN.) | 2.281 @ 0.80 pf | / | |
| GROUNDING IMPEDANCE: (TYPE/RATING) | Solidly Grounded / | | |
| GENERATOR COOLANT: | Air | | |

IMPEDANCE DATA

| (P.U. ON MACHINE BASE) | | (P.U. ON 100 MVA BASE) | | |
|------------------------------------|--------|------------------------------------|---------|--|
| SYNCHRONOUS REACTANCE (X_d) | 3.1179 | SYNCHRONOUS REACTANCE (X_d) | 136.690 | |
| TRANSIENT REACTANCE (X'_d) | 0.2188 | TRANSIENT REACTANCE (X'_d) | 9.592 | |
| SUBTRANSIENT REACTANCE (X''_d) | 0.1356 | SUBTRANSIENT REACTANCE (X''_d) | 5.945 | |
| NEG. SEQUENCE REACTANCE (X_2) | 0.1297 | NEG. SEQUENCE REACTANCE (X_2) | 5.686 | |
| ZERO SEQUENCE REACTANCE (X_0) | 0.0079 | ZERO SEQUENCE REACTANCE (X_0) | 0.346 | |
| Maximum MW OUTPUT (Pmax) | 1.825 | Minimum MW OUTPUT (Pmin) | 0.456 | |
| Maximum MVAR OUTPUT | 1.368 | Maximum MVAR INTAKE | 0 | |

IBM PLANT GEN-SET #2

| | |
|---------------------------------------|-------------------------------|
| GENERATOR NO.: | IBM Genset No. 2 |
| LOCATION: | IBM Plant Bldg. 301 |
| FUEL SOURCE: | Diesel |
| MANUFACTURER: | Caterpillar |
| YEAR OF MANUFACTURE: | 2006 |
| SERIAL NO.: | GZS00144 |
| PRIME MOVER: | Diesel Engine |
| VOLTAGE/CONNECTION: | 480/277 / Wye |
| PHASE/FREQ./SPEED: | 3 Phase / 60 Cycle / 1800 RPM |
| MVA RATING: (MAX./ MIN.) | 2.281 @ 0.80 pf / |
| GROUNDING IMPEDANCE: (TYPE/RATING) | Solidly Grounded / |
| GENERATOR COOLANT: | Air |

IMPEDANCE DATA

| (P.U. ON MACHINE BASE) | (P.U. ON 100 MVA BASE) | | |
|------------------------------------|------------------------|------------------------------------|---------|
| SYNCHRONOUS REACTANCE (X_d) | 3.1179 | SYNCHRONOUS REACTANCE (X_d) | 136.690 |
| TRANSIENT REACTANCE (X'_d) | 0.2188 | TRANSIENT REACTANCE (X'_d) | 9.592 |
| SUBTRANSIENT REACTANCE (X''_d) | 0.1356 | SUBTRANSIENT REACTANCE (X''_d) | 5.945 |
| NEG. SEQUENCE REACTANCE (X_2) | 0.1297 | NEG. SEQUENCE REACTANCE (X_2) | 5.686 |
| ZERO SEQUENCE REACTANCE (X_0) | 0.0079 | ZERO SEQUENCE REACTANCE (X_0) | 0.346 |
| Maximum MW OUTPUT (Pmax) | 1.825 | Minimum MW OUTPUT (Pmin) | 0.456 |
| Maximum MVAR OUTPUT | 1.368 | Maximum MVAR INTAKE | 0 |

WESTSIDE ENERGY UNIT #1

GENERATOR NO.: 1
 LOCATION: Westside Energy Station
 FUEL SOURCE: Natural Gas
 MANUFACTURER: Wartsila – ABB 1120LT10
 YEAR OF MANUFACTURE: 2016
 SERIAL NO.: Engine #1: PAAE289051, Generator #1: 4654485
 PRIME MOVER: Reciprocating Internal Combustion Engine
 VOLTAGE/CONNECTION: 13,800 / Wye
 PHASE/FREQ./SPEED: 3 Phase / 60 cycle / 720 RPM
 MVA RATING: (MAX./ MIN.) 11,712 @ 0.8 pf /
 GROUNDING IMPEDANCE: Neutral Resister / See Resister Data
 (TYPE/RATING)
 GENERATOR COOLANT: Air

IMPEDANCE DATA

| (P.U. ON MACHINE BASE 11.676 MVA) | | (P.U. ON 100 MVA BASE) | | |
|------------------------------------|-------|------------------------------------|---------|--|
| SYNCHRONOUS REACTANCE (X_d) | 1.75 | SYNCHRONOUS REACTANCE (X_d) | 14.9880 | |
| TRANSIENT REACTANCE (X'_d) | 0.33 | TRANSIENT REACTANCE (X'_d) | 2.8263 | |
| SUBTRANSIENT REACTANCE (X''_d) | 0.193 | SUBTRANSIENT REACTANCE (X''_d) | 1.6530 | |
| NEG. SEQUENCE REACTANCE (X_2) | 0.203 | NEG. SEQUENCE REACTANCE (X_2) | 1.7386 | |
| ZERO SEQUENCE REACTANCE (X_0) | 0.058 | ZERO SEQUENCE REACTANCE (X_0) | 0.4967 | |
| Maximum MW OUTPUT (Pmax) | 9.62 | Minimum MW OUTPUT (Pmin) | 3.97 | |
| Maximum MVAR OUTPUT | 9.70 | Maximum MVAR INTAKE | -5.00 | |

WESTSIDE ENERGY UNIT #2

GENERATOR NO.: 2
 LOCATION: Westside Energy Station
 FUEL SOURCE: Natural Gas
 MANUFACTURER: Wartsila – ABB 1120LT10
 YEAR OF MANUFACTURE: 2016
 SERIAL NO.: Engine #2: PAAE289052, Generator #2: 461406
 PRIME MOVER: Reciprocating Internal Combustion Engine
 VOLTAGE/CONNECTION: 13,800 / Wye
 PHASE/FREQ./SPEED: 3 Phase / 60 cycle / 720 RPM
 MVA RATING: (MAX./ MIN.) 11,712 @ 0.8 pf /
 GROUNDING IMPEDANCE: Neutral Resister / See Resister Data
 (TYPE/RATING)
 GENERATOR COOLANT: Air

IMPEDANCE DATA

| (P.U. ON MACHINE BASE 11.676 MVA) | | (P.U. ON 100 MVA BASE) | |
|------------------------------------|-------|------------------------------------|---------|
| SYNCHRONOUS REACTANCE (X_d) | 1.75 | SYNCHRONOUS REACTANCE (X_d) | 14.9880 |
| TRANSIENT REACTANCE (X'_d) | 0.33 | TRANSIENT REACTANCE (X'_d) | 2.8263 |
| SUBTRANSIENT REACTANCE (X''_d) | 0.193 | SUBTRANSIENT REACTANCE (X''_d) | 1.6530 |
| NEG. SEQUENCE REACTANCE (X_2) | 0.203 | NEG. SEQUENCE REACTANCE (X_2) | 1.7386 |
| ZERO SEQUENCE REACTANCE (X_0) | 0.058 | ZERO SEQUENCE REACTANCE (X_0) | 0.4967 |
| Maximum MW OUTPUT (Pmax) | 9.62 | Minimum MW OUTPUT (Pmin) | 3.97 |
| Maximum MVAR OUTPUT | 9.70 | Maximum MVAR INTAKE | -5.00 |

WESTSIDE ENERGY UNIT #3

GENERATOR NO.: 3
 LOCATION: Westside Energy Station
 FUEL SOURCE: Natural Gas
 MANUFACTURER: Wartsila – ABB 1120LT10
 YEAR OF MANUFACTURE: 2016
 SERIAL NO.: Engine #3: PAAE289053, Generator #3: 4654487
 PRIME MOVER: Reciprocating Internal Combustion Engine
 VOLTAGE/CONNECTION: 13,800 / Wye
 PHASE/FREQ./SPEED: 3 Phase / 60 cycle / 720 RPM
 MVA RATING: (MAX./ MIN.) 11,712 @ 0.8 pf /
 GROUNDING IMPEDANCE: Neutral Resister / See Resister Data
 (TYPE/RATING)
 GENERATOR COOLANT: Air

IMPEDANCE DATA

| (P.U. ON MACHINE BASE 11.676 MVA) | | (P.U. ON 100 MVA BASE) | | |
|------------------------------------|-------|------------------------------------|---------|--|
| SYNCHRONOUS REACTANCE (X_d) | 1.75 | SYNCHRONOUS REACTANCE (X_d) | 14.9880 | |
| TRANSIENT REACTANCE (X'_d) | 0.33 | TRANSIENT REACTANCE (X'_d) | 2.8263 | |
| SUBTRANSIENT REACTANCE (X''_d) | 0.193 | SUBTRANSIENT REACTANCE (X''_d) | 1.6530 | |
| NEG. SEQUENCE REACTANCE (X_2) | 0.203 | NEG. SEQUENCE REACTANCE (X_2) | 1.7386 | |
| ZERO SEQUENCE REACTANCE (X_0) | 0.058 | ZERO SEQUENCE REACTANCE (X_0) | 0.4967 | |
| Maximum MW OUTPUT (Pmax) | 9.62 | Minimum MW OUTPUT (Pmin) | 3.97 | |
| Maximum MVAR OUTPUT | 9.70 | Maximum MVAR INTAKE | -5.00 | |

WESTSIDE ENERGY UNIT #4

GENERATOR NO.: 4
 LOCATION: Westside Energy Station
 FUEL SOURCE: Natural Gas
 MANUFACTURER: Wartsila – ABB 1120LT10
 YEAR OF MANUFACTURE: 2016
 SERIAL NO.: Engine #4: PAAE289054, Generator #4: 4654486
 PRIME MOVER: Reciprocating Internal Combustion Engine
 VOLTAGE/CONNECTION: 13,800 / Wye
 PHASE/FREQ./SPEED: 3 Phase / 60 cycle / 720 RPM
 MVA RATING: (MAX./ MIN.) 11,712 @ 0.8 pf /
 GROUNDING IMPEDANCE: Neutral Resister / See Resister Data
 (TYPE/RATING)
 GENERATOR COOLANT: Air

IMPEDANCE DATA

| (P.U. ON MACHINE BASE 11.676 MVA) | | (P.U. ON 100 MVA BASE) | | |
|------------------------------------|-------|------------------------------------|---------|--|
| SYNCHRONOUS REACTANCE (X_d) | 1.75 | SYNCHRONOUS REACTANCE (X_d) | 14.9880 | |
| TRANSIENT REACTANCE (X'_d) | 0.33 | TRANSIENT REACTANCE (X'_d) | 2.8263 | |
| SUBTRANSIENT REACTANCE (X''_d) | 0.193 | SUBTRANSIENT REACTANCE (X''_d) | 1.6530 | |
| NEG. SEQUENCE REACTANCE (X_2) | 0.203 | NEG. SEQUENCE REACTANCE (X_2) | 1.7386 | |
| ZERO SEQUENCE REACTANCE (X_0) | 0.058 | ZERO SEQUENCE REACTANCE (X_0) | 0.4967 | |
| Maximum MW OUTPUT (Pmax) | 9.62 | Minimum MW OUTPUT (Pmin) | 3.97 | |
| Maximum MVAR OUTPUT | 9.70 | Maximum MVAR INTAKE | -5.00 | |

