SPANISH FORK PUBLIC WORKS

POLICY 4.61

Power and Light Master Plan

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POWER AND LIGHT MASTER PLAN

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4.61.010 Introduction

This Power and Light Master Plan was prepared initially by Intermountain Consumer Professional Engineers ("ICPE") in 2018. Model development is discussed in the "System Modeling" section of this report. System model development and analysis were performed on EDSA Paladin Design Base 4.0 Software. System modeling data was developed from Spanish Fork provided system data. Circuit models are based on the assumption that provided circuit maps and data (conductor sizes, circuit configurations, line lengths, etc.) are reflective of actual field conditions.

4.61.020 Spanish Fork City Load Projection

Table 1 and Figure 1 show projected Spanish Fork City load for the next 10 years. City loads have been updated based on historical data through 2010. Ten year average growth has been 3.13%. Load projections have been based on this 3.13% growth. Large users, such as the anticipated 6.5 MVA load from the IHC hospital (2020), will be taken into account with the growth rate.

Table 1
Projected 10-Year Peak Load

2020	Substation Group	2021	2022	2023	Substation Group	2024	2025	2026	2027	2028	Substation Group	2029	2030
38.03	North, Whitehead, Woodhouse T1, Woodhouse T2 Base: 62 MVA, Total: 120 MVA	38.94	40.05	41.01	North, Whitehead, Woodhouse T1, Woodhouse T2 Base: 72 MVA, Total: 120 MVA	42.02	43.05	44.11	45.18	46.27	North, Whitehead, Woodhouse T1, Woodhouse T2 Base: 62 MVA, Total: 120 MVA	47.72	49.21
18.65	Industrial, Argyle Base: 32 MVA, Total: 53.3 MVA	19.03	19.41	19.87	Industrial, Argyle, Leland Base: 32 MVA, Total: 86.6 MVA	20.42	21.00	21.59	22.21	22.83	Industrial, Argyle, Leland Base: 52 MVA, Total: 86.6 MVA	23.54	24.28
26.77	Canyon Road, Maple Mountain, Bonner Base: 44 MVA, Total: 73.3 MVA	27.30	27.81	28.33	Canyon Road, Maple Mountain, Bonner Base: 44 MVA, Total: 73.3 MVA	28.81	29.28	29.78	30.30	30.83	Canyon Road, Maple Mountain, Bonner Base: 44 MVA, Total: 73.3 MVA	31.79	32.79

