UES Capital

Reliability Study

2020

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1 Executive Summary

The purpose of this document is to report on the overall reliability performance of the UES Capital system from January 1, 2019 through December 31, 2019. The scope of this report will also evaluate individual circuit reliability performance over the same time period. The outage data used in this report excludes the data in Section 5 (sub-transmission and substation outages), as well as outage data from IEEE Major Event Days (MEDs). UES-Capital MEDs are listed in the table below:

Date	Type of Event	Interruptions	Customer Interruptions	Cust-Min of Interruption
6/30/19	Broken Tree	1	2,277	755,241
10/17/19	Thunderstorm	71	4,918	1,506,573

The following projects are proposed from the results of this study and are focused on improving the worst performing circuits as well as the overall UES Capital system reliability. These recommendations are provided for consideration and will be further developed with the intention to be incorporated into the 2021 budget development process.

Circuit / Line / Substation	Proposed Project	Cost ($)
4W4	Install Recloser and Switches	$112,083
6X3	Install Recloser	$36,753
8X3	Install Recloser	$42,836
Various	Fusesaver Installations	$79,403

Note: estimates do not include general construction overheads

UES Capital SAIDI was 103.51 minutes in 2019 after removing Major Event Days. The UES Capital target was 147.45 minutes. Charts 1, 2, and 3 below show UES Capital SAIDI, SAIFI, and CAIDI, respectively, over the past five years.

Chart 1
Annual Capital SAIDI

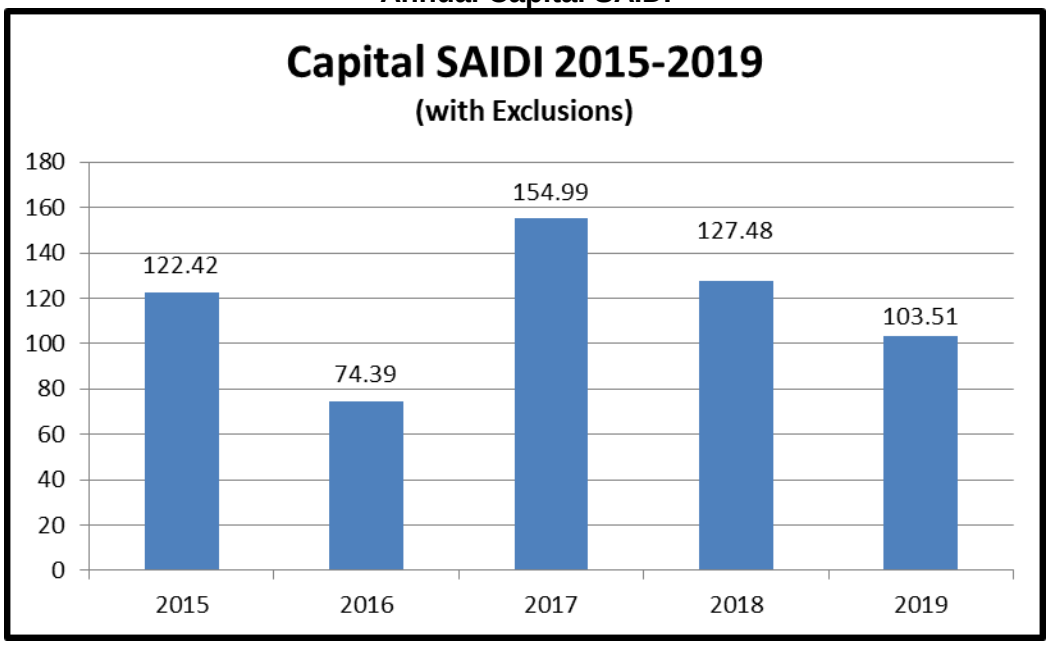


Chart 2
Annual Capital SAIFI

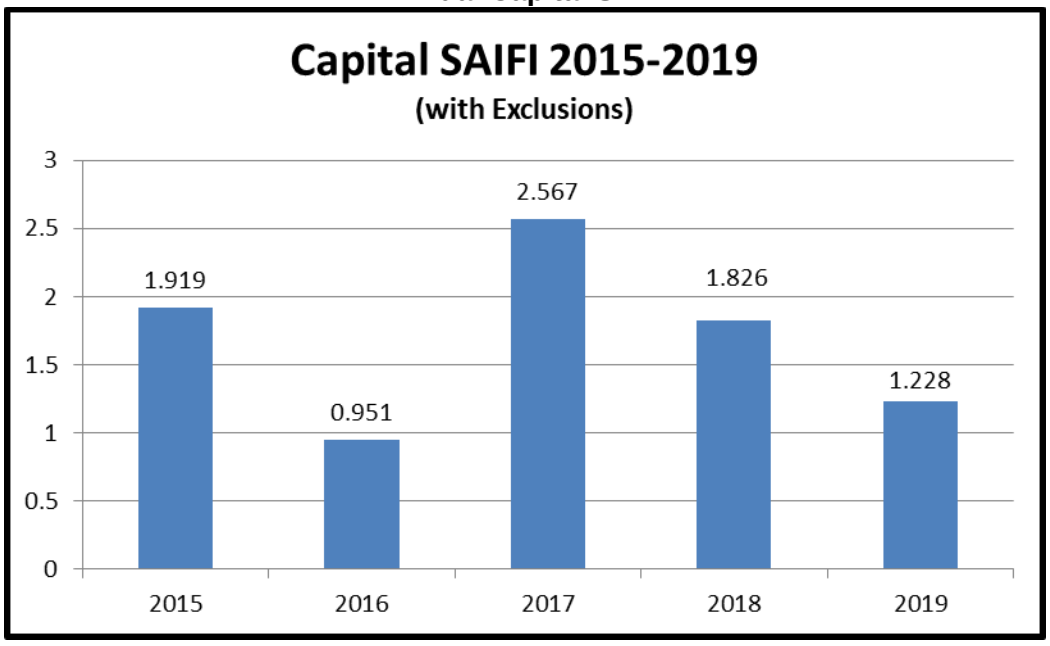
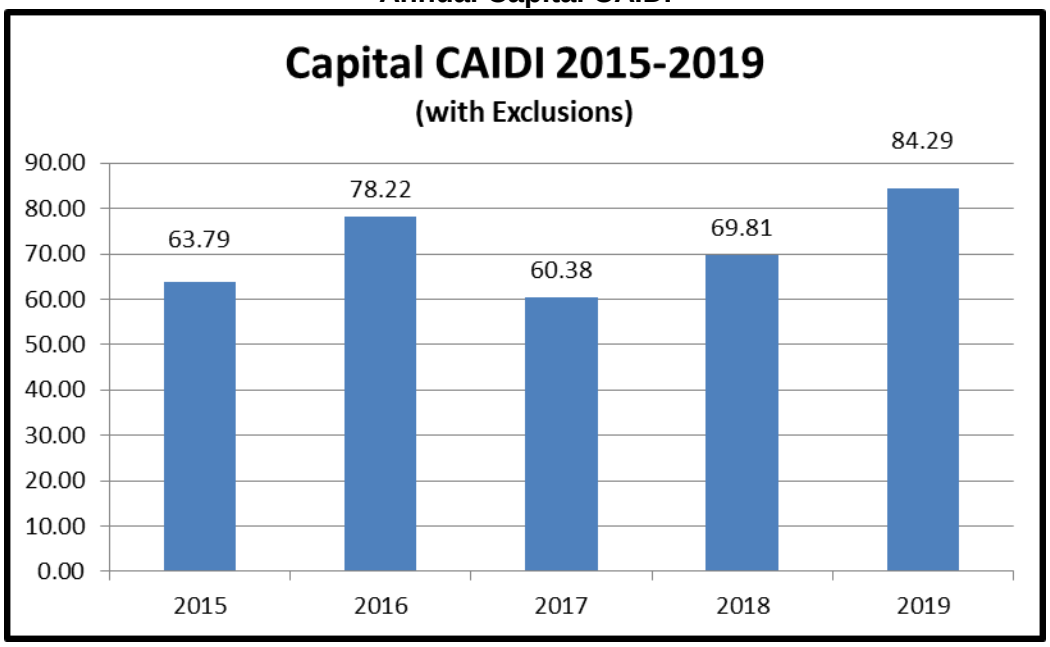


Chart 3
Annual Capital CAIDI



2 Reliability Benchmarks

The annual UES Capital system reliability benchmark for 2020 is set at 144 SAIDI minutes. This was developed by calculating the contribution of UES Capital to the Unitil system performance using the past five year average. The contribution factor was then set against the 2020 Unitil System goal. The 2020 Unitil System goal was developed through benchmarking the Unitil system performance with nationwide utilities.

Individual circuits will be analyzed based upon circuit SAIDI, SAIFI, and CAIDI. Analysis of individual circuits along with analysis of the entire UES Capital system is used to identify future capital improvement projects and/or operational enhancements which may be required in order to achieve and maintain these benchmarks.

3 Outages by Cause

This section provides a breakdown of all outages by cause code experienced during 2019. Charts 4, 5, and 6 show the number of interruptions, the number of customer interruptions, and total customer-minutes of interruptions due to each cause, respectively. Only the causes contributing 3% or greater of the total are labeled. Table 1 shows the number of interruptions for the top three trouble causes for the previous five years.

