ATTACHMENT 3

INVESTIGATION REPORT
OF OUTAGES DURING JULY AND AUGUST OF 2015
IN SOUTHERN CALIFORNIA EDISON COMPANY'S
LONG BEACH DISTRICT

PREPARED BY

THE SAFETY AND ENFORCEMENT DIVISION

ELECTRIC SAFETY AND RELIABILITY BRANCH

LOS ANGELES

JUNE 2016

TABLE OF CONTENTS

I. Executive Summary

During July and August of 2015, in a period of high temperatures and electrical demand, Southern California Edison Company's (SCE) electrical system serving downtown Long Beach experienced multiple significant power outages, including a five-day outage from July 15 to July 20, 2015, and a four-day outage from July 30, 2015 to August 3, 2015. Along with these outages, electrical problems caused fires in underground structures, resulting in explosions that sent manhole covers airborne. There were no injuries or fatalities associated with these outages.

The Safety and Enforcement Division (SED) of the California Public Utilities Commission (CPUC) investigated the outages and discovered significant problems with SCE's maintenance, inspection, and management of the electrical system in Long Beach, and with SCE's emergency response and communications during the outages. SED found SCE violated General Orders (G.O.), in particular G.O. 128 rules on acceptable maintenance and inspection,[1] Commission Decision (D.) 14-08-009, and Public Utilities Code (PU Code) Sections 768.6 and 451.

The Long Beach outages primarily affected 3,825 customers[2] served by SCE's Long Beach secondary network, a grid of redundant underground electrical conductors, but at times extended to 30,000 customers, including customers who received their power from radial circuits that feed the network.

SED discovered serious neglect and deterioration of SCE's Long Beach secondary network, improperly configured protective devices, equipment installed without critical components, deteriorated cables, poorly constructed and failed cable splices, and improperly racked equipment. SED's investigation also revealed that SCE's inadequate knowledge of the secondary network system contributed to longer restoration times.

SED attributes these equipment problems and other issues to multiple systemic factors, including:

- Poor management of network operation and maintenance,
- SCE's inadequate knowledge of its own system,
- Inadequate inspection and maintenance activities, a confusing management structure which did not place any specific entity in charge of secondary network facilities,
- Poor maintenance management processes including inadequate methods for recording problems in the network and assuring that problems were addressed in a timely manner, and
- Inadequate training for people performing work on the network, out-of-date network maps and schematics, and inadequate risk assessment.

[1] See "Violations", Section X in this report.

[2] The term "customers" refers to one metered account on SCE's billing system. For example, one household can be a customer. Additionally, a multi-unit complex with only one SCE meter is also considered a single customer. This definition will be used henceforth in the report.

In addition, SED found evidence that employees working on the network expressed concern over the maintenance of the network prior to the outages, but this information failed to reach appropriate levels in SCE and SCE did not act on this information. In one specific instance, a 2011 SCE internal report delineated multiple problems with the Long Beach secondary network. The presentation predicted a high possibility of a catastrophic failure of the network in the event of the failure of an important network component (e.g., a primary feeder circuit). SCE never fully completed this risk assessment, and failed to fully formulate and implement a comprehensive corrective action plan for the network.

SED also found multiple problems with SCE's emergency response to the outages, primarily with SCE's communications with Long Beach officials and first responders, as well as communications with the public. Among other issues, SED also found problems with SCE's restoration time estimates.

Although the outages at times extended to tens of thousands of customers, these periods of large outages were transient in nature. However, for a core of around 3,800 business and residential customers, many of whom were elderly or low income, the outages were lengthy, uncomfortable, costly, and potentially dangerous. Though a significant consideration, the size and duration of the outages is not the biggest factor of concern for SED. The most significant fact is that these outages were not triggered by any external event beyond the control of the utility, like massive outages caused by wind, snow, rain or heat storms. Rather, the 2015 Long Beach outages would have been completely avoidable with proper secondary network inspection, maintenance and operation protocols.