WESTSIDE ENERGY UNIT #5

GENERATOR NO.: 5
 LOCATION: Westside Energy Station
 FUEL SOURCE: Natural Gas
 MANUFACTURER: Wartsila – ABB 1120LT10
 YEAR OF MANUFACTURE: 2016
 SERIAL NO.: Engine #5: PAAE289055, Generator #5: 4654488
 PRIME MOVER: Reciprocating Internal Combustion Engine
 VOLTAGE/CONNECTION: 13,800 / Wye
 PHASE/FREQ./SPEED: 3 Phase / 60 cycle / 720 RPM
 MVA RATING: (MAX./ MIN.) 11,712 @ 0.8 pf /
 GROUNDING IMPEDANCE: Neutral Resister / See Resister Data
 (TYPE/RATING)
 GENERATOR COOLANT: Air

IMPEDANCE DATA

| (P.U. ON MACHINE BASE 11.676 MVA) | | (P.U. ON 100 MVA BASE) | |
|------------------------------------|-------|------------------------------------|---------|
| SYNCHRONOUS REACTANCE (X_d) | 1.75 | SYNCHRONOUS REACTANCE (X_d) | 14.9880 |
| TRANSIENT REACTANCE (X'_d) | 0.33 | TRANSIENT REACTANCE (X'_d) | 2.8263 |
| SUBTRANSIENT REACTANCE (X''_d) | 0.193 | SUBTRANSIENT REACTANCE (X''_d) | 1.6530 |
| NEG. SEQUENCE REACTANCE (X_2) | 0.203 | NEG. SEQUENCE REACTANCE (X_2) | 1.7386 |
| ZERO SEQUENCE REACTANCE (X_0) | 0.058 | ZERO SEQUENCE REACTANCE (X_0) | 0.4967 |
| Maximum MW OUTPUT (Pmax) | 9.62 | Minimum MW OUTPUT (Pmin) | 3.97 |
| Maximum MVAR OUTPUT | 9.70 | Maximum MVAR INTAKE | -5.00 |

POWER TRANSFORMER DATA

LEGEND

1. The underlined no load tap setting is a) the setting observed in service in 1979 when the original data was gathered or b) the setting selected upon commissioning for equipment installed after 1979.
2. The % impedance on transformer base is the actual impedance stamped on the transformer nameplate. This value is a test result using the transformer OA rating @ 55°C winding temperature as an MVA base. Impedance data that is shown for R + jX is derived from the manufacturer's test report for impedance and load losses. Impedance data is generally reported at 75°C or 85 °C and base rating.
R % = Load Losses/base rating.
3. The PU impedance on 100 MVA base is the actual impedance stamped on the transformer nameplate adjusted to a uniform system base of 100 MVA and expressed in per unit.
4. In cases where the transformer serves as a generator step-up transformer, for computer modeling purposes the impedance is also presented on the generator base MVA as required for PSS/E.
5. Transformer ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.

TRANSFORMER No. BVS T1

TRANSFORMER NO.: T1
 LOCATION: Bamber Valley Substation
 MANUFACTURER: Delta-Star
 YEAR OF MANUFACTURER: 2001
 SERIAL NO.: F68151101
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA / 20.0-FA / 25.0-FA
 MVA RATING: @65°C 16.8-OA / 22.4-FA / 28.0-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ±15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.274 + j9.196 = 9.20 | 0.01827 + j0.6131 = 0.6134 |

TRANSFORMER No. BVS T2

TRANSFORMER NO.: T2
 LOCATION: Bamber Valley Substation
 MANUFACTURER: GE Prolec
 YEAR OF MANUFACTURER: 1998
 SERIAL NO.: G381-01
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA/ 20.0-FA / 25.0-FA
 MVA RATING: @65°C / / 28.0-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(161kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 10 % RANGE, IN 32 STEPS OF 5/8 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.328 + j 9.761 = 9.767 | 0.02188 + j 0.6508 = 0.6511 |

NOTE: This transformer had been originally installed at Cascade Creek substation in the T1 location. The unit was relocated and commissioned at Bamber Valley in 2009.

TRANSFORMER No. CCS GSU2

TRANSFORMER NO.: GSU2
 LOCATION: Cascade Creek Substation
 MANUFACTURER: Waukesha
 YEAR OF MANUFACTURER: 2001
 SERIAL NO.: A4332T
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 37.5-ONAN / 50.0-ONAF / 62.5-ONAF
 MVA RATING: @65°C 42.0-ONAN / 56.0-ONAF / 70.0-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|--------------------------|----------------|---|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 169,050 | | |
| <u>Grd Wye</u> CONNECTED | 161000Y/92950 | 165,025 <u>161,000</u> 156,975 152,950 | 650kV/(138kV) | 750kV/(161kV) |
| LOW VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 13800 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON None WINDING, _____ % RANGE, IN _____ STEPS OF _____ %

IMPEDANCE DATA

| | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-------|-----------------------------------|--|
| HV-LV | 0.240 + j8.987 = 8.99 | 0.0064 + j0.23965 = 0.2397 |
| | | <u>P.U. IMPEDANCE ON 71.176 MVA BASE</u> |
| | | 0.1706 |

TRANSFORMER No. CCS T1

TRANSFORMER NO.: T1
 LOCATION: Cascade Creek Substation
 MANUFACTURER: Delta-Star
 YEAR OF MANUFACTURER: 2008
 SERIAL NO.: F74110109
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-ONAN / 26.7-ONAF / 33.3-ONAF
 MVA RATING: @65°C 22.5-ONAN / 29.9-ONAF / 37.5-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|--|
| HV-LV | 0.32 + j9.13 = 9.14 | 0.01595 + j0.4567 = 0.4570 |
| | | <u>P.U. IMPEDANCE ON 39.2 MVA BASE</u> |
| | | 0.1790 |

NOTE: For dynamics simulation, this transformer serves as a generator step-up transformer for Cascade Creek Combustion Turbine #1.

TRANSFORMER No. CCS T2

TRANSFORMER NO.: T2
 LOCATION: Cascade Creek Substation
 MANUFACTURER: ABB
 YEAR OF MANUFACTURER: 2018
 SERIAL NO.: CS000391001
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-ONAN / 26.7-ONAF / 33.3-ONAF
 MVA RATING: @65°C 22.4-ONAN / 29.9-ONAF / 37.3-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 150kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.326 + j 9.735 = 9.74 | 0.0163 + j0.4867 = 0.4870 |

TRANSFORMER No. CRS T1

TRANSFORMER NO.: T1
 LOCATION: Crosstown Substation
 MANUFACTURER: ABB
 YEAR OF MANUFACTURER: 1992
 SERIAL NO.: SLL5865
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-OA / 26.667-FA / 33.333-FA
 MVA RATING: @65°C 22.4-OA / 29.865-FA / 37.300-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(161kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800/7967 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.218 + j9.297 = 9.30 | 0.0109 + j0.4649 = 0.4650 |

TRANSFORMER No. CRS T2

TRANSFORMER NO.: T2
 LOCATION: Crosstown Substation
 MANUFACTURER: ABB
 YEAR OF MANUFACTURER: 1992
 SERIAL NO.: SLL5859
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-OA / 26.667-FA / 33.333-FA
 MVA RATING: @65°C 22.4-OA / 29.865-FA / 37.300-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(161kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800/7967 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.220 + j9.277 = 9.28 | 0.0110 + j0.4639 = 0.4640 |

TRANSFORMER No. DTS T1

TRANSFORMER NO.: T1
 LOCATION: Douglas Trail Substation
 MANUFACTURER: ABB
 YEAR OF MANUFACTURER: 2017
 SERIAL NO.: CS00390001
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-ONAN / 20.0-ONAF / 25.0-ONAF
 MVA RATING: @65°C 16.8-ONAN / 22.4-ONAF / 28.0-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 150kV/(15kV) | 150kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ±15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.3222 + j9.815 = 9.82 | 0.02148 + j0.6543 = 0.65466 |

TRANSFORMER No. DTS T2

TRANSFORMER NO.: T2
 LOCATION: Douglas Trail Substation
 MANUFACTURER: ABB
 YEAR OF MANUFACTURER: 2017
 SERIAL NO.: CS00427001
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-ONAN / 20.0-ONAF / 25.0-ONAF
 MVA RATING: @65°C 16.8-ONAN / 22.4-ONAF / 28.0-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 150kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ±15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.3329 + j9.734 = 9.74 | 0.02219 + j0.64895 = 0.64933 |

TRANSFORMER No. DTS T3

TRANSFORMER NO.: T3
 LOCATION: Douglas Trail Substation
 MANUFACTURER: Delta-Star
 YEAR OF MANUFACTURER: 2001
 SERIAL NO.: F68161001
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA / 20.0-FA / 25.0-FA
 MVA RATING: @65°C 16.8-OA / 22.4-FA / 28.0-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

IMPEDANCE DATA

| | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-------|-----------------------------------|---------------------------------------|
| HV-LV | 0.276 + j9.296 = 9.30 | 0.0184 + j0.6197 = 0.6200 |

NOTE: This transformer had been originally installed at Cascade Creek substation in the T2 location. The unit was relocated and commissioned at Douglas Trail in 2017.

