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GOVERNMENT OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE: April 16, 2025, Bluesky Total Blackout Event	**CASE NO. NEPR-IN-2025-0003** **SUBJECT:** Motion Submitting Corrected Redacted Versions of the June 16th Exhibit 1 and 2 in Compliance with September 8, 2026, Resolution and Order

MOTION SUBMITTING CORRECTED REDACTED VERSIONS OF THE JUNE 16TH EXHIBITS 1 AND 2 IN COMPLIANCE WITH SEPTEMBER 8, 2026, RESOLUTION AND ORDER

TO THE HONORABLE PUERTO RICO ENERGY BUREAU:

COME NOW LUMA Energy, LLC ("ManagementCo"), and **LUMA Energy Servco, LLC** ("ServCo") (jointly referred to as "LUMA"), through the undersigned counsel, and respectfully state and request the following:

I. Relevant Procedural Background

1. In compliance with a Resolution and Order issued by the Puerto Rico Energy Bureau of the Public Service Regulatory Board ("Energy Bureau") on April 22, 2025, which started the referenced investigation, on June 16, 2025, LUMA filed *a Motion to Submit Report of Investigation* ("June 16th Motion") in which it submitted to the Energy Bureau, as an Exhibit 1, a report of the investigation of an outage event which occurred on April 16, 2025 (the "Event") prepared by Exponent titled "Line 50100 Outage Event, April 16, 2025 Root Cause Evaluation" dated June 16, 2025 ("Final Report" or "June 16th Exhibit 1"). In addition, LUMA submitted to the Energy Bureau, as an Exhibit 2 to the June 16th Motion, a ShareFile folder with the documents and information referenced in the Final Report ("June 16th Exhibit 2" and, together with the June 16th Exhibit 1, the "June 16th Exhibits 1 and 2")). While acknowledging that the June 16th Exhibits

1 and 2 are to remain confidential until the conclusion of the investigation,[1] LUMA also requested that the June 16th Exhibits 1 and 2 be protected from disclosure during and after the conclusion of the Investigation because they contained information that garners protection from public disclosure pursuant to federal statutes and regulations, and the Energy Bureau's Policy on Management of Confidential Information, CEPR-MI-2016-0009 issued on August 31, 2016, as amended by the Resolution dated September 16, 2016 ("Policy on Management of Confidential Information"), as well as other information protected by law and/or the Policy on Management of Confidential Information. LUMA further indicated that it would be submitting a Memorandum of Law in support of such request accompanied by redacted/public versions of the June 16th Exhibits 1 and 2.

2. On July 7, 2025,[2] LUMA filed its *Memorandum of Law in Support of Request for Confidential Treatment of Exhibits 1 and 2 Submitted on June 16, 2025* ("July 7th Motion"), whereby LUMA stated the legal basis for the request to treat the June 16th Exhibits 1 and 2 confidentially. LUMA also included, as *Exhibits B and C* of the July 7th Motion, the public/redacted versions of the June 16th Exhibits 1 and 2 ("Initially Redacted Exhibits").

3. On September 8, 2026, the Energy Bureau issued a Resolution and Order ("September 8th Order") making determinations regarding the confidential nature of the June 16th Exhibits 1 and 2. In it, the Energy Bureau discusses the bases for confidential treatment raised with respect to the June 16th Exhibits 1 and 2- namely, those based on the documents containing Critical Energy Infrastructure Information ("CEII"), evidentiary privileges (including trade secrets and attorney-client privilege), and right to privacy. *See* September 8th Resolution and Order, pp.

[1] *See* Section 15.10 of the Energy Bureau's *Regulation on Adjudicative, Notice of Noncompliance, Rate Review and Investigation Procedures*, Regulation No. 8543.
[2] Following a request for extension. *See Motion for Extension of Time to File Memorandum of Law in Support of Confidential Treatment of Exhibits 1 and 2 Submitted on June 16, 2025* filed on June 25, 2025.

3-6. The Energy Bureau then makes determinations on the confidentiality requests indicating that certain types of information are confidential CEII while rejecting that information on individuals included in these exhibits (that is, employee names, roles, positions, corporate email addresses and corporate telephone numbers) should remain confidential pursuant to right to privacy laws because this information is used in the work context. *See id*., pp. 6-8. . The Energy Bureau then ordered LUMA to produce, within a period of ten (10) days, a corrected redacted version that is consistent with the determinations of the Energy Bureau included in the September 8th Order.

II. Submittal of the Corrected Redacted Versions of the June 16th Exhibits 1 and 2.

4. Based on the Energy Bureau's determinations above, which only expressly reject the confidential treatment of information of individuals (sought to be protected by LUMA based on right to privacy arguments), LUMA understands in good faith that the information to be corrected in the June 16th Exhibits 1 and 2 is circumscribed to eliminating the redactions of this information. Accordingly, in compliance with the September 8th Order, LUMA hereby submits, as **Exhibits A** and **B**, the corrected redacted versions of the June 16th Exhibits 1 and 2, respectively, in which the mentioned information has been unredacted. If this interpretation of the September 8th Order is deemed inconsistent with the Energy Bureau's request therein, LUMA respectfully requests the Energy Bureau to provide additional guidance and time to respond/and or revise this submittal, if applicable. The table below identifies the documents, references, and pages in the Initially Redacted Exhibits where information was originally redacted on right to privacy grounds.

Document	Pages, Figures in which Confidential Information is Found, as applicable	Description	Changes made	Date Filed
June 16th Exhibit 1	Page 29, space after "Supervisor"	Name of individual	Unredacted the name of supervisor	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 2, pages 19-20	Emails with descriptions of LiDar information, identification of line where fault occurred and location of fault, and names of individuals	Unredacted names and emails of LUMA employees	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 8, Page 170	Email with information on vegetation management inspections which includes names and contact information of individuals	Unredacted names of DLA Piper attorney and Exponent points of contact	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 8, Page 172	Name of supervisor	Unredacted name of LUMA supervisor	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 9, Page 176	Name of supervisor	Unredacted name of LUMA supervisor	June 16, 2025 Correction submitted September 18, 2026

Document	Pages, Figures in which Confidential Information is Found, as applicable	Description	Changes made	Date Filed
June 16th Exhibit 2	Reference 11, pages 182 – 184	Internal emails with information on transmission line inspections and names and contact information of individual	Unredacted the names and email addresses of DLA Piper attorney, Exponent points of contact, and LUMA employees	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 13, page 194	Names and contact information of individual	Unredacted name, office location, phone and email address of LUMA employee	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 14, page 196	Email containing data regarding characteristics of line where fault occurred, line identification, and names and contact information of individuals.	Unredacted name and email address of DLA Piper attorney and names of Exponent point of contact	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 22, pages 306 to 307	Description of legacy design defect and individuals' names	Unredacted name and email address of DLA Piper attorney and names of Exponent point of contact	June 16, 2025 Correction submitted September 18, 2026
June 16th Exhibit 2	Reference 23, pages 315-447	Supervisor's name, number of feeder, and GPS coordinates of inspected spot in LUMA Vegetation Maintenance Detailed Reports	Unredacted the name of LUMA supervisor for every LUMA Vegetation Maintenance Detailed Report	June 16, 2025 Correction submitted September 18, 2026

5. LUMA notes that, with the exception of the above-noted changes, all other redactions made in the Initially Redacted Exhibits remain unchanged. Thus, LUMA respectfully requests to replace the Initially Redacted Exhibits with **Exhibits A and B** herein as the corrected redacted versions of the June 16th Exhibit 1 and 2, respectively, which can become the public versions when the record is made public once this Investigation is concluded.

WHEREFORE, LUMA respectfully requests that the Energy Bureau **take notice** of the aforementioned; **accept** the corrected versions of the June 16th Exhibits 1 and 2, included herein as Exhibit A and B; and **deem** LUMA in compliance with the September 8th Order; and/or **provide** such additional guidance and time to respond as necessary if additional revisions of these exhibits are required.

RESPECTFULLY SUBMITTED.

In Guaynabo, Puerto Rico, this 18th day of September 2026.

We hereby certify that this notice and request was filed using the electronic filing system of this Energy Bureau.

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Exhibit A

Corrected Redacted Version of the June 16th Exhibit 1

CONFIDENTIAL

Engineering Sciences

Exponent®

Line [redacted] Outage Event
April 16, 2025

Root Cause Evaluation

Exponent®

Line [redacted] Outage Event
April 16, 2025

Root Cause Evaluation

Prepared for:

DLA Piper

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June 16, 2025

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Contents

Page

List of Figures **iv**

List of Tables **v**

Limitations **vi**

Executive Summary **vii**

1 Introduction **1**

2 Problem Statement **3**

3 Assumptions and Open Actions **4**

4 Event Description **6**

4.1. System Assets Involved in the Event 6

4.2. Event Description 7

4.2.1 Initiating Fault – 230 kV Transmission Line [redacted] 7

4.2.2 Protection System Response 10

4.2.3 System Collapse 19

4.2.4 Restoration 19

4.3. Event Timeline 20

4.4. Immediate and Interim Corrective Actions 21

5 Observations and Event Analysis **24**

5.1 Vegetation Management 24

5.2 Equipment Inspection and Maintenance Analysis 31

5.3 System Protection Assessment 40

5.4 Systems Operation Assessment 42

5.5 Asset Management 42

6 Causal Analysis **44**

6.1 Findings and Observations 44

6.2 Causal Analysis 47

7 Recommended Corrective Actions 55

8 References 59

Appendix A: Comparative Timeline
Appendix B: Event and Causal Factor Chart

List of Figures

Figure 1. 230 kV Transmission Assets Involved in Event (Note: 230 kV system is shown by blue lines). 7

Figure 2. Location of Fault Before and After Tree Removal.[7] 9

Figure 3. Vegetation with Burn Marks in Area where Fault Occurred.[7] 10

Figure 4. Line [redacted] Protection. 11

Figure 5. Damaged Control Wiring at Circuit Breaker [redacted] at [redacted].[7] 14

Figure 6. 230 kV Line [redacted] Configuration.[10] 17

Figure 7. [redacted] Bus Configuration. 18

Figure 8. Restoration History.[5] 20

Figure 9. Photo of L[redacted] After Reclamation in Flood Plain. 28

Figure 10. Additional Photo of Area After Reclamation. (Note that location of incident was Lat. [redacted].) 29

Figure 11. LIDAR from Event Location taken on May 15, 2025.[25,26] 30

Figure 12. Evidence of Rodents at Cambalache. 35

Figure 13. Condition of Control Room.[36] 36

Figure 14. [redacted] Control Cabinet.[36] 37

Figure 15. Line [redacted] Conductor at Fault Location (broken strand visible).[26] 39

Figure 16. Line [redacted] Conductor Repair at Fault Location. 39

List of Tables

Table 1.	Key Findings from Comparative Timeline	46
Table 2.	Cause Determination Chart	53
Table 3.	Recommendations	56

Limitations

At the request of DLA Piper, Exponent conducted a root cause evaluation of the Line [redacted] outage event on April 16, 2025. The purpose of this evaluation is to determine the root and contributing causes of this event and to define recommended actions to reduce the potential for recurrence of this event. The results and conclusions of this evaluation are based on the information supplied by LUMA and public records. The opinions and comments formulated during this assessment are based on observations and information available at the time of this assessment.

The findings presented herein are made to a reasonable degree of engineering certainty. If new data becomes available or there are perceived omissions or misstatements in this report regarding any aspect of those conditions, we ask that they be brought to our attention as soon as possible so that we have the opportunity to fully address them.

Additionally, there are open actions underway that are being performed to improve our understanding of this event. If the results of these actions change the conclusions or recommendations in the report, the report will be updated to reflect this new information.

Executive Summary[1]

On Wednesday, April 16, 2025, at approximately 1238 hours, a fault occurred on the 230 kV Transmission Line [redacted] between the [redacted] substation and the [redacted] substation. This fault resulted in an island-wide outage within about 19.5 seconds of the fault initiation. Inspection of Line [redacted] following the event identified vegetation clearance encroachment as the cause of the fault. The protection systems at each end of the line detected the fault and properly issued trip commands. The two transmission line breakers at [redacted] properly opened to isolate the fault from that end. However, only one of the two breakers at [redacted] opened, while the other [redacted] failed to operate. The breaker failure function designed to operate under this scenario at Cambalache GP also failed to operate. Post-event site inspections of the breaker that failed to operate showed damaged relay control wiring. This control wiring was evaluated in a laboratory inspection and it was determined that the damage was due to rodents. The failure point occurred in wiring within the conduit and not at the damage in the circuit breaker cabinet. The site inspection also discovered that due to a legacy design[2] of the [redacted]. After the initial trip command and the breaker failure protection command both failed to reach the trip coil, [redacted] remained closed and the fault was still active.