II. Introduction

On July 15-20, 2015, and on July 30 to August 3, 2015, the City of Long Beach experienced major power outages that affected a great number of customers. At the peak of the outages, approximately 30,000 customers were without power. These outages were due to equipment failures on SCE's secondary network system, a grid of conductors, protective devices, and associated equipment that serve the downtown Long Beach area. Although there were no fatalities or injuries as a result, the outages caused major hindrances to civilians, reduced public safety, and disrupted businesses throughout the City of Long Beach.

This report looks into the causes of the outages, SCE's communication with customers and public officials during the outages, and SCE's restoration efforts. Additionally, this report makes recommendations for improvements in SCE's maintenance and operation of its network system.

CPUC General Order (G.O.) 128 contains requirements for the construction, maintenance and operation of underground electric facilities in California. The PU Code contains statutory requirements for CPUC jurisdictional entities. In a Commission proceeding, the CPUC may issue a decision that has the force of law and requires a utility to undertake corrective actions. This report examines SCE's compliance with G.O. 128, and applicable PU Code requirements and CPUC decisions.

III. Background

A. Power Delivery

Electricity is delivered to consumers through three main steps: *generation, transmission, and distribution.* In generation, electricity is generated at a power plant, which may be located in the city being served or located many miles away. Transmission lines are used to transmit electricity at high voltages to substations, where voltages are stepped down (reduced) by transformers and electricity is transmitted to customers through distribution lines.

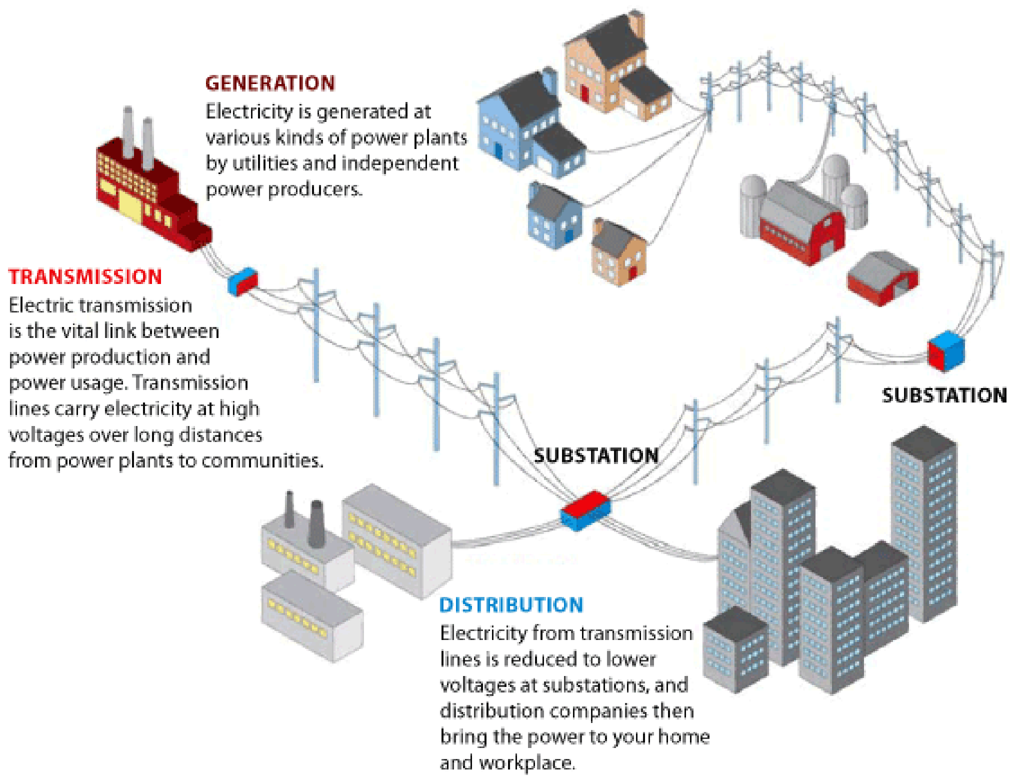

Figure 1: Typical electrical power delivery process. *Source: Indiana University*

There are two main types of electrical distribution systems: radial systems and secondary network systems.[3] In both, power comes from a substation and flows outwards to reach the consumer through distribution circuits. A substation usually provides power to several distribution circuits, with each circuit operating at a distribution voltage (also known as a primary voltage), commonly 12 kilovolts (kV). The difference between a radial system and a network system is in the configuration each uses to distribute power to customers. A description of the two systems is provided below.

