ELECTRIC SYSTEM STUDY REPORT

FOR

THE CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

JULY 2011

DeWild Grant Reckert
and Associates Company
CONSULTING ENGINEERS AND LAND SURVEYORS

ELECTRIC SYSTEM STUDY REPORT

FOR

THE CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

JULY 2011

REGISTERED PROFESSIONAL ENGINEER REG. NO. 9153 PAUL A. DAVIS SOUTH DAKOTA	I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of South Dakota. By ______________________ Paul A. Davis, P.E. Registration No. 9153 Date 7-27-11 Pages or sheets covered by this seal: All bound pages.

DGR Project No. 414811

DEWILD GRANT RECKERT AND ASSOCIATES COMPANY
CONSULTING ENGINEERS

ROCK RAPIDS, IOWA
SIOUX FALLS, SOUTH DAKOTA
SIOUX CITY, IOWA

ELECTRIC SYSTEM STUDY
REPORT

FOR

THE CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

Table of Contents

Page Number

EXECUTIVE SUMMARY

Introduction and Scope 1.1

Existing System .... 2.1 – 2.2

Load Growth Projections .... 3.1 – 3.3

Planning Criteria and Goals .... 4.1 – 4.4

Existing System Analysis .... 5.1 – 5.4

Recommended Capital Improvements Plan .... 6.1 – 6.7

Cost Estimate .... 7.1 – 7.3

Conclusion 8.1

Appendix A (Figures 1 through 8)

Appendix B (Case Study Summaries)

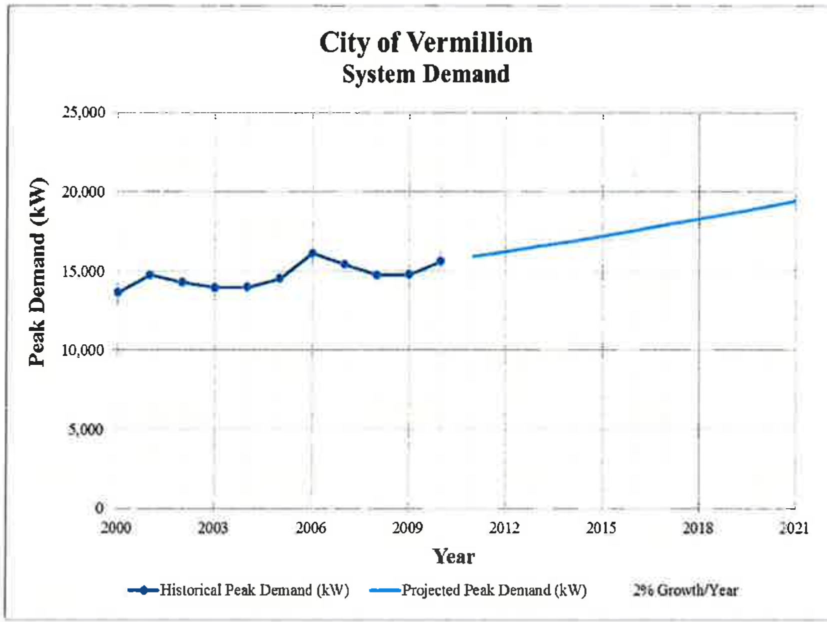
EXECUTIVE SUMMARY

This report is the result of a detailed study that focused on the capabilities of the City's substation and distribution system. The last such study for the electric utility system was completed in 1999, and whereas, the capital improvements plan in that study has been largely completed and significant system and loading changes have occurred in the interim.

EXISTING SYSTEM

The City's transmission system is comprised of two 115 kV transmission lines fed from Basin Electric Power Cooperative's Spirit Mound Substation, which provide power to two transformers in the City's substation. Each transmission line supplies one 115 kV/13.8 kV transformer through a series of two group-operated switches, with a set of two group-operated tie switches. Each transformer has a maximum capacity of 22.4 MVA. The existing distribution system provides electric service throughout Vermillion at 13.8 kV. The current configuration of circuits includes a total of six (6) load-serving circuits being fed throughout the system.

The City's electric utility system experienced load growth average of about 1.4% per year from 2000 to 2010, with a peak load of 16,132 kW in 2006. For this study, DGR has projected a 2% load growth. The chart below shows historical and projected peak loads for the City of Vermillion.



PLANNING CRITERIA AND GOALS

The following is a list of criteria and goals used in evaluation of the performance of the distribution system.

- Provide "N-1" (single contingency) level of reliability for all facilities.
- Provide ANSI "Class A" voltage service to all customers, under normal or emergency conditions.
- Do not exceed thermal limitations of facilities on the electric system, under normal or emergency conditions.
- Design a system that is flexible in terms of operational characteristics.
- Design a system to minimize the length of system outages.
- Develop a system that is expandable, so that load growth can be accommodated in an orderly manner.

- Be viewed by both internal clients (customers) and external clients (utility peers) as operating under the highest utility standards regarding service and reliability.

EXISTING SYSTEM DEFICIENCIES

Due to continued system growth and projected increasing loads on the system, the following deficiencies have been identified:

- Under normal system configurations and a system load based on 2010 peak kW demand, feeder circuits B2 and C3 have low voltage areas that exceed the recommended 3.5 voltage drop recommendation on the primary system.

- The City's distribution system lacks the capability to tie East and West sides of town together under peak loading without severe voltage drop occurring during emergency conditions such as the loss of a feeder or bus, and becomes more widespread under anticipated future load growth.

- Both 13.8 kV main circuit breakers (B1 and C1) and the bus tie circuit breaker (BC) at the substation switchgear have approached there useful life, and upgrades need to be completed. The existing building that contains the switchgear equipment would not be large enough to house new equipment and 115 kV breaker panels if upgrades were made.

- The 115 kV transmission system feeding the City currently lacks closed loop capability. In the event that either transmission lines 1 or 2 were disrupted, the City would be unable to maintain uninterrupted power. This lack of closed loop capability was listed as a deficiency in the previous system study conducted in 1999; however, projects addressing the deficiency were put on hold due to the recent 115 kV project.

- When the projected load of 2021 is applied to the system, along with the loss of either transformer, the load capacity of the individual substation transformer would be approached.

CAPITAL IMPROVEMENTS PLAN SUMMARY

The following table summarizes the planned improvements and associated estimated costs necessary to resolve the system deficiencies:

Phase 1 (Beginning of 2012 – End of 2012)	
Tie Switch Additions	
• Three (3) padmount switches and associated equipment.	$145,000
Total – Phase 1:	**$145,000**
Phase 2 (2012-2013)	
Substation Upgrades	
• 115 kV switchgear, control Building, two main breakers (B1, C1), one tie breaker (BC), and two breakers for station power and associated equipment.	$590,000
• 115 kV breakers and associated equipment	$490,000
Total – Phase 2:	**$1,080,000**
Phase 3 (2015 - 2016)	
Addition of Circuits C5 and B5	
• Circuit C5 and associated equipment	$334,000
• Circuit B5 and associated equipment	$245,000
Total – Phase 3:	**$579,000**

Phase 4 (2020 - 2021)

New substation, transmission line, two feeder egress circuits and associated equipment	$3,596,000
Total – Phase 4:	**$3,596,000**
Total – All Phases:	**$5,400,000**

1. <u>INTRODUCTION AND SCOPE</u>:

In 1999, a report was presented by DeWild Grant Reckert & Associates Company to the City of Vermillion (the City), containing the results of a 10 year Long Rang Plan Update & Load Flow Study. As a result, the City has completed the bulk of the system improvements planned in that study in the time frame since. Given that significant system and loading changes have occurred since the last study which impact the electric system, it was determined that the electric system should be re-evaluated and an updated study with long range plan be formulated.

This report is the result of a detailed study that focused on the capabilities of the City of Vermillion's distribution system, substation, and 115 kV equipment within the substation. This electric system study is centered on the following items:

- Evaluation of historical load growth trends, and future expected load trends.
- Determination of likely load growth areas within the City's electric service territory.
- Development of appropriate analysis criteria and goals, whereby system performance assessment can be made.
- Assessment of the ability of the electric system to accommodate existing and projected loads under the criteria developed.
- Development of a Capital Improvements Plan (CIP), along with budgetary cost estimates, that will enable the City to develop the electric system necessary to handle future loads and meet service and reliability criteria.

All of the staff members at DGR who participated in this study wish to acknowledge the contributions and insight of the City's staff during the study. All City staff were more than willing to find necessary data, provide input, and generally be helpful throughout the study process.

2. EXISTING SYSTEM:

2.1 **Transmission:** The City of Vermillion system receives its power through two 115 kV transmission lines from Basin Electric Cooperative's Spirit Mound Substation. The Western Area Power Administration (WAPA) and Missouri River Energy Services (MRES) account for power delivery to the City of Vermillion. Transmission line number one (approx. 10.25 miles) is fed from the Spirit Mound Substation and connects to the City's substation from the West, supplying power to transformer T1. Transmission line number 2 (approx. 11 miles) from the Spirit Mound Substation feeds transformer T2 from the East. The transmission lines are interconnected to the substation transformers through a series of group-operated air-break switches, with normally-open group-operated switches on the 115 kV cross bus, providing a tie option for the transformer high-side bus.

2.2 **Substation:** The City's substation consists of two 115 kV/13.8 kV transformers, each with ratings of 12/16/20 MVA at 55°C and 13.44/17.92/22.4 MVA at 65°C. The existing system one-line diagram, shown in Figure 1 of Appendix A, illustrates the electrical configuration of the substation.

Each substation transformer serves a switchgear bus. During normal configuration, transformer T2 supplies Bus C and transformer T1 supplies Bus B. Both buses have a main breaker with four (4) distribution feeder circuits, three (3) of which are being utilized, with one spare breaker on each bus. A bus tie breaker exists which connects the two switchgear busses. The substations are constructed with fully enclosed equipment on the 13.8 kV side, minimizing the exposure for outages. All substation transformers are equipped with load tap changers to automatically regulate the low-side voltage.

2.3 **Distribution:** The existing distribution system provides electric service throughout the City at 13.8 kV. The electric distribution system is comprised of almost entirely underground construction due to an ongoing overhead to underground conversion process started several years ago. Due to the nature of the underground distribution system, the City's 13.8 kV circuits are well protected against outages caused by faults from weather and human events.

A diagram of the existing electric distribution system mainline circuitry is shown in Figure 2 of Appendix A. The current configuration of circuits includes a total of six (6) load-serving circuits being fed throughout the system. The bulk of the mainline underground circuitry of the City's system consists of 4/0 Aluminum, with some 250 MCM conductor. 1/0 Aluminum is used for fused tap feeds off of the mainline. A small portion of the underground system consists of cable with bare concentric neutral (BCN) construction, which has been shown to fail prematurely with the deterioration of the non-jacketed neutral.

3. LOAD GROWTH PROJECTIONS:

3.1 **General:** In order to analyze the electric system's ability to provide satisfactory service in future years, the system and all proposed improvements must be analyzed under projected load levels to verify its adequacy. Table 1 summarizes both the historical system loading information, as well as the load growth projection which was used as a basis for system analysis for this study. Figure 1 graphically illustrates the load growth demand projections shown in Table 1.

Table 1

Basic Load Data and Projections

	Peak Demand (kW)			Peak Demand (kW)	
	Year	kW		Year	kW
Historical:	2000	13,646	**Projections:**	2011	15,931
	2001	14,745	**[1]**	2012	16,250
	2002	14,288		2013	16,575
	2003	13,964		2014	16,907
	2004	13,995		2015	17,245
	2005	14,533		2016	17,590
	2006	16,132		2017	17,941
	2007	15,424		2018	18,300
	2008	14,746		2019	18,666
	2009	14,776		2020	19,039
	2010	15,619		2021	19,420

Notes: [1] Projections are based on annual 2.0% growth rate

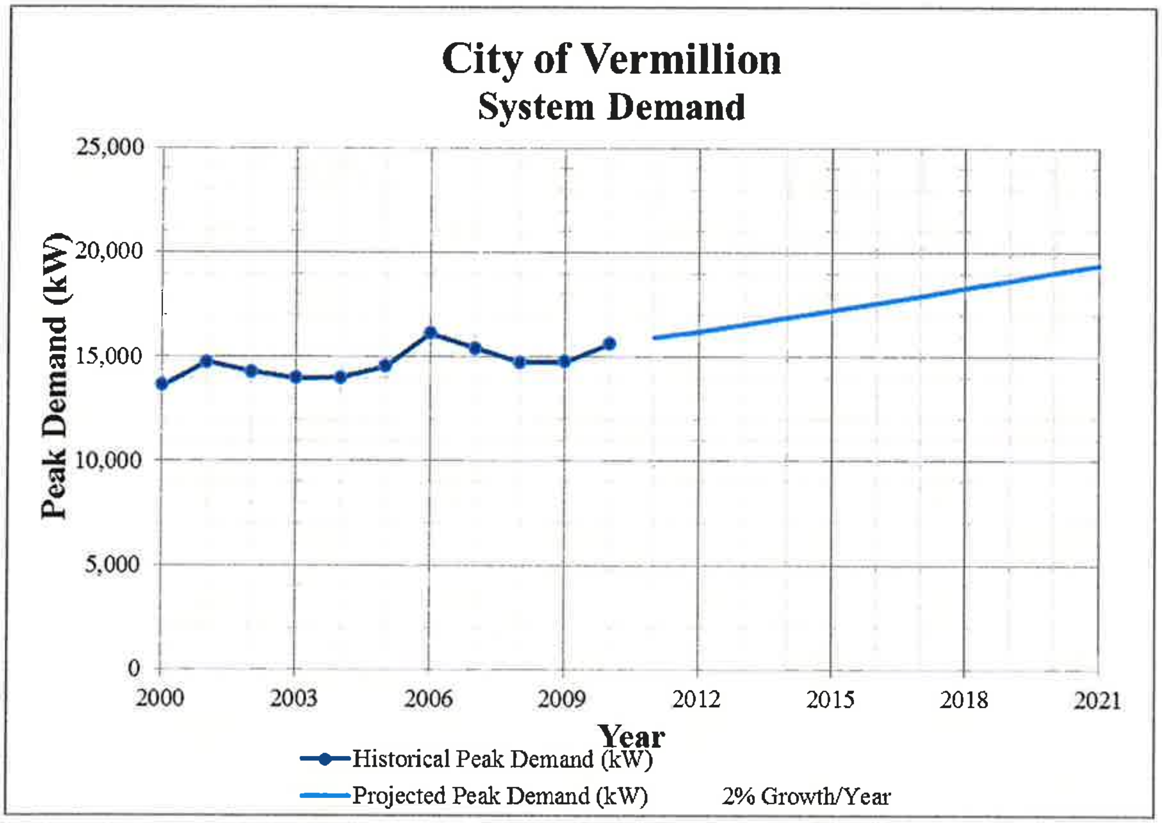


Figure 1: Vermillion System Demand Chart

Discussion of Load Growth Projection: During the past 10 years, the City's electric load has been growing at an annual 1.4% level, with accelerated peaking in 2001 and 2006. The City of Vermillion has experienced steady growth over the past several years with the addition of commercial and residential customers, and it appears that this trend will continue well into the future.