Chart 4
Number of Interruptions by Cause

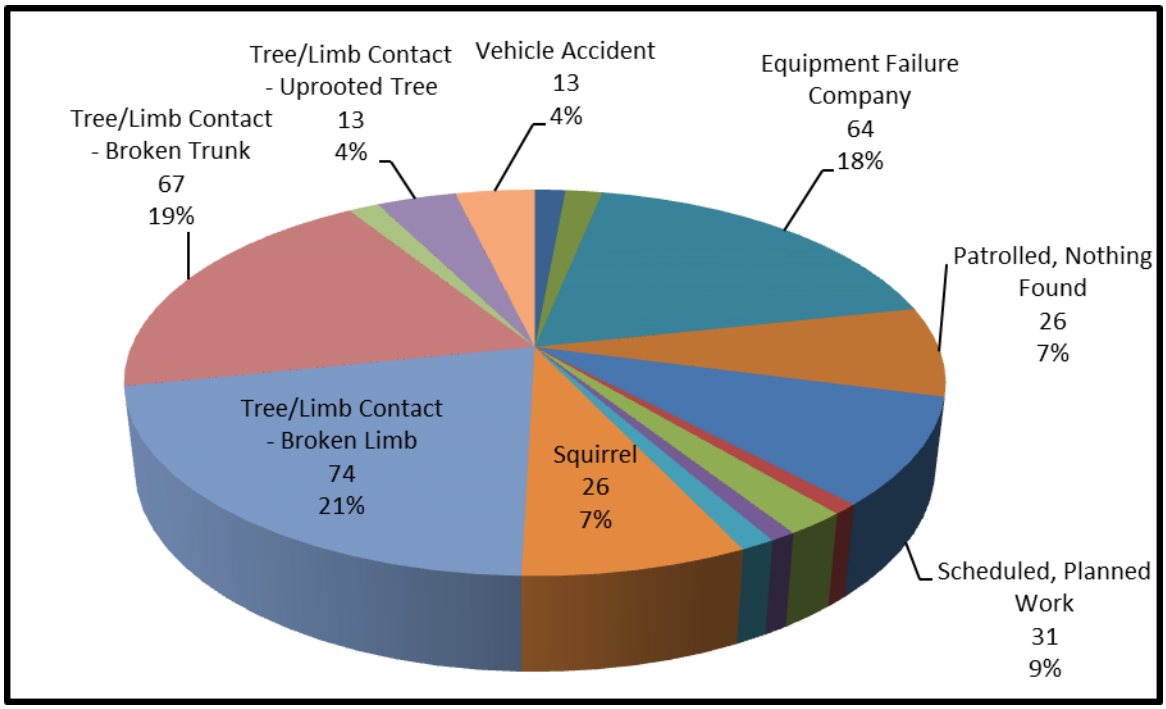


Chart 5
Number of Customer Interrupted by Cause

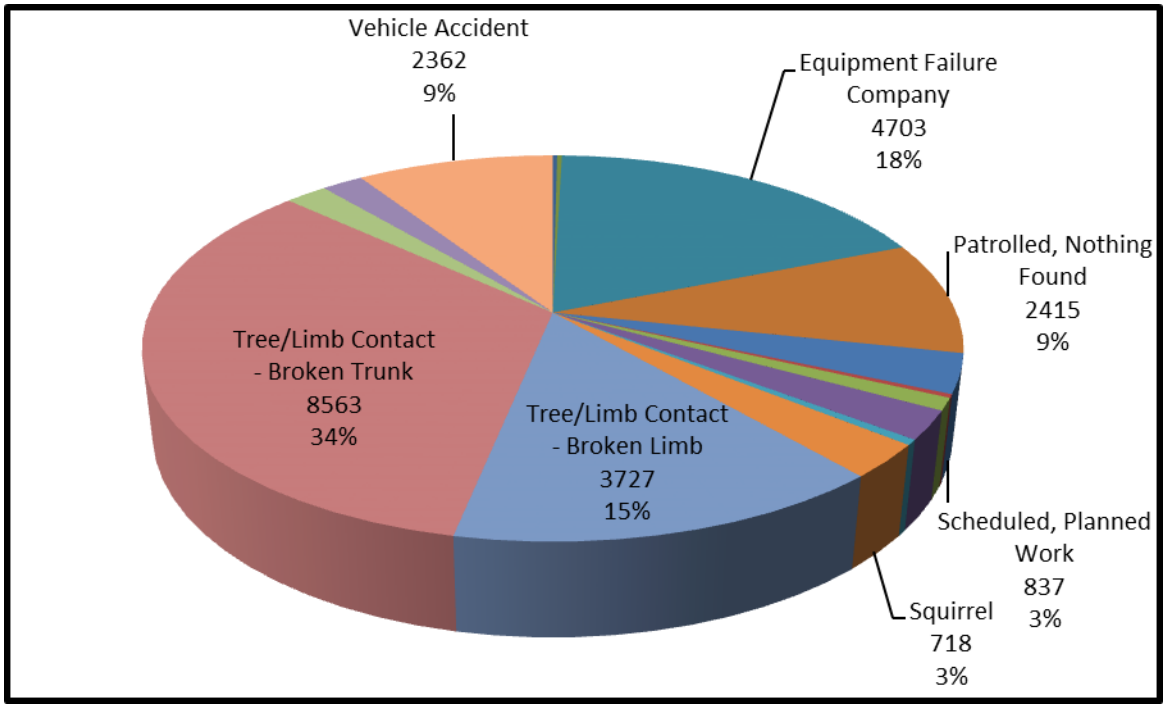


Chart 6
Percent of Customer-Minutes of Interruption by Cause

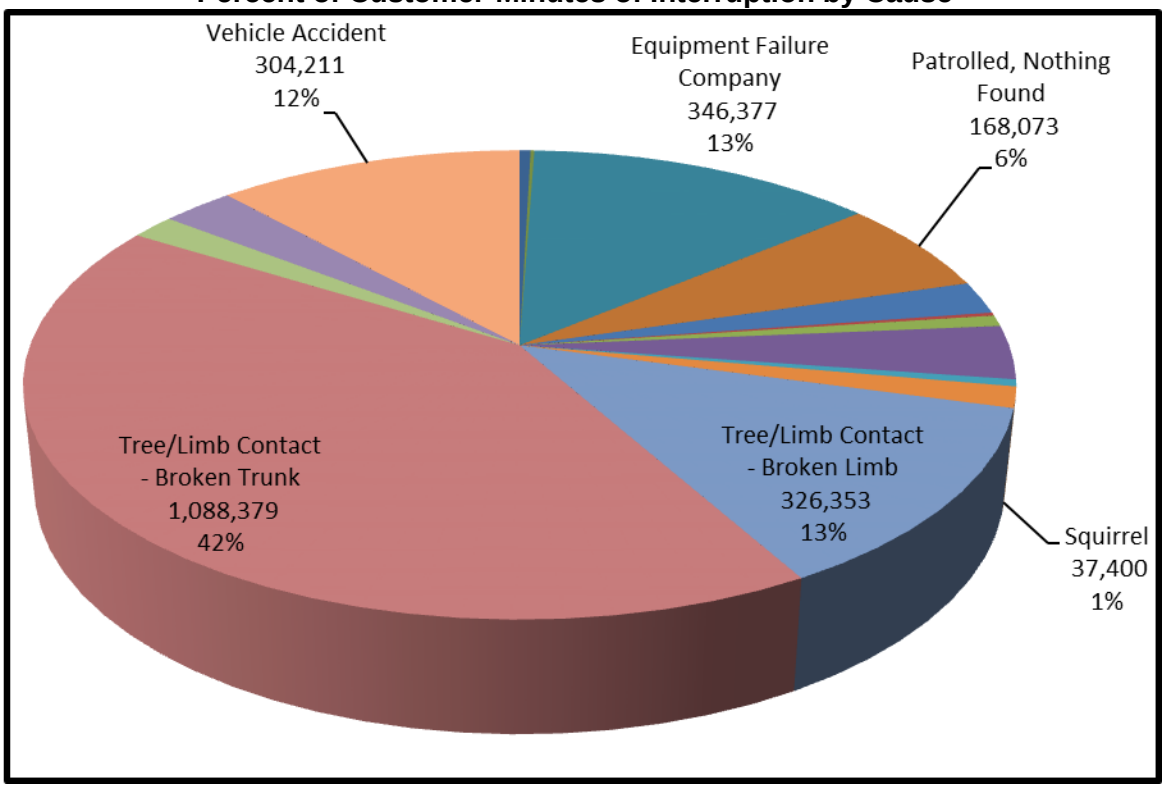


Table 1
Five-Year History of the Number of
Interruptions for the Worst Three Trouble Causes

Year	Tree/Limb Contact - Broken Limb	Tree/Limb Contact - Broken Trunk	Equipment Failure Company
2015	134	44	47
2016	117	34	52
2017	86	37	49
2018	134	102	68
2019	74	67	64

4 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2019 through December 31, 2019 are summarized in Table 2 below.

Table 2
Worst Ten Distribution Outages

Circuit	Description (Date/Cause)	No. of Customers Affected	No. of Customer Minutes	Capital SAIDI (min.)	Capital SAIFI
C2H2	01/01/2019 Tree/Limb Contact - Broken Trunk	1,065	209,267	0.01	0.000
C8X3	03/23/2019 Tree/Limb Contact - Broken Trunk	1,591	171,324	0.01	0.000
C2H2	04/03/2019 Tree/Limb Contact - Broken Trunk	1,066	151,819	0.05	0.001
C6X3	02/09/2019 Tree/Limb Contact - Broken Trunk	1,111	139,912	0.01	0.000
C13W2	06/27/2019 Vehicle Accident	987	115,528	0.08	0.003
C13W3	02/08/2019 Other	596	94,764	0.01	0.000
C13W3	11/19/2019 Vehicle Accident	511	88,659	0.00	0.000
C8X5	01/21/2019 Patrolled, Nothing Found	822	78,597	0.02	0.000
C8X5	08/03/2019 Equipment Failure Company	826	66,080	0.06	0.001
C13W3	11/01/2019 Tree/Limb Contact - Broken Trunk	333	47,752	0.04	0.001

Note: This table does not include outages that occurred at substations or on the subtransmission system, scheduled/planned work outages, or outages that occurred during excludable events.

5 Subtransmission and Substation Outages

This section describes the contribution of sub-transmission line and substation outages on the UES Capital system.

All substation and sub-transmission outages ranked by customer-minutes of interruption during the time period from January 1, 2019 through December 31, 2019 are summarized in Table 3 below.

Table 4 shows the circuits that have been affected by sub-transmission line and substation outages. The table illustrates the contribution of customer minutes of interruption for each circuit affected.

In aggregate, sub-transmission line and substation outages accounted for 24% of the total customer-minutes of interruption for UES Capital.

Table 3
Subtransmission and Substation Outages

Trouble Location	Description (Date/Cause)	No. Customers Affected	No. of Customer Minutes	UES CAPITAL SAIDI (min)	UES Capital SAIFI	No. Times on List (past 4 yrs)
C374	06/11/2019 Tree/Limb Contact - Broken Trunk	3,711	283,047	9.32	0.122	0
C37	01/01/2019 Tree/Limb Contact - Uprooted Tree	3,261	97,764	3.22	0.107	1
C34	02/09/2019 Tree/Limb Contact - Broken Trunk	1,704	80,146	2.64	0.056	3
C38	09/20/2019 Equipment Failure Company	880	57,742	1.90	0.029	1

Table 4
Contribution of Subtransmission and Substation Outages

Circuit	Trouble Location	Customer-Minutes of Interruption	% of Total Circuit Minutes	Circuit SAIDI Contribution	Number of Events
C13W2	Line 37	29,386	18%	29.80	1
C13W1	Line 37	14,708	22%	30.02	1
C37X1	Line 37	5,370	20%	29.83	1
C13W3	Line 37	48,300	12%	29.74	1
C2H2	Line 34	50,055	9%	46.96	1
C2H4	Line 34	4,324	68%	47.52	1
C2H1	Line 34	22,372	100%	46.80	1
C34X4	Line 34	105	100%	105.00	1
C33X5	Line 34	141	100%	47.00	1
C33X4	Line 34	3,055	84%	45.60	1
C33X3	Line 34	47	100%	47.00	1
C33X6	Line 34	47	100%	47.00	1
C3H3	Line 374	4,320	40%	40.37	1
C14H2	Line 374	26,640	36%	38.83	1
C18W2	Line 374	47,200	25%	40.00	1
C374X1	Line 374	240	52%	40.00	1
C14H1	Line 374	4,000	100%	40.00	1
C14X3	Line 374	240	41%	40.00	1
C3H2	Line 374	23,360	68%	39.93	1
C17X1	Line 374	40	100%	20.00	1
C396X2	Line 374	280	100%	40.00	1
C1H6	Line 374	31,711	98%	113.66	1
C3H1	Line 374	145,016	99%	291.20	1
C38	Line 38	11,707	10%	10.71	2
C24H2	Line 38	25,042	100%	66.60	1
C24H1	Line 38	20,993	100%	66.43	1

6 Worst Performing Circuits

This section compares the reliability of the worst performing circuits using various performance measures. All circuit reliability data presented in this section includes sub-transmission or substation supply outages unless noted otherwise.

6.1 Worst Performing Circuits in Past Year (1/1/19 – 12/31/19)

A summary of the worst performing circuits during the time period between January 1, 2019 and December 31, 2019 is included in the tables below.

Table 5 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The SAIFI and CAIDI for each circuit are also listed in this table.

Table 6 provides detail on the major causes of the outages on each of these circuits. Customer-Minutes of interruption are given for the six most prevalent causes during 2019.

Circuits having one outage contributing more than 80% of the Customer-Minutes of interruption were excluded from this analysis.

Table 5
Worst Performing Circuits Ranked by Customer-Minutes

Circuit	Customer Interruptions	Worst Event (% of CI)	Cust-Min of Interruption	Worst Event (% of CMI)	SAIDI	SAIFI	CAIDI
C2H2	3,906	27%	498,353	42%	467.50	3.664	127.59
C8X3	3,934	40%	407,321	42%	141.38	1.365	103.54
C13W3	2,665	22%	347,663	27%	214.08	1.641	130.46
C8X5	2,521	33%	191,018	41%	256.74	3.388	75.77
C6X3	1,435	77%	184,375	76%	166.25	1.294	128.48
C18W2	2,098	56%	142,816	41%	121.03	1.778	68.07
C15W1	1,039	25%	117,862	40%	118.34	1.043	113.44
C38	651	15%	101,667	41%	93.02	0.596	156.17
C7W3	603	29%	62,225	34%	68.15	0.660	103.19
C4W4	2,730	83%	59,067	39%	25.94	1.199	21.64

Note: all percentages and indices are calculated on a circuit basis

Table 6
Circuit Interruption Analysis by Cause

Circuit	Customer – Minutes of Interruption / # of Outages					
	Tree/Limb Contact - Broken Trunk	Equipment Failure Company	Tree/Limb Contact - Broken Limb	Patrolled, Nothing Found	Vehicle Accident	Other
C2H2	385,121 / 3	56,655 / 1	16,902 / 1	219 / 1	21,822 / 1	0 / 0
C8X3	283,733 / 18	3,814 / 6	79,500 / 18	8,537 / 5	6,361 / 2	1,250 / 2
C13W3	92,147 / 9	2,550 / 4	56,881 / 12	1,366 / 2	97,370 / 5	94,764 / 1
C8X5	2,821 / 1	66,080 / 1	41,268 / 2	78,652 / 2	0 / 0	0 / 0
C6X3	142,909 / 2	41,405 / 6	59 / 1	0 / 0	0 / 0	0 / 0
C18W2	18,090 / 2	6,298 / 1	9,389 / 6	60,675 / 4	0 / 0	0 / 0
C15W1	30,798 / 2	281 / 2	23,420 / 2	6,516 / 3	0 / 0	0 / 0
C38	0 / 0	80,515 / 4	1,564 / 3	0 / 0	0 / 0	0 / 0
C7W3	43,348 / 5	8,633 / 3	5,067 / 2	1,952 / 1	0 / 0	0 / 0
C4W4	7,971 / 3	37,392 / 7	1,645 / 1	348 / 1	0 / 0	0 / 0

6.2 Worst Performing Circuits of the Past Five Years (2015 – 2019)

The annual performance of the ten worst circuits in terms of circuit SAIDI and SAIFI for each of the past five years is shown in the tables below. Table 7 lists the ten worst performing circuits ranked by SAIDI and Table 8 lists the ten worst performing circuits ranked by SAIFI. Table 9 lists the ten worst performing circuits ranked by SAIDI and SAIFI over the past five years.

