# UES Capital

# Reliability Study

# 2023

Prepared By:
T. Vrettos
Unitil Service Corp.
10/31/2023

## Table of Contents

## 1 Executive Summary

The purpose of this document is to report on the overall reliability performance of the UES Capital system from January 1, 2022 through December 31, 2022. 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 outages that occurred during IEEE Major Event Days (MEDs). The UES-Capital 2022 MEDs are listed in the table below.

| Date | Type of Event | No. of Interruptions | Customer Interruptions | Cust-Min of Interruption |
|---|---|---|---|---|
| 7/12/2022 | IEEE MED | 14 | 11 | 459,833 |
| 12/23/2022 | IEEE MED | 260 | 26,688 | 9,804,038 |

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 2023 budget development process.

| Circuit / Line / Substation | Proposed Project | Cost ($) |
|---|---|---|
| 13W1 | 13W1 Mainline Spacer Cable Installation | $560,037 |
| 13W3 | Reconductor Daniel Webster Highway | $1,056,337 |
| 13W3 | N. Water Street and Rabbit Road Spacer Cable Installation | $1,457,712 |
| 18W2 | Create a Circuit Tie on White Rock Hill Rd | $312,467 |

Note: estimates do not include general construction overheads

The 2022 annual UES Capital system reliability benchmark was 133.12 minutes, after removing Major Event Days. The UES Capital SAIDI performance in 2022 was 62.17 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**

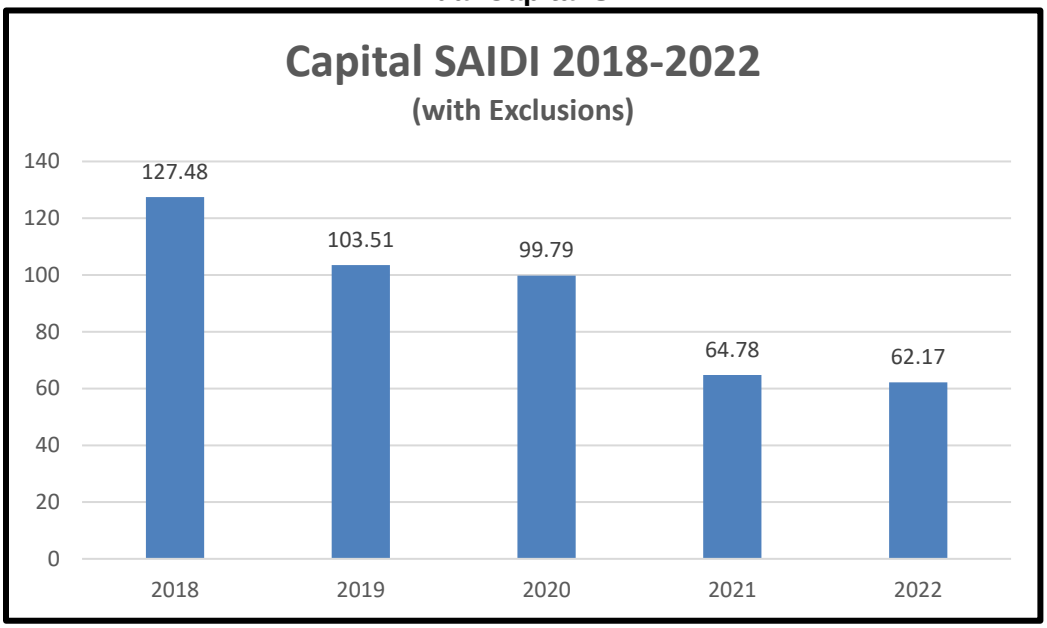



**Chart 2**
**Annual Capital SAIFI**

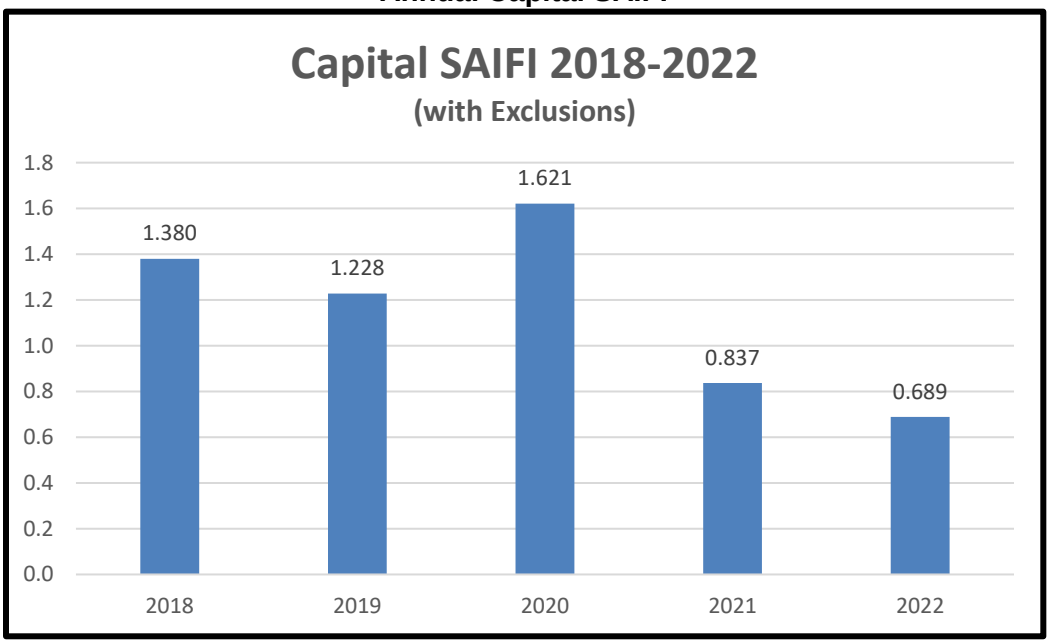
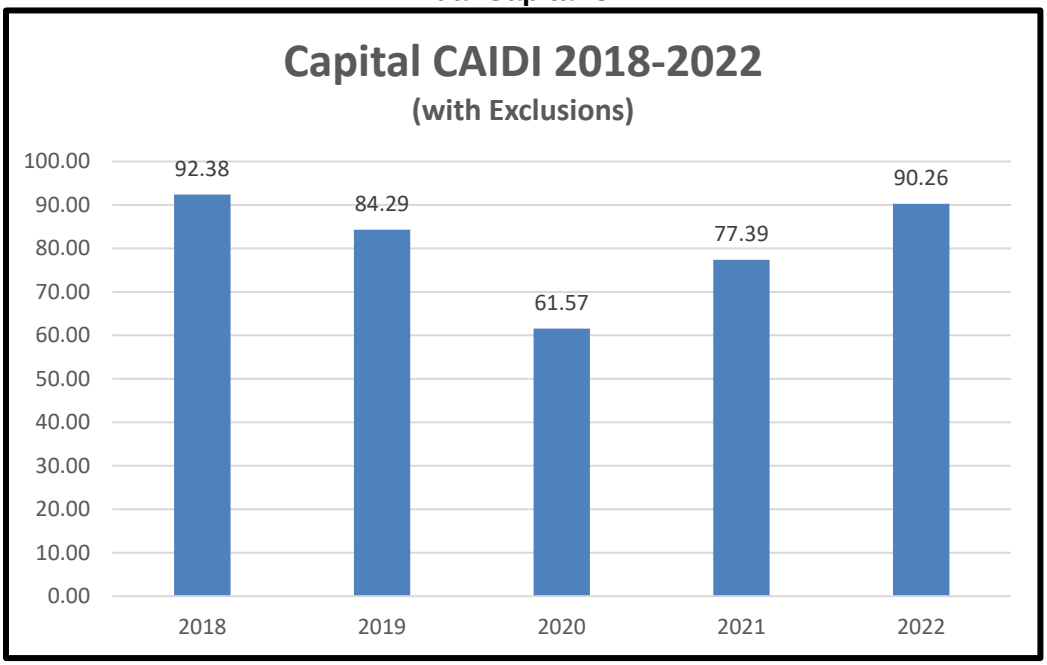


**Chart 3**
**Annual Capital CAIDI**




## 2 Reliability Benchmarks

The new annual UES Capital system reliability benchmark for 2023 is set at 110.98 SAIDI minutes. This was developed by calculating the typical contribution of UES Capital reliability performance to the Unitil system performance using the past five year average. The contribution factor was then set against the 2022 Unitil System goal. The 2022 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 2022. Charts 4, 5, and 6 show the number of interruptions, the number of customer interruptions, and total customer-minutes of interruption due to each cause, respectively. Only the causes contributing 5% 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**