[3] Secondary network systems are also commonly referred to as "network systems" in the electric distribution industry nationwide. This report will also utilize the term "network system" in reference to secondary networks in general or SCE's Long Beach secondary network system.

B. Radial Systems vs. Network Systems

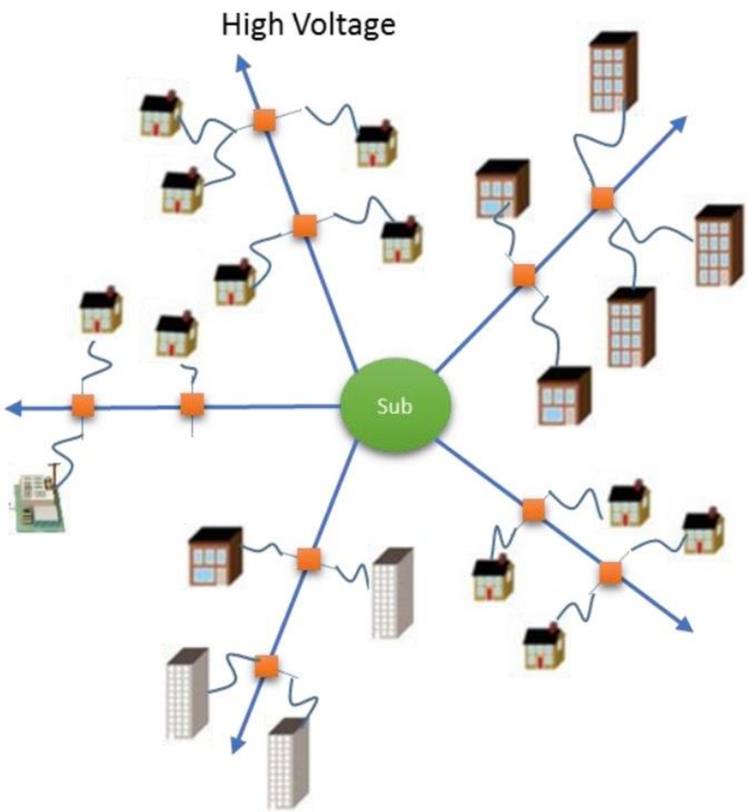

Figure 2: General schematic of a radial system. *Source: SCE*

In a radial system, each distribution circuit operates independently of the other circuits. Power is delivered to the customer from a single source (a substation) and flows outwards on distribution lines[4] that may then branch out to serve multiple customers. Each customer receives power from one circuit that connects to the substation, like a branch from a tree with a single trunk. Radial systems are the most commonly used electrical distribution system configuration due to their simplicity and cost effectiveness. However, radial systems also tend to be less reliable than network systems, as a failure of a circuit on a radial system also causes an outage to all customers who are served by the circuit.

A network system has multiple points of origins and sources of supply operating in parallel. In a network system, instead of a customer being served by a single distribution circuit, multiple distribution circuits feed into a network system that is an interconnection

[4] General Order 95, Rule 20.6, defines "circuit" as the following: "Circuit means a conductor or system of conductors located outside of buildings and through which an electric current flows or light is transmitted." General Order 95, Rule 22.1, defines "lines" as the following: "Lines mean those conductors together with their supporting poles or structures and appurtenances which are located outside of buildings." Although the General Order 95 contains specific definitions for the terms "circuits" and "lines", the two terms are often used interchangeably depending on the context. This report will follow the aforementioned convention.

of multiple distribution lines and other equipment. Each distribution circuit, referred to as a primary feeder, feeds power into the network through one or more network transformers (Figure 4) which also reduce the feeder voltage from the primary level, typically 12 KV, to a secondary voltage level (120V/208V) for use by customers. These network transformer connections are represented by the orange colored boxes in Figure 3 below. Although more difficult to construct, network systems are more reliable than radial systems because power/electricity that is lost by the failure of one circuit is compensated for by another circuit, thus, a failure of one circuit does not affect customers who are served by the network. Network systems are commonly used in densely populated metropolitan areas because of their reliability and where restoration efforts would be logistically difficult for a radial system.

