# 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**

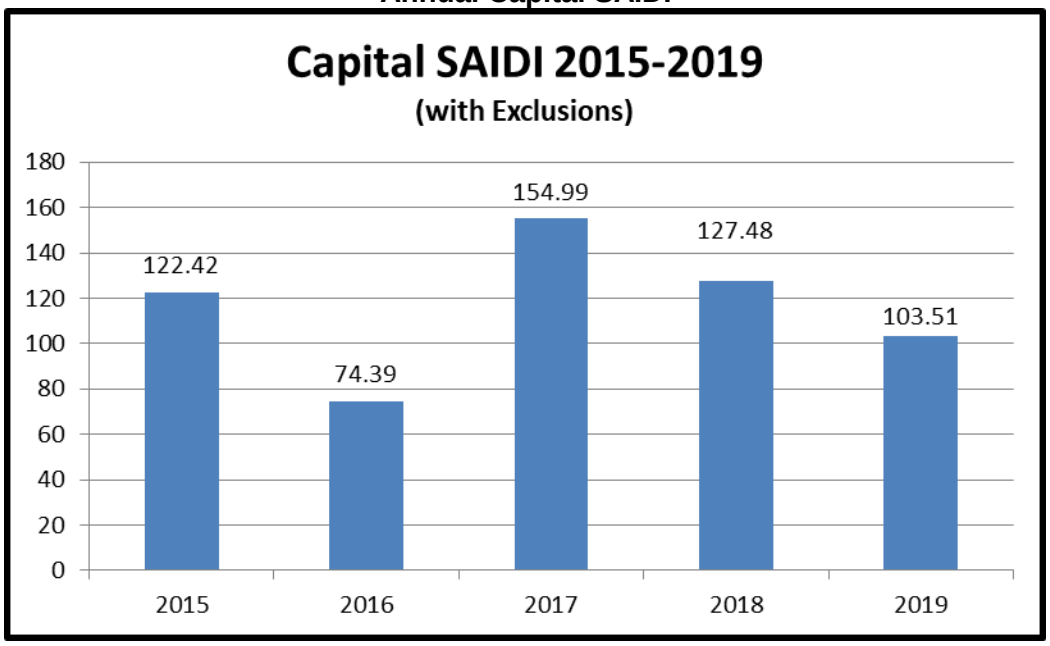