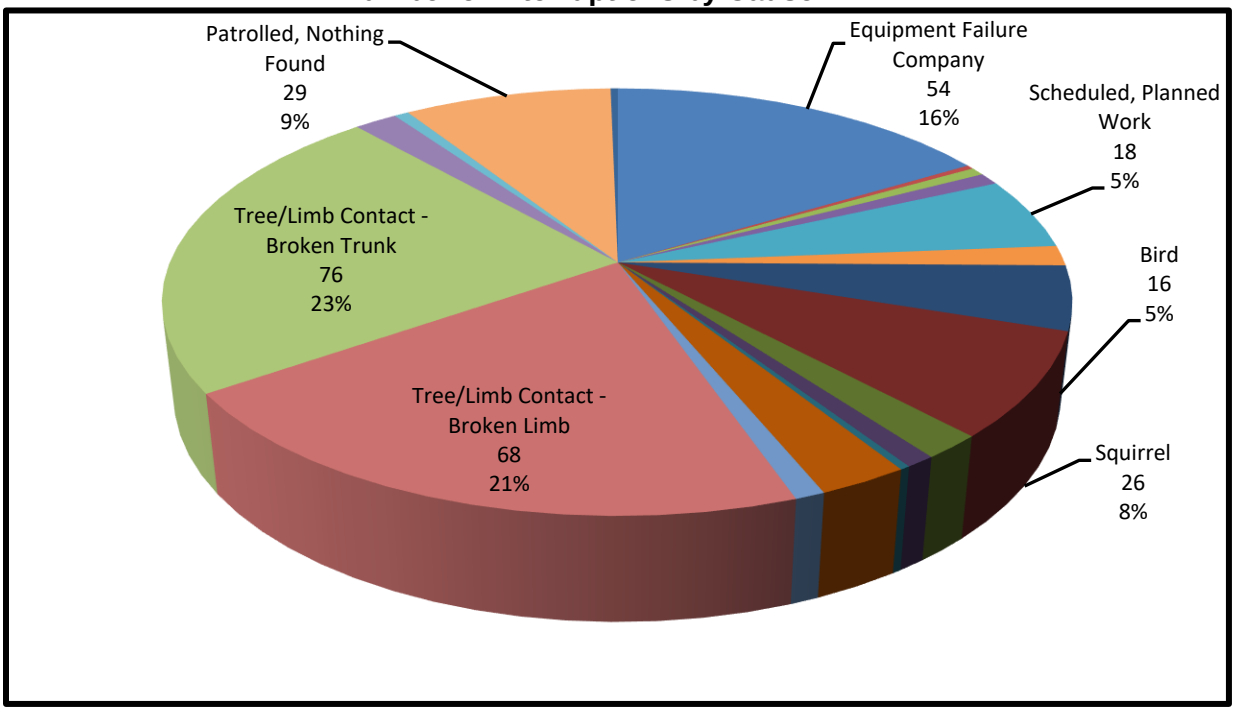



**Chart 5**
**Number of Customers Interrupted by Cause**

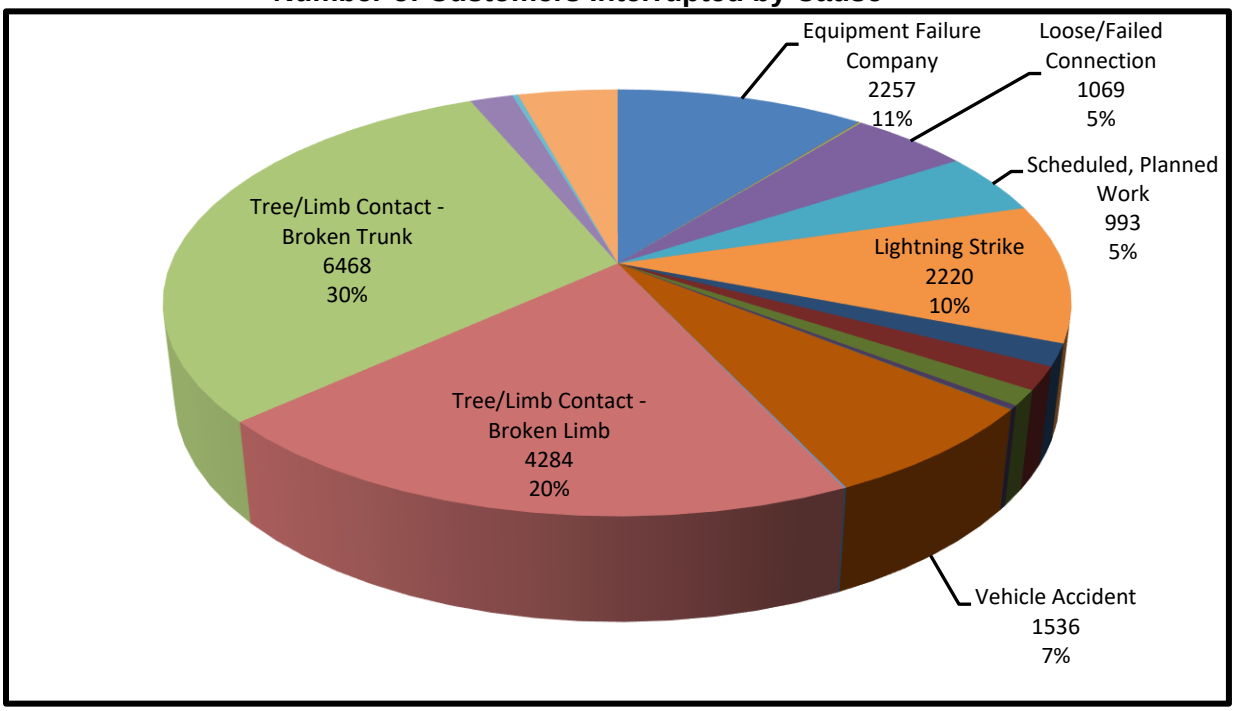


**Chart 6**
**Percent of Customer-Minutes of Interruption by Cause**

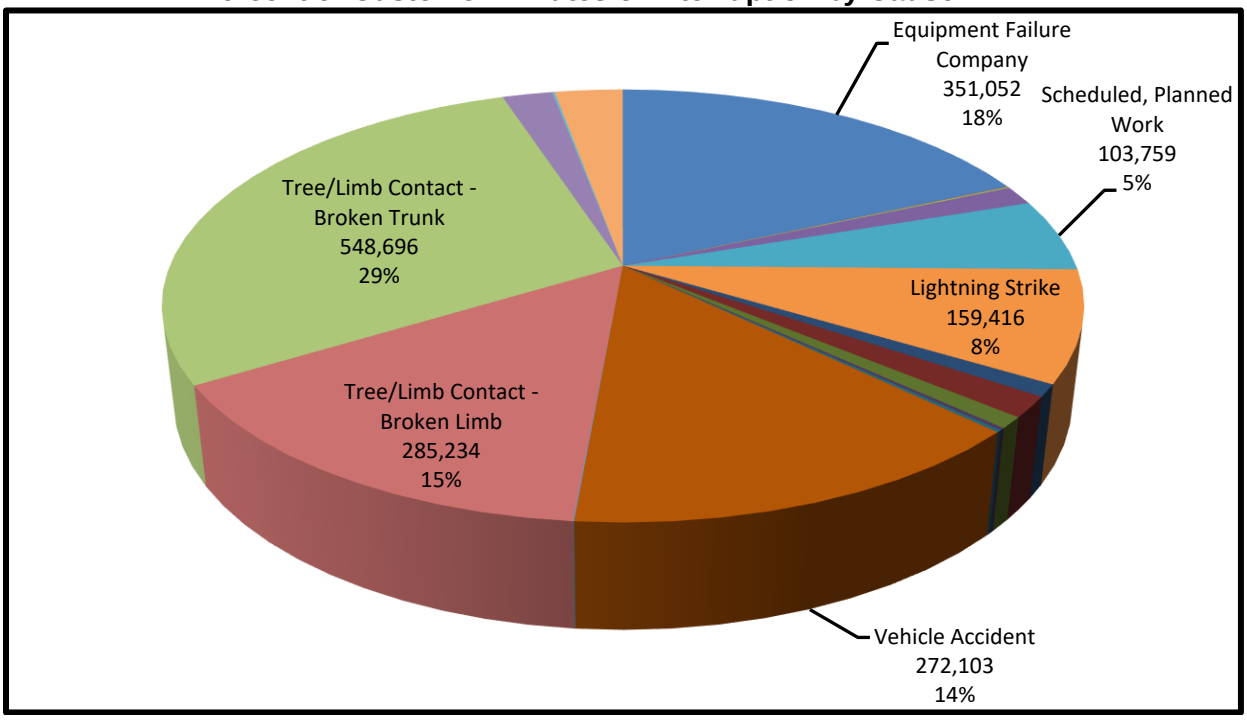



**Table 1**
**Five-Year History of the Number of Interruptions for the Worst Three Trouble Causes**

| Year | Tree/Limb Contact - Broken Trunk | Tree/Limb Contact - Broken Limb | Equipment Failure Company |
|---|---|---|---|
| 2022 | 76 | 68 | 54 |
| 2021 | 99 | 62 | 54 |
| 2020 | 93 | 133 | 64 |
| 2019 | 67 | 74 | 64 |
| 2018 | 102 | 134 | 68 |

## 4 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2022 through December 31, 2022 are summarized in Table 2 below.

**Table 2**
**Worst Ten Distribution Outages**

| Circuit | Description (Date/Cause) | Customer Interruptions | Cust-Min of Interruption | Capital SAIDI | Capital SAIFI |
|---|---|---|---|---|---|
| **C18W2** | 3/9/2022 Vehicle Accident | 951 | 229,066 | 244.21 | 1.014 |
| **C2H2** | 3/12/2022 Equipment Failure Company | 1,067 | 129,107 | 121.00 | 1.000 |
| **C13W3** | 2/16/2022 Tree/Limb Contact – Broken Trunk | 1,642 | 127,171 | 77.50 | 1.001 |
| **C8X3** | 8/2/2022 Equipment Failure Company | 240 | 64,880 | 22.00 | 0.081 |
| **C13W3** | 8/8/2022 Tree/Limb Contact – Broken Limb | 211 | 46,472 | 28.32 | 0.129 |
| **C22W3** | 8/5/2022 Tree/Limb Contact – Broken Trunk | 381 | 44,234 | 28.93 | 0.249 |
| **C8H1** | 8/31/2022 Scheduled, Planned Work | 303 | 43,935 | 70.64 | 0.487 |
| **C13W1** | 4/28/2022 Tree/Limb Contact – Broken Trunk | 502 | 43,615 | 86.88 | 1.000 |
| **C8X3** | 3/8/2022 Equipment Failure Company | 113 | 29,041 | 9.85 | 0.038 |
| **C8X3** | 12/3/2022 Tree/Limb Contact – Broken Trunk | 152 | 28,879 | 9.79 | 0.052 |

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 IEEE MEDs.

## 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, 2022 through December 31, 2022 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 12% of the total customer-minutes of interruption for UES Capital.

**Table 3**
**Subtransmission and Substation Outages**

| Trouble Location | Description (Date/Cause) | Customer Interruptions | Cust-Min of Interruption | Capital SAIDI | Capital SAIFI | No. Times on List (past 4 yrs) |
|---|---|---|---|---|---|---|
| 375 Line | 05/17/2022 Tree Limb Contact | 1,526 | 77,007 | 50.46 | 1.000 | 0 |
| 34 Line | 07/18/2022 Lightning Strike | 1,994 | 149,883 | 75.55 | 1.005 | 3 |

**Table 4**
**Contribution of Subtransmission and Substation Outages**

| Circuit | Trouble Location | Cust-Min of Interruption | % of Total Circuit Minutes | Circuit SAIDI Contribution | Number of Events |
|---|---|---|---|---|---|
| C16X4 | 375 Line | 27,648 | 74% | 48.17 | 1 |
| C16H3 | 375 Line | 29,760 | 100% | 47.92 | 1 |
| C16H1 | 375 Line | 14,496 | 41% | 47.84 | 1 |
| C16X6 | 375 Line | 48 | 100% | 48.00 | 1 |
| C375X1 | 375 Line | 288 | 100% | 48.00 | 1 |
| C16X5 | 375 Line | 4,767 | 100% | 227.00 | 1 |
| C21W1A | 34 Line | 20,025 | 100% | 77.92 | 1 |
| C2H4 | 34 Line | 6,900 | 56% | 75.00 | 1 |
| C33X4 | 34 Line | 5,250 | 38% | 75.00 | 1 |
| C2H1 | 34 Line | 36,539 | 96% | 75.65 | 1 |

| Circuit | Trouble Location | Cust-Min of Interruption | % of Total Circuit Minutes | Circuit SAIDI Contribution | Number of Events |
|---|---|---|---|---|---|
| C34X4 | 34 Line | 94 | >99% | 1.34 | 1 |
| C33X5 | 34 Line | 225 | 100% | 75.00 | 1 |
| C2H2 | 34 Line | 80,025 | 38% | 75.00 | 1 |
| C34X2 | 34 Line | 675 | 100% | 75.00 | 1 |
| C33X6 | 34 Line | 75 | 100% | 75.00 | 1 |
| C33X3 | 34 Line | 75 | 100% | 75.00 | 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 (1/1/22 – 12/31/22)

A summary of the worst performing circuits during the time period between January 1, 2022 and December 31, 2022 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 2022.

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 (CI) | Worst Event (% of CI) | Cust-Min of Interruption (CMI) | Worst Event (% of CMI) | SAIDI | SAIFI | CAIDI |
|---|---|---|---|---|---|---|---|
| C8X3 | 3,589 | 7% | 363,942 | 18% | 123.41 | 1.217 | 101.4 |
| C13W3 | 2,700 | 61% | 269,480 | 47% | 164.22 | 1.645 | 99.81 |
| C13W1 | 742 | 68% | 71,215 | 61% | 141.86 | 1.478 | 95.98 |
| C22W3 | 684 | 56% | 69,514 | 64% | 45.46 | 0.447 | 101.63 |
| C4X1 | 806 | 50% | 68,582 | 32% | 33.83 | 0.398 | 85.09 |
| C7W4 | 1,484 | 32% | 62,305 | 31% | 76.35 | 1.819 | 41.98 |
| C13W2 | 618 | 36% | 56,431 | 16% | 57.17 | 0.626 | 91.33 |
| C15W1 | 655 | 33% | 48,058 | 28% | 47.82 | 0.652 | 73.37 |
| C16H1 | 606 | 50% | 35,616 | 59% | 117.54 | 2.000 | 58.77 |
| C6X3 | 252 | 31% | 33,953 | 36% | 30.40 | 0.226 | 134.73 |

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 | Vehicle Accident | Lightning Strike | Scheduled, Planned Work |
| C8X3 | 75,033 / 15 | 145,901 / 17 | 62,147 / 14 | 8,269 / 1 | 164 / 1 | 0 / 0 |
| C13W3 | 181,112 / 16 | 3,450 / 1 | 57,209 / 11 | 4,579 / 1 | 0 / 0 | 0 / 0 |
| C13W1 | 53,400 / 7 | 15,729 / 7 | 2,014 / 4 | 0 / 0 | 0 / 0 | 360 / 1 |
| C22W3 | 55,232 / 5 | 144 / 2 | 7,614 / 6 | 0 / 0 | 0 / 0 | 1,555 / 1 |
| C4X1 | 47,480 / 8 | 4,164 / 1 | 13,295 / 4 | 0 / 0 | 0 / 0 | 1,161 / 1 |
| C7W4 | 43,244 / 3 | 6,005 / 2 | 10,878 / 1 | 0 / 0 | 0 / 0 | 1,200 / 1 |
| C13W2 | 5,209 / 3 | 25,441 / 5 | 7,190 / 2 | 0 / 0 | 9,002 / 1 | 0 / 0 |
| C15W1 | 26,145 / 3 | 830 / 1 | 12,042 / 2 | 8,400 / 1 | 261 / 1 | 227 / 1 |
| C16H1 | 0 / 0 | 0 / 0 | 14,496 / 1 | 0 / 0 | 0 / 0 | 0 / 0 |
| C6X3 | 16,075 / 2 | 480 / 1 | 12,075 / 1 | 5,323 / 1 | 0 / 0 | 0 / 0 |

### 6.2 Worst Performing Circuits of the Past Five Years (2018 – 2022)

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 IEEE major event days.