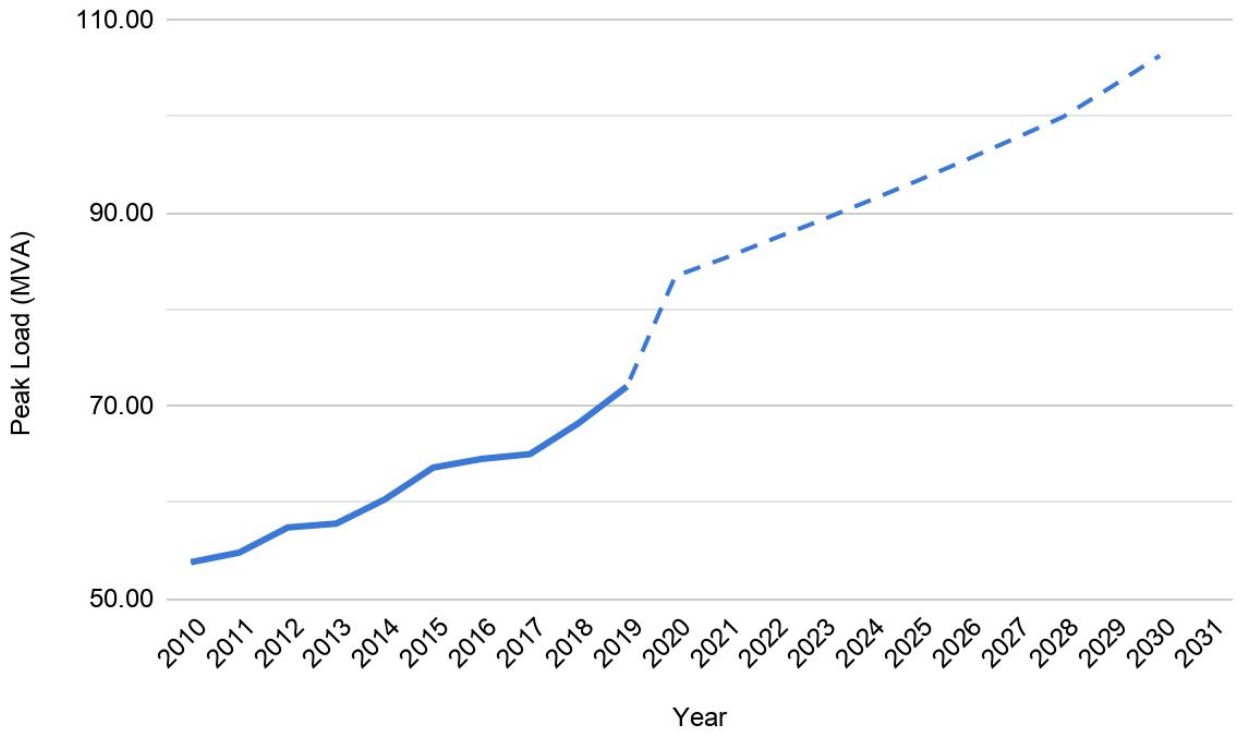

Figure 1
Projected 10-Year Peak Load

Table 2 identifies the total projected utilization through 2028 and the impact on the current municipal power system if no improvements are made.

According to the analysis completed by ICPE and Spanish Fork City, of the three substation groups, Industrial and Argyle will exceed base capacity in 2021 (see Table 2). In fiscal year 2020, Spanish Fork City will upgrade this substation group. There are no other existing deficiencies in the system.

Table 2
Projected Circuit Loads - No Improvements
Click Here to View Table 2

Table 3 identifies the total projected utilization through 2028 and the impact on the current municipal power system if improvements are carried out. The

Spanish Fork system functions as a single service area although each substation group is evaluated independently.

Table 3
Projected Circuit Loads - After Improvements
Click Here to View Table 3

4.61.030 Capital Improvement Plan (CIP)

Table 4 shows the anticipated capital improvement plan (CIP) projects and expenditures necessary to sustain the projected growth of Spanish Fork City's electrical system for the next 10 years. Costs shown are based on 2018 project material and labor pricing. Appendix B contains a cost breakdown for each project. Figure 2 and Figure 3 show the locations for each recommended CIP project without capacitor bank additions. Figure 2 shows the 46 kV projects, while Figure 3 shows the 12 kV projects. Detail design of capacitor bank size and location has not been completed.

Table 4
Capital Improvement Plan Summary

Map ID	Recommended Project	Approximate Time Frame	Approximate Cost
1	Upgrade Industrial Transformer*	2020	$ 1,135,369
2	Upgrade Whitehead Substation	2020	$ 2,633,062
3	12 kV 600 A Circuit US6	2020-2021	$ 320,891
4	Underground Line Woodhouse to Maple Mountain	2021	$ 330,097
5	Reconductor 400 North	2021	$ 381,000
6	Reconductor Canyon Road to Bonner	2022-2023	$ 1,000,000
7	Leland Circuit Upgrades	2022-2023	$ 600,000
8	Underground Line Along Mill Road	2024	$ 264,982
9	Reconductor 1100 E	2024	$ 149,000
10	Capacitor Bank Additions**	2024-2025	$ 250,000
11	Leland #2 Circuit	2025	$ 638,816
12	600 A Underground 2300 E 1850 S	2025	$ 496,000
13	Upgrade Industrial Reclosers	2026	$ 147,000
14	Upgrade Argyle Substation	2027	$ 1,250,000
15	Upgrade Woodhouse T1 Transformer	2029	$ 1,136,000
16	Build Leland Substation	2030	$ 2,721,572
	Total	2018-2030	$ 13,453,789

Costs do not include right of way or land.
* Cost that is shown for capacitor bank additions came from an existing 10 year CIP budget spreadsheet that was given to ICPE from Spanish Fork. ICPE was not able to develop costs for this project since capacitor bank sizes, types, and locations are not known.
** Actual Project Cost