**Chart 2**
**Annual Capital SAIFI**

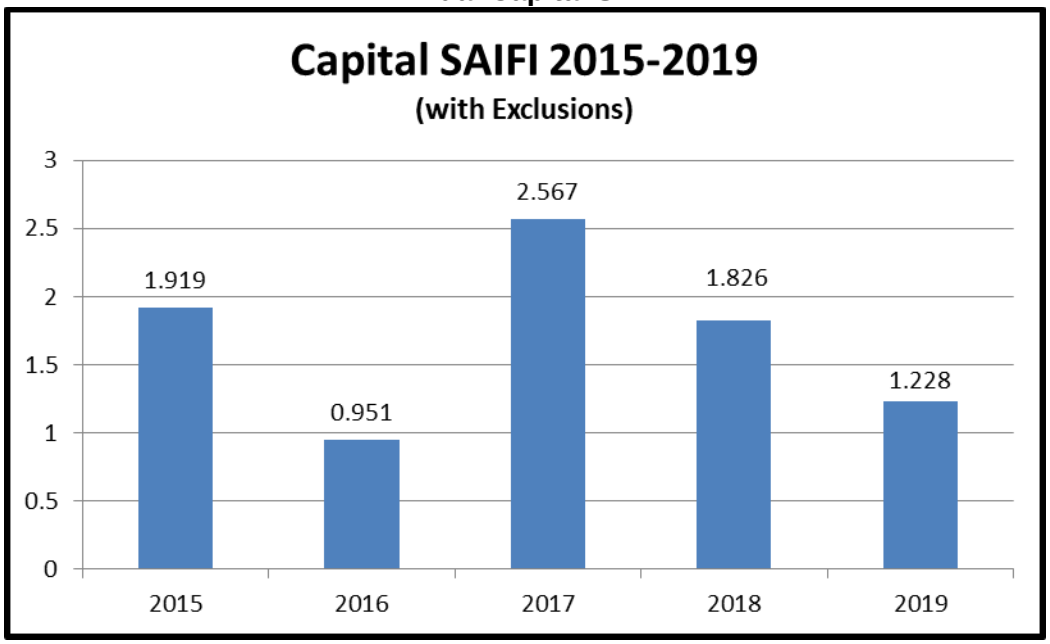
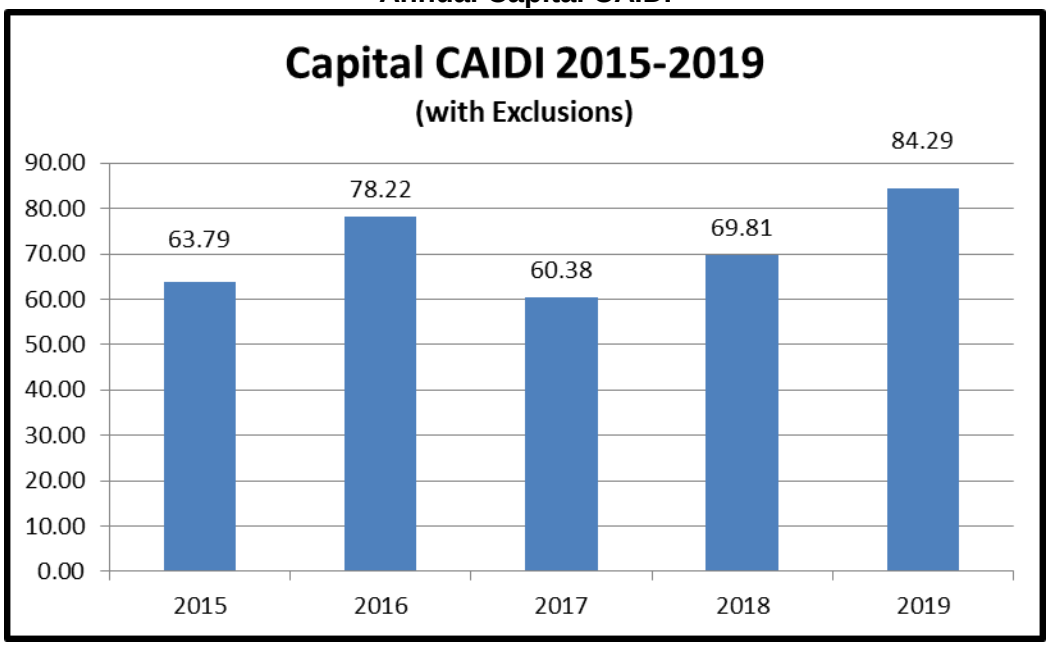