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) | 2022 | | 2021 | | 2020 | | 2019 | | 2018 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Circuit | SAIDI | Circuit | SAIDI | Circuit | SAIDI | Circuit | SAIDI | Circuit | SAIDI |
| 1 | C17X1 | 510 | C14X3 | 613.00 | C4W3 | 243.64 | C2H2 | 467.50 | C13W3 | 532.47 |
| 2 | C37X2 | 295.9 | C18W2 | 322.92 | C13W1 | 198.35 | C8X5 | 256.74 | C13W2 | 327.56 |
| 3 | C18W2 | 262.37 | C13W3 | 220.50 | C7W3 | 197.61 | C13W3 | 214.08 | C15W2 | 268.14 |
| 4 | C16X5 | 227 | C37X1 | 211.71 | C4X1 | 154.72 | C6X3 | 166.25 | C22W3 | 242.20 |
| 5 | C374X1 | 202.28 | C13W1 | 178.93 | C15W1 | 135.00 | C8X3 | 141.38 | C21W1A | 166.74 |
| 6 | C33X4 | 198.82 | C15W1 | 139.86 | C22W1 | 133.56 | C13W2 | 134.14 | C8X3 | 164.27 |
| 7 | C2H2 | 198.59 | C4W3 | 130.19 | C13W2 | 129.10 | C18W2 | 121.03 | C13W1 | 155.29 |
| 8 | C13W3 | 164.22 | C8X5 | 125.24 | C13W3 | 115.33 | C15W1 | 118.34 | C7W3 | 142.86 |
| 9 | C13W1 | 141.86 | C8X3 | 83.85 | C34X2 | 111.11 | C37X1 | 117.78 | C38 | 128.52 |
| 10 | C2H4 | 135.05 | C1H3 | 79.97 | C37X1 | 102.09 | C13W1 | 108.30 | C2H4 | 87.85 |

**Table 8**
**Circuit SAIFI**

| Circuit Ranking (1 = worst) | 2022 | | 2021 | | 2020 | | 2019 | | 2018 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Circuit | SAIFI | Circuit | SAIFI | Circuit | SAIFI | Circuit | SAIFI | Circuit | SAIFI |
| **1** | C33X4 | 2.129 | C18W2 | 3.946 | C4W3 | 3.933 | C2H2 | 3.664 | C13W2 | 6.694 |
| **2** | C2H2 | 2.025 | C13W3 | 3.258 | C7W3 | 2.685 | C8X5 | 3.388 | C13W1 | 5.818 |
| **3** | C2H4 | 2 | C13W1 | 3.082 | C22W1 | 2.612 | C18W2 | 1.778 | C13W3 | 5.267 |
| **4** | C16H1 | 2 | C37X1 | 3.071 | C13W2 | 2.483 | C13W3 | 1.641 | C16H3 | 4.693 |
| **5** | C7X1 | 2 | C14X3 | 2.000 | C4X1 | 2.458 | C37X1 | 1.506 | C18W2 | 4.131 |
| **6** | C1X7P | 1.875 | C15W1 | 1.515 | C16X4 | 2.359 | C3H3 | 1.383 | C8H2 | 3.122 |
| **7** | C7W4 | 1.819 | C15W2 | 1.500 | C13W1 | 2.219 | C8X3 | 1.365 | C8X3 | 3.108 |
| **8** | C13W3 | 1.645 | C13W2 | 1.455 | C1H1 | 2.199 | C15W2 | 1.350 | C17X1 | 3.000 |
| **9** | C13W1 | 1.478 | C4W3 | 1.451 | C37X1 | 1.568 | C13W2 | 1.335 | C396X2 | 3.000 |
| **10** | C18W2 | 1.319 | C21W1P | 1.199 | C15W2 | 1.228 | C6X3 | 1.294 | C37X1 | 2.770 |

**Table 9**
**Worst Performing Circuit past Five Years**

| SAIDI | | | SAIFI | | |
|---|---|---|---|---|---|
| Circuit Ranking | Circuit | # Appearances | Circuit Ranking | Circuit | # Appearances |
| **1** | C13W3 | 5 | **1** | C33X4 | 4 |
| **2** | C13W1 | 5 | **2** | C2H2 | 4 |
| **3** | C18W2 | 3 | **3** | C2H4 | 4 |
| **4** | C37X1 | 3 | **4** | C16H1 | 4 |
| **5** | C15W1 | 3 | **5** | C7X1 | 4 |
| **6** | C8X3 | 3 | **6** | C1X7P | 3 |
| **7** | C13W2 | 3 | **7** | C7W4 | 2 |
| **8** | C2H2 | 2 | **8** | C13W3 | 2 |
| **9** | C2H4 | 2 | **9** | C13W1 | 2 |
| **10** | C4W3 | 2 | **10** | C18W2 | 1 |

### 6.3 System Reliability Improvements (2022 and 2023)

Vegetation management projects completed in 2022 or planned for 2023 that are expected to improve the reliability of the 2022 worst performing circuits are included in table 10 below. Table 11 below details electric system upgrades that are scheduled to be completed in 2023, or were completed in 2022, that were performed to improve system reliability.

**Table 10**
**Vegetation Management Projects on Worst Performing Circuits**

| Circuit(s) | Year of Completion | Project Description |
|---|---|---|
| **C18W2** | 2022 | Cycle Pruning/Hazard Tree Mitigation |
| **C8X3** | 2022 | Cycle Pruning/Hazard Tree Mitigation |
| **C7W4** | 2022 | Storm Resiliency Program/Mid-Cycle Review |
| **C4W4** | 2022 | Hazard Tree Mitigation/Mid-Cycle Review |
| **C22W1** | 2022 | Mid-Cycle Review |
| **C22W2** | 2022 | Mid-Cycle Review |
| **C38** | 2022 | Mid-Cycle Review |
| **C8X5** | 2022 | Mid-Cycle Review |
| **C7W3** | 2022/2023 | Storm Resiliency Program/Forestry Reliability/Hazard Tree Mitigation/Mid-Cycle Review |
| **C13W1** | 2022/2023 | Hazard Tree Mitigation/Mid-Cycle Review/Forestry Reliability |
| **C4X1** | 2022/2023 | Hazard Tree Mitigation/Mid-Cycle Review |
| **C13W3** | 2023 | Cycle Pruning/Hazard Tree Mitigation |
| **C24H1** | 2023 | Cycle Pruning/Hazard Tree Mitigation |
| **C24H2** | 2023 | Cycle Pruning/Hazard Tree Mitigation |
| **C33X4** | 2023 | Cycle Pruning/Hazard Tree Mitigation |
| **C34X4** | 2023 | Cycle Pruning/Hazard Tree Mitigation |

| Circuit(s) | Year of Completion | Project Description |
|---|---|---|
| **C13W2** | 2023 | Cycle Pruning/Hazard Tree Mitigation |
| **C15W1** | 2023 | Hazard Tree Mitigation/Mid-Cycle Review |
| **C15W2** | 2023 | Hazard Tree Mitigation/Mid-Cycle Review |
| **C22W3** | 2023 | Hazard Tree Mitigation/Mid-Cycle Review/Forestry Reliability |
| **C3W1** | 2023 | Mid-Cycle Review |
| **C3W3** | 2023 | Mid-Cycle Review/Forestry Reliability |
| **C7X1** | 2023 | Mid-Cycle Review |

**Table 11**
**Electric System Improvements Performed to Improve Reliability**

| Circuit(s) | Year of Completion | Project Description |
|---|---|---|
| **Various** | 2022/2023 | Install Animal Guards |
| **13W2** | 2022 | Reconductor 13W2 Mainline with 336 Spacer |
| **13W1** | 2022 | Recloser Installation |
| **15W2** | 2022 | Replace Direct Buried Cable |
| **38 Line** | 2022 | Spacer Cable Replacement |
| **18W2** | 2023 | Reconductor Bow Center Rd |
| **8X3** | 2023 | Install a Fuse Saver on Horse Corner Rd |

## 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, 2022 and December 31, 2022. This section does not include subtransmission outages.

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 Interruptions | Cust-Min of Interruption | No. of Interruptions |
|---|---|---|---|
| **C13W3** | 2,615 | 259,979 | 33 |
| **C8X3** | 1,988 | 158,129 | 36 |
| **C22W3** | 607 | 63,177 | 14 |
| **C4X1** | 719 | 60,775 | 12 |
| **C13W1** | 606 | 55,414 | 11 |
| **C7W4** | 1,422 | 54,122 | 7 |
| **C15W1** | 538 | 38,187 | 7 |
| **C6X3** | 187 | 28,150 | 3 |
| **C4W3** | 114 | 21,414 | 5 |
| **C13W2** | 163 | 12,399 | 5 |

**Table 13**
**Multiple Tree Related Outages by Street**

| Circuit | Street, Town | No. Of Outages | Customer Interruptions | Cust-Min of Interruption |
|---|---|---|---|---|
| **C8X3** | Bear Hill Rd, Loudon | 4 | 608 | 53,275 |
| **C7W4** | South St, Concord | 4 | 494 | 19,818 |
| **C22W3** | Stickney Hill Rd, Hopkinton | 4 | 71 | 4,595 |
| **C13W3** | Daniel Webster Hwy, Boscawen | 3 | 380 | 66,671 |
| **C22W3** | Birchdale Rd, Bow | 3 | 451 | 51,981 |
| **C8X3** | Mountain Rd, Epsom | 3 | 150 | 15,648 |
| **C4X1** | Horse Hill Rd, Penacook | 3 | 136 | 13,104 |
| **C4X1** | West Parish Rd, Concord | 3 | 72 | 11,398 |
| **C8X3** | Horse Corner Rd, Chichester | 3 | 134 | 8,566 |
| **C13W3** | Mutton Rd, Webster | 3 | 66 | 8,471 |

## 8 Failed Equipment

This section is intended to clearly show all equipment failures throughout the study period from January 1, 2022 through December 31, 2022. 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**