TRANSFORMER No. HLS KU1

TRANSFORMER NO.: KU1
 LOCATION: Hydro Line Substation
 MANUFACTURER: Westinghouse
 YEAR OF MANUFACTURER: 1984
 SERIAL NO.: SDT 7191-0101
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C /
 MVA RATING: @65°C 3.75-OA /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|------------------------|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 36200 | | |
| <u>Wye</u> CONNECTED | 34400 | 35300 | 220kV/(34.5kV) | 200kV/(34.5kV) |
| | | 34400 | | |
| | | 33500 | | |
| | | 32600 | | |
| LOW VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 13800 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON None WINDING, _____% RANGE, IN _____ STEPS OF _____ %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 7.0 | 1.8667 |

TRANSFORMER No. IBM T1

TRANSFORMER NO.: T1
 LOCATION: IBM Substation
 MANUFACTURER: McGraw Edison
 YEAR OF MANUFACTURER: 1980
 SERIAL NO.: C-06225-5-1 Spec 15027-A
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-OA / 26.667-FA / 33.333-FA
 MVA RATING: @65°C 22.4-OA / 29.867-FA / 37.333-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|-----------------|-------------------------|--------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 x 115000 | <u>161000</u> 115000 | 650kV/(161kV) 450kV/(115kV) | 650kV/(161kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800/7968 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|--------------------------|-----------------------------------|---------------------------------------|
| HV-LV (161000 Volt Conn) | 0.362 + j9.623 = 9.63 | 0.01811+ j0.4812 = 0.4815 |

TRANSFORMER No. IBM T2

TRANSFORMER NO.: T2
 LOCATION: IBM Substation
 MANUFACTURER: McGraw Edison
 YEAR OF MANUFACTURER: 1980
 SERIAL NO.: C-06222-5-1 Spec 15027
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-OA / 26.667-FA / 33.333-FA
 MVA RATING: @65°C 22.4-OA / 29.867-FA / 37.333-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|--------------------------|-----------------|-------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 161000 x 115000 | <u>161000</u> 115000 | 650kV/(161kV) 450/(115kV) | 650kV/(161kV) |
| LOW VOLTAGE WINDING | | | | |
| <u>Grd.Wye</u> CONNECTED | 13800/7968 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|--------------------------|-----------------------------------|---------------------------------------|
| HV-LV (161000 Volt Conn) | 0.352 + j9.554 = 9.56 | 0.0176 + j0.4777 = 0.4780 |

TRANSFORMER No. MRS T1

TRANSFORMER NO.: T1
 LOCATION: Marion Road Substation
 MANUFACTURER: GE Prolec
 YEAR OF MANUFACTURER: 2023
 SERIAL NO.: G4843-01
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-ONAN / 26.70-ONAF / 33.30-ONAF
 MVA RATING: @65°C N/A / N/A / 37.5-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 750kV/(161kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 150kV/(15kV) | 150kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ±15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.318 + j9.761 = 9.766 | 0.0159 + j0.4881 = 0.4884 |

TRANSFORMER No. MRS T2

TRANSFORMER NO.: T2
 LOCATION: Marion Road Substation
 MANUFACTURER: GE Prolec
 YEAR OF MANUFACTURER: 2023
 SERIAL NO.: G4875-01
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-ONAN / 26.70-ONAF / 33.30-ONAF
 MVA RATING: @65°C N/A / N/A / 37.5-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 750kV/(161kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 150kV/(15kV) | 150kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ±15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.308 + j9.593 = 9.598 | 0.0154 + j0.4797 = 0.4799 |

TRANSFORMER No. NHS T1

TRANSFORMER NO.: T1
 LOCATION: Northern Hills Substation
 MANUFACTURER: General Electric
 YEAR OF MANUFACTURER: 1988
 SERIAL NO.: M122729
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA / 20.0-FA / 25.0-FOA
 MVA RATING: @65°C / / 28.0-FOA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(161kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.3274 + j10.465 = 10.47 | 0.02182 + j0.6977 = 0.6980 |

TRANSFORMER No. NHS T2

TRANSFORMER NO.: T2
 LOCATION: Northern Hills Substation
 MANUFACTURER: Delta Star
 YEAR OF MANUFACTURER: 2003
 SERIAL NO.: F69610903
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-ONAN / 20.0-ONAF / 25.0-ONAF
 MVA RATING: @65°C 16.8-ONAN / 22.4-ONAF / 28.0-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.272 + j10.096 = 10.1 | 0.01813 + j0.6731 = 0.6733 |

TRANSFORMER No. SLS T3

TRANSFORMER NO.: T3
 LOCATION: Silver Lake Substation
 MANUFACTURER: Pauwels
 YEAR OF MANUFACTURER: 1992
 SERIAL NO.: 90.4.6452
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-OA / 26.660-FA / 33.330-FA
 MVA RATING: @65°C 22.5-OA / 29.900-FA / 37.330-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.183 + j9.878 = 9.88 | 0.00916 + j0.4939 = 0.4940 |

TRANSFORMER No. SLS T4

TRANSFORMER NO.: T4
 LOCATION: Silver Lake Substation
 MANUFACTURER: Pauwels
 YEAR OF MANUFACTURER: 1991
 SERIAL NO.: 90.4.7203
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-OA / 26.660-FA / 33.330-FA
 MVA RATING: @65°C 22.5-OA / 29.900-FA / 37.330-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.184 + j9.848 = 9.85 | 0.0092 + j0.4924 = 0.4925 |

TRANSFORMER No. WES GSU1

TRANSFORMER NO.: GSU1
 LOCATION: Westside Energy Station
 MANUFACTURER: ABB
 YEAR OF MANUFACTURER: 2017
 SERIAL NO.: CA00045-001
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C / /
 MVA RATING: @65°C 37.5-ONAN / 50.0-ONAF / 62.5 ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|--------------------------|----------------|---|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 169050 | | |
| <u>Grd.Wye</u> CONNECTED | 161000Y | 165025 <u>161000</u> 156975 152950 | 650kV/(161kV) | 750kV/(138kV) |
| LOW VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 13800 | | 110kV/(15kV) | 110kV/(25kV) |

LTC DATA

LTC ON None WINDING, _____% RANGE, IN _____ STEPS OF _____ %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---|
| HV-LV GSU tie line | 0.355 + j 9.103 = 9.11 | 0.00947 + j 0.24275 = 0.24293 0.00006 + j 0.0003 |
| | | <u>Total P.U. IMPEDANCE ON 62.5 MVA BASE*</u> |
| | | 0.00596 + j 0.15191 |

* This impedance includes the generator tie line for computer modeling purposes.

TRANSFORMER No. WSS T1

TRANSFORMER NO.: T1
 LOCATION: Westside Substation
 MANUFACTURER: Delta-Star
 YEAR OF MANUFACTURER: 2010
 SERIAL NO.: F74120110
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 20.0-ONAN / 26.7-ONAF / 33.3-ONAF
 MVA RATING: @65°C 22.5-ONAN / 29.9-ONAF / 37.5-ONAF

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(138kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.34 + j9.91 = 9.92 | 0.0170 + j0.4957 = 0.4960 |

Note: This transformer has an NGR, see below data sheet.

TRANSFORMER No. WCS T1

TRANSFORMER NO.: T1
 LOCATION: Willow Creek Substation
 MANUFACTURER: Pauwels
 YEAR OF MANUFACTURER: 1994
 SERIAL NO.: 94.4.3337
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA / 20.0-FA / 25.0-FA
 MVA RATING: @65°C 16.8-OA / 22.4-FA / 28.0-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| HV-LV | 0.3182 + j17.817 = 17.82 | 0.01136 + j0.6363 = 0.6364 |

Note: transformer nameplate impedance is measured at 28MVA, and values are reflected here

TRANSFORMER No. WCS T2

TRANSFORMER NO.: T2
 LOCATION: Willow Creek Substation
 MANUFACTURER: Delta-Star
 YEAR OF MANUFACTURER: 2000
 SERIAL NO.: F66700101
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA / 20.0-FA / 25.0-FA
 MVA RATING: @65°C 16.8-OA / 22.4-FA / 28.0-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 | None | 650kV/(161kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

IMPEDANCE DATA

| | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-------|-----------------------------------|---------------------------------------|
| HV-LV | 0.2853 + j9.296 = 9.30 | 0.01902 + j0.6197 = 0.6200 |

TRANSFORMER No. ZRS T1

TRANSFORMER NO.: T1
 LOCATION: Zumbro River Substation
 MANUFACTURER: RTE
 YEAR OF MANUFACTURER: 1982
 SERIAL NO.: A6584
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA / 20.0-FA / 25.0-FA
 MVA RATING: @65°C 16.9-OA / 22.5-FA / 28.0-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|---|-----------------|-------------------------|--------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING <u>Delta</u> CONNECTED | 161000 x 115000 | <u>161000</u> 115000 | 650kV/(161kV) 450kV/(115kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| 161000-13800 | 0.321 + j9.655 = 9.66 | 0.02138 + j0.6436 = 0.6440 |

TRANSFORMER No. ZRS T2

TRANSFORMER NO.: T2
 LOCATION: Zumbro River Substation
 MANUFACTURER: RTE
 YEAR OF MANUFACTURER: 1982
 SERIAL NO.: A6585
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 15.0-OA / 20.0-FA / 25.0-FA
 MVA RATING: @65°C 16.9-OA / 22.5-FA / 28.0-FA

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|--------------------------|-----------------|-------------------------|--------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 161000 x 115000 | <u>161000</u> 115000 | 650kV/(161kV) 450kV/(115kV) | 650kV/(138kV) |
| LOW VOLTAGE WINDING | | | | |
| <u>Grd.Wye</u> CONNECTED | 13800Y/7970 | | 110kV/(15kV) | 110kV/(15kV) |

LTC DATA

LTC ON LV WINDING, ± 15 % RANGE, IN 32 STEPS OF 15/16 %

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-----------------------|-----------------------------------|---------------------------------------|
| 161000-13800 | 0.3193 + j9.745 = 9.75 | 0.0213 + j0.6496 = 0.6500 |

PLANT AUXILIARY TRANSFORMER DATA

LEGEND

1. The underlined no load tap setting is a) the setting observed in service in 1979 when the original data was gathered or b) the setting selected upon commissioning for equipment installed after 1979.
2. The % impedance on transformer base is the actual impedance stamped on the transformer nameplate. This value is a test result using the transformer OA rating @ 55°C winding temperature as an MVA base. On transformers where the MVA rating is given only on the basis of a 65°C winding temperature, the % impedance is given for the OA rating at that winding temperature.
3. The PU impedance on 100 MVA base is the actual impedance stamped on the transformer nameplate adjusted to a uniform system base of 100 MVA and expressed in per unit.
4. Transformer ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.