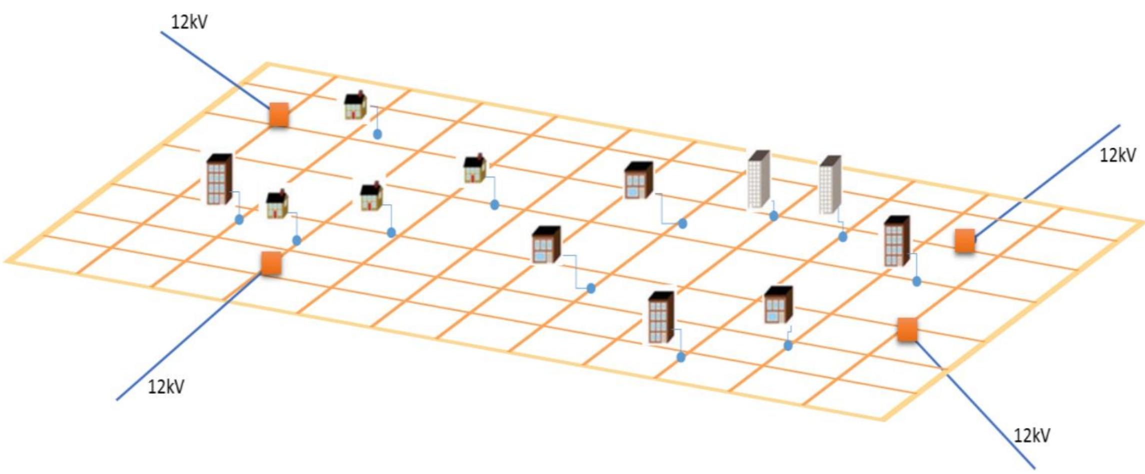

Figure 3: General schematic of a network system, each 12 kV is a primary feeder. *Source: SCE*

Figure 4: A network transformer. *Source: General Electric*

Although a network system is more reliable than a radial system, a network system can still suffer from circuit failures. As with a radial system, a network system also utilizes relays and circuit breakers to stop and mitigate the effects of circuit failures. Each primary feeder circuit has a relay and a circuit breaker at the substation to detect and help clear a primary circuit failure or fault, much like in a radial system. However, the configuration of the network system necessitates another level of protection that is not used in the radial system. This second level of protection is provided on the secondary side of the network transformer, by a critical component called a network protector (Figure 5), a specialized protective device that contains a circuit breaker and a controlling relay. Each network transformer is connected to a network protector, which can connect or disconnect the transformer from the network depending on whether the protector's internal circuit breaker is open or closed. A typical network protector has three settings – manual open, manual closed, or automatic. In the manual settings, the network protector bypasses its internal relay and remains permanently open or closed regardless of the conditions in the network or on the primary feeder circuits.

Figure 5: Example of a network protector. *Source: Richards Manufacturing, Renewal Parts Catalog, 313NP*

In a network system, current (or power) should always flow from the primary feeder into the secondary network. A network protector's purpose is to automatically disconnect its associated power transformer from the network's secondary conductors when the protector's internal relay detects reverse current flowing from the network, through the transformer, and into the feeder, typically due to a fault or de-energization of the primary feeder. This reverse current is also called "backfeeding."[5]

During normal operations a network protector is set in automatic position and it "opens" or "closes" by itself based on fault conditions in order to protect the network conductors and primary feeders.

If a network protector is set in the manual open or closed position, this bypasses its internal relay and the circuit breaker within the network protector remains in either the open or closed position regardless of conditions in the network or on the feeder circuit. A network protector in the manual open position is undesirable as it typically denotes a problem on the network system, which must be rectified as soon as practicable. Additionally, placing network protectors in the manual open position results in fewer network protectors supplying power to the secondary network conductors. This causes current to be transmitted by fewer network transformers and secondary conductors, causing stress to these facilities. This may also lead to a drop in voltage on the network, which can further stress the secondary conductors.