After weighing the effects of several factors, it was decided to use a 2.0% annual growth rate for the load growth projection. This rate is slightly more than the City has been experiencing in recent years, but when taking into account potential factors that could increase load growth such as a warmer summer seasons and potential industrial growth, it was determined a 2.0% rate would be prudent for this study. The end effect of this growth rate would be a total system load of approximately 19.420 MW by the year 2021, equaling 3801 kW of new loads over and above the peak 2010 load. For this study, the rounded value of 4 MW load growth was used to model the 2021 projected peak, totaling 19.619 MW at the end of the study period.

If the growth rate were to change significantly, and especially if a large industrial load were to locate within the City's system for instance, the load growth projection could be too low. Under this scenario, the additional system loads would likely serve to speed up the necessity of some of the improvements that are scheduled in later years.

3.3 **Expected Load Growth Areas:** It is necessary to identify the areas of the system that are expected to experience load growth in future years, in order that future system improvements can be appropriately planned. Through discussions with the City's staff in conjunction with the future land use map, it was determined that load growth will likely occur primarily along the perimeter of the community. Residential growth is expected to continue in the west and east edges of the community, while commercial and industrial growth is expected along the northwest and northeast areas of the City. Figure 8 in Appendix A shows a map of the projected load growth areas.

For the most part, significant growth is not expected to occur in other areas of the City, although it is not unusual to see slow growth occur in already-developed areas as upgrades to facilities and normal ongoing improvements are made.

4. PLANNING CRITERIA AND GOALS:

4.1 General: In order to properly make an assessment of the performance of an electric system, it is necessary to establish the criteria around which such an evaluation will be made. This section of the report identifies and explains the criteria used in this study.

In addition to system analysis criteria, other goals have been identified as desirable when planning the electric system. Many of them do not lend themselves to easy quantifying; however, they do provide guidance to system planners.

4.2 Planning Criteria: The following is a list of criteria used in evaluation of the performance of the distribution system. Each will be described further below:

Criterion #1 Provide "N-1" (single-contingency) level of reliability for all facilities.

Criterion #2 Provide ANSI "Class A" voltage service to all customers, under normal or emergency conditions.

Criterion #3 Do not exceed thermal limitations of facilities on the electric system, under normal or emergency conditions.

Criterion #1 states that the City's system shall be designed and constructed to provide the desired level of service at all times, assuming the unavailability of any one piece of equipment or line section. "Single contingency" design is defined as the ability to operate the system at peak load with the loss of any single major system component. The electric customers have undoubtedly come to expect that electric service be available at all times, except for minor weather-related outages. We feel that it is important that the electric system be able to survive the loss of any one piece of equipment. In all cases, the system's ability to achieve this is measured in light of criteria #2 and #3, which comprises technical items that can be objectively evaluated.

Criterion #2 is an objective, quantifiable measure that should be maintained at all times. The American Natural Standards Institute (ANSI) has promulgated a standard that defines what constitutes "Class A" service. It is this standard that is applied to all scenarios investigated in the course of this study. The ANSI standard defines voltage limits on a 120 volt base. The ANSI voltage limits, as measured at utilization equipment, are as follows:

Maximum Voltage	126 volts
Minimum Voltage	110 volts
Maximum Daily Voltage Swing	8 volts

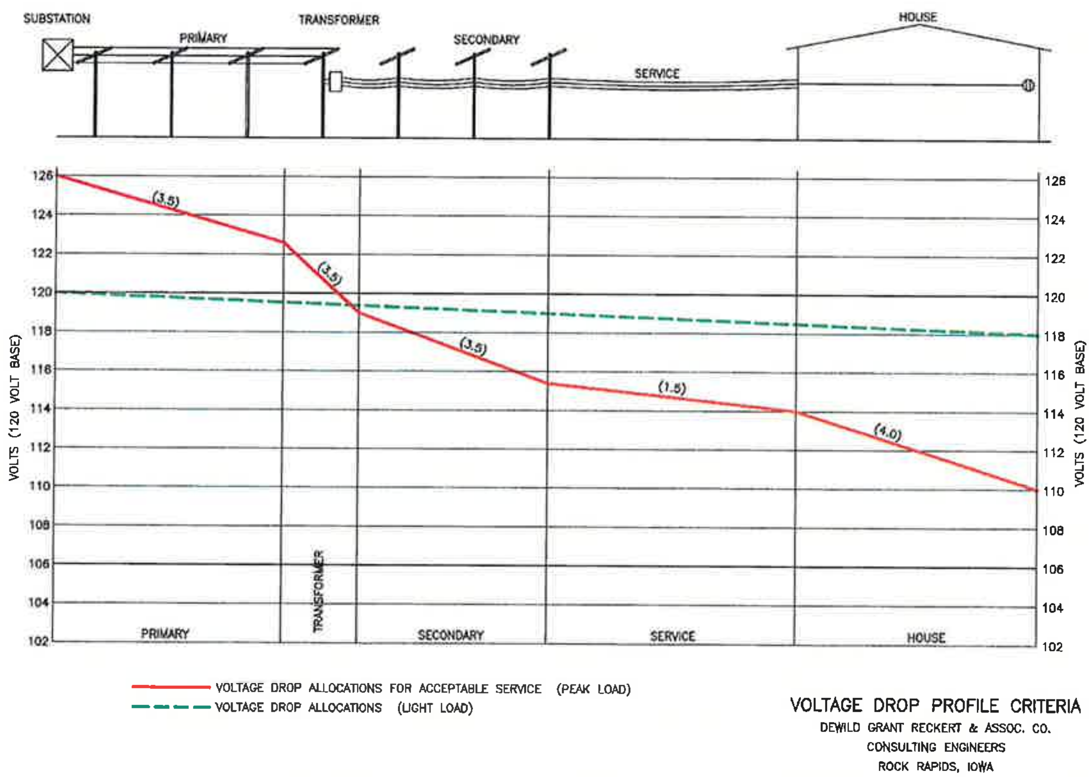
The figures given above are the maximum and minimum voltages that any customer could experience at utilization equipment, and still be in compliance with ANSI standards. In addition, no customer could experience a difference (swing) of more than 8 volts in any 24-hour period, without violating ANSI standards. This voltage range will provide a satisfactory service window for the customer's utilization, including modern electronic equipment such as computers.

Voltage drop is a natural occurrence on an electric system. Voltage drop through the various pieces of electrical equipment must be accommodated and planned for. In order for the voltage drop to not exceed that allowed by standards, the following components of drop in the various portions of the system are assumed:

Primary Circuits	3.5 volts
Distribution Transformers	3.5 volts
Secondaries	3.5 volts
Services	1.5 volts
Customer Wiring	4.0 volts
	16.0 volts

The voltage drop profile, in Figure 2 below, illustrates the allowable voltage drop components listed above. The specific portion of the assigned voltage drop that is controllable directly by a utility is that portion assigned to primary circuits. Hence, planning is done to ensure that voltage drop on primary circuits does not exceed the above figure, under the assumption that the other components of drop will be present.

FIGURE 2
VOLTAGE DROP PROFILE CRITERIA



In addition to the voltage criteria developed above, Criterion #3 was used in evaluation of the system. This criterion requires that equipment and lines be kept within published thermal limits at all times, during both normal and emergency operations. Exceeding the thermal ratings of equipment, especially during summer months, can cause insulation breakdown and consequently damage to electrical equipment. The use of "dynamic" ratings, where an attempt is made to account for real-time environmental factors that may increase the thermal limits of equipment, was deemed to be inappropriate for the City's facilities and is not used in the analysis.

The narrative in Section 5 of this report uses the criteria described above in the analysis of the system.

4.3 **Goals:** In addition to development of planning criteria, a number of goals were established that served to influence the development of the system plan. These goals are summarized below:

- Design a system that is flexible in terms of operational characteristics.
- Design a system to minimize the length of system outages.
- Develop a system that is expandable, so that load growth can be accommodated in an orderly manner.
- Be viewed by both internal clients (customers) and external clients (utility peers) as operating under the highest utility standards for service and reliability.

The goals listed above are to a certain extent subjective in nature. The goals are listed to provide guidance in development of the Capital Improvement Plan, rather than to stipulate hard and fast rules.

5. EXISTING SYSTEM ANALYSIS:

5.1 General: The analysis of the City of Vermillion's electrical system was done using the Windmil® computer analysis program. This program is a commercial product that can perform load flow, short-circuit, and other analysis of a modeled electrical system. In particular, the voltage level and capacity constraints of the system under existing and projected peak loading conditions were analyzed. The model was constructed based on the mapping information provided by the City. Load data by circuit and for large power customers was collected from City personnel and incorporated into the computer analysis.

The model provides an accurate tool for analyzing various every-day scenarios such as the loss of specific pieces of equipment, different switching scenarios, effects of load growth on the system, and available fault currents to a particular site. As such, we recommend the City make use of this tool as the need arises, and that any significant future mapping updates be updated in the computer model as well. The configuration of the existing electric system is shown in Appendix A.

5.2 Voltage and Capacity Analysis: The computer analysis of the City of Vermillion's system indicates that the existing system experiences low voltage conditions on areas of the distribution system, even with no outage conditions present. In particular, the voltage condition on areas of the 13.8 kV primary system exceeds American National Standard Institute (ANSI) limits for Class A voltage service during more heavily loaded periods. This situation will further deteriorate as load grows, since voltage drop is directly proportional to load current.

Under emergency scenarios (such as the loss of a distribution feeder or switchgear bus), voltage conditions worsen. With the loss of either Bus B or Bus C at the City's substation, the system is incapable of serving the entire load without overloaded circuits and poor voltage conditions. As the system currently exists, there are a lack of tie switches and circuit capacity on the distribution system needed to back-feed down-line circuits in the event of a 13.8 kV switchgear bus or distribution feeder outage at the substation. These deficiencies show a need for additional circuits and switches in the near future, especially when considering anticipated load growth on the system.

It appears that the conductor size being used by the City for new underground mainline circuitry, 4/0 AWG Aluminum, is sufficient for the loads being served and the circuit lengths on the system as long as there are enough circuits as previously mentioned.

Under normal peak operating conditions the system transformer capacity is 44.8 MVA with both transformers available at the substation. It is apparent that at current loading levels, the source substation has adequate capacity for the maximum peak of 15.6 MW in 2010. Under emergency conditions (loss of a substation transformer) the substation capacity of 22.4 MVA is sufficient to handle the peak load in 2010, but approaches its limits when the projected load of 19.6 MW in 2021 is considered. Based on projected loads, there will be a need for a new substation to handle the future peak load around the year 2021.

5.3 **Current and Ongoing Projects**: The City of Vermillion is currently working on upgrading the existing substation relays. These new relays will communicate with the City's proposed SCADA system which will be added in conjunction with the relay project. The new SCADA system will gather information from the City's substation as well as the Spirit Mound Substation.

The City will be working on adding distribution ties on portions of the system. These ties will be added along Cherry St, east of Pine St, and will loop various transformer services together, eliminating radial feeds. These tie additions will be accomplished under the electric systems yearly improvements schedule.

5.4 **Existing System Deficiencies**: Due to continued system growth and projected increasing loads on the system, the following deficiencies have been identified:

- Under normal system configurations and a system load based on 2010 peak kW demand, feeder circuits B2 and C3 have low voltage areas that exceed the recommended 3.5 voltage drop recommendation on the primary system.

- The City's distribution system lacks the capability to tie East and West sides of town together under peak loading without severe voltage drop occurring during emergency conditions such as the loss of a feeder or bus, and becomes more widespread under anticipated future load growth.

- Both 13.8 kV main circuit breakers (B1 and C1) and the bus tie circuit breaker (BC) at the substation switchgear have approached there useful life, and upgrades need to be completed. The existing building that contains the switchgear equipment would not be large enough to house new equipment and 115 kV breaker panels if upgrades were made.

- The 115 kV transmission system feeding the City currently lacks closed loop capability. In the event that either transmission lines 1 or 2 were disrupted, the City would be unable to maintain uninterrupted power. This lack of closed loop capability was listed as a deficiency in the previous system study conducted in 1999; however, projects addressing the deficiency were put on hold due to the recent 115 kV project.

- When the projected load of 2021 is applied to the system, along with the loss of either transformer, the load capacity of the individual substation transformer would be approached.

The case study summaries in Appendix B, depict the results of the detailed analysis of the system intact and the emergency scenarios. Summaries are provided for: 1) analysis of the existing system at existing peak loading levels, 2) analysis of the existing system at projected future loading levels, and 3) analysis of the proposed system at projected future loading levels.

