Investigation Report

Nasonville Substation Fire on August 23, 2022

EC-2022-26

STATE OF RHODE ISLAND

DIVISION OF PUBLIC UTILITIES & CARRIERS

Engineering Section

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Appendix A - Definitions

Bolted Fault – A fault with no fault impedance.

CB - Circuit Breaker

DC - Direct Current

DER - Distributed Energy Resources

DELTA – A way to configure 3-phase power.

Dielectric – Electrical insulator

GMP - Grid Modification Plan

GPS - Global Positioning System

ICE - Interruption Cost Estimate

Impedance – The combined effects of ohmic resistance and reactance.

ISR – Infrastructure Safety and Reliability

KW-Kilowatt

LTC – Load Tap Changer -adjusts the turns ratio inside of a transformer which changes the output voltage.

MOS - Motor Operated Switch

MVA – Megavolt-Amperes, means 1 million volts-amps. Units used to show the capacity of large transformers.

MW -Megawatt

MWhrs - Megawatt hours

OHL - Over Head Line

PPL - PPL Corporation. A Pennsylvania corporation organized under the laws of Delaware that purchased The Narragansett Electric Company, a Rhode Island corporation, from National Grid USA on May 25, 2022. The Narragansett Electric Company now does business as Rhode Island Electric, but formerly did business as National Grid Electric while owned by National Grid USA. At the time of the incident addressed by this report, The Narragansett Electric Company was operating as a indirect subsidiary wholly owned by PPL Corporation.

PUD - Pascoag Utility District

PV - Photovoltaic

RIDPUC – Rhode Island Division of Public Utilities and Carriers

SCADA - Supervisory Control And Data Acquisition

RIE - Rhode Island Energy

ROW - Right of Way

R/W - Right of Way

USDOE- United Stated Department of Energy

WYE - A way to configure 3-phase power.

Executive Summary

This report is a cumulation of reports and other communication provided by The Narragansett Electric Company dba Rhode Island Energy and Pascoag Utility District which were submitted by those utilities as requested by the Division of Public Utilities and Carriers under Engineering reference number 2022-26 (“EC-2022-26”) regarding the “Nasonville Substation[1]”.

On Tuesday, August 23, 2022, at 18:23 (6:23 p.m.) during a thunderstorm, Rhode Island Energy’s (“RIE”) Nasonville Substation, located on Douglas Turnpike in Burrillville, Rhode Island, had an issue, causing a fire within the substation. Initial reports from Pascoag Utility District (“PUD” or “Pascoag”) to the Rhode Island Division of Public Utilities and Carriers (“RIDPUC” or “Division”) stated that the fire was caused by a lightning strike. However, it was later determined that the fire was most likely caused by a dielectric failure between the rosette to stab connection on the number 41-feeder breaker C-phase terminal to the switchgear bus that is located inside of the switchgear building within the Nasonville Substation. No injuries were reported.

The dielectric failure happened after a tree fell across the 41-feeder three-phase wires resulting in a significant through fault current and, subsequently, cycling of a recloser which cleared the tree fault. Nasonville Substation differential relaying operated in response to the switch gear bus fault. The differential relaying at the Nasonville substation attempted to de-energize. The differential relaying was designed to open all 15kV breakers, close the 115kV grounding switch (which will create a 115kV fault and cause the West Farnum circuit breakers to open), and then have the three-phase gang motor operated air-break switch at Nasonville open to isolate the substation. However, the grounding switch failed to close, and the three-phase gang motor operated air-break switch opened under load (causing the contact arms to flash, resulting in significant damage to them), which caused a fault since the switch was not designed to open under load. This fault is what caused the West Farnum circuit breakers to open. The 15kV fault did not cause the West Farnum circuit breakers to operate.

This incident caused 4,700 Pascoag and 4,617 RIE customers to lose power; in total 9,317 electric customers lost power. These customers were gradually restored using a variety of methods including feeder transfers, a new battery storage system at Pascoag, onsite generation, and roll-on generation. The roll-on generation was run during the peak loading periods of each day. During restoration, while transferring loads, a splice failed on a primary wire located on Smithfield Road in Woonsocket, resulting in the wire falling to the ground, prompting a separate recloser to de-energize that circuit. Restoration efforts also experienced high and low voltage issues that required adjustments to equipment in order to correct.

A temporary mobile relay station[2] and other equipment were installed at the Nasonville Substation while tests of the Nasonville Substation transformer were performed. The duration of the event was Tuesday, August 23, 2022, at 18:23, to Saturday, August 27, 2022, at 19:00, when 100% of the load served by the Nasonville Substation had been transferred to the mobile switchgear. (The decommissioning of the “roll-on” generation occurred on Wednesday, September 1, 2022.)

Incident Summary

No injuries were reported in this incident. On Tuesday, August 23, 2022, during a severe thunderstorm that included torrential downpours, lightning, and wind gusts of 17 mph, at 18:20:27

[1] See appendix B and C. Also, the Electric Infrastructure Safety Reliability (“ISR”) reports Docket Number 22-53-EL (FY-2023-2024)
[2] Also referred to as a switch station or mobile switchgear.

(6:20:27 p.m.), the 641026 recloser[3] located on pole number 227[4], which protects the 127W41 feeder, tripped due to a phase-to-phase fault caused by a fallen tree (discussed in more detail later in this report). The recloser, which acts as a self-resetting circuit breaker, was pre-programmed to a four-shot reclosing sequence.

At 18:20:31 (6:20:31 p.m.), the Nasonville Substation 127W41[5] breaker opened, reclosed approximately 5 seconds later, opened, and then closed approximately 12 seconds later (this 127W41 feeder breaker was found in the open position[6]). Approximately three (3) minutes later, at 18:23 (6:23 p.m.), the Nasonville transformer differential lockout relay[7] operated. This transformer is located within RIE's Nasonville Substation[8]. This substation is numbered 127, built in the 1981-1982 timeframe, and provides electric power to the northwestern part of Rhode Island (including retail service to portions of North Smithfield, Burrillville, Gloucester, and wholesale service to the Pascoag Utility District). The substation has one transformer[9] and is located at 445 Douglas Turnpike, Burrillville, Rhode Island.

Concurrently, the 271-1 Motor Operated Switch (MOS)[10] opened, and the West Farnum Substation[11] 1710 and 1712 breakers opened. Since the West Farnum substation provides 115kV electricity to Nasonville, this resulted in the loss of all Nasonville Substation's feeders (in other words, loss of power to some RIE customers and all PUD customers) which triggered alarms at RIE's Distribution Dispatch located in Lincoln, Rhode Island. When the 271-1 MOS opened, it flashed over[12], damaging its contact arms due to the through fault current (discussed in more detail in a few other sections in this report, also see "Equipment Failure" specifically the grounding switch[13] that failed to operate).

When an RIE Substation Supervisor arrived at the Nasonville Substation, he found a fire with thick smoke emanating from inside the station switchgear building[14]. RIE's overhead line department isolated the feeders from the switchgear and, once the isolation was confirmed, firefighters were allowed to enter the switchgear building and put out the smoldering fire with portable chemical extinguishers while additional RIE engineers and operations personnel responded to this substation.

PUD personnel also responded to the substation and had a similar explanation of events after they surveyed the situation and documented what they witnessed with pictures (see pictures in Appendix A). A resulting email from Pascoag to the Division explained that all of Pascoag's customers were out from approximately 6:30 p.m. to 12:00 a.m. (roughly five and a half hours) and once the fire was extinguished, RIE crews and operations team were able to reroute feeders to restore power to Pascoag and the rest of the town. The email also explained that the outage was

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[3] G&W Electric Catalog #: VIP378ER-12S, 15.5 kV, 800 amperes, 12.5 kA interrupting, manufactured in August of 2010, installed in 2013, and inspected annually. Source: See RIE's report dated March 3, 2023 response to question 34,35, and 36.
[4] GPS location: 41.96316, -71.64439, 1422 Victory Highway, Oakland, RI 02858.
[5] Also referred to as W41 or 41 feeder in this report or reference reports.
[6] RIE response to question 41 in their March 3, 2023, report (see Appendix C).
[7] The substation relaying was last tested on January 3, 2022. Proposed FY2024 Electric ISR 22-53-EL dated January 6, 2023.
[8] GPS coordinates 41.974456,-71.609834.
[9] 115 kV to 13.8 kV load tap changing transformer with a delta/wye winding configuration, 30 degree lagging. 28,000/37,333/46,667 kVA OA/FA/FA @ 65 deg C rise. The switchgear feeds four 13.8 kV grounded wye distribution feeders: 127W40, 127W41, 127W42, and 127W43.
[10] Motor Operated Switch ("MOS") which in this case is the 3-phase air-break gang switch located on the A-frame structure within Nasonville substation.
[11] Substation number 17, located at 231 Greenville Road, North Smithfield, RI, 02896.
[12] See picture in Appendix A showing the thermal damage to the contact arms.
[13] The grounding switch was last functionally tested and inspected on March 11, 2006. Source: Proposed FY2024 Electric ISR 22-53-EL dated January 6, 2023.
[14] Sometimes referred to as a relay station in this report or other referenced reports.

due to a catastrophe at RIE's Nasonville Substation which was caused by a lightning strike (it was later determined that lightning was not the cause).

This event initially caused the 127W40, 127W41, 127W42, and 127W43 distribution feeders leaving the Nasonville Substation to go offline, resulting in 4,617 RIE customers and 4,700 PUD customers losing electricity[15] (in total 9,317 customers, including Eleanor Slater Hospital, Zambarano unit, and other large customers).

RIE took immediate action, with over fifty (50) RIE personnel mobilized for the restoration of service through switching operations, deployment of contracted emergency generation, replacement of the failed switchgear, and working to bring customers online. At approximately 22:30 (10:30 p.m.), during the restoration of the Nasonville load, the tree that fell across the Nasonville W41[16] feeder, caused another fault (when power was being diverted around the Nasonville Substation through alternate feeders, the same tree that caused the first power outage, caused a second outage), which resulted in a reclose sequence from the Woonsocket 26W5 feeder. The through fault currents caused a splice (tension sleeve) to fail, causing an energized primary wire[17] to fall to the ground between poles 409 and 410 on Smithfield Road in Woonsocket, Rhode Island[18]. This resulted in recloser 642135[19] opening (which immediately de-energized that circuit, so it only created a public safety hazard for a very short time). Restoration also resulted in high and low voltage issues for some customers.

Even though power was restored to all customers by August 27, 2022, at 19:00 hours, the Nasonville substation remained out of service, which resulted in capacity limitations and the need for additional localized generation and conservation measures. Per RIE's request, one 4-6 megavolt ampere ("MVA") customer agreed to shut down for the first two days after this incident[20]. PUD cooperated fully with Rhode Island Energy and utilized their one (1) megawatt ("MW") generator and nine (9) megawatt hours ("MWhs") of energy storage equipment to provide load relief during peak load periods while the system was in its reconfigured state. This required very close coordination between RIE and PUD during the event. Eleanor Slater Hospital, Zambarano unit, also cooperated with RIE with their deployment of 750 Kilowatt ("kW") of emergency backup generation. Separately, a large commercial customer (a food production and manufacturing company) located in the Town of Burrillville also cooperated with RIE by curtailing loads and canceling a working shift. Additional restoration efforts included the use of existing distributed generation (solar PV), and existing and roll-on diesel generation, to support system load during constraint periods over the multi-day effort[21]. Fortunately, through the use of a prior agreement[22] in place with National Grid, RIE was able to expeditiously obtain mobile switchgear and mobile substation cables by 9:00 a.m. the next morning. For more details, see the section "Called Upon Distributed Generation and Details" below.

RIE investigated what caused the 41 feeder recloser (641026) to trip and found that a tree[23] (previously mentioned above) growing just outside of the 70-foot-wide transmission easement

15 For details, see Appendix B, response to question 9.
16 Also referred to as the 127W41.
17 This primary wire had a voltage of 7,967 volts (RMS value).
18 GPS Coordinates 41.98550, - 71.52141.
19 Located on pole 590 Victory Highway, North Smithfield, GPS Coordinates 42.00682, -71.58334.
20 RIE used an United States Department of Energy ("USDOE") Interruption Cost Estimate ("ICE") calculator to calculate this interruption cost;
21 See Appendix B, response to question A, for more details response.
22 Transition Services agreement that was entered into on May 25, 2022 (the date acquisition from National Grid to PPL Rhode Island Holdings). See details Appendix B under the response to question 8.
23 GPS coordinates 41.961967,-71.662496.

between the Nasonville Substation and PUD's substation fell[24] onto the 41 feeder which consisted of three-phase[25] power lines. When this tree fell on the 41 feeder, it caused phase-to-phase fault current[26]. On August 24, 2023, at 1:26 p.m., the tree on the 41 feeder that caused the initial fault was cleared from the power lines. PUD owns the Right of Way ("ROW") easement for the affected transmission line, but RIE is responsible for the vegetation management in this ROW. RIE also explained that this section of the feeder was checked for hazardous trees during its routine maintenance cycle in April and May of 2022, about three months before the incident. A review of the section of this report "Pictures of the Tree that Fell on the 41-Feeder", one can see that the tree that fell causing this problem still had leaves on it, suggesting that it would not have been obvious during the April-May 2022 maintenance cycle that this was a tree that was in distress or otherwise at risk of falling.

From August 24, 2022, to August 27, 2022, Division personnel were onsite at the Nasonville Substation to witness firsthand the extensive damage to the switchgear building and other utility equipment in addition to monitoring the restoration efforts including repairs, maintenance, and inspection of the utility assets. It was also explained to the Division personnel that foot patrols were done on the B-23 transmission feeder that supplies power to this substation to ensure no damage was found and it was safe to re-energize.

On August 27, 2022, Division personnel witnessed a utility inspection helicopter fly over the B-23 transmission feeder and then circle the Nasonville substation. The Division was also informed that the transformer passed all of the tests and RIE was preparing to energize it later that afternoon. During the initial re-energization of the transformer, the substation needed to be evacuated as a precautionary measure, which is standard utility protocol. Division personnel observed solid copper bars that were installed in the A-frame structure within the Nasonville Substation to temporarily replace the damaged copper contact arms of the motor-operated three-phase gang switch (see pictures in appendix A).

The duration of this event ended on Saturday, August 27, 2022, at 19:00 (7:00 p.m.), with mobile switchgear and mobile substation cables remaining in place with 100% of the load served by Nasonville having been transferred to the mobile switchgear. The decommissioning of the "roll-on" generation occurred on Wednesday, September 1, 2022.

Further Investigation

As the investigation progressed, the evidence suggested that it was likely that the through fault current from the fallen tree damaged the rosette-to-stab connection on the 41-breaker[27] C-phase terminal to the switchgear bus[28]. This damaged connection created a dielectric failure[29] resulting in sustained arcing with extreme heat within the C-phase rosette terminal (rosette-to-stab connection) between the switchgear bus and the breaker[30] terminal located inside of the 41-feeder

24 Between pole 253 and pole 254, near Clear River Road, GPS Coordinates 41.96206, -71.66249.
25 WYE configuration.
26 Phase currents were approximately 3,156 amperes peak (2,231 amperes RMS) and 2,600 amperes peak (1,838 amperes RMS).
27 Installed in 2010, source RIE's response to Division question 26, dated March 3, 2023. No specific maintenance is required on the rosette to stab connection; however, inspections are done every 15 years. This switchgear was last inspected in 2009, source RIE's report dated March 3, 2023 response to question 33.
28 The expected life of a present-day switchgear circuit breaker is approximately 30 years. Source RIE's response to Division question 25, dated March 3, 2023.
29 See RIE's report dated March 3, 2023 response to question 32 and 33 and other locations within the report. Also, RIE's report dated November 16, 2023, response to question 2.
30 The 41 feeder ABB breaker was an is manufactured by Federal Pacific, make and model: ABB RMVAC DST-2-15-500-12 vacuum circuit breaker, 15 kV, 1,200 ampere.

cubicle within the Nasonville Substation, thereby destroying isolation and insulation systems and causing the faulting of the switchgear bus. In other words, when the fault occurred, the large amount of fault current (and mechanical forces associated with it) caused the rosette breaker connection to the switchgear bus to loosen and the impedance to increase. Once the pole top recloser[31] cleared the fault, normal load current flowed through the connection. The increased impedance, in conjunction with the load current, caused the breaker connection to heat up, arc, and eventually start the fire within the switchgear.

As the arc evolved, the West Farnum Substation over current protection scheme operated, but it was not designed to operate directly from fault current on the medium voltage 15kV system. When a fault occurred on the 15kV bus at Nasonville Substation, the differential scheme should have operated, which should have closed the 115kV grounding switch (creating a 115kV single line to ground fault), which would have created enough fault current to cause the West Farnum circuit breakers to open.

RIE had previously been alerted during a maintenance inspection of the Nasonville Substation in June of 2019 that a damaged rosette was found. RIE explained that, in general, Federal Pacific electrical equipment designs have **not** been known to be the most robust. Nasonville Substation is the **only** station in Rhode Island to have the Federal Pacific plug-in connections[32]. A spare breaker was installed in this feeder cubicle until a replacement rosette could be delivered. In March 2020, a new rosette was installed, the spare breaker was removed, and the original breaker was returned to service.

The Division questioned RIE about whether a test was done on the repair and RIE explained that the repair was completed without testing. However, when asked about the testing process, RIE explained that testing these terminal connections would necessitate taking the entire Nasonville switchgear bus out of service. In this case, the testing was not performed because the repair was thought to be complete (replacement of the damaged rosette) and did not necessitate testing[33], and RIE believes that it is very unlikely that testing would have indicated a problem[34]. RIE explained that had a test been done, it would have been tested at 100 amps DC[35], which is well below the through fault current that the rosette experienced. The Division also asked if it is industry standard to perform tests after such repairs, what the standard is, and where that information can be found if available. RIE explained that they know of no specific industry standard that specifies the testing of rosettes after replacement[36].

RIE explained to the Division that, given that the switchgear was damaged beyond repair, and because the site configuration allows for it, RIE was moving forward with the standard PPL Corporation ("PPL") open-air double-ended substation[37].

On September 13, 2022, the Division sent its first set of data requests to RIE. RIE responded to those requests on November 16, 2022, which described the tree that fell on the 41-feeder. On November 22, 2022, Division personnel went onsite to where the tree fell on the 41-feeder, observed the tree and the surrounding area, and took pictures. It was noted that the tree failed at

31 641026 recloser
32 RIE response dated March 3, 2023, to question 23.
33 Response to question 20 in RIE's March 3, 2023 report.
34 Response to question 21 in RIE's March 3, 2023 report.
35 Response to question 22 in RIE's March 3, 2023, report. PPL is RIE's parent corporation.
36 Response to question 54.b in RIE's March 3, 2023, report.
37 Source: FY2023 Electric Infrastructure, Safety and Reliability ("ISR") Plan dated March 2, 2023.

its base, from what appeared to be insect damage and associated decay. The base (stump) of the tree was located several feet outside of the tree line edge of the ROW. A large number of leaves were observed on the tree, suggesting it may have still been a living tree when it fell. Pictures were also taken of the 41-feeder recloser. For pictures, see Appendix A.

Equipment Failure

RIE was asked if any of the equipment failed. Their responses are below:

- It is likely that 41-breaker C-phase terminal to the switchgear bus connection failed from the initial feeder fault current.
- The single-phase high-side grounding switch failed to operate. That resulted in damage to the 115 kV motorized disconnect switch but did not contribute significantly to the damage to the switchgear. The grounding switch was inspected and found to have not operated due to oil bleed of the lubricating grease.
- One phase of the Woonsocket Substation 26W5 feeder fell down resulting from the additional load of the Nasonville feeders and a fallen tree.

Additional Details on RIE's Restoration Efforts

Power restoration was a multi-step effort that was completed over several days.

Step 1 included immediate action by the Rhode Island Energy Distribution Dispatch in Lincoln, Rhode Island, using existing feeder ties to pick up load as soon as possible (details below).

Step 2 included the use of existing distributed generation, inclusive of solar, battery energy storage, and both existing and roll-on diesel generation, to support system load during constraint periods over the multi-day effort (details below).

Step 3 included the installation of the mobile switchgear for restoration of all feeders to normal configuration (details below).

Step 1 (8/23/2022)

18:23 4,617 Rhode Island Energy customers and 4,700 Pascoag Utility District customers out at beginning of event (127W40, 127W41, 127W42, & 127W43 Feeders)

19:03 2,623 Rhode Island Energy customers out, 1,994 customers restored using OHL crews via field ties (two-thirds of 127W40 feeder re-energized)

19:30 1,684 Rhode Island Energy customers out, 939 additional customers restored using OHL crews via field ties (remaining 127W40 feeder re-energized)

19:44 661 Rhode Island Energy customers out, 1,023 additional customers restored using OHL crews via field ties (127W42 re-energized)

20:31 658 Rhode Island Energy customers out, 3 additional customers restored, Pascoag Utility District customers restored, using OHL crews via field ties (127W43 re-energized)

21:35 19 Rhode Island Energy customers out, 639 additional customers restored using OHL crews via field ties (most of 127W41 re-energized)

**At this time waiting on loads to decrease and crews to investigate a possible recloser issue to pick up remaining customers.

22:25 Tree branch in ROW on the 127W41 feeder causes a fault which results in a phase burning down on Providence Pike[38]. Due to previous restore 26W5 CB locks out, which causes 5,404 customers to lose power (most of 127W40, most of 127W41, all of 127W42 and 50% of normal 26W5 customers). This is the second outage of the event to 4,108 customers, first outage of event to 1,315 customers.

23:01 Phase Down issue isolated, 70 customers restored via remote switching, 5,334 remaining out (Original 26W5 customers)

08/24/2022

00:37 Further repairs made to Providence Pike[39], OHL crews keep Nasonville load isolated and restore 1,245 customers via OHL field switching (all original 26W5 customers now restored)

00:52 Further patrol completed with no issues found, OHL crews completed switching to restore 473 customers. 3,616 customers still out. (Portion of 127W40 restored)

01:13 Further patrol completed with no issues found, 1,015 customers restored via remote SCADA switching 2,601 customers still out (Portion of 127W40)

01:26 Tree in R/W issue cleared, remaining R/W patrol completed with no other issues found. All customers restored via remote SCADA switching.

Step 2 (8/24/2022 – 8/27/2022)

• Continuous monitoring of third party owned solar generating sites. This effort was primarily reactive to adjust for loss of solar due to cloud coverage.

• Continuous coordination with Pascoag, optimizing use and dispatch of their battery energy storage system and rotating generation.

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[38] This was an error in RIE's response in their report dated November 16, 2022, in response to question 9. The correction can be found in RIE's response to question 16, section "C", in their report dated March 3, 2023; it was corrected to Smithfield Road.

[39] This was an error in RIE's response in their report dated November 16, 2022 in response to question 9. The correction can be found in RIE's response to question 16, section "C", in their report dated March 3, 2023; it was corrected to Smithfield Road.

• 3 Megawatts of roll-on generation was installed at the Harrisville Fire District Water Department Site (115 Central St., Burrillville, RI). The equipment was on site on 8/25/2022 at 15:30 and picked up load at 20:05.

• 3 Megawatts of roll-on generation was installed along the ROW, adjacent to the Burrillville Wastewater Treatment Plant (151 Clear River Dr., Burrillville, RI). The equipment was on site on 8/25/2022 at 20:00 and picked up load on 8/26/2022 at 14:40.

• 3 Megawatts of roll-on generation was installed along the ROW near the Burrillville Police Station (1477 Victory Highway, Oakland, RI). The equipment was on site on 8/26/2022 at 12:30 and picked up load at 18:00.

Step 3 (8/24/2022 – 9/6/2022)

• Mobile switchgear and a mobile battery-bank were delivered to Nasonville on Wednesday morning, 8/24/2022. Feeder cables were removed from the existing switchgear and extended to the mobile switchgear. Primary supply and control cables were installed from the transformer to the mobile switchgear. A temporary AC service was installed. Low voltage supply and control cables were installed from the mobile battery-bank to the mobile switchgear. The substation transformer was tested and confirmed to be acceptable for service. On Saturday, August 27th, the mobile switchgear was energized and the Nasonville feeders were restored to normal configurations by 7:00 p.m. On September 6, 2022, a remote terminal unit and the cellular antenna[40] were installed for SCADA indication and control.

Feeder transfers:

- Portions of the Woonsocket Sub. 26W1 feeder were transferred to the Woonsocket Sub. 26W7 feeder.
- Portions of the Woonsocket Sub. 26W5 feeder were transferred to the Riverside Sub. 108W53 and the Riverside Sub. 108W61 feeder.
- All of the Nasonville 127W43 feeder including Pascoag was transferred to the Woonsocket 26W1 feeder.
- All of the Nasonville 127W42 feeder was transferred to the Woonsocket 26W5 feeder.
- Portions of the Nasonville 127W41 feeder were transferred to the Woonsocket 26W5 (RI Energy customers) and the 26W1 (Pascoag).
- Portions of the Nasonville 127W40 feeder were transferred to the Woonsocket 26W5 feeder, 321W2 feeder, and 26W7 feeder.

100% of the load served by Nasonville had been transferred to the mobile switchgear as of Saturday, August 27th at 19:00.

[40] RIE explained to the Division that cell phone coverage in this area is poor. To resolve this, RIE installed a 55 foot tall utility pole to get better reception.