AUXILIARY TRANSFORMER No. CCS MA1

TRANSFORMER NO.: MA1
 LOCATION: Cascade Creek
 MANUFACTURER: _____
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: _____
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @80°C 2.0 -OA / /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|------------------------|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 14490 | | |
| <u>Delta</u> CONNECTED | 13800 | 14145 | (15kV) | (15kV) |
| | | 13800 | | |
| | | 13455 | | |
| | | 13110 | | |
| LOW VOLTAGE WINDING | | | | |
| <u>Wye</u> CONNECTED | 2400 | | | |

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-------------------------|-----------------------------------|---------------------------------------|
| HV-LV (13800 Volt Conn) | | |

AUXILIARY TRANSFORMER No. CCS MA2

TRANSFORMER NO.: MA2
 LOCATION: Cascade Creek
 MANUFACTURER: _____
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: _____
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @80°C 2.0 -OA / /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|------------------------|----------------|---|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 14490 | | |
| <u>Delta</u> CONNECTED | 13800 | 14145 <u>13800</u> 13455 13110 | (15kV) | (15kV) |
| LOW VOLTAGE WINDING | | | | |
| <u>Wye</u> CONNECTED | 2400 | | | |

IMPEDANCE DATA % IMPEDANCE ON TRANS. BASE P.U. IMPEDANCE ON 100 MVA BASE
 HV-LV (13800 Volt Conn)

AUXILIARY TRANSFORMER No. SLP MA3

TRANSFORMER NO.: MA3
 LOCATION: Silver Lake Plant
 MANUFACTURER: Allis Chalmers
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: 3362633
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @80°C 2.0 -OA / 2.67 -FA /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|------------------------|----------------|---|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 14490 | | |
| <u>Delta</u> CONNECTED | 13800 | 14145 <u>13800</u> 13455 13110 | (15kV) | (15kV) |
| LOW VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 2400 | | | |

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-------------------------|-----------------------------------|---------------------------------------|
| HV-LV (13800 Volt Conn) | 5.6 | 2.80 |

AUXILIARY TRANSFORMER No. SLP RA1

TRANSFORMER NO.: RA1
 LOCATION: Silver Lake Plant
 MANUFACTURER: Westinghouse
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: 4085183
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 0.75 -OA / /
 MVA RATING: @65°C / /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|--|----------------|----------------------------|-----------------------------------|-----------------------------------|
| HIGH VOLTAGE WINDING <u>Grd. Wye</u> CONNECTED | 13800/7970 | None | (15kV) | (15kV) |
| LOW VOLTAGE WINDING <u>Delta</u> CONNECTED | 480 | | | |

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P. U. IMPEDANCE ON 100 MVA BASE</u> |
|-------------------------|---------------------------------------|--|
| HV-LV (13800 Volt Conn) | 8.1 | 10.80 |

AUXILIARY TRANSFORMER No. SLP RA3

TRANSFORMER NO.: RA3
 LOCATION: Silver Lake Plant
 MANUFACTURER: Allis Chalmers
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: 3362632
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @80°C 2.0 -OA / 2.67 -FA /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|------------------------|----------------|---|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 14490 | | |
| <u>Delta</u> CONNECTED | 13800 | 14145 <u>13800</u> 13455 13110 | (15kV) | (15kV) |
| LOW VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 2400 | | | |

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P.U. IMPEDANCE ON 100 MVA BASE</u> |
|-------------------------|-----------------------------------|---------------------------------------|
| HV-LV (13800 Volt Conn) | 5.6 | 2.80 |

AUXILIARY TRANSFORMER No. SLP RA4

TRANSFORMER NO.: RA4
 LOCATION: Silver Lake Plant
 MANUFACTURER: General Electric
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: F964397
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 7.5-OA/ 8.4-FA /
 MVA RATING: @65°C / 10.5-FA /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|------------------------|----------------|------------------------|-------------------------------|-------------------------------|
| HIGH VOLTAGE WINDING | | 14400 | | |
| <u>Delta</u> CONNECTED | 13800 | 14100 | (15kV) | (15kV) |
| | | <u>13800</u> | | |
| | | 13500 | | |
| | | 13200 | | |
| LOW VOLTAGE WINDING | | | | |
| <u>Delta</u> CONNECTED | 2400 | | | |

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P. U. IMPEDANCE ON 100 MVA BASE</u> |
|-------------------------|-----------------------------------|--|
| HV-LV (13800 Volt Conn) | 5.6 | 0.7467 |

AUXILIARY TRANSFORMER No. SLP SA1

TRANSFORMER NO.: SA1
 LOCATION: Silver Lake Plant
 MANUFACTURER: Westinghouse
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: 4085185
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 0.75 -OA / /
 MVA RATING: @65°C / /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|--|----------------|----------------------------|-----------------------------------|-----------------------------------|
| HIGH VOLTAGE WINDING <u>Grd. Wye</u> CONNECTED | 13800/7970 | None | (15kV) | (15kV) |
| LOW VOLTAGE WINDING <u>Delta</u> CONNECTED | 480 | | | |

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P. U. IMPEDANCE ON 100 MVA BASE</u> |
|-------------------------|---------------------------------------|--|
| HV-LV (13800 Volt Conn) | 8.1 | 10.80 |

AUXILIARY TRANSFORMER No. SLP SA2

TRANSFORMER NO.: SA2
 LOCATION: Silver Lake Plant
 MANUFACTURER: Westinghouse
 YEAR OF MANUFACTURER: _____
 SERIAL NO.: 4085184
 TYPE: Two winding
 PHASE/CYCLE: 3 Phase / 60 Cycle
 MVA RATING: @55°C 0.75 -OA / /
 MVA RATING: @65°C / /

| | <u>VOLTAGE</u> | <u>NO LOAD TAPS AT</u> | <u>WINDING BIL/(kV CLASS)</u> | <u>BUSHING BIL/(kV CLASS)</u> |
|--|----------------|----------------------------|-----------------------------------|-----------------------------------|
| HIGH VOLTAGE WINDING <u>Grd. Wye</u> CONNECTED | 13800/7970 | None | (15kV) | (15kV) |
| LOW VOLTAGE WINDING <u>Delta</u> CONNECTED | 480 | | | |

| <u>IMPEDANCE DATA</u> | <u>% IMPEDANCE ON TRANS. BASE</u> | <u>P. U. IMPEDANCE ON 100 MVA BASE</u> |
|-------------------------|---------------------------------------|--|
| HV-LV (13800 Volt Conn) | 8.1 | 10.80 |

GENERATOR REACTOR, RESISTOR, & BUS DUCT DATA

LEGEND

1. The rating information for this section is the actual rating stamped on the equipment nameplate or as provided on manufacturer's drawings and documentation.
2. The PU impedance on 100 MVA base is the actual impedance for the equipment adjusted to a uniform system base of 100 MVA and expressed in per unit.
8. All electric generators at Silver Lake Plant were decommissioned December, 2016. Data for these retired machines and related auxiliary equipment has been deleted. Refer to version 16 or prior of the System Data Book for machine information if needed.
3. Equipment ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.

PHASE REACTOR at CCS GT1

| | |
|-----------------------------------|---|
| REACTOR NO.: | Gen. No. 1 Phase |
| LOCATION: | Cascade Creek Substation |
| MANUFACTURER: | Areva T & D |
| YEAR OF MANUFACTURE: | 2008 |
| CAT. NO./ SERIAL NO.: | 3xLCC-3316/2000 / 08.9125-01 |
| TYPE: | 3 Single Phase Inrush Current Limiting |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 47,800 kVA |
| CONTINUOUS CURRENT RATING: | 2000A |
| SHORT CIRCUIT CURRENT RATING: | 5.1 kA Thermal 2 sec. / 13 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 110 kV / 15 kV |
| OPERATING VOLTAGE DROP: | 2750 V |
| TOTAL OPERATING LOSSES: | 40.3 kW per phase at 75 deg. C |
| IMPEDANCE (ACTUAL OHMS): | R = 0.01 ohms, X = 1.25 ohms, 3.316 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.0053+j0.6564 |

NON-SEGREGATED PHASE BUS – CC GT1 to 7GTB

VOLTAGE: 13.8 kV

TERMINALS: Cascade Creek Gen. 1
Phase reactor

TO: Phase reactor
 TO: 13.8 kV Bus 1

| | |
|--|--|
| MANUFACTURER: | <u>Westinghouse / Eaton *</u> |
| YEAR OF MANUFACTURE: | <u>1975 / 2008</u> |
| PHASE CONDUCTOR | <u>6" x 0.375" T copper bar, 1 per phase</u> |
| SHIELD ENCLOSURE | <u>air-insulated aluminum</u> |
| CONFIGURATION | <u>3 phase, Horizontal parallel bar</u> |
| PRIMARY VOLTAGE | <u>15 kV</u> |
| LOADING CAPACITY (MVA) | <u>47.8</u> |
| LOADING CAPACITY (AMPS PER PHASE CONDUCTOR) | <u>2000</u> |
| BUS LENGTH | <u>152 ft. + 98 ft = 250 ft.</u> |
| DIM. OF PHASE ENCLOSURE | <u>20" W x 17.38" H</u> |
| PHASE SPACING A – B | <u>5.38 inch</u> |
| PHASE SPACING B – C | <u>5.38 inch</u> |
| PHASE SPACING A – C | <u>10.76 inch</u> |

| <u>IMPEDANCE DATA</u> | <u>TOTAL</u> |
|--------------------------|------------------|
| POSITIVE SEQUENCE (OHMS) | 0.00118+j0.00925 |
| ZERO SEQUENCE (OHMS) | 0.00118+j0.00925 |
| POSITIVE SEQUENCE (P.U.) | 0.00062+j0.00486 |
| ZERO SEQUENCE (P.U.) | 0.00062+j0.00486 |

* Approximately 47 ft. original bus duct. Approximately 203 ft. added when phase reactors were installed.

NEUTRAL GROUNDING REACTOR at CCS GT1

| | |
|-----------------------------------|--------------------------|
| REACTOR NO.: | Gen. No. 1 Neutral |
| LOCATION: | Cascade Creek Substation |
| MANUFACTURER: | Westinghouse |
| YEAR OF MANUFACTURE: | |
| CAT. NO./ SERIAL NO.: | / |
| TYPE: | Indoor Neutral Reactor |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 17,600 – 60 sec. |
| CONTINUOUS CURRENT RATING: | |
| SHORT CIRCUIT CURRENT RATING: | 10,200 |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 95 kV / 15 kV |
| OPERATING VOLTAGE DROP: | 1725 V |
| IMPEDANCE (ACTUAL OHMS): | 0.1690 ohms |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.0887 |

NEUTRAL GROUNDING RESISTOR at CCS GT2

RESISTOR NO.: Gen. No. 2

LOCATION: Cascade Creek Substation

MANUFACTURER: Pratt & Whitney / Brush

YEAR OF MANUFACTURE: 2001

CAT. NO./ SERIAL NO.: /

TYPE: Neutral Grounding Transf. / Secondary Resistor

PHASE / CYCLE: Single Phase / 60 Cycle

TRANSF. KVA RATING: 96.6 kVA (30 seconds)

PRIMARY VOLTAGE: 13.8 kV

SECONDARY VOLTAGE: 120 / 240 V (resistor connected at 240 V)

BIL / (KV CLASS): 110 kV / 15 kV

EQUIVALENT TRANSFORMER RESISTANCE
(REFERRED TO SECONDARY): 0.104 OHMS @ 75°C.