6. RECOMMENDED CAPITAL IMPROVEMENTS PLAN:

6.1 **General:** The improvements contained herein are recommended in order to meet the criteria and goals developed in Section 4 of this report. The improvements, related costs, and recommended time frame for implementation are discussed in detail below.

The improvements can be categorized into the following general areas:

- Improvements to distribution system.
- Equipment replacements, which are necessary due to equipment reaching the end of its useful life.
- Improvements to the substation.
- Infrastructure addition.

Cost estimates for the improvements can be found in Section 7 of this report.

6.2 **Recommended Improvements – Phase 1**: The improvements recommended for Phase 1 are shown in Appendix A, and are described in this section.

6.2.1 **Construction Description – Phase 1**: Construction in this Phase includes the following items:

Distribution Improvement

- Installation of three (3) tie switches and interconnecting circuitry on distribution system

6.2.2 **Timing of Phase 1**: The improvements in Phase 1 should be scheduled for construction to start in early 2012 and be completed in late 2012.

6.2.3 **Discussion of Phase 1**: The addition of three tie switches on the distribution system would address the need of additional tie points between the substation Bus B and Bus C circuits. These additional tie switches would allow the City to maintain voltage levels and feeder capacity more effectively when back-feeding circuits on the distribution system.

Currently, the distribution system is configured so that if Bus B experiences an outage, the affected feeder circuits could only be back-fed through the feeder circuit C2. This situation leads to severe voltage drop on the C2 circuit, as well as exceeding the current carrying capacity of the line. The limits of the relay settings would also be exceeded, causing the feeder breaker to open. In the event of a Bus C outage at the substation, similar severe voltage drop, current capacity and relay tripping issues are seen on circuit B4.

The locations of the tie switches are shown in the Phase 1 Improvements Map in Figure 3 of Appendix A. The proposed location for one of the switches is located just to the north of the substation, and would provide as a tie point for Feeders C4 and B3. A second switch is to be located south of the substation, serving as a tie point for Feeders C3 and B4. A third switch, located just south of the substation as well, is to serve as a tie point for feeders C2 and B2.

6.2.4 **Cost of Phase 1**: The estimated construction costs for this Phase total $145,000. A breakdown of the cost estimate for this Phase can be found in Section 7.

6.3 **Recommended Improvements – Phase 2**: The improvements recommended for Phase 2 are shown in Appendix A and are described in this section.

6.3.1 **Construction Description – Phase 2**: Construction in this Phase includes the following items:

Substation Modifications

- Installation of 115 kV Breakers
- Construction of new control building
- Replacement of two main breakers (B1, C1), one tie breaker (BC), and two breakers for station power and associated equipment

6.3.2 **Timing of Phase 2**: The improvements in Phase 2 should be scheduled for construction in the 2012 - 2013 time frame.

6.3.3 **Discussion of Phase 2**: The proposed phase 2 improvements address the City's need for uninterrupted transmission service to the substation and replacement of old equipment that has approached the end of its usable life. Figure 4 in Appendix A shows a one-line diagram of the proposed phase 2 improvements.

The installation of 115 kV Circuit Breakers would provide uninterrupted power, with the loss of either the East or West transmission feed due to a fault condition. The 115 kV equipment would be operated in closed-loop fashion.

The replacement of the existing main breakers, tie breaker, along with the addition of the station power breakers, is considered necessary in order to insure stable electrical service in future years. The existing equipment is considered near the end of its designed life cycle, therefore increasing the risk of unexpected equipment failure. The addition of the two station power breakers would eliminate the existing station power fuses.

In order to house the new substation equipment, a new control house would need to be constructed. The existing facility is not large enough to house the new 13.8 kV switchgear along with the 115 kV control panels. The City's substation site was designed for expansion to the west of the existing south control building. When the equipment is removed from the existing north building, the facility could be used for storage or be removed completely.

6.3.4 Cost of Phase 2: The estimated construction costs for this Phase total $1,080,000. A breakdown of the cost estimate for this Phase can be found in Section 7.

6.4 Recommended Improvements – Phase 3: The improvements recommended for Phase 3 are shown in Figure 5 of Appendix A and are described in this section.

6.4.1 Construction Description – Phase 3: Construction in this Phase includes the following items:

Distribution Improvements

- Addition of two new mainline feeder circuits, B5 and C5
- The installation of 4 new padmount switches for interconnecting the new circuits
- Installation of underground distribution line along west side of Vermillion High School, from Main St. to Lewis St.
- Replacement of the existing Bare Concentric Neutral (BCN) conductor in the northeast area of the City's electric system.

6.4.2 Timing of Phase 3: The improvements in Phase 3 should be scheduled for construction to start in 2015 and be completed by 2016.

6.4.3 Discussion of Phase 3: If the system loads continue to increase at the levels shown in the projections, additional distribution circuit capacity will be needed within the next 5 years. The distribution work included in this phase would include installation of underground distribution lines, 4 padmount switches, and the feeder equipment at the substation. These two (2) new feeder circuits, B5 and C5, are needed to improve back-feeding capabilities, overall load carrying capacity of the City's distribution system, and improve voltage drop conditions under normal operation. The City has buried a spare conduit for the majority of the future C5 circuit route. This will allow for an easier installation when added in the future.

In addition to the new construction proposed, it was verified by City staff that parts of line in the northeast area of the system showed completely deteriorated concentric neutral. It is recommended that existing conductors of BCN construction be replaced in this phase of the capital improvements plan. However, if these spans of BCN underground cable begin to cause problems on the system, replacement should be conducted in an earlier phase.

6.4.4 **Cost of Phase 3**: The estimated construction costs for this Phase total $579,000. A breakdown of the cost estimate for this Phase can be found in Section 7.

6.5 **Recommended Improvements – Phase 4**: The improvements recommended for Phase 4 are shown in Figures 6 and 7 of Appendix A and are described in this section.

6.5.1 **Construction Description – Phase 4**: Construction in this Phase includes the following items:

New Substation

- (1) 12/22.4 MVA 115-13.8 kV transformer, Control Building and Switchgear

Transmission Facilities to New Substation

- Construct 115 kV transmission lines extending from the existing 115 kV lines to serve the proposed new substation in the northeast area of Vermillion.

Distribution Improvements

- Construct two (2) new feeder egress circuits as required to connect the new substation to the existing distribution system

6.5.2 **Timing of Phase 4**: The improvements in Phase 4 should be scheduled for construction to start in 2020 and be completed by 2021.

6.5.3 **Discussion of Phase 4**: If the peak load demand of the City's electric system increases as expected and the City completes phases 1 and 3 sequentially, the system will be able to operate under normal conditions with satisfactory voltage levels and capacity. However, in the event that an outage is necessary requiring back-feed scenarios on the distribution system, the City will experience low voltage levels and cable capacity problems on various parts of the system. Based on the projected City loads of 2021, additional substation and distribution circuit capacity will need to be considered toward the end of the study period.

The desired location for the additional substation capacity will be driven by where the loads grow on the system over the next several years. For the purposes of planning and budgeting well into the future, we have established a new substation location and costs associated with it. The substation could be located somewhere in the northeast area of town. We are showing this substation on the extreme northeast end of the system, but it could end up occurring elsewhere depending on where load growth occurs.

To supply the new substation, a new 115 kV transmission line would need to be constructed, tapping off of the existing East transmission line. The new line would be an estimated 1.2 miles long, feeding the new substation in a similar arrangement as the City's existing substation.

The distribution work included in this phase would include the necessary mainline work to establish new feeders out of the proposed substation. In addition, two (2) switches are proposed in this phase for interconnection to the existing system, therefore improving back-feeding conditions and increasing system load capacity.

6.6 **Cost of Phase 4**: The estimated construction costs for this Phase total $3,596,000. A breakdown of the cost estimate for this Phase can be found in Section 7.

7. COST ESTIMATE:

7.1 General: This section of the report provides breakdown for the aggregate costs given in the preceding section. More detailed estimates serve as the basis for the summary-level numbers given below. The estimates are broken out by project.

The construction costs in the CIP are 2nd Quarter 2011 estimates and include labor, materials, engineering, and contingencies, and assume contractor-built facilities. Costs for any required right-of-way are not included and costs for future work are not escalated to include the effects of inflation. The cost estimates are intended for budgetary uses only.

7.2 Phase 1 Cost Estimate: The costs associated with the proposed work for Phase 1 as discussed in Section 6 are as follows:

Tie Switch Installations

Three (3) padmount switches and interconnection circuitry	
• Labor	$8,000
• Materials	$112,000
• Engineering & Contingencies	$25,000
Total – Phase 1:	$145,000

7.3 **Phase 2 Cost Estimate**: The costs associated with the proposed work for Phase 2 as discussed in Section 6 are as follows:

Substation Upgrades New control building Two (2) main breakers, one (1) bus tie, Two (2) station power breakers	- Labor & Materials	$477,000
115 kV breakers and associated equipment	- Labor & Materials	$395,000
Phase 2 Engineering & Contingencies		$208,000
	Total – Phase 2:	$1,080,000

7.4 **Phase 3 Cost Estimate**: The costs associated with the proposed work for Phase 3 as discussed in Section 6 are as follows:

Feeder circuit C5 addition, underground tie and associated underground cable	
• Labor	$75,000
• Materials	$119,000
• Engineering & Contingencies	$50,000
Feeder circuit B5 addition and associated equipment	
• Labor	$133,000
• Materials	$139,000
• Engineering & Contingencies	$63,000
Total – Phase 3:	$579,000

7.5 **Phase 4 Cost Estimate**: The costs associated with the proposed work for Phase 4 as discussed in Section 6 are as follows:

Proposed substation	
• Labor & Materials	$2,492,000
• Engineering & Contingencies	$440,000
115 kV Transmission line	
• Labor & Materials	$280,000
• Engineering & Contingencies	$58,000
Two (2) feeder egress circuits and associated equipment	
• Labor	$139,000
• Materials	$124,000
• Engineering & Contingencies	$63,000
Total – Phase 4:	$3,596,000

7.6 **Cost Estimate Total – Summary**: The following is a brief summary of the costs for all recommended phases of work:

Phase 1 Total Cost	$145,000
Phase 2 Total Cost	$1,080,000
Phase 3 Total Cost	$579,000
Phase 4 Total Cost	$3,596,000
TOTAL COST ESTIMATE – ALL PHASES	**$5,400,000**

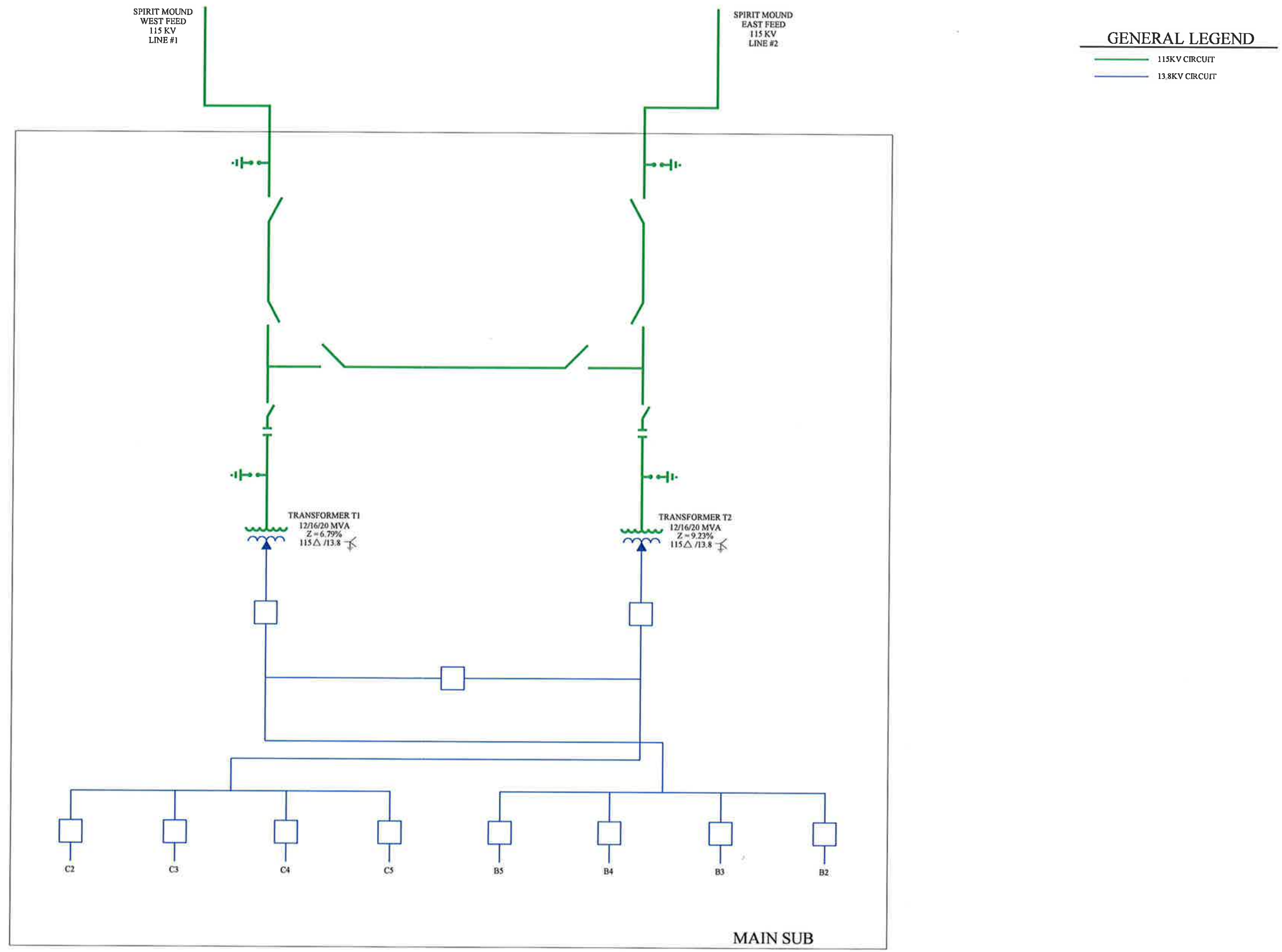
8. CONCLUSION

The analysis and resulting plan contained herein sets out a framework for the City of Vermillion's electric system as it enters the future. The plan will prepare the City for both expected growth that has been identified as likely over the next several years, as well as for possible unexpected growth that may develop in a community as progressive as Vermillion.