Lessons Learned

Rhode Island Energy explained that the following are lessons learned from this event:

a) Good communication between field groups allowed an extensive amount of work to be sequenced efficiently and safely.

b) Availability of spare equipment is important.

c) Rhode Island Energy was able to procure and deploy roll-on generation at various locations to provide load relief to Burrillville area customers during the time that the system was reconfigured and Nasonville load was fed from adjacent substations. These generators were run during the peak loading periods of each day.

d) Rhode Island Energy coordinated with Pascoag to utilize their generation and energy storage equipment to provide load relief during peak load periods while the system was in its reconfigured state. This required very close coordination with Rhode Island Energy and Pascoag during the event.

e) Over 20 MWs of distributed generation exists within the contingency response area. Reliance of these resources was important in providing power to area customers; however, the significant intermittency due to cloud cover or other events, reduced the distributed generation dependability.

f) High solar penetration in the served area, complicated the deployment of roll-on generation because of system stability.

g) Advanced device sensing (capacitors and reclosers) capabilities were critical to providing important information to manage the system during the event.

h) Lessons "e" to "g", above, indicate the need for more sensing, monitoring, and control locations necessary for optimal contingency response.

i) Cellular communication coverage in the area of Nasonville Substation is poor.

j) Scheduling detail officers on an emergency basis is not possible.

k) Best practice is for Rhode Island Energy Operations to continue to work closer with the Customer team, including the staff that have the relationships with key accounts, in response situations like the one encountered.

l) Proactively notifying customers allows them to make informed business decisions, which can improve recovery times and prevent product spoilage.

m) Working to curtail a few large customers may be preferential to disrupting hundreds of smaller customers.

n) Large customers should employ a soft/staggered restart strategy when turning high demand equipment back on.

o) Communication is crucial – Rhode Island Energy's key account manager had internal access to the right information at the right time leading to responsive decision making all because lines of communication were kept open with the Customer team, which lead to openness with the large commercial customer (a food production and manufacturing company) throughout the duration of the event.

Called Upon Distributed Generation and Details:

- Pascoag was called on to deploy their 1 MW of generation and 9 MWhrs of energy storage equipment.

- Eleanor Slater Hospital, Zambarano was called upon to deploy 750 kW of emergency backup generation.

- Solar generation sites are not typically designed to be dispatched. The sites generate when the sunlight and utility connection is supportive.

- Typically, solar generation sites of 1 MW or greater connect to the distribution system through reclosers equipped with radio communications. Real time data for generation sites of less than 1 MW are typically not available to Rhode Island Energy Distribution Dispatch.

- 1 MW PV RI 16721813, Brandywick LLC, 90 Tifft Rd.: 26W7 Feeder
- 1 MW PV, P24-33 Tifft Rd., 26W7 Feeder
- 6.22 MW PV, RI 26549231, King Solar, 20 Oxford Rd., 26W7 Feeder
- 2 MW PV, RI 24201390, 19733795, North Smithfield Solar, 1 Pound Hill Rd., 26W1 Feeder
- 6.22 MW PV, RI 24845370, Turning Point Energy, P117-3 Pound Hill Rd. 26W1 Feeder
- 0.84 MW PV, RI 25255833, Greenville Rd. Solar, P62-4 Greenville Rd., 26W1 Feeder
- 1.6 MW Hydro, RI 138, Ridgewood Power, P37-24 ROW off St. Paul St., 26W5 Feeder
- 2.54 MW PV, RI 23918636, Nautilus Solar, P302-3 Victory Highway, 127W42 Feeder
- 3.3 MW PV, RI 2399135, 0 Danielle Drive, Burrillville Solar, 127W42 Feeder
- 3.9 MW PV, FI 29106677, 0 Log Rd., Log Rd. Solar, 127W40 Feeder
- 1 MW Generation, Pascoag Municipal, 127W41, 127W43 Feeders

For additional details, see the March 3, 2023, report on feeder transfers, distributed generation, capacitor and recloser information, restoration efforts, etc.

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The Nasonville incident has been used by RIE to support the need for immediate Grid Modernization Plan ("GMP") investments, see the Electric 22-53-EL ISR filing and appendix "C" for more details.

***

Cost of Restoration[41]

- Rhode Island Energy explained that the following expenses were occurred during this event:
- Emergency restoration Rhode Island Energy: $461,000
- 9 MWs of contracted emergency generator deployment: $400,000
- Leasing of mobile switchgear: $100,000
- The cost to install a replacement station to restore the original station capability is approximately $5 million.

Cost and Plan to Rebuild the Nasonville Substation

In the FY2023-2024 Electric ISR, under the Nasonville Project, it was explained that the Company will replace the failed switchgear with an open-air straight bus that will include a main breaker, capacitor breaker, and four (4) feeder breakers. Restoration and commencement of design, engineering, and procurement of long lead time materials is captured in the FY 2023 ISR Plan, where the Company incurred $2 million of expenditures in the Damage/Failure category and $1 million in System Capacity. The Company has budgeted an additional $2.7 million in Damage/Failure and $4.5 million in the 21-Month Plan for switchgear replacement. The Company's Northwest Rhode Island Area Study had previously identified the need for Nasonville station upgrades due to contingency load at risk, recommending that a future new 115kV supply line be installed along with a second transformer. RIE will reassess that study as a result of this failure and outcomes will be evaluated by the Division. For the immediate planned work, the Division does not propose modifications to the Company's project implementation plans or budgets and has concurred with the FY 2024 ISR Plan spend as proposed.

Update: (During the creation of this report: The new 115kV supply line and second transformer installation at Nasonville was proposed and approved under the FY24 ISR plan. The Northwest Rhode Island Area Study will not be reassessed as it was already determined that the Nasonville substation needs to be expanded. RIE will proceed with the Damage & Failure work along with the approved Nasonville expansion project.)

[41] RIE's response to question 11 in their report dated November 16, 2022 (Appendix B).

Division Conclusion & Recommendations

It needs to be pointed out that PPL[42] had recently purchased (May 25, 2022) the distribution system in Rhode Island, and did an excellent job responding to this incident, as did PUD. Customer services were restored in a matter of hours due to the utilities planning for these scenarios and excellent communication skills, both with each other and with their largest customers and State regulators. The success in arranging for several large customers to either reduce their own demands during this emergency, or provide distributed generation back to the utilities, is particularly noteworthy. Both the utilities and their customers are to be commended for their response to this emergency.

A tree fault, caused by a tree located outside of the utility easement, but falling onto the power lines, should not have created a fault condition that caused substation equipment to fail. RIE confirmed, as did the prior National Grid switchgear analysis, that this switchgear was in "good condition" and had many years of remaining life. However, RIE also explained that Federal Pacific electrical equipment designs have **not** been known to be the most robust. Nasonville Substation was the **only** station in Rhode Island to have the Federal Pacific plug in connections. We would note, however, that this particular electrical equipment design had been in place for many years, and was probably installed before issues with this type of Federal Pacific electrical equipment design were identified.

RIE believes that the 41-feeder recloser properly cleared the tree fault. However, RIE further explained that engineering guidelines recommend that bolted faults at the end of the protected zone trip under 1-second. However, higher impedance faults, such as a tree fault, are allowed to take longer to trip since fault current will be lower. At this fault current level, the recloser clearing time aligns with the trip curve of this recloser.

The evidence suggests that the likely cause of this substation fire and outage event was a failure between the rosette to stab connection on the 41-feeder[43] breaker C-phase terminal to the switchgear bus that is located inside of the switchgear building within the Nasonville Substation. The failure most likely occurred from through fault current after a tree fell on the 41-feeder. The damaged rosette terminal connection resulted in sustained arcing with extreme heat, destroying isolation and insulation systems, and causing the faulting switchgear bus.
This substation fire resulted in 9,317 customers, including a hospital, losing electricity; however, most customers were restored in a short number of hours. Some customers were asked to stay offline for an extended time because their loads were too high, and others were asked to operate their backup generators. Restoration efforts were complicated by solar farms back feeding electricity to the grid, fluctuating loads, roll-on generation, and high and low voltages that took additional manpower to correct. Some customers reported voltages as low as 96 volts.

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[42] PPL Corporation. A Pennsylvania corporation organized under the laws of Delaware that purchased The Narragansett Electric Company, a Rhode Island corporation, from National Grid USA on May 25, 2022. The Narragansett Electric Company now does business as Rhode Island Electric ("RIE"), but formerly did business as National Grid Electric while owned by National Grid USA. At the time of the incident addressed by this report, The Narragansett Electric Company was operating as a indirect subsidiary wholly owned by PPL Corporation.
43 Installed in 2010, source RIE's response to Division question 26, dated March 3, 2023. No specific maintenance is required on the rosette to stab connection; however, inspections are done every 15 years. This switchgear was last inspected in 2009, source RIE's report dated March 3, 2023 response to question 33.

The best "root cause" analysis RIE has is that a dielectric failure on the C-phase rosette terminal is to blame for this incident because the damage was so extensive; however, an absolute firm "root cause" is not possible to definitively identify.

Considering that Nasonville Substation is the **<u>only</u>** station in Rhode Island to have the Federal Pacific plug-in connections, this failure would appear to be an isolated incident not likely to reoccur with any other substations in Rhode Island.

<u>Appendix B</u>

Photographs of Key locations regarding the Nasonville Substation Fire

<u>Pictures of the Nasonville Substation Aerial Views and Fire Damage</u>

Nasonville Substation before the fire

Map Source: Google Maps, (GPS Coordinates 41.974456,-71.609834)

Below shows pictures of the Nasonville Substation fire that were emailed to the Division from PUD

Below shows the fire damage to the station switchgear building dated August 24, 2022.

Below shows the fire damage to the inside of the station switchgear building, dated August 24, 2022.

Below shows the fire damage to the inside of the station switchgear building, from the opposite end of the building than the picture above, dated August 24, 2022.

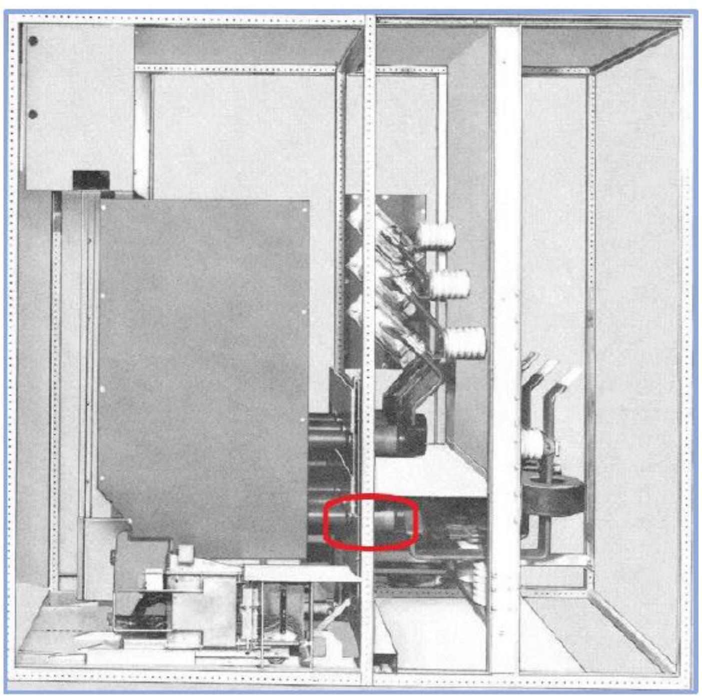
Below shows the fire damage to the inside of the station switchgear building, specifically the 41-breaker cell, dated August 24, 2022. The majority of the fire damaged occurred inside of this cell.

Below, the white circle, shows the outside access to the 41-feeder breaker cell which shows extensive fire damage.

Below, shows the outside access to the 41-feeder breaker cell (left) which shows extensive fire damage and the far less damage to the neighboring breaker cell (right). Dated August 24, 2022.

Below, shows the fire damage to the back of the station switchgear building, dated August 24, 2022.

Illustration of what failed (Source RIE report dated November 16, 2022, additional picture in Appendix B)



New installation Picture (Source RIE report dated November 16, 2022, additional pictures in Appendix B)

2011 Installation of Replacement

<u>Picture after incident (Source RIE report dated November 16, 2022, additional pictures in Appendix B)</u>

Failed 41 Feeder Breaker

<u>Below shows the two sides of the Rosette insulating tubes (Source RIE report dated November 16, 2022, additional pictures in Appendix B)</u>


11/02/2022

Pictures of the Tree that Fell on the 41-Feeder

The location where the tree fell on the 41-feeder wires[44]

44 Map Source: Google Maps, (GPS coordinates 41.961967, -71.662496).

Below shows the rotted base of the tree that fell into the 41-feeder (the wires are slightly visible at the top of the picture).

Below on the right side of the picture, shows the tree that fell. On the left side of the picture, the top of the tree branches that were cut off of the tree remain. Note how the tree still had leaves on it, therefore the tree may not have appeared to be a distressed tree.

Below shows the base of the tree stump where it split in half from what appears to be insect damaged and rot. The tree section to the left fell towards the power lines. It is unknown why two 5-gallon bucks are inside of each other with a blue tarp inside of the inner bucket, it was found like this, however, the buckets do a good job providing scale to show how large this tree was.

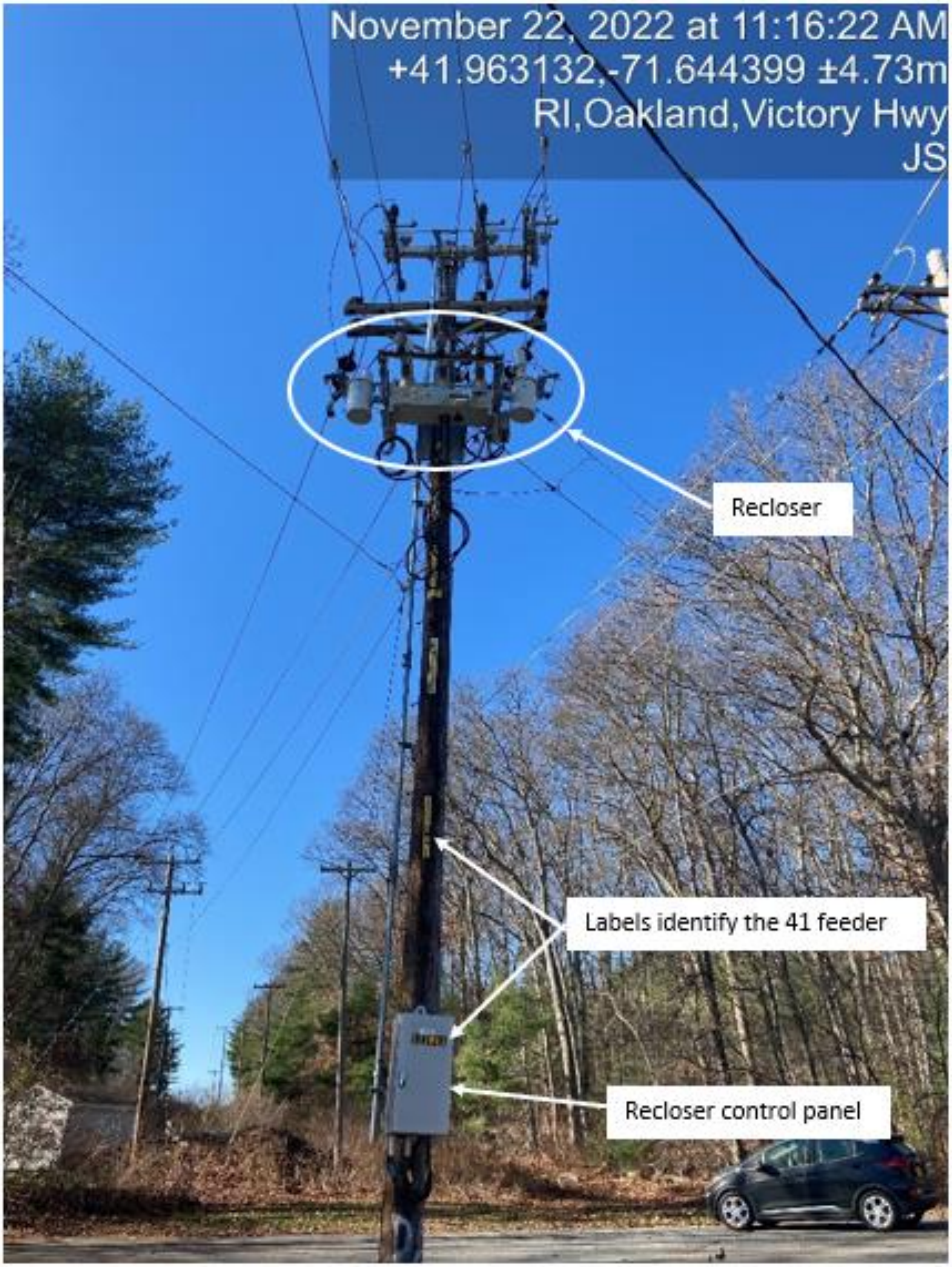
Below, picture of pole 253, shows marking indicating this is a class 3 pole that is 40 feet long.

Below, the force of the falling tree appears to have moved the utility pole (pole 253); this was later repaired.

Pictures of the 41-Feeder Recloser

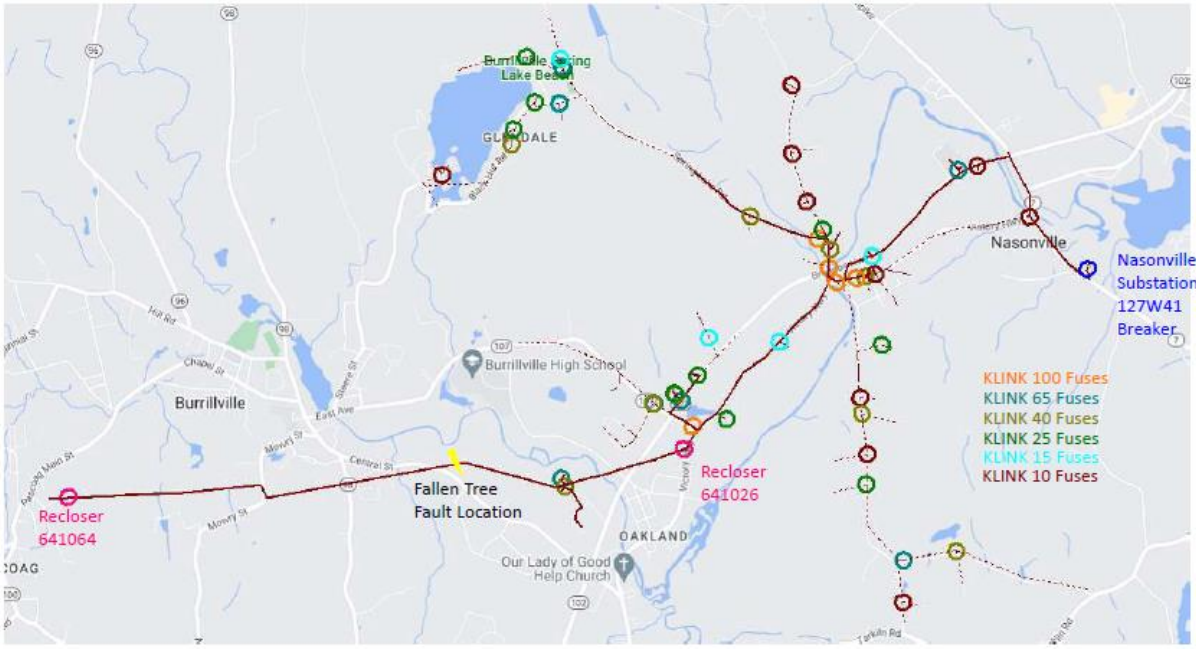
41-Feeder Recloser (GPS Coordinates 41.963132,-71.644399)

Map Source: Google Maps

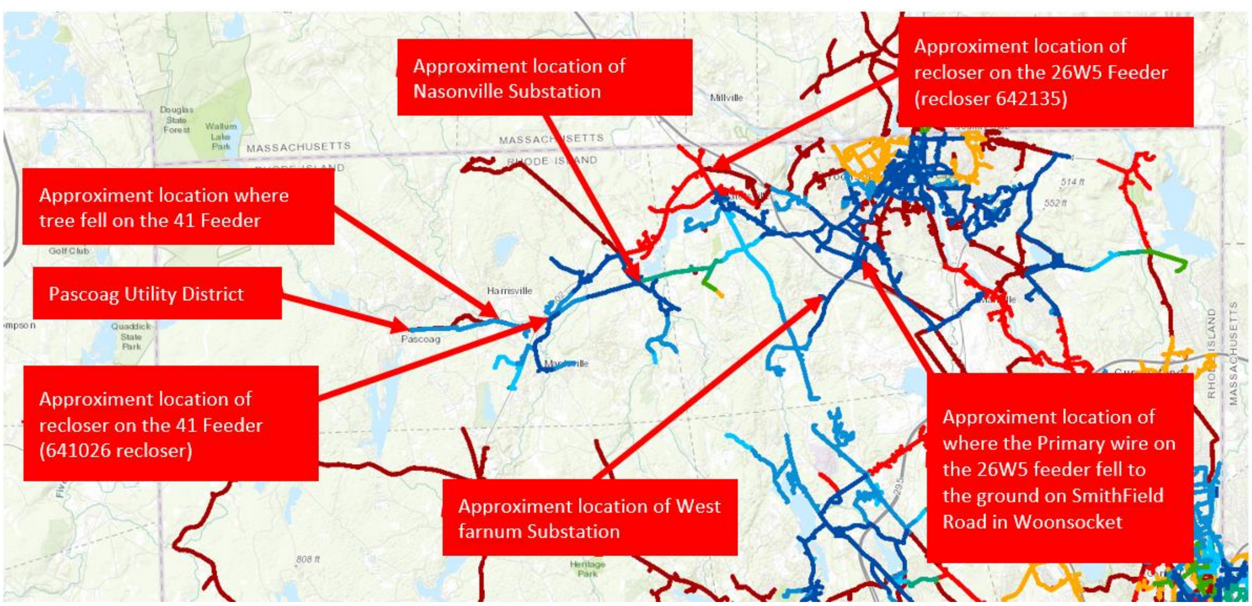

November 22, 2022 at 11:16:22 AM
+41.963132,-71.644399 ±4.73m
RI,Oakland,Victory Hwy
JS
Recloser
Labels identify the 41 feeder
Recloser control panel

Feedер Line Diagram

127W41 Feeder One-Line Diagram and Fuse Sizes[45]



Picture of a Map Showing Key Locations on a Large Scale[46]



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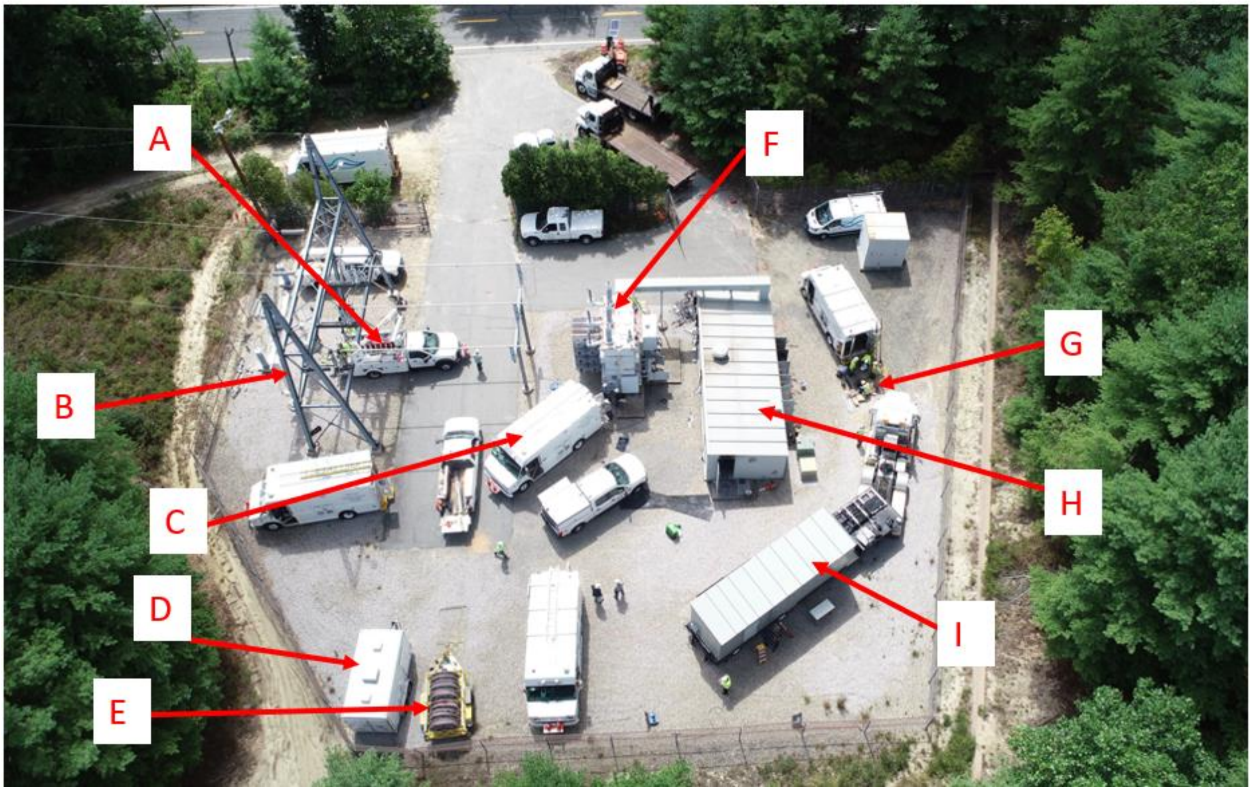
45 Source: Rhode Island Energy's report dated March 3, 2023 (found in Appendix C).
46 Map source: https://www.arcgis.com/apps/webappviewer/index.html?id=5250bccafd06466881b7ba794c3115bf.

Pictures of the Restoration Efforts at Nasonville Substation

Bellow, dated August 24, 2022, shows RIE mobilized onsite at Nasonville Substation.



A. RIE crews working on the MOS that was damaged by flashover.
B. "A" frame structure that holds the MOS.
C. RIE crews working on the transformer.
D. Trailer where the batteries are stored that power the mobile switchgear building .
E. Trailer that is holding the temporary insulated distribution wires on spools, later, these wires were taken off the spools and used to connect the transformer to the mobile switchgear building. Other pictures in this report show these wires on the ground in preparation to being energized.
F. Substation transformer.
G. A crew near a manhole. This manhole is used to access conduit that holds the wires that go out underground to the four nearby feeders.
H. Fire damaged switchgear building.
I . Mobile (trailered) switchgear building.