EQUIVALENT TRANSFORMER REACTANCE
(REFERRED TO SECONDARY): 0.173 OHMS

RESISTOR CONTINUOUS CURRENT: 400 Amps

OPERATING VOLTAGE DROP: 100 V

INSULATION CLASS: 600 V

THERMAL RATING: / 0.5 minutes

RESISTOR IMPEDANCE (ACTUAL OHMS): 0.25

TOTAL IMPEDANCE (P.U. ON 100 MVA BASE): 614.584 + J300.347

NEUTRAL GROUNDING RESISTOR at WES UNIT 1

RESISTOR NO.: Gen. No. 1

LOCATION: Westside Energy Station

MANUFACTURER: PowerOhm by Hubbell Power Systems

YEAR OF MANUFACTURE: 2016

DRAWING NO./ SERIAL NO.: P20757 / 23907261

TYPE: Neutral Grounding Resistor

PHASE / CYCLE: Single Phase / 60 Cycle

PRIMARY VOLTAGE: 13.8 kV

BIL KV / (KV CLASS): 110 kV / 15 kV

RESISTOR CONTINUOUS CURRENT: 5 Amps for 10 seconds

THERMAL RATING: 760 deg. C rise / 10 seconds

RESISTOR IMPEDANCE (ACTUAL OHMS): 1605.0 + j 0.0

TOTAL IMPEDANCE (P.U. ON 100 MVA BASE): 842.8 + j 0.0

NEUTRAL GROUNDING RESISTOR at WES UNIT 2

RESISTOR NO.: Gen. No. 2

LOCATION: Westside Energy Station

MANUFACTURER: PowerOhm by Hubbell Power Systems

YEAR OF MANUFACTURE: 2016

DRAWING NO./ SERIAL NO.: P20757 / 23907262

TYPE: Neutral Grounding Resistor

PHASE / CYCLE: Single Phase / 60 Cycle

PRIMARY VOLTAGE: 13.8 kV

BIL KV / (KV CLASS): 110 kV / 15 kV

RESISTOR CONTINUOUS CURRENT: 5 Amps for 10 seconds

THERMAL RATING: 760 deg. C rise / 10 seconds

RESISTOR IMPEDANCE (ACTUAL OHMS): 1608.0 + j 0.0

TOTAL IMPEDANCE (P.U. ON 100 MVA BASE): 844.4 + j 0.0

NEUTRAL GROUNDING RESISTOR at WES UNIT 3

RESISTOR NO.: Gen. No. 3

LOCATION: Westside Energy Station

MANUFACTURER: PowerOhm by Hubbell Power Systems

YEAR OF MANUFACTURE: 2016

DRAWING NO./ SERIAL NO.: P20757 / 23907263

TYPE: Neutral Grounding Resistor

PHASE / CYCLE: Single Phase / 60 Cycle

PRIMARY VOLTAGE: 13.8 kV

BIL KV / (KV CLASS): 110 kV / 15 kV

RESISTOR CONTINUOUS CURRENT: 5 Amps for 10 seconds

THERMAL RATING: 760 deg. C rise / 10 seconds

RESISTOR IMPEDANCE (ACTUAL OHMS): 1616.0 + j 0.0

TOTAL IMPEDANCE (P.U. ON 100 MVA BASE): 848.6 + j 0.0

NEUTRAL GROUNDING RESISTOR at WES UNIT 4

RESISTOR NO.: Gen. No. 4

LOCATION: Westside Energy Station

MANUFACTURER: PowerOhm by Hubbell Power Systems

YEAR OF MANUFACTURE: 2016

DRAWING NO./ SERIAL NO.: P20757 / 23907264

TYPE: Neutral Grounding Resistor

PHASE / CYCLE: Single Phase / 60 Cycle

PRIMARY VOLTAGE: 13.8 kV

BIL KV / (KV CLASS): 110 kV / 15 kV

RESISTOR CONTINUOUS CURRENT: 5 Amps for 10 seconds

THERMAL RATING: 760 deg. C rise / 10 seconds

RESISTOR IMPEDANCE (ACTUAL OHMS): 1614.0 + j 0.0

TOTAL IMPEDANCE (P.U. ON 100 MVA BASE): 847.5 + j 0.0

NEUTRAL GROUNDING RESISTOR at WES UNIT 5

RESISTOR NO.: Gen. No. 5

LOCATION: Westside Energy Station

MANUFACTURER: PowerOhm by Hubbell Power Systems

YEAR OF MANUFACTURE: 2016

DRAWING NO./ SERIAL NO.: P20757 / 23907265

TYPE: Neutral Grounding Resistor

PHASE / CYCLE: Single Phase / 60 Cycle

PRIMARY VOLTAGE: 13.8 kV

BIL KV / (KV CLASS): 110 kV / 15 kV

RESISTOR CONTINUOUS CURRENT: 5 Amps for 10 seconds

THERMAL RATING: 760 deg. C rise / 10 seconds

RESISTOR IMPEDANCE (ACTUAL OHMS): 1612.0 + j 0.0

TOTAL IMPEDANCE (P.U. ON 100 MVA BASE): 846.5 + j 0.0

GENERATOR No. WES 1 CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Generator 1 TO: WES 13.8 KV Plant Switchgear Brkr.

| | <u>TOTAL</u> |
|--|-----------------------|
| LINE MILES | 0.03239 (171 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (IN CABLE TRAY) | 3-1/C #750 MCM CU EPR |
| SHIELD CONDUCTOR | CU tape shielded |
| CHARGING KVA | 3.329 |
| CHARGING AMPS | 0.4173 |
| LOADING CAPACITY (MVA) | 14.6 |
| LOADING CAPACITY (90 deg. C) (AMPS PER PHASE CONDUCTOR) | 610 |
| <u>IMPEDANCE DATA (20 deg. C) ESTIMATED</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00153+j0.00484 |
| ZERO SEQUENCE (OHMS) | |
| POSITIVE SEQUENCE (P.U.) | 0.0008+j0.00254 |
| ZERO SEQUENCE (P.U.) | |

Installation is flat lay in Aluminum cable tray

GENERATOR No. WES 2 CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Generator 2 TO: WES 13.8 KV Plant Switchgear Brkr.

| | <u>TOTAL</u> |
|--|-----------------------|
| LINE MILES | 0.03542 (187 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (IN CABLE TRAY) | 3-1/C #750 MCM CU EPR |
| SHIELD CONDUCTOR | CU tape shielded |
| CHARGING KVA | 3.329 |
| CHARGING AMPS | 0.4173 |
| LOADING CAPACITY (MVA) | 14.6 |
| LOADING CAPACITY (90 deg. C) (AMPS PER PHASE CONDUCTOR) | 610 |
| <u>IMPEDANCE DATA (20 deg. C) ESTIMATED</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00153+j0.00484 |
| ZERO SEQUENCE (OHMS) | |
| POSITIVE SEQUENCE (P.U.) | 0.0008+j0.00254 |
| ZERO SEQUENCE (P.U.) | |

Installation is flat lay in Aluminum cable tray

GENERATOR No. WES 3 CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Generator 3 TO: WES 13.8 KV Plant Switchgear Brkr.

| | <u>TOTAL</u> |
|--|-----------------------|
| LINE MILES | 0.03826 (202 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (IN CABLE TRAY) | 3-1/C #750 MCM CU EPR |
| SHIELD CONDUCTOR | CU tape shielded |
| CHARGING KVA | 3.329 |
| CHARGING AMPS | 0.4173 |
| LOADING CAPACITY (MVA) | 14.6 |
| LOADING CAPACITY (90 deg. C) (AMPS PER PHASE CONDUCTOR) | 610 |
| <u>IMPEDANCE DATA (20 deg. C) ESTIMATED</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00153+j0.00484 |
| ZERO SEQUENCE (OHMS) | |
| POSITIVE SEQUENCE (P.U.) | 0.0008+j0.00254 |
| ZERO SEQUENCE (P.U.) | |

Installation is flat lay in Aluminum cable tray

GENERATOR No. WES 4 CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Generator 4 TO: WES 13.8 KV Plant Switchgear Brkr.

| | <u>TOTAL</u> |
|--|-----------------------|
| LINE MILES | 0.04072 (215 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (IN CABLE TRAY) | 3-1/C #750 MCM CU EPR |
| SHIELD CONDUCTOR | CU tape shielded |
| CHARGING KVA | 3.329 |
| CHARGING AMPS | 0.4173 |
| LOADING CAPACITY (MVA) | 14.6 |
| LOADING CAPACITY (90 deg. C) (AMPS PER PHASE CONDUCTOR) | 610 |
| <u>IMPEDANCE DATA (20 deg. C) ESTIMATED</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00153+j0.00484 |
| ZERO SEQUENCE (OHMS) | |
| POSITIVE SEQUENCE (P.U.) | 0.0008+j0.00254 |
| ZERO SEQUENCE (P.U.) | |

Installation is flat lay in Aluminum cable tray

GENERATOR No. WES 5 CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Generator 5 TO: WES 13.8 KV Plant Switchgear Brkr.

| | <u>TOTAL</u> |
|--|-----------------------|
| LINE MILES | 0.04356 (230 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (IN CABLE TRAY) | 3-1/C #750 MCM CU EPR |
| SHIELD CONDUCTOR | CU tape shielded |
| CHARGING KVA | 3.329 |
| CHARGING AMPS | 0.4173 |
| LOADING CAPACITY (MVA) | 14.6 |
| LOADING CAPACITY (90 deg. C) (AMPS PER PHASE CONDUCTOR) | 610 |
| <u>IMPEDANCE DATA (20 deg. C) ESTIMATED</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00153+j0.00484 |
| ZERO SEQUENCE (OHMS) | |
| POSITIVE SEQUENCE (P.U.) | 0.0008+j0.00254 |
| ZERO SEQUENCE (P.U.) | |

Installation is flat lay in Aluminum cable tray

WES PLANT SWITCHGEAR TO GSU1 CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Transformer GSU1 TO: WES 13.8 KV Plant Switchgear Brkr.

| | <u>TOTAL</u> |
|--|---|
| LINE MILES | 0.01420 (75 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (IN CABLE TRAY) | 4-1/C #750 MCM CU 220 mil EPR CPE Jacket Per Phase |
| SHIELD CONDUCTOR | CU tape shielded |
| CHARGING KVA | 13.3 |
| CHARGING AMPS | 1.6692 |
| LOADING CAPACITY (MVA) | 58.3 |
| LOADING CAPACITY (90 deg. C) (AMPS PER PHASE CONDUCTOR) | 610 |
| <u>IMPEDANCE DATA (20 deg. C) ESTIMATED</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00038 + j0.00121 |
| ZERO SEQUENCE (OHMS) | |
| POSITIVE SEQUENCE (P.U.) | 0.0002 + j0.00064 |
| ZERO SEQUENCE (P.U.) | |

Installation is flat lay in Aluminum cable tray

TRANSFORMER REACTOR DATA

LEGEND

1. The rating information for this section is the actual rating stamped on the equipment nameplate or as provided on manufacturer's drawings and documentation.
2. The PU impedance on 100 MVA base is the actual impedance for the equipment adjusted to a uniform system base of 100 MVA and expressed in per unit. Winding R is included if known, otherwise Z is reactive only.
3. Equipment ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.

NEUTRAL GROUNDING REACTOR at CCS T2

REACTOR NO.: CC T2 Neutral

LOCATION: Cascade Creek Substation

MANUFACTURER: Trench Ltd.