With [redacted] still closed, the fault was still being fed from 230 kV Line [redacted] ([redacted]) and 230 kV Line [redacted] ([redacted]). The three gas peaking units that connected to the [redacted] bus were offline at the time as they were not needed for generation and were therefore not feeding the fault. Line [redacted] to [redacted] and [redacted] tripped properly. However, Line [redacted] did not trip and therefore, the fault remained active from being supplied from [redacted]. Under this condition, Line [redacted] ([redacted] to [redacted]) tripped. With the loss of [redacted] generation, system frequency fell rapidly.

[1] The executive summary is a high level review of the event and event analysis. Detailed discussion and citation to references are included the body of the report.

[2] The term "legacy" as used in this report refers to equipment, systems, operations, asset information, asset condition and documents that existed prior to the beginning of LUMA operation of the transmission and distribution system in June 2021.

All generation tripped offline within 19.5 seconds after the initial fault. The underfrequency load shedding schemes were not effective for this specific operational condition.

Customer restoration was completed on April 18, 2025 with over 98% of customer base returned to service by 0215 hours on April 18, 2025.

A causal analysis was performed using the following root cause tools:

- Comparative timeline
- Review of key work processes related to the event
- Event and causal factor chart

The results of the timeline analysis and review of work processes identified the following key findings:

- A fault occurred on 230 kV Line [redacted] about [redacted] miles from the [redacted] substation as the result of vegetation clearance encroachment.

- There was a helicopter patrol of Line [redacted] on April 11, 2025, that did not identify the vegetation clearance encroachment at the fault location.

- There was a pre-existing condition where one of the [redacted] for Line [redacted] was out-of-service due to a legacy [redacted]. [Note that based on how the event unfolded, the unavailability of this [redacted] did not directly contribute to the event. This is explained in further detail in Section 4.2.2.]

- The other primary [redacted] ([redacted]) for Line [redacted] saw the fault and issued a trip signal but the breaker ([redacted] did not operate. The backup [redacted] also issued a trip signal, as appropriate, but the breaker did not operate.

- Post-event site inspection identified damaged control wiring in the breaker control cabinet (subject to laboratory testing to determine failure mode) and also identified the [redacted] due to the legacy design ([redacted].

- All 230 kV lines and sources attached to the [redacted] 230 kV bus were off-line (peaker generation units) or tripped to clear the fault from the [redacted] (230/115 kV transformer, Line [redacted] to [redacted] and [redacted]). The only exception was Line [redacted] ([redacted] to [redacted]), which remained energized. Line [redacted] had been recently updated as part of a larger on-going 230 kV transmission system [redacted] upgrade. The goal of the upgrade was to bring the transmission [redacted] system up to current industry practices.[3] [redacted]. This [redacted] effort consists of performing studies and providing [redacted] settings using current industry practices. [redacted]. The [redacted] settings update [redacted].

[3] A study was completed for the 230 kV system in October 2024. The study included [redacted]. The implementation was on-going and all but three lines had been implemented at the time of the Incident.

[redacted].

- Since this was not the case, Line [redacted] ([redacted] to [redacted]) tripped and resulted in about 300 MW loss of generation and under frequency.

- With the fault still active, the automatic under frequency load shed scheme activated, but was not effective in preventing system collapse.

The results of the casual analysis resulted in the following root and contributing causes:

- Root Causes (RC):

    - RC #1: Legacy [redacted] electrical design and installation for [redacted] at [redacted] created [redacted].

- Contributing Causes (CC):

    - CC #1: The preventive and corrective maintenance program for substations did not effectively identify the equipment and wiring condition issues in the cabinet in question.

    - CC #2: Management of the change process for the [redacted], being implemented to bring the system to current industry standards, did not take into consideration the state of the system protection (e.g. [redacted]) so [redacted]. Therefore, while the [redacted] was not yet complete, it was not

able to handle this particular fault condition. [Note: The impact of the [redacted] has been considered a contributing event. While operation of the [redacted] breakers would have isolated the fault on Line [redacted], it would also have removed another 230 kV line from the transmission system. LUMA is performing a dynamic system analysis to determine what would have happened in the case of the loss of Line [redacted] and whether the system response would have prevented the collapse. Pending these results, this cause is considered as contributing.]

- CC #3: The vegetation management program after the initial reclamation in 2024 for the 230 kV lines was ineffective in identifying and preventing vegetation clearance encroachment in this case. LUMA inspects via aerial patrols the entire stretch of the 230kV lines at an appropriate frequency and only documents (photographs and notes) potential adverse clearance locations. However, the current practice does not have a mechanism to confirm the results of the inspection (other than for those areas identified as potential adverse clearance locations) for quality assurance purposes. [Note: Normally, the initiating event causes would be a root cause since eliminating the initiating event would prevent the incident. However, faults on overhead lines occur due to many causes (equipment failure, weather and external forces, wildlife, third party damage, etc.). These lines have protection systems to isolate faults on a single line and to prevent wide-spread outages. The root cause problem statement was focused on what led to the system collapse and an island-wide outage. A single fault should not result in a major outage; therefore, the initiating action potential causes are considered as contributing causes in this investigation.]

There are additional findings described in the report as well as recommendations to reduce the opportunity for this type of event in the future.

1 Introduction

On Wednesday, April 16, 2025, at approximately 1238 hours, a fault occurred on the 230 kV Transmission Line [redacted] between the [redacted] substation and the [redacted] substation. This fault resulted in an island-wide outage within about 19.5 seconds of the fault initiation.[4]

Inspection of Line [redacted] following the event identified vegetation clearance encroachment as the cause of the fault. The protection systems at each end of the line detected the fault as designed and issued trip commands. The two transmission line breakers at [redacted] opened to isolate the fault from that end as designed. However, only one of the two breakers at [redacted] opened, while the other failed to operate as it was supposed to in accordance with the protection design. The breaker failure function designed to operate under this scenario at [redacted] also failed to operate. Post-event inspections of the breaker that failed to operate showed damaged relay control wiring which did not deliver the trip signals to the breaker trip coil. The inspection also identified that control wiring [redacted]. Since the 230 kV breaker and the [redacted] did not operate, the fault was still active.[4]

Additional transmission lines operated as another layer of backup protection, including:[4]

- The 230 kV line [redacted] breakers opened at the [redacted] and [redacted] stations to isolate the fault from these ends as intended with its existing protection design.
- Line [redacted] from [redacted] to [redacted] did not trip. With Line [redacted] still energized, the fault was still active.

[4] 25.04.19_April 16th Island-wide Outage Event Preliminary Report (Ref. 1).

- Line [redacted] - [redacted] tripped via [redacted] protection to isolate the fault from EcoEléctrica.

Tripping of Line [redacted] disconnected the EcoEléctrica generating facility from the system. This resulted in a system frequency decline and then the subsequent loss of AES and Costa Sur [redacted], leading to a system collapse. The initiating fault was still present at the time of system collapse.[4]

At approximately 1400 hours, on Friday, April 18, 2025, all customers were returned to service.[4, 5]

DLA Piper has retained Exponent to perform a root cause analysis of this incident. The objectives of this analysis are to determine the root and contributing causes of this event and to define recommendations to reduce the potential for future events. Exponent performed an independent assessment utilizing information provided by LUMA relating to equipment performance, system operating status, system protection performance, equipment maintenance assessment, and other relevant information to develop the root cause and recommended actions. Reference documents are included as footnotes throughout the report and as references at the end of the report in Section 8.

This causal analysis was performed within a limited timeframe allotted by the ongoing regulatory investigation and is based on the information available as of the date of this report. There are several issues currently under study and this information can be included later when it becomes available if they change conclusions or recommendations. These items are identified in Section 3 and in the body of the report, as appropriate.

[5] Restoration Process Blackout Apr16.xlsx (Ref. 27).

2 Problem Statement

The problem statement provides the focus of the root cause analysis to ensure that the appropriate issues are addressed. Exponent personnel reviewed the available documentation and defined the problem statement for the root cause analysis. The problem statement developed for performing this root cause analysis is:

"On April 16, 2025 at approximately 1238 hours, a fault occurred on 230 kV transmission line [redacted] between [redacted] and [redacted] that resulted in system collapse within 19.5 seconds from fault initiation and outages to approximately 1.4 million customers."

Exponent is not aware of any safety issues that occurred as a result of this event so there is no assessment of LUMA safety processes and protocols in this report.

3 Assumptions and Open Actions

The assessment was performed to meet reporting requirements for LUMA to provide information to its regulators. At the time of completion of this report, there are several confirmatory tasks that are still in progress. The issues and open actions are summarized below and are highlighted later in the report where appropriate:

- [redacted] Circuit Breaker [redacted] relay control wiring: The relay control wiring from the control room to the circuit breaker cabinet was identified as showing signs of damage during the post-event site inspection. Also, the trip coil monitoring lights during the post-event site inspection showed intermittent connectivity in the trip coil circuits. It is suspected that the damage to the control wiring prevented the relay signal from reaching the circuit breaker trip coil to open the breaker for both primary protection and breaker failure protection. This control wiring was examined in a laboratory to determine the potential cause of damage. The damage was identified as rodent damage and the failure location was wiring within the conduit and not in the cabinet. When the laboratory inspection are finalized, the results will be reviewed to determine if any changes to conclusions or recommendations in this report are required.[6]

- System protection response during the event: LUMA is performing additional analysis to evaluate the protection actions and performance of the protection system relative to this event. When the results become available, they can be reviewed to determine if any changes to the conclusions or recommendations in this report are required.[6]

- System response during the event and other scenario analysis: LUMA will be performing a series of steady-state power flow analyses and a dynamic stability analysis to try to replicate the event and to provide additional insight into the event. These studies are intended to address several "what-if" scenarios including the tripping of breakers at Costa Sur and the follow-on system response. This analysis may improve the

[6] Discussions with LUMA personnel.

understanding of the event and may identify further recommendations or improvements. When these become available, they can be reviewed to determine if any changes to the conclusions or recommendations in this report are required.[6]

4 Event Description

The event description provides a general description of the system configuration of the 230 kV system as well as key assets (transmission lines, substations and generation plant) directly involved in the event; a summary of the event; and the event timeline. The event timeline is utilized to identify the key findings that form the starting point of the causal analysis.

4.1. System Assets Involved in the Event

The event was initiated by a fault on 230 kV transmission line [redacted] which connects [redacted] substation to [redacted] substation as shown by the arrow in Figure 1. As the event progressed, the following assets were also involved (also shown in Figure 1):

- 230 kV Transmission Line [redacted] which connects [redacted] and [redacted] to [redacted]
- 230 kV Transmission Line [redacted] which connects [redacted] to [redacted]
- 230 kV Transmission Line [redacted] which connects [redacted] to [redacted] [redacted]
- 230 kV buses at [redacted], [redacted], [redacted], [redacted], [redacted], and [redacted] Stations

Additionally, system protection equipment and schemes associated with the transmission line assets were involved in this event.

A more detailed discussion of these assets and how they affected the event is presented in the event description in Section 4.2.



Figure 1. 230 kV Transmission Assets Involved in Event (Note: 230 kV system is shown by blue lines).[7]

4.2. Event Description

A description of the event is provided here which details the key actions during the event. Additional information is included in the event timeline (Section 4.3) and in Reference 1.[7]

4.2.1 Initiating Fault – 230 kV Transmission Line [redacted]

The initiating event was a Phase A to ground fault on the 230 kV transmission line [redacted] between [redacted] and [redacted]. Line sensors (installed by LUMA in April 2023) identified the location of the fault as approximately [redacted] and [redacted] from the [redacted] and [redacted] substations, respectively. This record was automatically generated by the system.

[7] 25.04.19_April 16th Island-wide Outage Event Preliminary Report (Ref. 1).

SCADA waveform captures show that the event started as a phase-to-ground fault, quickly evolved to a phase-to-phase fault, and then evolved further to a three-phase fault.[8] This is consistent with the 230 kV line arcing to vegetation, ionizing the surrounding air, and then arcing through the ionized air to the other phases. Post incident photographs of the location show that the tree had grown near the phase conductor, but had not grown into the phase conductor. This is consistent with the fault starting by arcing from the phase conductor to the tree.