Below is a close up of the temporary insulated distribution wires on spools (dated August 25, 2022).

Below is the trailered mobile relay station (before the tempoary distibution wires are connected to it, dated August 25, 2022)

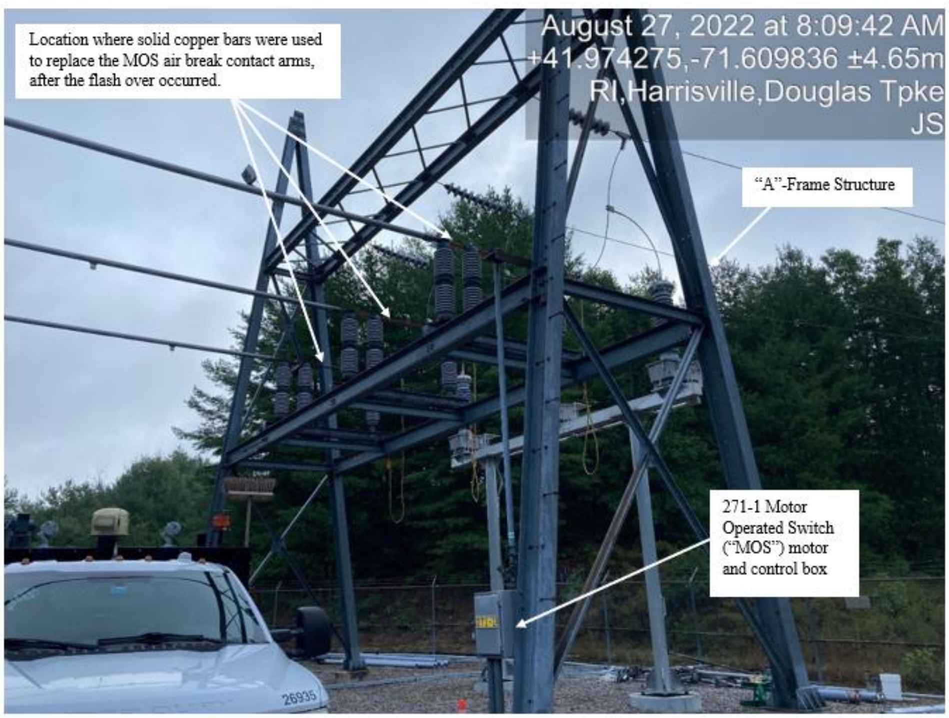
Below, in the trailer, is the portable battery station used to power the mobile relay station computers during power outage events. The batteries are in a state of constant charge.

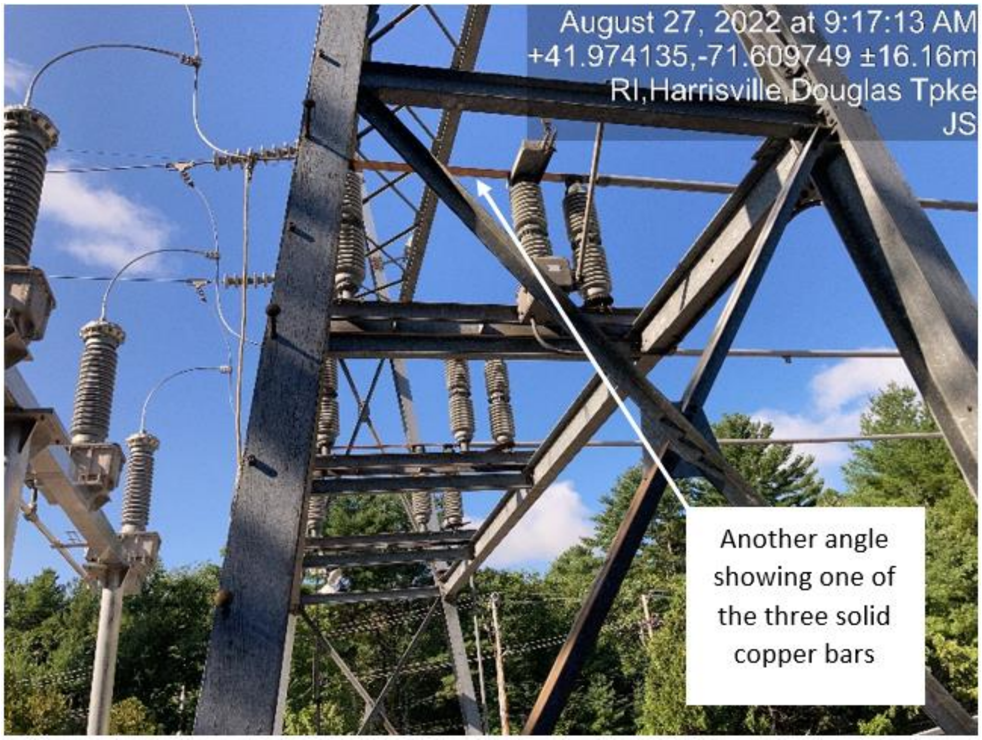
Below, shows temporary secondary wires connectinng the transformer to the trailered mobile relay station (the trailered mobile relay station is mostly behind the transfomer in this picture).

Pictures of the Motor Operated Switch (MOS) Damage and Temporary Repair

The picture below shows damaged/melted parts of the original MOS 3-phase gang switch (the damaged parts were removed, and temporarily replaced with solid copper bars).


August 27, 2022 at 9:16:47 AM
+41.974135,-71.609749 ±16.16m
RI,Harrisville,Douglas Tpke
JS


Location where solid copper bars were used to replace the MOS air break contact arms, after the flash over occurred.
August 27, 2022 at 8:09:42 AM
+41.974275,-71.609836 ±4.65m
RI,Harrisville,Douglas Tpke
JS
"A"-Frame Structure
271-1 Motor Operated Switch ("MOS") motor and control box
26935



Pictures of the Recloser at 590 Victory Highway

Below, is the recloser (recloser 642135) that tripped when the primary wire fell to the ground, located on pole 590 Victory Highway, North Smithfield. GPS Coordinates 42.00682, -71.58334. Photo source: Google Maps, street view.

Pictures of the Wire Spice that Failed Resulting in a Primary Wire Falling to the Ground

Below, is the location where the splice failed, and the primary wire fell to the ground (exact location is unknown). GPS Coordinates 41.98550, - 71.52141. Picture source: Google Maps Street View.

Pictures of Temporary Roll-on Generation[47]

[47] Rhode Island Energy's report dated November 16, 2022 (appendix B).


30Aug22 12:11
50–98 Clear River Dr, Oakland RI 02858, US 30-Aug-22 12:11:48

Appendix C "RIE's Response to the Division's Questions Dated November 16, 2022"

Andrew S. Marcaccio, Counsel
PPL Services Corporation
AMarcaccio@pplweb.com

280 Melrose Street
Providence, RI 02907
Phone 401-784-7263

Rhode Island Energy™
a PPL company

November 16, 2022

VIA ELECTRONIC MAIL

Robert D. Bailey, P.E.
Division of Public Utilities and Carriers
89 Jefferson Boulevard
Warwick, RI 02888

**RE: The Narragansett Electric Company d/b/a Rhode Island Energy
EC-2022-26 Nasonville Substation**

Dear Mr. Bailey:

On behalf of The Narragansett Electric Company d/b/a Rhode Island Energy (the "Company"), enclosed please find the Company's report in response to a letter to the Company from the Division of Public Utilities and Carriers ("Division") dated September 13, 2022. The Company's report consists of responses to the 19 questions posed by the Division in its September 13, 2022 letter regarding the Nasonville Substation fire that occurred on August 23, 2022.

Thank you for your attention to this transmittal. If you have any questions, please contact me at 401-784-4263.

Sincerely,

Andrew S. Marcaccio

Enclosures

cc: John Spirito, Division
Anthony Manni, Division
Joseph Shilling, Division
David Bonenberger, Rhode Island Energy

1. **What event occurred?**
    a. On Tuesday August 23, 2022, at 18:23 the Nasonville Substation # 127 Transformer tripped off by transformer differential relaying. Operations of the equipment at the Nasonville Substation resulted in loss of all Nasonville Substation feeders and triggered alarms to Rhode Island Energy Distribution Dispatch in Lincoln, Rhode Island. A Rhode Island Energy Substation Supervisor arrived at the station shortly thereafter. There was fire burning inside the station switchgear with thick smoke. The Rhode Island Energy Overhead Line Department isolated the feeders from the switchgear. After confirming the isolation, the firefighters were allowed to enter the switchgear and put out the smoldering fire with portable chemical fire extinguishers. During this time additional Rhode Island Energy Engineering and Operations personnel responded to the station. Customers were picked up on feeder ties.

2. **What is the exact cause of this event?**
    a. The protective relaying operations at the Nasonville Substation were preceded by a feeder fault on the 41 feeder caused by a fallen tree between poles 253 and 254 Clear River Road (Pascoag ROW). A pole mounted recloser located on the 41 feeder between the fallen tree and the station cleared the feeder fault. Shortly after this feeder fault, there was a dielectric failure in the Nasonville switchgear in the 41 feeder cubicle. It is likely that the through fault from the fallen tree damaged the connection of the 41 breaker C phase terminal to the switchgear bus. This damaged connection resulted in sustained arcing with extreme heat, destroying isolation and insulation systems, causing the faulting of the switchgear bus.

3. **What is the approximate time and date of this event?**
    a. The duration of the event was Tuesday August 23, 2022, at 18:23 to Saturday, August 27, 2022, at 19:00 with the decommissioning of "roll on" generation occurring on Wednesday, September 1, 2022.

4. **Were any injuries reported? If there were injuries, what were the injuries and what is the current status of the injured?**
    a. There were no injuries associated with the failure or the emergency restoration effort.

5. **What were the weather conditions at the time of this event?**
    a. At the time, there was a severe thunderstorm with torrential downpours and lightning, which dumped several inches of rain on Southern New England. The temperature was approximately 74 degrees Fahrenheit with 17 mph wind gusts.

6. **Was this an unusual event or a common occurrence at substations in general or at this substation specifically?**
    a. This was an unusual event. Normally, faults are cleared and isolated by existing protection equipment, but overlapping common mode failure is not expected to occur. Sustained arcing faults are not typical at 15 kV distribution voltages.

7. **Does Rhode Island Energy plan on changing the design/layout of this substation or others to help mitigate these events?**
    a. The design is changing to expedite the replacement of the temporary switchgear and to increase the contingency response capability. This design will result in less risk of catastrophic loss of all feeders that are served by the substation.

8. **Did Rhode Island Energy have all the resources available to begin making immediate repairs or were outside resources needed?**
    a. Over 50 Rhode Island Energy personnel were mobilized for the restoration of service through switching, deployment of contracted emergency generation, and replacement of the failed switchgear. Rhode Island. Energy had an existing agreement in place with National Grid; specifically, the Transition Services Agreement (TSA) with National Grid USA Service Company, Inc., which was entered into on May 25, 2022, the date the Company was acquired by PPL Rhode Island Holdings, LLC from National Grid USA. In this case, a mobile switchgear and mobile substation cables were delivered to the site by 9:00 am the next morning. Emergency generation was supplied by an outside supplier.
    b. System capacity constraints required the Company to consider and subsequently acquire roll on generation to support load during the time of temporary repair. The Company does not own generation resources but has established relationships with third party vendors who were contacted August 24, 2022, to provide approximately 9 MWs of support.

9. **Please explain how power was restored to the customers and how long it took.**
    a. Power restoration was a multi-step effort that was completed over several days.
        - Step 1 included immediate action by the Rhode Island Energy Distribution Dispatch in Lincoln, Rhode Island using existing feeder ties to pick up load as soon as possible.
        - Step 2 included the use of existing distributed generation, inclusive of solar, battery energy storage, and both existing and roll-on diesel generation to support system load during constraint periods over the multi-day effort.
        - Step 3 included the installation of the mobile switchgear and restoration of all feeders to normal configuration.

Step 1

8/23/2022

18:23 4,617 Rhode Island Energy customers and 4,700 Pascoag Utility District customers out at beginning of event. 127W40, 127W41, 127W42, and 127W43 Feeders all out

19:03 2,623 Rhode Island Energy customers out, 1,994 customers restored using OHL crews via field ties (2/3 of 127W40 feeder restored)

19:30 1,684 Rhode Island Energy customers out, 939 additional customers restored using OHL crews via field ties (remaining 127W40 feeder)

19:44 661 Rhode Island Energy customers out, 1,023 additional customers restored using OHL crews via field ties (127W42 restored)

20:31 658 Rhode Island Energy customers out, three additional customers restored, Pascoag Utility District customers restored, using OHL crews via field ties (127W43 restored)

21:35 19 Rhode Island Energy customers out, 639 additional customers restored using OHL crews via field ties (most of 127W41 restored)

**At this time, waiting on loads to decrease and crews to investigate a possible recloser issue to pick up remaining customers.

22:25 Tree branch in R/W on the 127W41 wire causes a fault which results in a phase burning down on Providence Pike. Due to previous restore 26W5 CB locks out which causes 5,404 customers to lose power (most of 127W40, most of 127W41, all of 127W42 and 50% of normal 26W5 customers). This is second outage of the event to 4,108 customers, first outage of event to 1,315 customers.

23:01 Phase Down issue isolated, 70 customers restored via remote switching, 5,334 remaining out (Original 26W5 customers)

08/24/2022

00:37 Further repairs made to Providence Pike, OHL crews keep Nasonville load isolated and restore 1,245 customers via OH field switching (all original 26W5 customers now restored)

00:52 Further patrol completed with no issues found, OH crews completed switching to restore 473 customers. 3,616 customers still out. (Portion of 127W40 restored)

01:13 Further patrol completed with no issues found, 1,015 customers restored via remote SCADA switching 2,601 customers still out (Portion of 127W40)

01:26 Tree in R/W issue cleared, remaining R/W patrol completed with no other issues found. All customers restored via remote SCADA switching.

Step 2 (8/24/2022 – 8/27/2022)

- Continuous monitoring of third party owned solar generating sites. This effort was primarily reactive to adjust for loss of solar due to cloud coverage.
- Continuous coordination with Pascoag Municipal, optimizing use and dispatch of their battery energy storage system and rotating generation.
- 3 Megawatts of roll-on generation was installed at the Harrisville Fire District Water Department Site (115 Central St., Burrillville, Rhode Island). The equipment was on site on 8/25/2022 at 15:30 and picked up load at 20:05.
- 3 Megawatts of generation was installed along the ROW, adjacent to the Burrillville Wastewater Treatment Plant (151 Clear River Drive, Burrillville, Rhode Island). The equipment was on site on 8/25/2022 at 20:00 and picked up load on 8/26/2022 at 14:40.
- 3 Megawatts of generation was installed along the ROW near the Burrillville Police Station (1477 Victory Highway, Oakland, Rhode Island). The equipment was on site on 8/26/2022 at 12:30 and picked up load at 18:00.

Step 3 (8/24/2022 – 9/6/2022)

- A mobile switchgear and mobile battery were delivered to Nasonville on Wednesday morning, 8/24/2022. Feeder cables were removed from the existing switchgear and extended to the mobile switchgear. Primary supply and control cables were installed from the transformer to the mobile switchgear. A temporary AC service was installed. Low voltage supply and control cables were installed from the mobile battery to the mobile switchgear. The substation transformer was tested and confirmed to be acceptable for service. On Saturday, August 27, 2022, the mobile switchgear was energized and the Nasonville feeders were restored to normal configurations by 7:00 pm. On September 6, 2022, a remote terminal unit and cellular antenna was installed for SCADA indication and control.

10. What lessons were learned from this event?

a. Good communication between field groups allowed an extensive amount of work to be sequenced efficiently and safely.
b. Availability of spare equipment is important.

c. Rhode Island Energy was able to procure and deploy roll on generation at various locations to provide load relief to Burrillville area customers during the time that the system was reconfigured and Nasonville load was fed from adjacent substations. These generators were run during the peak loading periods of each day.
d. Rhode Island Energy coordinated with Pascoag Municipal to utilize their generation and energy storage equipment to provide load relief during peak load periods while the system was in its reconfigured state. This required very close coordination with Rhode Island Energy and Pascoag during the event.
e. Over 20 MWs of distributed generation exists within the contingency response area. Reliance of these resources was important in providing power to area customers; however, the significant intermittency due to cloud cover or other events, reduced the distributed generation dependability.
f. High solar penetration in the served area, complicated the deployment of roll-on generation because of system stability.
g. Advanced device sensing (capacitors and reclosers) capabilities were critical to providing important information to manage the system during the event.
h. Lessons "e." to "g." above indicate the need for more sensing, monitoring, and control locations necessary for optimal contingency response.
i. Cellular communication coverage in the area of Nasonville Substation is poor.
j. Scheduling detail officers in an emergency basis is not possible.
k. Best practice is for Rhode Island Energy Operations to continue to work closer with the Customer team, including the staff that have the relationships with key accounts in response situations like the one encountered.
l. Proactively notifying customers allows them to make informed business decisions, which can improve recovery times and prevent product spoilage.
m. Working to curtail a few large customers may be preferential to disrupting hundreds of smaller customers.
n. Large customers should employ a soft/staggered restart strategy when turning high demand equipment back on.
o. Communication is crucial – Rhode Island Energy's key account manager had internal access to the right information at the right time leading to responsive decision making all because lines of communication were kept open with the Customer team, which lead to openness with Daniele Foods throughout the duration of the event.

11. What is the approximate cost to repair the damage?

a. Emergency restoration Rhode Island Energy: $461,000
b. 9 MWs of contracted emergency generator deployment: $400,000
c. Leasing of mobile switchgear: $100,000

   d. The cost to install a replacement station to restore the original station capability is approximately $5 million.

12. Was there any equipment failure?

   a. It is likely that 41 breaker C phase terminal to the switchgear bus connection failed from the initial feeder fault current.
   b. The single-phase high side grounding switch failed to operate. This resulted in damage to the 115 kV motorized disconnect switch but did not contribute significantly to the damage to the switchgear. The grounding switch was inspected and found to have not operated due to oil bleed of the lubricating grease.
   c. One phase of the Woonsocket Substation 26W5 feeder fell down resultant from the additional load of the Nasonville feeders and a fallen tree.

13. Please provide a high-level timeline listing the repair process for the event.

   a. Please refer to response # 9.

14. Was the damaged equipment near the end of its life cycle?

   a. No. Even though the switchgear was installed in 1981, it had been maintained and was in good condition. The circuit breakers had been replaced in 2010.

15. What is the date and time the substation was put back into service?

   a. The station was placed back into service on Saturday, August 27, 2022, at 19:00 using a mobile switchgear and a mobile battery.

16. Was the damage isolated or did it impact the entire substation?

   a. The damage was isolated to the switchgear building and the 115 kV motorized disconnect switch.

17. Does Rhode Island Energy regularly train for this type of incident or similar incidents?

   a. Both Overhead and Underground personnel switch, ground circuits, install cable and splice almost daily, on both "blue-sky" days and emergency conditions. Substation Department personnel install and test substation equipment as part of their normal job scope. These were the functions necessary to complete the work safely and efficiently. Rhode Island Energy service personnel also attend Annual Expert Training which includes how to respond to events safely and professionally.
   b. Distribution Control Center has pre-written contingency guides for all single sourced substations in Rhode Island territory so in the event of loss one of these

substations, operators can quickly review loading and start having resources head to locations to expediate customer restoration. These pre-written contingency guides are reviewed/updated periodically by the System Operators, this constitutes training as well.

18. Did any devices fail to do their job to protect this substation?

a. The protective relays appear to have operated as designed; however, they lacked the ability to detect this type of arcing fault. The single phase high speed grounding switch did not close which resulted in damage to the 115 kV disconnect switch but did not contribute significantly to the damage to the switchgear.

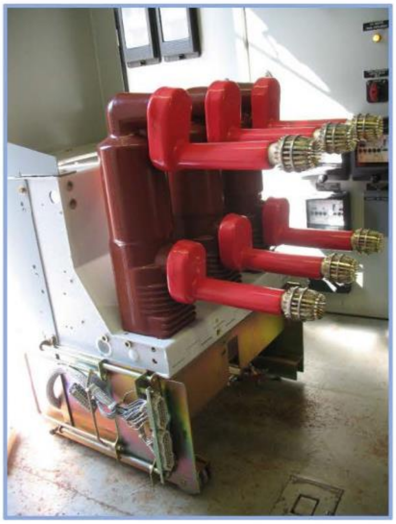
19. Please feel free to share any other information that you believe is important.

a. Pascoag Municipal cooperated fully with Rhode Island Energy and utilized their 1 MW of generation and 9 MWHrs of energy storage equipment to provide load relief during peak load periods while the system was in its reconfigured state. This required very close coordination with Rhode Island Energy and Pascoag during the event.
b. Eleanor Slater Hospital, Zambarano unit also cooperated with Rhode Island Energy with their deployment of 750 kW of emergency backup generation.
c. Daniele Foods also cooperated with Rhode Island Energy by curtailing loads and cancelling a shift.

Nasonville Switchgear

Nasonville Switchgear

Nasonville Switchgear Interior



2011 Installation of Replacement

Failed 41 Feeder Breaker

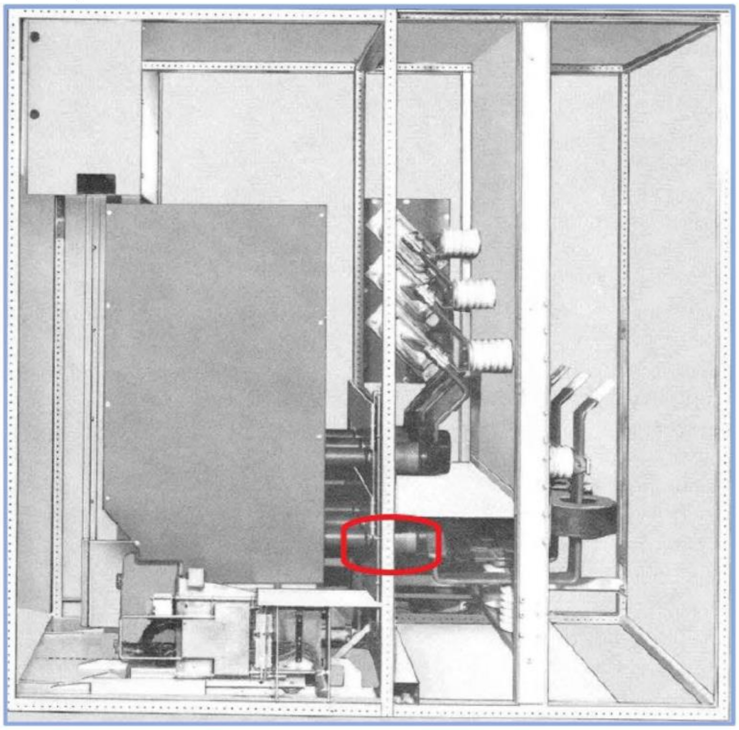


Illustration of Federal Pacific Electric metal-clad switchgear cell.

Failure initiating area identified in red.

Failed 41 Feeder Breaker Showing Condition of the Rosettes

Note: Top middle and right breaker conductor tubes have been reattached to show rosette positions.

Note: Top left rosette completely burned from arcing.

41 Feeder Switchgear Cell

Rosette Insulating Tubes: View from Rear of Switchgear

Note the breakdown of the left tube.

Rosette Insulating Tubes

Two of the Three Portable Generation

Appendix D "RIE's Response to the Division's questions dated March 3, 2023"

Celia B. O'Brien
Associate General Counsel
PPL Services Corporation
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Rhode Island Energy™
a PPL company

March 3, 2023

VIA ELECTRONIC MAIL

Robert D. Bailey, P.E.
Rhode Island Division of Public Utilities and Carriers
89 Jefferson Boulevard
Warwick, RI 02888

RE: EC-2022-26 – Nasonville Substation Report
The Narragansett Electric Company d/b/a Rhode Island Energy's
Report Responding to the Division's Letter Dated January 5, 2023

Dear Mr. Bailey:

On behalf of The Narragansett Electric Company d/b/a Rhode Island Energy ("Rhode Island Energy" or the "Company"), attached is the electronic version of Rhode Island Energy's report in response to a letter to the Company from the Division of Public Utilities and Carriers ("Division") dated January 5, 2023, in the above-referenced matter.

The Company's report consists of responses to 54 questions posed by the Division in its second set of questions regarding the Nasonville Substation fire that occurred on August 23, 2022.

Thank you for your attention to this matter. If you have any questions, please contact me at 401-578-2700.

Very truly yours,

Celia B. O'Brien

Celia B. O'Brien

Attachment

cc: John Spirito, Division
Anthony Manni, Division
Joseph Shilling, Division
David Bonenberger, Rhode Island Energy

1. **What was the maximum fault current level on feeder 41 which apparently initiated the switchgear failure?**
   Please see the Company's response to Division 4-5 part a. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report.

2. **Provide any event recorder data that would have been recorded by the feeder recloser or substation relaying.**
   Please see the Company's response to Division 4-5 part b. and Attachment DIV 4-5-1 in RIPUC Docket No. 22-53-EL, which are provided in Attachment 1 to this report.

3. **Provide a substation one line diagram with depicting all the relays and include all relay settings and time current coordination curves.**
   Please see the Company's response to Division 4-5 part c. and Attachment DIV 4-5-2 in RIPUC Docket No. 22-53-EL, which are provided in Attachment 1 to this report.

4. **Why was there not a bus breaker or overcurrent relaying on the low side of the transformer which would have detected the bus fault and cleared it in advance of the differential relaying?**
   Please see the Company's response to Division 4-5 part d. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report.

5. **National Grid had previously completed an extensive study of all substation metal clad switchgear. Explain why this study did not determine the deficiencies in the bus which would result in a bus failure due to a feeder fault.**
   Please see the Company's response to Division 4-5 part e. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report.

6. **Provide the comparison between the bus fault design capability and the fault current event level.**
   Please see the Company's response to Division 4-5 part f. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report.