**Chart 3**
**Annual Capital CAIDI**




## 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**

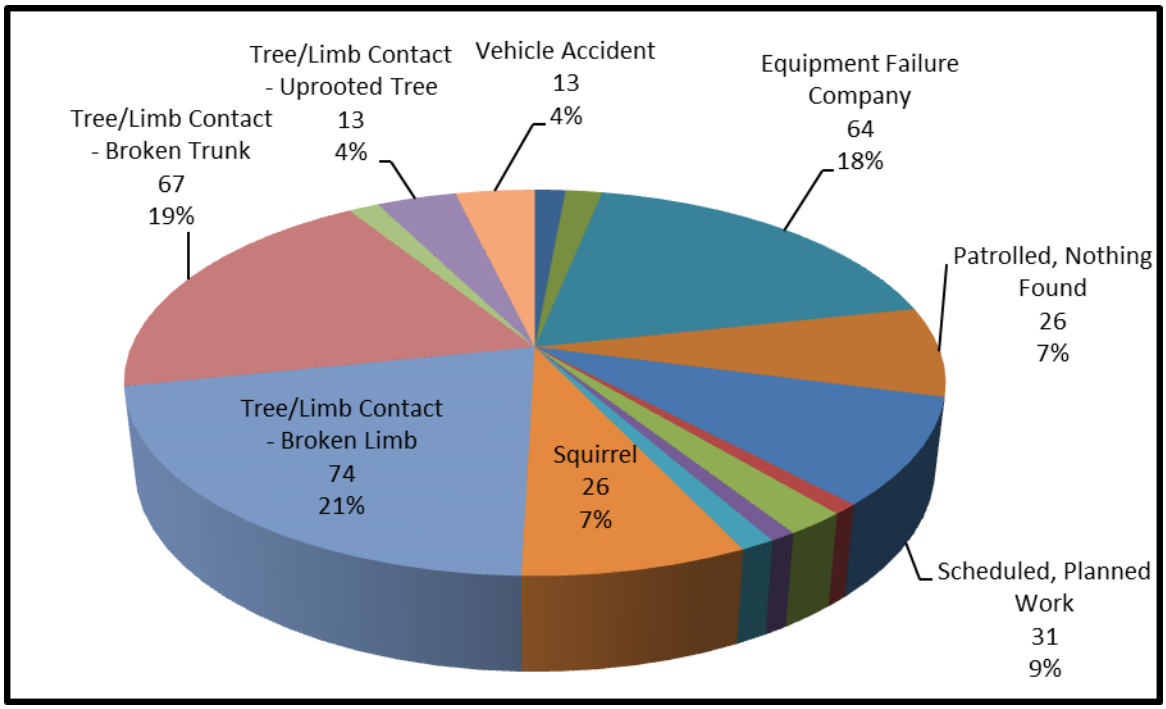



**Chart 5**
**Number of Customer Interrupted by Cause**

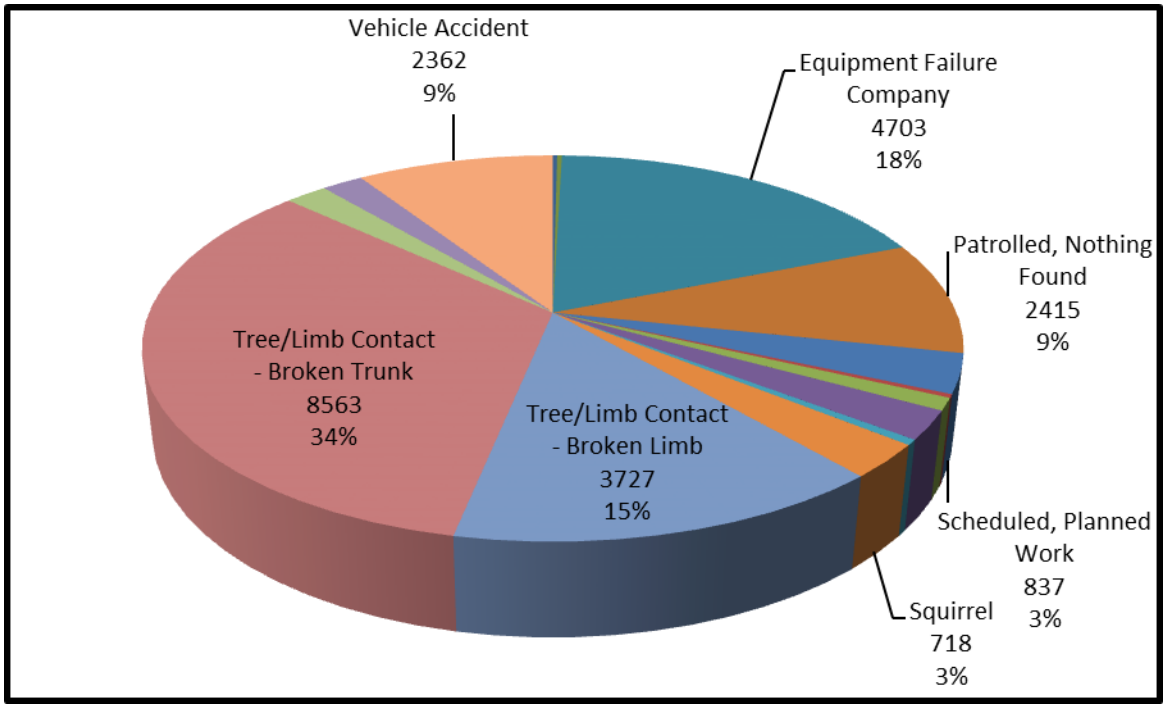


**Chart 6**
**Percent of Customer-Minutes of Interruption by Cause**

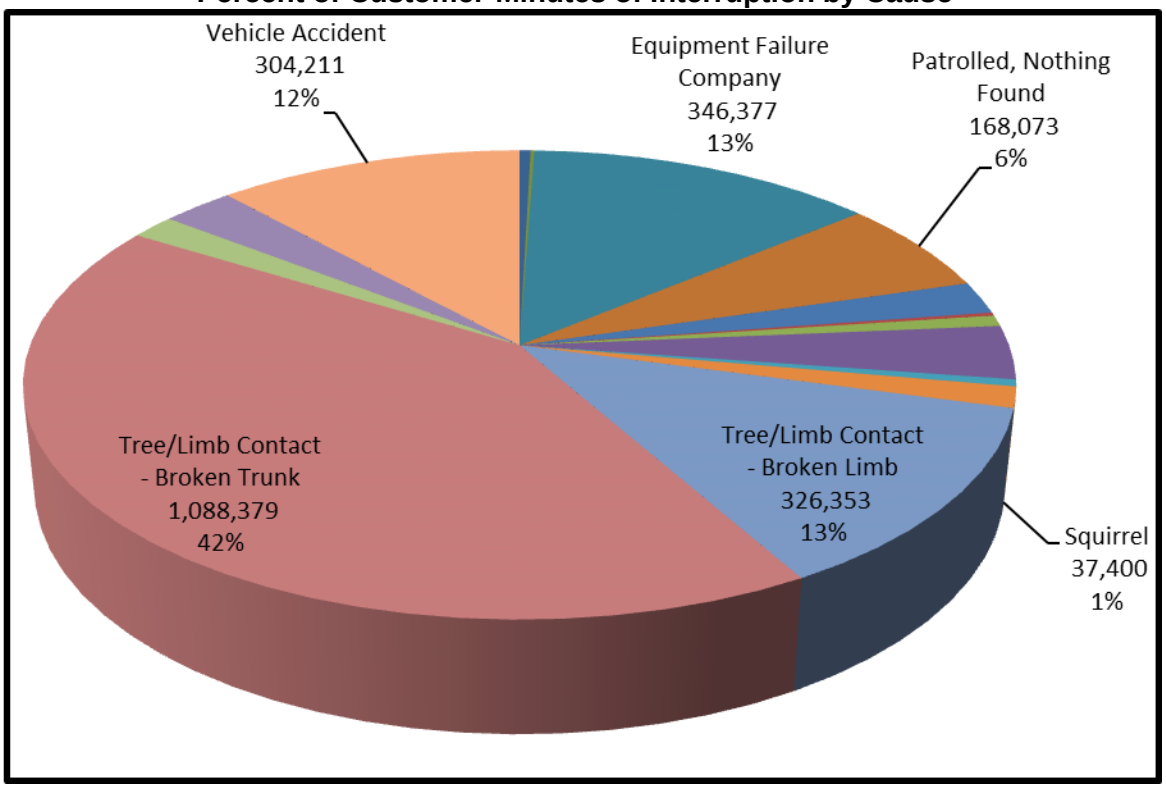



**Table 1**
**Five-Year History of the Number of**
**Interruptions for the Worst Three Trouble Causes**

| 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 | 6.86 | 0.035 |
| **C8X3** | 03/23/2019 Tree/Limb Contact - Broken Trunk | 1,591 | 171,324 | 5.62 | 0.052 |
| **C2H2** | 04/03/2019 Tree/Limb Contact - Broken Trunk | 1,066 | 151,819 | 4.98 | 0.035 |
| **C6X3** | 02/09/2019 Tree/Limb Contact - Broken Trunk | 1,111 | 139,912 | 4.59 | 0.036 |
| **C13W2** | 06/27/2019 Vehicle Accident | 987 | 115,528 | 3.79 | 0.032 |
| **C13W3** | 02/08/2019 Other | 596 | 94,764 | 3.11 | 0.020 |
| **C13W3** | 11/19/2019 Vehicle Accident | 511 | 88,659 | 2.91 | 0.017 |
| **C8X5** | 01/21/2019 Patrolled, Nothing Found | 822 | 78,597 | 2.58 | 0.027 |
| **C8X5** | 08/03/2019 Equipment Failure Company | 826 | 66,080 | 2.17 | 0.027 |
| **C13W3** | 11/01/2019 Tree/Limb Contact - Broken Trunk | 333 | 47,752 | 1.57 | 0.011 |