Helicopter crews were dispatched and left the ground around 1350 hours. Helicopter surveys and on-site inspections performed after the event confirmed the fault was caused by vegetation clearance encroachment from a tree near the location identified by the sensors.[7] The specific location of the fault occurred between Structures [redacted] and [redacted], which are located in a flood plain area.[9] The area in the vicinity of the fault is shown in Figure 2. The left image shows the tree that encroached the line clearance before its removal. The right image shows the site after the tree was removed. Vegetation damage at the location of the fault is shown in Figure 3. This figure shows burning and desiccation of vegetation due to arcing from the line to the vegetation and current flowing from the conductor through the tree and into the ground.

[8] Fault records.pdf (Ref. 37).

[9] 041625 Event Transmission Line Review of 2022 Lidar Information Addl Info.pdf (Ref. 2).



Figure 2. Location of Fault Before and After Tree Removal.[7]



Figure 3. Vegetation with Burn Marks in Area where Fault Occurred.[7]

4.2.2 Protection System Response

The protection systems for faults on Line [redacted] are at the ends of the lines at [redacted] and [redacted] substations. The protection systems for 230 kV Line [redacted] include circuit breakers [redacted] and [redacted] at [redacted] and circuit breakers [redacted] and [redacted] at [redacted] which are utilized to isolate Line [redacted] from the 230 kV system as shown in Figure 4.



Figure 4. Line [redacted]. [10]

[10] Information for this chart is taken from: 20220315 Transmission System Single-Line Diagram (Ref. 3).

The [redacted] systems consisted of [redacted] including:[7,11]

- [redacted]. At the time of the event, [redacted].
- [redacted]) and [redacted] that was in service at time of the event.

After the initial fault, the [redacted] at [redacted] trips the line instantaneously and [redacted] trips the line in approximately 0.55 seconds at [redacted]. Circuit breakers [redacted] and [redacted] at [redacted] both opened as intended. This action isolated the fault from the [redacted] end of the line. Circuit breaker [redacted] at [redacted] also opened as intended. Circuit breaker [redacted] at [redacted] did not open.[7] Post-event inspection indicated that the relay wiring to the circuit breaker trip coil was damaged and therefore, the circuit breaker did not receive the trip signal to open. The damaged wiring is shown in Figure 5. As previously indicated in Section 3, this wiring was subject to laboratory review and results indicated that rodents caused the wire damage. It was also noted that the point of failure was wiring in a conduit and not within the cabinet. Also, the post-event site inspection identified this [redacted] due to its legacy design for the circuit breaker [redacted].[12] [It should be noted that if the [redacted], it is likely that [redacted] would still not have opened. Also, it should be noted that LUMA was upgrading its [redacted] on its 230 kV system, but Line [redacted].][13,14]

[11] Discussions with LUMA personnel.

[12] EXTERNAL Privileged Confidential New design to mitigate the single common point of failure for Cambalache Planta (Ref. 22).

[13] Discussions with LUMA personnel.

[14] CAP L[redacted] Drawings.pdf (Ref. 30).

Backup protection is provided for each circuit breaker by the breaker failure relay. This relay sends a signal to open the breaker in the event of failure of the primary relay in the presence of a detected fault. The breaker failure relay identified the fault and sent a trip signal, but [redacted] did not open. Post-event site inspection identified that [redacted] due to its legacy design and therefore, the [redacted] trip coil never received the signal to trip due to [redacted].[12]

With [redacted] remaining closed, the fault was not cleared from the [redacted] end of the line and the fault remained active.[7]



Figure 5. Damaged Control Wiring at Circuit Breaker [redacted] at [redacted].[7]

With the fault not isolated from [redacted], all sources connected to the 230 kV bus at [redacted] were feeding the fault. As shown in Figure 4, the following 230 kV bus connections are:

- Three gas plants
- 230/115 kV transformer
- 230 kV Line [redacted] ([redacted] to [redacted] and [redacted])
- 230 kV Line [redacted] ([redacted] to [redacted])

Additional protection schemes were required from these sources to isolate the fault on Line [redacted]. The protection actions for these sources were:[7]

- The three gas plants are peaking units which were not necessary for the system loading at the time of the event. These plants were offline and therefore, these plants had no impact on the event.

- The 230/115 kV transformer at [redacted] tripped on backup protection as intended so that this source was isolated from the fault.

- Line [redacted] ([redacted] to [redacted] and [redacted]z) acted as backup protection that functioned as intended to isolate this source from the fault. Figure 6 shows the protection for Line [redacted]. Circuit Breakers [redacted] and [redacted] opened at [redacted] and Circuit Breaker [redacted] opened at [redacted] to isolate these substations from the fault on Line [redacted].

- Line [redacted] ([redacted] to [redacted]) did not trip [redacted], as [redacted] had been disabled. A [redacted] effort consisted of performing studies and providing [redacted] using current industry practices. In most terminals on the 230kV system, [redacted]. [redacted],

preventing the island wide blackout. The [redacted].

- Line [redacted] ([redacted] to [redacted]) is connected to the [redacted] 230 kV bus and is about 1.6 kilometers away. Figure 7 shows the configuration at [redacted]. EcoEléctrica [redacted] distance protection tripped as backup protection and removed about 300 MW of generation from the system at 4 seconds after the initial fault. However, this action did not isolate the fault, and the fault on Line [redacted] remained active as Line [redacted] was still energized.

At the completion of the protection actions, the fault on Line [redacted] was still active and being fed through [redacted]. Detailed discussion on the actions at [redacted] are provided in Section 5.3.



Figure 6. 230 kV Line [redacted] Configuration.[10]



Figure 7. [redacted] 230 kV Bus Configuration.[15]

[15] [redacted] 230 kV Swyd - Exist. One Line 7-28-2022 (Ref. 31).

4.2.3 System Collapse

After EcoEléctrica tripped off-line about 4 seconds after the start of the event and with the fault still active, the system frequency started to drop. The automatic Under Frequency Low Shed (UFLS) activated at about 10 seconds after the start of the event and quickly started to shed load blocks. After the last load block was shed, AES Generation and Costa Sur Generator [redacted]6 tripped offline at about 16 seconds after the start of the event. The system frequency dropped below 56 Hz and all generation units dropped off-line and the system collapsed at about 19 seconds after the start of the event.[7] A more detailed timeline of the UFLS and loss of generation is provided in Reference 1.

4.2.4 Restoration

After the event at 1238 hours on April 16, 2025, LUMA took the following actions to support recovery and restoration:

- LUMA set up the LEOC for emergency response.
- Conducted appropriate post-event assessments to identify location of the fault and identify any damage that would prevent restoration.
- Performed aerial patrols for 230 kV Lines [redacted] ([redacted] to [redacted]) and [redacted] ([redacted] to [redacted]).
- Cleared 230 kV Line [redacted] which was the line that had the fault.
- Identified and removed vegetation at the fault location on Line [redacted].

LUMA followed a restoration protocol based on past successful restorations (similar to the 12/31/2024 event). Not all generation units can be used for black start and required some time to come back online. The general process was to black start using plants at Palo Seco and San Juan and then proceed to add generation progressing from the north side of the Island to the south side of the Island. The general restoration went smoothly but the return to service is guided by the automatic protection and underfrequency load shedding schemes with some operator-intervention to bring the system back. Occasionally, load sheds occur so operators can restore the system safely. During this restoration, there were three underfrequency load sheds that

occurred. From an overall perspective, the return to service occurred with no major issues.[16] The customer restoration is shown in Figure 8 with all customers being restored by 1400 hours on April 18, 2025.

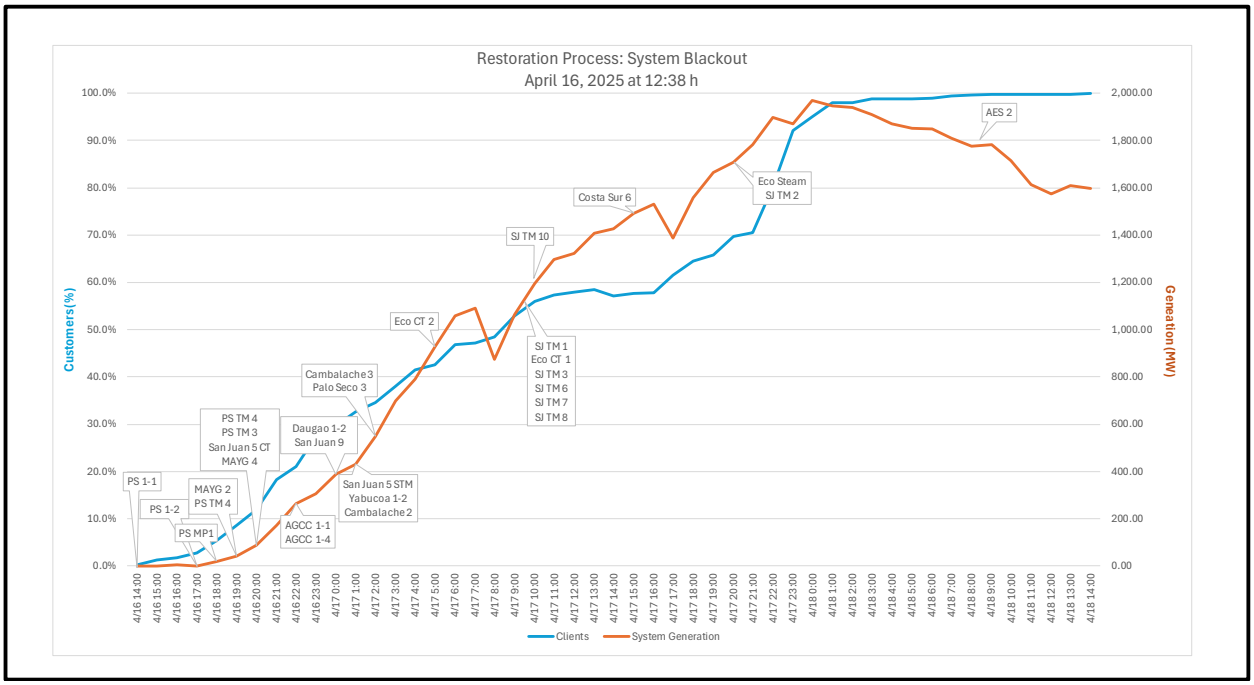


Figure 8. Restoration History.[5]

4.3. Event Timeline

The event scenario is determined based on an evaluation of the event information from the various operating and monitoring sources, failure analysis information, and various LUMA event reports. Additional details of the event scenario are found in those references. Based on an assessment of this data, a comparative timeline is prepared to assist in describing the sequence of events and also to identify findings and observations that are included in the causal analysis. Additional assessments of various work processes are detailed in Section 5 which are used to provide additional findings and observations for use in the causal analysis.

The comparative timeline is provided in Appendix A. The comparative timeline serves two main purposes. It provides a sequence of events that describes how the event unfolded, and it

[16] Discussions with LUMA personnel.

looks at each step to identify if the action was according to expectations. If the actions were not in accordance with expectation, a finding or observation is identified, and these are used to start the causal analysis. Additional timeline details are also found in Reference 1.

The first part of the timeline in Appendix A provides the sequence of events with the following information relative to each step in the event:

- Date
- Time
- Reference
- Equipment involved
- Initiating organization
- What happened

The remainder of the comparative timeline is used in the casual analysis and is described in Section 6.1.

4.4. Immediate and Interim Corrective Actions

After this event, LUMA took the following corrective actions in preparation of restoring the system:

- Line [redacted] helicopter patrol to identify the location of the fault was completed on April 16, 2025.

- Foot patrols to the affected areas and performance of corrective actions to eliminate vegetation issues were completed on April 17, 2025.

- Aerial inspections (including thermography) on Lines [redacted] and [redacted] were performed on April 24, 2025.

- Site inspections of [redacted] and [redacted] 230 kV substations including thermography performed on April 25, 2025.

- Site examination of [redacted] Circuit Breaker [redacted] and associated equipment and performance of corrective actions to address damaged equipment and [redacted]. LUMA is taking the following actions:[12]

  - Line [redacted] will have [redacted].

  - Each of [redacted].

  - Two control cables will be used for tripping circuits, one cable is for [redacted] and the other cable is [redacted].

- On-going evaluation of [redacted] under current conditions and configurations to determine interim actions. These actions include:[17]

  - LUMA has engaged an external engineering review of [redacted]t.

  - Until all 230 kV relay upgrades are completed and the additional external review is completed, LUMA has included a temporary [redacted] function addition at

[17] [redacted].

isolated lines including [redacted] to [redacted].

- LUMA has performed a repair on the damaged wire on Line [redacted]. LUMA installed a star clamp on the conductor which acts to reinforce the damaged conductor.