7. **When was the last protective coordination study completed for this substation? Provide a copy.**
   Please see the Company's response to Division 4-5 part g. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report.

8. **Did the Dispatch in Lincoln pick up load using existing ties through system automation or did line crews have to be dispatched?**
   Please see the Company's response to Division 4-5 part h. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report. Please also see the Company's response to Division 1-31 part (e) in RIPUC Docket No. 22-53-EL, which is provided as Attachment 2 to this report.

9. **What assistance came directly from PPL?**
   Please see the Company's response to Division 4-5 part i. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report.

10. **In the RIE report dated November 16, 2022, in the response to question 10, part "g", provide a detailed explanation of how the advanced device sensing capabilities were critical and explain where these were located.**
    Please see the Company's response to Division 4-5 part j. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report. Please also see the Company's response to Division 1-31 part (h) and Attachment DIV 1-31-2 in RIPUC Docket No. 22-53-EL, which are provided as Attachment 2 to this report. Please also see the Company's response to Division 1-33 in RIPUC Docket No. 22-53-EL, which is provided as Attachment 3 to this report.

11. **What were power supply deficiencies (MW, dates, duration) without solar production?**
    Please see the Company's response to Division 4-5 part k. and Attachment DIV 4-5-3 in RIPUC Docket No. 22-53-EL, which are provided in Attachment 1 to this report.

12. **In the RIE report dated November 16, 2022, in the response to question 10, part "f", states that high solar penetration in the served area complicated the deployment of roll-on generation because of system stability. Did RIE consider curtailing intermittent solar generation and replacing solar contributions through firm resources as Opposed to reactive monitoring and control of DEF during the term or the emergency? Explain how advanced devices will resolve system stability issues caused by soler intermittency.**
    Please see the Company's response to Division 4-5 part l. in RIPUC Docket No. 22-53-EL, which is provided in Attachment 1 to this report.

13. **When was the substation relaying last tested?**
    Please see the Company's response to Division 4-5 part m. and Attachment DIV 4-5-4 in RIPUC Docket No. 22-53-EL, which are provided in Attachment 1 to this report.

14. **When was the grounding switch last functionally tested and when was it last inspected? Please provide copies of the test and inspection reports.**
Please see the Company's response to Division 4-5 part n. and Attachment DIV 4-5-5 in RIPUC Docket No. 22-53-EL, which are provided in Attachment 1 to this report.

15. **In the RIE report dated November 16, 2022, in the response to question 11, it states, "Leasing of mobile switchgear: $ 100,000" Who was this mobile switchgear leased from?**
The mobile switchgear was leased from National Grid.

16. **In the RIE report dated November 16, 2022, in the response to question 9, under the time of 22:25 it was mentioned that *"Tree branch in R/W on the 127W41 wire causes a fault which results in a phase burning down on Providence Pike."***

    a. **Please describe in detail what happened here?**
    Fault current resulting from the tree on the primary in the right-of-way ("ROW") caused the conductor at a tension sleeve to fail, resulting in a phase conductor falling to the ground.

    b. **Did the high amperage from the fault cause this wire (phase) to literally melt and fall to the ground?**
    The high current caused the conductor at a tension sleeve to fail. The failure could have been from electromechanical forces pulling the conductor out of the sleeve or from thermal failure of the conductor at the sleeve or the sleeve itself. The sleeve was not retained for analysis.

    c. **Did this wire (phase) fall across Providence Pike Road?**
    No, the wire fell along the side of Smithfield Road.

    d. **What was the voltage of the phase that burned down?**
    7.967 kV (RMS value).

    e. **What was the amperage in this phase during failure?**
    The amperage in this phase during failures unknown. Records from the recloser operation in August had been overwritten and were no longer stored in the recloser control.

    f. **What caused the phase to burn down?**
    Current caused by the fault caused the tension sleeve splice to fail. The current most likely caused the sleeved connection to heat up and fail.

g. **Did this create a hazard to the public?**
The fault current caused the Woonsocket 26W5 feeder breaker and the P590 Victory Highway 642135 recloser to operate, de-energizing the circuit. The conductor fell along the side of the road. This did create a hazard, but the hazard was minimized through the operation of protective relaying to immediately deenergize the circuit.

h. **Please provide pictures if you have them.**
No photographs were taken at the time of the failure.

i. **Please provide the location of where this happened using decimal GPS Coordinates (for example, our office is located at 41.74856, -71.436838).**
The conductor fell between poles 409 and 410, Smithfield Road, Woonsocket, RI (41.98550, -71.52141)

j. **Was the "Tree Branch" Mentioned under question 9 at the time of 22:25 the same fault that was mentioned under the time of 01:26 under "Tree"?**
Yes.

17. **How was it learned that there was an issue between the switch gear bus and the ABB breaker terminal?**
A damaged rosette was identified during a maintenance inspection of the Nasonville 41 feeder breaker.

18. **When was it learned that there was an issue between the switch gear bus and the ABB breaker terminal?**
A damaged rosette was identified during a maintenance inspection in June 2019. A spare breaker was installed in the Nasonville 41 feeder cubicle until a replacement rosette could be delivered.

19. **When were the repair done between the switch gear bus and the ABB breaker terminal?**
The damaged circuit breaker rosette, identified in the June 2019 maintenance, was replaced in March of 2020.

20. **It was explained to the Division that a test was not done after repairs were made between the switch gear bus and the ABB breaker terminal because the test would have required customer outages. Since multiple feeders provide electricity to Pascoag, could the 41 feeder have been isolated so outages would not have occurred during the test between the switch gear bus and the ABB breaker terminal? (note: in the RIE report dated November 16, 2022, in the response to question 9 at the time of 20:31, it states "*Pascoag Utility District customers restored, using OHL crews via field ties (127W43 restored)*", this suggests that Pascoag Utility District can operate on just one feeder.)**
The circuit breaker terminals connect to both the 41 feeder and the Nasonville switchgear bus. Testing these terminal connections would necessitate taking the entire Nasonville switchgear bus out of service. In this case, the testing was not considered because the repair was thought to be complete (replacement of the damaged rosette) and did not necessitate testing.

21. **If the test would have been done, would the test have resulted in catastrophic substation damage / fire? Or would both the terminal and breaker have been relocated to a safe area to do the test?**
No, the testing would not have resulted in catastrophic substation damage/fire. The rosette was replaced. It is very unlikely that testing would have indicated a problem.

22. **If a test were done, what would the test amps have been between the switchgear bus and the ABB breaker terminal?**
Low resistance testing of substation equipment is typically performed at 100 amperes DC.

23. **Are there any other situations like this in Rhode Island that could cause catastrophic failure of a substation? If yes, how are they being mitigated?**
Plug in connections (rosette and stabs) of circuit breakers are applied universally throughout all manufacturers and voltage levels. The plug-in connection design varies by manufacturer. In general, Federal Pacific electrical equipment designs have not been known to be the most robust. Nasonville Substation was the only station in Rhode Island to have the Federal Pacific plug in connections.

24. **When was Nasonville Substation built?**
The Nasonville substation was built in the 1981-1982 timeframe.

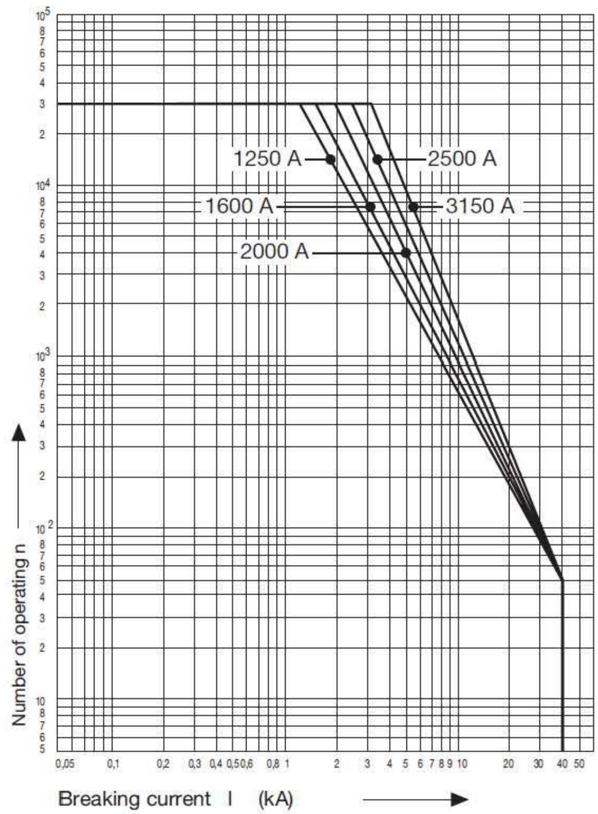
25. **What is the expected life of the 41 feeder ABB breaker in years? (Note: RIE response in question 14 states that the breaker was installed in 2010. Page 9 of 12 in RIE report states that the breaker failed.)**
    The expected life of a present-day switchgear circuit breaker is approximately 30 years. The circuit breaker manufacturer lists the typical life expectancy of the 41 breaker model as up to 50,000 operating cycles. The breaker operations counter was at 250 after the switchgear failure. The Rhode Island Energy report did not specifically state that the breaker had failed. The photo of the breaker was labelled as "Failed 41 Feeder Breaker" because it was the breaker that had the probable failed breaker to bus (rosette to stab) connection.

26. **How may prior faults have occurred on the failed 41 feeder ABB breaker since it was installed in 2010?**
    Records indicate that there have been approximately 10 lockouts of the 41 feeder breaker since its installation in 2010. These lockouts would have resulted in 30 circuit interruptions based on the three shot reclosing sequence. Data indicating which phases interrupted fault current is not available. Data on the magnitudes of the fault operations is also not available. Fault operations for temporary faults, which do not result in feeder lockout, are not recorded and are thus not represented in the 30 circuit interruption total.

27. **Was the failed 41 feeder ABB breaker new when it was installed in 2010? (Note: RIE response in question 14 states that the breaker was installed in 2010. Page 9 of 12 in RIE report states that the breaker failed.)**
    Yes, the ABB breaker installed in the 41 feeder in 2010 was new.

28. **Did the failed 41 feeder ABB breaker have a recommended limit on a specified number of fault trips (cycles) before it should be replaced or have maintenance done? If yes, what is that number and please provide details.**
    Yes. The 41 breaker was an ABB RMVAC DST-2-15-500-12 vacuum circuit breaker, 15 kV, 1200 ampere. See figure below for the permissible number of vacuum interrupter operating cycles. The magnetic actuator mechanism is maintenance free.

Figure



29. Please provide the maintenance records for the failed 41 feeder ABB breaker since it was new.
Please refer to Attachment 4.

30. What is the make and model of the failed 41 ABB breaker? (Note: Page 10 of 12 in the November 16, 2022 report states Federal Pacific is the manufacture of the metal clad switch gear.)
The 41 ABB Breaker was an ABB RMVAC DST-2-15-500-12 withdrawal type vacuum circuit breaker.

31. **When was the switchgear bus that connects to the ABB breaker installed? Was it installed new?**
The switchgear bus that connects to the ABB breaker was part of the original Federal Pacific switchgear, installed in the 1981/1982 timeframe. This switchgear was new at the time of the original Nasonville Substation installation.

32. **How old was the switch gear bus that connected to the 41 ABB breaker where the dielectric failure occurred? Found answer: RIE response in question 14 states the switchgear was installed in 1981, but was it installed new?**
Yes, the switchgear installed in the 1981-1982 timeframe was installed new.

33. **Does the 41 ABB breaker terminal switchgear bus that connected to the ABB breaker where the dielectric failure occurred require any maintenance? If yes, please explain and provide the maintenance records since new.**
No, the rosette to stab connection does not require any specific maintenance. During scheduled breaker maintenance, the rosettes are visually inspected. Up to year 2022, the maintenance interval for complete general switchgear inspections was every 15 years. The switchgear was last inspected in 2009. Please refer to Attachment 5.

34. **What is the make and model of the 41 feeder recloser?**
G&W Electric Catalog #: VIP378ER-12S
15.5 kV, 800 amperes, 12.5 kA interrupting, Manuf: 08/2010

35. **Please provide the maintenance records for the 41 feeder recloser since it was new.**
The recloser was installed in 2013. The recloser is inspected annually. The annual inspection card for 2021 is provided as Attachment 6. Prior year inspection cards are not available.

36. **How old is the 41 feeder recloser?**
The recloser was manufactured in August of 2010; thus, it was 12 years old at the time of the switchgear failure.

37. **What is the location of this 41 feeder recloser? (Near a street intersection, pole number, GPS location, etc.)**
641026 Recloser, P227, GPS location: 41.96316, -71.64439, 1422 Victory Highway, Oakland, RI 02858, approximately 460' south of Victory Highway/East Avenue intersection.

38. **When was the 41 feeder recloser installed at this location?**
The 41 feeder recloser was installed in 2013.

39. How many prior faults occurred on the 41 feeder recloser since it was new?
Records indicate that there have been approximately three lockouts of the 41 feeder recloser since its installation in 2010. These lockouts would have resulted in 12 circuit interruptions based on the four-shot reclosing sequence. Fault operations for temporary faults, which do not result in feeder lockout are not recorded in a central data base and are thus not represented in the 12 circuit interruption total.

40. Does the 41 feeder recloser have a recommended limit on a specific number of fault trips before it should be replaced or have maintenance done? If yes, what is that number and please provide details.
Yes. The G&W Viper-S recloser has a minimum mechanical life of 10,000 operations. See table below for fault trip wear.

kA Interrupted per Operation (per phase)	Number of Close/Open Operations
1.2	10,000
2	2,500
12.5	65

41. Any known manufacturing defects or recalls on either the 41 feeder failed ABB breaker, 41 ABB breaker, or 41 feeder recloser, switchgear, switch gear bus, etc.?
Yes.

<u>41 feeder breaker</u>:
ABB RMVAC DST-2-15-500-12 vacuum circuit breaker, 15 kV, 1200 ampere
ABB recommends replacing the control board if it has a revision prior to revision 9. Note: The revision of the control board on the 41 feeder breaker is unknown. Note: The 41 breaker was found to be in the open position.

<u>41 feeder recloser</u>:
Rhode Island Energy is not aware of any known manufacturing defects or recalls associated with the 2010 vintage 15.5 kV, 800 ampere G&W VIP378ER-12S recloser.

<u>Switchgear bus</u>:
Rhode Island Energy is not aware of any know manufacturing defects or recalls associated with the 1970s Federal Pacific metal clad switchgear with DST-2 magnetic air circuit breakers.

42. **Have any other similar incidents occurred at any other substation owned and operated by RIE? If yes, what was the cause?**
No.

43. **For the tree that fell between poles 253 and 354 on the 41 feeder, when was that section of the feeder last checked for hazardous trees?**
That section of the feeder would have been checked for hazardous trees during its routine maintenance cycle in April and May of 2022.

44. **For the tree that fell between the poles 253 and 254 on the 41 feeder, was the tree in the ROW?**
The tree was just off-of the ROW. The trouble-man was able to clear the branches from it.

45. **How wide, in feet, is the ROW where the tree fell near pole numbers 253 and 254 Clear River Road (as mentioned in response to question two (2) in RIE report dated November 16, 2022)?**
The ROW in this location is 70' wide.

46. **For the tree that fell between the poles 253 and 254 on the 41 feeder, RIE response to question two (2) in their November 16, 2022 report, states it is a Pascoag ROW. Is Pascoag or RIE responsible for vegetation management in this ROW?**
The Company is responsible for the vegetation management in that ROW.

47. **Who is responsible for the maintenance and repairs to the wires, poles, etc. around poles 253 and 254 on the 41 feeder where the tree fell?**
Maintenance and repairs related to poles, wire, and equipment on the distribution line in and around pole 253 and 254 is the responsibility of the Rhode Island Energy Capital Region Operations Office located in Lincoln, Rhode Island.

48. **Is there any reason to believe that the 41 feeder recloser, 41 feeder terminals, or failed 41 feeder ABB breaker was damaged from prior faults? If yes, why do you think that?**
There is no reason to believe that there was any damage to these devices from prior faults except for the typical contact wear from mechanical operation and current interruption.

49. **Could an animal or nest have contributed to the fire at the Nasonville Substation? Are these areas routinely checked for animals and animal nests? If yes, how often? Was there any evidence found inside buildings similar to the one that caught fire during this incident?**
Although mice are generally a problem at most older switchgear substations, there is no evidence that an animal or animal nest contributed to the fire at the Nasonville Substation. A visual and operational inspection of the station is performed once every two months. Mouse or animal activity had not been noted since 2008. An exterminator visits all switchgear stations every two months. During the on-going disassembly of the Nasonville switchgear, there has been no evidence of animal nests.

50. **In the RIE report dated November 16, 2022, in the response to question 2, states: "*It is likely that the through fault from the fallen tree damaged the connection of the 41 breaker C phase terminal to the switchgear bus.*" Please explain this "*through fault*" in more detail (it is understood that a through fault occurs when a fault gets outside the protective zone, but how did this happen? In the same response, it also states that "*A pole mounted recloser located on the 41 feeder between the fallen tree and the station cleared the feeder fault*". So how did the fault get past the recloser?).**
The reference to "through fault" is an abbreviation for the more complete and specific term "through fault current." The term "through fault current" should have been used.

A "through fault" occurs any time a fault occurs beyond the upstream protective device's "zone of protection." In the scenario that unfolded at Nasonville, a tree fell down-stream of the pole mounted recloser located on the 41 feeder. This fault was inside the recloser "zone-of-protection." Therefore, up until the pole mounted recloser operated and cleared the fault, all equipment upstream of the pole mounted recloser saw a "through fault." The protection operated as designed and the protective device closest to the fault operated to clear the fault.

51. **In the RIE report dated November 16, 2022, in the response to question 6, states: "*This was an unusual event. Normally, faults are cleared and isolated by existing protection equipment, but overlapping common mode failure is not expected to occur. Sustained arcing faults are not typical at 15 kV distribution voltages*". Please provide more details to what you mean by "overlapping common mode failure", also during the Divisions onsite visits to Nasonville Substation, Division personal were told the distribution voltages were 13.8 kV, please explain the discrepancy.**
What is meant by "overlapping common mode failure" is that the low impedance breaker connection to the switchgear bus degraded during the initial fault caused by the tree. When the fault initiated, the large amount of fault current (and mechanical

forces that associated it) caused the breaker connection to the switchgear bus to loosen and the impedance to increase. Once the pole top recloser cleared the fault, normal load current flowed through the connection. The increased impedance, in conjunction with the load current, caused the breaker connection to heat up, arc, and eventually started the fire within the switchgear. 15 kV distribution voltage refers to a class rating of equipment, "15 kV class." 15 kV class equipment would be operated at typical system voltages such as 13.8 kV, 13.2 kV, or 12.47 kV.

52. Please state, in order, how each step of the damage to the power grid / Nasonville Substation unfolded. (Basically, the Division is asking for more details to RIE's response (in the November 16, 2022 report) to question one (1) about the events that occurred). Please include the location of each event in decimal GPS (for example, our office is located at 41.74856, - 71.43638, these GPS locations can be located using Google maps).
(For example:

1. **On Tuesday, August 23, 2022 at 18:23, during a storm, a tree fell between poles 253 and 254 on the 41 feeder right of way (GPS location xx.xxxxx, xx.xxxxx).**

2. **The recloser (GPS location xx.xxxxx, xx.xxxxx) cycled X number of times in an attempt to eliminate or isoate the fault, since this fault (full tree laying across all thee phase near pole numbers 253 and 254 on the 41 feeder) did not clear, the recloser locked out on the X cycle).**

3. **During the cycling of the recloser (prior to lock out) high current (xxx amps) damaged the following … in the order of ….please include all switch gear, air break gang switch, differential relaying, dielectric failure in the Nasonville switchgear in the 41 feeder cubicle, the phase burning down on Providence Pike, etc.))**

On August 23, 2022, at approximately 18:20:27, the 641026 Recloser, P227, GPS location: 41.96316, -71.64439, 1422 Victory Highway, Oakland, RI 02858, tripped for a phase-to-phase fault because of a tree that fell across the Nasonville W41 feeder between poles 253 and 254 Clear River Road. 41.96206, -71.66249. Phase currents were approximately 3,156 amperes peak (2,231 amperes RMS) and 2,600 amperes peak (1,838 amperes RMS).

At 18:20:31, the Nasonville 127W41 breaker opened, reclosed approximately 5 seconds later, opened, and then closed approximately 12 seconds later. Approximately 3 minutes later, the Nasonville transformer differential lockout relay operated, the 271-1 MOS opened, and the West Farnum 1710 and 1712 breakers opened. The 271-1 MOS flashed over when opening because of the through fault current.

It is likely that the through fault current from the fallen tree damaged the connection of the 41 breaker C phase terminal to the switchgear bus. This damaged connection resulted in sustained arcing with extreme heat, destroying isolation and insulation systems, causing the faulting of the switchgear bus.

On August 23, 2022, at approximately 22:30, during the restoration of the Nasonville load, the tree that fell across the Nasonville W41 feeder between poles 253 and 254 Clear River Road 41.96206, -71.66249 caused a fault, which resulted in a reclose sequence from the Woonsocket 26W5 feeder. The through fault currents caused a splice to fail between poles 409 and 410 Smithfield Rd., Woonsocket, RI (41.98550, -71.52141) and the P590 Victory Highway, North Smithfield (recloser 642135) (42.00682, -71.58334) to open.

53. **In the RIE report dated November 16, 2022, in the response to question 9, under section 3 is states: "…On September 6, 2022, a remote terminal unit and cellular antenna was installed for SCADA indication and control." Then under the response to question 10, under section "i" it states that "Cellular communication coverage in the area of Nasonville Substation is poor." Since there is poor cellular coverage in this area, is the reliability of the SCADA a concern? Have test been done to verify this SCADA setup will work, if yes, please explain the results.**
    Because of the poor cellular coverage in the area of Nasonville Substation, a remote terminal unit ("RTU") cellular modem external antenna was installed on a 55' utility pole. Reliability statistics for EMS/Nasonville RTU communications for the past 60 days (November 19, 2022, to January 18, 2023) confirm a reliable connection with calculated uptime of 99%.

54. **It was explained to the Division that a test was not done after repairs were made between the switchgear bus and the ABB breaker terminal.**
    a. **Please describe the repairs that were made.**
       During the June 2019 maintenance, the damaged circuit breaker rosette was recognized. A spare breaker was installed. A replacement rosette was purchased, the damaged rosette was replaced, and the breaker was returned to service.

    b. **Is it industry standard to do tests after repairs like this are made? If yes, what is the standard and where can the division find this standard?**
       Rhode Island Energy knows of no specific industry standard that specifies the testing of rosettes after replacement.

Division 4-5

Request:

Regarding the Nasonville outage:

a. What was the maximum fault current level on Feeder 41 which apparently initiated the switchgear failure?

b. Provide any event recorder data that would have been recorded by the feeder recloser or substation relaying.

c. Provide a substation one line diagram and feeder one line diagram depicting all the relays and include all relay settings and all feeder reclosers and fuses and settings and time current coordination curves for all the protective equipment.

d. Why was there not a bus breaker or overcurrent relaying on the low side of the transformer which would have detected the bus fault and cleared it in advance of the differential relaying?

e. National Grid had previously completed an extensive study of all substation metal clad switchgear. Explain why this study did not determine the deficiencies in the bus which would result in a bus failure due to a feeder fault.

f. Provide the comparison between the bus fault design capability and the fault current event level.

g. When was the last protective coordination study completed for this substation and its feeders? Provide a copy.

h. Did the Dispatch in Lincoln pick up load using existing ties through system automation or did line crews have to be dispatched?

i. What assistance came directly from PPL?

j. Provide a detailed explanation of how the advanced device sensing capabilities were critical and explain where these were located.

k. What were power supply deficiencies (MW, dates, duration) without solar production?

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l. The Company states that high solar penetration in the served area complicated the deployment of roll-on generation because of system stability. Did RIE consider curtailing intermittent solar generation and replacing solar contributions through firm resources as opposed to reactive monitoring and control of DER during the term of the emergency? Explain how advanced devices will resolve system stability issues caused by solar intermittency.

m. When was the substation relaying last tested?

n. When was the grounding switch last functionally tested and when was it last inspected? Provide copies of the test and inspection reports.

Response:

a. The maximum fault current level from the fallen tree event that initiated the switchgear failure was 2450-amp A-phase fault current recorded at 2/23/22 18:20:27.415 by pole top recloser 641026 on pole 227 of feeder 127W41.

b. Please refer to Attachment DIV 4-5-1 for recorded DFR data which depicts:
   - Figure 1:
     - The start of the fallen tree event showing approximately 2300-amp A-phase and 2150-amp B-phase fault currents, depicted in red and green respectively, recorded at 8/23/22 18:20:27.227 by pole top recloser 641026.
   - Figure 2:
     - The end of the fallen tree event recorded at 8/23/22 18:20:28.173 by pole top recloser 641026 showing the fault currents lasted a total duration of 0.9 seconds.
   - Figure 3:
     - The 115kV protection operation at the West Farnum substation. Initially, there were approximately 1600-amp fault currents on all three phases, depicted in red, green, and blue respectively, recorded at 8/23/22 18:23:20.378 by the B23 line protection relay at West Farnum substation. These fault currents are suspected to be related to the MOS 271-1 airbreak damage and medium voltage switchgear fire. The exact cause or the contributions for these fault currents cannot be determined. Then, B-phase fault current increased to approximately 8400-amps, which tripped the West Farnum instantaneous overcurrent relay. The exact cause of this increase in B-phase fault current cannot be determined.