The data used in this analysis includes all system outages except those outages that occurred during the 2016 July Wind/Thunder storm, 2017 March Windstorm, 2017 October Tropical Storm, 2018 May Windstorm, 2018 June Thunderstorm, 2019 Broken Tree, and 2019 October Thunderstorm.

The data used in this analysis includes all distribution circuits except those that do not have an interrupting device, e.g. fuse or recloser, at their tap location.

Table 7

Circuit SAIDI

Circuit Ranking (1 = worst)	2019		2018		2017		2016		2015	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	C2H2	467.50	C13W3	532.47	C13W2	577.74	C21W1A	892.82	C21W1A	803.71
2	C8X5	256.74	C13W2	327.56	C18W2	560.64	C7W3	272.49	C34X2	399.45
3	C13W3	214.08	C15W2	268.14	C13W1	555.75	C34X2	244.80	C13W3	357.44
4	C6X3	166.25	C22W3	242.20	C13W3	496.50	C37X1	176.22	C375X1	318.05
5	C8X3	141.38	C21W1A	166.74	C396X2	454.70	C18W2	155.42	C14H2	288.10
6	C13W2	134.14	C8X3	164.27	C17X1	410.37	C15W1	147.96	C16X4	281.37
7	C18W2	121.03	C13W1	155.29	C16H3	403.03	C4X1	146.38	C16H1	281.30
8	C15W1	118.34	C7W3	142.86	C8X3	326.03	C13W1	140.76	C7W3	281.18
9	C37X1	117.78	C38	128.52	C33X4	246.98	C22W3	136.51	C16H3	280.82
10	C13W1	108.30	C2H4	87.85	C8H2	246.67	C13W3	117.09	C16X5	280.05

Table 8
Circuit SAIFI

Circuit Ranking (1 = worst)	2019		2018		2017		2016		2015	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	C2H2	3.664	C13W2	6.694	C21W1A	3.993	C21W1A	6.356	C24H1	7.143
2	C8X5	3.388	C13W1	5.818	C37X1	2.418	C16X4	5.023	C24H2	6.987
3	C18W2	1.778	C13W3	5.267	C18W2	1.995	C16H1	5.020	C15W2	6.597
4	C13W3	1.641	C16H3	4.693	C15W1	1.938	C16X5	5.000	C22W3	5.832
5	C37X1	1.506	C18W2	4.131	C13W1	1.785	C16X6	5.000	C3H1	4.251
6	C3H3	1.383	C8H2	3.122	C1X7P	1.778	C375X1	5.000	C22W1	4.034
7	C8X3	1.365	C8X3	3.108	C4X1	1.738	C16H3	4.998	C38W	4.022
8	C15W2	1.350	C17X1	3.000	C22W3	1.509	C7W3	4.850	C22W2	4.000
9	C13W2	1.335	C396X2	3.000	C7W3	1.396	C13W3	4.567	C7W3	3.982
10	C6X3	1.294	C37X1	2.770	C13W3	1.348	C18W2	4.127	C14X3	3.500

Table 9
Worst Performing Circuit past Five Years

SAIDI			SAIFI		
Circuit Ranking	**Circuit**	**# Appearances**	**Circuit Ranking**	**Circuit**	**# Appearances**
1	C13W3	5	**1**	C18W2	4
2	C21W1A	3	**2**	C21W1A	2
3	C13W2	3	**3**	C13W3	4
4	C18W2	3	**4**	C37X1	3
5	C34X2	2	**5**	C13W1	2
6	C13W1	4	**6**	C13W2	2
7	C7W3	3	**7**	C15W2	2
8	C8X3	3	**8**	C16H3	2
9	C2H2	1	**9**	C22W3	2
10	C22W3	2	**10**	C24H1	1

6.3 System Reliability Improvements (2019 and 2020)

Vegetation management projects completed in 2019 or planned for 2020 that are expected to improve the reliability of the 2019 worst performing circuits are included in table 10 below. Table 11 below details electric system upgrades that are scheduled to be completed in 2020, or were completed in 2019, that were performed to improve system reliability.

Table 10
Vegetation Management Projects on Worst Performing Circuits

Circuit(s)	Year of Completion	Project Description
C13W1	2019	Planned Cycle Pruning/ Planned Hazard Tree Mitigation
C22W1	2019	Planned Cycle Pruning
C22W2	2019	Planned Cycle Pruning
C38	2019	Planned Cycle Pruning
C4W4	2019	Planned Cycle Pruning/ Planned Hazard Tree Mitigation
C4X1	2019	Planned Cycle Pruning/ Planned Hazard Tree Mitigation
C7W4	2019	Planned Cycle Pruning
C8H1	2019	Planned Cycle Pruning
C8H2	2019	Planned Cycle Pruning
C8X5	2019	Planned Cycle Pruning

C24H1	2019	Planned Hazard Tree Mitigation
C24H2	2019	Planned Hazard Tree Mitigation
C18W2	2019/2020	Planned Hazard Tree Mitigation/Planned Mid-Cycle Review/Planned Tree-Related Analysis
C6X3	2019	Planned Hazard Tree Mitigation
C37X1	2019	Planned Hazard Tree Mitigation
C4W3	2019/2020	Planned Hazard Tree Mitigation/Planned Tree-Related Analysis
C22W3	2019/2020	Planned Tree-Related Analysis/ Planned Cycle Pruning/ Planned Hazard Tree Mitigation
C8X3	2019/2020	Planned Tree-Related Analysis/ Planned Hazard Tree Mitigation/Planned Mid-Cycle Review
C14H1	2020	Planned Cycle Pruning
C14H2	2020	Planned Cycle Pruning
C14X3	2020	Planned Cycle Pruning
C15W1	2020	Planned Cycle Pruning
C15W2	2020	Planned Cycle Pruning
C1H1	2020	Planned Cycle Pruning
C1H2	2020	Planned Cycle Pruning
C1H3	2020	Planned Cycle Pruning
C1H4	2020	Planned Cycle Pruning
C1H5	2020	Planned Cycle Pruning
C7W3	2020	Planned Cycle Pruning
C7X1	2020	Planned Cycle Pruning
C13W3	2020	Planned Tree-Related Analysis

Table 11
Electric System Improvements Performed to Improve Reliability

Circuit(s)	Year of Completion	Project Description
38	2019	UG Cable Injection
13W3	2019	Hydraulic Recloser Replacement (for coordination)
16H3	2019	UG Cable Injection

Circuit(s)	Year of Completion	Project Description
396X1	2019	Microprocessor Controlled Recloser Installation
7W3	2019	Microprocessor Controlled Recloser Installation
7W3	2019	Fusesaver Installation
8X3 and 8X5	2019	New Circuit Tie
VARIOUS	2019	Animal Guard Installation
13W2	2020	Fusesaver Installation
15W1	2020	Microprocessor Controlled Recloser Installation
1H2 and 1H3	2020	Replace Switchgear and add Tie
22W3	2020	Fusesaver Installation
37X1	2020	Replace Sub-T Pole and Install Microprocessor Controlled Recloser
6X3	2020	Microprocessor Controlled Recloser Installation
7W3	2020	Fusesaver Installation
8X3	2020	Fusesaver Installation
8X3	2020	Hydraulic Recloser Replaced with Microprocessor Controlled Recloser
8X5	2020	Microprocessor Controlled Recloser Installation
38	2019	UG Cable Injection

7 Tree Related Outages in Past Year (1/1/19 – 12/31/19)

This section summarizes the worst performing circuits by tree related outage during the time period between January 1, 2019 and December 31, 2019.

Table 12 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The number of customer-interruptions and number of outages are also listed in this table.

All streets on the UES CAPITAL system with three or more tree related outages are shown in Table 13 below. The table is sorted by number of interruptions and customer-minutes of interruption.

Table 12
Worst Performing Circuits – Tree Related Outages

Circuit	Customer-Minutes of Interruption	Number of Customers Interrupted	No. of Interruptions
C2H2	402,023	3,544	4
C8X3	365,380	3,412	40
C13W3	149,878	3,065	22
C6X3	142,969	1,155	3
C15W1	101,227	774	6
C18W2	74,815	1,926	10
C13W1	49,174	801	17
C7W3	48,737	435	8
C8X5	46,285	872	4
C4W3	43,875	513	8

Table 13
Multiple Tree Related Outages by Street

Circuit	Street, Town	# Outages	Customer-Minutes of Interruption	Number of Customer Interruptions
C18W2	Putney Rd, Bow	4	9,241	118
C15W1	Oak Hill Rd, Loudon	3	30,931	195
C13W1	Morrill Rd, Canterbury	3	18,683	121
C4W4	Lakeview Dr, Concord	3	9,097	108
C8X5	North Pembroke Rd, Pembroke	3	8,621	50
C4W3	Mountain Rd, Concord	3	7,131	169
C13W3	Mutton Rd, Webster	3	6,973	66
C13W1	Kimball Pond Rd, Canterbury	3	4,762	21
C8X3	Sanborn Hill Rd North, Epsom	3	4,331	30
C13W3	Cashell Lane, Webster	3	2,531	20

8 Multiple Device Operations and Streets with Highest Number of Outages

This section is intended to clearly show all equipment failures throughout the study period from January 1, 2019 through December 31, 2019. Chart 7 shows all equipment failures throughout the study period. Chart 8 shows each equipment failure as a percentage of the total failures within this same study period. The number of equipment failures in each of the top three categories of failed equipment for the past five years are shown below in Chart 9.