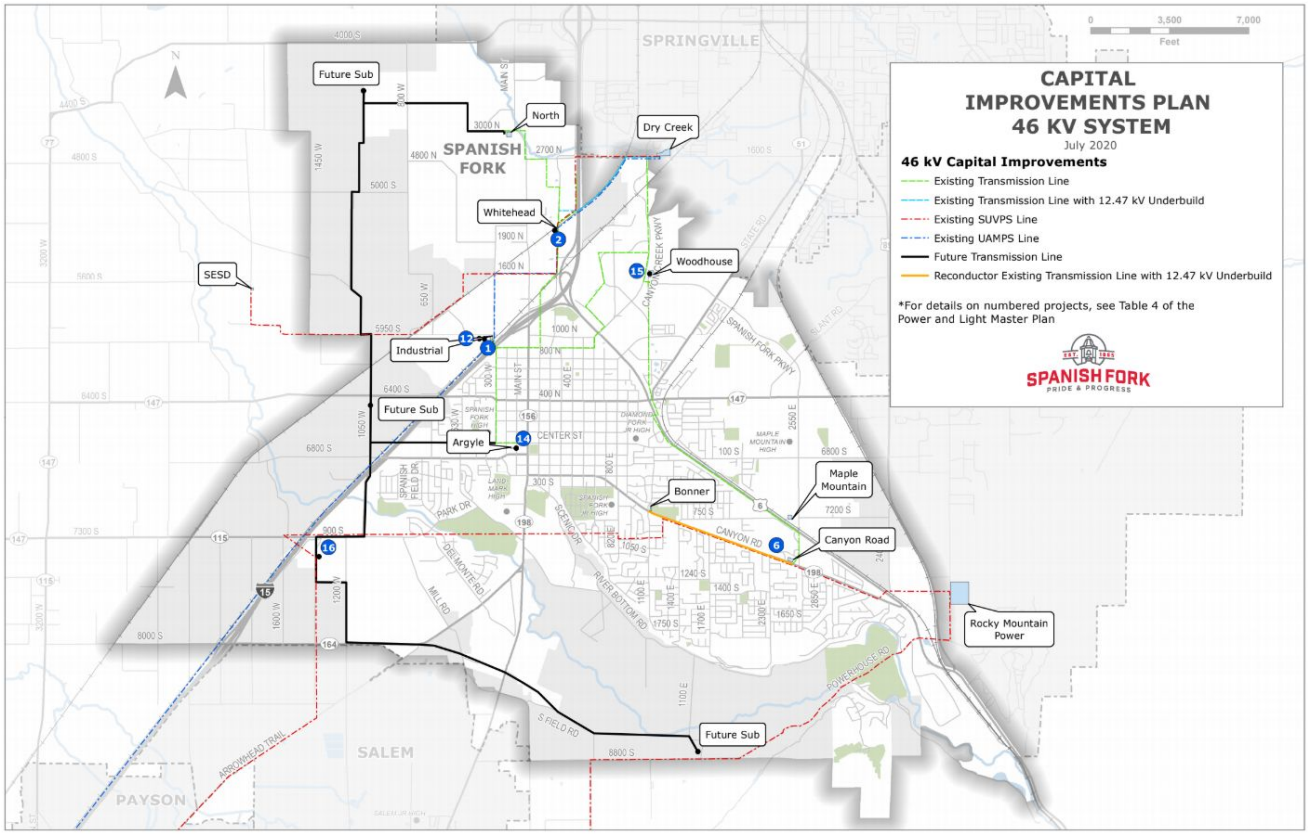

Figure 2
Capital Improvements Overview 46 kV System

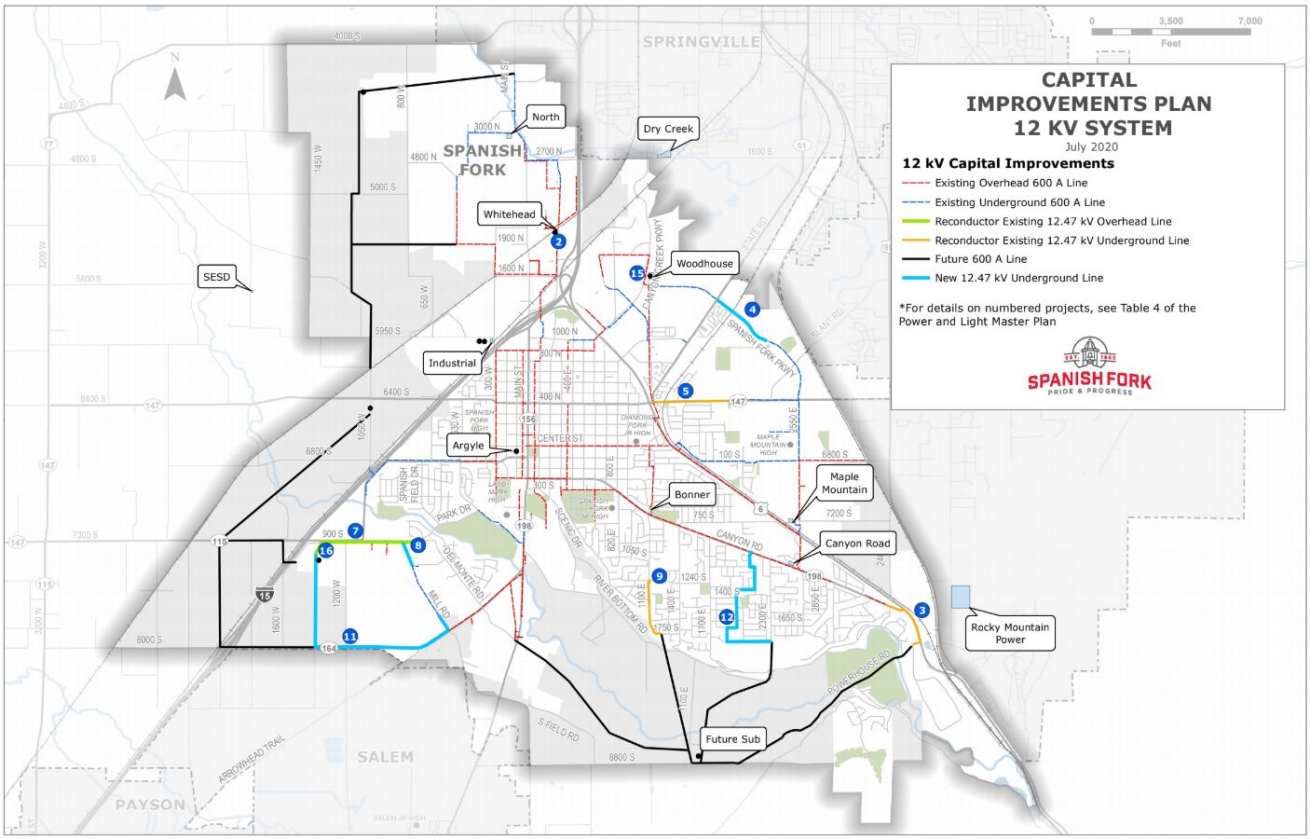

Figure 3
Capital Improvements Overview 12 kV System

4.61.03.010 Recommended Projects

Project #1 Upgrade Industrial Transformer (2020)

It is recommended to replace the transformer at Industrial with a new 20/26.67/33.33 MVA transformer and then move the 12/16/20 MVA transformer at Industrial to Argyle. Load on Industrial transformer is currently 13.28 MVA on a 12/16/20 MVA transformer which is above base rating. Projected load by 2023 on Industrial transformer is 14.95 MVA. The area to the west of Industrial Substation is expected to be annexed in the future which may lead to additional load on Industrial transformer.

Project #2 Upgrade Whitehead Substation (2020)

It is recommended to upgrade the Whitehead transformer to a new 20/26.67/33.33 MVA transformer. The load on Whitehead transformer is currently 6.05 MVA on a 7.5/9.375/10.5 MVA transformer. It is proposed to add a backup circuit to Whitehead for the new Hospital. The circuit will provide a partial backup for 4.5 MVA of the Hospital's load. The addition of this load will put the transformer above capacity.

Upgrading the Whitehead transformer will require rebuilding the substation. It is hoped to be able to reuse the control building. All breakers, reclosers, transformers, and bus work will be new. Additional land may be required to fit the new substation.