Prepared by or under the supervision of: Ryan Constable

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c. See Attachment DIV 4-5-2 which depicts:
   - Figure 1: Nasonville Relay Diagram
   - Figure 2: 127W41 Feeder One-Line Diagram
   - Figure 3: Relay, Recloser and Fuse Settings Table
   - Figure 4: Phase and Ground Overcurrent Time Current Coordination Curves

d. This station was designed without a transformer low-side breaker. The station includes transformer high-side phase overcurrent and transformer low-side ground overcurrent relaying that covers the transformer and medium voltage switchgear. The station also has a differential relaying scheme with a protection zone that encloses the transformer and medium voltage switchgear. Given the sensitivity and instantaneous response of the differential relaying, the bus fault that was within the differential relaying protection zone caused the differential relaying to trip before the transformer high-side phase overcurrent and transformer low-side ground overcurrent relaying.

   If the station was designed with a low-side bus breaker, the low-side bus breaker would have a differential relaying scheme protecting the medium voltage switchgear in addition to low-side overcurrent relaying. This differential relaying scheme protecting the medium voltage switchgear would pick up in advance of the overcurrent relaying in the event of a bus fault. Generally, differential relaying schemes operate faster than overcurrent relaying schemes.

e. The metalclad study reviewed all relevant substations in Rhode Island. As can be seen from Figure DIV 4-5e-1, Nasonville was included in this review and ranked as one of the least critical stations. As explained within the response to EC-2022-26, the likely failed component was a 41 breaker C phase terminal to the switchgear bus connection. This internal component would not have been identified in a station asset condition review that informed the metalclad substation study.

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Figure DIV 4-5e-1

Location	Total Health Score	Total Safety Score	Total Performance Score	Total Customer Impact Score	Total Score	Total No. Metalclads	Notes
Vernon 23	1600.4	260.4	206	80	2147	1	Retire
Centre St Unit 106	1200.8	260.4	0.4	120	1582	2	Retire
Southeast Sub 60	1200.8	260.4	0.4	40	1502	1	Retire
Lee Street 30	920.8	260.4	0.4	120	1302	2	Retire
Front St 24	1200.8	0.4	0.4	60.2	1262	1	Retire
Pawtucket 1 107 Sub	532.8	0.8	400	260	1194	2	Replace
Hospital Sub 146	920.8	200.6	6.2	40	1168	1	Replace
Kingston 131	920.8	60.6	20.2	80	1082	1	Replace
Clarke Street 65	640.8	60.6	206	120	1027	2	Replace
Central Falls 104	812.8	0.8	6.2	120	940	1	Replace
Daggett Ave 113	801.2	0.4	6.2	80	888	1	Retire
Hospital Sub 146	560.8	200.6	6.2	40	808	2	Replace
Kingston 131	640.8	60.6	20.2	80	802	1	Replace
South Aquidneck 122	413.2	0.8	206	120	740	1	Replace
Kingston 131	560.8	60.6	20.2	80	722	1	Replace
Riverside 8	401.6	200.6	220	260	683	1	Refurbished
Valley Sub 102	441.2	0.4	120	120	682	2	Replace
East George St 77	532.8	0.8	0.4	80	614	2	Potential Retire
Crossman Street 111	521.2	0.4	0.4	80	602	1	Retire
Cottage Street 109	413.2	0.4	66	120	600	2	Retire
Staples 112	413.2	0.4	26	120	560	1	Refurbished
Dexter 36	413.2	0.4	0.4	120	534	1	Good Condition
Hyde Ave 28	441.2	0.4	6.2	80	528	1	Retire
North Aquidneck 21	241.2	0.4	6.2	66	314	1	Replace
Lippitt Hill 79	121.6	80.4	0.4	80	282	2	Being Done
Harrison 32	121.6	0.4	20.2	120	262	1	Replace
West Howard 154	121.6	1.2	12	120	255	3	Refurbished
Washington Sub 126	13.6	0.4	20.2	120	154	2	Good Condition
Nasonville 127	2	0.4	26	120	148	1	Good Condition
West Farnum 17	121.2	0.4	0.4	20.2	142	1	Being Rebuilt/GIS
Merton 51	2	0.4	6.2	80	89	2	Primary Refurbished
Raytheon - Portsmouth	1.6	0.4	0.4	0.4	3	1	Customer Owned

f. The approximate 2450-amp fault current level was below the station's 13.8kV breaker interrupting capacity of 40kA. The West Farnum 115kV breaker has an interrupting capacity of 63kA.

g. When the Company establishes a new substation, a protection and coordination review is performed using existing Company databases and models. The Company does not produce paper or hard copies of the protection and coordination efforts. Any protection related work remains in Company models and databases. Once a study is completed and prior to the project going into service, any necessary protective setting changes are issued and performed in the field.

h. All line crews needed to be dispatched to close feeder ties that transferred the Nasonville substation load to Woonsocket substation. For a detailed description of the switching steps that made this transfer, please refer to the Company's response to Division 1-31€.

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i. The PPL distribution protection engineering group assisted in fault event analysis and deriving relay settings for the mobile switchgear. The balance of effort from the Company's standpoint came from local knowledge and personnel.

j. Please refer to the Company's response to Division 1-33 for a description of how the advanced device sensing capabilities were critical during the Nasonville outage. Please refer specifically to the Company's response to Division 1-31(h) for advanced device sensing locations.

k. RTU data was collected and analyzed to find the power supply deficiencies of the 26W1 and 26W5 feeders without solar production. The Nasonville substation load was transferred to these two feeders after the switchgear failure. These feeders' power supplies were considered deficient when any of the feeders' phase currents exceeded overhead line ratings out of the substation. The two feeders were analyzed for power supply deficiency under the following conditions:
   - 26W1 without solar production from 3 large sites (2MW, 6.22MW and 0.84MW)
   - 26W5 without solar and hydro production from 4 large sites (1.6MW. 2.54MW, 3.3MW and 3.9MW)

   The 26W1 and 26W5 power supply deficiency from the switchgear failure event on 8/23/22 18:23 to the mobile switchgear energization on 8/27/22 19:00 is summarized in Table 4-5k-1 below:

Table 4-5k-1
26W1 and 26W5 Power Supply Deficiency Summary

Feeder	Total MVAh Power Supply Deficiency without solar production	Total Hours Power Supply was Deficient without solar production
26W1	16.9	20
26W5	6	12
Total	22.9	32

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Please refer to Attachment DIV 4-5-3 for 26W1 and 26W5 power supply deficiency plots, which depicts:

- Figure 1:
  - 26W1 power supply deficiency plotted between the switchgear failure event and the mobile switchgear energization.

- Figure 2:
  - 26W5 power supply deficiency plotted between the switchgear failure event and the mobile switchgear energization.

l. The Company assumes the term "firm resources" in the Division's question refers to roll-on generation because Company-owned and dispatchable firm resources are not permanently installed and available on the distribution system. The Company did not consider curtailing intermittent solar generation and replacing solar contributions with roll-on generation. The Company did deploy roll-on generation, but this was necessary in addition to the solar generation. The Company raised the issue of solar generation intermittency to emphasize the need for greater visibility and control of the distribution system. The Company would not replace solar generation with roll-on generation in any circumstance. Instead, it would install technologies to obtain needed sensing data and control to coordinate and optimize the roll-on generation with the existing solar generation.

   There is also a mobilization issue associated with roll-on generation. The first 3MW of roll-on generation was on site on 8/25/22 at 15:30 and picked up load at 20:05. The second 3MW of roll-on generation was on site on 8/25/22 at 20:00 and picked up load on 8/26/22 at 14:40. The third 3MW of roll-on generation was on site at 8/26/22 at 12:30 and picked up load at 18:00. While the 9MW of roll-on generation was being transported and setup, all the PV sites, totaling 25MW in nameplate capacity, were supporting the Woonsocket substation picking up the Nasonville load.

m. The substation relaying was last tested on 1/3/22. Please refer to attachment DIV 4-5-4 for the substation relaying test maintenance report.

n. The grounding switch was last functionally tested and inspected on 3/11/06. Please refer to attachment DIV 4-5-5 for the grounding switch test and inspection report.

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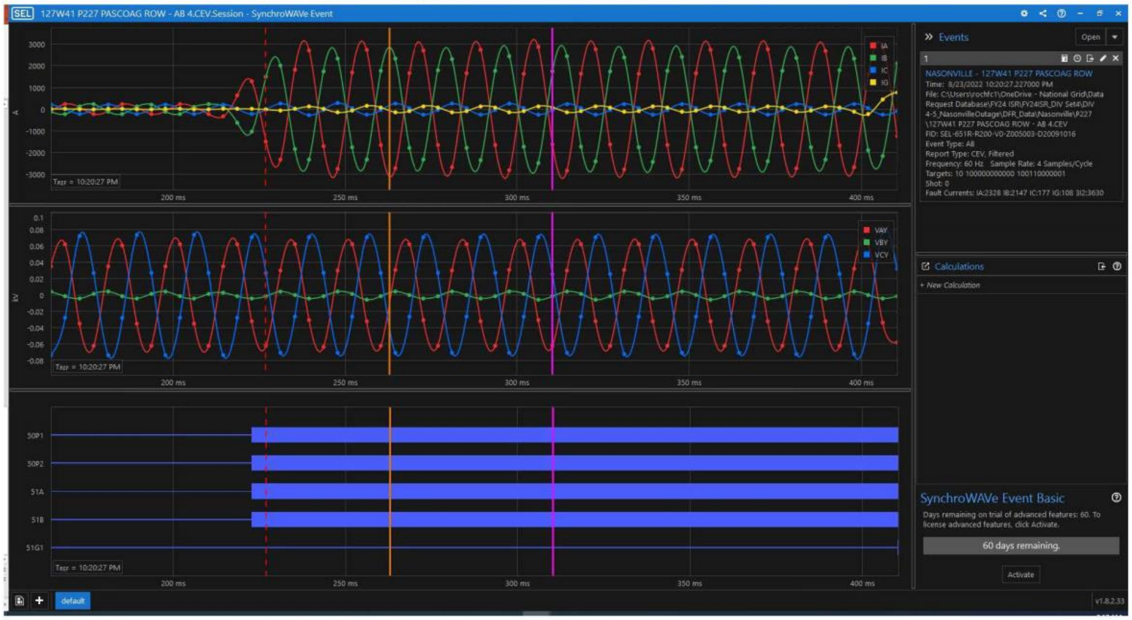
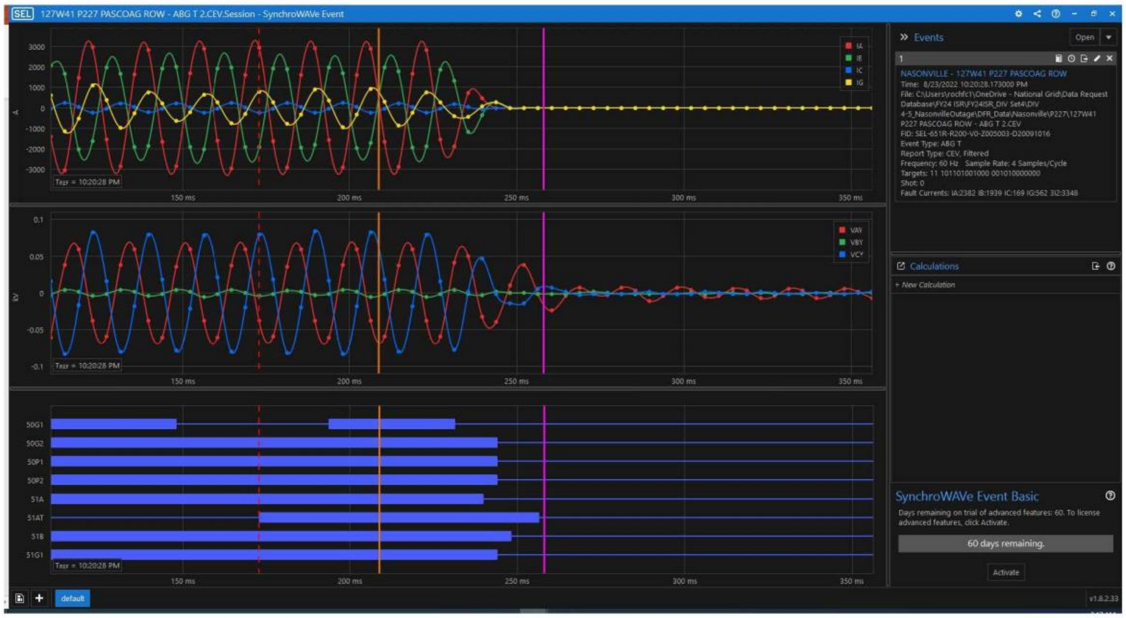
Attachment 4-5-1

Figure 1 – Tree Fault Start



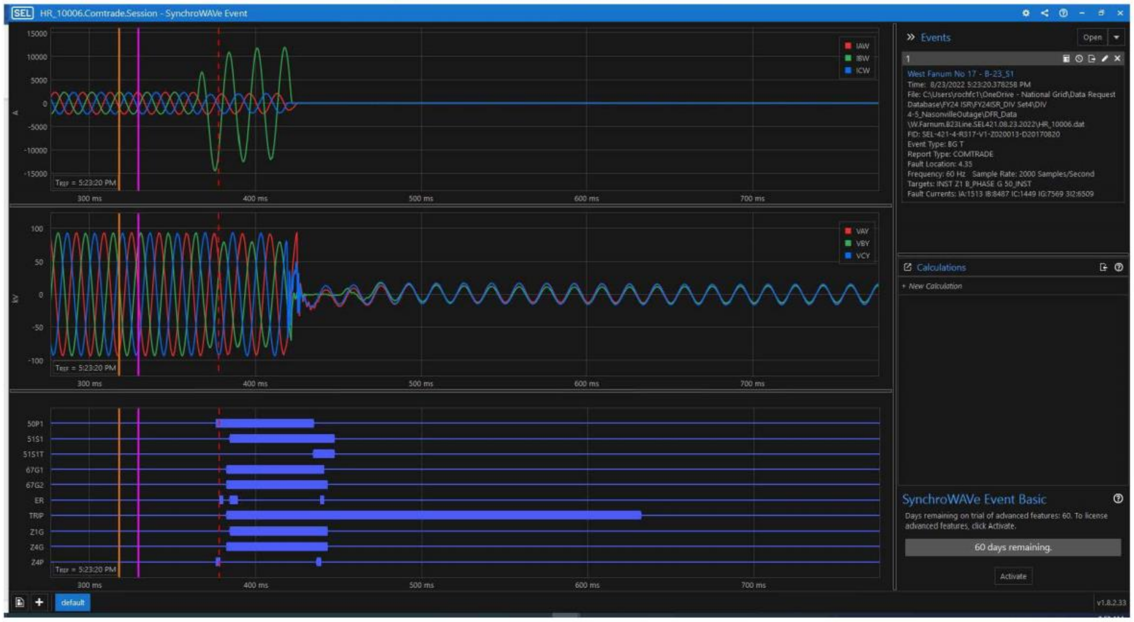
Attachment 4-5-1

Figure 2 – Tree Fault End



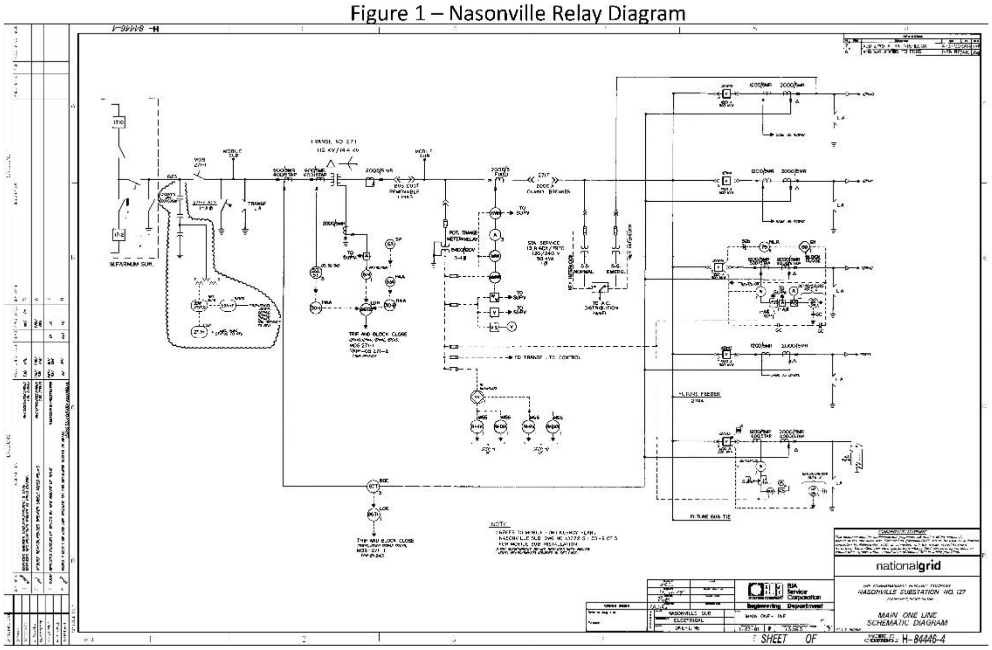
Attachment 4-5-1

Figure 3 – Substation Fault End



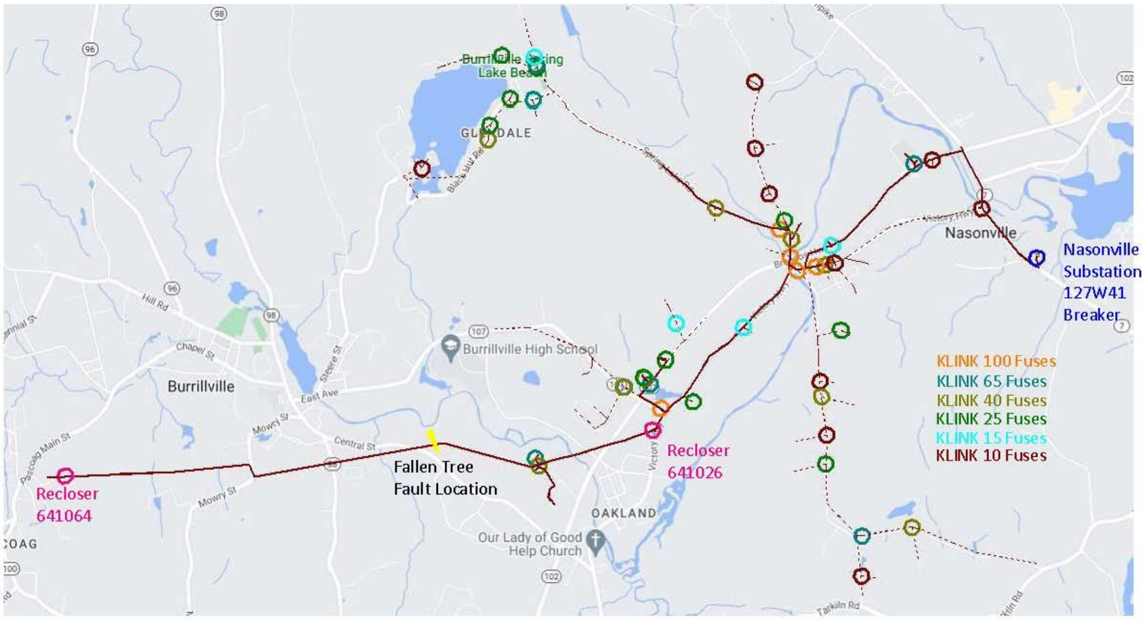
Attachment 4-5-2

Figure 1 – Nasonville Relay Diagram



Attachment 4-5-2

Figure 2 – 127W41 Feeder One-Line Diagram



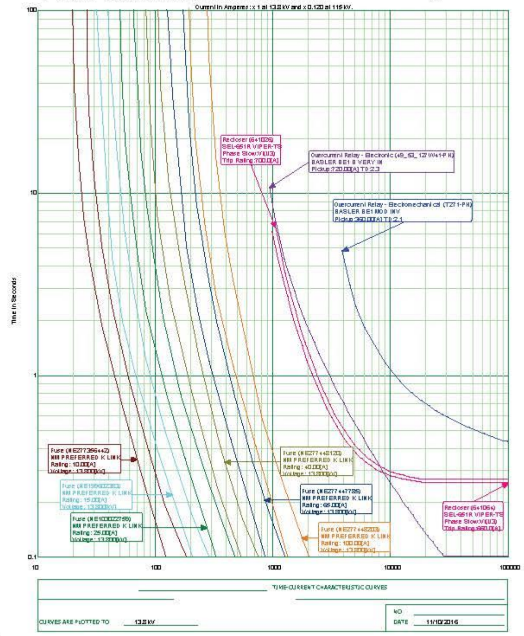
Attachment 4-5-2
Figure 3 – Relay, Recloser and Fuse Settings Table

Substation/Feeder?	One Line Symbol Text/ Color	Protection Type	Position	Voltage	Controlled Device Type	Controller/Relay Manufacturer	Controller/Relay Part Number	Turns Ratio	Range	Secondary Pickup	Primary Pickup	Curve Type	Curve Number	Time Dial
Substation	27-IH	Undervoltage	271TR Transformer Primary	115kV	Breaker	Basler	ES-27	1000		92.4 V				
	59N-271TR	3V0 Overvoltage	271TR Transformer Primary	115kV	Breaker	Schweitzer	SEL-351-6	1000	0-300 V	100 V		60 cycles		
										150 V		Instantaneous		
	50/51	Phase Overcurrent	271TR Transformer Primary	115kV	Breaker	Basler	BE1-50/51B229	120	0.5-15.9 A	3 A	360 A	BE1 M Moderately Inverse	99-1372	2.1
									1-99 A	25 A	3000 A	Instantaneous		
	63	Transformer Pressure	271TR Transformer Tank	N/A	Breaker	Qualitrol	909-007-01							
	87T	Transformer Differential	271TR Transformer Primary	115kV	Breaker	GE	BDD15816A	80	2.9-8.7 Tap A	3.2 Tap A				
			271TR Transformer Secondary	13.8kV				400	2.9-8.7 Tap A	8.7 Tap A				
	51N	Transformer Ground Overcurrent	271TR Transformer Secondary	13.8kV	Breaker	Basler	BE1-50/51B229	400	0.5-15.9 A	2.5 A	1000 A	BE1 M Moderately Inverse	99-1372	3.3
	81-1X	Underfrequency	271TR Transformer Secondary	13.8kV	Breaker	Schweitzer	SEL-351	70						
	51	Phase Overcurrent	127W41 Feeder Position	13.8kV	Breaker	Basler	BE1-50/51B229	120	0.5-15.9 A	6 A	720 A	BE1 B BS142 Very Inverse	99-1376	2.3
	50/51N	Ground Overcurrent	127W41 Feeder Position	13.8kV	Breaker	Basler	BE1-50/51B229	120	0.5-15.9 A	2.5 A	300 A	BE1 B BS142 Very Inverse	99-1376	4.4
Feeder	641026	Phase Overcurrent	127W41 P227 off Victory Hwy	13.8kV	Recloser	Schweitzer	SEL-651R				700 A	U3 Very Inverse		2
		Ground Overcurrent									230 A	U3 Very Inverse		5
	641064	Phase Overcurrent	127W41 P309 Pascoag ROW	13.8kV	Recloser	Schweitzer	SEL-651R2				660 A	U3 Very Inverse		1.9
		Ground Overcurrent									220 A	U3 Very Inverse		4
	Orange	Overcurrent	127W41 Downstream of Breaker and Reclosers	13.8kV	Fuse	Various					100 A	Type K (Fast)		
	Dark Teal	Overcurrent	127W41 Downstream of 100 A Fuses	13.8kV	Fuse	Various					65 A	Type K (Fast)		
	Dark Yellow	Overcurrent	127W41 Downstream of 65 A Fuses	13.8kV	Fuse	Various					40 A	Type K (Fast)		
	Green	Overcurrent	127W41 Downstream of 40 A Fuses	13.8kV	Fuse	Various					25 A	Type K (Fast)		
	Light Blue	Overcurrent	127W41 Downstream of 25 A Fuses	13.8kV	Fuse	Various					15 A	Type K (Fast)		
	Dark Red	Overcurrent	127W41 Downstream of 15 A Fuses	13.8kV	Fuse	Various					10 A	Type K (Fast)		