Chart 7
Equipment Failure Analysis by Cause

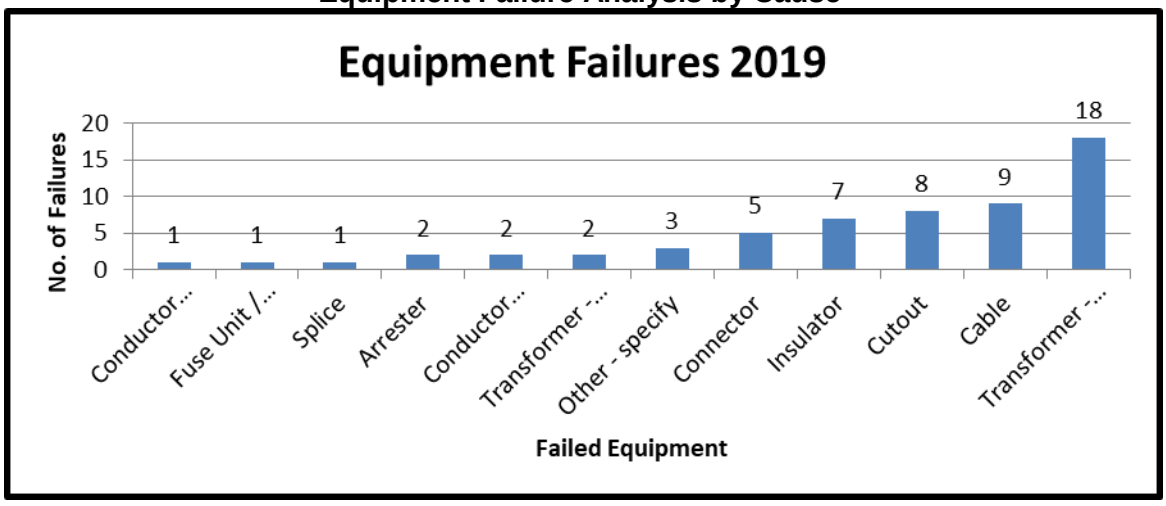


Chart 8
Equipment Failure Analysis by Percentage of Total Failures

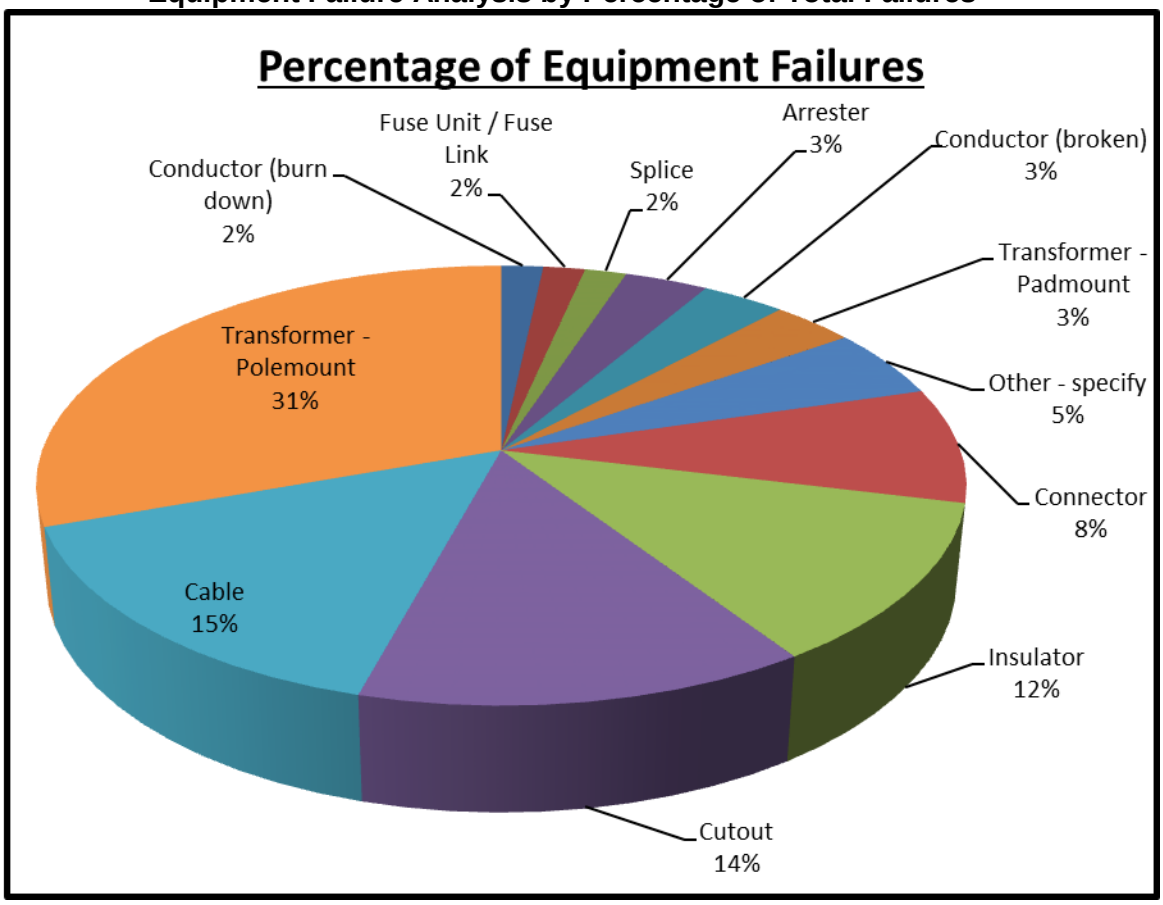
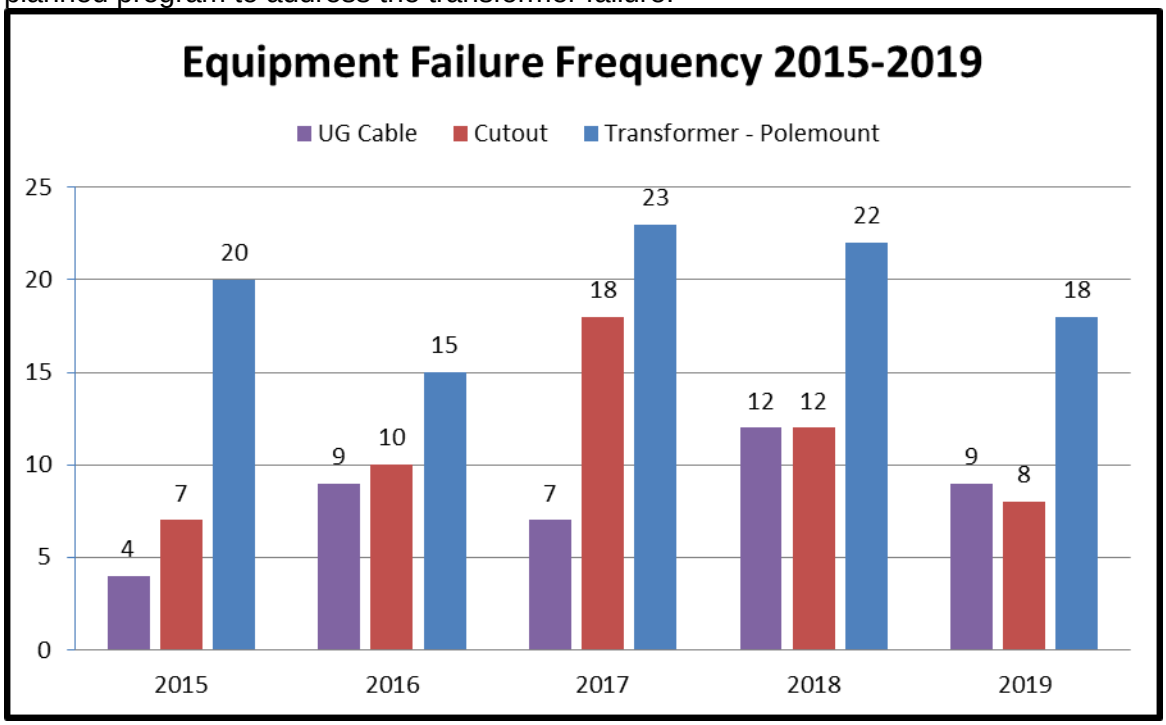


Chart 9
Annual Equipment Failures by Category (top three)

The top three equipment failures continue to be underground cables, cutouts, and polemount transformers. Underground cable failures continue to occur, however, with the cable injection projects in 2016 and 2019, the total failures have remained low.. Two life-extending cable injections were executed in 2019. Additional cable injections and direct-buried cable replacement projects are planned for 2021-2022. Starting in 2018, any found porcelain cutouts were replaced. A budgeted porcelain cutout replacement program is planned for 2019-2021. The downtrend of cutout failures is indicative of the replacement programs. Polemount transformer failures continue to be the highest rate of failure; however the number of failures are still below industry average. There is no planned program to address the transformer failure.



9 Multiple Device Operations and Streets with Highest Number of Outages

A summary of the devices that have operated four or more times from January 1, 2019 to December 31, 2019 are included in table 14 below. Refer to section 11 for project recommendations that address some of the areas identified.

A summary of the streets on the UES Capital system that had customers with 7 or more non-exclusionary outages in 2019 is included in Table 15 below. The table is sorted by circuit and then the maximum number of outages seen by a single customer on that street.

Table 14
Multiple Device Operations

Circuit	Device	Number of Operations	Customer Minutes	Customer Interruptions	# of Times on List in Previous 4 Years
C15W1	Fuse, Pole 25, Mountain Rd, Concord	4	60,473	473	1
C18W2	Fuse, Pole 50, Putney Rd, Bow	4	9,655	132	0

Table 15
Streets with the Highest Number of Outages

Circuit	Street	Max Number of Outages Seen by a Single Customer	Number of Times on List in Previous 4 Years
C18W2	Putney Rd	9	0
C18W2	Blevens Dr	9	0
C2H2	Penacook St	9	0
C4W4	District 5 Rd	9	0
C13W3	White Plains Rd	8	1
C8X3	Philbrick Rd	7	0

10 Other Concerns

This section is intended to identify other reliability concerns that would not necessarily be identified from the analysis above.

10.1 13.8kV Underground Electric System Improvements

There are condition concerns in the 13.8kV Concord Downtown Underground. Portions of the cable have been replaced due to faults. There is historical evidence of connector failure as well. Transformers with primary switches are still in the process of being installed in place of the existing transformers. By the end of 2020, 18 of 21 transformers will have switches in them. A 2021 budget project will also create a loop out of manhole 25, allowing for additional restoration switching. A project in 2019 combined with the completion of the Gulf St conversion project creates a back up to restore the downtown underground. This is expected to reduce outage duration and allow time for condition-based replacement as opposed to a quick fix to restore customers quickly.

10.2 URD Cable Failure

URD cables are failing at an average rate of 8.2 failures per year over the last five years, for a total of 41 cable failures in five years. When a direct buried cable fails, Unitil splices in a small section of new cable into the existing cable. Generally, cable failures in conduit result in cable replacement. The remaining aged cable in the area is still susceptible to failure. In recent years, projects to address direct buried cable failures have included cable injection

and replacement with conduit. Projects for rejuvenation and replacement with conduit were completed in 2019 and further proposed for the 2021 budget.

11 Recommendations

This following section describes recommendations on circuits, sub-transmission lines and substations to improve overall system reliability. The recommendations listed below will be compared to the other proposed reliability projects on a system-wide basis. A cost benefit analysis will determine the priority ranking of projects for the 2021 capital budget. All project costs are shown without general construction overheads.

11.1. Circuit 13W3: Create a Loop between Water St and High St

11.1.1. Identified Concerns

Circuit 13W3 had three of the worst distribution outages in 2018, including the number one worst outage. It has been on the list of worst performing circuits four out of the last five years, ranked by SAIDI and SAIFI.

11.1.2. Recommendations

Build N. Water St, Boscawen from single phase to three phase spacer cable. Extend the phases through to P.50 Old Turnpike Rd, Salisbury. Install two microprocessor reclosers and one three-phase, remote and motor operated switch. Implement an auto transfer scheme. One recloser is to be installed at P.49 Old Turnpike Rd and the other recloser is to be installed at P.1 Rabbit Rd. The switch is to be installed in the area of the intersection of N. Water St. and Long St., Boscawen. Ultimately, this project is to create a loop between High St and Water St in Boscawen. It will allow for the entirety of the Webster territory or Salisbury territory to be restored after a fault on either Water St or High St, respectively.

Estimated Project Cost (without construction overheads): $1,200,000

Estimated Annual Savings:

Customer Minutes: 144,600
Customer Interruptions: 673

11.2. Circuit 13W3: Install a recloser at P.49 Old Turnpike Rd, Salisbury

Install a microprocessor recloser at P.49 Old Turnpike Rd, Salisbury. This project is a piece of project 11.1., but carries benefit on its own and begins working toward the full project.

Estimate Project Cost (without construction overheads): $50,000

Estimated Annual Savings:

Customer Minutes: 1,746
Customer Interruptions: 21

11.3. Circuit 6X3: Install Recloser on Pleasant St

11.3.1. Identified Concerns

6X3 splits into two directions just outside of the substation. An electronic recloser is being installed in the easterly direction in 2020. This new recloser is to be installed in the westerly direction to protect the other half of the circuit. This recloser will limit the scale of outages on the circuit. It also will prevent the Concord Hospital from experiencing an outage from faults to the west of Langley Parkway.

11.3.2. Recommendations

Install an electronic recloser in the vicinity of Pole 83 on Pleasant St, Concord.

Estimated Project Cost (without construction overheads): $54,439

Estimated Annual Savings:

Customer Minutes: 11,563
Customer Interruptions: 192

11.4. Circuit 2H2: Install Microprocessor Controlled Recloser

11.4.1. Identified Concern

Penacook St, Concord experienced an increased number of outages in 2019. Replacing fusing with a recloser at the intersection of Penacook St and Rumford St is expected to provide increased reliability.

11.4.2. Recommendation

Install a Recloser at P.18 Penacook St, Concord

Estimated Project Cost (without construction overheads): $38,759

Estimated Annual Savings:
Customer Minutes of Interruption: 2,392
Customer Interruptions: 34

11.5. Circuit 13W2: Reconductor N. Main St, Boscawen with Spacer

11.5.1. Identified Concern

The master plan is to create a backup for the 37 Line, as it radially feeds the Boscawen S/S. The 13W2 circuit will be converted to 34.5kV and tie with 4X1 from Penacook. This project is expected to provide increased reliability for 13W2 right now, but also establish the back bone for even greater reliability at the sub-transmission and distribution levels.

11.5.2. Recommendation

Reconductor 13W2 mainline from the S/S, down N. Main St, Boscawen, and end at the Village St bridge in Penacook. The reconductoring and reinsulating will be done to system planning capacity and 34.5kV construction. This construction is approximately 2.5 miles of spacer cable construction.

Estimated Project Cost (without construction overheads): $674,174

Estimated Annual Savings:
Customer Minutes of Interruption: 107,510
Customer Interruptions: 1,294

11.5.3 Alternate Option

Reconductor 13W2 mainline with fully insulated wire in open construction instead of spacer construction.