5 Observations and Event Analysis

This section details the various data collection and analysis activities associated with this root cause evaluation. The key analysis aspects of the assessment include:

- Vegetation management
- Equipment analysis
- System protection assessment
- System operations assessment
- Asset management assessment

This information will provide the basis for analysis of the event and the determination of findings to support the causal analysis.

5.1 Vegetation Management

The initiating action for this event was a fault on 230 kV Line [redacted] from [redacted] to [redacted] due to vegetation clearance encroachment. The location of the fault was between Structures [redacted] and [redacted] which are about 3-4 miles from [redacted] and 16-17 miles from [redacted].[9] A history of vegetation-related activities and performance of this line is reviewed to provide background for the causal analysis.

LUMA's overall vegetation management strategy is outlined in its Vegetation Management Plan[18] and the Systems Improvement Plan.[19] "The 230 kV system has had reclamation work done on all lines; therefore, preventative (cyclical) maintenance will be performed from the oldest to newest completion dates. The work will be working edge-to-edge of the easement, removing resprouted or new growth trees and using approved herbicide control. Also, the

[18] Exhibit 1_Vegetation Management Plan_Final.pdf (Ref. 4).

[19] 20240719-MI20240005-Submittal-of-Updated-Preliminary-Plan.pdf (Ref. 5).

230 kV will be flown quarterly by the Operations transmission team to identify any potential issues related to vegetation."[19]

Key vegetation management activities performed on 230 kV Transmission Line [redacted] by LUMA include the following:

- The initial reclamation work was performed starting March 13, 2023 and completed by April 12, 2024 and included 25.70 total miles.[20] The work performed during this reclamation included clearing entire easement width of any vegetation capable of growing within 25 feet of the conductor at maximum sag (incompatible species) and treating all removed trees.[21] Figure 9 and Figure 10 show the results of a representative area in the flood plain after this reclamation.[22]

- LUMA had performed helicopter patrols of this line prior to the event on:[7]

    - September 24, 2024
    - December 30, 2024
    - January 21, 2025
    - April 11, 2025

    There were locations identified for corrective vegetation work during the April 11, 2025 patrol and identified as P30 priority[22] (a preventive priority which requires actions to be completed within 30 days)[7]. These correctives had not yet been completed at the time of the event.[22] LUMA also performed post-event patrols on April 17 and April 24, 2025. There were P30 locations identified in these patrols also and these correctives are still pending.[22,23]

[20] TransmissionHistory.xlsx (Ref. 6).

[21] Transmission Clearance Guidelines.pdf (Ref. 7).

[22] EXTERNAL FW 041625 RCI questions.msg (Ref. 8).

[23] [redacted] Request History.xlsx (Ref. 10).

- The helicopter patrol on April 11, 2025 did not identify vegetation clearance encroachment at the location where the event occurred on April 16, 2025.[24] LUMA is continuing to refine its work practices to capture this lesson learned.

- LIDAR scans were performed on Line [redacted] on May 15, 2025, between Structures [redacted] and [redacted], where the event occurred. LIDAR readings showed a clearance between the lowest line and the vegetation of 29.5 ft. slightly less than the LUMA requirements of 30.5 ft.[25,26] This clearance between the line and vegetation would be considered as a P30 priority based on discussions with LUMA personnel. Figure 11 shows the LIDAR results.

In reviewing the LUMA processes for vegetation related matters, a few key observations are:[27]

- When performing helicopter patrols, although the entirety of the lines is patrolled, documentation (photography and notes) is only generated for potential clearance issues that are identified. This limits the opportunity for a second check on the assessment of the remaining areas of the line.

- During maintenance planning activities, LUMA makes a decision on whether significant vegetation work (such as mowing) is required during the line maintenance effort. As part of the planning, an arborist determines the need for vegetation work and if required, this is added to the maintenance scope. If not, personnel will identify any vegetation clearance issues that they see on the job.

- If vegetation work is identified, any trees that are cut down have the resulting stumps treated with herbicide so it will not grow back. For the reclamation work, the initial clearing involved mowing of the entire right-of-way. The mowed tree stumps were not treated with herbicide, as this was intended to be performed during future inspections

[24] EXTERNAL FW 041625 RCI questions.msg (Ref. 11).

[25] EXTERNAL FW profile.msg (Ref. 14).

[26] [redacted] INCIDENT PROFILE-FINAL.pdf (Ref. 15).

[27] Discussions with LUMA personnel.

should the stumps be identified as growing back. It is typical for crews to go back about one year after the vegetation management work to check for growth and to spray stumps. This effort had not occurred for Line [redacted] after the completion of work in March 2024.

A review of faults on Line [redacted] was performed to determine the history of vegetation-related faults on this line. The fault data is tracked based on the breaker operations so that for this assessment, operation of breakers [redacted] and [redacted] at [redacted] and [redacted]0 and [redacted] at [redacted] were reviewed. Based on a review of fault data from July 2021 to present, there were only two events related to vegetation with both occurring in early 2024.[28]

The key observations from the vegetation management review indicate that Line [redacted] had significant vegetation management work in 2023-early 2024, has been patrolled quarterly (as appropriate), and had experienced few vegetation management issues. LUMA is continuing to process lessons learned from this event and to identify potential areas for improvement.

[28] 230 KV FAULTS JANUARY 2022 TO MARCH 2025 updated.xlsx (Ref. 16).



Figure 9. Photo of L[redacted] After Reclamation in Flood Plain.[29]

[29] LUMA Vegetation Maintenance (January 2024) - Data [redacted].pdf (Ref. 9).

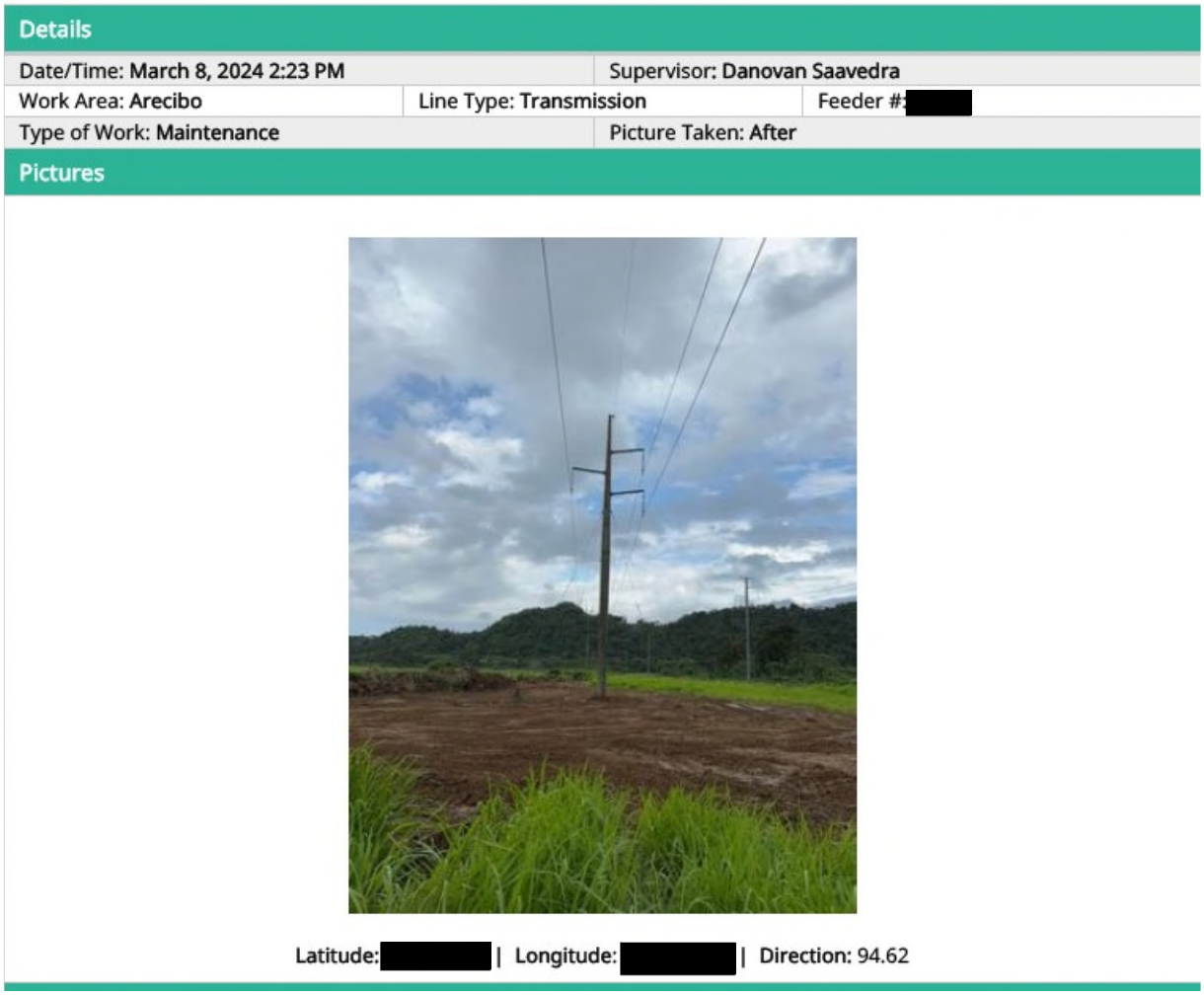


Figure 10. Additional Photo of Area After Reclamation.[30] (Note that location of incident was Lat. / Long. .)

[30] 20_LUMA_2024_March_10-25.pdf (Ref. 23).



Figure 11. LIDAR from Event Location taken on May 15, 2025.[25,26]

5.2 Equipment Inspection and Maintenance Analysis

The event was impacted by the failure of Circuit Breaker [redacted] at [redacted] to open when required to clear the fault on line [redacted]. As indicated in Section 4.2.2, there were two issues found related to [redacted]:

- Damaged control cable in the breaker control cabinet: This control wiring goes from the control room to the breaker and enters at the bottom of the breaker cabinet. The control wiring was found damaged during the post-event site inspection. Damage to wiring can be caused by mechanical means (fatigue, wear, vibration), installation issues, wildlife, or external forces (weather, etc.) The control wiring has been laboratory-inspected and it was determined that the damage was caused by rodents. Also, the damage occurred in wiring in the conduit and not within the control cabinet. The control cabinet had significant rust and holes in the bottom of the cabinet. Also, Figure 12 shows rodent bait around the control room indicating presence of rodents at the site.

- Legacy design issue: It was determined that a [redacted]. This condition leads to the potential for [redacted]. LUMA is in the process of performing a major upgrade of their 230 kV [redacted] (see Section 5.3 for additional details). Line [redacted] had not yet been upgraded at the time of the event, but the upgrade would have included [redacted]. If this upgrade had been completed at the time of the event, the [redacted]. The fault would have been cleared and the system would not have collapsed. This [redacted] effort consists of performing studies and providing [redacted] using current industry practices. In most terminals on the 230kV system, update of the [redacted]. The [redacted] update did not include [redacted]

[redacted].[31]

A review of the equipment inspection and maintenance activities was performed to identify any observations and findings related to the equipment programs. The programs related to this event are inspection and maintenance of circuit breakers and relays as well as substation visual inspection walkdowns.

- From a review of the past fault data, the breaker had its last operation prior to this event on November 7, 2024 due to a weather related fault on Line [redacted].[28] The breaker was also operated after this event to isolate Line [redacted]. There was no evidence of circuit breaker malfunction of the breaker mechanical system for [redacted] at [redacted].

- The circuit breaker [redacted] was installed in February 1997 and its most recent maintenance activities on this breaker are:[7]

    - Complete breaker maintenance in 2015
    - SF6 gas sampling in 2023
    - Power factor and capacitance testing in 2022
    - Relay functional testing in 2022

[31] EXTERNAL Privileged Confidential New design to mitigate [redacted] (Ref. 22).

There was no identification of condition issues with the circuit breaker performance. The post-Fiona assessment was reviewed and no issues with [redacted] were identified.[32]

- A prior inspection of the [redacted] substation was performed in 2019 after Hurricane Maria to assess the condition of assets.[33] This inspection included a visual assessment of the substation. Relevant observations from this inspections included:
    - For overall 230 kV circuit breakers, the following observations were noted:
        - "The (11) 230 kV GCBs (manufactured by ABB) were all in service and were in good, working condition.
        - The majority of the GCBs had severe corrosion on their control cabinets; however, this does not affect circuit breaker performance.
        - The majority of the GCBs had major corrosion of their support structures; however, this does not affect circuit breaker performance.
        - No circuit breaker wiring or terminals could be assessed due to restricted cabinet enclosure access."
    - Specifically for [redacted], the observations were:
        - "Overall Condition was 3 [which indicates no major issues noted.[34]]
        - Circuit breaker notes: This circuit breaker was manufactured by ABB and exhibited heavy rust on the structural, control cabinet and ground lug attachment to breaker is corroding (typical)."