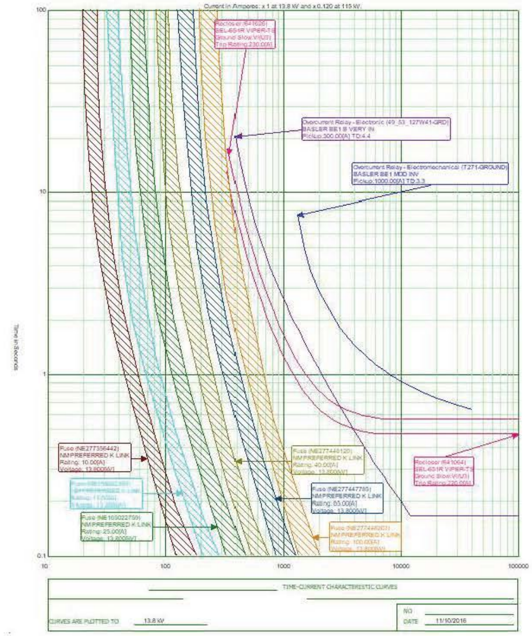
Attachment 4-5-2

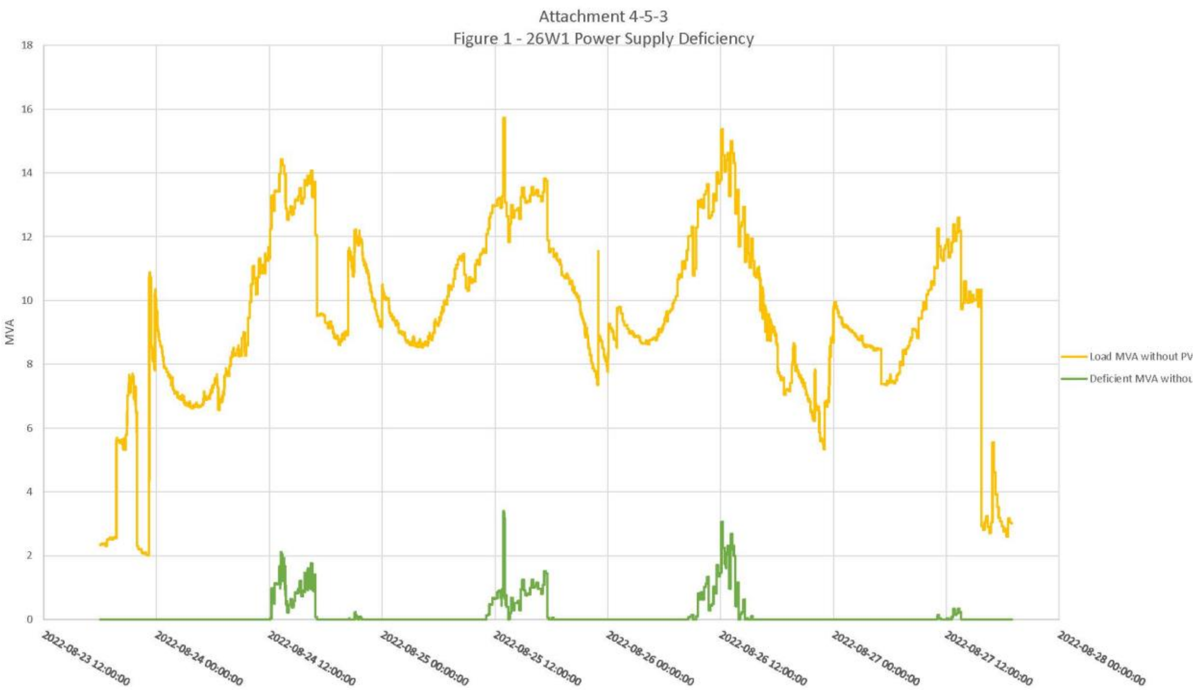
Figure 4 – Time Current Curves

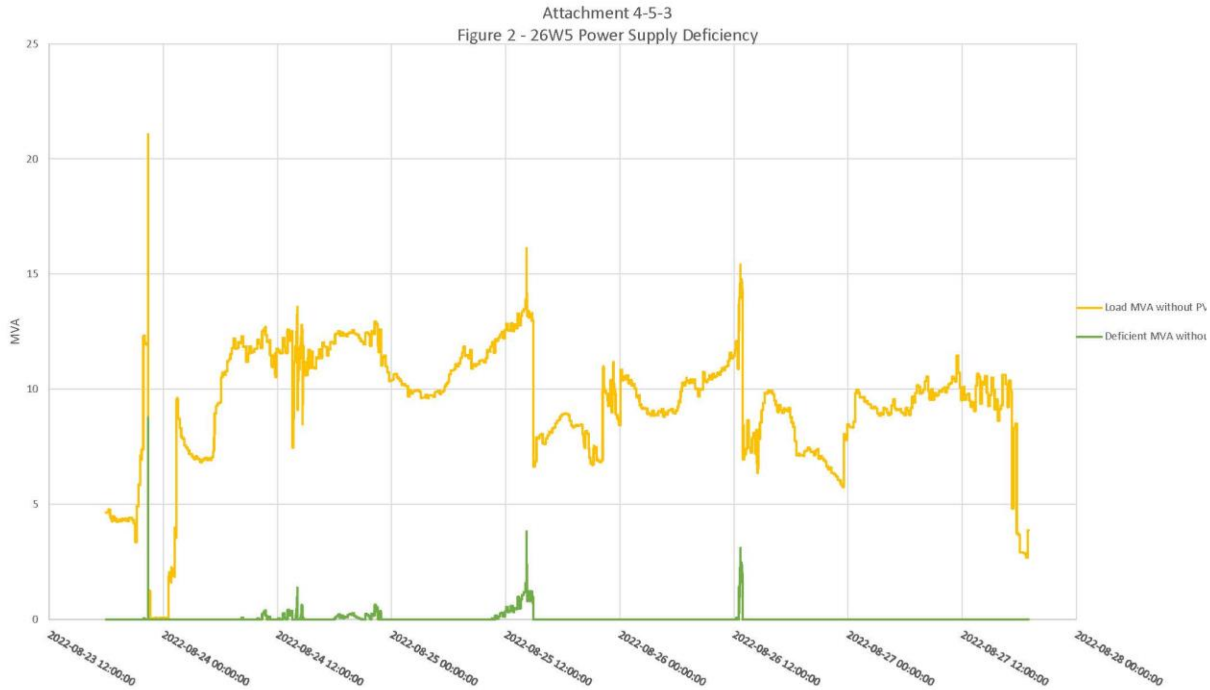
Phase Overcurrent TCC Curves



Ground Overcurrent TCC Curves




Attachment 4-5-3
Figure 1 - 26W1 Power Supply Deficiency
MVA
18
16
14
12
10
8
6
4
2
0
2022-08-23 12:00:00
2022-08-24 00:00:00
2022-08-24 12:00:00
2022-08-25 00:00:00
2022-08-25 12:00:00
2022-08-26 00:00:00
2022-08-26 12:00:00
2022-08-27 00:00:00
2022-08-27 12:00:00
2022-08-28 00:00:00
Load MVA without PV
Deficient MVA withou


Attachment 4-5-3
Figure 2 - 26W5 Power Supply Deficiency
MVA
25
20
15
10
5
0
2022-08-23 12:00:00
2022-08-24 00:00:00
2022-08-24 12:00:00
2022-08-25 00:00:00
2022-08-25 12:00:00
2022-08-26 00:00:00
2022-08-26 12:00:00
2022-08-27 00:00:00
2022-08-27 12:00:00
2022-08-28 00:00:00
Load MVA without PV
Deficient MVA withou

nationalgrid

Relay System Test – Maintenance Report

Station: Nasonville   Type: ____   Start Date: 01/03/22

C&I (Calibration / Inspection): X   F-TR (Functional trip): ☐   F-BF (Functional Breaker failure): ☐   Stop Date: 01/06/22

General Relay System Calibration / Maintenance Test :

Good: X   Fair: ☐   Poor: ☐   Application #: D21-370045

CT circuits: X   PT circuits: X   Output Trip circuits: X

13.8kV Relay Maintenance on all Feeder OC Relays, Transformer Diff and OC, GV3, UF Lock-Out/Aux Relay Verification, and UV Relay.

No Issues seen, no adjustments made to any equipment

	Yes	No
1.) Problems – Relay system would have mis-operated.		X
2.) Problems- Alert other divisions – May be trend.		X
3.) Problems – Academic inform other divisions.		X

Data Cards: X   Relay Setting Sheets: X   Nameplate Cards: X

Estimated Man-Days 4__   Actual Man-Days ___6_________.

Technician(s): JT   Date:01/06/22______   Division Supv. JHB_____ Date: 1/7/2022

EOP 409.03.3 HIGH SPEED GROUNDING SWITCH INSPECTION 11/04/2005

Substation	Circuit Designation	Manufacturer	Breaker Type	Mechanism Type	Reference #	Work Order #	Date
Nasonville	271-2AGS				09-6399		3/11/06

VISUAL AND OPERATIONAL (V&O) INSPECTION

- ☐ Check Insulators
- ☑ Check Blades and Jaws for Damage or Deterioration
- ☑ Check Spring Mechanism for Damage or Deterioration
- ☑ Check Wiring and Conduits for Damage or Deterioration
- ☐ Check Indicating Lights
- ☐ Record Operations Counter

DIAGNOSTIC INSPECTION

- ☐ Perform V&O Inspection
- ☐ Check and Lubricate Blades, Jaws and Hinges
- ☐ Check and Lubricate Spring Mechanism.
- ☑ Test Operation - Relay Department to Test Through Relaying If Possible.
- ☑ Check Alignment and Penetration.
- ☐ Perform Contact Resistance Test

micro ohm
AS FOUND OK
AS Left OK

Counter

As Found	—

ABNORMAL CONDITIONS / REPAIRS MADE

Inspected By DH JA Reviewed By:

Division 1-31

Request:

Provide complete details on the Nasonville substation and outage, including but not limited to the following:

a. Substation characteristics including location, area served, voltages, transformer arrangement, feeders, etc.

b. Description of the incident including date, time, weather conditions, and cause.

c. Estimated substation and feeder loading at time of incident compared to substation/circuit normal and emergency ratings.

d. Number of customers impacted.

e. Restoration activities and timeline of customer count and load restored.

f. A detailed circuit diagram indicating all interconnected feeders and what loads were transferred to adjacent substations

g. The duration of time it took for the Company to place a mobile transformer/substation in service to serve load and how much of the load was served from the mobile.

h. Indicate for each adjacent circuit each smart device and device location that provided increased visibility for the event, loads and DG capability.

i. Show each DG and its location that was called upon to serve load during the event and explain in detail what communications the Company had through telemetry to allow it to know the DG output in real time.

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Response:

(a)

- Nasonville substation (#127) is located at 445 Douglas Pike, Smithfield, RI. Nasonville Substation serves the northwestern part of Rhode Island. Areas served include portions of North Smithfield, Burrillville, Gloucester, and Pascoag Municipal.
- The station consists of one 115 kV to 13.8 kV load tap changing transformer with a delta/wye winding configuration, 30 degree lagging. 28,000/37,333/46,667 kVA OA/FA/FA @ 65 deg C rise
- The switchgear feeds four 13.8 kV grounded wye distribution feeders: 127W40, 127W41, 127W42, and 127W43.

(b)

- On Tuesday August 23, 2022, at 18:23, the Nasonville Substation transformer tripped off by transformer differential relaying. Operations of the equipment at the Nasonville Substation resulted in loss of all Nasonville Substation feeders and triggered alarms to Rhode Island Energy Distribution Dispatch in Lincoln, RI. A Rhode Island Energy Substation Supervisor arrived at the station shortly thereafter. There was fire burning inside the station switchgear with thick smoke. The Rhode Island Energy Overhead Line ("OHL") Department isolated the feeders from the switchgear. After confirming the isolation, the firefighters were allowed to enter the switchgear and put out the smoldering fire with portable chemical fire extinguishers. During this time, additional Rhode Island Energy Engineering and Operations personnel responded to the station. Customers were picked up on feeder ties.

- At the time, there was a severe thunderstorm with torrential downpours and lightning, which dumped several inches of rain on Southern New England. The temperature was approximately 74 degrees F with 17 mph wind gusts.

- The protective relaying operations at the Nasonville Substation were preceded by a feeder fault on the 41 feeder caused by a fallen tree between poles 253 and 254 Clear River Road (Pascoag ROW). A pole mounted recloser located on the 41 feeder between the fallen tree and the station cleared the feeder fault. Shortly after this feeder fault, there was a dielectric failure in the Nasonville switchgear in the 41 feeder cubicle. It is likely that the thru-fault from the fallen tree damaged the connection of the 41 breaker C phase terminal to the switchgear bus. This damaged connection resulted in sustained arcing

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with extreme heat, destroying isolation and insulation systems, causing the faulting of the switchgear bus.

(c)

Circuit	Loading at Time of Failure	Normal Rating	Emergency Rating
Nasonville 271 TR	25 MVA	51.3 MVA	57.8 MVA
127W43	325 A	559 A	597 A
127W42	225 A	495 A	495 A
127W41	150 A	495 A	495 A
127W40	175 A	495 A	495 A
Woonsocket 1 TR	15 MVA	52 MVA	60 MVA
26W7	175 A	515 A	515 A
26W5	200 A	515 A	515 A
26W1	125 A	515 A	d

(d) Approximately 4,617 Rhode Island Energy customers (kWh meters) and 4,700 Pascoag Utility District customers (kWh meters).

(e) Power restoration was a multi-step effort that was completed over several days.

- Step 1 included immediate action by the Rhode Island Energy Distribution Dispatch in Lincoln, RI using existing feeder ties to pick up load as soon as possible.
- Step 2 included the use of existing distributed generation, inclusive of solar, battery energy storage, and both existing and roll-on diesel generation to support system load during constraint periods over the multi-day effort.
- Step 3 included the installation of the mobile switchgear and restoration of all feeders to normal configuration.

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Division 1-31, page 4

Step 1
8/23/202

18:23	4,617 Rhode Island Energy customers and 4,700 Pascoag Utility District customers out at beginning of event. 127W40, 127W41, 127W42, & 127W43 Feeders all out
19:03	2,623 Rhode Island Energy customers out, 1,994 customers restored using OHL crews via field ties (2/3 of 127W40 feeder restored)
19:30	1,684 Rhode Island Energy customers out, 939 additional customers restored using OHL crews via field ties (remaining 127W40 feeder)
19:44	661 Rhode Island Energy customers out, 1,023 additional customers restored using OHL crews via field ties (127W42 restored)
20:31	658 Rhode Island Energy customers out, 3 additional customers restored, Pascoag Utility District customers restored, using OHL crews via field ties (127W43 restored)
21:35	19 Rhode Island Energy customers out, 639 additional customers restored using OHL crews via field ties (most of 127W41 restored)

**At this time waiting on loads to decrease and crews to investigate a possible recloser issue to pick up remaining customers.

22:25	Tree branch in R/W on the 127W41 wire causes a fault which results in a phase burning down on Providence Pike. Due to previous restore 26W5 CB locks out, which causes 5,404 customers to lose power (most of 127W40, most of 127W41, all of 127W42 and 50% of normal 26W5 customers). This is the second outage of the event to 4,108 customers, first outage of event to 1,315 customers.
23:01	Phase Down issue isolated, 70 customers restored via remote switching, 5,334 remaining out (Original 26W5 customers)

08/24/2022

00:37	Further repairs made to Providence Pike, OHL crews keep Nasonville load isolated and restore 1,245 customers via OHL field switching (all original 26W5 customers now restored)
00:52	Further patrol completed with no issues found, OHL crews completed switching to restore 473 customers. 3,616 customers still out. (Portion of 127W40 restored)
01:13	Further patrol completed with no issues found, 1,015 customers restored via remote SCADA switching 2,601 customers still out (Portion of 127W40)

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Division 1-31, page 5

01:26 Tree in R/W issue cleared, remaining R/W patrol completed with no other issues found. All customers restored via remote SCADA switching.

Step 2 (8/24/2022 – 8/27/2022)

- Continuous monitoring of third party owned solar generating sites. This effort was primarily reactive to adjust for loss of solar due to cloud coverage.
- Continuous coordination with Pascoag Municipal, optimizing use and dispatch of their battery energy storage system and rotating generation.
- 3 Megawatts of roll-on generation was installed at the Harrisville Fire District Water Department Site (115 Central St., Burrillville, RI). The equipment was on site on 8/25/2022 at 15:30 and picked up load at 20:05.
- 3 Megawatts of generation was installed along the ROW, adjacent to the Burrillville Wastewater Treatment Plant (151 Clear River Dr., Burrillville, RI). The equipment was on site on 8/25/2022 at 20:00 and picked up load on 8/26/2022 at 14:40.
- 3 Megawatts of generation was installed along the ROW near the Burrillville Police Station (1477 Victory Highway, Oakland, RI). The equipment was on site on 8/26/2022 at 12:30 and picked up load at 18:00.

Step 3 (8/24/2022 – 9/6/2022)

- A mobile switchgear and mobile battery were delivered to Nasonville on Wednesday morning, 8/24/2022. Feeder cables were removed from the existing switchgear and extended to the mobile switchgear. Primary supply and control cables were installed from the transformer to the mobile switchgear. A temporary AC service was installed. Low voltage supply and control cables were installed from the mobile battery to the mobile switchgear. The substation transformer was tested and confirmed to be acceptable for service. On Saturday, August 27th, the mobile switchgear was energized and the Nasonville feeders were restored to normal configurations by 7:00 pm. On September 6, 2022, a remote terminal unit and cellular antenna was installed for SCADA indication and control.

(f) Please refer to Attachment DIV 1-31-1, which reflects:.

- Page 1:Portions of the Woonsocket Sub. 26W1 feeder were transferred to the Woonsocket Sub. 26W7 feeder.

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- Page 2:Portions of the Woonsocket Sub. 26W5 feeder were transferred to the Riverside Sub. 108W53 and the Riverside Sub. 108W61 feeder.
- Page 3:All of the Nasonville 127W43 feeder including Pascoag Muni was transferred to the Woonsocket 26W1 feeder.
- Page 4:All of the Nasonville 127W42 feeder was transferred to the Woonsocket 26W5 feeder.
- Page 5:Portions of the Nasonville 127W41 feeder were transferred to the Woonsocket 26W5 (RI Energy customers) and the 26W1 (Pascoag Muni).
- Page 6:Portions of the Nasonville 127W40 feeder transferred to the Woonsocket 26W5 feeder, 321W2 feeder, and the 26W7 feeder.

(g)
- All durations pertinent to this restoration were provided in section E of this response:
- 100% of the load served by Nasonville had been transferred to the mobile switchgear as of Saturday August 27th at 19:00.

(h) Please refer to Attachment DIV 1-31-2, which shows:
- 26W7 Feeder: Recloser 642001, P6-90 Cap Bank, P8 Graham Drive Feeder Monitor, Recloser 642118, recloser 642094, P16 capacitor bank, recloser 642117, recloser 642086, P 18 capacitor bank, Recloser 642085, Recloser 642109, recloser 642112, P26 capacitor bank
- 26W1 Feeder: Recloser 642098, Pole 194 Pascoag ROW Feeder Monitor, Recloser 642006, Recloser 642086, capacitor bank 642003, Recloser 642079, P132 Providence Pike capacitor bank, Recloser 642099
- 26W5 Feeder: Recloser 642027, capacitor bank P33 St. Paul St., Recloser 642082, P511 Great Rd., capacitor bank
- 127W43 Feeder: P391 Pascoag ROW capacitor bank, Recloser 641066, Recloser 127W43
- 127W42 Feeder: Recloser 641049, Recloser 641047
- 127W41 Feeder: P144 Bronco Highway capacitor bank, recloser 641026, recloser 641064, recloser 127W41
- 127W40 feeder: recloser 641056, P226 Douglas Pike capacitor bank, P294 Douglas Pike capacitor bank, recloser 641012, recloser 641008, recloser 642135, recloser 641063

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(i)

- Pascoag Municipal was called on to deploy their 1 MW of generation and 9 MWHrs of energy storage equipment.
- Eleanor Slater Hospital, Zambarano was called upon to deploy 750 kW of emergency backup generation.
- Solar generation sites are not typically designed to be dispatched. The sites generate when the sunlight and utility connection is supportive.
- Typically, solar generation sites of 1 MW or greater connect to the distribution system through reclosers equipped with radio communications. Real time data for generation sites of less than 1 MW are typically not available to Rhode Island Energy Distribution Dispatch.
- DG sites greater than 1 MWs: Please refer to Attachment DIV 1-31-2:
    - 1 MW PV RI 16721813, Brandywick LLC, 90 Tifft Rd.: 26W7 Feeder
    - 1 MW PV, P24-33 Tifft Rd., 26W7 Feeder
    - 6.22 MW PV, RI 26549231, King Solar, 20 Oxford Rd., 26W7 Feeder
    - 2 MW PV, RI 24201390, 19733795, North Smithfield Solar, 1 Pound Hill Rd., 26W1 Feeder
    - 6.22 MW PV, RI 24845370, Turning Point Energy, P117-3 Pound Hill Rd. 26W1 Feeder
    - 0.84 MW PV, RI 25255833, Greenville Rd. Solar, P62-4 Greenville Rd., 26W1 Feeder
    - 1.6 MW Hydro, RI 138, Ridgewood Power, P37-24 ROW off St. Paul St., 26W5 Feeder
    - 2.54 MW PV, RI 23918636, Nautilus Solar, P302-3 Victory Highway, 127W42 Feeder
    - 3.3 MW PV, RI 2399135, 0 Danielle Drive, Burrillville Solar, 127W42 Feeder
    - 3.9 MW PV, FI 29106677, 0 Log Rd., Log Rd. Solar, 127W40 Feeder
    - 1 MW Generation, Pascoag Municipal, 127W41, 127W43 Feeders

The following figures show examples of capacitor and recloser information obtained through telemetry to determine the DG output in real-time.

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Figure DIV 1-31-1 – Typical Capacitor Information Screen
(red box shows real-time data)

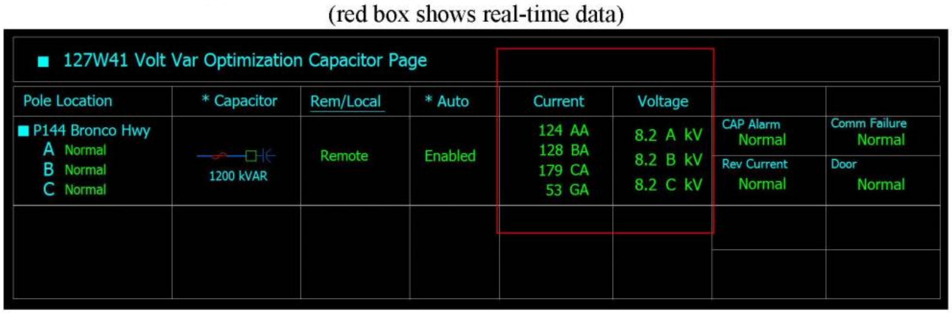
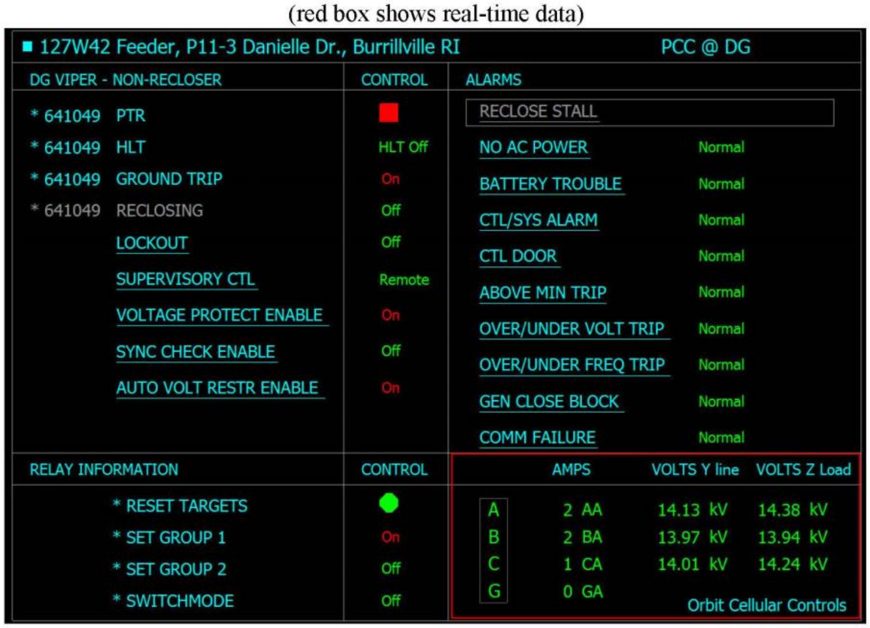


Figure DIV 1-31-2 – Typical Recloser Information Screen
(red box shows real-time data)