Estimated Project Cost (without construction overheads):

Estimated Annual Savings:
Customer Minutes of Interruption: 44,348
Customer Interruptions: 534

11.6 Circuit 13W1: Reconductor Morrill Rd, Canterbury

11.6.1 Identified Concern

A number of tree related outages on this single phase lateral occurred in 2018. There are limited trimming abilities in the area. Reconductoring the #6 with 1/0 ACSR fully insulated wire will reduce the number of outages. The insulation and breaking strength improve the overall reliability by being less susceptible to faults and less likely to break (compared to uninsulated, #6 Cu)

11.6.2 Recommendation

Reconductor approximately 14,000 ft of #6 Cu with 1/0 ACSR fully insulated wire on Morrill Rd, Canterbury.

Estimated Project Cost (without construction overheads): $445,000

Estimated Annual Savings:
Customer Minutes of Interruption: 7,630
Customer Interruptions: 84

11.7 Circuit 13W3: Reconductor Long St, Webster with Spacer Cable

11.7.1 Identified Concern

The sectionalizers on P.138 Long St, Boscawen operated several times in 2018, most outages were patrolled and nothing was found. Reconductoring approximately 1.6 miles of three phase mainline will

reduce the number of outages normally associated with trees and animals.

11.7.2 Recommendation

Reconductor approximately 1.6 miles of three-phase mainline on Long St, Boscawen and Webster with 13.8kV, 336AAC spacer.

Estimated Project Cost (without construction overheads): $533,935.83

Estimated Annual Savings:
Customer Minutes of Interruption: 23,315
Customer Interruptions: 281

11.8 Circuit 13W1: Reconductor West Rd, Canterbury and Install Recloser

11.8.1 Identified Concern

13W1 does not have a circuit tie that can back feed the circuit for restoration. This project aims to harden the stand alone system, lessen overall outage impact with an additional reclosing point, and prepare for a potential future tie, according to the master plan.

11.8.2 Recommendation

Reconductor approximately 4 miles of three phase mainline on West Rd, Canterbury with 13.8kV, 336AAC spacer.

Install a microprocessor-based recloser at P.31 North West Rd, Canterbury.

Estimated Project Cost (without construction overheads): $750,000

Estimated Annual Savings:
Customer Minutes of Interruption: 73,583
Customer Interruptions: 886

11.9 Circuit 8X3: Install a Recloser on Dover Rd, Epsom

11.9.1 Identified Concern

8X3 does not currently have a circuit backup to restore load for an outage outside of the substation. Adding sectionalizing points will limit the impact of outages beyond the new recloser.

11.9.2 Recommendations

Install a Recloser at P.5 Dover Rd, Epsom.

Estimated Project Cost (without construction overheads): $50,000

Estimate Annual Savings:

Customer Minutes of Interruption: 50,025
Customer Interruptions: 602

11.10 Fusesaver Installation Locations

11.10.1 Identified Concern

In an effort to continually improve upon reliability, fusesavers have been identified as capable to eliminate most momentary outages by allowing for a single trip clearing time. The following is a list of locations in which fusesavers have been identified as beneficial additions.

11.10.2 Recommendations

1) Install a fusesaver at P.8 W. Portsmouth St, Concord.

Estimated Annual Savings:
Customer Minutes of Interruption: 2,166
Customer Interruptions: 25

2) Install three fusesavers at P.1 Rocky Point Dr., Bow.

Estimated Annual Savings:
Customer Minutes of Interruption: 5,073
Customer Interruptions: 61

3) Install a fusesaver at P.62 Elm St, Boscawen.

Estimated Annual Savings:
Customer Minutes of Interruption: 4,733
Customer Interruptions: 57

4) Install a fusesaver at P.145 Old Turnpike Rd, Salisbury.

Estimated Annual Savings:
Customer Minutes of Interruption: 4,271
Customer Interruptions: 35

5) Install a fusesaver at P.50 Borough Rd, Canterbury.

Estimated Annual Savings:
Customer Minutes of Interruption: 4,200
Customer Interruptions: 20

Overall estimated project cost (without construction overheads): $86,115

11.11. Miscellaneous Circuit Improvements to Reduce Recurring Outages

11.11.1. Identified Concerns & Recommendations

The following concerns were identified based on a review of Tables 12 & 13 of this report; Multiple Tree Related Outages by Street and Multiple Device Operations respectively.

Mid-Cycle Forestry Reviews

The areas identified below experienced three or more tree related outages in 2019. It is recommended that a forestry review of these areas be performed in 2020 in order to identify and address any mid-cycle growth or hazard tree problems.

- C13W1
  - Kimball Pond Rd, Canterbury
  - Morrill Rd, Canterbury
- C13W3
  - Mutton Rd, Webster
  - Cashell Lane, Webster
- C15W1
  - Oak Hill Rd, Concord and Loudon
- C18W2
  - Putney Rd, Bow
- C22W3
  - Putney Rd, Bow
- C4W3
  - Mountain Rd, Concord
- C4W4
  - Lakeview Dr, Concord
- C8X3
  - Sanborn Hill Rd North, Epsom
- C8X5
  - North Pembroke Rd, Pembroke

Animal Guard Installation Recommendations

The areas identified below experienced three or more patrolled nothing found / animal outages in 2019.

- Mountain Rd, Concord

12 Conclusion

During 2019, tree related outages still present one of the largest problems in the UES-Capital System, compared to other causes. Although compared to previous years, the worst performing circuits have seen a dramatic decrease in Customer Minutes of Interruption from tree related outages. Enhanced tree trimming efforts are still being implemented, which is expected to improve reliability for most of the worst performing circuits identified in this study.

The animal guard installation project was completed in 2019. In 2019, there were the fewest squirrel outages recorded in the last five years. Furthermore, animal guards are continually being placed on equipment whenever an animal causes an outage. In addition, when there is an animal-related outage, any equipment in the vicinity will be

checked. If nearby equipment does not have animal guards, the animal guards will be installed at that location. Also, all streets and circuits identified as having high numbers of animal related outages will be checked and proper animal protection will be installed where applicable.

Recommendations developed from this study are mainly focused on reducing the impact of multiple permanent outages and improving reliability of the sub transmission system. This report is also intended to assist Unitil Forestry in identifying areas of the system that are being frequently affected by tree related outages to allow proactive measures to be taken. In addition, new ideas and solutions to reliability problems are always being explored in an attempt to provide the most reliable service possible.

Unitil Energy Systems – Seacoast

Reliability Study
2020

Prepared By:

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Unitil Service Corp.

October 19, 2020

Table of Contents

1 Executive Summary

The purpose of this document is to report on the overall reliability performance of the Unitil Energy Systems – Seacoast (UES-Seacoast) system from January 1, 2019 through December 31, 2019. The scope of this report will also evaluate individual circuit reliability performance over the same time period. The outage data used in this report excludes the data in Section 5 (sub-transmission and substation outages), as well as the outage data from IEEE Major Event Days (MEDs). UES-Seacoast MEDs are listed in the table below:

# MEDs in Event	Dates of MEDs	Interruptions	Customer Interruptions	Cust-Min of Interruption
1	10/17/19	133	13,323	7,733,848

The following projects are proposed from the results of this study and are focused on improving the worst performing circuits as well as the overall UES-Seacoast system reliability. These recommendations are provided for consideration and will be further developed with the intention to be incorporated into the 2021 budget development process.

Circuit / Line / Substation	Proposed Project	Cost ($)
6W1	Re-conductor portion of South Road with Spacer Cable	$250,000
6W1	Install Two Reclosers	$104,000
22X1	Install Reclosers and Implement Distribution Automation	$116,000
21W1	Install Sectionalizers on Sawmill Rd	$4,000
3W4	Install Recloser on Church St	$6,000

Note: estimates do not include general construction overheads

The 2019 annual UES-Seacoast system reliability goal was set at 116.19 SAIDI minutes, after removing exclusionary outages. UES-Seacoast's SAIDI performance in 2019 was 69.06 minutes. Charts 1, 2, and 3 below show UES-Seacoast's SAIDI, SAIFI, and CAIDI performance over the past five years.

Chart 1
Annual UES-Seacoast SAIDI

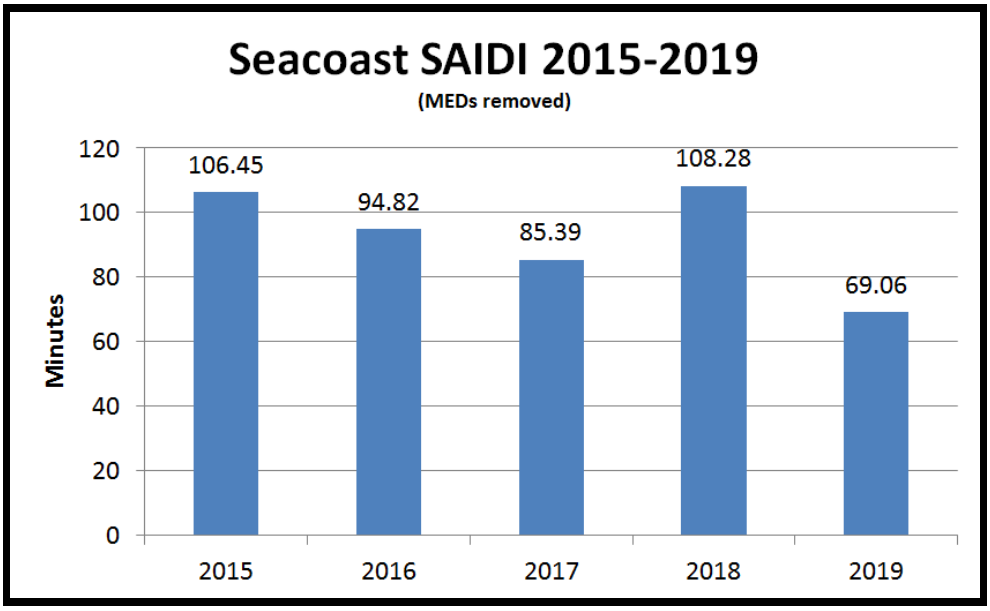


Chart 2
Annual UES-Seacoast SAIFI

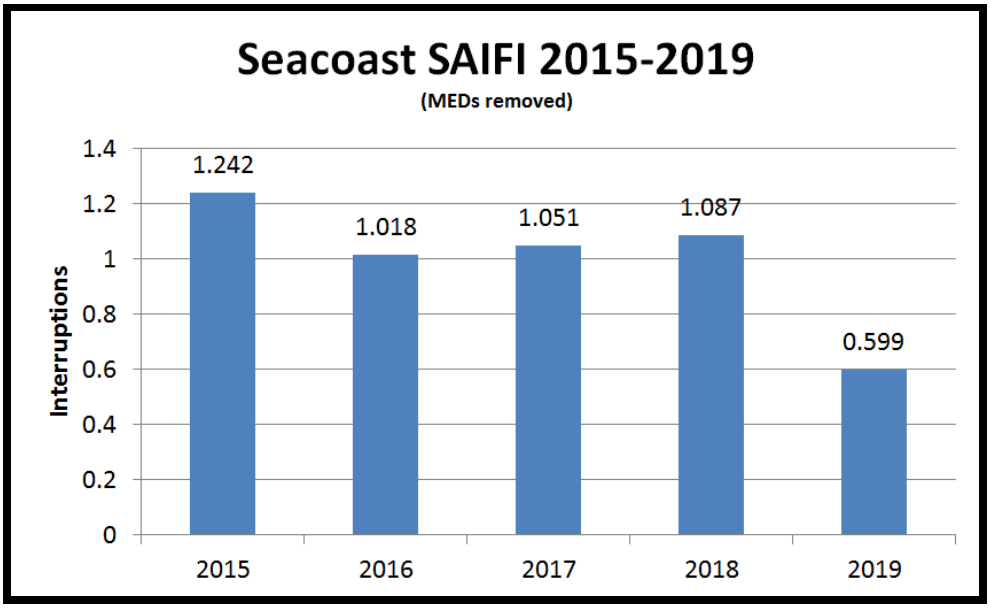
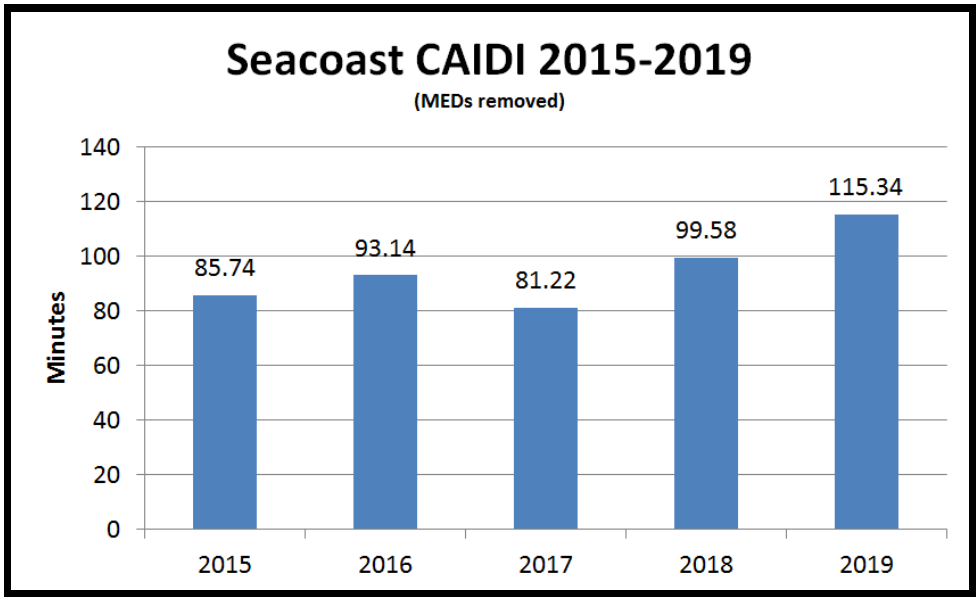


Chart 3
Annual UES-Seacoast CAIDI



2 Reliability Benchmarks

The new annual UES-Seacoast system reliability benchmark for 2020 is 114 SAIDI minutes. This was developed by calculating the contribution of UES-Seacoast to the Unitil system performance using the past five year average. The contribution factor was then set against the 2020 Unitil system goal. The 2020 Unitil system goal was developed through benchmarking the Unitil system performance with nationwide utilities.