The plan accomplishes the criteria and goals listed herein, which largely revolve around reliability-centered issues. In particular, it incorporates planning processes that will allow the City to accommodate the day-to-day occurrences that are experienced on an electric system, and do so in a fashion that maintains an appropriately high level of service demanded by the types of loads served by the City.

We recommend that the City of Vermillion move forward to implement the recommendations in this report, and we commend the City's staff for their dedicated efforts in providing the highest level of service to their customers.

APPENDIX A



REV	DATE	DESCRIPTION

DGR — DeWild Grant Reckert & Assoc. Co. Consulting Engineers, Rock Rapids, Iowa

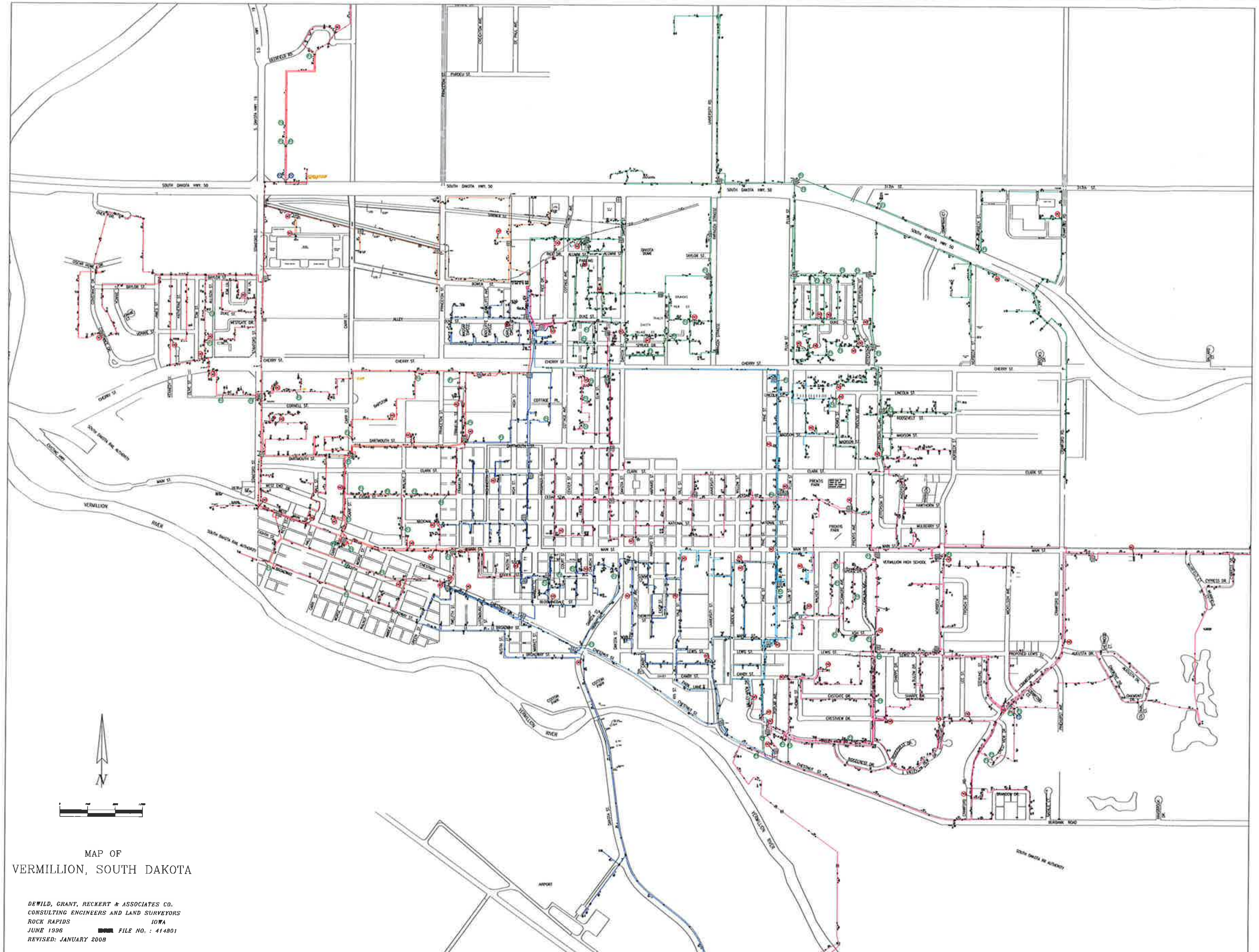
Date: 7-11
Designed By: JDL
Project Manager: PAD
Project Number: 414811

CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

EXISTING SYSTEM ONE-LINE DIAGRAM

DWG NO FIGURE 1

P:\0414811\DWG\EXISTING ONELINE.DWG



CIRCUIT LEGEND

- B2 SOUTHEAST CIRCUIT
- B3 NORTHEAST CIRCUIT
- B4 SOUTH CIRCUIT
- C2 SOUTH CIRCUIT
- C3 SOUTHWEST CIRCUIT
- C4 NORTHWEST CIRCUIT

REV	DATE	DESCRIPTION

DeWild Grant Reckert & Assoc. Co.
Consulting Engineers
Rock Rapids, Iowa

Date: 7-11
Designed By: JDL
Project Manager: PAD
Project Number: 414811

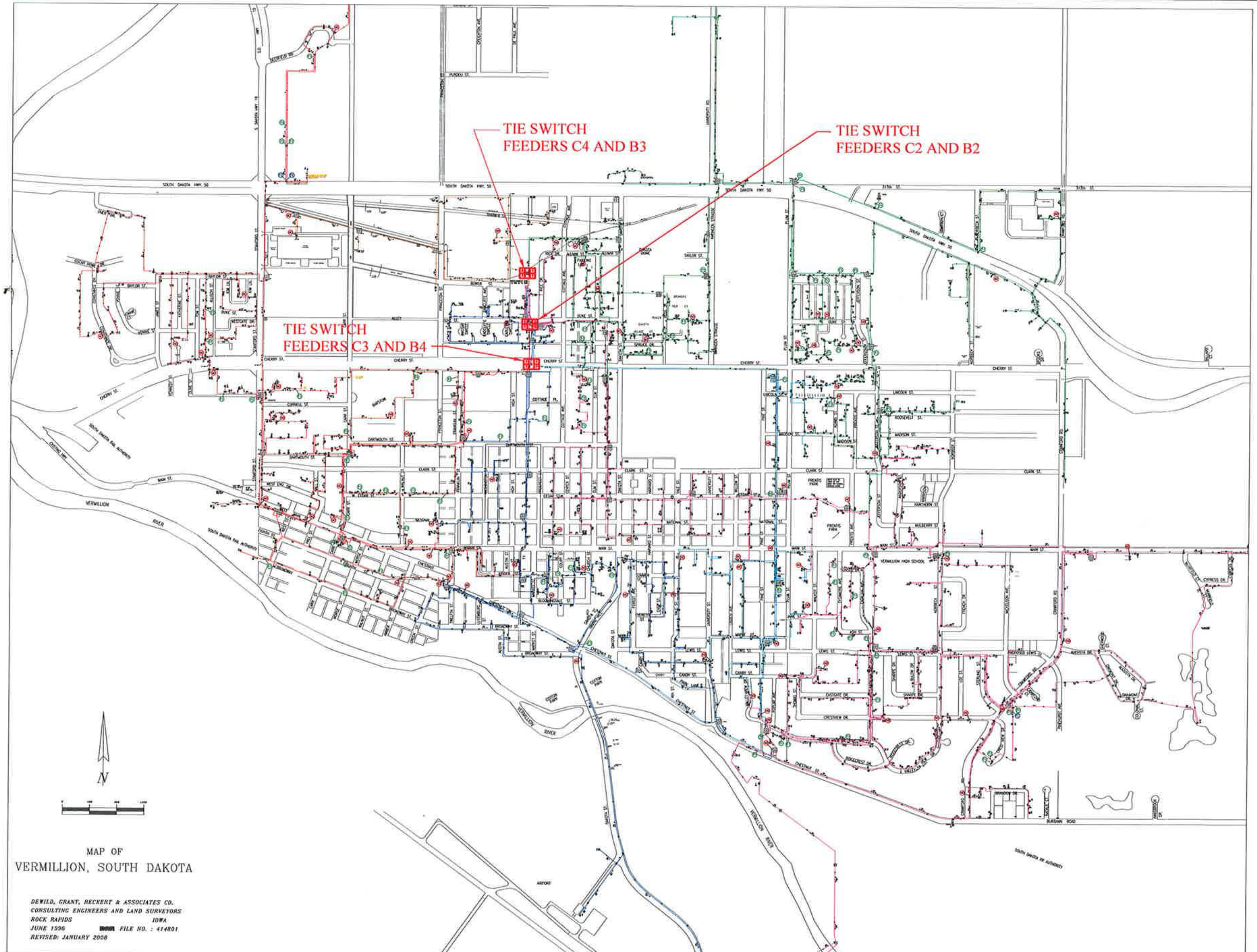
CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

EXISTING SYSTEM MAP

DWG NO

FIGURE 2

P:\414811\DWG\EXISTING SYS MAP.DWG



LEGEND

PHASE 1 TIE SWITCH LOCATIONS

CIRCUIT LEGEND

- B2 SOUTHEAST CIRCUIT
- B3 NORTHEAST CIRCUIT
- B4 SOUTH CIRCUIT
- C2 SOUTH CIRCUIT
- C3 SOUTHWEST CIRCUIT
- C4 NORTHWEST CIRCUIT

REV	DATE	DESCRIPTION

DeWild Grant Reckert & Assoc. Co.
Consulting Engineers
Rock Rapids, Iowa

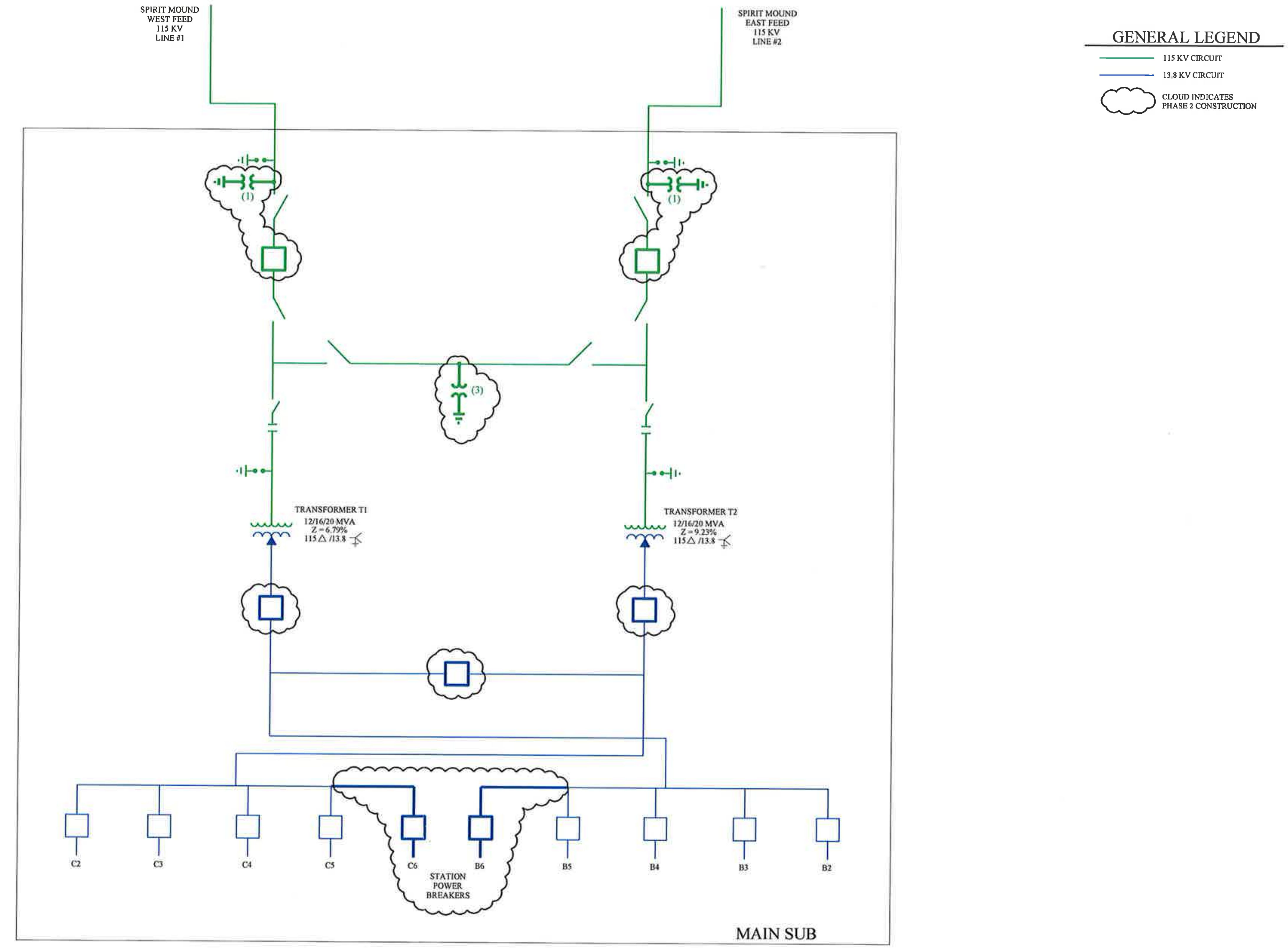
Date:	7-11
Designed By:	JDL
Project Manager:	PAD
Project Number:	414811

CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

PHASE 1 IMPROVEMENTS
SYSTEM MAP

DWG NO FIGURE 3

P:\0414811\DWG\PH1-SYS MAP.DWG



P:\04\148\11\DWG\PH2-ONELINE.DWG

REV	DATE	DESCRIPTION

DeWild Grant Reckert & Assoc. Co.
Consulting Engineers
Rock Rapids, Iowa

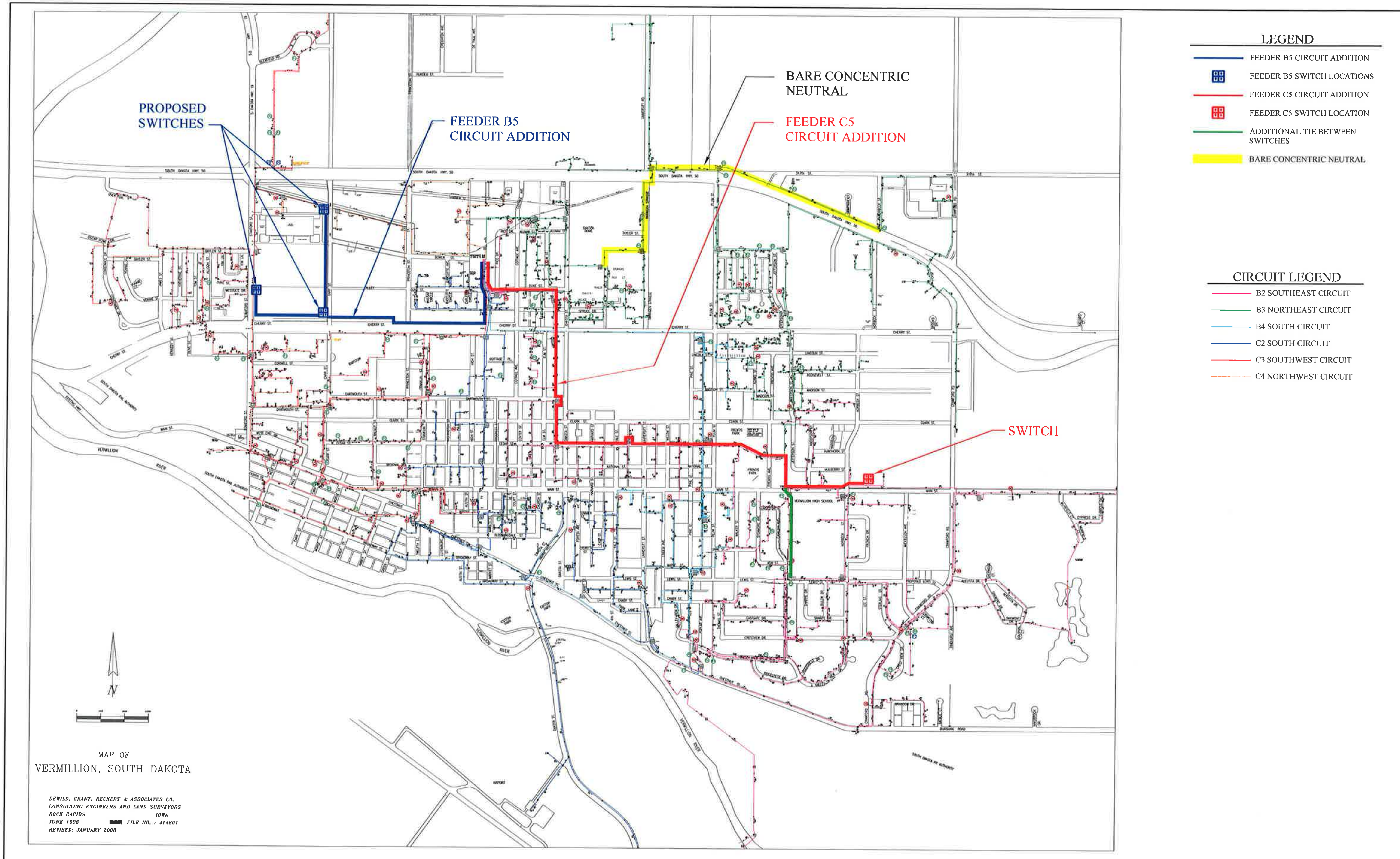
Date:	7-11
Designed By:	JDL
Project Manager:	PAD
Project Number:	414811

CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

PHASE 2 IMPROVEMENTS
ONE-LINE DIAGRAM

DWG NO

FIGURE 4



REV	DATE	DESCRIPTION

DGR — DeWild Grant Reckert & Assoc Co. Consulting Engineers, Rock Rapids, Iowa

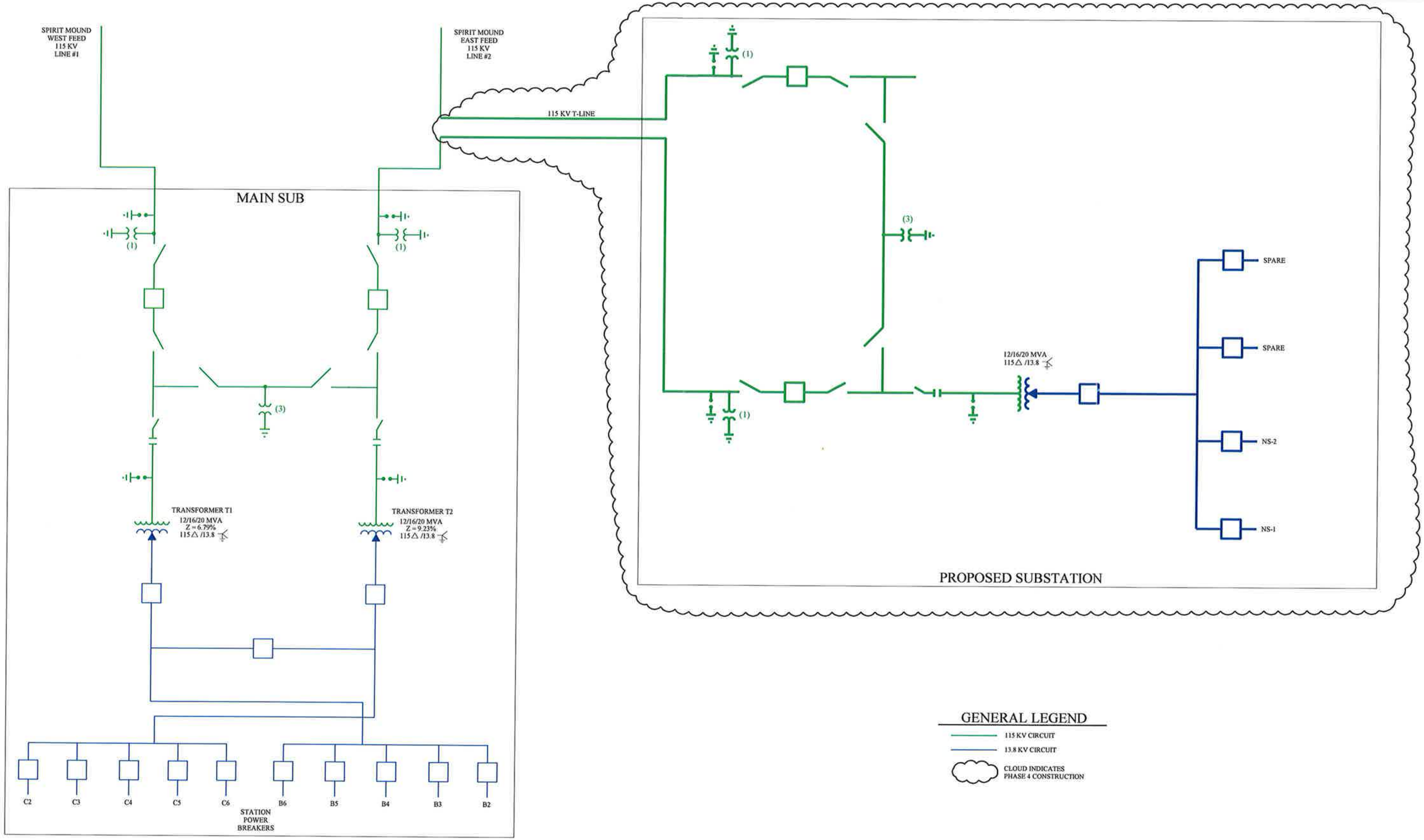
Date:	7-11
Designed By:	JDL
Project Manager:	PAD
Project Number:	414811

CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

PHASE 3 IMPROVEMENTS
SYSTEM MAP

DWG NO FIGURE 5

P:\0414811\DWG\PH3-SYS MAP.DWG



P:\0414811\DWG\PH4-ONELINE.DWG

REV	DATE	DESCRIPTION

DGR DeWild Grant Reckert & Assoc. Co.
Consulting Engineers
Rock Rapids, Iowa

Date:	7-11
Designed By:	JDL
Project Manager:	PAD
Project Number:	414811

CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

PHASE 4 IMPROVEMENTS
ONE-LINE DIAGRAM

DWG NO FIGURE 6

LEGEND

- PHASE 4 CIRCUIT ADDITION
- PHASE 4 SWITCH LOCATIONS
- NEW SUBSTATION LOCATION

CIRCUIT LEGEND

- B2 SOUTHEAST CIRCUIT
- B3 NORTHEAST CIRCUIT
- B4 SOUTH CIRCUIT
- C2 SOUTH CIRCUIT
- C3 SOUTHWEST CIRCUIT
- C4 NORTHWEST CIRCUIT

REV	DATE	DESCRIPTION

DGR — DeWild Grant Reckert & Assoc. Co. Consulting Engineers, Rock Rapids, Iowa

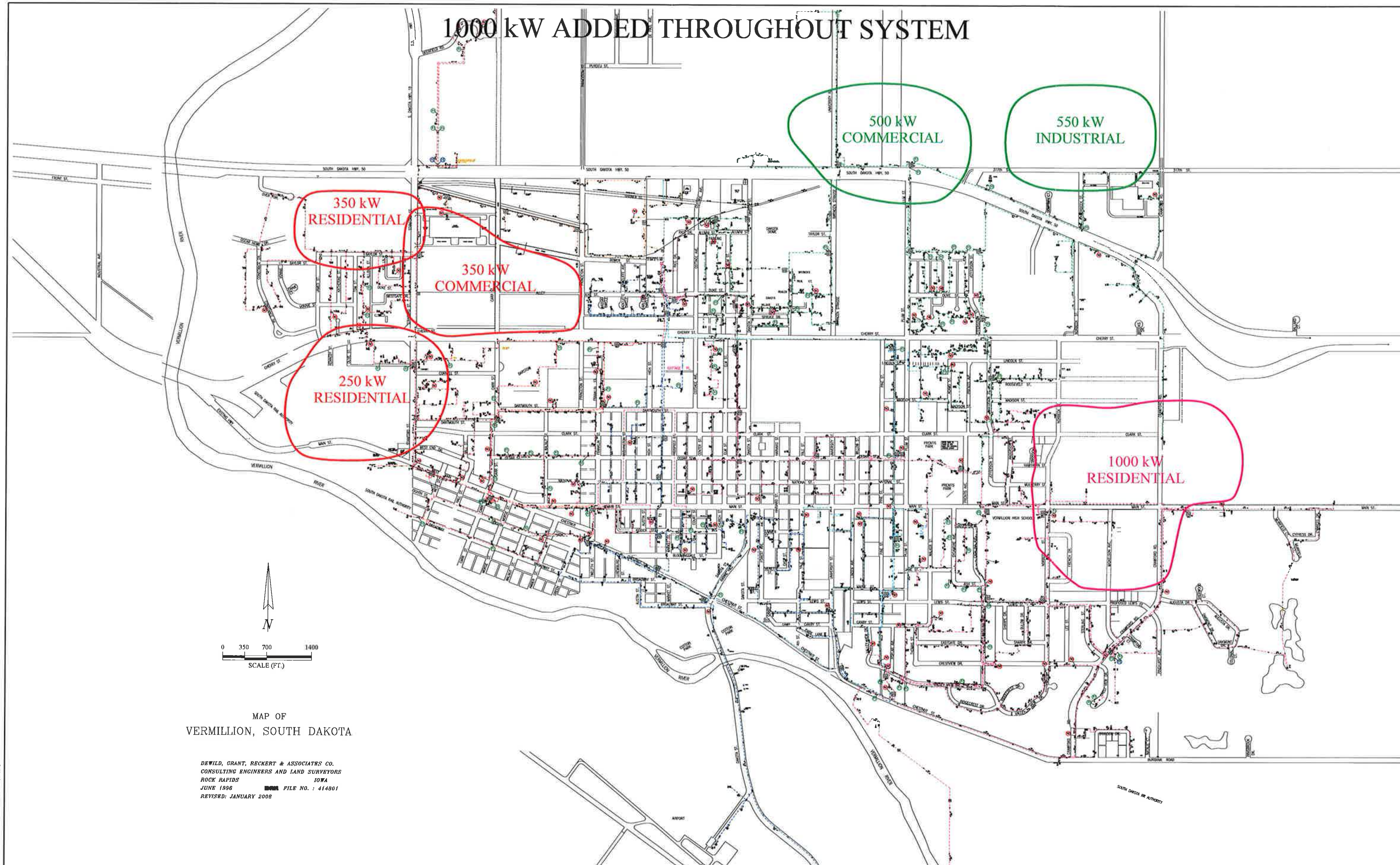
Date:	7-11
Designed By:	JDL
Project Manager:	PAD
Project Number:	414811

CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

PHASE 4 IMPROVEMENTS
SYSTEM MAP

DWG NO FIGURE 7

P:\0414811\DWG\PH4-SYS MAP.DWG



P:\041\41811\DWG\SYSMAP-PROJECTED LOADS.DWG

REV	DATE	DESCRIPTION

DGR — DeWild Grant Reckert & Assoc. Co. Consulting Engineers, Rock Rapids, Iowa

Date:	7-11
Designed By:	JDL
Project Manager:	PAD
Project Number:	414811

CITY OF VERMILLION
VERMILLION, SOUTH DAKOTA

PROJECTED LOADS - 2021

DWG NO FIGURE 8

APPENDIX B

EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- System Intact

DGR

Main Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	176	197	196	4.13	4.72	6.44	4,539	4,349
B3	107	78	109	1.22	0.61	1.90	2,344	2,252
B4	92	79	91	1.48	0.47	1.68	2,089	1,911
						Totals:	8,973	8,512

Transformer #2 115-13.8/7.98 kV -12 MVA

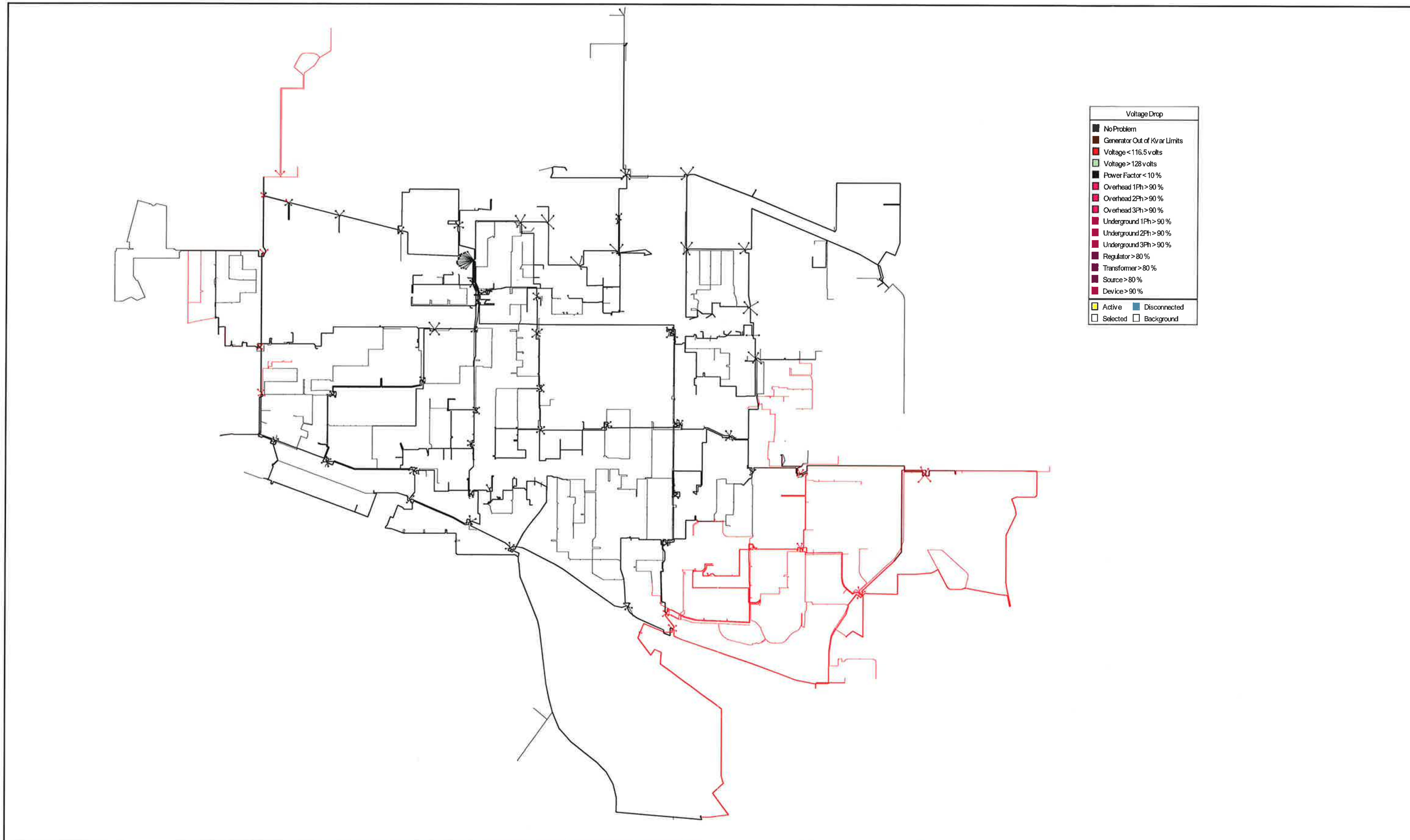
Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	57	70	87	0.05	0.59	0.40	1,707	1,478
C3	190	227	135	2.64	3.80	1.95	4,390	4,197
C4	52	48	49	0.00	0.23	0.12	1,187	1,080
						Totals:	7,284	6,755

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

System Total: kW 15,267

Existing System
2010 Peak
Voltage Drop



EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- Optimized System

DGR

Main Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	135	120	102	3.47	1.61	3.64	2,854	2,783
B3	107	78	109	1.22	0.61	1.90	2,344	2,252
B4	92	79	91	1.48	0.47	1.68	2,089	1,911
						Totals:	7,287	6,946

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	88	130	160	1.18	2.69	3.55	3,007	2,995
C3	155	179	88	2.00	2.86	0.83	3,361	3,214
C4	86	93	96	1.46	1.19	1.42	2,185	2,040
						Totals:	8,553	8,249

System Total: kW 15,195

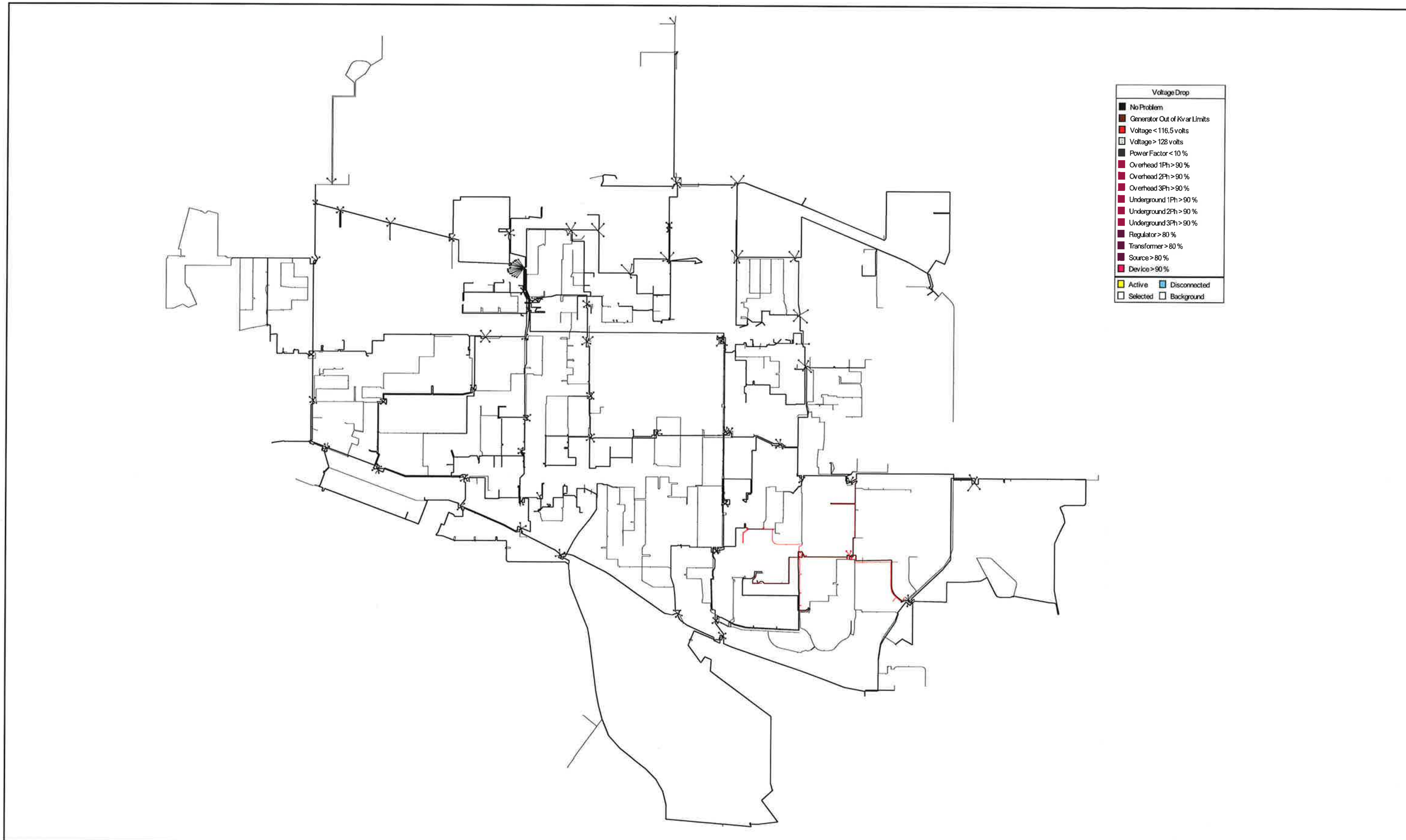
Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

City of Vermillion
Vermillion System Study 2011_Base Run - Opt Sys

Existing System - Optimized Switching
2010 Peak
Voltage Drop

Electric System Study



EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- Bus B Outage

Main Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	---	---	---	---	---	---	---	---
B3	---	---	---	---	---	---	---	---
B4	---	---	---	---	---	---	---	---
						Totals:	0	0

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	467	440	508	20.08	14.82	19.26	11,231	10,884
C3	191	227	135	3.14	3.96	2.37	4,391	4,198
C4	52	48	49	0.25	0.20	0.56	1,187	1,080
						Totals:	16,809	16,162

System Total: kW 16,162

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion
- DGR Project No.: 414811
- Unbalanced Voltage Drop
- Bus C Outage

DGR

Main Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	172	160	166	4.13	4.72	6.44	3,956	3,811
B3	107	79	110	1.22	0.61	1.90	2,345	2,252
B4	406	501	393	13.21	20.39	12.28	10,329	9,993
						Totals:	16,630	16,056

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	---	---	---	---	---	---	---	---
C3	---	---	---	---	---	---	---	---
C4	---	---	---	---	---	---	---	---
						Totals:	0	0

System Total: **kW** **16,056**

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- Loss of Feeder B2

Main Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	---	---	---	---	---	---	---	---
B3 (with B2 Load)	271	268	298	6.67	8.37	10.37	6,664	6,349
B4 (with B2 Load)	291	285	319	7.33	8.38	11.30	7,130	6,792

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	225	259	269	8.11	9.08	8.43	5,998	5,963
C3	190	227	135	2.62	4.00	1.93	4,390	4,197
C4	52	48	49	0.00	0.23	0.12	1,187	1,080

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- Loss of Feeder C3

DGR

Main Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	176	197	196	4.13	4.72	6.44	4,539	4,349
B3	107	78	109	1.22	0.61	1.90	2,344	2,252
B4	92	79	91	1.48	0.47	1.68	2,089	1,911

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2 (with C3 Load)	237	284	206	4.45	5.79	2.94	5,798	5,766
C3	---	---	---	---	---	---	---	---
C4 (with C3 Load)	246	280	184	5.09	6.59	1.94	5,655	5,350

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- Bus B Outage

- Tie switches added to system

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Bus B Outage

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	---	---	---	---	---	---	---	---
B3	---	---	---	---	---	---	---	---
B4	---	---	---	---	---	---	---	---
						Totals:	0	0