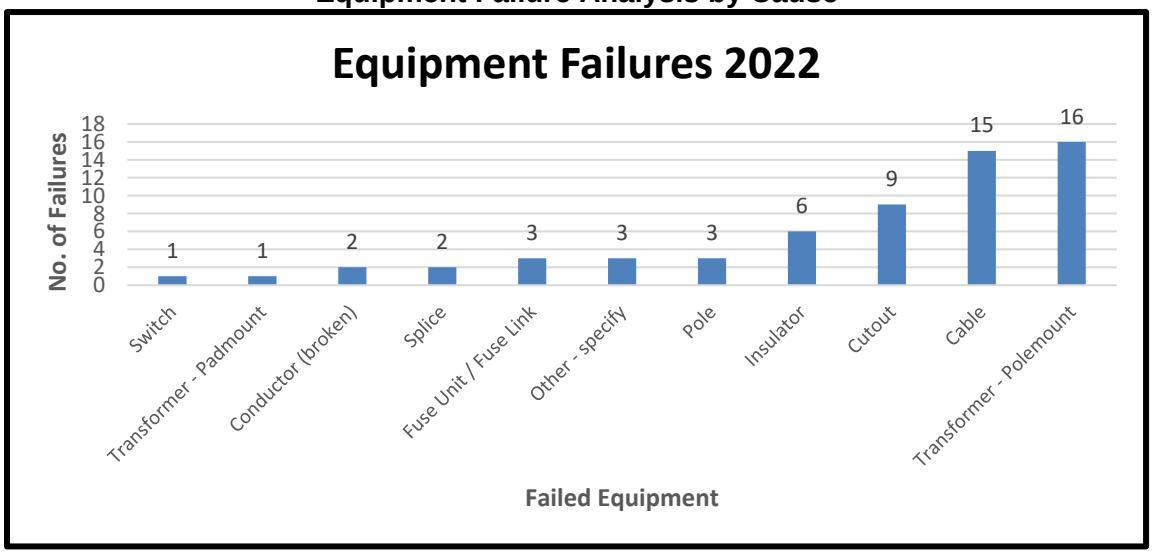


**Chart 8**
**2022 Equipment Failure Analysis by Percentage of Total Failures**

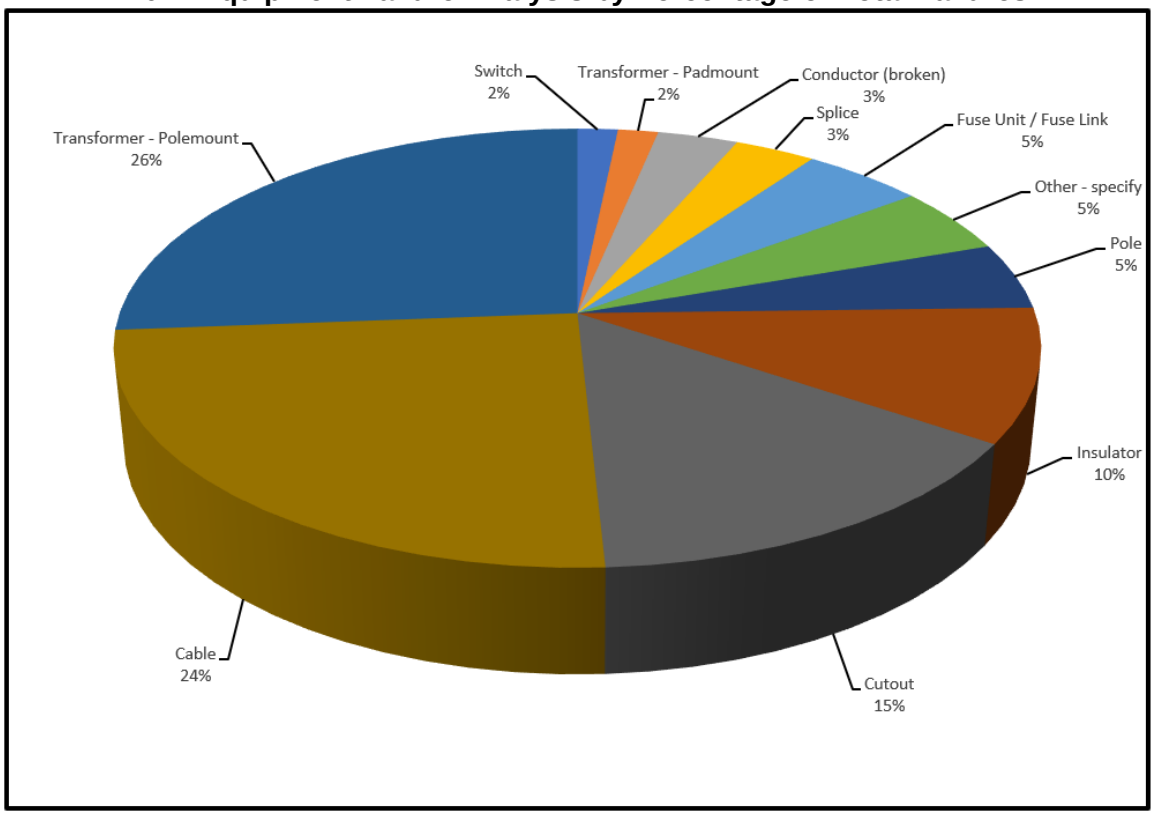
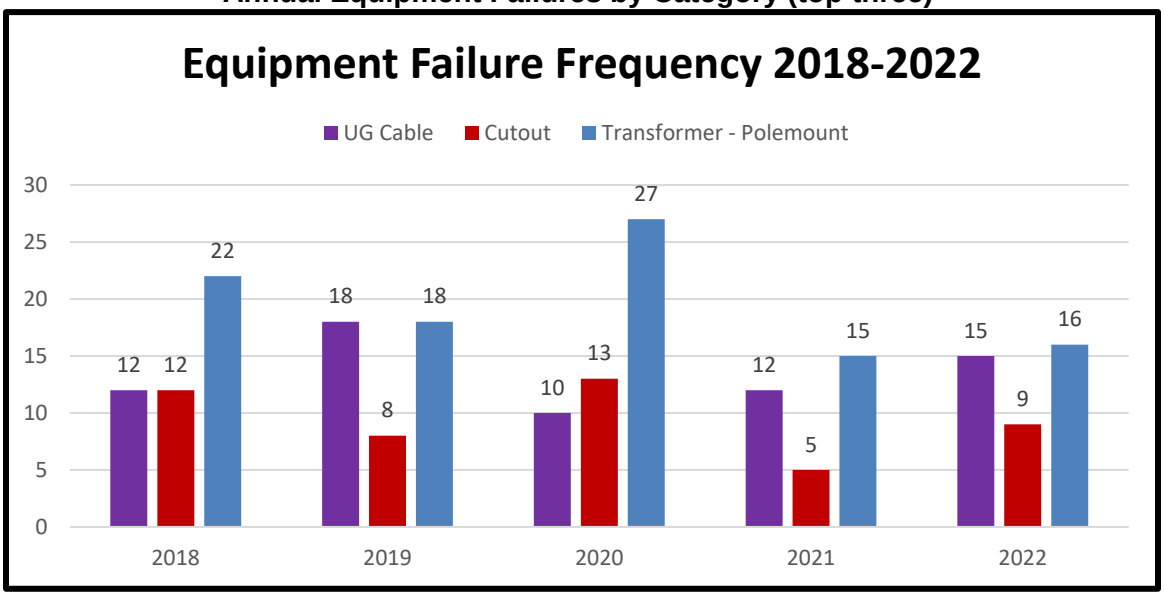



**Chart 9**
**Annual Equipment Failures by Category (top three)**




The top three equipment failures continue to be underground cables, cutouts, and polemount transformers. The polemount transformer failures, although high, do not show signs of increasing over the last 5 years and are consistent with historical failure rates. Cutout failures are trending downward as a result of the cutout replacement program

that occurred in 2018 and 2019. Operations and engineering will continue to review locations in which cable injection and replacement of direct buried cable could reduce the frequency of underground cable failures.

## 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, 2022 to December 31, 2022 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 2022 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 |
|---|---|---|---|---|---|
| **C8X3** | Fuse, Pole 2, Bear Hill Rd, Chichester | 5 | 60,272 | 760 | 1 |
| **C8X3** | Fuse, Pole 43, Lane Rd, Chichester (Right/East Fuse) | 4 | 9,929 | 92 | 0 |
| **C4X1** | Fuse, Pole 17, Horse Hill Rd, Penacook | 4 | 17,268 | 181 | 0 |
| **C8X3** | Fuse, Pole 1, Mountain Rd, Epsom | 4 | 19,218 | 201 | 1 |

**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 |
|---|---|---|---|
| C8X3 | Ferrin Rd | 7 | 1 |
| C8X3 | Durgin Rd | 7 | 2 |

## 10 Other Concerns

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

### 10.1 URD Cable Failure

URD cables are failing at an average rate of 13.4 failures per year over the last five years, for a total of 67 cable failures in the past five years. When a direct buried cable fails, Unitil typically excavates the area of the failure and splices in a small section of new cable into the existing cable. In these cases

the remaining aged cable in the area remains. Generally, cable failures in conduit result in the cable run being replaced. In recent years, projects to address direct buried cable failures have included cable injection and replacement with cable in conduit where cable injection has been deemed unfeasible. It is anticipated that additional projects for cable injection and or direct buried cable replacement will be proposed in future years.

# 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 2024 capital budget. All project costs are shown without general construction overheads.

## 11.1. Circuit 13W1: 13W1 Spacer Cable and Tree Wire Installation

### 11.1.1. Identified Concerns

Circuit 13W1 was on the SAIDI worst performing circuit list 5 times in the past 5 years and was on the SAIFI worst performing circuit list 2 times in the past 5 years. It is also 5$^{th}$ place on the Worst Performing Circuits – Tree Related Outages list.

Broken trunks were responsible for 43,704 customer minutes of interruption in 2022.

A broken trunk on Carter Hill Road resulted in an outage to 502 customers and totaled 43,615 customer minutes of interruption. Additionally, there are large trees on both sides of Center Road that could cause damage to the three-phase line in the event of broken trunks or limbs.

### 11.1.2. Recommendations

#### 11.1.2.1. 13W1 Mainline Spacer Cable Installation

Reconductor the mainline of 13W1 from pole 59 West Rd to pole 33 North West Rd with 336Al spacer cable, 052AWA messenger and 4/0ACSR neutral.

Estimated Project Cost (without construction overheads): $560,037

Estimated Annual Savings:

Customer Minutes: 27,776

Customer Interruptions: 305

## 11.2. Circuit 13W3: 13W3 Spacer Cable Installation

### 11.2.2.1. Identified Concerns

Circuit 13W3 was on the SAIDI worst performing circuit list 5 times in the past 5 years and was on the SAIFI worst performing circuit list 2 times in the past 5 years. Additionally, it is the worst circuit on the Worst Performing Circuits – Tree Related Outages list. 13W3 is a radial circuit with no back up to adjacent circuits.

### 11.2.2. Recommendation

#### 11.3.2.1. Reconductor Daniel Webster Highway

Reconductor Daniel Webster Highway from pole 187 to pole 285 with 336Al spacer cable, 052AWA messenger and 4/0ACSR neutral.

Estimated Project Cost (without construction overheads): $1,056,337

Estimated Annual Savings:

Customer Minutes: 25,538

Customer Interruptions: 276

## 11.3. Circuit 13W3: Reconductoring and Creation of an Internal Circuit Tie

### 11.3.1. Identified Concerns

Circuit 13W3 was on the SAIDI worst performing circuit list 5 times in the past 5 years and was on the SAIFI worst performing circuit list 2 times in the past 5 years. Additionally, it is the worst circuit on the Worst Performing Circuits – Tree Related Outages list. 13W3 is a radial circuit with no back up to adjacent circuits.

### 11.3.2. Recommendation

#### 11.3.2.1. N. Water Street and Rabbit Road Spacer Cable Installation

Rebuild N. Water Street and Rabbit Road from Long Street to Old Coach Road with 336AL spacer cable, 052AWA messenger and 4/0ACSR neutral. Install three microprocessor controlled reclosers and implement an auto transfer scheme. The first recloser is to be installed at P.49 Old Turnpike Rd, the second at P.1 Rabbit Rd and the third in the area of the intersection of N. Water St and Long St. 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): $1,457,712

Estimated Annual Savings:

Customer Minutes: 30,069

Customer Interruptions: 668

## 11.4. Circuit 18W2: Create New Tie with 22W3

### 11.4.1. Identified Concerns

Circuit 18W2 was on the SAIDI worst performing circuit list 3 times in the past 5 years.

There was a 2021 outage on Bow Center Rd which caused 113,901 customer minutes of interruption for 948 customers. Additionally, the southwest portion of 18W2 does not currently have a tie to an adjacent circuit and the existing 18W2 tie to 22W3 is in close proximity to Bow Bog substation.

### 11.4.2. Recommendations

#### 11.4.2.1. Create a Circuit Tie on White Rock Hill Rd

Rebuild the single-phase portion of White Rock Hill Road on circuits 18W2 and 22W3 to three-phase. A new normally open tie switch will be installed along White Rock Hill Road creating a new circuit tie between 18W2 and 22W3. Replace the fuses on pole 18/104 on Bow Center Rd and the fuses on pole 122/53 on White Rock Hill Rd with solid blades.

Estimated Project Cost (without construction overheads): $312,467

Estimated Annual Savings:

Customer Minutes: 11,168

Customer Interruptions: 8

## 11.5. Miscellaneous Circuit Improvements to Reduce Recurring Outages

### 11.5.1. 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 and reviewing the fault locations on the worst performing circuits.

**Forestry Reviews**

It is recommended that a forestry review of the areas below be performed in order to identify and address any mid-cycle growth or hazard tree problems.

- C8X3
  - Horse Corner Rd. area, Chichester
  - Bear Hill Rd, East Ricker Rd area, Loudon
  - Mountain Rd, Epsom
- C22W3
  - Stickney Hill Rd. area, Hopkinton
  - Birchdale Rd. area, Bow
- C13W3
  - Daniel Webster Hwy area Boscawen
  - Mutton Rd area, Webster
- C7W4
  - South St area, Concord
- C4X1
  - Horse Hill Rd area, Penacook
  - West Parish Rd area, Concord

**Animal Guard Installation Recommendations**

It is recommended that the on-going animal guard installation program be continued in 2024. The areas identified below should be reviewed and have animal guards installed where needed.