YEAR OF MANUFACTURE: 2009

CAT. NO./ SERIAL NO.: / C090189-1

TYPE: Outdoor Neutral Reactor

PHASE / CYCLE: Single Phase / 60 Cycle

KVA RATING:

CONTINUOUS CURRENT RATING: 400A

SHORT CIRCUIT CURRENT RATING: 20 kA Thermal 2 sec. / 51 kA Mechanical peak

SYSTEM NOMINAL VOLTAGE: 10 kV

BIL / (KV CLASS): 110 kV / 15 kV

OPERATING VOLTAGE DROP:

IMPEDANCE (ACTUAL OHMS): 0.527 ohms, 1.398 mH

IMPEDANCE (P.U. ON 100 MVA BASE): 0.2767

Note: Z_{base} is $(13800)^2 / 100\,000\,000 = 1.9044$

NEUTRAL GROUNDING REACTOR at DTS T1

| | |
|-----------------------------------|--|
| REACTOR NO.: | Douglas Trail T1 NGR |
| LOCATION: | Douglas Trail Substation |
| MANUFACTURER: | Alstom Grid |
| YEAR OF MANUFACTURE: | 2016 |
| CAT. NO./ SERIAL NO.: | / 5192210845.10.01 |
| TYPE: | Outdoor Neutral Grounding Reactor |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 80 KVA _r |
| CONTINUOUS CURRENT RATING: | 400A |
| SHORT CIRCUIT CURRENT RATING: | 20 kA Thermal 2 sec. / 51 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 95 kV / 13.8 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.52477 ohms, 1.392 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.27556 |

Note: Z_{base} is $(13800)^2 / 100\,000\,000 = 1.9044$

NEUTRAL GROUNDING REACTOR at DTS T2

| | |
|-----------------------------------|--|
| REACTOR NO.: | Douglas Trail T2 NGR |
| LOCATION: | Douglas Trail Substation |
| MANUFACTURER: | GE-Alstom |
| YEAR OF MANUFACTURE: | 2016 |
| CAT. NO./ SERIAL NO.: | / 5192210845.10.02 |
| TYPE: | Outdoor Neutral Grounding Reactor |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 80 KVA _r |
| CONTINUOUS CURRENT RATING: | 400A |
| SHORT CIRCUIT CURRENT RATING: | 20 kA Thermal 2 sec. / 51 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 95 kV / 13.8 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.5278 ohms, 1.400 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.27714 |

Note: Z_{base} is $(13800)^2 / 100\,000\,000 = 1.9044$

NEUTRAL GROUNDING REACTOR at DTS T3

| | |
|-----------------------------------|--|
| REACTOR NO.: | Douglas Trail T3 Neutral |
| LOCATION: | Douglas Trail Substation |
| MANUFACTURER: | GE-Alstom |
| YEAR OF MANUFACTURE: | 2017 |
| CAT. NO./ SERIAL NO.: | / 5192224142.10.01 |
| TYPE: | Outdoor Neutral Grounding Reactor |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 80 KVA _r |
| CONTINUOUS CURRENT RATING: | 400A |
| SHORT CIRCUIT CURRENT RATING: | 20 kA Thermal 2 sec. / 51 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 95 kV / 13.8 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.5267 ohms, 1.397 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.2765 |

Note: Z_{base} is $(13800)^2 / 100\,000\,000 = 1.9044$

NEUTRAL GROUNDING REACTOR at IBM T2

Commented [TC6]: Confirmed with Mike Beck in the field that reactors are switched up

| | |
|-----------------------------------|-----------------------------------|
| REACTOR NO.: | IBM T1 Neutral |
| LOCATION: | IBM Substation |
| MANUFACTURER: | General Electric |
| YEAR OF MANUFACTURE: | 1981 |
| CAT. NO./ SERIAL NO.: | AA-JCL-60 / M103956 |
| TYPE: | Outdoor Neutral Grounding Reactor |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 3075 kVA |
| CONTINUOUS CURRENT RATING: | 386A |
| SHORT CIRCUIT CURRENT RATING: | 10,000A -10 Sec. |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 110 kV / 15 kV |
| OPERATING VOLTAGE DROP: | 63 V (reactive) |
| IMPEDANCE (ACTUAL OHMS): | 0.008759 + j 0.1632 = 0.1634 ohms |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.08582 |

Note: Z_{base} is $(13800)^2 / 100\,000\,000 = 1.9044$

NEUTRAL GROUNDING REACTOR at IBM T1

| | |
|-----------------------------------|-------------------------------------|
| REACTOR NO.: | IBM T2 Neutral |
| LOCATION: | IBM Substation |
| MANUFACTURER: | General Electric |
| YEAR OF MANUFACTURE: | 1981 |
| CAT. NO./ SERIAL NO.: | AA-JCL-60 / M103957 |
| TYPE: | Outdoor Neutral Reactor |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 3075 kVA |
| CONTINUOUS CURRENT RATING: | 386A |
| SHORT CIRCUIT CURRENT RATING: | 10,000A - 10 Sec. |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 110 kV / 15 kV |
| OPERATING VOLTAGE DROP: | 64 V (reactive) |
| IMPEDANCE (ACTUAL OHMS): | $0.008771 + j 0.1658 = 0.1660$ ohms |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.08718 |

Note: Z_{base} is $(13800)^2 / 100\,000\,000 = 1.9044$

NEUTRAL GROUNDING REACTOR at MRS T1

| | |
|-----------------------------------|--|
| REACTOR NO.: | <u>Marion Road T1 Neutral</u> |
| LOCATION: | <u>Marion Road Substation</u> |
| MANUFACTURER: | <u>Trench</u> |
| YEAR OF MANUFACTURE: | <u>2022</u> |
| CAT. NO./ SERIAL NO.: | <u>5171891-2 / Order No 422100904-10</u> |
| TYPE: | <u>Outdoor Neutral Reactor</u> |
| PHASE / CYCLE: | <u>Single Phase / 60 Cycle</u> |
| KVA RATING: | <u>not listed, rated voltage of 10kV</u> |
| CONTINUOUS CURRENT RATING: | <u>400A</u> |
| SHORT CIRCUIT CURRENT RATING: | <u>20 kA Thermal 2 sec. / 51 kA Mechanical peak</u> |
| SYSTEM NOMINAL VOLTAGE: | <u>13.8 kV</u> |
| BIL / (KV CLASS): | <u>95 kV / 15 kV</u> |
| OPERATING VOLTAGE DROP: | <u>not listed</u> |
| IMPEDANCE (ACTUAL OHMS): | <u>0.012692 + j 0.5164 ohms, 1.3698 mH</u> |
| IMPEDANCE (P.U. ON 100 MVA BASE): | <u>0.2712 (0.5164 / 1.9044 which is Z_{base})</u> |

Note: Z_{base} is $(13800)^2 / 100\,000\,000$

NEUTRAL GROUNDING REACTOR at MRS T2

| | |
|-----------------------------------|--|
| REACTOR NO.: | <u>Marion Road T2 Neutral</u> |
| LOCATION: | <u>Marion Road Substation</u> |
| MANUFACTURER: | <u>Trench</u> |
| YEAR OF MANUFACTURE: | <u>2022</u> |
| CAT. NO./ SERIAL NO.: | <u>5171891-1 / Order No 422100904-10</u> |
| TYPE: | <u>Outdoor Neutral Reactor</u> |
| PHASE / CYCLE: | <u>Single Phase / 60 Cycle</u> |
| KVA RATING: | <u>not listed, rated voltage of 10kV</u> |
| CONTINUOUS CURRENT RATING: | <u>400A</u> |
| SHORT CIRCUIT CURRENT RATING: | <u>20 kA Thermal 2 sec. / 51 kA Mechanical peak</u> |
| SYSTEM NOMINAL VOLTAGE: | <u>13.8 kV</u> |
| BIL / (KV CLASS): | <u>95 kV / 15 kV</u> |
| OPERATING VOLTAGE DROP: | <u>not listed</u> |
| IMPEDANCE (ACTUAL OHMS): | <u>0.012890 + j 0.5164 ohms, 1.3696 mH</u> |
| IMPEDANCE (P.U. ON 100 MVA BASE): | <u>0.2712 (0.5164 / 1.9044 which is Z_{base})</u> |

Note: Z_{base} is $(13800)^2 / 100\,000\,000$

PHASE REACTOR at SLP RA4

| | |
|-----------------------------------|--|
| REACTOR NO.: | Transformer RA4 Phase |
| LOCATION: | Silver Lake Plant |
| MANUFACTURER: | Areva T & D |
| YEAR OF MANUFACTURE: | 2007 |
| CAT. NO./ SERIAL NO.: | 3xLCC-35/2000 / |
| TYPE: | 3 Single Phase Current Limiting |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 8314 kVA |
| CONTINUOUS CURRENT RATING: | 2000A |
| SHORT CIRCUIT CURRENT RATING: | 32 kA Thermal 2 sec. / 81.6 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 2.4 kV |
| BIL / (KV CLASS): | 60 kV / 2.4 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.0132 ohms, 0.035 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.0576 |

NEUTRAL GROUNDING REACTOR at WSS T1

| | |
|-----------------------------------|--|
| REACTOR NO.: | Westside T1 Neutral |
| LOCATION: | Westside Substation |
| MANUFACTURER: | Trench Ltd. |
| YEAR OF MANUFACTURE: | 2010 |
| CAT. NO./ SERIAL NO.: | / C091013-1 |
| TYPE: | Outdoor Neutral Reactor |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | |
| CONTINUOUS CURRENT RATING: | 400A |
| SHORT CIRCUIT CURRENT RATING: | 20 kA Thermal 2 sec. / 51 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 110 kV / 15 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.53 ohms, 1.406 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.2783 |

Note: Zbase is $(13800)^2 / 100\ 000\ 000$

STATION CAPACITOR BANK DATA

LEGEND

1. The rating information for this section is the actual rating stamped on the equipment nameplate or as provided on manufacturer's drawings and documentation.
2. The PU impedance on 100 MVA base is the actual impedance for the equipment adjusted to a uniform system base of 100 MVA and expressed in per unit.
3. Equipment ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.