Project #3 12 kV 600 A Circuit US6 (2020-2021)

A new substation in the river bottoms will be required in the future as growth continues on Bonner and Canyon Road circuits in the south part of town. New circuits from this substation will be required to tie into existing Bonner and Canyon Road circuits. Existing circuit conductors are mainly 1/0 and 4/0 AL. These are not large enough conductors to tie the new circuits into the existing system. In preparation for the new substation, the underground line along US-6 from Canyon Road to Power House Rd should be reconductored. Conductor is currently 4/0 AWG AL. New conductor is planned to be 500 kcmil CU reduced diameter cable. Cost estimates assume that existing 4” conduit can be reused. New 500 kcmil CU cable will have approximately 500 A capacity. It is recommended that installing a new 6” conduit with 1100 kcmil conductor also be considered. This would allow the line to be rated at 600 A.

Project #4 Underground Line Woodhouse to Maple Mountain (2021)

Woodhouse T2 South circuit currently has minimal load on it and lacks the ability to pick up load from other circuits. It needs to be tied into the rest of the system. A new 1100 kcmil underground line section is needed that will connect the South circuit with the Maple Mountain East circuit.

Project #5 Reconductor 400 North (2021)

Woodhouse T2 South circuit currently has minimal load on it and lacks the ability to pick up load from other circuits. It needs to be tied into the rest of the system. The circuit along 400 North from Hwy 6 to 1880 East needs to be reconducted to 1100 kcmil. This will connect the South circuit with the 1100 East circuit. Existing conduit is 4" which is not large enough for the new conductors. It is proposed to bore in new 6" conduit. Once 400 North is reconductored it is proposed to move some of the 1100 East circuit load to the South circuit.

Project #6 Reconductor Canyon Road to Bonner (2022-2023)

For an outage of Dry Creek Substation the entire city must be fed from the south. The 46 kV system could be split so that substations on the west side of the city are fed by the line going west out of Canyon Road and Substations on the east side of the City are fed by the line going north out of Canyon Road. Doing this puts the 46 kV line between Canyon Road and Argyle near capacity by 2023. It is proposed to reconductor this 46 kV line section to 795 ACSR to improve capacity. Loading of the 46 kV lines should be re-evaluated if load growth is higher than expected or if a large load that was not planned for is added to the system. The cost estimate assumes that new poles will be required and that the conductor for the 12.47 kV underbuild can be reused.

Project #7 New Leland Feeder Along 900 South (2022-2023)

In order to be able to tie the proposed Leland Substation to the rest of the system, the overhead line along 900 South from Leland Substation to Mill Road will need to be reconducted. This will serve as a new feeder fed from Leland Substation. Conductor is currently #2 ACSR. New conductor should be 477 ACSR.

Project #8 Underground Line Along Mill Road (2024)

In order to be able to tie proposed Leland Substation to the rest of the system, two missing pieces of 600 Amp underground line along Mill Road should be installed. The two line sections are from 900 South Mill Road to 1100 South Mill Road and from 1550 South Mill Road to Mill Road Arrowhead Trail Road. The new underground conductor should be 1100 kcmil.

Project #9 Reconductor 1100 E (2024)

A new substation in the River Bottoms will be required in the future as growth continues on Bonner and Canyon Road circuits in the south part of town. New circuits from this substation will be required to tie into existing Bonner and Canyon Road circuits. Existing circuit conductors are mainly 1/0 and 4/0 AL. These are not large enough conductors to tie the new circuits into the existing system. In preparation for the new substation, the underground line along 1100 E from 1240 S to 1750 S should be reconductored. Conductor is currently 1/0 AWG AL. New conductor is planned to be a 500 kcmil CU reduced diameter cable. Cost estimates assume that existing 4" conduit can be reused. New 500 kcmil CU cable will have approximately 500 A capacity. It is recommended that installing a new 6" conduit with 1100 kcmil conductor also be considered. This would allow the line to be rated at 600 A.