[32] PRIVILEGED AND CONFIDENTIAL - ATTORNEY WORK PRODUCT - Post Fiona Testing Tracker – 20231023 [redacted].xlsx (Ref. 17).

[33] A-9 - [redacted]_Switchyard.pdf (Ref. 24).

[34] SL-014468.TD_TD Condition Assessment_Final_Rev.1_14Jun2019.pdf (Ref. 25).

- Visual inspections (walkthrough of the facility) are documented in walk down notes that only highlight findings. A review of the visual inspections is provided in an Excel spreadsheet.[35] These results noted no issues with [redacted] except for a comment on the post-Fiona assessment, which was reviewed; and as stated previously, there were no issues identified. However, photos taken after the event on April 16, 2025, show poor condition of the control cabinets and control room at [redacted]:

    - Figure 12 shows evidence of rodents present at the site.

    - Figure 13 shows general condition of control room building.

    - Figure 14 shows circuit breaker control cabinet.

    These photos are indicative of conditions at [redacted]. These visual walkthrough inspections generally look for obvious visible damage. However, these visual inspections do not inspect inside cabinets so that potential wiring issues would not be identified.

The key observation from the preventive maintenance and inspection program indicates that the current maintenance practices and visual walkthroughs were not effectively identifying damage to systems and components inside cabinets that have the potential to affect operations, and that are not immediately visible in the walkthrough. Although the frequency of the walkthrough inspection is adequate, the current process does not require visual inspections within cabinets (other than when maintenance requires opening of the cabinet). In this case, inspections of interior cabinets would have benefitted by occurring more frequently.

[35] [redacted] inspections.xlsx (Ref. 18).



Figure 12. Evidence of Rodents at [redacted].[36]

[36] Photos of [redacted].pdf (Ref. 19).



Figure 13. Condition of Control Room.[36]



Figure 14. [redacted] Control Cabinet.[36]

There were two other equipment related issues that did not directly impact the event but are discussed here for completeness.

- [redacted] Line [redacted]: There are [redacted] installed on Line [redacted]: [redacted]. Both of these [redacted] to detect faults on the line to send signals to the

appropriate circuit breakers to open to clear a fault. At the time of this event, [redacted].

LUMA has performed a review for extent of condition for these [redacted]. LUMA is determining if any additional actions are required for these installations.[37,38]

- Line [redacted] at Fault Location: As a result of the fault on Line [redacted], there was minor damage to the conductor at the event location as shown in Figure 15. The conductor shows a damaged strand and some burn marks. The conductor is 1192.5 ACSR 36/1.[39] LUMA made a decision to repair the conductor using a star clamp to reinforce the damaged conductor (see Figure 16).[40]

[37] Discussions with LUMA personnel.

[38] [redacted] (Ref. 32).

[39] Discussion with LUMA personnel.

[40] Photos of Line [redacted] Repairs.pdf (Ref. 28).



Figure 15. Line [redacted] Conductor at Fault Location (broken strand visible).[26]



Figure 16. Line [redacted] Conductor Repair at Fault Location.

5.3 System Protection Assessment

The [redacted] schemes were unable to clear the fault on Line [redacted] during this event. The legacy design of the [redacted] at [redacted] showed a [redacted].

LUMA was undertaking an upgrade to the 230 kV transmission [redacted] to bring the system up to current industry standards. [redacted]. A summary of the activities and changes are discussed below:[41]

- A system [redacted] study was completed in 2022 for the 230 kV system using the [redacted] ing:
    - [redacted].

[41] [redacted].docx (Ref. 20).

- [redacted]
- [redacted].
- [redacted].
- [redacted].
- [redacted].
- [redacted].
- [redacted].

- An additional study was performed to address inaccuracies in the [redacted] model and to validate [redacted]. This effort was completed at the end of 2023.

- The study was continued and completed for the 230 kV system in October 2024. The study [redacted].

  - [redacted].
  - [redacted].
  - [redacted].
  - [redacted].

The incident occurred when the 230 kV [redacted] had not yet fully been completed. At the time of the Incident, [redacted]

[redacted].

Therefore, the circuit breakers protecting Line [redacted] at [redacted]r did not trip during the event. The [redacted] and [redacted] substations were [redacted]. [redacted]. This action led to reductions in system frequency, loss of other generation and collapse of the system.

LUMA is performing a dynamic system analysis to tune their model to match the event and then to assess various "what-if" scenarios. Specifically, the study will examine the scenario where [redacted] cleared Line [redacted], and whether that action would have been sufficient to prevent the system collapse. While Line [redacted] being de-energized would have cleared the fault on Line [redacted] from the system, the system would have four 230 kV transmission lines ([redacted]) de-energized and the response of the system to this has not yet been determined.

5.4 Systems Operation Assessment

The systems operation assessment includes a review of underfrequency load shedding schemes. These schemes operated in this event as the frequency dropped during the event. The sequence of load shedding events continued until all load shed blocks were activated.[7] In this event, there was a long duration fault that was not cleared and the load shed scheme was unable to prevent system collapse.

5.5 Asset Management

LUMA has embarked on significant updates to its asset management programs over the past several years. Historically, the electric system in Puerto Rico has suffered from damage from

major storms events as well as a lack of maintenance and inspection. There are several major asset management programs underway to address age and obsolescence.

- LUMA is performing a major upgrade of its [redacted] to incorporate current industry standards and to provide for [redacted]. This upgrade program began in 2022 and is continuing today.[41,42]

- LUMA has prepared and implemented a Systems Improvement Plan[19] to address out-of-service equipment, equipment and facility upgrades, and major capital projects. In the System Improvement Preliminary Plan, LUMA indicates the work that is prioritized and planned for substations and transmission lines. For the [redacted] substation and for Line [redacted], there are currently no planned equipment upgrades to these facilities included over the next few years, except for preventive and corrective maintenance as well as the transmission protection upgrade.

[42] Event Discussion and WAPC Summary April 30 2025 Final.pdf (Ref. 21).

6 Causal Analysis

The causal analysis is performed by identifying issues from the timeline and the event analysis to determine actions that were not in accordance with expectations. These actions are used as the starting point for the causal analysis. The causal analysis was performed using the following root cause tools:

- Comparative timeline: The comparative timeline is used to describe the sequence of events and also to identify findings, which are actions that did not go as planned and that had an impact on the overall cascading outage event. The comparative timeline is provided in Appendix A.

- Event and causal factor chart: This tool is used to evaluate each finding along the timeline of events and to determine the causes that led to the finding. The event and causal factor chart is provided in Appendix B.

- Cause Determination Worksheet: This tool reviews causes to determine root and contributing causes. This worksheet is provided in Table 2.

Based on the information in Sections 4 and 5, the causal analysis is presented below.

6.1 Findings and Observations

The comparative timeline is used to identify findings and observations for activities that did not go as intended. In addition to the sequence of events, the comparative timeline captures information such as:

- What happened?
- What should have happened?
- Consequences of the difference between what happened and what should have happened.
- Significance of the difference.

- Was there a missed opportunity to impact what happened?
- Finding or observation of that action in the sequence of events

This list of findings is the initiation point for the causal analysis. Based on the event timeline, the major findings related to this event are summarized in Table 1.

Table 1. Key Findings from Comparative Timeline

No.	Finding	Equipment / Organization Involved	Description
1	Fault occurred on 230 kV Line [redacted] ([redacted]	230 kV Transmission Line [redacted]	Phase A to ground fault initiated by vegetation clearance encroachment.
2	Vegetation clearance encroachment with Line [redacted] not identified in helicopter patrol	Operations / Vegetation Management	Aerial patrol of Line [redacted] performed on April 11, 2025 prior to the event, but did not identify tree that resulted in initial fault
3	[redacted]	Line [redacted] [redacted]	Pre-existing condition that had [redacted].
4	Primary protection sees fault and sends signal but [redacted] at [redacted] does not operate	[redacted] 230 kV Circuit Breaker and associated equipment	One of the primary protection schemes sees the fault and sends signal but CB trip coil does not operate to open and isolate the fault from [redacted]
5	Breaker failure relay sends signal but [redacted] at [redacted] does not operate	[redacted] 230 kV Circuit Breaker and associated equipment	Breaker failure relay sends signal but breaker does not operate to open and isolate the fault from [redacted]
6	Relay control wiring damaged on [redacted] at [redacted]	[redacted] 230 kV Circuit Breaker and associated equipment	Post event inspection identified damaged control wiring from the control room to the breaker cabinet.
7	Control wiring for circuit breaker is [redacted].	[redacted] and associated equipment	Post-event inspection identified that [redacted].
8	Breakers at [redacted] did not operate to clear fault on Line 51200 from [redacted]	230 kV Circuit Breakers [redacted] and [redacted] at [redacted]	The [redacted] [redacted] was updated as part of a larger [redacted] upgrade and this was in progress at the time of the event.
9	EcoEléctrica trips generation prior to trip for Line [redacted] at [redacted]	EcoEléctrica Generation Plant	The [redacted] tripped Line [redacted] from [redacted] to EcoEléctrica and resulted in the loss of its generation prior to action by the [redacted] breakers.
10	Automatic underfrequency load shedding unable to prevent system collapse	Automatic underfrequency load shed functionality	The automatic UFLS functionality performed to off-load assigned load shed blocks. However, these actions did not prevent the system collapse.

6.2 Causal Analysis

The causal analysis is performed through the use of an event and causal factor diagram. This tool shows the findings on a timeline basis and evaluates the potential causes of the finding. The event and causal factor chart is included in Appendix B.

The first set of findings (#1 and #2) are associated with the initiating event, which is a fault on Line [redacted] due to vegetation clearance encroachment. The causal chains for the initiating event are related to the vegetation management practices to clear the right of way and to the on-going helicopter patrols to identify clearance issues on the lines.

- For the vegetation management practices, the past clearing of the vegetation in the flood plain did not prevent the growth of the tree that was involved in this event. The vegetation had been cleared in early 2024, but the program to cut down and treat the stump to prevent tree growth was not effective in this situation, as it had not taken place from the time of the initial clearing until the time of the incident. The use of herbicide to preclude tree growth is only applied when trees are cut down manually, not when the right of way is initially cleared and mowed. There had not yet been a follow-up assessment of the vegetation management actions to determine their effectiveness.

- For the helicopter patrols, a recent patrol on April 11, 2025, did not identify the vegetation clearance encroachment at the location of the event. Discussions with LUMA personnel indicated several possibilities for not identifying the encroachment. This patrol did identify potential clearance issues at other locations and issued P30 priority corrective work. The current work processes do not allow for any additional quality review or verification other than the patrol team. Photography is taken only of sites identified as potential clearance issues and therefore, there is no desktop review after the patrol (except for those locations identified in the patrol).

The next set of findings (#3 through #7) is related to the fault on Line [redacted] not being cleared at [redacted]. A fault on Line [redacted] should have been cleared at [redacted] and [redacted] that would have ended the event with minimal impact since the line was relatively lightly loaded at

the time of the event. However, Circuit Breaker [redacted] at [redacted] did not operate (open) and therefore, the fault persisted. There were multiple causal chains for this issue.

- One of the [redacted] legacy [redacted] was out-of-service at the time of the event (Finding #3). The [redacted]. However, the maintenance prioritization, scheduling and planning to remedy this condition was not effective in fixing this condition or replacing this equipment in a timely manner (in this case, the [redacted] was not repairable and needed to be completely replaced). It should be noted that this is part of a [redacted] the scheme being in-service would likely not have precluded this event due to the [redacted] due to the legacy design.

- The other redundant protection scheme consisted of a distance scheme. The relay saw the fault and issued a signal to [redacted] to open (Finding #4). However, the breaker did not operate. During the post-event inspection, the relay wiring in the breaker control cabinet was identified as damaged (Finding #6) and therefore, the signal was not received at the trip coil. The condition of the relay wiring was not identified for repair during the substation visual walkthroughs or routine preventive maintenance. It is intended to examine the cabinets only during breaker maintenance. The routine preventive and corrective maintenance was ineffective in identifying the damaged wiring. If the wiring had been in good condition, it is likely the breaker would have operated. The breaker was successfully operated in November 2024 and after the event.