CAPACITOR BANK No. SLP 306 / 306C

CAPACITOR NO.: 306C

LOCATION: Silver Lake Plant

MANUFACTURER: McGraw Edison

YEAR OF MANUFACTURE: 1981

CAT. NO./ SERIAL NO.: /

TYPE: Edisol Fluid-Insulated

PHASE / CYCLE: Three Phase / 60 Cycle

KVAR RATING STAGE 1: 4800 kVAR

KVAR RATING STAGE 2: 4200 kVAR

SYSTEM NOMINAL VOLTAGE: 13.8 kV

BIL / (KV CLASS): 95 kV / 15 kV

CAPACITOR BANK No. SLP 306 / 306C STAGE 2 REACTOR

| | |
|-----------------------------------|--|
| REACTOR NO.: | 306C |
| LOCATION: | Silver Lake Plant Capacitor Bank |
| MANUFACTURER: | Joslyn |
| YEAR OF MANUFACTURE: | 1981 |
| CAT. NO./SERIAL NO.: | 3059X0016G1 / |
| TYPE: | 3 Single Phase Inrush Current Limiting |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 3187 kVA |
| CONTINUOUS CURRENT RATING: | 400A |
| SHORT CIRCUIT CURRENT RATING: | 20,000 |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 110 kV / 15 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.00566 ohms, 0.04 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.00297 |

CAPACITOR BANK No. SLP 306 / 306C CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Silver Lake Plant Bus #3

TO: 13.8 KV Capacitor Bank 306

| | <u>TOTAL</u> |
|--|-------------------------------------|
| LINE MILES | 0.0426 (225 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (UNDERGROUND) | 3-1/C 500 MCM Cu EPR with Jacket |
| SHIELD CONDUCTOR | Copper Concentric Neutral |
| LOADING CAPACITY (MVA) | 10.0 |
| LOADING CAPACITY (AMPS PER PHASE CONDUCTOR) | 418 * |

IMPEDANCE DATA

| | |
|--------------------------|----------------|
| POSITIVE SEQUENCE (OHMS) | 0.0071+j0.0092 |
| ZERO SEQUENCE (OHMS) | 0.0203+j0.0054 |
| POSITIVE SEQUENCE (P.U.) | 0.0037+j0.0048 |
| ZERO SEQUENCE (P.U.) | 0.0107+j0.0028 |

* Note: Cable ampacity is selected at the continuous level, 90 deg. C. rating of 10 MVA.

CAPACITOR BANK No. ZRS 816 / 816C

| | |
|-------------------------|-------------------------|
| CAPACITOR NO.: | 816 / 816C |
| LOCATION: | Zumbro River Substation |
| MANUFACTURER: | Cooper Power Systems |
| YEAR OF MANUFACTURE: | 2007 |
| CAT. NO./ SERIAL NO.: | CEB07030E0218D1 / |
| TYPE: | Edisol Fluid-Insulated |
| PHASE / CYCLE: | Three Phase / 60 Cycle |
| KVAR RATING STAGE 1: | 5400 kVAR |
| KVAR RATING STAGE 2: | 5400 kVAR |
| SYSTEM NOMINAL VOLTAGE: | 14.41 / 8.3 kV |
| BIL / (KV CLASS): | 110 kV * / 15 kV |

* Individual capacitor units are rated 95 kV BIL.

CAPACITOR BANK No. ZRS 816 / 816C STAGE 1 REACTOR

| | |
|-----------------------------------|--|
| REACTOR NO.: | 816 |
| LOCATION: | Zumbro River Capacitor Bank |
| MANUFACTURER: | Trench Ltd. |
| YEAR OF MANUFACTURE: | 2007 |
| CAT. NO./ SERIAL NO.: | / |
| TYPE: | 3 Single Phase Inrush Current Limiting |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 6.08 kVA |
| CONTINUOUS CURRENT RATING: | 400A |
| SHORT CIRCUIT CURRENT RATING: | 10 kA Thermal 1 sec. / 25.5 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 200 kV / 34.5 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.0380 ohms, 0.10 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.0200 |

CAPACITOR BANK No. ZRS 816 / 816C STAGE 2 REACTOR

| | |
|-----------------------------------|--|
| REACTOR NO.: | 816C |
| LOCATION: | Zumbro River Capacitor Bank |
| MANUFACTURER: | Trench Ltd. |
| YEAR OF MANUFACTURE: | 2007 |
| CAT. NO./ SERIAL NO.: | / |
| TYPE: | 3 Single Phase Inrush Current Limiting |
| PHASE / CYCLE: | Single Phase / 60 Cycle |
| KVA RATING: | 6.08 kVA |
| CONTINUOUS CURRENT RATING: | 400A |
| SHORT CIRCUIT CURRENT RATING: | 10 kA Thermal 1 sec. / 25.5 kA Mechanical peak |
| SYSTEM NOMINAL VOLTAGE: | 13.8 kV |
| BIL / (KV CLASS): | 200 kV / 34.5 kV |
| OPERATING VOLTAGE DROP: | |
| IMPEDANCE (ACTUAL OHMS): | 0.0380 ohms, 0.10 mH |
| IMPEDANCE (P.U. ON 100 MVA BASE): | 0.0200 |

CAPACITOR BANK No. ZRS 816 / 816C CABLE BUS

VOLTAGE: 13.8 KV

TERMINALS: Zumbro River Bus 2 Brkr. 816

TO: 13.8 KV Capacitor Bank 816

| | <u>TOTAL</u> |
|--|-----------------------|
| LINE MILES | 0.01894 (100 ft.) |
| MUTUAL MILES | |
| PHASE CONDUCTOR (UNDERGROUND) | 3-1/C #750 MCM CU EPR |
| SHIELD CONDUCTOR | CU tape shielded |
| CHARGING KVA | 3.329 |
| CHARGING AMPS | 0.4173 |
| LOADING CAPACITY (MVA) | 13.5 |
| LOADING CAPACITY (90 deg. C) (AMPS PER PHASE CONDUCTOR) | 565 |
| <u>IMPEDANCE DATA (20 deg. C)</u> | |
| POSITIVE SEQUENCE (OHMS) | 0.00153+j0.00484 |
| ZERO SEQUENCE (OHMS) | |
| POSITIVE SEQUENCE (P.U.) | 0.0008+j0.00254 |
| ZERO SEQUENCE (P.U.) | |

SUBSTATION BUS & PHASING DATA

LEGEND

1. Aluminum tube bus ratings are based on the NEMA CC1 standard.
2. The current carrying capacity of tubular bus is determined on the basis of:
 - a. Aluminum allow conductivity:
 - i. 53% conductivity IACS (6063-T6 Alum. alloy)
 - ii. 43% conductivity IACS (6061-T6) = $I_{(53\%)} \times (0.43/0.53)^{1/2}$
 - b. Indoor ratings are calculated for a 30 deg. C rise above the ambient temperature of 40 deg. C in still but unconfined air.
 - c. Outdoor ratings are calculated for a 30 deg. C rise above the ambient temperature of 40 deg. C, wind velocity 2 ft. per second, and emissivity of 0.35.
 - d. Emergency ratings are 10% over normal ratings.
3. The current carrying capacity of bus jumpers are determined on the basis of:
 - a. Outdoor ratings are calculated for a 35 or 50 deg. C rise above the ambient temperature of 40 deg. C, wind velocity 2 ft. per second, solar absorptivity and emissivity of 0.5, Industrial atmosphere, 1100 ft. above sea level, 44 degrees N latitude.
4. The rating information for switchgear is the actual rating stamped on the equipment nameplate or as provided on manufacturer's drawings and documentation.
5. Equipment ratings are based on RPU's Facilities Ratings Methodology for Transmission, Substation, and Generation Equipment, in compliance with NERC FAC-008-3.
6. Phasing data has been obtained from Xcel Energy (A.K.A. Northern States Power). The information has not been audited for accuracy.

Summary of 161 kV Bus Configurations

| Substation | Bus tube main diameter (inches) | Bus Rating (Amps) | Bus Jumper | Bus Jumper Rating 75 deg C (Amps) | Bus Jumper Rating 90 deg C (Amps) |
|---------------------|---------------------------------|-------------------|----------------|-----------------------------------|-----------------------------------|
| Bamber Valley | 3.5 | 1945 | 2-636 MCM AAC | 1266 | 1536 |
| Cascade Creek | 4 | 2000 | 2-795 MCM ACSR | 1502 | 1828 |
| Cascade Creek GSU | 3 | 1670 | 1-954 MCM AAC | 813 | 990 |
| Crosstown | 3 | 1670 | 2-636 MCM AAC | 1266 | 1536 |
| Douglas Trail | 4 | 2000 | 2-1590 MCM AAC | 2208 | 2706 |
| IBM | 4 | 2000 | 2-636 MCM AAC | 1266 | 1536 |
| Northern Hills | 4 | 2000 | 2-1590 MCM AAC | 2208 | 2706 |
| Silver Lake | 3 | 1670 | 2-636 MCM AAC | 1266 | 1536 |
| Willow Creek | 3 | 1670 | 2-636 MCM AAC | 1266 | 1536 |
| Westside | 4 | 2000 | 2-1590 MCM AAC | 2208 | 2706 |
| Westside Energy GSU | 3 | 1670 | 1-954 MCM AAC | 813 | 990 |
| Zumbro River | 5 | 2730 | 2-636 MCM AAC | 1266 | 1536 |

Summary of Box Structure 161kV Bus Configurations

| Substation | Bus tube main diameter (inches) | Bus Rating (Amps) | Bus Jumper | Bus Jumper Rating 75 deg C (Amps) | Bus Jumper Rating 90 deg C (Amps) |
|---------------|---------------------------------|-------------------|----------------|-----------------------------------|-----------------------------------|
| Cascade Creek | 4 | 2000 | 2-795 MCM ACSR | 1502 | 1828 |
| Chester | 4 | 2230 | 2-1590 MCM AAC | 2208 | 2706 |