Individual circuits will be analyzed based upon circuit SAIDI, SAIFI, and CAIDI. Analysis of individual circuits along with analysis of the entire UES-Seacoast system is used to identify future capital improvement projects and/or operational enhancements which may be required in order to achieve and maintain these goals.

3 Outages by Cause

This section provides a breakdown of all outages by cause code experienced during 2019. Charts 4, 5, and 6 list the number of interruptions, the number of customer interruptions, and total customer-minutes of interruption due to each cause respectively. Only the causes contributing 3% or greater of the total are labeled. Table 1 shows the number of interruptions for the top three trouble causes for the previous five years.

Chart 4
Number of Interruptions by Cause

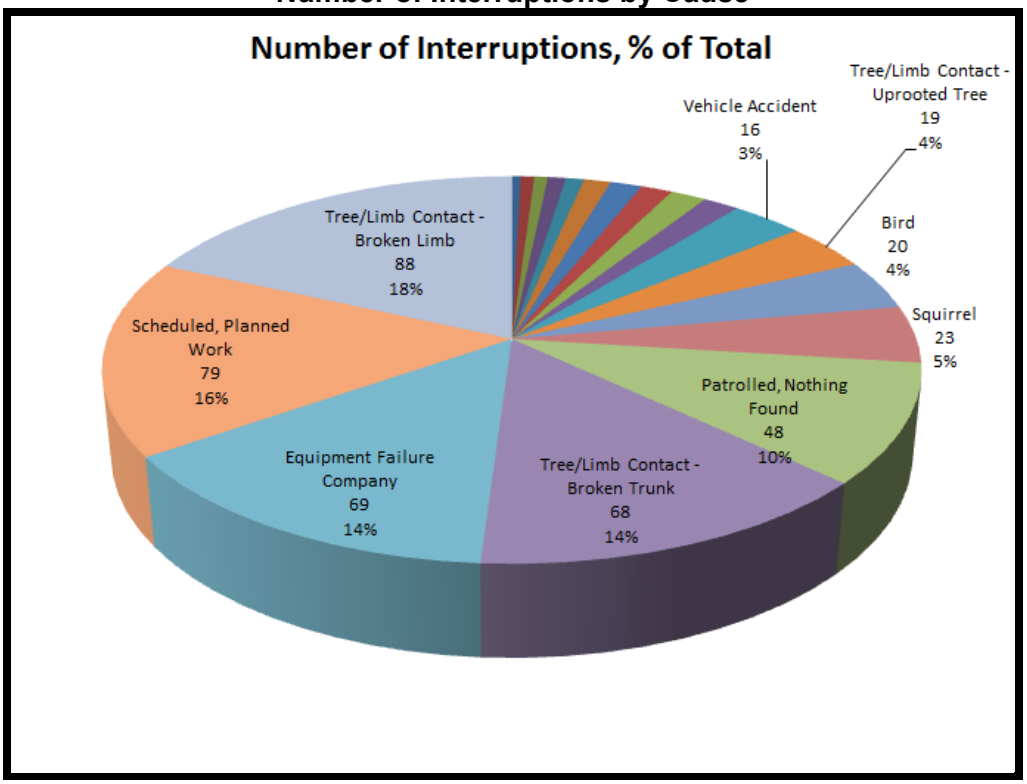


Chart 5
Number of Customer Interruptions by Cause

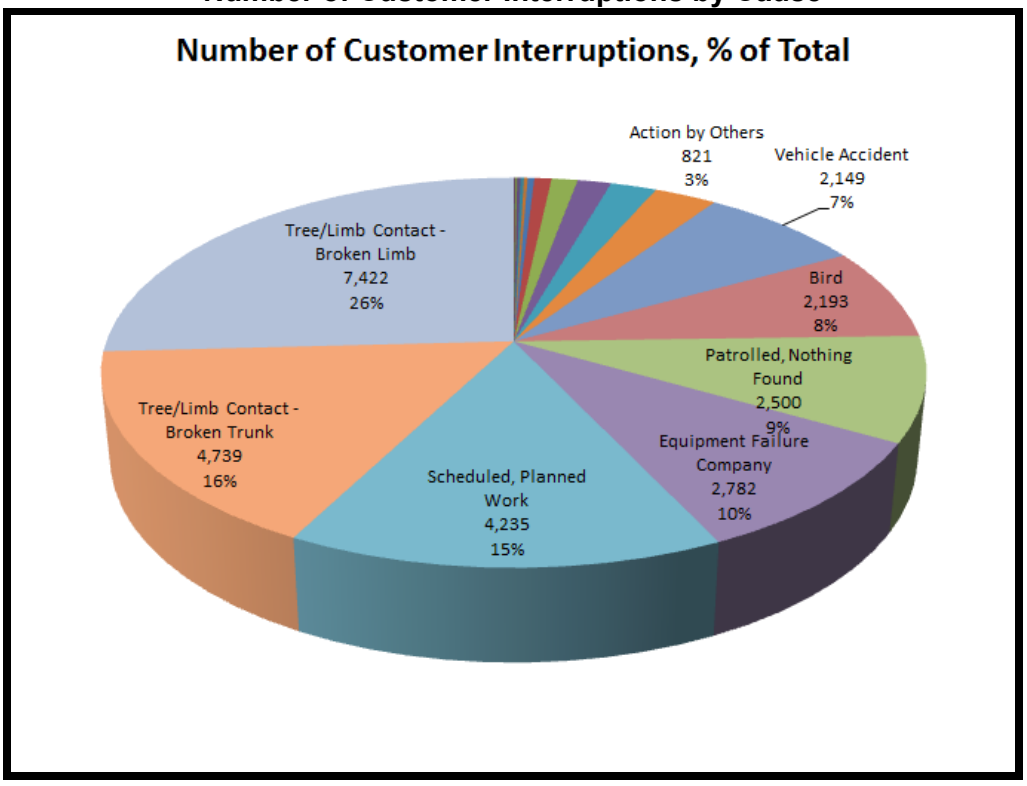


Chart 6
Percent of Customer-Minutes of Interruption by Cause

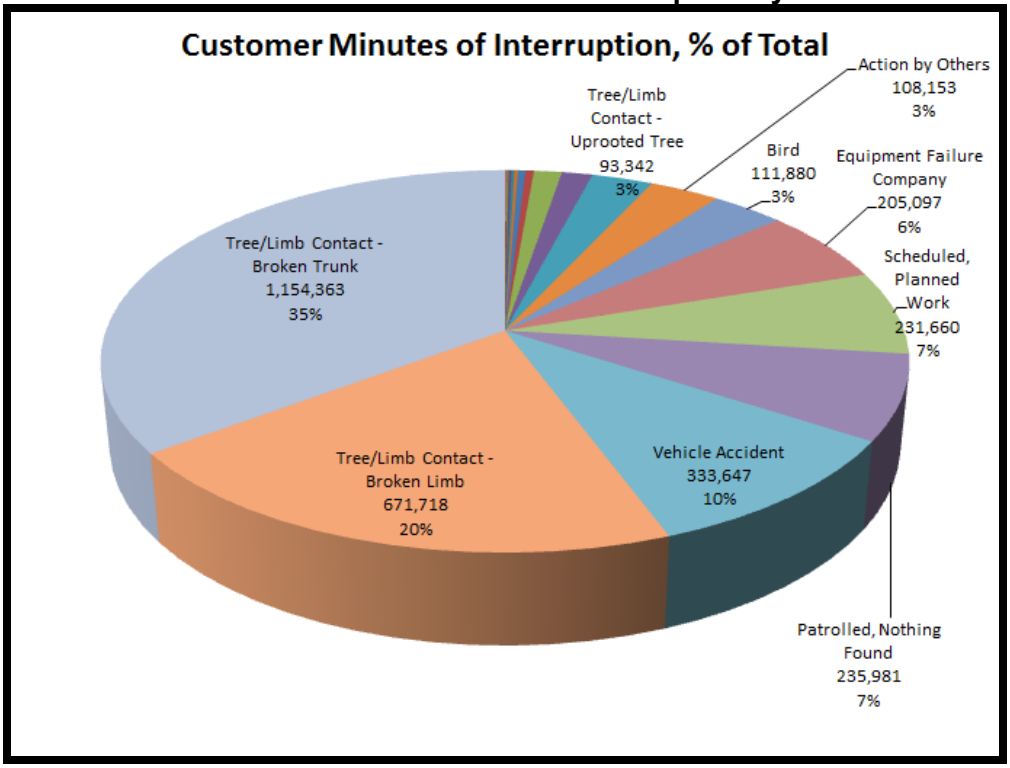


Table 1
Five-Year History of the Number of
Interruptions for the Worst Three Trouble Causes

Year	# of Interruptions Per Trouble Cause		
	Tree/Limb Contact - Broken Limb	Equipment Failure Company	Patrolled, Nothing Found
2019	88	69	48
2018	179	93	57
2017	121	79	43
2016	147	79	46
2015	87	90	62

4 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2019 through December 31, 2019 are summarized in Table 2 below.

Table 2
Worst Ten Distribution Outages

Circuit	Date/Cause	Customer Interruptions	Cust-Min of Interruption	SAIDI	SAIFI
E51X1	08/07/2019 Tree/Limb Contact - Broken Trunk	1,088	501,330	10.56	0.023
E6W1	02/25/2019 Tree/Limb Contact - Broken Trunk	367	218,194	4.6	0.008
E21W1	06/15/2019 Tree/Limb Contact - Broken Limb	1,371	190,363	4.01	0.029
E6W1	08/08/2019 Tree/Limb Contact - Broken Limb	881	135,424	2.85	0.019
E22X1	04/03/2019 Tree/Limb Contact - Broken Trunk	992	125,716	2.65	0.021
E15X1	09/01/2019 Vehicle Accident	250	98,000	2.06	0.005
E11X1	07/24/2019 Action by Others	642	91,025	1.92	0.014
E22X1	12/10/2019 Vehicle Accident	997	78,760	1.66	0.021
E51X1	06/10/2019 Tree/Limb Contact - Broken Limb	836	64,821	1.37	0.018
E13W1	02/09/2019 Vehicle Accident	214	58,052	1.22	0.005

5 Sub-transmission and Substation Outages

This section describes the contribution of sub-transmission line and substation outages on the UES-Seacoast system.

In 2019, there were no sub-transmission line or substation outages in the UES-Seacoast system.

6 Worst Performing Circuits

This section compares the reliability of the worst performing circuits using various performance measures.

6.1 Worst Performing Circuits in Past Year (1/1/19 – 12/31/19)

A summary of the worst performing circuits during the time period between January 1, 2019 and December 31, 2019 is included in the tables below.

Table 3 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The SAIFI and CAIDI for each circuit are also listed in this table.

Table 4 provides detail on the major causes of the outages on each of these circuits. Customer-Minutes of interruption are given for the six most prevalent causes during 2019.

Circuits having one outage contributing more than 80% of the Customer-Minutes of interruption were excluded from this analysis.