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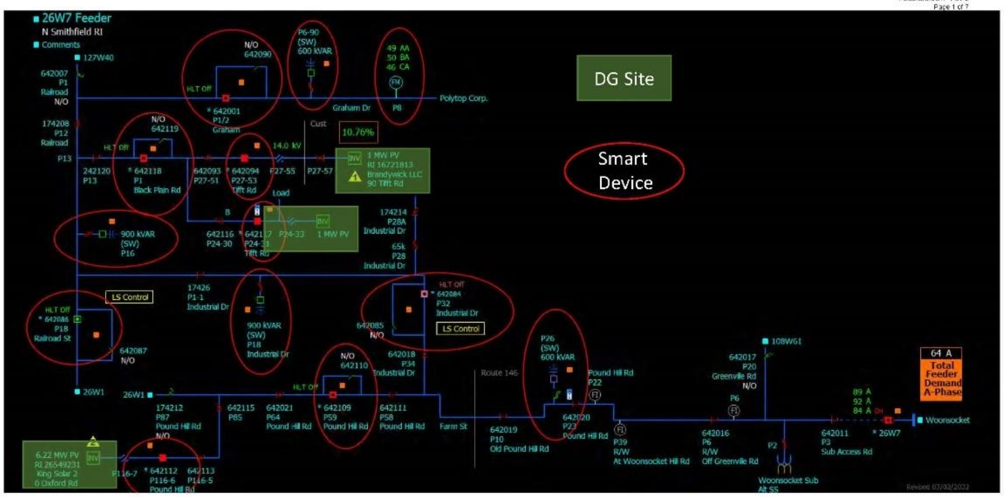
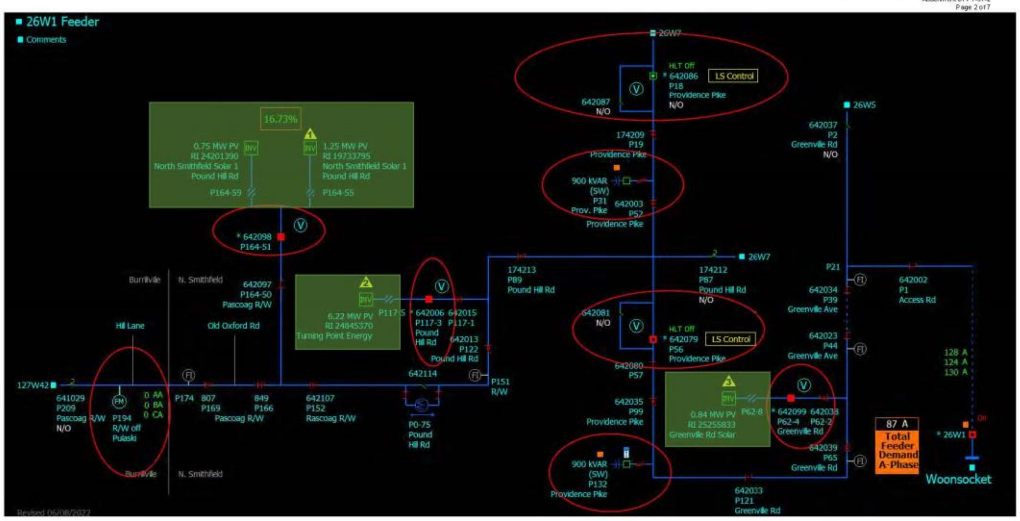
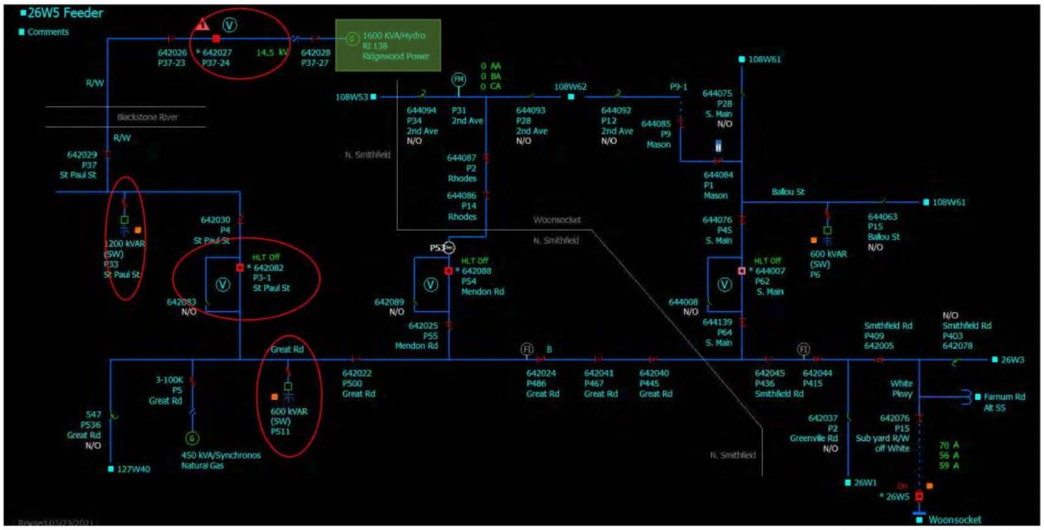
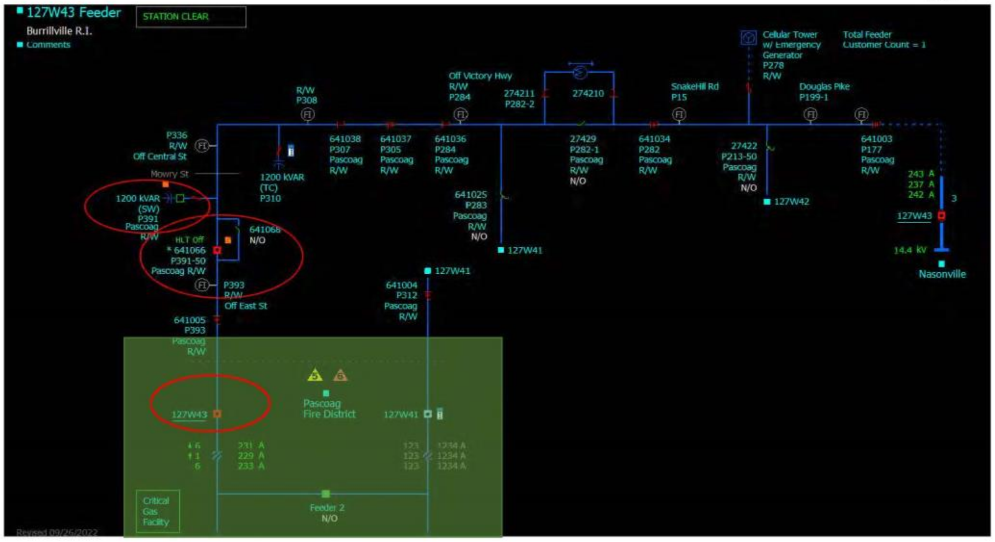
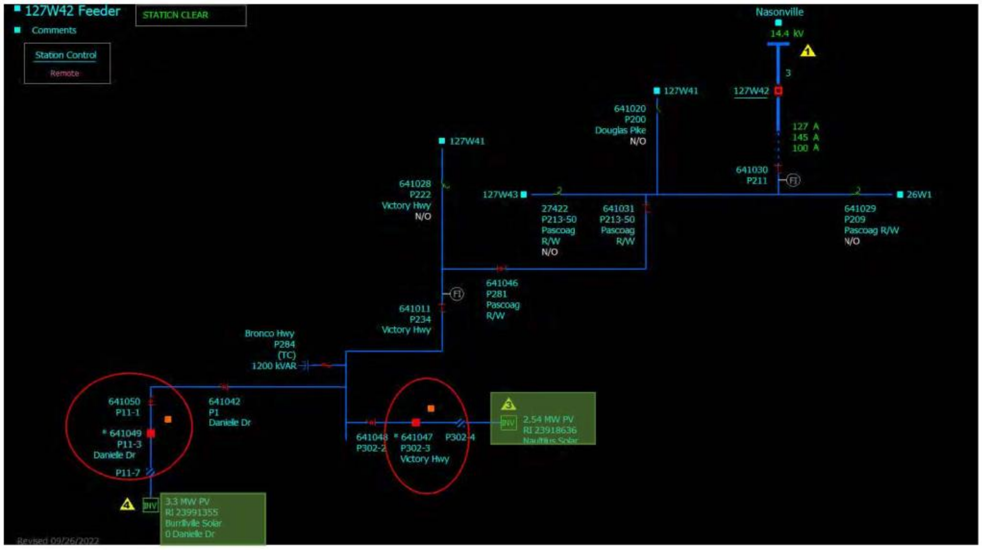
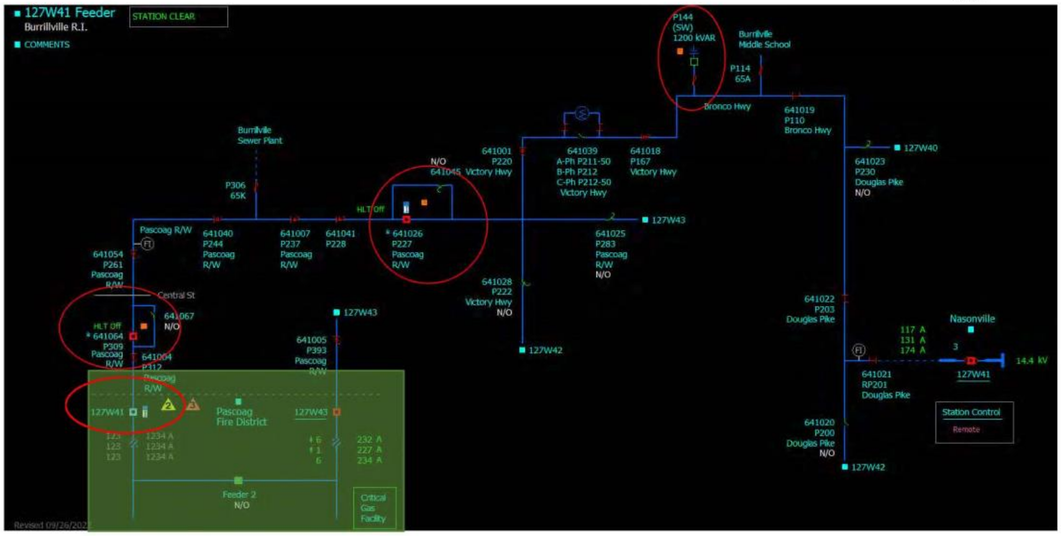

26W7 Feeder
N Smithfield RI
Comments
DG Site
Smart
Device
10.76%
14.0 kV
1 MW PV
6.22 MW PV
900 kVAR
(SW)
600 kVAR
LS Control
HLT Off
Route 146
Woonsocket
64 A
Total
Feeder
Demand
A-Phase

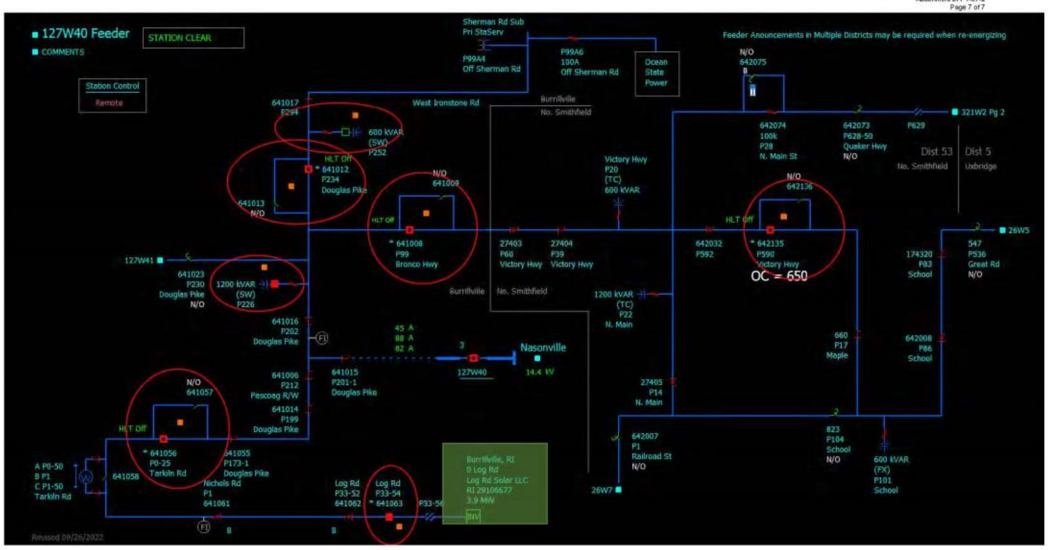

26W1 Feeder
Comments
16.73%
0.75 MW PV
RI 24201390
North Smithfield Solar 1
Pound Hill Rd
P164-59
1.25 MW PV
RI 19733795
North Smithfield Solar 1
Pound Hill Rd
P164-55
* 642098
P164-51
Burrillville
N. Smithfield
642097
P164-50
Pascoag R/W
6.22 MW PV
RI 24845370
Turning Point Energy
P117-5
* 642006
P117-3
Pound
Hill Rd
642015
P117-1
642013
P122
Pound Hill Rd
Hill Lane
Old Oxford Rd
127W42
641029
P209
Pascoag R/W
N/O
P194
R/W off
Pulaski
0 AA
0 BA
0 CA
P174
807
P169
849
P166
Pascoag R/W
642107
P152
Rascoag R/W
642114
P0-75
Pound
Hill Rd
P151
R/W
Revised 06/08/2022
26W7
HLT Off
* 642086
P18
Providence Pike
N/O
LS Control
642087
N/O
174209
P19
Providence Pike
900 kVAR
(SW)
P31
Prov. Pike
642003
P52
Providence Pike
174213
P89
Pound Hill Rd
174212
P87
Pound Hill Rd
N/O
26W7
642081
N/O
HLT Off
* 642079
P56
Providence Pike
LS Control
642080
P57
642035
P99
Providence Pike
0.84 MW PV
RI 25255833
Greenville Rd Solar
P62-8
* 642099
P62-4
642033
P62-2
Greenville Rd
900 kVAR
(SW)
P132
Providence Pike
642033
P121
Greenville Rd
26W5
642037
P2
Greenville Rd
N/O
P21
642034
P39
Greenville Ave
642023
P44
Greenville Ave
642039
P65
Greenville Rd
642002
P1
Access Rd
128 A
124 A
130 A
87 A
Total
Feeder
Demand
A-Phase
* 26W1
Woonsocket


26W5 Feeder
Comments
642026
P37-23
* 642027
P37-24
14.5 kV
642028
P37-27
1600 KVA/Hydro
RI 138
Ridgewood Power
R/W
Blackstone River
R/W
642029
P37
St Paul St
1200 kVAR
(SW)
P33
St Paul St
642030
P4
St Paul St
HLT Off
* 642082
P3-1
St Paul St
642083
N/O
0 AA
0 BA
0 CA
108W53
644094
P34
2nd Ave
N/O
P31
2nd Ave
644093
P28
2nd Ave
N/O
108W62
644092
P12
2nd Ave
N/O
P9-1
644085
P9
Mason
644075
P28
S. Main
N/O
108W61
N. Smithfield
644087
P2
Rhodes
644086
P14
Rhodes
Woonsocket
N. Smithfield
P53
HLT Off
* 642088
P54
Mendon Rd
642089
N/O
642025
P55
Mendon Rd
644084
P1
Mason
Ballou St
108W61
644076
P45
S. Main
600 kVAR
(SW)
P6
644063
P15
Ballou St
N/O
HLT Off
* 644007
P62
S. Main
644008
N/O
644139
P64
S. Main
Smithfield Rd
P409
642005
N/O
Smithfield Rd
P403
642078
26W3
Great Rd
3-100K
P5
Great Rd
600 kVAR
(SW)
P511
642022
P500
Great Rd
B
642024
P486
Great Rd
642041
P467
Great Rd
642040
P445
Great Rd
642045
P436
Smithfield Rd
642044
P415
White
Pkwy
Farnum Rd
Alt SS
547
P536
Great Rd
N/O
127W40
450 kVA/Synchronos
Natural Gas
N. Smithfield
642037
P2
Greenville Rd
N/O
642076
P15
Sub yard R/W
off White
70 A
56 A
59 A
26W1
On
* 26W5
Woonsocket


127W43 Feeder
Burrillville R.I.
Comments
STATION CLEAR
Cellular Tower w/ Emergency Generator P278 R/W
Total Feeder Customer Count = 1
Douglas Pike P199-1
SnakeHill Rd P15
Off Victory Hwy R/W P284
274211 P282-2
274210
R/W P308
P336 R/W Off Central St
Mowry St
1200 kVAR (TC) P310
641038 P307 Pascoag R/W
641037 P305 Pascoag R/W
641036 P284 Pascoag R/W
27429 P282-1 Pascoag R/W N/O
641034 P282 Pascoag R/W
27422 P213-50 Pascoag R/W N/O
641003 P177 Pascoag R/W
243 A
237 A
242 A
127W43
14.4 kV
Nasonville
127W42
641025 P283 Pascoag R/W N/O
127W41
1200 kVAR (SW) P391 Pascoag R/W
HLT Off
641066 P391-50 Pascoag R/W
641066 N/O
P393 R/W Off East St
641004 P312 Pascoag R/W
641005 P393 Pascoag R/W
Pascoag Fire District
127W43
127W41
231 A
229 A
233 A
Feeder 2 N/O
Critical Gas Facility
Replay 09/26/2022


127W42 Feeder
STATION CLEAR
Comments
Station Control
Remote
Nasonville
14.4 kV
3
127W41
127W42
641020
P200
Douglas Pike
N/O
127 A
145 A
100 A
127W41
641028
P222
Victory Hwy
N/O
641030
P211
127W43
26W1
27422
P213-50
Pascoag
R/W
N/O
641031
P213-50
Pascoag
R/W
641029
P209
Pascoag R/W
N/O
641046
P281
Pascoag
R/W
641011
P234
Victory Hwy
Bronco Hwy
P284
(TC)
1200 kVAR
641050
P11-1
641042
P1
Danielle Dr
* 641049
P11-3
Danielle Dr
P11-7
641048
P302-2
* 641047
P302-3
Victory Hwy
P302-4
2.54 MW PV
RI 23918636
3.3 MW PV
RI 23991355
Burrillville Solar
0 Danielle Dr
Revised 09/26/2022


127W41 Feeder
Burrillville R.I.
COMMENTS
STATION CLEAR
P144
(SW)
1200 kVAR
Burrillville
Middle School
P114
65A
Bronco Hwy
641019
P110
Bronco Hwy
127W40
641023
P230
Douglas Pike
N/O
Burrillville
Sewer Plant
P306
65K
N/O
641045
641001
P220
Victory Hwy
641039
A-Ph P211-50
B-Ph P212
C-Ph P212-50
Victory Hwy
641018
P167
Victory Hwy
HLT Off
641026
P227
Pascoag
R/W
127W43
641025
P283
Pascoag
R/W
N/O
Pascoag R/W
641040
P244
Pascoag
R/W
641007
P237
Pascoag
R/W
641041
P228
641054
P261
Pascoag
R/W
Central St
641067
N/O
HLT Off
641064
P309
Pascoag
R/W
641004
P312
Pascoag
R/W
641005
P393
Pascoag
R/W
641028
P222
Victory Hwy
N/O
127W42
641022
P203
Douglas Pike
Nasonville
117 A
131 A
174 A
14.4 kV
641021
RP201
Douglas Pike
127W41
Station Control
Remote
641020
P200
Douglas Pike
N/O
127W42
127W41
Pascoag
Fire District
127W43
232 A
227 A
234 A
Feeder 2
N/O
Critical
Gas
Facility


127W40 Feeder
COMMENTS
STATION CLEAR
Station Control
Remote
Sherman Rd Sub
Pri StaServ
P99A4
Off Sherman Rd
P99A6
100A
Off Sherman Rd
Ocean State Power
Feeder Anouncements in Multiple Districts may be required when re-energizing
N/O
642075
B
642074
100k
P28
N. Main St
642073
P628-50
Quaker Hwy
N/O
P629
321W2 Pg 2
Dist 53
No. Smithfield
Dist 5
Uxbridge
641017
P294
West Ironstone Rd
Burrillville
No. Smithfield
600 kVAR
(SW)
P252
HLT Off
* 641012
P234
Douglas Pike
641013
N/O
N/O
641009
HLT Off
* 641008
P99
Bronco Hwy
Victory Hwy
P20
(TC)
600 kVAR
27403
P60
Victory Hwy
27404
P39
Victory Hwy
642032
P592
N/O
642136
HLT Off
* 642135
P590
Victory Hwy
OC = 650
174320
P83
School
547
P536
Great Rd
N/O
26W5
127W41
641023
P230
Douglas Pike
N/O
1200 kVAR
(SW)
P226
Burrillville
No. Smithfield
1200 kVAR
(TC)
P22
N. Main
641016
P202
Douglas Pike
FI
45 A
88 A
82 A
3
Nasonville
127W40
14.4 kV
660
P17
Maple
642008
P86
School
641006
P212
Pascoag R/W
641015
P201-1
Douglas Pike
27405
P14
N. Main
641014
P199
Douglas Pike
N/O
641057
HLT Off
* 641056
P0-25
Tarkiln Rd
641055
P173-1
Douglas Pike
642007
P1
Railroad St
N/O
823
P104
School
N/O
600 kVAR
(FX)
P101
School
A P0-50
B P1
C P1-50
Tarkiln Rd
641058
Nichols Rd
P1
641061
Log Rd
P33-52
641062
Log Rd
P33-54
* 641063
P33-56
Burrillville, RI
0 Log Rd
Log Rd Solar LLC
RI 29106677
3.9 MW
INV
26W7
B
B
Revised 09/26/2022

Division 1-33

Request:

The Company has discussed that GMP investments would be important in restoration efforts following an event similar to Nasonville. To expand on the Company's statement, describe the GMP investments, how the Company would rely on the investments, how the GMP investments would change or improve restoration efforts achieved by the Company, the quantifiable improvement in reliability that would be expected with GMP investments, and the estimated cost of the GMP investments.

Response:

The Grid Modernization Plan ("GMP") investments could have assisted the Nasonville restoration in many ways. The following list describes the issues, how the GMP investments could have mitigated the issues, and approximate quantification of the benefits. The costs of the GMP investments are not provided in this response because the GMP investments represent a comprehensive solution that cannot be broken down and attributed to a single event. The Nasonville event alone does not justify the GMP investments. Instead, the Nasonville event provides a recent case of how the GMP investments provide a number of benefits and provide those benefits immediately.

1. Voltage Management:
    a. Voltage Issue 1 - Voltage dropped below American National Standards Institute limits because of extended feeder length under outage reconfiguration. Approximately half of the devices had remote monitoring to provide visibility into low voltage issues, but the other half did not. Some customers outside the Control Center's voltage visibility reported voltage as low as 96V at their houses.
    b. Voltage Issue 2 - A Woonsocket load tap changer ("LTC") set point adjustment was needed to compensate for the higher voltage drop resulting in lower remote end voltage because of additional loading and extended feeder length. A crew was dispatched to manually change the LTC set point.
    c. Voltage Issue 3 – The system had high voltage while trying to get the first mobile generator to come online. The high voltage prevented the generator from relieving load for approximately two hours. Remote tripping of capacitors was used to reduce voltage, but further voltage reduction was required. A crew was dispatched to adjust an upstream non-advanced regulator. Manual tap position adjustment of the generator's step-up transformer and generator control power factor adjustment were ultimately necessary to bring the voltage within an acceptable range to bring the unit online.

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   d. Voltage Issue 4 - A non-advanced regulator controller had a controller failure during the event resulting in high voltage. Crews were dispatched to troubleshoot the controller.
2. Loadflow Analysis:
   a. Loadflow Issue - Modeling the reconfigured system to perform load flow simulations that assessed potential contingency actions was necessary to support operations. It was difficult to perform these assessments with offline simulation tools because of repeated manual entry of multiple meter data points that was required to make the offline model sufficiently accurate to aid contingency planning.
3. Distributed Energy Resource ("DER") Dispatch:
   a. DER Dispatch Issue 1 - Pascoag Municipal's battery dispatch was conducted through phone calls between Rhode Island Energy's Control Center and Pascoag Municipal personnel. The daily dispatch was setup each morning. Although the initial daily battery dispatch setup was reasonable, cloud coverage of large photovoltaic ("PV") sites on the 26W1 feeder combined with the battery charging schedule sometimes exacerbated loading issues. Operations needed to quickly adjust and readjust through phone calls with Pascoag Municipal personnel to change the battery status.
   b. DER Dispatch Issue 2 – PV generation sites tripped because of large voltage deviations, which resulted in excessive feeder loading.
4. Load Management:
   a. Loading Issue 1 – Crews had to be dispatched to switch locations for initial restoration and to restore the system to normal configuration.
   b. Loading Issue 2 - A large customer was asked to curtail their operations during the event to avoid system overloads. The customer shutdown their operations for approximately two days.
   c. Loading Issue 3 – Because the system was near its loading limits, load shed plans were developed. Customer communications were distributed for potential evening load shed needs during the immediate days following the station event. Although no load shed actions were taken, the proposed actions were developed using existing switch and protective device locations.

GMP Actions and Equipment:

   a. Voltage Visibility GMP Benefit – More granular voltage visibility along feeders would allow operations to respond to more voltage issues before customer

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b. complaints or equipment damage occur. This would be accomplished with an ADMS system, communication system, advanced capacitors and regulators, and real-time loadflow.
c. Distribution Voltage Operational GMP Benefit 1 - Remote switching of capacitors and regulators would solve voltage issues and DER dispatch issues without dispatch of line crews. This would be accomplished with an ADMS system, communication system, advanced capacitors and regulators, and real-time loadflow.
d. Distribution Voltage Operational GMP Benefit 2 - Remote control of capacitors and regulators would inform the Control Center of equipment or control issues before those equipment issues become critical. This would be accomplished with an ADMS system, communication system, and advanced capacitors and regulators.
e. Substation Voltage Operational GMP Benefit - Remote adjustment of LTC controls could have avoided the need to dispatch a crew to adjust the LTC manually. This would be accomplished with an ADMS system, communication system, and sensing from advanced capacitors and meters.
f. Real-Time Load Flow GMP Benefits - Real-time load flow tools would have merged real-time system configuration and meter data into the model automatically for fast simulations to evaluate potential contingency actions. This would be accomplished with an ADMS system, communication system, sensing from capacitors, meters, and reclosers, and real-time loadflow.
g. DER Dispatch GMP Benefit 1 - Direct control of battery storage would allow for a faster coordinated response to provide optimal feeder load management during significant loading or generation changes. This would be accomplished with an ADMS system, communication system, sensing from capacitors, meters, and reclosers, real-time loadflow, and a DER monitor/manage system.
h. DER Dispatch GMP Benefit 2 - DER monitor/manage would enable volt/var inverter controls that regulate voltage locally at PV sites to prevent tripping and prevent voltage swings should nearby sites trip or cloud cover occur. This would be accomplished with an ADMS system, communication system, sensing from capacitors, meters, and reclosers, real-time loadflow, and a DER monitor/manage system.
i. Load Management GMP Benefit 1 – Advanced reclosers would provide system self-healing and quicken restoration. This would be accomplished with an ADMS

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j. system, communication system, advanced reclosers, sensing from capacitors, and meters, and real-time loadflow.
k. Load Management GMP Benefit 2 – With the monitoring, load flow, and voltage control benefits of GMP, the large customer's load could have been managed to avoid shutdown. This would be accomplished with an ADMS system, communication system, sensing from capacitors, reclosers, and meters, and real-time loadflow.
l. Load Management GMP Benefit 3 – Load shed plan could be developed at a much more granular level, potentially to the individual meter. This would be accomplished with an ADMS system, communication system, sensing from capacitors, reclosers, and meters, and real-time loadflow.

GMP Benefits Quantification:

The following benefit quantifications are estimates, not actuals, and have been developed for the Company's response to this data request. Rhode Island Energy does not typically quantify benefits for a specific outage event. The pending GMP calculates systemwide benefits in a similar manner to the items below.

a. Avoided Crew Dispatch for Switching – Approximately two crews for five hours would have been avoided at the beginning and end of the system reconfiguration duration for a total of $7,500.
b. Avoided Crew Dispatch for Troubleshooting – Approximately five crew dispatches would have been avoided at $1000 per dispatch, equaling $5,000. This includes crew, operator, and engineering time. The failed regulator control required significant resources and time, so this estimate may be conservatively low.
c. Value of Self-Healing – The United States Department of Energy ("USDOE") Interruption Cost Estimate ("ICE") Calculator was used to evaluate the first two switching steps as self-healed. A value of $480,000 was calculated.

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d. Value of Customer Curtailment – USDOE ICE Calculator was used to evaluate the large customer shutdown for two days. A value of $24,000 per day was calculated, or $48,000 total for the two days.[1]
e. Value of Real-Time Loadflow – Time for two engineers for three days at a total of $9,000

Other system level benefits have not been quantified. For example, Control Center efficiencies have not been quantified. These would include switching order development and execution, operator time savings associated with access to real-time load flow, and faster decision making with access to granular system data.