A network protector in a manual closed position is also undesirable because it is not be able to interrupt the current from backfeeding into the primary feeder in case of a fault on the primary feeder.

In addition to network protectors, another protective device in a network system is a device called a mole limiter. A mole limiter is used to protect secondary cables by acting as a fuse and burning open in the event of a fault on the secondary network. When a mole limiter burns open, the section of secondary conductor connected to it is no longer be available to carry current. This causes the current to be carried by the remaining secondary cables, thus causing stress on those remaining cables. Therefore, in order for mole limiters to be used properly, they should be replaced any time they burn open. Network protectors and transformers may also contain their own internal fuses.

Although more difficult to construct, and with more equipment to monitor and maintain, network systems are more reliable than radial systems. Under normal circumstances, an outage in one area of a network system typically has no effect on the network customers. This is due to the redundancies in the network system attributed to multiple primary feeder circuits, and multiple secondary conductors providing multiple pathways to serve a customer. Network systems are commonly used in densely populated metropolitan areas where restoration efforts would be logistically difficult and would simultaneously impact many customers. The network system in the City of Long Beach is the only area in SCE's service territory where a network system is utilized.

C. SCE's Long Beach Network System

SCE's Long Beach secondary network system covers approximately one square mile and serves more than 3,800 customers in the Downtown Long Beach area (Figure 6). The

[5] Backfeeding is a reverse current that flows from the secondary side of the network transformer onto the primary feeder circuits. This can perpetuate fault conditions on the primary feeder circuits causing secondary network cables to potentially overload and fail.

network system was constructed in the mid-1920s, and the last major outage to affect the Long Beach network system was in 1959. A total of 62 network protectors of varying models regulate the Long Beach network system. The majority of network system circuitry is located underground and is accessible through manholes and underground vaults. There are a total of ten primary feeder circuits that supply the Long Beach network system. The primary feeders serve customers on a radial system and the network system, and originate from three different substations: Seabright substation, State Street substation, and Cherry substation. The ten primary feeder circuits are:

- Float 12kV Circuit (out of Seabright substation)
- Steam 12kV Circuit (out of Seabright substation)
- Cargo 12kV Circuit (out of Seabright substation)
- Ocean 12kV Circuit (out of Seabright substation)
- Chestnut 12kV Circuit (out of State Street substation)
- Loop 12kV Circuit (out of State Street substation)
- Tribune 12kV Circuit (out of State Street substation)
- Afton 12kV Circuit (out of Cherry substation)
- Dusk 12kV Circuit (out of Cherry substation)
- Hoback 12kV Circuit (out of Cherry substation)