Table 3
Worst Performing Circuits Ranked by Customer-Minutes

Circuit	Customer Interruptions	Worst Event (% of CI)	Cust-Min of Interruption	Worst Event (% of CMI)	SAIDI	SAIFI	CAIDI
E51X1	3,278	33%	687,131	73%	354.92	1.693	209.62
E6W1	1,760	21%	405,875	54%	459.13	1.991	230.61
E21W1	1,768	78%	242,228	79%	176.68	1.29	137.01
E22X1	2,400	41%	232,167	54%	170.09	1.758	96.74
E58X1	955	16%	134,712	28%	60.06	0.426	141.06
E18X1	2,269	43%	128,875	38%	71.6	1.261	56.8
E13W1	656	33%	122,574	47%	113.6	0.608	186.85
E23X1	1,593	6%	107,745	36%	112.91	1.677	67.34
E6W2	879	33%	90,801	44%	93.03	0.901	103.3
E19X3	798	10%	81,477	21%	23.24	0.228	102.1

Note: all percentages and indices are calculated on a circuit basis

Table 4
Circuit Interruption Analysis by Cause

Circuit	Customer-Minutes of Interruption / # of Outages					
	Tree/Limb Contact - Broken Limb	Tree/Limb Contact - Broken Trunk	Equipment Failure Company	Squirrel	Patrolled, Nothing Found	Loose/Failed Connection
E51X1	510,633 / 4	111,767 / 11	0 / 0	5,408 / 4	56,061 / 10	0 / 0
E6W1	234,087 / 3	155,333 / 5	0 / 0	2,242 / 4	0 / 0	1,922 / 2
E21W1	18,602 / 1	190,363 / 1	4,782 / 1	952 / 1	1,201 / 1	0 / 0
E22X1	126,416 / 3	1,425 / 2	78,760 / 1	12,900 / 2	3,105 / 1	0 / 0
E58X1	72,241 / 5	2,705 / 4	8,140 / 3	868 / 2	35,265 / 1	0 / 0
E18X1	357 / 1	105,082 / 9	0 / 0	2,456 / 1	18,225 / 2	155 / 1
E13W1	20,747 / 3	8,818 / 1	72,484 / 2	417 / 2	727 / 1	148 / 1
E23X1	10,484 / 5	15,374 / 11	38,682 / 1	17,587 / 1	6,815 / 3	0 / 0
E6W2	8,213 / 1	3,312 / 2	9,525 / 2	12,687 / 2	0 / 0	15,570 / 3
E19X3	22,485 / 7	1,006 / 3	1,289 / 1	8,335 / 4	22,264 / 7	0 / 0

6.2 Worst Performing Circuits of the Past Five Years (2015 – 2019)

The annual performance of the ten worst circuits in terms of SAIDI and SAIFI for each of the past five years is shown in the tables below. Table 5 lists the ten worst performing circuits ranked by SAIDI and Table 6 lists the ten worst performing circuits ranked by SAIFI. Table 7 lists the ten worst circuits in terms of SAIFI and SAIDI for the past five years.

The data used in this analysis includes all system outages except those outages that occurred during the IEEE MEDs in 2015 through 2019.

Table 5
Circuit SAIDI

Circuit Ranking (1=worst)	2019		2018		2017		2016		2015	
	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI
1	E3W1	2.062	E7W1	6.569	E6W1	4.096	E43X1	2.945	E47X1	3.824
2	E6W1	1.991	E6W1	3.257	E22X1	2.606	E3H2	2.867	E6W1	2.871
3	E22X1	1.758	E54X2	2.949	E15X1	2.536	E21W2	2.641	E51X1	2.511
4	E51X1	1.693	E21W1	2.519	E54X2	2.271	E17W2	2.309	E58X1	2.354
5	E23X1	1.677	E6W2	2.334	E19H1	2.012	E21W1	2.198	E2X3	2.176
6	E11X1	1.356	E54X1	2.115	E23X1	1.527	E58X1	2.107	E22X1	1.922
7	E21W1	1.29	E21W2	2.053	E59X1	1.496	E22X1	1.922	E17W2	1.86
8	E18X1	1.261	E13W2	1.777	E43X1	1.481	E27X1	1.917	E13X3	1.466
9	E17W2	0.998	E43X1	1.465	E18X1	1.414	E54X1	1.892	E13W1	1.444
10	E6W2	0.901	E22X1	1.458	E19X2	1.387	E6W1	1.772	E21W2	1.425

Table 6
Circuit SAIFI

Circuit Ranking (1=worst)	2019		2018		2017		2016		2015	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	E6W1	459.13	E7W1	520.93	E54X2	275.94	E3H2	463.53	E6W1	429.2
2	E51X1	354.92	E54X2	338.4	E6W1	269.71	E7W1	375.29	E58X1	371.96
3	E21W1	176.68	E21W1	285.58	E19H1	254.56	E3H3	255.03	E47X1	362.03
4	E22X1	170.09	E54X1	221.90	E22X1	238.1	E54X2	249.35	E6W2	306.7
5	E11X1	167.39	E22X1	209.94	E5H1	200.6	E6W1	241.11	E51X1	201.87
6	E15X1	116.15	E6W1	205.87	E15X1	192.52	E43X1	226.55	E22X1	168.43
7	E17W2	115.43	E13W2	196.23	E51X1	158.75	E21W2	214.57	E56X2	138.86
8	E13W1	113.6	E2H1	192.59	E58X1	134.36	E17W2	210.69	E17W2	136.96
9	E23X1	112.91	E23X1	176.73	E59X1	125.01	E58X1	203.82	E27X1	126.5
10	E6W2	93.03	E58X1	167.86	E22X2	117.33	E54X1	196.61	E3W4	97.95

Table 7
Worst Performing Circuits in Past Five Years

SAIDI			SAIFI		
Circuit Ranking (1=worst)	**Circuit**	**# of Times in Worst 10**	**Circuit Ranking (1=worst)**	**Circuit**	**# of Times in Worst 10**
1	E6W1	5	**1**	E6W1	5
2	E7W1	2	**2**	E22X1	5
3	E58X1	4	**3**	E7W1	1
4	E22X1	4	**4**	E21W1	3
5	E51X1	3	**5**	E21W2	3
6	E54X2	3	**6**	E58X1	2
7	E21W1	2	**7**	E43X1	3
8	E6W2	2	**8**	E54X2	2
9	E17W2	3	**9**	E6W2	2
10	E23X1	2	**10**	E51X1	2

6.3 System Reliability Improvements (2019 and 2020)

Vegetation management projects completed in 2019 or planned for 2020 that are expected to improve the reliability of the 2019 worst performing circuits are included in Table 8 below. Table 9 below details electric system upgrades scheduled to be completed in 2020 or completed in 2019 to improve system reliability of the 2019 worst performing circuits.

Table 8
Vegetation Management Projects Worst Performing Circuits

Circuit(s)	Year of Completion	Project Description
E6W1	2020	Cycle Pruning
E51X1	2019	Hazard Tree Mitigation Mid-Cycle Pruning
	2020	Hazard Tree Mitigation
E22X1	2020	Cycle Pruning Hazard Tree Mitigation
E21W1	2019	Cycle Pruning Hazard Tree Mitigation
	2020	Hazard Tree Mitigation
E6W2	2019	Hazard Tree Mitigation
	2020	Cycle Pruning
E18X1	2019	Cycle Pruning Storm Resiliency Pruning

Circuit(s)	Year of Completion	Project Description
E23X1	2019	Storm Resiliency Pruning
	2020	Cycle Pruning
E58X1	2019	Hazard Tree Mitigation
E11X1	2019	Storm Resiliency Pruning
E13W1	2019	Cycle Pruning Hazard Tree Mitigation
	2020	Hazard Tree Mitigation
E17W2	2019	Hazard Tree Mitigation
	2020	Reliability Trimming
E15X1	2019	Hazard Tree Mitigation
E54X2	2020	Hazard Tree Mitigation
E56X1	2020	Hazard Tree Mitigation
E19X3	2019	Mid-Cycle Pruning Hazard Tree Mitigation
3346 Line[1]	2020	Sub-Transmission Clearing
3359 Line[2]	2019	Sub-Transmission Clearing
3341/3352 Line[3]	2020	Sub-Transmission Clearing
3342/3353 Line[4]	2020	Sub-Transmission Clearing

Table 9
Electric System Improvements Performed to Improve Reliability

Circuit(s)	Year of Completion	Project Description
Various	2019	Porcelain Cutout Replacements
E5X3/E58X1	2019	Establish Distribution Circuit Tie
E17W1	2019	Install Hydraulic Reclosers – North Shore Road
E17W2	2019	Install Electronically Controlled Recloser – Little River Road

[1] The 3346 line is the normal feed for the High Street (#17) Substation
[2] The 3359 line is the normal feed for the Cemetery Lane (#15) Substation and the Mill Lane (#23) Tap
[3] The 3341 and 3352 lines are the normal and alternate feeds for the Gilman Lane (#19) Substation
[4] The 3342 and 3353 lines are the normal and alternate feeds for the Hampton Beach (#3) Substation

Circuit(s)	Year of Completion	Project Description
E3W1, E3W4, E17W1	2019	Conversion of Hampton Beach area included the creation of distribution circuit ties between circuits 3W1/3W4 and 3W1/17W1 and the installation of two electronically controlled reclosers.
E51X1	2019	Install Sectionalizer - High St
E13W1	2019	Install FuseSaver – Culver St
E18X1	2019	Fuse changes to address/improve device coordination
E15X1	2019	Fuse changes to address/improve device coordination
E58X1	2019	Fuse changes to address/improve device coordination
E6W2	2019	Fuse changes to address/improve device coordination
E19X3	2019	Fuse changes to address/improve device coordination
3346 Line[1]	2019	Install Reclosers and Implement an Automatic Transfer Scheme
3343/3354 Lines[2]	2020	Install Two Electronically Controlled Reclosers

7 Tree Related Outages in Past Year

This section summarizes the worst performing circuits by tree related outage during the time period between January 1, 2019 and December 31, 2019.

Table 10 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The number of customer-interruptions and number of outages are also listed in this table.

All streets on the UES-Seacoast system with three or more tree related outages are shown in Table 11 below. The table is sorted by number of interruptions and customer-minutes of interruption.

[1] The 3346 line is the normal feed for the High St (#17) Substation
[2] The 3343 and 3354 lines are the normal and alternate feeds for the New Boston Rd (#54) and East Kingston (#6) Substations

Table 10
Worst Performing Circuits – Tree Related Outages

Circuit	Customer Minutes of Interruption	Number of Customers Interrupted	No. of Interruptions
E51X1	623,188	2,752	17
E6W1	396,541	1,582	10
E21W1	214,786	1,581	5
E22X1	128,816	1,029	7
E18X1	105,439	1,983	10
E58X1	77,097	479	12
E6W2	51,394	358	4
E17W1	34,109	307	3
E54X2	32,077	185	11
E56X1	29,899	111	4

Table 11
Multiple Tree Related Outages by Street

Circuit(s)	Street, Town	# Outages	Customer-Minutes of Interruption	Number of Customer Interruptions
E51X1	Winnicut Rd, Stratham	5	106,935	1,448
E54X2	Country Shore Camp, Kingston	5	4,699	25
E18X1	Exeter Rd, Stratham	4	34,131	743
E27X1, E2X3	Drinkwater Rd, Hampton Falls	4	12,572	198
E23X1, E27X1	Amesbury Rd, Kensington	4	7,936	71
E23X1	Woodman Rd, South Hampton	4	3,050	38
E58X1	Main St, Atkinson	3	25,618	200
E2X2	Mill Rd, Stratham	3	5,107	191

8 Failed Equipment

This section is intended to clearly show all equipment failures throughout the study period from January 1, 2019 through December 31, 2019. Chart 7 shows all equipment failures throughout the study period. Chart 8 shows each equipment failure as a percentage of the total failures within this same study period. The number of equipment failures in each of the top three categories of failed equipment for the past five years are shown below in Chart 9.