[1] Pending customer claim is reportedly in the vicinity of $120,000, suggesting it is possible that the ICE Calculator is conservatively low in this instance.

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SMP 401.03.3 VACUUM CIRCUIT BREAKER INSPECTION CARD Version 3.0 01/10/13

Substation	Circuit Designation	Manufacturer	Breaker Type	Mechanism Type	Reference #	Work Order #	Date
NASONVILLE	27W41	ABB	RMVAC	DST 2-15-500-12	01-94	28444000	6-11-19

VISUAL AND OPERATIONAL (V&O) INSPECTION

- [x] Perform Circuit Breaker Mechanism (SMP 401.20.3) V&O Inspection Items
- [x] Check For Abnormal Noise
- [x] Check Bushings
- [x] Check High Voltage Cabinet Heater with CT clamp on ammeter
- [x] Check Ready Light Illuminated
- [x] Check Primary and Ground Connections
- [x] Check Animal protection

DIAGNOSTIC INSPECTION

- [x] Perform the V&O Inspection Items
- [x] Complete all outstanding work orders
- [x] Visually Check Shutter Doors Closed (truck type)
- [x] Perform Circuit Breaker Mechanism (SMP 401.20.3) Mechanism Inspection Items
- [x] Perform and Record Insulation Resistance Test
- [x] Perform and Record Contact Resistance Test
- [x] HiPot Vacuum Bottles
- [x] Check Contact Erosion (measurement or wear indicators)
- [x] Check for Simultaneous Contact Make and Break (15kV and below)

Magnetic Actuator Checks

- [x] Remove Front Cover & Check Circuit Board for Bulging Caps, loose hardware or wiring within the breaker.
- [x] Check breaker can be opened by manual spring charged handle when disconnected and in a fully discharged state.
- [ ] Check breaker can be operated by pushbuttons. 3 times in succession without becoming not ready or going trip-free. Indicating lights correctly follow breaker status.
- [x] Check breaker becomes ready light from a total discharged state in less than 2 minutes
- [x] Truck Type Check that when placed in light comes on indicating capacitor discharge underway and goes out after approximately 10 seconds, disconnect from connected that close
- [x] Remove power to control board (Open 08 switch for outdoor breaker or close interlock microswitch on truck type breaker) and check not ready alarm received at control center.
- [ ] Perform Travel Analyzer Tests 23 kV and Above, if required (Attach Sheets) (Not required if 3 phase Profiler test was performed and main contact times recorded)
- [x] Check High Voltage Cabinet Heaters and Thermostats
- [x] Check Foundation Clamps Tight
- [x] Check all Control Wiring Tight
- [ ] Clean Cubicle
- [x] HiPot Test 1through 6 performed on withdrawal (truck) types before racking in
- [x] Paint touched up or in good condition
- [x] Check Primary and Ground Connections Physically

ACCEPTANCE INSPECTION

- [ ] Perform the V&O Inspection Items
- [ ] Perform Diagnostic Inspection Items

ABNORMAL CONDITIONS / REPAIRS MADE

Inspected By	Reviewed By
B.P K.K. SL	[signature]

SMP 401.20.3 CIRCUIT BREAKER MECHANISM INSPECTION CARD Version 3.1 04/01/15

Substation	Circuit Designation	Manufacturer	Breaker Type	Mechanism Type	Reference #	Work Order #	Date
NASONVILLE	127W41	ABB	RMVAC	OST 2-15-500-12	01.942	38444030	6-11-19

GENERAL

V&O Inspection
- ☑ Check Position Indicator
- ☑ Check Cabinet Weather Proofing
- ☐ Check for Corrosion
- ☐ Check Painted Surfaces
- ☐ Check for Moisture in Cabinet
- ☐ Check Heaters and Thermostats
- ☐ Record Counters and Hour Meters
- ☐ Check Control Lights
- ☐ Record and Reset Relay Targets (record under Abnormal Conditions,)
- ☐ Check Reclosing Relay Reset
- ☐ Check Control Voltage and Fuses
- ☐ Check Air Vents and Air Filters

Mechanism Inspection
- ☐ Perform V&O Inspection Items
- ☐ Perform and Record Initial Trip Timing (Profiler). Note in Abnormal conditions if fails
- ☐ Attach Profiler Test Lead Connection Point Tags if Not Present
- ☐ Clean and Lubricate Mechanism only if 1st trip fails – See Procedure
- ☐ Operate Breaker By Control Handle
- ☐ Check Counter for Proper Operation
- ☐ Check trip coil
- ☐ Check Operating Rods
- ☐ Check Manual Trip and 69 Switch
- ☐ Check auxiliary (stack) switch alignments (per SMP 401.06.2 Section 5.14)
- ☐ Check Dash Pots or Shock Absorbers
- ☐ Check Position Indicator for Proper Operation
- ☐ Test and Record Alarms and Pressures (Air, SF6, Hydraulic)
- ☐ Check and Verify Clearance Dimensions According to Manufacturer's Instruction Book
- ☐ Check Reclosing Relay (if electromechanical)
- ☐ Perform maintenance trip
- ☐ Operate Breaker Remotely

PNEUMATIC MECHANISM

V&O Inspection
- ☐ Record Air Pressure and Operating Hours
- ☐ Check for Air Leaks
- ☐ Check Belts and Pulleys
- ☐ Drain Moisture for Tank (if above 40° F)
- ☐ Visually Check Motor
- ☐ Check Compressor Oil Level
- ☐ Record Cut-in and Cut-out Pressures
- ☐ Check Un-loader Valve

Mechanism Inspection
- ☐ Perform V&O Inspection Items
- ☐ Check Closing Valve and Pilots
- ☐ Check and Record Pressure Alarm Switches Operation
- ☐ Change Compressor Oil
- ☐ Clean/Replace Air Filter

Pneumatic Air Tank Inspection
- ☐ (Done with Mechanism Inspection)
- ☐ Operate air tank safety valve
- ☐ Check tank integrity

Diagnostic Inspection
- ☐ Perform V&O and Mechanism Inspection Items
- ☐ Check and Record Compressor Pump up time.
- ☐ Check and Record of Operations to Lockout

HYDRAULIC, PNEUDRAULIC MECHANISM

V&O Inspection
- ☐ Check for Hydraulic Leaks
- ☐ Check Hydraulic Fluid Level (if Possible)
- ☐ Record Hydraulic Pressure and Operating Hours
- ☐ Record cut-in and Cut-out pressures

Mechanism Inspection
- ☐ Perform V&O Inspection Items
- ☐ Check Hydraulic Pump and Motor
- ☐ Check Hand Pump
- ☐ Check and Record Nitrogen Precharge Pressure
- ☐ Check Sump
- ☐ Check and Record Compressor Pump up time.
- ☐ Check and Record Pressure Switches Operation

Diagnostic Inspection
- ☐ Perform V&O and Mechanism Inspection Items
- ☐ Check and Record Number of Operations to Lockout
- ☐ Change Hydraulic Oil and Replace Hydraulic Filter (If Necessary)
- ☐ Check sump

MOTOR SPRING MECHANISM

V&O Inspection
- ☐ Verify That Spring Is Charged
- ☐ Visually Check Motor

Mechanism Inspection
- ☐ Perform V&O Inspection Items
- ☐ Check Motor Brushes if Easily Accessible
- ☐ Check Ratchet Gear for Wear
- ☐ Check Limit Switches
- ☐ Check Primary Connections (stabs) Breaker side Only
- ☐ Check and Lubricate Racking Mechanism
- ☐ Check Manual Close
- ☐ Clean Cubicle

SOLENOID MECHANISM

V&O Inspection
- ☐ Check Closing Solenoid for Signs of Overheating

Mechanism Inspection
- ☐ Check Closing Solenoid Connections Tight
- ☐ Check Closing Contactor Contacts and Arc Chutes
- ☐ Check Primary Connections (stabs) Breaker side Only
- ☐ Check and Lubricate Racking Mechanism
- ☐ Clean Cubicle

SMP 401.03.3 VACUUM CIRCUIT BREAKER INSPECTION CARD

Breaker Type	Mechanism Type	Reference #	Date
RM VAC	PST 2-15-500-12	01-9421	6.11.19

Insulation Resistance (Megger)

	Test Voltage kV	Breaker Open			Breaker Closed		
		Bushing 1-2	Bushing 3-4	Bushing 5-6	Bushing 1-G	Bushing 3-G	Bushing 5-G
As Found	5kV	247 G	334 G	375G	88 G	91G	97G
As Left	5KV	247 G	334G	375G	88G	91G	97G

Contact Resistance

	Test Amps	Pole 1	Pole 2	Pole 3	Mfr Limit
As Found Micro-Ohms	100	16µA	15.4µA	16.1µA	
As Left Micro-Ohms	100	16µA	15.4µA	16.1µA	

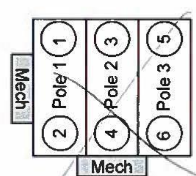
Vacuum Bottle HiPot (Integrity Test)

Test Voltage kV	27 kV
HiPot Used	☑ AC ☐ DC
------------------------	Leakage Current
Mfr Limit (if available)	
Pole 1**	(Pass)/Fail
Pole 2 **	(Pass)/Fail
Pole 3 **	(Pass)/Fail

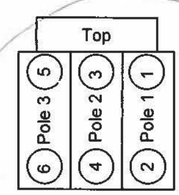
**Test all bottles individually

Contact Erosion Measurement or "OK" For Wear Indicator

	Pole 1	Pole 2	Pole 3	Mfr Spec
As Found				
As Left				



Stand alone Vacuum Circuit Breaker

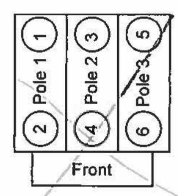


Horizontal roll-in insertion truck

HiPot Tests AC Hi pot

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Passed (√)	10µA	10µA	10µA	10µA	10µA	10µA
Failed (HiPot Set Tripped Out)						

Test 1 = Stab/Bushing 1, Test 2 = Stab 2, etc.



Vertical lift insertion truck

127W99

SMP 401.20.3 CIRCUIT BREAKER MECHANISM INSPECTION CARD

Breaker Type	Mechanism Type	Reference #	Date
RM VAC	2-15-500-12	01-9421	6-11-19

TWO PRESSURE GAS BREAKERS

Mechanism Inspection
- ☐ Perform Gas Analysis Inspection
- ☐ Change Gas Compressor Oil, if Necessary
- ☐ Check and Record Moisture Content (High and Low Pressure Systems)
- ☐ Test Low Pressure Trip on High Pressure System
- ☐ Test Low Pressure Alarm on Low Pressure System

Operations to Lockout and Pump Up Time

	As Found	As Left	Inst .Book
Operations to Lockout			
Pump Up Time			

SF6 Pressure, and Temperature

	Outside Temp.	Single Pressure Pole 1	Pole 2	Pole 3	Mfr Spec	Two Pressure High	Low	Mfr Spec
As Found								
As Left								

Operations and Compressor/Pump Hours

	As Found	Previous	Change	As Left
Operations Counter	162			177
Air Compressor / Hydraulic Pump				
Gas Compressor				

Alarm, Lockout and Trip Pressures

	As Found	As Left	Inst. Book
Low Air/Hydraulic Pressure Alarm			
Low Air/Hydraulic Pressure Lockout			
Low Air/Hydraulic Pressure Trip			
Low SF6 Gas Pressure Alarm			
Low SF6 Gas Pressure Lockout			
Low SF6 Gas Pressure Trip			
Low SF6 Gas Pressure Alarm (2 Pressure High Pressure)			
Low SF6 Gas Pressure Lockout (Two Pressure High Pressure)			
Low SF6 Gas Pressure Trip (Two Pressure High Pressure)			

Timing Tests- Trip Only (Profiler)

	As Found 1	2	3	2nd Test 1	2	3	As Left 1	2	3	Limit
M Con	48.2	48.4	48.4							
End	54.0									
V Ini	54.4			SPREAD 0.2						
V Min	53.0									

Profiler Test (First Shot)

	Yes	No	Remarks / Comments on Failure
Passed	X		
Lubricant Applied		X	

Air, Gas and Hydraulic Cut-In/Cut-Out Pressures

	Pressure As Found	As Left	Cut-in As Found	As Left	Inst. Book	Cut-out As Found	As Left	Inst. Book
Air Compressor / Hydraulic Pump								
Gas Compressor								

Nitrogen Pre-charge Pressure

As Found	As Left	Inst. Book

ABNORMAL CONDITIONS / REPAIRS MADE

S/N 1VAFTRNK0732001 B10
PROFILED OFF LINE
DC PRIDE WAS PUT ON POSITIVE

NOTE: If the DC TRIP COIL VERIFICATION CHECK was coordinated with the CB MECHANISM INSPECTION, promptly complete the CMMS DC Trip Coil Verification Check **AND** CB Mechanism Inspection Cascade Work Orders

Inspected By: B.P KK S.L

Reviewed By: [signature]

SMP401.03.3 VACUUM CIRCUIT BREAKER INSPECTION CARD Version 1.4 10/14/2008

Substation	Circuit Designation	Manufacturer	Breaker Type	Mechanism Type	Reference #	~~Work Order #~~ WR	Date
Nasonville	127 W 41	ABB	RM VAC	DST 2-15-500-12	01-9421	7496733	3-22-10

VISUAL AND OPERATIONAL (V&O) INSPECTION

- ☑ Perform Circuit Breaker Mechanism (SMP 401.20.3) V&O Inspection Items
- ☑ Check For Abnormal Noise
- ☑ Check Bushings
- ☑ Check High Voltage Cabinet
- ☐ Check Primary and Ground Connections
- –☐– Check Animal protection

APPARATUS INSPECTION

- ☑ Perform the V&O Inspection Items
- ☑ Complete all outstanding work orders
- ☑ Visually Check Shutter Doors Closed (truck type)
- ☑ Perform Circuit Breaker Mechanism (SMP 401.20.3) Mechanism Inspection Items
- ☑ Perform and Record Insulation Resistance Test
- ☑ Perform and Record Contact Resistance Test
- ☑ HiPot Vacuum Bottles
- –☐– Check Contact Erosion (measurement or wear indicators)
- –☐– Check for Simultaneous Contact Make and Break (15kV and below)
- –☐– Perform Travel Analyzer Tests 23 kV and Above, if required (Attach Sheets) (Not required if 3 phase Profiler test was performed and main contact times recorded)
- ☑ Check High Voltage Cabinet Heaters and Thermostats
- –☐– Check Foundation Clamps Tight
- ☑ Check all Control Wiring Tight
- ☑ Clean Cubicle
- ☑ HiPot Test 1through 6 performed on withdrawal (truck) types before racking in
- ☑ Paint touched up or in good condition
- –☐– Check Primary and Ground Connections Physically

ACCEPTANCE INSPECTION

- ☑ Perform the V&O Inspection Items
- ☑ Perform Apparatus Inspection Items

ABNORMAL CONDITIONS / REPAIRS MADE

S/N 1 VAFTRNK0732001 B10
COUNTER - 63

Inspected By JC SC CS JP   Reviewed By:

SMP 401.03.3 VACUUM CIRCUIT BREAKER INSPECTION CARD

Breaker Type	Mechanism Type	Reference #	Date
RMI VAC	DST 2-15-500-12	01- 9421	3-22-10

127 W41

Insulation Resistance (Megger)

	Test Voltage kV	Breaker Open			Breaker Closed		
		Bushing 1-2	Bushing 3-4	Bushing 5-6	Bushing 1-G	Bushing 3-G	Bushing 5-G
As Found	5	100G	100G	100G	>100G	>100G	>100G
As Left							

Contact Resistance

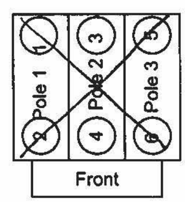
	Test Amps	Pole 1	Pole 2	Pole 3	Mfr Limit
As Found Micro-Ohms	100	23.6	23.1	23.7	
As Left Micro-Ohms					

Vacuum Bottle HiPot

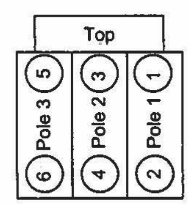
Test Voltage	40
~~AC~~/DC HiPot	
----------------------	Leakage Current
Mfr Limit	
Pole 1	3.2 uA
Pole 2	1 uA
Pole 3	1 uA

Contact Erosion Measurement or "OK" For Wear Indicator

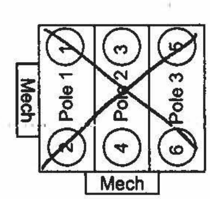
	Pole 1	Pole 2	Pole 3	Mfr Spec
As Found				
As Left				



Vertical lift insertion truck



Horizontal roll-in insertion truck



HiPot Tests

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Passed	1.1uA	1.2uA	.9uA	.8uA	1.4uA	.8uA
Failed (HiPot Set Tripped Out)						

Test 1 = Stab/Bushing 1, Test 2 = Stab 2, etc.

SMP 417.02.3 METAL-CLAD BUS AND SWITCHGEAR INSPECTION CARD

Substation	Voltages	Date
NASONVILLE	13 KV	11-1-09

Contact Resistance Tests – See procedure for Test Method

Phase /Neutral	Location	Micro-ohms	Test Current	Notes
A Ø	INSIDE METAL CLAD	262	100A	
B Ø	" " "	271	100	
C Ø	" " "	255	100	
A	TRAN THROAT → METAL CLAD	39	100	
B	" " "	42	"	
C	" " "	37	"	

Tests should be done with 100 amps. If repaired list before repair value in Notes.

Hi-Pot Tests

Phase	Location	Current Micro-Amps	Test Volts kV	AC /DC	Pass /Fail	Notes
A	INSIDE METAL CLAD	60 UA	37	DC	PASS	
B	" " "	20 UA	37	"	"	
C	" " "	30 UA	37	"	"	
A	TRAN. THROAT → METAL CLAD	50 UA	37	DC	PASS	
B	" " "	20 UA	37	"		
C	" " "	40 UA	37	"		

See procedure for method to hot-collar test individual insulation without disconnecting them.

SMP 417.02.3 METAL-CLAD BUS, SWITCHGEAR AND SUBSTATION INSPECTION CARDVersion 1.1 07/31/2007

Substation: NASONVILLE
Voltages: 13 KV
Date: 11-1-09

VISUAL AND OPERATIONAL (V&O) INSPECTION

- ☐ Perform Normal Substation V&O) Inspection (see SMP 400.06.2 and SMP 400.06.3)
- ☑ Check ground grid/ground rod connections to metal clad.
- ☑ Verify bus enclosure heaters working. Record current from clamp-on or installed ammeters
- ☑ Inspect cable entries for animal proofing
- ☑ Inspect perimeter of metal clad (ground level) for possible animal entry points. Record any found
- ☑ Inspect metal-clad and bus enclosure for corrosion, water or moisture damaged. Record any found
- ☑ Inspect walk-in switch gear, metal-clad substation, and bus enclosure for condition of gasketed/sealed joints. Record any problems found
- ☑ Listen for any indication of arcing or tracking.
- ☑ Verify operation of ventilating fans and shutters, if installed
- ☑ Inspect building and compartment air filters, clean as required
- ☐ Verify operation of air conditioners, if installed
- ☑ Check Indoor Lights
- ☑ Listen for sounds of arcing or discharge

DIAGNOSTIC INSPECTION

- ☐ Perform Profiler 1st trip test while switching out - see procedure
- ☑ Check heaters on before testing – see procedure
- ☑ Isolate and Hi-pot test all buses. Record hi-pot current. (See procedure for method to hot collar test individual insulators without disconnecting them)
- ☑ Micro-ohm test all bus phases and neutrals.
- ☑ Record readings (See procedure for test method)

Busses (Enclosed and Metal-clad)

- ☑ Open all access covers
- ☑ Visually inspect for corrosion and water/moisture damage. Record any found.
- ☑ Check for tracking
- ☑ Visually inspect insulators for surface contamination, surface damage or deterioration and tracking. Record any found.
- ☑ Check for tracking on inter-cubicle spacers, bus coverings, and other insulation.
- ☑ Visually inspect bolted electrical connections for signs of overheating. Record any found.
- ☑ Visually inspect all primary cable terminations for damage or deterioration. Record any found

Circuit Breakers and Cubicles

- ☑ Visually inspect for corrosion and water/moisture damage. Record any found.
- ☑ Visually inspect racking mechanisms. Lubricate as required
- ☐ Perform first trip Profiler test on all breakers removed from service (switched out). Record results. Previously taken Profiler data may be used if less than 2 years old.
- ☑ Visually inspect potential transformers, and their disconnecting devices, if applicable
- ☑ Visually inspect control power (station service) transformers, and their disconnecting devices, if applicable
- ☑ Rack out all breakers removed from service (switched out) and inspect insulators, stabs, breaker and cubicle grounding, and control power connections/connectors.
- ☑ Inspect bus and feeder HV connections, insulators and potheads if de-energized.

Building and Bus Enclosure Corrosion or Damage

Location (Attach photographs)	Repaired (Yes/No)	Notes

Fall 2021

KEY	Feeder #	Area	Pole #	Pole Suffice	ROW	Street	Town	Reference Number	Additional Comments
C&A	38F1		40			Snake Hill Rd.	Glocester		

KEY	Oil Leak Status	Battery Voltage	Battery Voltage Load	Battery Date	Control Height	Mechanism / Ser #	Animal Protection	Control Power 1 or 2 Sources	Manufacturer	Control Serial Number	Control Type	Counter Reading	Loop Scheme
C&A	C	13.8	13.6	2-18	11'		Y		G+W			33	

KEY	Feeder #	Area	Pole #	Pole Suffice	ROW	Street	Town	Reference Number	Additional Comments
C&A	127W41		227			Victory Hwy	Burrillville		

KEY	Oil Leak Status	Battery Voltage	Battery Voltage Load	Battery Date	Control Height	Mechanism / Ser #	Animal Protection	Control Power 1 or 2 Sources	Manufacturer	Control Serial Number	Control Type	Counter Reading	Loop Scheme
C&A	C	13.9	13.6	5-19	7'		Y		G+W			56	

KEY	Feeder #	Area	Pole #	Pole Suffice	ROW	Street	Town	Reference Number	Additional Comments
C&A	127W42		11-3			Daniele Dr	Burrillville		

KEY	Oil Leak Status	Battery Voltage	Battery Voltage Load	Battery Date	Control Height	Mechanism / Ser #	Animal Protection	Control Power 1 or 2 Sources	Manufacturer	Control Serial Number	Control Type	Counter Reading	Loop Scheme
C&A	C	14.1	13.7	8-18	10'		Y		G+W			152	

Appendix E "Circuit Breaker Data"

IEEE Std C37.04-2018
IEEE Standard for Ratings and Requirements for AC High-Voltage Circuit Breakers
with Rated Maximum Voltage Above 1000 V

6.3 Preferred ratings for class S1 circuit breakers

Table 8, Table 9, Table 10, and Table 11 are applicable to class S1 circuit breakers (formerly referred to as indoor circuit breakers).

Table 8—Preferred ratings for class S1 circuit breakers for cable systems below 100 kV [a, b]

Line no.	Rated maximum voltage (1) U_r	Rated continuous current (6)	Rated short-circuit and short-time current (I_{sc})	Rated interrupting time (2)	Maximum permissible tripping time delay	Rated closing and latching current (3) (4)
	kV, rms	A, rms	kA, rms	ms	Y, sec	kA, peak
	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
1	4.76	1200, 2000	31.5	50 or 83	2	82
2	4.76	1200, 2000	40	50 or 83	2	104
3	4.76	1200, 2000, 3000, 4000	50	50 or 83	2	130
4	4.76	1200, 2000, 3000, 4000	63	50 or 83	2	164
5	8.25	1200, 2000, 3000	40	50 or 83	2	104
6	15	1200, 2000	20	50 or 83	2	52
7	15	1200, 2000	25	50 or 83	2	65
8	15	1200, 2000	31.5	50 or 83	2	82
9	15	1200, 2000, 3000	40	50 or 83	2	104
10	15	1200, 2000, 3000	50	50 or 83	2	130
11	15	1200, 2000, 3000, 4000	63	50 or 83	2	164
12	27	1200	16	50 or 83	2	42
13	27	1200, 2000, 3000	25	50 or 83	2	65
14	38	1200	16	50 or 83	2	42
15	38	1200, 2000	25	50 or 83	2	65
16	38	1200, 2000, 3000, 4000	31.5	50 or 83	2	82
17	38	1200, 2000, 3000, 4000	40	50 or 83	2	104
18	72.5	1200	25	50 or 83	2	65
19	72.5	1200, 2000, 3000	31.5	50 or 83	2	82
20	72.5	2000, 3000, 4000	40	50 or 83	2	104

[a] Numbers in parenthesis refer to the information items in 6.3.1 for Table 8, Table 9 and Table 10.
[b] For preferred capacitive current switching ratings, see Table 11. For preferred dielectric ratings, see Table 6 and Table 7.

Table 1: IEEE Std C37.04-2018 standard ratings for S1 circuit breakers

5.6.2.3 Rated closing, latching, and short-time current carrying capability

The circuit breaker shall be capable of the following:

a) Closing and latching any power frequency making current whose maximum peak (peak making current) is:

1) Equal to or less than 2.6 times the rated short circuit current for 60 Hz power rated frequency and having time constants less than or equal to 45 ms

2) Equal to or less than 2.5 times the rated short circuit current for 50 Hz power rated frequency and having time constants less than or equal to 45 ms

3) Equal to or less than 2.7 times the rated short circuit current for all time constants greater than 45 ms up to 133 ms

b) Carrying a short-circuit current (short-time current), I_{sc}, for a period of time as specified in Clause 6 under the list of preferred ratings. These time durations establish the maximum permissible tripping time delay, Y, for each circuit breaker group.

Figure 1: IEEE Std C37.04-2018 standard rated closing, latching, and short-time current carrying capability.