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** | 452,078 | 3,544 | 4 |
| **C8X3** | 365,380 | 3,412 | 40 |
| **C13W3** | 198,178 | 3,065 | 22 |
| **C6X3** | 142,969 | 1,155 | 3 |
| **C18W2** | 122,015 | 1,926 | 10 |
| **C15W1** | 104,936 | 849 | 7 |
| **C13W1** | 63,882 | 801 | 17 |
| **C7W3** | 49,338 | 443 | 9 |
| **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**

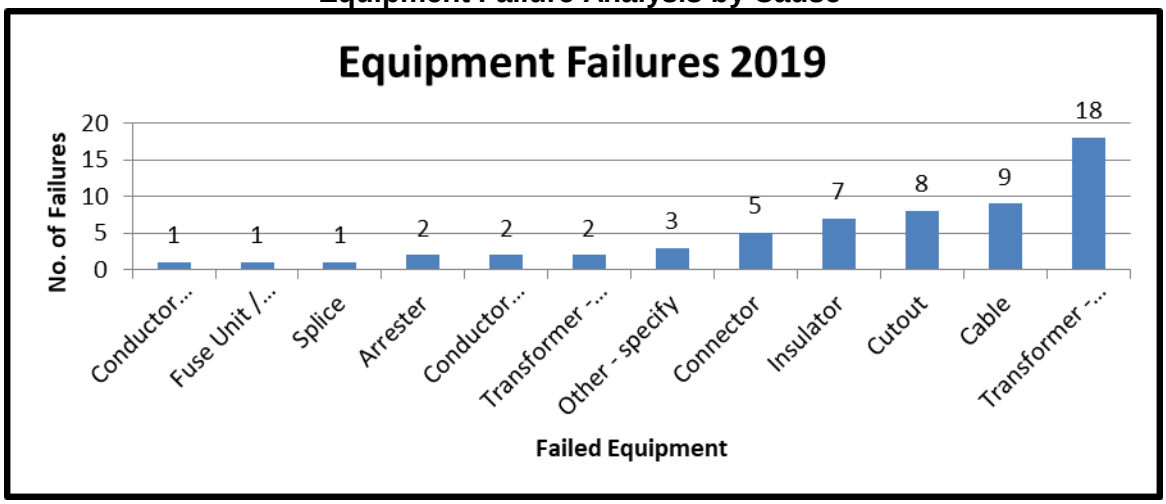


**Chart 8**
**Equipment Failure Analysis by Percentage of Total Failures**

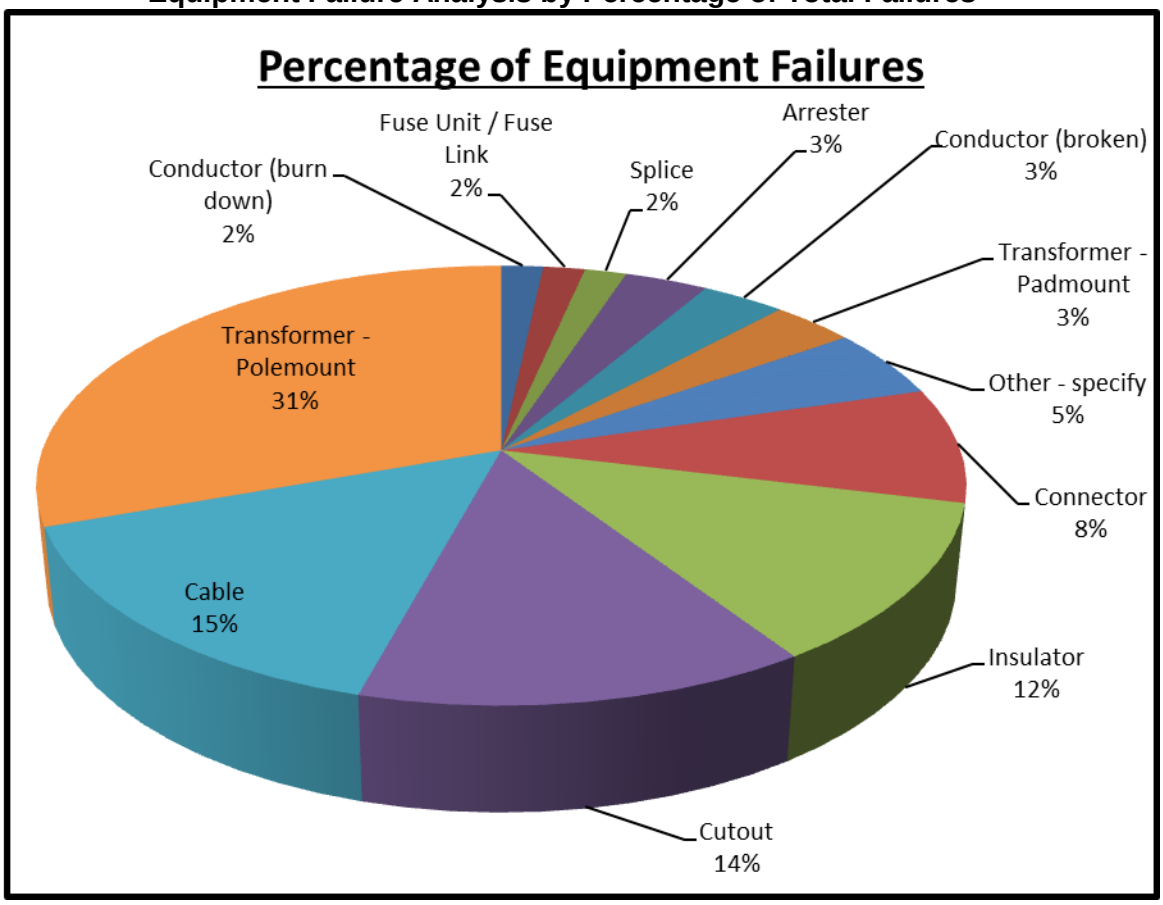
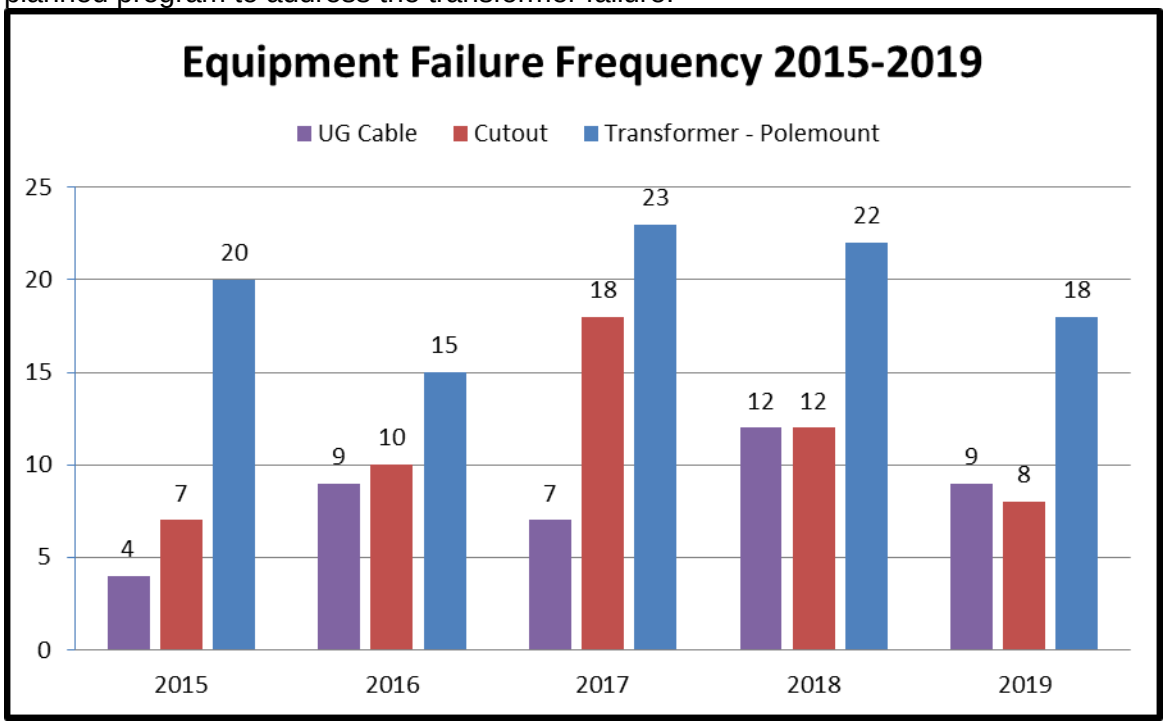


**Chart 9**
**Annual Equipment Failures by Category (top three)**

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.