- The breaker failure relay operates as a backup to the primary protection when it sees that the breaker did not operate as required (Finding #5). The breaker failure relay sent a trip signal to [redacted] but the breaker did not operate. During post-event inspections it was identified that the [redacted]. This wire was damaged and had a similar cause as for Finding #4. However, the inspection also identified that [redacted]

[redacted]. This condition is a legacy design issue that had previously gone unnoticed. [redacted]

The final finding (Finding #8) related to [redacted]n to isolate the fault on Line [redacted]. With [redacted] being unable to clear the fault, all lines associated with the [redacted] bus needed to open to clear the fault. As discussed earlier in the report, the three gas peaker plants were off-line at the time of the event; the breakers at [redacted] and [redacted] opened to isolate Line [redacted] from the [redacted] bus; and the 230/115 kV transformer at [redacted] tripped in response to the fault. However, Line [redacted] from [redacted] to [redacted] did not trip at the [redacted] end and therefore, the fault persisted. This is because [redacted] This ultimately led to the system collapse.

Based on the event and causal factor chart, there are a set of potential causes for this event which require evaluation of root and contributing causes or as additional findings. The potential findings and causal determination are included in Table 2.

For this event, there is one root cause, that if eliminated would have prevented the island wide outage. There are three contributing cause that played a role in the event but cannot be confirmed for preventing the major outage.

- Normally, the initiating event causes would be a root cause since eliminating the initiating event would prevent the incident. However, faults on overhead lines occur due to many causes (equipment failure, weather and external forces, wildlife, third party damage, etc.). These lines have protection to isolate faults on a single line and to prevent wide-spread outages. The root cause problem statement was focused on what led to the system collapse and an island-wide outage. A single fault should not result in a major outage; therefore, the initiating action potential causes are considered as contributing causes in this investigation and recommended actions are provided.

- The impact of the [redacted] upgrade at [redacted] has been considered as a contributing event. While operation of the [redacted] breakers would have isolated the fault on Line [redacted], it would also have removed another 230 kV line from the transmission system. LUMA is performing a dynamic system analysis to determine what would happen in the case of the loss of Line [redacted] and whether the system response would have prevented the collapse. Pending these results, this cause is considered as contributing and recommended actions are provided.

The root and contributing causes for this event are:

- Root Cause (RC):

    - RC #1: Legacy [redacted] design and installation for [redacted] at [redacted] created a [redacted].

- Contributing Causes (CC):

    - CC #1: The preventive and corrective maintenance program for substations did not effectively identify the equipment and wiring condition issues in the cabinet in question.

- CC #2: Management of the change process for the [redacted] upgrade, being implemented to bring the system to current industry standards, [redacted].

- CC #3: The vegetation management program after the initial reclamation in 2024 for the 230 kV lines was ineffective in identifying and preventing vegetation clearance encroachment in this case. LUMA inspects via aerial patrols the entire stretch of the 230kV lines at an appropriate frequency and only documents (photographs and notes) potential adverse clearance locations. However, the current practice does not have a mechanism to confirm the results of the inspection (other than for those areas identified as potential adverse clearance locations) for quality assurance purposes.

Through the root cause assessment, there are other observations which do not contribute to the cause of the event, but that may warrant consideration. One of these additional findings is from the causal analysis and there are two from observations. These additional findings are summarized:

- Additional Finding (AF) #1: Maintenance program was ineffective in prioritizing, scheduling and completing work on identified [redacted] deficiencies in a timely manner. LUMA determined that the legacy system was unrepairable and needs to be replaced. However, LUMA has identified [redacted]

[redacted]. It is recommended that LUMA develop or complete the plan for repair or replacement of these systems (including schedule and funding).

- Additional Finding (AF) #2: Operating experience indicates that many of the large island-wide outages are related to the loss of generation from Costa Sur and EcoEléctrica, which feeds into Costa Sur. While the causes of these events are different, it appears that loss of these generation units creates a major stress on the system. It may be prudent to develop a specific strategy or special protection scheme that addresses loss of generation from this location.

- Additional Finding (AF) #3: With the deployment of a new wide area protection strategy, the need to continue to develop the load shed models remains and the need to obtain information from the generators to ensure proper coordination and modelling still exists. This action has been identified previously and LUMA has indicated it has had difficulty in obtaining the necessary information from the generators for a more accurate model. The need to complete these models is still relevant here.

Table 2. Cause Determination Chart

Problem Statement:

"On April 16, 2025 at approximately 1238 hours, a fault occurred on 230 kV transmission line [redacted] between [redacted] and [redacted] that resulted in system collapse within 19.5 seconds from fault initiation and outages to approximately 1.4 million customers."

Notes:

1. Elimination of cause: High: If the cause is eliminated, then there is a high probability that the event will be prevented.
   Medium: If the cause is eliminated, then there is a roughly 50/50 probability that the event will be prevented.
   Low: If cause is eliminated, then it is likely the event would not be prevented.

2. Ability to Control: If LUMA has full control, then the answer is yes.
   If LUMA does not have sole control or no control, then the answer is no.

3. Cause Type: Root if "high" and "yes" to the two questions.
   Contributing if "medium" and "yes".
   Additional Finding if "low" and "yes or no"

No.	Potential Causes	Final Causal Statement	Elimination of Cause Prevents Event (High, Medium or Low)	Ability to Eliminate Cause within LUMA Control (Yes or No)	Cause Type (Root, Contributing, Additional Finding or N/A)	Comment
1	Inadequate assessment of effectiveness of vegetation work	The vegetation management program after the initial reclamation in 2024 for the 230 kV lines was ineffective in identifying and preventing vegetation clearance encroachment in this case. LUMA inspects via aerial patrols the entire stretch of the 230kV lines at an appropriate frequency and only documents (photographs and notes) potential adverse clearance locations. However, the current practice does not have a mechanism to confirm the results of the inspection (other than for those areas identified as potential adverse clearance locations) for quality assurance purposes.	High	Yes	Contributing	Normally, the initiating event causes would be a root cause since eliminating the initiating event would prevent the incident. However, faults on overhead lines occur due to many causes (equipment failure, vegetation, wildlife, third party damage, etc.). These lines have protection to isolate faults on a single line and to prevent wide-spread outages. The root cause problem statement was focused on what led to the system collapse and island-wide outage. A single fault should not result in a major outage; therefore, the initiating action potential causes are considered as contributing causes in this investigation and recommended actions are provided.
2	Work processes do not provide for additional patrol verification					
3	Maintenance program ineffective in remedying this condition	Maintenance program was ineffective in prioritizing, scheduling and completing work on identified deficiencies in a timely manner.	Low	Yes	Additional Finding	This cause is considered as contributing since there were redundant protection schemes available as contingencies.

No.	Potential Causes	Final Causal Statement	Elimination of Cause Prevents Event (High, Medium or Low)	Ability to Eliminate Cause within LUMA Control (Yes or No)	Cause Type (Root, Contributing, Additional Finding or N/A)	Comment
4	Gaps in inspection program to identify cabinet and cable condition issues	The preventive and corrective maintenance program for substations did not effectively identify the equipment and wiring condition issues in the cabinet in question.	Moderate	Yes	Contributing	This is considered a contributing cause since the actual wiring failure occurred within the conduit and not the control cabinet. The failure was caused by rodent damage per laboratory inspection. While the identification of failure in the cabinet may have resulted in repair of the damaged wiring, it may not have identified the damage in the conduit. However, the inability to identify equipment problems contributed to an escalation of this event.
5	Legacy design that included [redacted]	Legacy [redacted] design and installation for [redacted] at [redacted] created [redacted].	High	Yes	Root	This is considered a root cause since [redacted]
6	Inadequate management of change process to evaluate impact of change	Management of the change process for the [redacted] upgrade, being implemented to bring the system to current industry standards, did not take into consideration [redacted].	Moderate	Yes	Contributing	The impact of the t[redacted] has been considered as a contributing event. While operation of the [redacted] breakers would have isolated the fault on Line [redacted], it would also have removed another 230 kV line from the transmission system. LUMA is performing a dynamic system analysis to determine what would happen in the case of the loss of Line [redacted] and whether the system response would have prevented the collapse. Pending these results, this cause is considered as contributing and recommended actions are provided.

7 Recommended Corrective Actions

The key to a successful causal evaluation is the identification of corrective actions to prevent recurrence of the event. The recommendations for the root and contributing causes are defined in Table 3.

Table 3. Recommendations

Root or Contributing Cause	Recommendation
RC #1: Legacy [redacted] l design and installation for [redacted] at [redacted] created a [redacted].	1. Evaluate a new design approach to remove the [redacted] for these breakers. LUMA has already begun to take action on a proposed new design for [redacted] at [redacted] including:[43] ○ [redacted] line will have redundant line differential protection relays powered from different DC power supply. ○ [redacted]. [Complete] ○ [redacted]. [Complete] ○ Breaker failure [redacted] will be next project and improve later. 2. Perform an extent of condition analysis to identify [redacted]s. 3. Prepare an appropriate design strategy to address these [redacted] locations and perform more detailed substation patrols to identify potential condition issues related to these circuit breakers.
CC #1: The preventive and corrective maintenance program for substations did not effectively identify the equipment and wiring condition issues in the cabinet in question.	4. Revise the preventative maintenance program to incorporate a more timely inspection of "hard to see", such as cabinets, wiring, etc. This may include redefining the substation walk-through program to include a more rigorous visual inspection at least once per year or on a time frame developed by LUMA Asset Management to identify condition issues not visually seen during the normal walkthroughs. 5. Repair the damaged wiring at [redacted] cabinet (See action 1 above)

[43] EXTERNAL Privileged Confidential New design to mitigate t[redacted].msg (Ref. 22).

Root or Contributing Cause	Recommendation
CC #2: Management of the change process for the [redacted] being implemented to bring the system to current industry standards, did not take into consideration [redacted].	6. Develop and implement a robust change management process to identify risks during and after implementation of major programs which affect the system operation. 7. Perform a review of the [redacted]y and strategy change to ensure that the final solution satisfies operation with the system in its current configuration and condition. Based on post-event assessment, LUMA has identified and is taking action relative to its [redacted].[41] These actions include: ○ LUMA has engaged an external engineering review of their [redacted]. ○ Until all 230 kV [redacted]. 8. LUMA should continue with performing a series of steady-state power flow analyses and a dynamic stability analysis to try to replicate the event and to provide additional insight into the event. These studies are intended to address several "what-if" scenarios including the tripping of breakers at [redacted]r and the follow-on system response. This analysis may improve the understanding of the event and may identify further recommendations or improvements. LUMA should continue to request generator information from Genera to improve its various system models.

Root or Contributing Cause	Recommendation
CC #3: The vegetation management program after the initial reclamation in 2024 for the 230 kV lines was ineffective in identifying and preventing vegetation clearance encroachment in this case. LUMA inspects via aerial patrols the entire stretch of the 230kV lines at an appropriate frequency and only documents (photographs and notes) potential adverse clearance locations. However, the current practice does not have a mechanism to confirm the results of the inspection (other than for those areas identified as potential adverse clearance locations) for quality assurance purposes.	9. Consider the use of a follow-up review where vegetation management actions have been taken to provide a level of quality control that these actions are being effective or if additionally measures are necessary. LUMA is currently reviewing the need for follow-up assessments of vegetation management actions at 4-6 months after actions are completed.[44] 10. Consider development of a time-based approach to LIDAR assessment for 230 kV lines to serve as a quality check on the 230 kV quarterly patrols. 11. Consider taking video of the entire line being patrolled to provide a means for a desktop review as a quality check on the helicopter patrols. 12. Evaluate program requirements and training for performance of helicopter patrols and monitor to ensure consistency in patrol results. 13. Continue current path to review all tickets (regardless of priority) with independent helicopter flights to post-check work that has been done (all 230kV lines) 14. Continue to develop and evaluate potential tools to track known areas of vegetation clearance risk to track identified corrective actions and continue to develop a comprehensive work management system to track on-going vegetation management work.

[44] Discussions with LUMA personnel.