Transformer #2 115-13.8/7.98 kV -12 MVA Bus B Outage

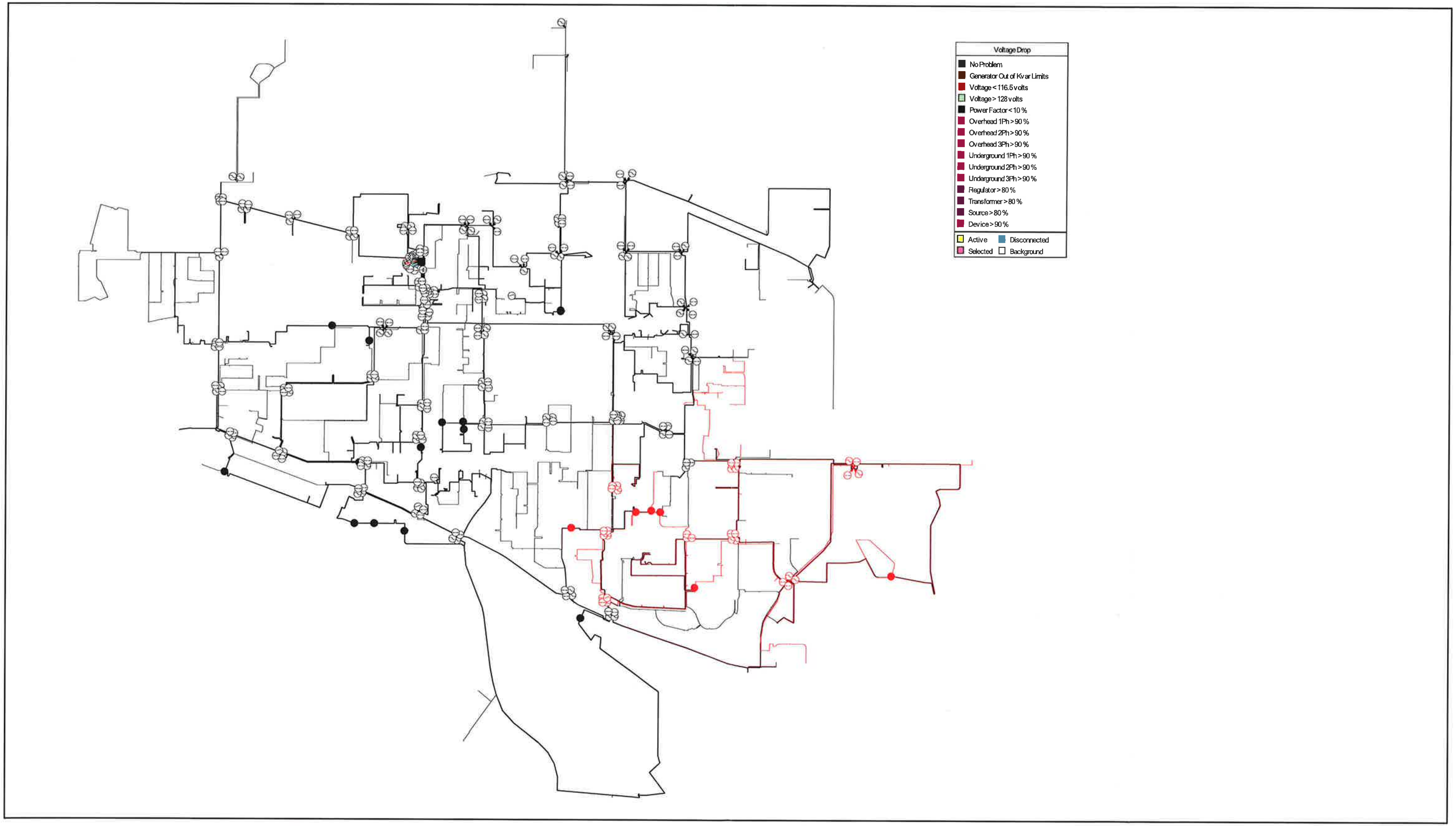
Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	143	219	222	4.12	3.39	2.93	4,632	4,632
C3	267	208	168	4.69	2.99	3.62	5,111	4,784
C4	252	255	261	1.78	2.76	1.92	6,103	5,806
						Totals:	15,846	15,222

System Total: kW 15,222

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

2010 Peak Load
Tie Switches Added - Bus B Outage
Voltage Drop



EXISTING SYSTEM ANALYSIS - EXISTING LOADS

- City of Vermillion
- DGR Project No.: 414811
- Unbalanced Voltage Drop
- Bus C Outage
- Tie switches added to system

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Bus C Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	209	211	210	4.26	3.53	3.54	4,632	5021
B3	229	236	244	1.47	2.44	1.76	4,632	5388
B4	212	236	190	4.48	2.88	3.32	4,632	4771
						Totals:	13,896	15,180

Transformer #2 115-13.8/7.98 kV -12 MVA Bus C Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	---	---	---	---	---	---	---	---
C3	---	---	---	---	---	---	---	---
C4	---	---	---	---	---	---	---	---
						Totals:	0	0

System Total: kW 15,180

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

EXISTING SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion
- DGR Project No.: 414811
- Unbalanced Voltage Drop
- System Intact
- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	237	261	259	5.39	6.75	7.31	6,015	5,682
B3	155	125	158	1.60	1.24	3.03	3,477	3,340
B4	98	85	97	1.36	1.32	2.27	2,225	2,033
						Totals:	11,716	11,055

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	61	74	94	0.99	0.47	0.28	1,814	1,576
C3	227	256	169	3.07	3.86	2.47	5,171	4,922
C4	72	82	73	0.20	1.65	0.36	1,803	1,650
						Totals:	8,788	8,148

System Total: kW 19,203

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)

- New Tie Switches

- Optimized System

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	237	261	259	5.39	6.75	7.31	6,015	5,682
B3	155	125	158	1.60	1.24	3.03	3,477	3,340
B4	98	85	97	1.36	1.32	2.27	2,225	2,033
						Totals:	11,716	11,055

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	61	74	94	0.99	0.47	0.28	1,814	1,576
C3	227	256	169	3.07	3.86	2.47	5,171	4,922
C4	72	82	73	0.20	1.65	0.36	1,803	1,650
						Totals:	8,788	8,148

System Total: kW 19,203

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)

- Tie Switches Added on Feeders

- Values for Bus B & Bus C Outages

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Bus C Outage

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	233	218	223	5.75	4.33	5.06	5376	5,109
B3	278	257	291	1.79	1.49	2.31	6578	6,222
B4	318	384	303	5.84	5.25	3.36	8011	7,880
					System Total:		**19,966**	**19,211**

Transformer #2 115-13.8/7.98 kV -12 MVA Bus B Outage

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	127	174	196	2.21	3.86	4.65	3875	3875
C3	324	376	277	2.09	3.59	3	7614	7270
C4	410	335	362	7.63	3.39	4.25	8634	8072
					System Total:		**20,123**	**19,217**

Capacity ≥ 100% of Equipment Rating

p:\04\148\11\sprdsht\verm-studyruns- proposed sys_projected loading.xls

PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS
- **City of Vermillion**
- **DGR Project No.: 414811**
- **Unbalanced Voltage Drop**
- **2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)**
- **New Tie Switches**
- **Loss of Feeders B2 & C3**

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Feeder B2 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	---	---	---	---	---	---	---	---
B3	332	283	299	8.37	6.48	6.10	7,296	6,954
B4	165	193	214	2.89	4.23	5.99	4,576	4,217
						Totals:	11,872	11,171

Transformer #2 115-13.8/7.98 kV - 12 MVA Feeder B2 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	61	74	94	0.99	0.47	0.28	1,814	1,576
C3	227	256	169	3.07	3.86	2.47	5,171	4,922
C4	72	82	73	0.20	1.65	0.36	1,803	1,650
						Totals:	8,788	8,148

System Total: kW 19,319

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Feeder C3 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	233	218	223	5.75	4.33	5.06	5,726	5,655
B3	155	125	156	1.66	1.21	2.27	3,870	3,340
B4	273	287	200	2.79	2.88	1.63	6,061	5,711
						Totals:	14,706	14,706

Transformer #2 115-13.8/7.98 kV -12 MVA Feeder C3 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	61	74	94	0.15	0.51	0.41	1,815	1,576
C3	---	---	---	---	---	---	---	---
C4	123	132	136	1.38	1.36	1.59	3,106	2,878
						Totals:	4,921	4,454

System Total: kW 19,160

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion
- DGR Project No.: 414811
- Unbalanced Voltage Drop
- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)
- Tie Switches Added
- Feeders B5 & C5 Added
- Optimized System

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	110	98	85	3.16	1.16	3.32	2,336	2,270
B3	155	125	157	1.68	1.22	2.31	3,476	3,340
B4	98	85	96	1.44	1.40	1.57	2,225	2,034
B5	85	82	94	1.30	0.97	1.30	2,075	1,959
						Totals:	10,112	9,603

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	65	105	134	3.41	1.77	2.30	2,387	2,330
C3	156	187	91	1.34	2.48	0.50	3,442	3,293
C4	57	67	59	0.25	0.59	0.17	1,454	1,334
C5	115	112	108	2.82	3.09	2.83	2,673	2,510
						Totals:	9,956	9,467

Capacity ≥ 100% of Equipment Rating

System Total: kW 19,070

Voltage Drop ≥ 3.5 V

p:\04\148\11\sprdsht\verm-studyruns- proposed sys_projected loading.xls

PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)

- Tie Switches Added

- Feeders B5 & C5 Added

- Bus Outages

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Bus C Outage

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	273	271	288	5.65	4.35	5.13	6,619	6,575
B3	212	191	217	1.68	1.25	2.31	4,923	4,675
B4	201	229	176	5.82	2.99	3.24	4,834	4,504
B5	156	186	165	1.87	2.88	1.84	4,049	3,996
						System Total:	**20,425**	**19,750**

Transformer #2 115-13.8/7.98 kV -12 MVA Bus B Outage

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	165	201	220	3.15	1.83	2.63	4,659	4,659
C3	254	269	183	1.80	2.61	1.59	5,619	5,282
C4	299	274	310	1.93	1.70	2.31	7,019	6,651
C5	112	112	108	2.83	3.04	2.85	2,646	2,487
						System Total:	**19,943**	**19,079**

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)

- Tie Switches Added

- Feeders B5 & C5 Added

- Feeder B2 & C3 Outages

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Feeder B2 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	---	---	---	---	---	---	---	---
B3	155	125	157	1.74	1.18	2.26	3,476	3,340
B4	211	185	182	4.46	3.24	3.22	4,613	4,356
B5	85	82	94	1.30	0.97	1.30	2,075	1959
						Totals:	8,090	9,655

Transformer #2 115-13.8/7.98 kV - 12 MVA Feeder B2 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	64	105	131	3.46	1.78	2.40	2,366	2,305
C3	156	187	91	1.34	2.48	0.60	3,442	3,293
C4	57	67	59	0.25	0.59	0.27	1,454	1,334
C5	112	112	108	2.88	3.05	2.78	2,646	2486
						Totals:	7,262	9,418

System Total: kW 19,073

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Feeder C3 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	111	99	85	3.23	0.83	3.39	2,336	2,270
B3	155	125	156	1.75	1.21	2.25	3,476	3,340
B4	255	271	186	1.85	2.63	1.59	5,669	5,337
B5	85	82	94	1.29	0.90	1.37	2,075	1959
						Totals:	13,557	12,906

Transformer #2 115-13.8/7.98 kV -12 MVA Feeder C3 Outage

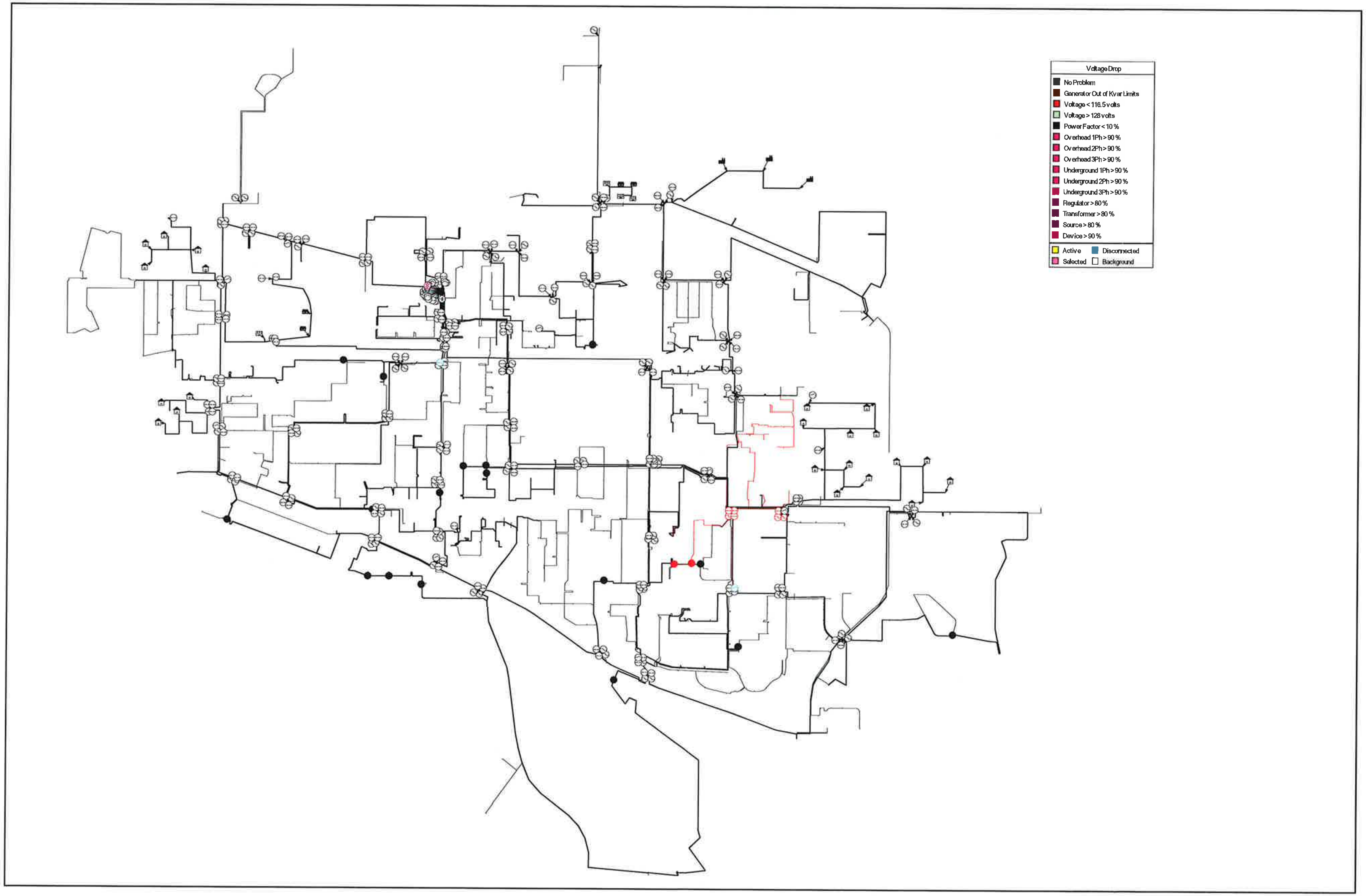
Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	65	105	131	3.57	1.70	2.37	2,367	2,306
C3	---	---	---	---	---	---	---	---
C4	57.4	66.96	58.49	0.28	0.53	0.25	1,454	1334
C5	112	113	107	2.88	3.10	2.76	2,646	2486
						Totals:	6,468	6,126