- C8X3
  - Bear Hill Rd. area, Chichester
  - Center Hill Rd. area, Epsom
  - Connemara Dr. area, Chichester
  - Durgin Rd. area, Chichester
  - Horse Corner Rd. area, Chichester
  - Bailey Rd. area, Chichester
  - King Rd. and Canterbury Rd. area, Chichester and Loudon
  - Durgin Rd. area, Chichester
  - Highland Dr. area, Chichester
  - Colonial Dr. area, Epsom
  - Albert Nye Dr. area, Epsom (around McClary Hill)
  - Baybutt Rd., Epsom
- C13W1
  - Goodwin Rd. area, Canterbury
- C13W2
  - Academy St. area, Boscawen
  - Best Ave. area, Boscawen
  - Chandler St. area, including Hollins Ave, Boscawen
- C13W3
  - Water St. area, Boscawen
  - Keneval Ave. area, Boscawen
  - White Plains Rd. area, Webster
  - Area surrounding Walker Pond and Corser Hill, Webster

  - Warner Rd. area, Salisbury
- C18W2
  - Bow Center Rd. area, Bow
  - Risingwood Dr. area, Bow

## 12 Conclusion

During 2022, 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 along the mainlines for most of the worst performing circuits identified in this study.

Due to the number of animal related outages that occur on the UES-Capital system an animal guard installation program began in 2019. This program is expected to continue in 2023. 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, animal guards will be installed at that location. Also, 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. 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**
# **2023**

~DRAFT~

Prepared By:

Jake Dusling
Unitil Service Corp.
August 29, 2023

# 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, 2022 through December 31, 2022. 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 sub-transmission and substation outages (listed in Section 5), as well as outages during 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 | 12/23/2022 | 147 | 9,565 | 5,944,918 |

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 2024 budget development process.

| Circuit / Line / Substation | Proposed Project | Cost ($) |
|---|---|---|
| 6W1/6W2 | Construct Circuit Tie | $1,330,000 |
| 58X1/5X3/3358 | Increase Circuit Tie Capacity and Reconfigure | $1,350,000 |
| 46X1/2X2/3346 | Create Circuit Tie and Reconfigure | $1,625,000 |

Note: estimates do not include general construction overheads

The 2022 annual UES-Seacoast system reliability goal was set at 121.68 SAIDI minutes, after removing exclusionary outages. UES-Seacoast's SAIDI performance in 2022 was 76.33 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**

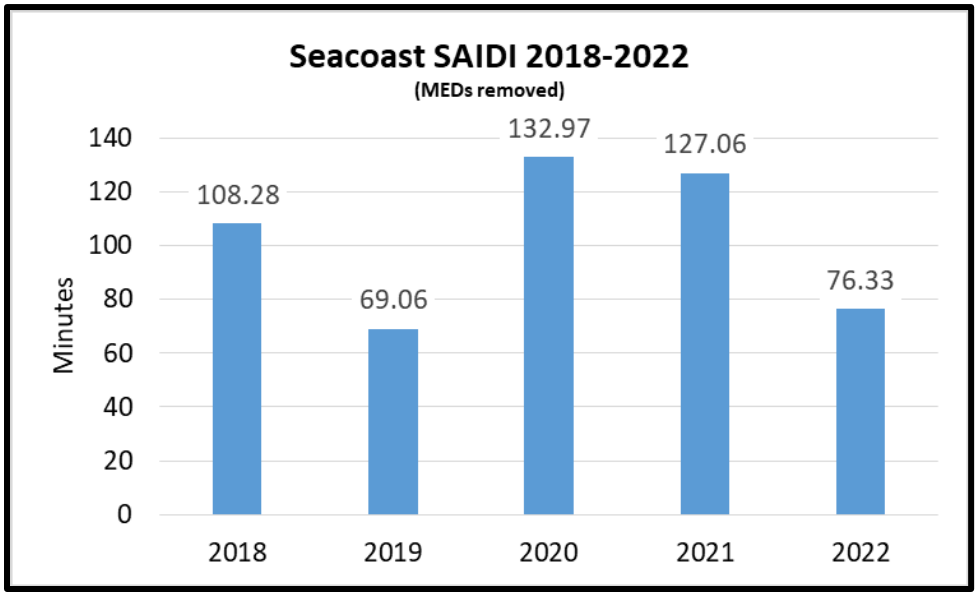



**Chart 2**
**Annual UES-Seacoast SAIFI**

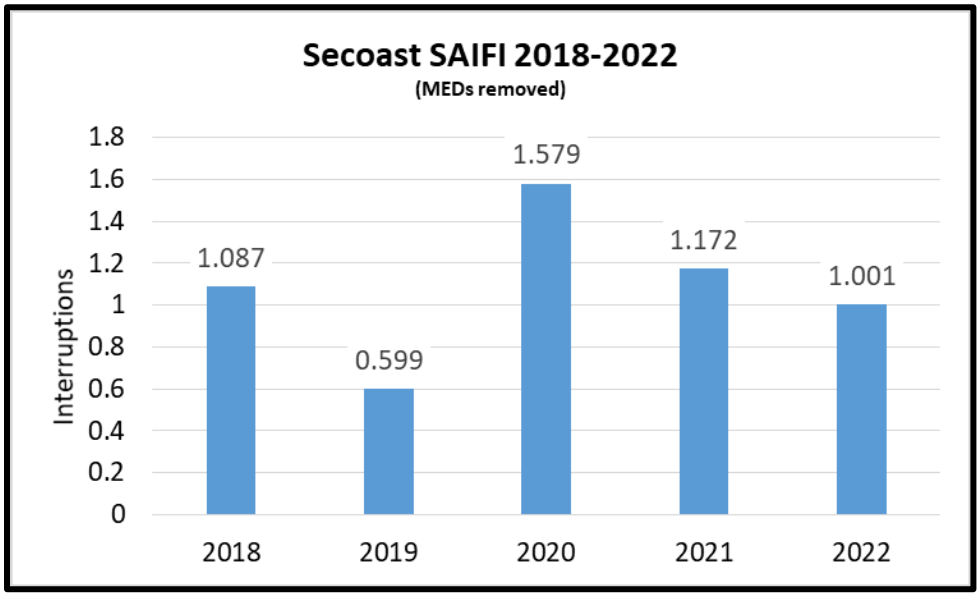
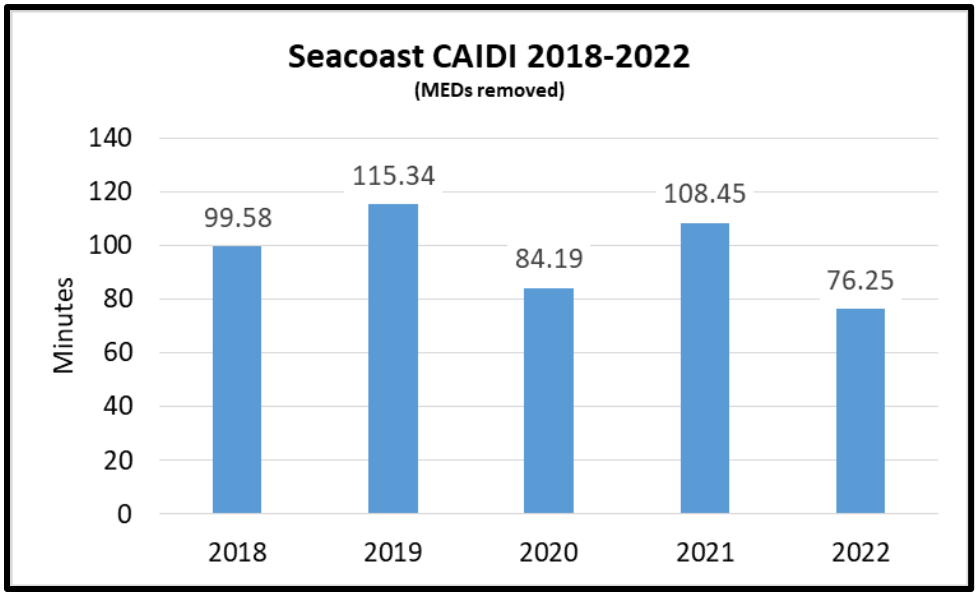


**Chart 3**
**Annual UES-Seacoast CAIDI**




## 2 Reliability Benchmarks

The new annual UES-Seacoast system reliability benchmark for 2023 is 124.56 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 2023 Unitil system goal. The 2023 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 2024. 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**