Summary of 13.8 kV Bus Switchgear

| Substation / Bus | Switchgear Manuf / Type | | Bus Equipment Rating | | | | |
|-----------------------|-------------------------|--------------------------|----------------------|------------------|---------------|---------------|------|
| | | | Rated Int. time | Tested Int. time | Cont. Current | Rated AIC Sym | Year |
| Bamber Valley bus 1 | Allis-Chalmers | FCV-500 | 3 | 2.2 | 2000 | 18000 | 1977 |
| Bamber Valley bus 2 | Eaton | 150VCP-W40C | 3 | 2.1 | 2000 | 40000 | 2009 |
| Cascade Creek bus 1 + | GE MagnaBlast | AM-13.8-500-6H | 5 | 4.7 | 2000 | 18000 | 1968 |
| Cascade Creek bus 2 | Siemens-Allis | FCV-750 | 3 | 1.5 | 2000 | 28000 | 1983 |
| Cascade Creek CCGT1 | Westinghouse | | 5 | NA | 2000 | 18000 | 1973 |
| Cascade Creek CCGT2 | Powell | Powl-Vac 15PV508TDX-1 | 3 | 2.0 | 2000 | 50000 | 2002 |
| Crosstown bus 1 * | Square D VacArc | VAD-3 15kV 750 MVA | 3 | 1.5 | 2000 | 28000 | 1992 |
| Crosstown bus 2 * | Square D VacArc | VAD-3 15kV 750 MVA | 3 | 1.5 | 2000 | 28000 | 1992 |
| Douglas Trail bus 1 | Eaton | 150VCP-W40C | 3 | 2.1 | 2000 | 40000 | 2016 |
| Douglas Trail bus 2 | Eaton | 150VCP-W40C | 3 | 2.1 | 2000 | 40000 | 2016 |
| Douglas Trail bus 3 | Eaton | 150VCP-W40C | 3 | 2.1 | 2000 | 40000 | 2016 |
| IBM bus 1 * | Pederson / Eaton | 150VCP-W40C | 3 | 2.1 | 2000 | 40000 | 2012 |
| IBM bus 2 * | Pederson / Eaton | 150VCP-W40C | 3 | 2.1 | 2000 | 40000 | 2012 |
| Silver Lake bus 1 & 2 | GE MagnaBlast | AM-13.8-750-5H | 5 | NA | 2000 | 28000 | 1975 |
| Silver Lake bus 3 ** | Powell | Powl-Vac 15PV750-2 | 5 | 1.8 | 2000 | 28000 | 1991 |
| Silver Lake bus 4 ** | Powell | Powl-Vac 15PV750-2 | 5 | 2.2 | 2000 | 28000 | 1991 |
| Northern Hills bus 1 | ASEA Brown Boveri | 15VHK500 | 3 | 2.2 | 2000 | 19300 | 1987 |
| Northern Hills bus 2 | Square D MasterClad | VR 15kV 750 MVA | 3 | 1.7 | 2000 | 28000 | 2003 |
| Westside bus 1 | Pederson / Eaton | 150VCP-W40C | 3 | 2.1 | 2000 | 40000 | 2014 |
| Willow Creek bus 1 | GE MagnaBlast | AM-13.8-500-6H | 5 | 4.2 | 2000 | 18000 | 1968 |
| Willow Creek bus 2 | Siemens | 15-GMI-750 | 5 | 2.2 | 2000 | 28000 | 2000 |
| Zumbro River bus 1 | GE MagnaBlast | Main & Fdrs AM-13.8-750- | 5 | 4.7 | 2000 | 28000 | 1976 |
| Zumbro River bus tie | GE MagnaBlast | Bus Tie AM-13.8-500-7HB | 5 | 3.0 | 2000 | 18000 | 1976 |
| Zumbro River bus 2 | Westinghouse | 150 VCP 500 | 5 | 2.5 | 2000 | 18000 | 1982 |

* Customer-owned Mayo and IBM bus tie breakers are normally closed, as is the Crosstown substation bus tie.

+ Cascade Creek bus time may only be closed when generation is off line.

Summary of 13.8 kV Non-Segregated Phase Bus Duct

| Substation / Bus | Bus Manuf / Type | | Bus Equipment Rating | | | | |
|-------------------------------|------------------|--|----------------------|--------------------------|----------------|---------------|------|
| | | | Cont. Current Ph/C | Bar / Joint Insulation | Rated Asym Icc | Rated Sym Icc | Year |
| Bamber Valley bus 1 | Siemens-Allis | (2) 0.625 x 4" Alum ph. with 0.375 x 4" Alum ground | 2000/1000 | Neryl Sleeve/taped | 60.0 | 37.5 | 1978 |
| Bamber Valley bus 2 | Eaton | (1) 0.375 x 6" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 49.0 | | 2009 |
| Cascade Creek bus 1 | Technibus | (1) 0.625 x 4" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 40.0 | 25.8 | 2018 |
| Cascade Creek bus 2 | Technibus | (1) 0.625 x 4" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 40.0 | 25.8 | 2018 |
| Cascade Creek CCGT1 original | Westinghouse | (1) 0.375 x 6" Copper ph. with 0.25 x 2" Copper ground | 2000 | Neryl Sleeve/taped boot | | | 1973 |
| Cascade Creek CCGT1 extension | Eaton | (1) 0.375 x 6" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | | | 2009 |
| Cascade Creek CCGT2 | Unibus | (1) 0.5 x 8" Copper ph. with 0.25 x 2" Copper ground | 3000/1200 | Liquid Epoxy/molded boot | 65.0 | 41.9 | 2002 |
| Crosstown bus 1 | Square D | (1) 0.625 x 4" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 60.0 | 37.5 | 1992 |
| Crosstown bus 2 | Square D | (1) 0.625 x 4" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 60.0 | 37.5 | 1992 |
| Douglas Trail bus 1 | Technibus | (1) 0.625 x 4" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 45.0 | 25.8 | 2016 |
| Douglas Trail bus 2 | Technibus | (1) 0.625 x 4" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 45.0 | 25.8 | 2016 |
| IBM bus 1 | GE | (1) 0.5 x 6" Alum ph. with 0.5 x 6" Alum ground | 2000 | Neryl Sleeve/taped | | | 1983 |
| IBM bus 2 | GE | (1) 0.5 x 6" Alum ph. with 0.5 x 6" Alum ground | 2000 | Neryl Sleeve/taped | | | 1983 |
| Willow Creek bus 1 | Technibus | (1) 0.625 x 4" Copper ph. with 0.25 x 2" Copper ground | 2000 | Liquid Epoxy/molded boot | 40.0 | 25.8 | 2021 |
| Willow Creek bus 2 | Technibus | (1) 0.625 x 4" copper ph. with 0.25 x 3" copper ground | 2000 | Liquid Epoxy/molded boot | 58.0 | 36.3 | 2001 |

Summary of 13.8 kV Cable Bus

| Substation / Bus | Conductor / Brand / Configuration | | Bus Equipment Rating | | |
|--------------------------|--|---------|----------------------------|------|------|
| | | | Cont. Current | Year | |
| Douglas Trail T3 - bus 3 | 750 MCM Al, 220 mil EPR, JCN | | 4 per phase | 1672 | 2018 |
| Silver Lake Cap Bank 306 | 750 MCM Al, 220 mil EPR, JCN | | 1 per phase | 418 | 2020 |
| Silver Lake bus tie 2-3 | 500 MCM Cu NJCN | | 4 per phase | 1672 | 1991 |
| Silver Lake bus tie 3-4 | 500 MCM Cu NJCN | | 4 per phase | 1672 | 1991 |
| Silver Lake T3 - bus 3 | 500 MCM Cu, 220 mil EPR, NJCN 17-#10 | Pirelli | 4 per phase | 1672 | 1992 |
| Northern Hills bus 1 | 750 MCM Cu compact, 220 mil EPR, JTS, 350 MCM Cu Grd | Okonite | 3 per phase, 1.50" overall | 1830 | 2019 |
| Northern Hills bus 2 | 500 MCM Cu, 220 mil EPR, JCN | | 3 per phase | 1254 | 2003 |
| Westside bus 1 | 750 MCM Al, 220 mil EPR, JCN | | 4 per phase | 1672 | 2014 |
| Westside Energy GSU | 750 MCM Cu, 220 mil EPR, JTS | General | 4 per phase | 2440 | 2016 |
| Zumbro River Cap Bank | 750 MCM Cu, 220 mil EPR, JTS, 4.0 Cu Grd | General | 1 per phase, 1.65" overall | 610 | 2008 |
| Zumbro River bus 1 | 750 MCM Cu compact, 220 mil EPR, JTS, 350 MCM Cu Grd | Okonite | 3 per phase, 1.50" overall | 1830 | 2019 |
| Zumbro River bus 2 | 750 MCM Cu compact, 220 mil EPR, JTS, 350 MCM Cu Grd | Okonite | 3 per phase, 1.50" overall | 1830 | 2019 |

Phasing Designations of Companies Interconnected with NSP (Xcel Energy)

| INTERCONNECTED COMPANIES | COMPANY ABBR. | CONNECTED VOLTAGE | | | | | | | | |
|---------------------------------------|---------------|-------------------|--------|--------|--------|--------|--------|--------|--------|---|
| | | 115 KV | 138 KV | 161 KV | 230 KV | 345 KV | 500 KV | | | |
| AMERICAN ELECTRIC POWER CON. | AEP | | A C | B | | | A C | B | | |
| BASIN ELECTRIC POWER COOP | BEPC | C B | A | | | | | | | |
| COMMONWEALTH EDISON | CE | | A C | B | | | A C | B | | |
| COOPERATIVE POWER ASSOC. | CPA | C B | A | | | C B | A | C B | A | |
| DAIRYLAND POWER COOP. (RPU) | DPC | | | B A | C | | | | | |
| ILLINOIS POWER | IP | | A C | B | | | A C | B | | |
| INTERSTATE POWER CO. | IPW | | C B | A | | | C B | A | | |
| IOWA ELECTRIC LIGHT & POWER | IELP | | 3 2 | 1 | | | 3 2 | 1 | | |
| IOWA-ILLINOIS GAS & ELECTRIC | IIGE | | C B | A | | | 3 2 | 1 | | |
| IOWA POWER & LIGHT | IPL | | C B | A | | | C B | A | | |
| IOWA PUBLIC SERVICE | IPS | | C B | A | | | C B | A | | |
| KANSAS CITY POWER & LIGHT | KCPL | | A C | B | | | A C | B | | |
| LAKE SUPERIOR DIST. POWER | LSDP | C B | A | | C B | A | | | | |
| MANITOBA HYDRO ELECTRIC BOARD | MHEB | | | | C B | A | | C B | A | |
| MINNESOTA POWER | MP | C B | A | | C B | A | | C B | A | |
| MINNKOTA POWER COOP * | MPC | C B | A | | C B | A | | | | |
| NEBRASKA PUBLIC POWER DISTRICT | NPPD | C B | A | | | | C B | A | | |
| NORTHERN STATES POWER * | NSP | C B | A | | C B | A | C B | A | C B | A |
| NORTHWESTERN PUBLIC SERVICE CO. | NWPS | C B | A | | | | | | | |
| OMAHA PUBLIC POWER DISTRICT | OPPD | | | C B | A | | C B | A | | |
| OTTER TAIL POWER | OTP | C B | A | | C B | A | | | | |
| ST. JOSEPH LIGHT & POWER | SJLP | | | C B | A | | C B | A | | |
| SOUTHERN MINN. MUNICIPAL POWER AGENCY | SMMPA | | | C B | A | | C B | A | | |
| UNION ELECTRIC | UE | | 1 3 | 2 | 1 3 | 2 | 1 3 | 2 | | |
| UNITED POWER ASSOCIATION | UPA | C B | A | | C B | A | C B | A | | |
| WESTERN AREA POWER ADMIN. | WAPA | C B | A | | | | C B | A | | |
| WISCONSIN ELECTRIC POWER | WEP | | A C | B | | | A C | B | | |
| WISCONSIN MICHIGAN POWER | WMP | | A C | B | | | | | | |
| WISCONSIN POWER & LIGHT | WPL | | A C | B | | | A C | B | | |
| WISCONSIN PUBLIC SERVICE | WPS | C B | A | | C B | A | | | | |

NOTE:

- Phase Rotation - Counter Clockwise
*Distribution Phasing for MPC (Grand Forks) is A-C-B
- Transmission engineering must also approve

**PHASING AND CONNECTIONS
PHASING DESIGNATIONS OF
COMPANIES INTERCONNECTED WITH NSP**

Control Engineering Design Standards
CE-1.0305
Date Approved: 9/13/84