Project #10 Capacitor Bank Additions (2024-2025)

It is recommended that Spanish Fork Power factor be improved to at least 0.98. This will help support voltage during power system peak loading and during outage conditions. The need for power factor correction becomes more important as transformer and line loading levels increase. Improving power factor also reduces system losses. Improved power factor helps both the Spanish Fork distribution system as well as the SUVPS transmission system.

A detailed capacitor bank study should be performed when the necessary circuit power factor information is available. The cost that is shown for capacitor bank additions came from an existing 10 year CFP budget spreadsheet that was given to ICPE from Spanish Fork. ICPE was not able to develop costs for this project since capacitor bank sizes, types, and locations are not known.

Project #11 New Leland #2 Circuit (2025)

In order to feed load in the Leland area it is proposed to add a Leland #2 circuit. Proposed route will connect Leland Substation with Argyle's 300 West circuit at

approximately Mill Road Arrowhead Trail. The new underground conductor should be 1100 kcmil.

Project #12 600 A Underground 2300 E 1850 S (2025)

A new substation in the river bottoms will be required in the future as growth continues on Bonner and Canyon Road circuits in the south part of town. New circuits from this substation will be required to tie into existing Bonner and Canyon Road circuits. Existing circuit conductors are mainly 1/0 and 4/0 AL. These are not large enough conductors to tie the new circuits into the existing system. In preparation for the new substation, a new underground 1100 kcmil line from 2070 E Canyon Road to 1850 S 2300 E should be installed in an existing 6" empty conduit.

Project #13 Upgrade Industrial Reclosers (2026)

Industrial Substation reclosers are getting old. They do not meet the current standard recloser type that the city is using. It is proposed to replace the Industrial Substation reclosers. The ABB PCD relays used to protect the reclosers will also be updated at the same time.

Project #14 Upgrade Argyle Substation (2027)

Due to its age and past history, Spanish Fork does not trust being able to load Argyle transformer to its full rating. It needs to be replaced with a newer more reliable transformer. In addition to this, the transformer is recommended to be replaced for load growth and N-1 needs as discussed below.

It is recommended to replace the 8.4/10.5/11.76 MVA Argyle transformer with the 12/16/20 MVA transformer at Industrial. (The Industrial transformer is proposed to be replaced with a new 20/26.67/33.33 MVA transformer.) The load on Argyle is currently 6.26 MVA on a 8.4/10.5/11.76 MVA transformer and projected load by 2023 on Argyle is 6.7 MVA. Studies show that additional MVA capacity is needed on Argyle transformer during N-1 outages of Industrial substation.

Upgrading the Argyle transformer will require rebuilding the entire substation. The existing substation does not have a control building, transformer breaker, etc. A larger piece of land will be required to fit the new substation. Spanish Fork is in the process of trying to obtain that land.

Project #15 Upgrade Woodhouse T1 Transformer (2029)

It is recommended to upgrade the Woodhouse T1 transformer to a new 20/26.67/33.33 MVA transformer. The load on Woodhouse T1 transformer is currently 10.86 MVA on a 10/12/14 MVA transformer which is above its base rating. Projected load by 2023 on Woodhouse T1 transformer is 14.38 MVA which is above transformer capacity. Significant load increases at Woodhouse include 6.5 MVA for a new hospital, 2 MVA load increase for SAPA, and 1 MVA for new Lowes store. Studies show that additional MVA capacity is needed on Woodhouse T1 transformer during N-1 outages of North substation. The upgraded transformer would also allow backup of Woodhouse T2 transformer using the substation tie switch.

Until the transformer can be upgraded, it would be helpful to be able to shift load from Woodhouse T1 transformer to Woodhouse T2 if possible. It is proposed to shift part of 1100 East circuit load to new South circuit. Woodhouse T2 transformer is currently lightly loaded, but is expected to have a significant loading increase over the next five years. Woodhouse T2 load is projected to be 9.65 MVA by 2023. Total Woodhouse load by 2023 is predicted to be 24.03 MVA.

It is hoped that the Woodhouse T1 transformer upgrade can be done with minimal changes to existing bus work, breakers, reclosers, etc. Relaying in the existing control building can be reused.