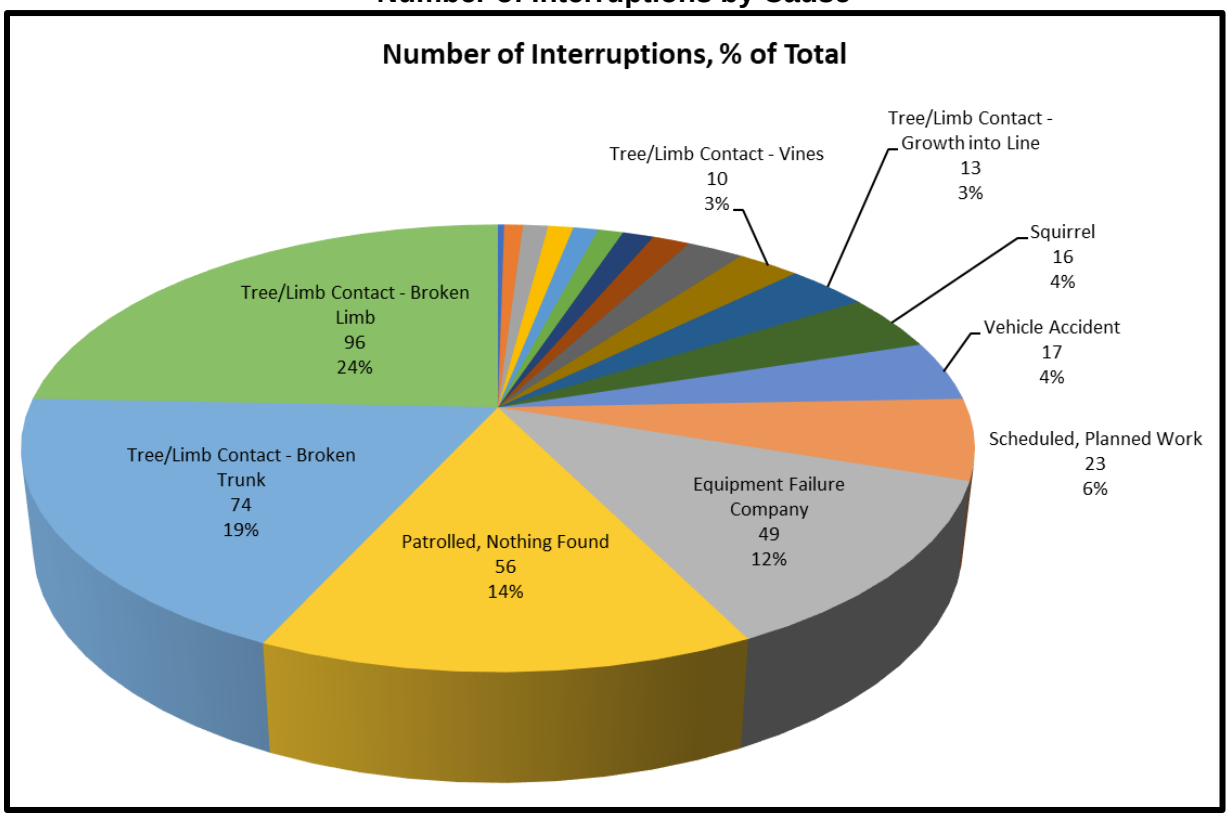



**Chart 5**
**Number of Customer Interruptions by Cause**

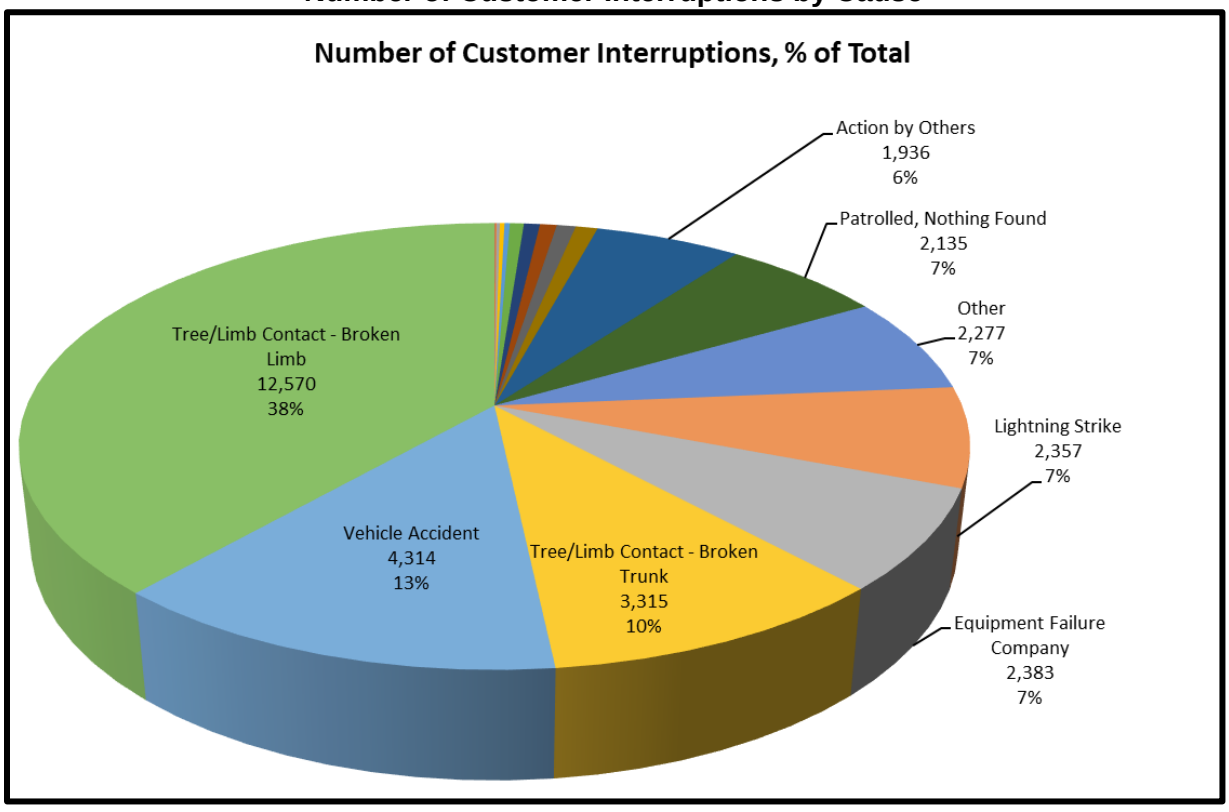


**Chart 6**
**Percent of Customer-Minutes of Interruption by Cause**

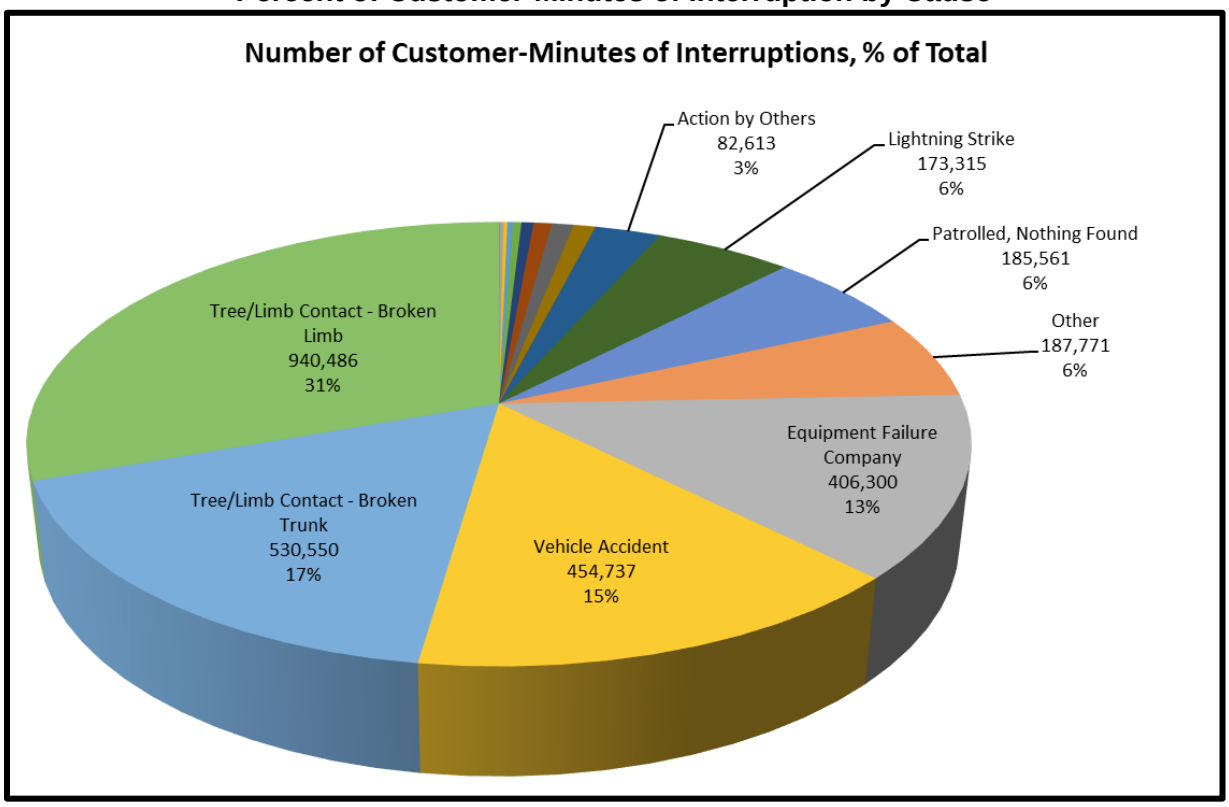



**Table 1**
**Worst Three Trouble Causes over Past Five-Years**
**Number of Interruption**

| Year | # of Interruptions Per Trouble Cause | | |
|---|---|---|---|
| | Tree/Limb Contact - Broken Limb | Tree/Limb Contact - Broken Trunk | Equipment Failure Company |
| 2022 | 96 | 74 | 49 |
| 2021 | 128 | 109 | 77 |
| 2020 | 132 | 84 | 61 |
| 2019 | 88 | 69 | 69 |
| 2018 | 178 | 57 | 89 |

## 4 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2022 through December 31, 2022 are summarized in Table 2 below.

**Table 2**
**Worst Ten Distribution Outages**

| Circuit | Date/Cause | Customer Interruptions | Cust-Min of Interruption | SAIDI | SAIFI |
|---|---|---|---|---|---|
| E27X1 | 7/23/2022<br>Equipment Failure Company | 699 | 205,028 | 4.26 | 0.015 |
| E17W1 | 1/17/2022<br>Other – Debris (Aluminum Siding) Contact | 2,029 | 146,494 | 3.04 | 0.042 |
| E54X1 | 1/25/2022<br>Equipment Failure Company | 1,025 | 135,348 | 2.81 | 0.021 |
| E7X2 | 2/12/2022<br>Tree/Limb Contact – Broken Trunk | 1,325 | 134,973 | 2.80 | 0.028 |
| E19X3 | 7/21/2022<br>Lightning Strike | 1,834 | 129,706 | 2.69 | 0.038 |
| E23X1 | 6/20/2022<br>Vehicle Accident | 517 | 126,648 | 2.63 | 0.011 |
| E51X1 | 7/21/2022<br>Tree/Limb Contact – Broken Trunk | 401 | 101,807 | 2.11 | 0.008 |
| E22X1 | 2/18/2022<br>Tree/Limb Contact – Broken Limb | 1,402 | 100,827 | 2.09 | 0.029 |
| E56X1 | 5/25/2022<br>Vehicle Accident | 336 | 95,514 | 1.98 | 0.007 |
| E47X1 | 1/5/2022<br>Tree/Limb Contact – Broken Limb | 914 | 81,815 | 1.70 | 0.019 |

## 5 Sub-transmission and Substation Outages

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

All substation and sub-transmission outages ranked by customer-minutes of interruption during the time period from January 1, 2022 through December 31, 2022 are summarized in Table 3 below.

Table 4 shows the substations 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 16% of the total customer-minutes of interruption for UES-Seacoast.

**Table 3**
**Sub-transmission and Substation Outages**

| Line / Substation | Date/Cause | Customer Interruptions | Cust-Min of Interruption | SAIDI | SAIFI | Number of Outages in Prior Four Years |
|---|---|---|---|---|---|---|
| Kingston S/S | 8/22/2022 Operator Error/System Malfunctions | 9,760 | 58,860 | 3.82 | 0.062 | 0 |
| Hampton Beach S/S | 6/16/2022 Equipment Failure Company | 3,284 | 314,655 | 2.72 | 0.063 | 0 |
| Hampton S/S | 8/11/2022 Operator Error/System Malfunctions | 2,524 | 220,976 | 4.97 | 0.038 | 0 |

**Table 4**
**Affected Substations/Circuits**

| Substation/Tap | Circuits | Substation / Transmission Line Outage | Customer Interruptions | Cust-Min of Interruption | Number of Events |
|---|---|---|---|---|---|
| Kingston | E22X1 | Kingston S/S | 1,414 | 8,484 | 1 |
| Timberlane | E13W1, E13W3, E13X3 | Kingston S/S | 2,979 | 17,874 | 1 |
| Plaistow | E5X3 | Kingston S/S | 794 | 4,764 | 1 |
| Hunt Road | E56X1 | Kingston S/S | 714 | 4,284 | 1 |
| Munt Hill | E28X1 | Kingston S/S | 515 | 3,090 | 1 |
| Shaw's Hill | E27X1, E27X2 | Kingston S/S | 1,134 | 6,804 | 1 |
| Dorre Road | E56X2 | Kingston S/S | 157 | 942 | 1 |
| Hampton Beach | E3W1, E3W4 | Hampton Beach S/S | 3,284 | 314,655 | 1 |
| Hampton | E2X2 | Hampton S/S | 2,524 | 220,976 | 1 |

## 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

A summary of the worst performing circuits during the time period between January 1, 2022 and December 32, 2021 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 2022.

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 |
|---|---|---|---|---|---|---|---|
| E19X3 | 3,167 | 58% | 292,228 | 44% | 6.07 | 0.066 | 92.27 |
| E51X1 | 2,272 | 19% | 282,224 | 36% | 5.86 | 0.047 | 124.22 |
| E27X1 | 1,200 | 42% | 247,331 | 55% | 5.13 | 0.025 | 206.11 |
| E54X1 | 3,291 | 31% | 246,355 | 55% | 5.11 | 0.068 | 74.86 |
| E47X1 | 2,731 | 33% | 222,676 | 37% | 4.62 | 0.057 | 81.54 |
| E56X1 | 994 | 34% | 200,086 | 48% | 4.15 | 0.021 | 201.29 |
| E7X2 | 1,513 | 88% | 170,635 | 79% | 3.54 | 0.031 | 112.78 |
| E22X1 | 2,563 | 55% | 143,339 | 70% | 2.98 | 0.053 | 55.93 |
| E13W2 | 2,385 | 69% | 125,854 | 16% | 2.61 | 0.050 | 52.77 |
| E6W1 | 1,246 | 16% | 124,551 | 47% | 2.59 | 0.026 | 99.96 |

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 Limb | Tree/Limb Contact - Broken Trunk | Vehicle Accident | Equipment Failure Company | Other | Patrolled, Nothing Found |
| E19X3 | 15,067 / 4 | 19,338 / 1 | 67,259 / 3 | 6,270 / 1 | 0 / 0 | 0 / 0 |
| E51X1 | 215,781 / 8 | 12,177 / 1 | 0 / 0 | 5,889 / 7 | 876 / 1 | 43,273 / 8 |
| E27X1 | 21,442 / 5 | 19,674 / 2 | 0 / 0 | 205,256 / 2 | 0 / 0 | 195 / 2 |
| E54X1 | 65,683 / 3 | 556 / 1 | 0 / 0 | 135,534 / 2 | 0 / 0 | 1,921 / 2 |
| E47X1 | 215,814 / 5 | 2,277 / 2 | 0 / 0 | 1,484 / 1 | 0 / 0 | 20 / 1 |
| E56X1 | 18,162 / 3 | 75,109 / 1 | 95,514 / 1 | 89 / 1 | 0 / 0 | 676 / 1 |
| E7X2 | 134,973 / 1 | 32,555 / 2 | 0 / 0 | 1,211 / 2 | 0 / 0 | 291 / 1 |
| E22X1 | 102,548 / 4 | 15,412 / 5 | 23,156 / 2 | 1,648 / 2 | 0 / 0 | 0 / 0 |
| E13W2 | 29,739 / 8 | 931 / 3 | 54,502 / 3 | 1,760 / 2 | 0 / 0 | 16,440 / 3 |
| E6W1 | 31,640 / 4 | 29,595 / 3 | 58,819 / 1 | 3,303 / 1 | 0 / 0 | 115 / 1 |

### 6.2 Worst Performing Circuits of the Past Five Years

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 7 lists the ten worst performing circuits ranked by SAIFI and Table 8 lists the ten worst performing circuits ranked by SAIDI. Table 9 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 2018 through 2022.