8 References

Reference No.	Document	Filename	Use
1	25.04.19_April 16th Island-wide Outage Event Preliminary Report	25.04.19_April 16th Island-wide Outage Event Preliminary Report.pdf	Event sequence and analysis
2	2022 Lidar Information L[redacted]	041625 Event Transmission Line Review of 2022 Lidar Information Addl Info.pdf	Fault location
3	20220315 Transmission System Single-Line Diagram	20220315 Transmission System Single-Line Diagram.pdf	Event and protection analysis
4	Vegetation Management Plan (June 2024)	Exhibit 1_Vegetation Management Plan_Final.pdf	Vegetation management program background
5	Systems Improvement Preliminary Plan (July 2024)	20240719-MI20240005-Submittal-of-Updated-Preliminary-Plan.pdf	Vegetation management program background
6	Vegetation Management 230 kV and 115kV Transmission History	TransmissionHistory.xlsx	L[redacted] vegetation work history
7	Transmission Clearance Requirements	Transmission Clearance Guidelines	L[redacted] vegetation work history
8	Data Requests on Vegetation Management of L[redacted]	EXTERNAL FW 041625 RCI questions.msg	L[redacted] vegetation work history
9	Past Vegetation Photos for L[redacted]	LUMA Vegetation Maintenance (January 2024) - Data [redacted].pdf	L[redacted] vegetation work history
10	Vegetation Corrective Issues for L[redacted]	[redacted] Request History.xlsx	L[redacted] vegetation work history
11	Email: Related to April 11, 2025 Helicopter Patrol	EXTERNAL FW 041625 RCI questions.msg	April 11, 2025 helicopter patrol
12	Not used		
13	2022 Lidar Information L[redacted]	041625 Event Transmission Line Review of 2022 Lidar information.pdf	L[redacted] vegetation work history

Reference No.	Document	Filename	Use
14	Email: Related to 2025 Lidar Information L[redacted]	EXTERNAL FW profile.msg	L[redacted] LIDAR 2022
15	2025 Lidar Information L[redacted]	[redacted] INCIDENT PROFILE-FINAL.pdf	L[redacted] LIDAR 2025
16	Fault Data for 230 kV Lines	230 KV FAULTS JANUARY 2022 TO MARCH 2025 updated.xlsx	Fault data for events on L[redacted]
17	Post-Fiona Inspections at [redacted]	PRIVILEGED AND CONFIDENTIAL - ATTORNEY WORK PRODUCT - Post Fiona Testing Tracker – 20231023 [redacted].xlsx	[redacted] condition
18	[redacted] Walkthrough Inspection Results	Cambalache GP inspections.xlsx	[redacted] condition
19	[redacted] Photos (Post Event)	Photos of [redacted].pdf	[redacted] condition
20	[redacted] White Paper	LUMA [redacted] Strategy.docx	Protection philosophy
21	LUMA [redacted] Update	Event Discussion and [redacted] Summary April 30 2025 Final (003)	[redacted]
22	Email: New Design for Control System (relays and wiring) for [redacted] at [redacted]	EXTERNAL Privileged_Confidential New design to mitigate the [redacted].msg	Repair / redesign [redacted] relay and control logic
23	Vegetation Maintenance Detailed Report	20_LUMA_2024_March_10-25.pdf	Line [redacted] vegetation management (reclamation)
24	Independent Engineering Report: Transmission and Distribution Attachment A-9 [redacted]	A-9 - [redacted]_Switchyard.pdf	Condition of [redacted] switchyard
25	Independent Engineering Report: Transmission and Distribution	SL-014468.TD_TD Condition Assessment_Final_Rev.1_14Jun2019.pdf	Condition of [redacted] switchyard
26	Not Used		
27	April 16, 2025 Customer Restoration Timeline	Restoration Process Blackout Apr16.xlsx	Restoration
28	Email: Description of Conductor Repair	Photos of Line [redacted] Repairs.pdf	Line [redacted] conductor repair

Reference No.	Document	Filename	Use
29	Not Used		
30	[redacted] Substation Drawings: Relay Replacement	CAP L[redacted] Drawings	Relay and protection upgrade design
31	[redacted] One-Line Diagram	[redacted] 230 kV Swyd - Exist. One Line 7-28-2022 (1)	[redacted] 240kV bus layout
32	Email: Description of Extent of Condition of [redacted]	EXTERNAL FW [redacted] list.msg	Extent of condition review
33	Situation Overview 2025-04-16 @ 1700 hours	2025-04-16_Islandwide Event_LEOCReport_1700hrs.pdf_Final	Restoration
34	Situation Overview 2025-04-17 @ 0800 hours	2025-04-17_Islandwide Event_LEOCReport_0800hrs	Restoration
35	Situation Overview 2025-04-17 @ 1700 hours	2025-04-17_Islandwide Event_LEOCReport_1700hrs	Restoration
36	Situation Overview 2025-04-18 @ 1300 hours	2025-04-18_Islandwide Event_LEOCReport_1300hrs	Restoration
37	Email: Description of Fault Evolution	Fault records.pdf	Event description (fault progression)

Appendix A: Comparative Timeline

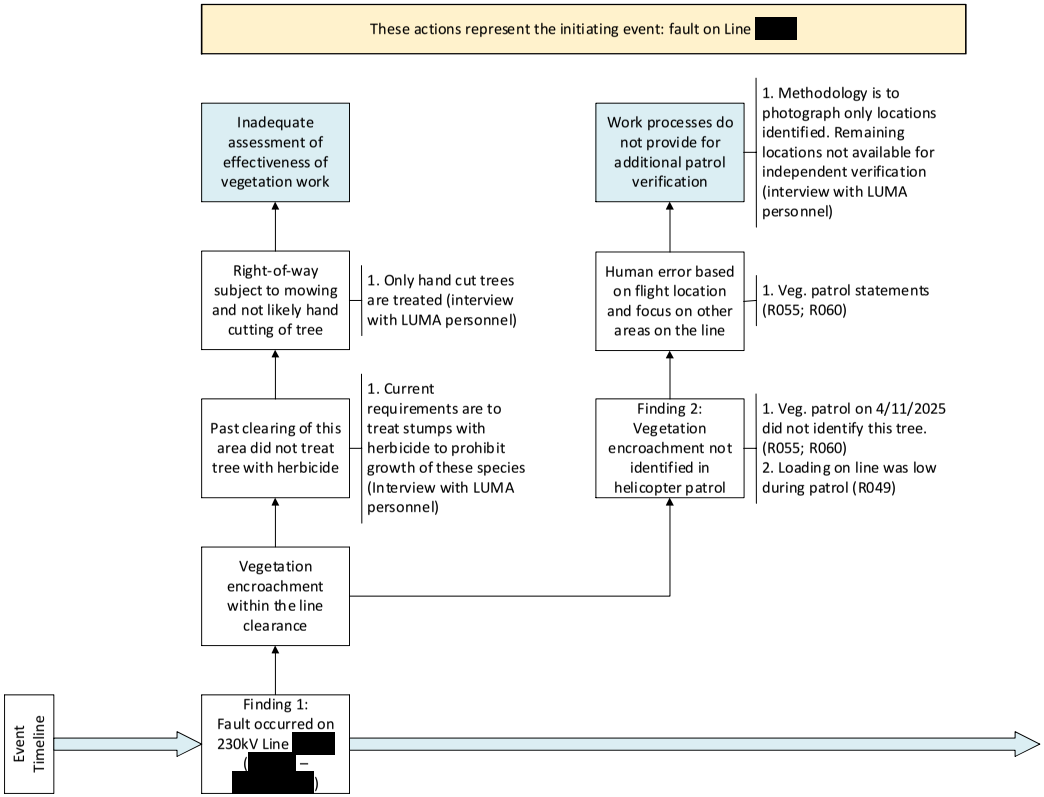
Sequence #	Date	Time	Reference Doc	Equipment Involved	Initiating Organization	What Happened?	What Should Have Happened?	Consequences of Differences	Significance of Differences	Findings / Observation	Missed Opportunity Review	Comment
1	Prior to event	N/A	Ref. 1	Circuit breaker [redacted] at [redacted]	N/A	Control wiring for circuit breaker is a [redacted]	[redacted]	Prevented successful operation [redacted]	Negated effectiveness of [redacted]	Control wiring for circuit breaker is [redacted] .(Finding #7)		Post event identifies damaged control wiring from relay to CB as [redacted]
2	Prior to event	N/A	Ref. 1	Circuit breaker [redacted] at [redacted]	N/A	Damaged control wiring from circuit breaker relay to trip coil in the breaker control cabinet	Control wiring should have been intact	Prevented delivery of signal from relays to trip coil	Prevented operation of [redacted] and clearance of fault on Line [redacted]	Relay control wiring damaged on [redacted] at [redacted] (Finding #6)		Post-event inspection identified control wire damage. Inspection of control wiring being performed to determine cause of damage
3	Prior to event	N/A	Ref. 1	One of r[redacted] [redacted] on Line [redacted] for [redacted]	Operations / Asset Management	Pre-existing condition	[redacted]	[redacted]	None	One of r[redacted] [redacted] (Finding #3)		Post-event inspection of [redacted] indicated that [redacted]. As described later, if this had been in operation, trip signal would likely not have resulted in breaker operation.
4	Prior to event	N/A	Ref. 1	230 kV Line [redacted]	N/A	Vegetation encroached within the line clearance	Vegetation should have proper clearance from line	Allowed for conditions to produce initial fault	Initial action that started the event	(See Sequence #6)		Post-event inspection identified vegetation clearance encroachment as cause of initial fault
5	4/11/2025	N/A	Ref. 1; Ref. 10	230 kV Line [redacted]		Aerial patrol of Line [redacted] performed but did not identify vegetation clearance encroachment within the line clearance	Tree should have been identified for corrective measures	Allowed for conditions to produce initial fault	Initial action that started the event	Vegetation clearance encroachment with Line [redacted] clearance not identified in helicopter patrol (Finding #2)		