Project #16 Build Leland Substation (2030)

Load growth in the Southwest part of Spanish Fork is projected to increase significantly over the next few years. This area is currently served by Industrial and Argyle substations. Proposed upgrades to Industrial and Argyle substations help to delay the need for Leland Substation for 4-5 years. If for some reason the upgrades to Industrial and Argyle substations are delayed or if load growth in the southwest part of Spanish Fork is faster than predicted, then Leland substation will be needed sooner.

Leland Substation will be located at approximately 900 S 1400 W. An existing 46 kV SUVPS line between Canyon Road and Taylor Substations is located near the proposed location of Leland Substation. Leland Substation could pick up load from Industrial and Argyle as well as new load in the southwest of Spanish Fork.

4.61.03.020 Major Equipment Loss

Load flows were modeled with substation transformers taken out of service one at a time. Loads from the transformer that was out of service were transferred to adjacent transformers or substations. Doing this also covered the case of a failed recloser or failed main line near a substation since similar load switching would be required. In certain outage cases, it became apparent that system improvements were necessary. Table 5 lists the results and discusses required system improvements. Improvements that are required due to load growth are also discussed. Results are based on projected peak (summer) load levels. During winter load levels the outages would not have as great of an effect.

4.61.040 System Modeling

To perform a comprehensive load flow a system computer model is necessary. System modeling data was developed from Spanish Fork provided system data. The model is based on the assumption that provided transformer data, generator data, system maps and data (conductor sizes, system configurations, line lengths, etc.) are reflective of actual field conditions.

Overhead and underground distribution circuit impedance values as developed for this study are presented in Tables 6-9 shown below. Transformer and generator data is also shown below. Detailed model input data is shown in the Appendix D.

Table 6
46 kV Overhead Distribution Circuit

Conductor Size	Ampacity (Amps)	Z(+) Ohms/1000'		Z(0) Ohms/1000'		1/2 Bpu mmho/1000'
		R	X	R	X	
336	530	0.05799	0.13089	0.13830	0.49451	0.00000
477	670	0.04089	0.12384	0.12119	0.48750	0.00000
795	900	0.02439	0.12195	0.10398	0.47386	0.00000
1272	1200	0.01415	0.11403	0.10080	0.51040	0.00000

Table 7
12.47 kV Overhead Distribution Circuit

Conductor Size	Ampacity (Amps)	Z(+) Ohms/1000'		Z(0) Ohms/1000'		1/2 Bpu mmho/1000'
		R	X	R	X	
#6	100	0.67428	0.14788	0.79699	0.54896	0.00000
#4	140	0.42430	0.14280	0.56133	0.50536	0.00000
#2	180	0.26712	0.13784	0.40331	0.45241	0.00000
1/0	230	0.16773	0.13269	0.28527	0.40348	0.00000
3/0	300	0.10545	0.12729	0.19648	0.36841	0.00000
4/0	340	0.08369	0.12443	0.16195	0.35568	0.00000
336	530	0.05271	0.11564	0.11011	0.33116	0.00000
477	670	0.03718	0.11085	0.08206	0.31913	0.00000

Table 8
12.47 kV Underground Distribution Circuit

Conductor Size	Ampacity (Amps)	Z(+) Ohms/1000'		Z(0) Ohms/1000'		1/2 Bpu mmho/1000'
		R	X	R	X	
1/0	175	0.21100	0.05150	0.36800	0.06500	0.01204
4/0	255	0.10800	0.04630	0.32200	0.09500	0.01517
750	510	0.03010	0.04090	0.19400	0.06000	0.02541
1100	620	0.02280	0.03880	0.11400	0.03000	0.02782

Table 9
Transformer Data

Transformer	MVA Rating	Voltage Rating	% Z1 @ Nominal
North	12/16.05/20	46-12.47 kV Delta-Gnd-Y	Z1 = 6.93%
Whitehead	7.5/9.375.10.5 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 6.78%
Industrial	12/16.05/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.09%
Argyle	8.4/10.5/11.76 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 6.92%
Canyon Road	12/16.05/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 6.89%
Maple Mountain	12/16.05/20 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 7.11%
Woodhouse T1	10/14 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 8.08%
Woodhouse T2	20/26.67/33.33 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 8.08%
Bonner	20/26.67/33.33 MVA	46-12.47 kV Delta-Gnd-Y	Z1 = 8.07%