**Table 7**
**Circuit SAIFI**

| Circuit Ranking (1=worst) | 2022 | | 2021 | | 2020 | | 2019 | | 2018 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Circuit | SAIFI | Circuit | SAIFI | Circuit | SAIFI | Circuit | SAIFI | Circuit | SAIFI |
| 1 | E54X1 | 3.217 | E21W1 | 4.395 | E15X1 | 3.597 | E3W1 | 2.062 | E7W1 | 6.569 |
| 2 | E22X1 | 2.811 | E15X1 | 3.587 | E21W1 | 2.924 | E6W1 | 1.991 | E6W1 | 3.257 |
| 3 | E2H1 | 2.000 | E23X1 | 3.148 | E51X1 | 2.486 | E22X1 | 1.758 | E54X2 | 2.949 |
| 4 | E27X1 | 1.719 | E59X1 | 2.473 | E6W2 | 2.103 | E51X1 | 1.693 | E21W1 | 2.519 |
| 5 | E47X1 | 1.634 | E27X1 | 2.384 | E13X3 | 2.000 | E23X1 | 1.677 | E6W2 | 2.334 |
| 6 | E13W2 | 1.457 | E6W1 | 2.256 | E19H1 | 2.000 | E11X1 | 1.356 | E54X1 | 2.115 |
| 7 | E6W1 | 1.418 | E54X1 | 2.154 | E17W2 | 1.518 | E21W1 | 1.290 | E21W2 | 2.053 |
| 8 | E56X1 | 1.396 | E22X1 | 1.957 | E6W1 | 1.505 | E18X1 | 1.261 | E13W2 | 1.777 |
| 9 | E13W1 | 1.193 | E18X1 | 1.718 | E56X1 | 1.484 | E17W2 | 0.998 | E43X1 | 1.465 |
| 10 | E51X1 | 1.153 | E7X2 | 1.467 | E2H1 | 1.223 | E6W2 | 0.901 | E22X1 | 1.458 |

**Table 8**
**Circuit SAIDI**

| Circuit Ranking (1=worst) | 2022 | | 2021 | | 2020 | | 2019 | | 2018 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Circuit | SAIDI | Circuit | SAIDI | Circuit | SAIDI | Circuit | SAIDI | Circuit | SAIDI |
| 1 | E27X1 | 354.34 | E21W1 | 517.49 | E51X1 | 370.76 | E6W1 | 459.13 | E7W1 | 520.93 |
| 2 | E56X1 | 281.02 | E15X1 | 387.02 | E13X3 | 335.64 | E51X1 | 354.92 | E54X2 | 338.40 |
| 3 | E54X1 | 240.82 | E22X1 | 371.47 | E15X1 | 283.77 | E21W1 | 176.68 | E21W1 | 285.58 |
| 4 | E2H1 | 239.32 | E23X1 | 303.66 | E21W1 | 240.24 | E22X1 | 170.09 | E54X1 | 221.90 |
| 5 | E23X1 | 152.95 | E27X1 | 283.93 | E6W2 | 225.28 | E11X1 | 167.39 | E22X1 | 209.94 |
| 6 | E51X1 | 143.30 | E59X1 | 258.19 | E21W2 | 219.48 | E15X1 | 116.15 | E6W1 | 205.87 |
| 7 | E6W1 | 141.70 | E27X2 | 218.64 | E6W1 | 166.78 | E17W2 | 115.43 | E13W2 | 196.23 |
| 8 | E47X1 | 133.26 | E47X1 | 182.46 | E22X2 | 154.73 | E13W1 | 113.6 | E2H1 | 192.59 |
| 9 | E3W4 | 109.60 | E54X1 | 172.53 | E22X1 | 153.40 | E23X1 | 112.91 | E23X1 | 176.73 |
| 10 | E22X1 | 107.30 | E6W1 | 148.90 | E19H1 | 147.89 | E6W2 | 93.03 | E58X1 | 167.86 |

**Table 9**
**Worst Performing Circuits in Past Five Years**

| SAIFI | | | SAIDI | | |
|---|---|---|---|---|---|
| Circuit Ranking (1=worst) | Circuit | # of Times in Worst 10 | Circuit Ranking (1=worst) | Circuit | # of Times in Worst 10 |
| **1** | E54X1 | 3 | **1** | E27X1 | 2 |
| **2** | E22X1 | 4 | **2** | E56X1 | 1 |
| **3** | E2H1 | 2 | **3** | E54X1 | 3 |
| **4** | E27X1 | 2 | **4** | E2H1 | 2 |
| **5** | E47X1 | 1 | **5** | E23X1 | 4 |
| **6** | E13W2 | 2 | **6** | E51X1 | 3 |
| **7** | E6W1 | 5 | **7** | E6W1 | 5 |
| **8** | E56X1 | 2 | **8** | E47X1 | 2 |
| **9** | E13W1 | 1 | **9** | E3W4 | 1 |
| **10** | E51X1 | 3 | **10** | E22X1 | 5 |

### 6.3 System Reliability Improvements

Vegetation management projects completed in 2022 or planned for 2023 that are expected to improve the reliability of the 2022 worst performing circuits are included in Table 10 below. Table 11 below details electric system upgrades scheduled to be completed in 2023 or completed in 2022 to improve system reliability of the 2022 worst performing circuits.

**Table 10**
**Vegetation Management Projects Worst Performing Circuits**

| Circuit(s) | Year of Completion | Project Description |
|---|---|---|
| **E19X3** | 2023 | Reliability Pruning |
| **E51X1** | 2023 | Storm Resiliency Pruning |
| **E27X1** | 2022 | Reliability Pruning |
| | 2023 | Hazard Tree Mitigation<br>Cycle Pruning |
| **E54X1** | 2022 | Hazard Tree Mitigation<br>Cycle Pruning |
| **E47X1** | 2022 | Mid-Cycle Pruning<br>Reliability Pruning |
| **E56X1** | 2022 | Hazard Tree Mitigation<br>Cycle Pruning |
| **E7X2** | 2022 | Hazard Tree Mitigation<br>Mid-Cycle Pruning |
| **E13W2** | 2023 | Storm Resiliency Pruning<br>Hazard Tree Mitigation<br>Cycle Pruning |

| Circuit(s) | Year of Completion | Project Description |
|---|---|---|
| **E22X1** | 2023 | Hazard Tree Mitigation<br>Mid-Cycle Pruning |
| **E6W1** | 2023 | Hazard Tree Mitigation<br>Mid-Cycle Pruning |
| **E2H1** | 2023 | Hazard Tree Mitigation<br>Cycle Pruning |
| **E13W1** | 2022 | Mid-Cycle Pruning |
| | 2023 | Reliability Pruning |
| **E23X1** | 2023 | Hazard Tree Mitigation<br>Mid-Cycle Pruning |

**Table 11**
**Electric System Improvements Performed to Improve Reliability**

| Circuit(s) | Year of Completion | Project Description |
|---|---|---|
| **E51X1** | 2022 | Install Sectionalizers |
| **E27X1** | 2024 | Convert to 34.5kV, Install Reclosers and Implement Auto-Restoration Scheme with 23X1 |
| **E22X1** | 2023 | Install Reclosers and Implement Auto-Restoration Scheme with 54X2 |
| | 2022 | Install FuseSavers |
| **E23X1** | 2024 | Convert to 34.5kV, Install Reclosers and Implement Auto-Restoration Scheme with 27X1 |

## 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, 2022 and December 31, 2022.

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-Seacoast 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 13 indicates that there were thirteen streets that experienced three or more tree related outages in 2022. It is recommended that a forestry review of the areas identified in Table 13 be performed in 2023 in order to identify and address any growth or hazard tree problems.

**Table 12**
**Worst Performing Circuits – Tree Related Outages**

| Circuit | Customer Minutes of Interruption | Number of Customers Interrupted | No. of Interruptions |
|---|---|---|---|
| E51X1 | 227,957 | 1,434 | 14 |
| E47X1 | 220,739 | 2,705 | 10 |
| E7X2 | 168,276 | 1,491 | 4 |
| E22X1 | 117,960 | 1,506 | 9 |
| E56X1 | 96,456 | 583 | 8 |
| E13W1 | 67,035 | 1,243 | 8 |
| E54X1 | 66,396 | 1,034 | 5 |
| E6W1 | 61,408 | 951 | 8 |
| E43X1 | 59,345 | 1,431 | 11 |
| E15X1 | 52,177 | 212 | 4 |

**Table 13**
**Multiple Tree Related Outages by Street**

| Circuit(s) | Street, Town | # Outages | Customer-Minutes of Interruption | Number of Customer Interruptions |
|---|---|---|---|---|
| E28X1 | Exeter Road, Hampton Falls | 6 | 3,241 | 24 |
| E56X1 | Hunt Road, Kingston | 5 | 17,800 | 267 |
| E2X3 | Drinkwater Road, Hampton Falls | 4 | 8,621 | 62 |
| E23X1 | Woodman Road, South Hampton | 4 | 5,755 | 38 |
| E51X1 | Winnicutt Road, Stratham | 3 | 106,692 | 785 |
| E6W1 | South Road, East Kingston | 3 | 43,186 | 705 |
| E13W2 | Highland Road, Newton | 3 | 17,571 | 179 |
| E13W1 | North Main Street, Plaistow | 3 | 12,964 | 91 |
| E6W2 | Rockrimmon Road, Kingston | 3 | 10,764 | 52 |
| E19X3 | Linden Street, Exeter | 3 | 10,743 | 165 |
| E13W2 | Main Street, Newton | 3 | 10,001 | 55 |
| E47X1 | Hersey Lane, Stratham | 3 | 2,287 | 6 |
| E6W2 | North Road, Kingston | 3 | 387 | 3 |

## 8 Failed Equipment

This section is intended to clearly show all equipment failures throughout the study period from January 1, 2022 through December 31, 2022. 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**