System Total: kW 19,032

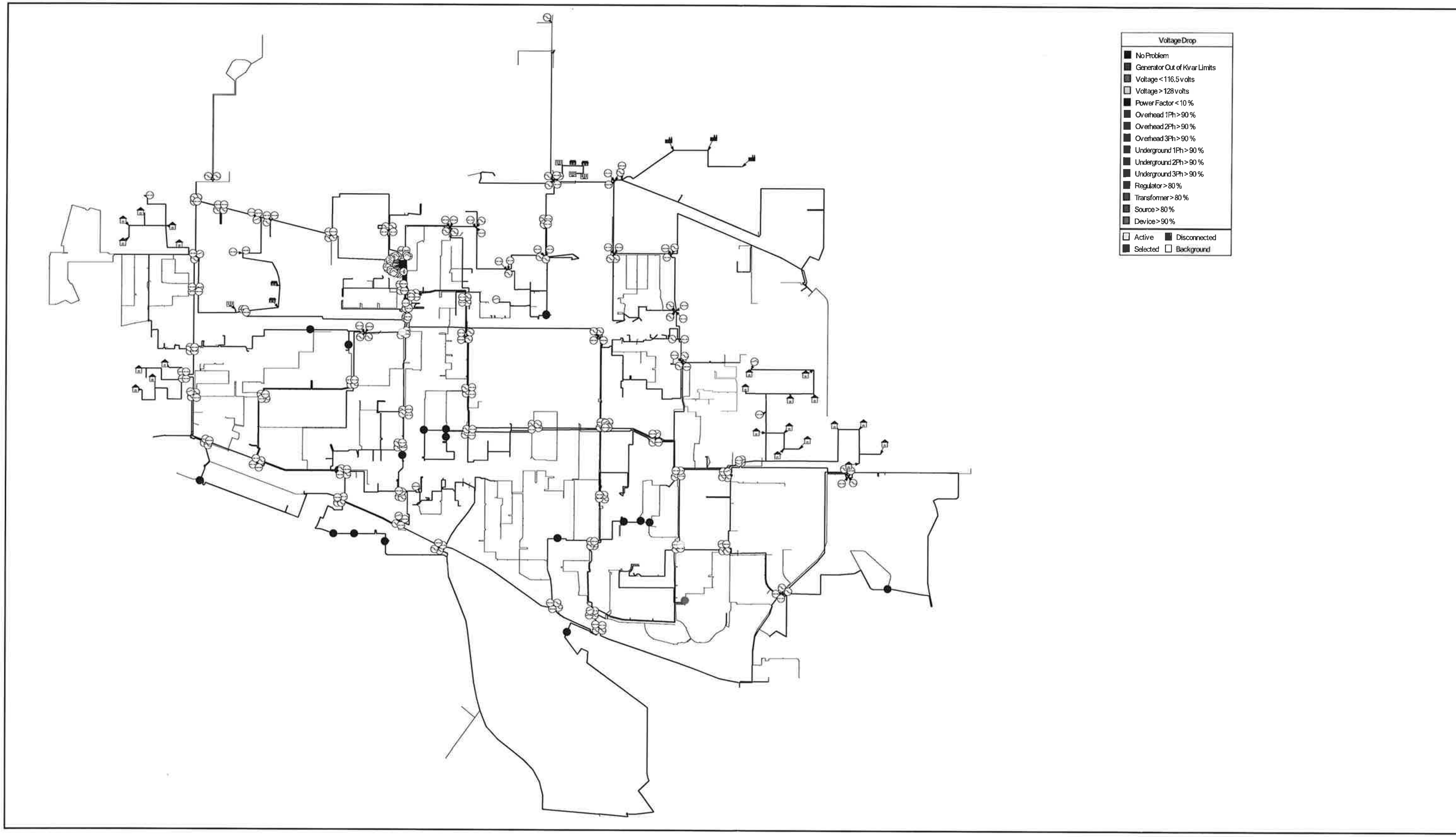
Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V

2021 Projected Peak Load
Tie Switches _Feeders C5 and B5 Added – Feeder B2 Outage
Voltage Drop



2021 Projected Peak Load
Tie Switches _Feeders C5 and B5 Added - Feeder C3 Outage
Voltage Drop



PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion

- DGR Project No.: 414811

- Unbalanced Voltage Drop

- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)

- Tie Switches Added

- Feeders C5 & B5 Added

- New Substation

- Optimized System

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
B2	55	96	80	0.43	1.25	0.99	1,842	1,819
B3	114	86	114	1.12	0.64	1.59	2,504	2,412
B4	98	85	96	1.44	1.37	1.54	2,225	2,033
B5	85	82	94	1.26	0.94	1.34	2,075	1,959
						Totals:	8,645	8,223

Transformer #2 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
C2	61	100	111	1.65	1.83	1.63	2,147	2,050
C3	156	187	91	1.29	2.45	0.59	3,442	3,293
C4	57	67	58	0.27	0.56	0.26	1,454	1,334
C5	62	7	32	2.75	0.10	0.57	796	725
						Totals:	7,839	7,402

Proposed Substation

1 Transformer: 115-13.8/7.98 kV -12 MVA

Circuit	Phase Amps			Max V Drop			Total kVA	Total kW
	A	B	C	A	B	C		
NS-1	110	112	107	1.92	2.09	1.91	2,633	2,467
NS-2	40	38	42	0.32	0.30	0.68	950	912
						Totals:	3,583	3,379

Capacity ≥ 100% of Equipment Rating

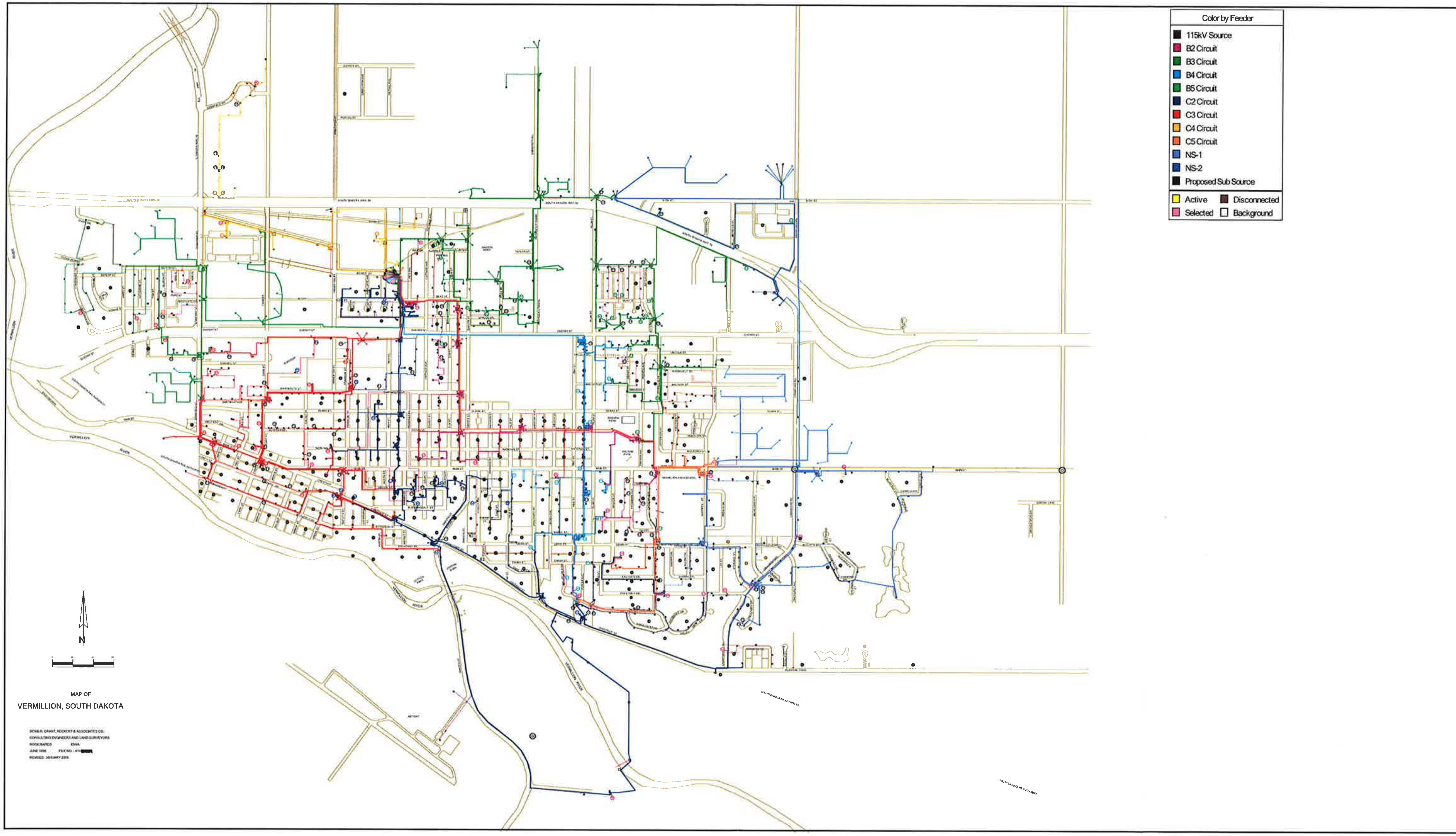
System Total: kW 19,004

Voltage Drop ≥ 3.5 V

City of Vermillion
VERMSYSSTUDY_2021 PROJPK_NEWTIESW+NEW FDRS+NEW SUB - OPT SYS

Projected 2021 Peak Load
Tie Switches, New Feeders(B5 _C5), and Proposed Sub
Feeder Map

Electric System Study



PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion
- DGR Project No.: 414811
- Unbalanced Voltage Drop
- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)
- Tie Switches Added
- Feeders C5 & B5 Added
- New Substation
- Bus Outages

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Bus C Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	108	180	201	3.04	1.82	2.64	3,864	3,845
B3	213	203	203	1.53	1.37	1.61	4,930	4,636
B4	200	190	136	1.74	1.63	1.54	4,182	3,907
B5	79	105	75	1.15	1.72	1.04	2,056	1,974
						Totals:	15,032	14,362

Proposed Substation

1 Transformer: 115-13.8/7.98 kV - 12 MVA Bus C Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
NS-1	169	113	113	3.24	1.98	1.63	3,134	2,923
NS-2	70	67	91	0.71	0.87	1.65	1,812	1,736
						Totals:	4,945	4,659
						System Total:	kW	19,021

Existing Substation

Transformer #2 115-13.8/7.98 kV -12 MVA Bus B Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	106	177	157	1.83	3.19	2.14	3,488	3,482
C3	241	269	199	1.83	3.37	2.72	5,641	5,384
C4	143	149	154	1.93	1.77	2.16	3,546	3,308
C5	75	24	48	2.98	0.40	1.27	1,177	1,079
						Totals:	13,852	13,253

Proposed Substation

1 Transformer: 115-13.8/7.98 kV -12 MVA Bus B Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
NS-1	111	112	107	1.90	2.09	1.88	2,629	2,467
NS-2	155	125	156	2.10	1.20	1.81	3,474	3,342
						Totals:	6,104	5,809

Capacity ≥ 100% of Equipment Rating

System Total: kW 19,062

Voltage Drop ≥ 3.5 V

PROPOSED SYSTEM ANALYSIS - PROJECTED LOADS

- City of Vermillion
- DGR Project No.: 414811
- Unbalanced Voltage Drop
- 2021 Projected Peak Load (2% Growth/Yr ≈ 19619 kW)
- Tie Switches Added
- Feeders C5 & B5 Added
- New Substation
- Feeder Outages

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Feeder B2 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	---	---	---	---	---	---	---	---
B3	114	86	114	1.14	0.71	1.57	2,504	2,412
B4	152	183	177	1.83	3.36	2.92	4,089	3,894
B5	85	82	94	1.26	0.94	0.94	2,075	1,959
						Totals:	8,668	8,265

Transformer #2 115-13.8/7.98 kV -12 MVA Feeder B2 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	61	100	111	1.65	1.83	1.63	2,147	2,050
C3	155	187	90	1.29	2.45	0.59	3,442	3,293
C4	57	67	58	0.27	0.56	0.26	1,454	1,334
C5	62	7	29	2.78	1.05	0.53	768	700
						Totals:	7,811	7,377

Proposed Substation

1 Transformer: 115-13.8/7.98 kV - 12 MVA Feeder B2 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
NS-1	110	112	107	1.92	2.09	1.91	2,629	2,467
NS-2	40	38	42	1.54	0.73	1.52	950	912
						Totals:	3,579	3,379
					System Total:		kW	19,021

Existing Substation

Transformer #1 115-13.8/7.98 kV - 12 MVA Feeder C3 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
B2	55	96	80	0.43	1.25	0.99	1,842	1,819
B3	114	86	114	1.12	0.64	1.59	2,504	2,412
B4	234	242	155	1.61	2.47	1.2	4,964	4,671
B5	85	82	94	1.26	0.94	1.34	2,075	1,959
						Totals:	11,384	10,861

Transformer #2 115-13.8/7.98 kV -12 MVA Feeder C3 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
C2	83	126	137	2.04	2.71	2.16	2,742	2,710
C3	---	---	---	---	---	---	---	---
C4	57	67	58	0.82	0.56	0.26	1,454	1,334
C5	62	7	29	2.82	0.79	0.56	710	700
						Totals:	4,905	4,744

Proposed Substation

1 Transformer: 115-13.8/7.98 kV -12 MVA Feeder C3 Outage

Circuit	Phase Amps A	Phase Amps B	Phase Amps C	Max V Drop A	Max V Drop B	Max V Drop C	Total kVA	Total kW
NS-1	111	111	107	1.90	2.10	1.90	2,630	2,468
NS-2	40	38	42	0.29	0.33	0.68	950	912
						Totals:	3,580	3,380
					System Total:		kW	18,985

Capacity ≥ 100% of Equipment Rating

Voltage Drop ≥ 3.5 V