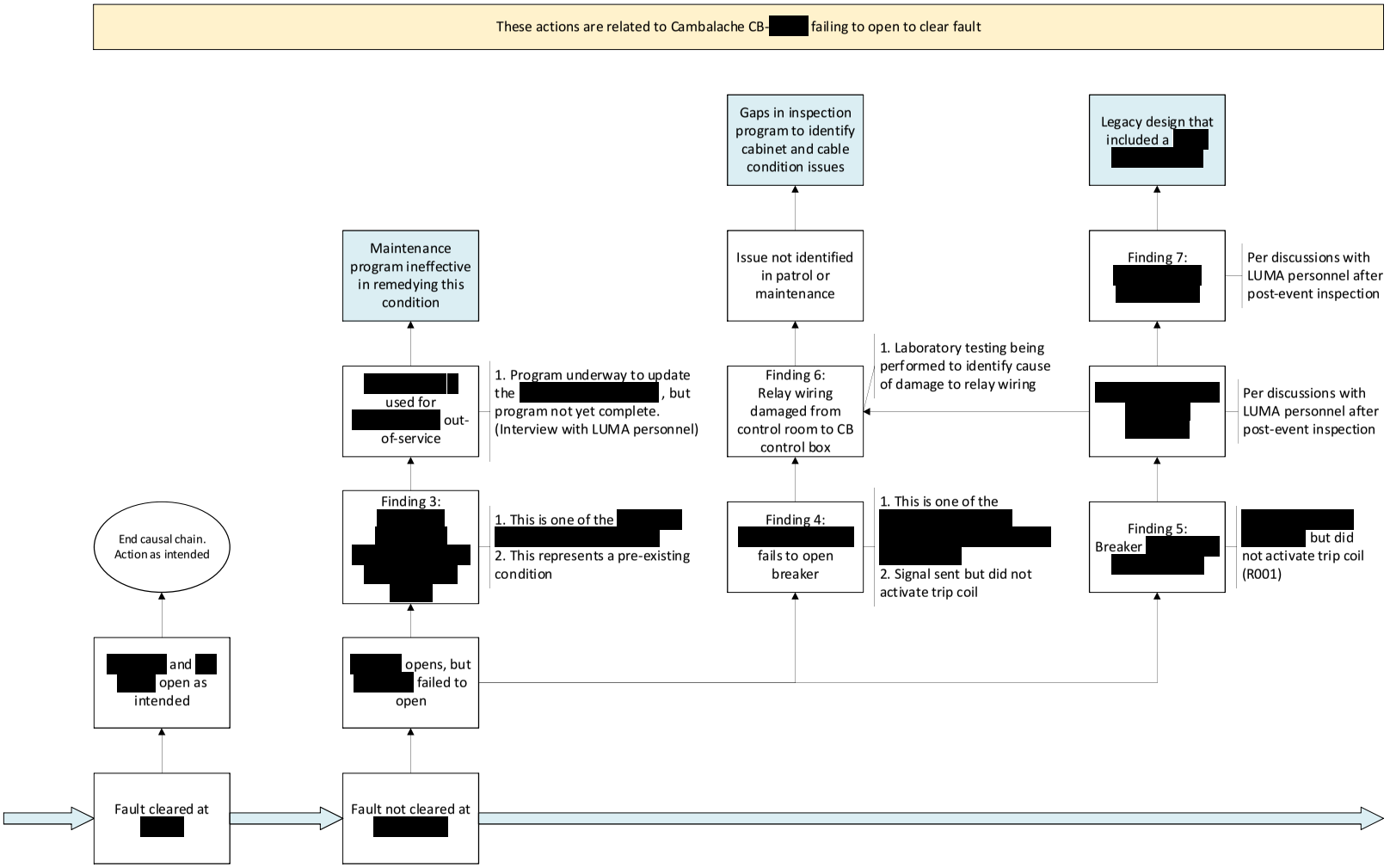
Sequence #	Date	Time	Reference Doc	Equipment Involved	Initiating Organization	What Happened?	What Should Have Happened?	Consequences of Differences	Significance of Differences	Findings / Observation	Missed Opportunity Review	Comment
6	4/16/2025	12:38:46.062	Ref. 1	230 kV Line [redacted]	N/A	Phase A to ground fault initiated by vegetation clearance encroachment within the line clearance	Vegetation should have proper clearance from line	Fault occurred	Initiated sequence of events leading to system wide outage	Fault initiated on Line [redacted] (Finding #1)		Post event identifies vegetation clearance encroachment within the 230 kV line clearance
7	4/16/2025	12:38:46.133	Ref. 1	230 kV Circuit Breakers [redacted] and [redacted] at [redacted]	N/A	Breakers trip to clear fault on Line [redacted] at [redacted]	Breakers trip to clear fault on Line [redacted] at [redacted]	None	None	None	None	Action per expectations
8	4/16/2025	12:38:46.690	Ref. 1	230 kV Circuit Breaker [redacted] and [redacted] at [redacted]	N/A	[redacted] trips but [redacted] does not trip	Both breakers trip to clear fault on Line [redacted] at [redacted]	Fault is not cleared on Line [redacted] at [redacted]	Active fault remains in the system	Primary protection sees fault and sends signal but [redacted] at [redacted] does not operate (Finding #4); Breaker failure relay sends signal but [redacted] at [redacted] does not operate (Finding #5)		Post-event inspection identifies damaged control wiring from relay to CB and indicates [redacted]
9	4/16/2025	12:38:47.990	Ref. 1	230 kV Line [redacted]	N/A	Fault evolves to Phase A to B to ground and sourced from [redacted]	Fault should have cleared from [redacted]	Active fault remains in the system	Event continues to develop	None	None	
10	4/16/2025	12:38:48.018	Ref. 1	230/115kV Transformer at [redacted]	N/A	Transformer trips in response to active fault	Transformer trips in response to active fault	None	None	None	None	Action per expectations
11	4/16/2025	12:38:48.025	Ref. 1	230 kV Circuit Breaker [redacted] at [redacted]	N/A	Breaker trips to clear fault on Line [redacted] at [redacted] (Line [redacted] is 230 kV line from [redacted] to [redacted] to [redacted])	Breaker trips to clear fault on Line [redacted] at [redacted]	None	None	None	None	Action per expectations
12	4/16/2025	12:38:49.060	Ref. 1	230 kV Circuit Breakers [redacted] and [redacted] at [redacted]	N/A	Breakers trip to clear fault on Line [redacted]0 at [redacted]	Breakers trip to clear fault on Lin[redacted]	None	None	None	None	Action per expectations
13	4/16/2025	12:38:50.070	Ref. 1	230 kV Line [redacted] from [redacted] to [redacted]	N/A	Line opens on protection for EcoEléctrica plants	Protection coordination with [redacted] should have allowed [redacted] to trip first	Approximately 300MW of generation removed from system	Initiates frequency decline in the system	EcoEléctrica trips generation prior to trip for Line [redacted] at [redacted] (Finding #8)		The [redacted] was still in implementation and not fully complete throughout the system.

Sequence #	Date	Time	Reference Doc	Equipment Involved	Initiating Organization	What Happened?	What Should Have Happened?	Consequences of Differences	Significance of Differences	Findings / Observation	Missed Opportunity Review	Comment
14	4/16/2025	12:38:49.060	Ref. 1	230 kV Circuit Breakers [redacted] and [redacted] at [redacted]	N/A	Breakers at [redacted] do not operate to clear fault on Line [redacted] from [redacted]	Breakers trip to clear fault on Line [redacted]	Active fault remains in the system	Event continues to develop	EcoEléctrica trips generation prior to trip for Line [redacted] at [redacted] (Finding #8)		Post event identifies [redacted]. was still in implementation and not fully complete throughout the system.
15	4/16/2025	12:38:55.930 to 12:38:57.300	Ref. 1	Automatic Load Shedding Schemes	N/A	UFLS unable to maintain system frequency and declines trigger load to all shed blocks	UFLS stabilizes system to maintain frequency	System frequency declines to below 56.0Hz initiating generator trips	Initiates generation trips	Automatic underfrequency load shedding unable to prevent system collapse (Finding #9)	None	
16	4/16/2025	12:39:01.780	Ref. 1	Generation protection	N/A	System frequency declines below 56.0 Hz and trips generation off line	System frequency declines below 56.0 Hz and trips generation off line	Initiates generation trips	Leads to loss of generation	None	None	
17	4/16/2025	12:39:02.000	Ref. 1	AES Generation	N/A	AES Generation (506MW) trips in response to frequency	AES Generation trips in response to frequency	None	None	None	None	
18	4/16/2025	12:39:02:380	Ref. 1	Costa Sur Unit [redacted]	N/A	Costa Sur Unit [redacted] (279MW) trips in response to frequency	Costa Sur Unit [redacted] trips in response to frequency	None	None	None	None	
19	4/16/2025	12:39:05.530	Ref. 1	Electric System	N/A	Total power system collapse						
20	4/16/2025	1700 hours	Ref. 33	Restoration	LEOC / TOC	0.6% customers restored	Restored customers	None	None	None	None	
21	4/17/2025	0800 hours	Ref. 34	Restoration	LEOC / TOC	47.0% customers restored	Restored customers	None	None	None	None	
22	4/17/2025	1700 hours	Ref. 35	Restoration	LEOC / TOC	58.6% customers restored	Restored customers	None	None	None	None	
23	4/18/2025	0215 hours	Ref. 1	Restoration	LEOC / TOC	98.8% customers restored	Restored customers	None	None	None	None	
24	4/18/2025	1300 hours	Ref. 36	Restoration	LEOC / TOC	99.8% customers restored	Restored customers	None	None	None	None	

Appendix B: Event and Causal Factor Chart

PROBLEM STATEMENT
On April 16, 2025 at approximately 1238 hours, a fault occurred on 230kV transmission line [redacted] between [redacted] and [redacted] that resulted in system collapse within 19.5 seconds of fault initiation and outages to approximately 1.4 million customers.




These actions are related to Cambalache CB-[redacted] failing to open to clear fault
Gaps in inspection program to identify cabinet and cable condition issues
Legacy design that included a [redacted]
Maintenance program ineffective in remedying this condition
Issue not identified in patrol or maintenance
Finding 7:
Per discussions with LUMA personnel after post-event inspection
[redacted] used for [redacted] out-of-service
1. Program underway to update the [redacted], but program not yet complete. (Interview with LUMA personnel)
Finding 6: Relay wiring damaged from control room to CB control box
1. Laboratory testing being performed to identify cause of damage to relay wiring
[redacted]
Per discussions with LUMA personnel after post-event inspection
End causal chain. Action as intended
Finding 3: [redacted]
1. This is one of the [redacted]
2. This represents a pre-existing condition
Finding 4: [redacted] fails to open breaker
1. This is one of the [redacted]
2. Signal sent but did not activate trip coil
Finding 5: Breaker [redacted]
[redacted] but did not activate trip coil (R001)
[redacted] and [redacted] open as intended
[redacted] opens, but [redacted] failed to open
Fault cleared at [redacted]
Fault not cleared at [redacted]

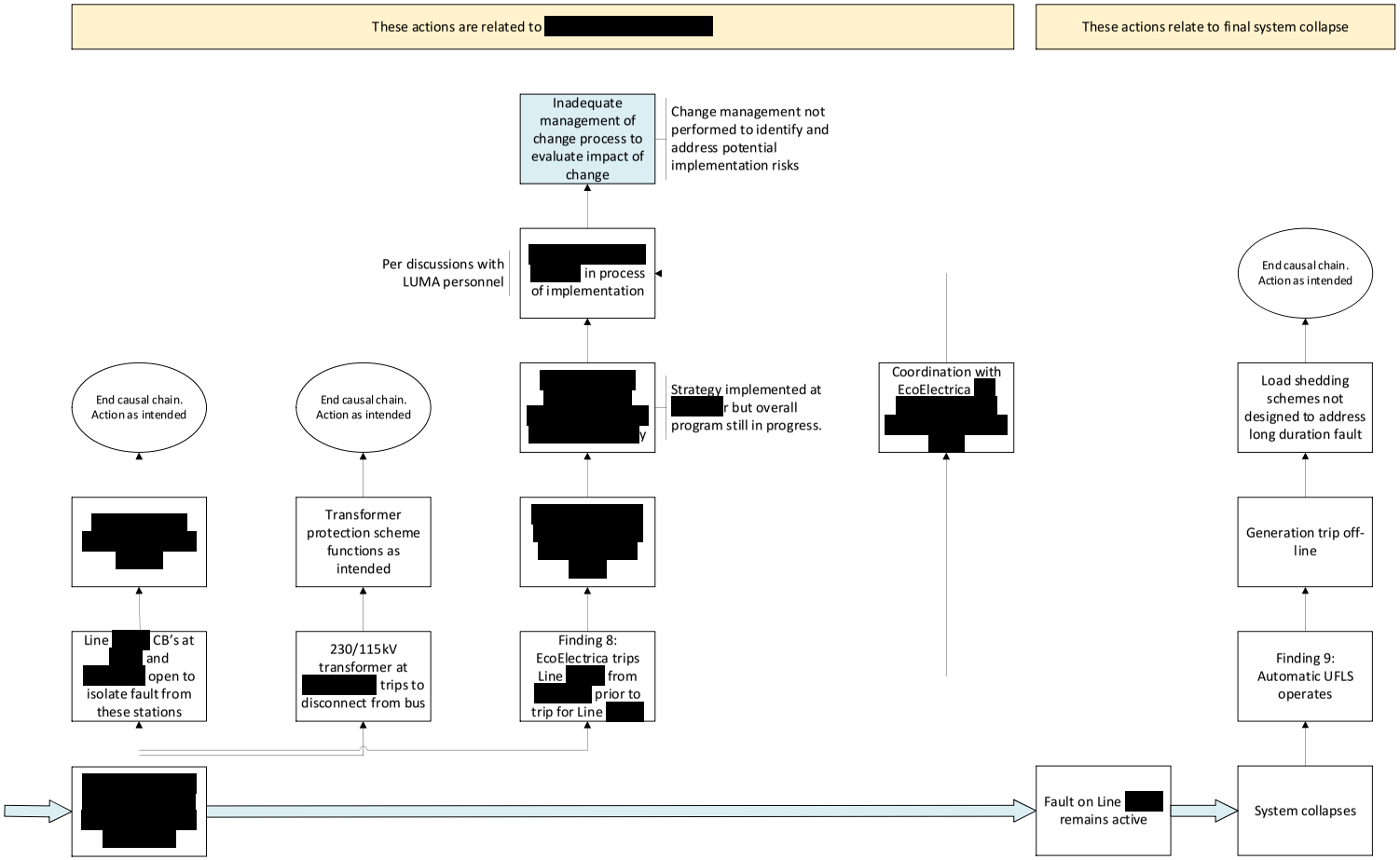

These actions are related to [redacted]
These actions relate to final system collapse
Inadequate management of change process to evaluate impact of change
Change management not performed to identify and address potential implementation risks
Per discussions with LUMA personnel
[redacted] in process of implementation
End causal chain. Action as intended
End causal chain. Action as intended
[redacted]
Strategy implemented at [redacted] but overall program still in progress.
Coordination with EcoElectrica [redacted]
End causal chain. Action as intended
Load shedding schemes not designed to address long duration fault
[redacted]
Transformer protection scheme functions as intended
[redacted]
Generation trip off-line
Line [redacted] CB's at [redacted] and [redacted] open to isolate fault from these stations
230/115kV transformer at [redacted] trips to disconnect from bus
Finding 8: EcoElectrica trips Line [redacted] from [redacted] prior to trip for Line [redacted]
Finding 9: Automatic UFLS operates
[redacted]
Fault on Line [redacted] remains active
System collapses

Exhibit B

Corrected Redacted Version of the June 16th Exhibit 2

[Submitted via Sharefile]