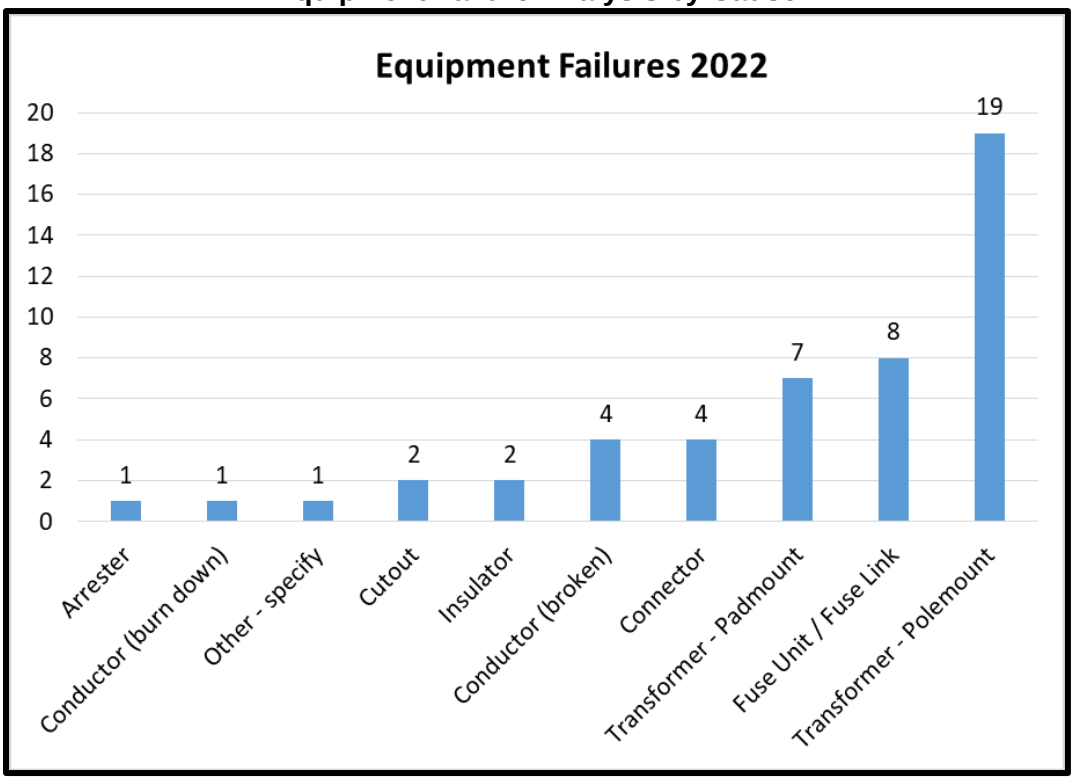



**Chart 8**
**Equipment Failure Analysis by Percentage of Total Failures**

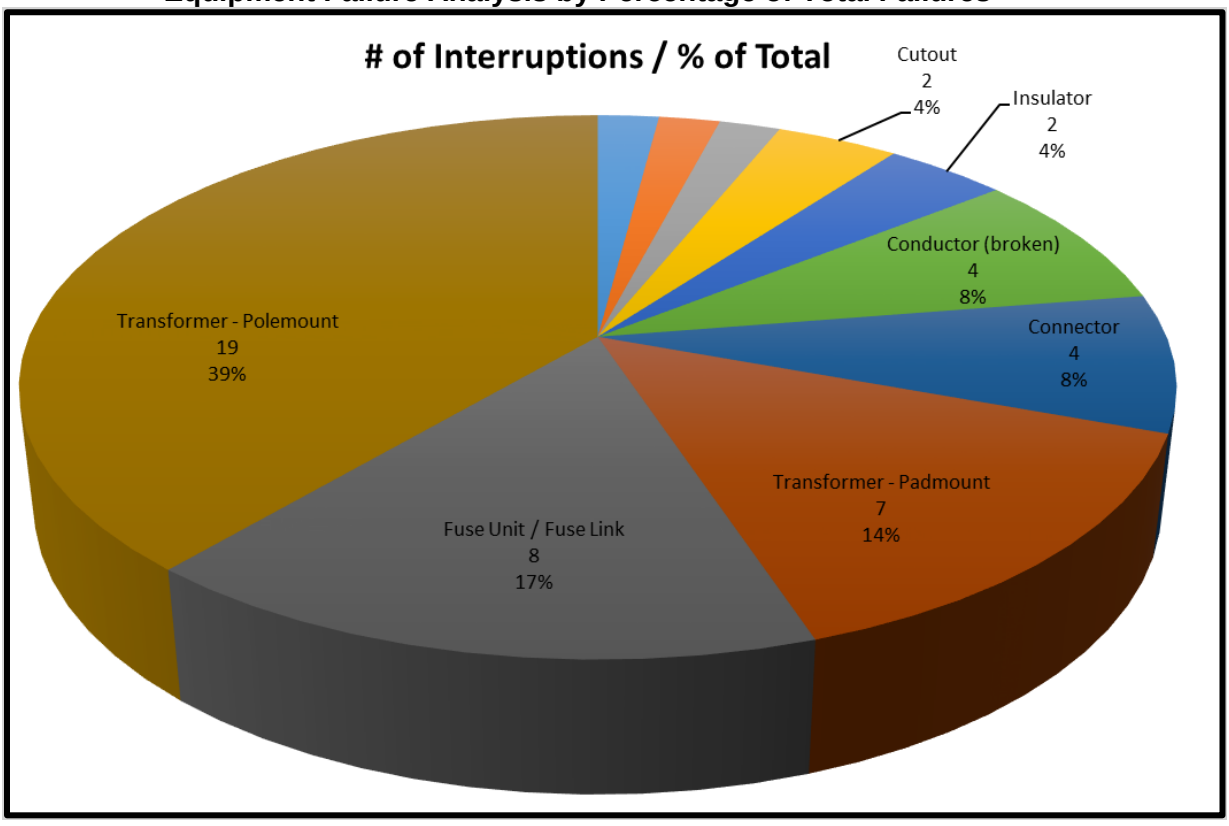
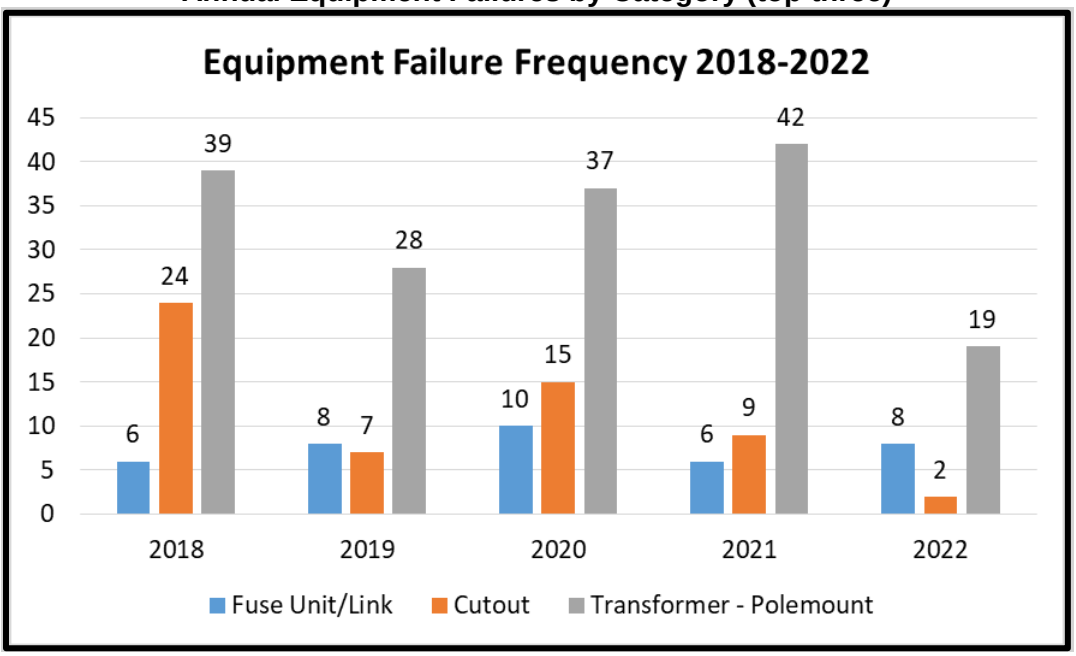


**Chart 9**
**Annual Equipment Failures by Category (top three)**




## 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, 2022 to December 31, 2022 is included in Table 14 below.

The UES-Seacoast system did not have any customers with 7 or more non-exclusionary outages in 2022.

**Table 14**
**Multiple Device Operations**

| Circuit | Number of Operations | Device | Customer Minutes | Customer Interruptions | # of Times on List in Previous 4 Years |
|---|---|---|---|---|---|
| E28X1 | 4 | Fuse, P. 108 Exeter Rd, Hampton Falls | 1,038 | 8 | 0 |
| E6W1 | 3 | Recloser, P. 2 South Rd, East Kingston | 38,616 | 501 | 1 |
| E54X1 | 3 | Recloser, P. 4-A New Boston Rd, Kingston | 241,331 | 3,070 | 1 |
| E13W2 | 3 | Fuse, P. 6 Highland, Newton | 17,571 | 179 | 0 |
| E47X1 | 3 | Fuse, P. 3 Hersey Lane, Stratham | 2,287 | 6 | 0 |
| E47X1 | 3 | Recloser, P. 56 Heights Rd, Stratham | 213,490 | 2,629 | 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 2024 capital budget. All project costs are shown without general construction overheads.

## 10.1 Circuits 6W1 and 6W2 – Construct Circuit Tie

### 10.1.1 Identified Concerns

Circuit 6W1 has been one of the ten worst performing circuits in the UES-Seacoast system in terms of SAIDI and SAIFI for each of the past ten years. Additionally, the owner of a section of property along South Road on 6W1 has repeatedly refused to allow effective pruning and hazard tree mitigation, and this section has been the cause of several tree outages over the past several years.

A project to re-conductor the section of South Road with spacer has been proposed in the past, but even if the project could have been justified for reliability spending, it was impossible to construct because the level of trimming needed for the spacer cable construction wasn't achievable.

### 10.1.2 Recommendation

This project will consist of rebuilding and converting portions of circuit 6W1 and 6W2 from 4.16kV operation to 13.8kV to create a new circuit tie between the two circuits.

Circuits 6W1 and 6W2 along Powwow River Road and Burnt Swamp Road from pole 28 Depot Road Kingston to pole 1 South Road, South Hampton will be rebuilt and converted to three-phase 13.8kV operation.

A new normally open recloser between the circuits will be installed in the vicinity of pole 1 South Road, South Hampton. A normally closed recloser will also be installed at pole 1 South Road in South Hampton.

This project sets the stage for the installation of additional reclosers and the implementation of a future distribution automation scheme.

Customer Exposure = 771 customers

The projected average annual savings for this project is 105,000 customer minutes of interruptions and 0 customer interruptions.

Estimated Project Cost: $1,330,000

## 10.2 Circuits 58X1 and 5X3 – Increase Circuit Tie Capacity and Reconfigure

### 10.2.1 Identified Concerns

Circuit 58X1 and Westville substation as served via the aging radial 3358 line. There is not sufficient distribution circuit tie capacity to restore circuit 58X1 and/or Westville substation for the loss of the 3358 line. Additionally, circuit 58X1 is one of the larger circuits of the UES Seacoast system, serving nearly 11.5MW of load and over 2,250 customers.

### 10.2.2 Recommendation

This project will consist of rebuilding and converting circuit 5X3 from Plaistow substation to the intersection of Sweet Hill Road and Pollard Road. This will allow a majority of the eastern portion of circuit 58X1 to be transferred to circuit 5X3.

To accommodate this load transfer the 5X3 regulators at Plaistow substation will be upgraded to larger units.

The larger 5X3 regulators and the installation of a new gang-operated switch on the 3358 line should provide circuit 5X3 will sufficient capacity to restore circuit 58X1 and Westville substation for the loss of the 3358 line.

Customer Exposure = 5,280 customers (3358 line)

The projected average annual savings for this project is 235,000 customer minutes of interruptions and 450 customer interruptions.

Estimated Project Cost: $1,350,000

## 10.3 Circuits 46X1 and 2X2 – Create Circuit Tie and Reconfigure

### 10.3.1 Identified Concerns

Circuit 46X1 is served from the radial 3346 line without any distribution back-up. Additionally, the 46X1 tap stepdown transformers and structure are aging and are in need of repair and/or replacement.

Circuit 2X2 is one of the larger circuits of the UES Seacoast system, serving nearly 10MW of load and over 2,500 customers.

The circuit tie between 2X2 and circuit 18X1, which has historically allowed the circuit to back one another up is approaching its capacity. The total load and customers served between circuits 2X2 and 18X1 is approximately 23MW and 4,350 customers, respectively.

### 10.3.2 Recommendation

This project will consist of rebuilding and converting circuit 46X1 from Winnacunnet Road tap to the intersection of Winnacunnet Road and Landing Road. This will allow the eastern portion of circuit 2X2 to be transferred to circuit 46X1.

This project will provide sufficient circuit tie capacity to allow circuit 2X2 and 18X1 to back each other up for the foreseeable future. Additionally, this will allow the new circuit tie between circuit 2X2 and 46X1 to be utilized to restore circuit 46X1 and High Street substation for the loss of the 3346 line between the 3346 line tap and the Winnacunnet Road tap.

Customer Exposure = 3,520 customers (3346 line)

The projected average annual savings for this project is 166,000 customer minutes of interruptions and 0 customer interruptions.

Estimated Project Cost: $1,625,000

## 11 Conclusion

The annual electric service reliability of the UES-Seacoast system has seen improvement in the last ten years over prior years after discounting MEDs. 2022 had the second best reliability performance on record to 2019. Much of the overall improvement in reliability can be attributed to an aggressive vegetation management program; however, the most significant risk to reliability of the electric system continues to be vegetation.

The recommendations in this report focus on creating new circuit ties to increase the flexibility of the system to facilitate quicker restoration of customers that can be isolated from faulted sections of the system. This includes upgrading portions of circuits to create back-up supply to the worst performing circuit over the past five years and radial subtransmission lines. This report is also intended to assist the Unitil Forestry group in identifying areas of the system that are being frequently affected by tree related outages to allow proactive measure to be taken.