Chart 7
Equipment Failure Analysis by Cause

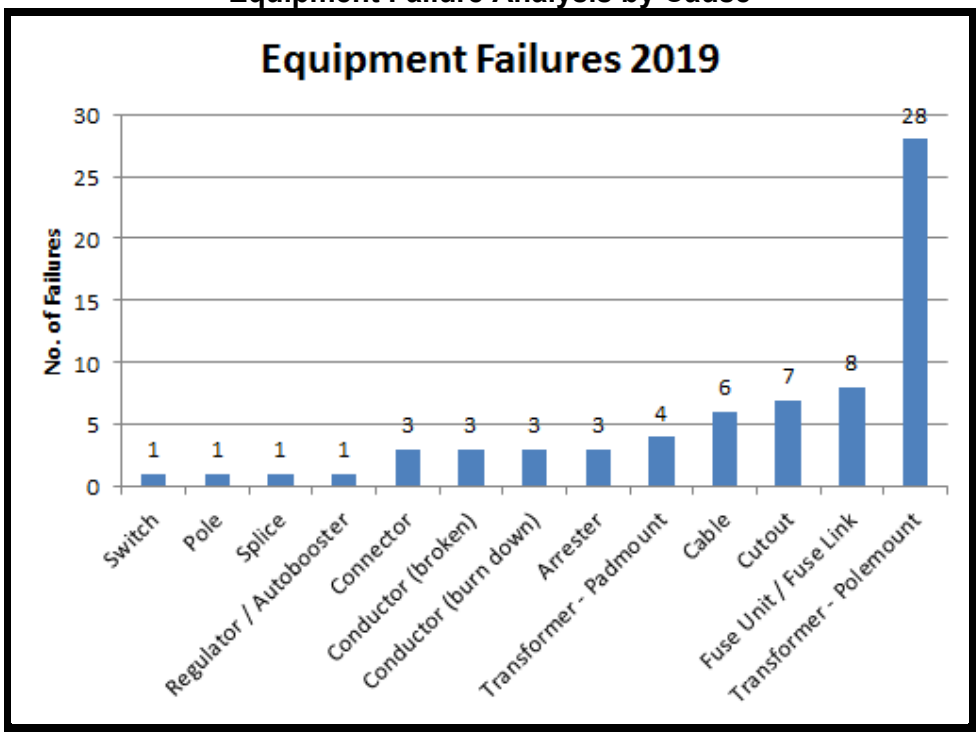


Chart 8
Equipment Failure Analysis by Percentage of Total Failures

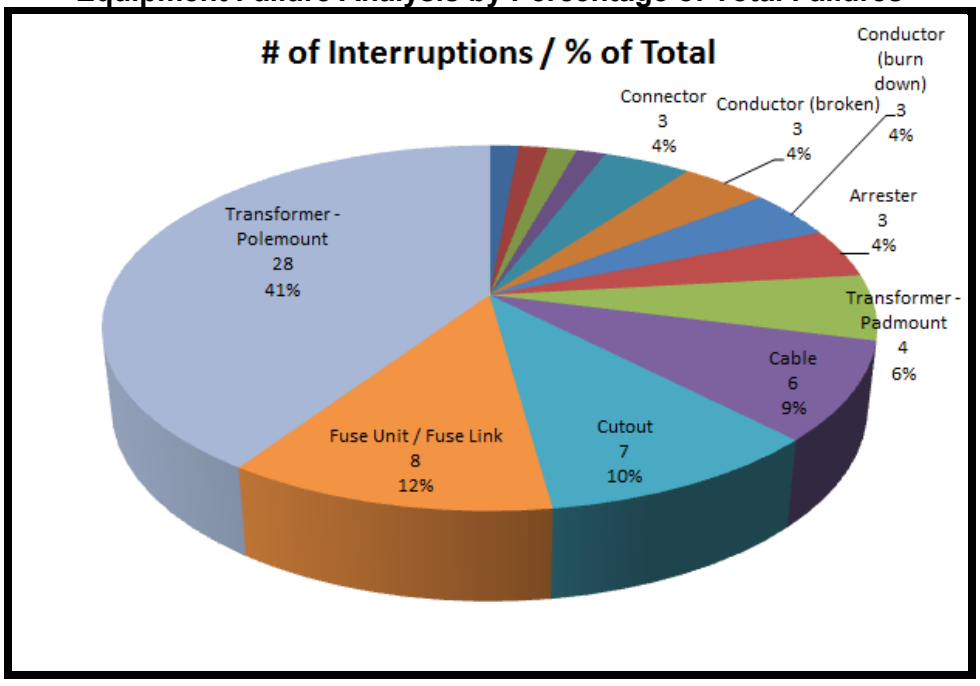
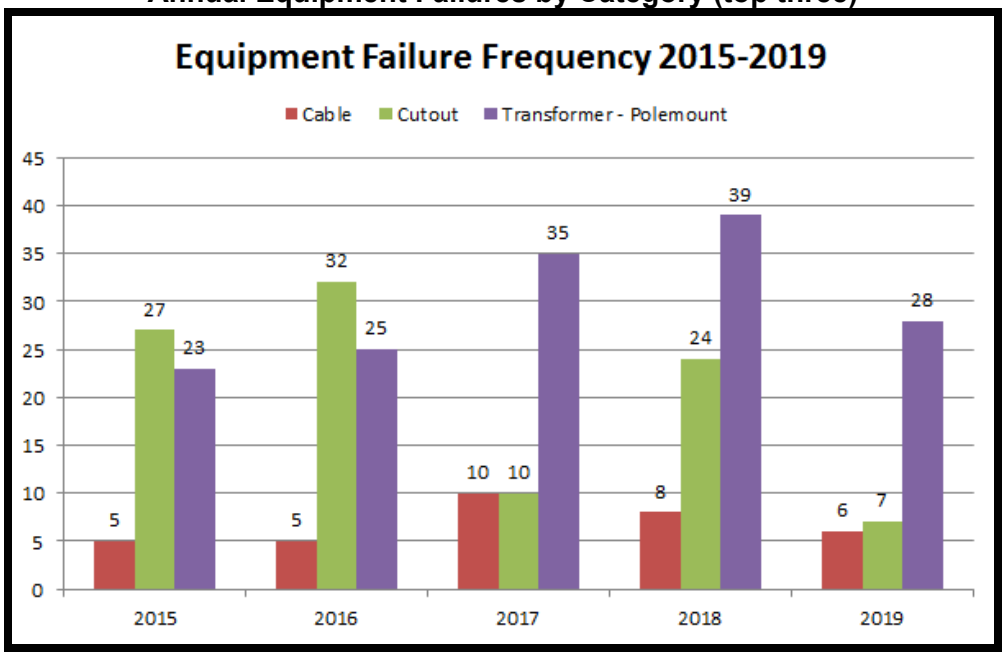


Chart 9
Annual Equipment Failures by Category (top three)



9 Multiple Device Operations and Streets with Highest Number of Outages

A summary of the devices that have operated three or more times from January 1, 2019 to December 31, 2019 is included in Table 12 below. Refer to section 11.6 for recommendations to address some of the areas identified that have experienced recurring outages in 2019.

A summary of the streets on the UES-Seacoast system that had customers with 6 or more non-exclusionary outages in 2019 is included in Table 13 below. The table is sorted by circuit and then the maximum number of outages seen by a single customer on that street.

Table 12
Multiple Device Operations

Circuit	Number of Operations	Device	Customer Minutes	Customer Interruptions	# of Times on List in Previous 4 Years
E54X2	5	Fuse, Pole 12, Country Shore Camp, Kingston	4,671	25	0
E3W4	4	Fuse, Pole 20, Church St, Hampton	11,952	236	0
E17W2	4	Fuse, Pole 40, Little River Rd, Hampton	71,823	621	1
E22X1	3	Fuse, Pole 45, Main St, Danville	6,340	72	0
E18X1	3	Recloser, Pole 100, Exeter Rd, Hampton	51,270	921	0
E18X1	3	Fuse, Pole 1, Langdale Dr, Hampton	9,981	144	2
E13W1	3	Fuse, Pole 54, North Main St, Plaistow	47,096	251	0

Table 13
Streets with the Highest Number of Outages

Circuit	Street	Max Number of Outages Seen by a Single Customer	Number of Times on List in Previous 4 Years
E3W1	Ocean Blvd, Hampton	7	0
E54X2	Green Rd, Kingston	6	0

10 Recommendations

This following section describes recommendations on circuits, sub-transmission lines and substations to improve overall system reliability. The recommendations listed below will be compared to the other proposed reliability projects on a system-wide basis. A cost benefit analysis will determine the priority ranking of projects for the 2021 capital budget. All project costs are shown without general construction overheads.

10.1 Miscellaneous Circuit Improvements to Reduce Recurring Outages

10.1.1 Forestry Review

Table 11 of this report; Multiple Tree Related Outages by Street indicates that there were fifteen streets that experienced three or more tree related outages in 2019.

It is recommended that a forestry review of the areas identified in Table 11 be performed in 2020 in order to identify and address any growth or hazard tree problems.

10.2 Circuit 6W1 – Re-conductor Portion of South Road with Spacer Cable - revisit for 2021 project

10.2.1 Identified Concerns

6W1 has been on the worst performing SAIDI and SAIFI list for the last five consecutive years. The owner of a section of property along South has repeatedly refused to allow effective pruning and hazard tree mitigation. Within the last five years, this section of South Road has experienced five interruptions due to tree contacts, totaling 1,557 customer interruptions and 696,479 customer minutes of interruption.

10.2.2 Recommendation

Re-conductor South Road from pole 28 to pole 49 with spacer cable.

Customer Exposure = 367 customers

The projected average annual savings for this project is 230,000 customer minutes of interruptions and 500 customer interruptions.

Estimated Project Cost: $250,000

It was determined by forestry and operations that appropriate pruning could not be performed to increase pole height to accommodate spacer cable construction. Other options will need to be identified.

10.3 Circuit 6W1 – Install Two Reclosers

10.3.1 Identified Concerns

6W1 has been on the worst performing SAIDI and SAIFI list for the last five consecutive years.

10.3.2 Recommendation

This project will consist of installing two microprocessor-controlled reclosers along the mainline of circuit 6W1.

- One recloser will replace the disconnects at Main St Pole 34
- One recloser will replace the existing hydraulic reclosers at South Rd Pole 2

Customer Exposure = 329 customers

The projected average annual savings for this project is 23,573 customer minutes of interruptions and 226 customer interruptions.

Estimated Project Cost: $104,000

10.4 Circuit 22X1 – Install Reclosers and Implement Distribution Automation

10.4.1 Identified Concerns

Circuit 22X1 is typically one of the worst performing circuits on the UES-Seacoast system. It is on both the Worst Performing Circuits in the Past Five Years SAIDI and SAIFI lists.

10.4.2 Recommendation

This project will consist of installing two electronically controlled reclosers along circuit 22X1.

One of the reclosers will replace the 22X1J2 switch at Main St, Danville Pole 2. The 22X1J54X2 tie switch at Kingston Rd Pole 15 will also be replaced with a recloser.

Once installed a distribution automation scheme will be implemented between the new reclosers and the existing 54X2R1 recloser. The intent of the scheme is to have 22X1 and 54X2 automatically reconfigure for permanent faults on the mainline of either circuit.

- Fault between 22X1 and 22X1J2 – 22X1 and 22X1J2 lockout and 22X1J54X2 closes.
- Fault between 54X2 and 54X2R1 – 54X2 and 54X2R1 lockout and 22X1J54X2 closes.

Customer Exposure = 1,441 customers

The projected average annual savings for this project is 178,588 customer minutes of interruptions and 2,042 customer interruptions.

Estimated Project Cost: $116,000

10.5 Circuit 21W1 – Install Sectionalizers on Sawmill Rd

10.5.1 Identified Concerns

Circuit 21W1 is typically one of the worst performing circuits on the UES-Seacoast system. It is on both the Worst Performing Circuits in the Past Five Years SAIDI and SAIFI lists.

10.5.2 Recommendation

This project will consist of replacing the solid blades at Sawmill Rd Pole 1 with cutout-mounted sectionalizers.

Customer Exposure = 321 customers

The projected average annual savings for this project is 16,477 customer minutes of interruptions and 204 customer interruptions.

Estimated Project Cost: $4,000

10.6 3W4 – Install Recloser on Church St

10.6.1 Identified Concerns

The fuse at Church St, Hampton Pole 20 operated four times in 2019. Two of these operations were due to birds, and one was a patrolled nothing found.

10.6.2 Recommendation

This project will consist of replacing the fuse at Church St Pole 20 with a hydraulic recloser.

Customer Exposure = 315 customers

The projected average annual savings for this project is 681 customer minutes of interruptions and 8 customer interruptions.

Estimated Project Cost: $6,000

11 Conclusion

The annual electric service reliability of the UES-Seacoast system over the last few years has been some of the best years on record after discounting MEDs. 2019 was the best year on record in regards to SAIDI and SAIFI. The improvement in reliability can be largely attributed to an aggressive vegetation management program. Still, the most significant risk to reliability of the electric system continues to be vegetation.

The recommendations in this report focus on addressing equipment concerns as well as increasing the flexibility of the system to facilitate quicker restoration of customers that can be isolated from a faulted section of the system. This includes upgrading equipment and adding additional circuit sectionalizing points and protection where it will be most effective. This report is also intended to assist Unitil Forestry in identifying areas of the system that are being frequently affected by tree related outages to allow proactive measure to be taken.