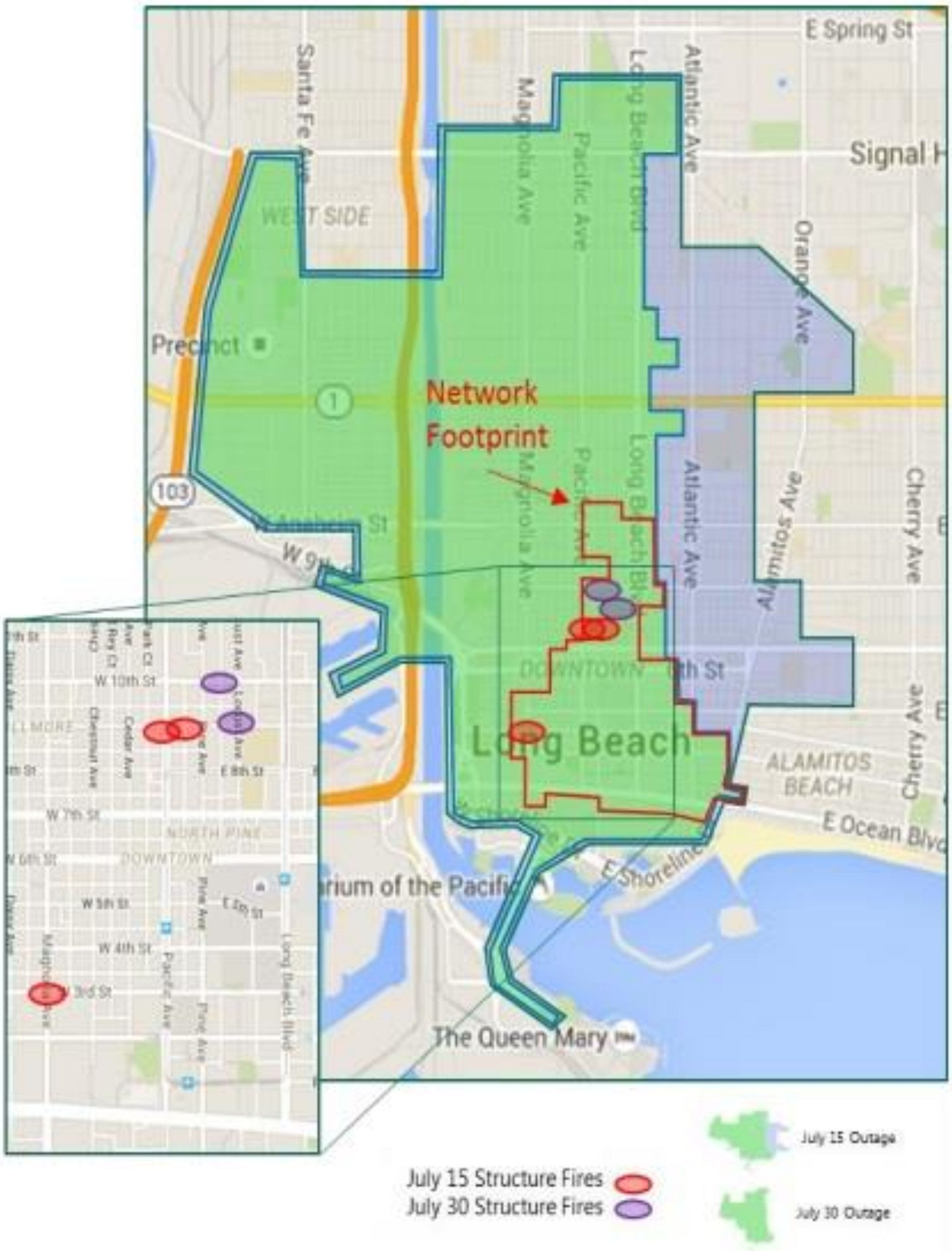

Figure 6: Downtown Long Beach Network System footprint and area of outages. *Source: SCE, California State Legislature Town Hall: 2015 Long Beach Power Outages, August 22, 2015.*

IV. Cause and Sequence of Outages

During the months of July and August 2015, the City of Long Beach experienced two major events that resulted in outages to a high number of customers. At the peak of the outages, approximately 30,000 customers were simultaneously without power during the hot summer weather. The first outage event occurred during July 15-20, 2015, and the second outage event occurred during July 30, 2015, to August 3, 2015. The following shows the cause and sequence of events that are related to the outages and their effect:

A. July 15-20, 2015, Outages Causes

The precipitating event for the July 15, 2015, outages was insulation degradation and ignition of the Float 12kV Paper Insulated Lead Cable (PILC) splice. The splice failure also contributed to the accelerated and premature failure of the Steam 12kV PILC splice, as they were located in the same vault. The fire or electrical arcs from the Float 12kV PILC splice caused collateral damage to the Steam 12kV PILC splice. The failures of the Float and Steam 12kV PILC splices caused their respective circuits to relay and lockout,[6] ultimately de-energizing the circuits and significantly reducing the number of network protectors available to regulate and protect the network system, as well as interrupting power to SCE's radial network customers that are served by the Float and Steam 12 kV circuits.

Figure 6: Float 12kV (front) and Steam 12kV (rear) PILC splices. *Source: CPUC*

[6] A protective device, such as a relay, detects a fault current or other abnormal conditions on the circuit and responds by tripping open a circuit breaker at the substation, de-energizing the circuit. Often, an abnormal condition may be temporary; therefore, it may be practicable for the utility to quickly reclose the circuit breaker and re-energize the circuit. In the *reclosing* process, a relay may attempt to open and reclose a circuit breaker several times to clear a temporary abnormal condition. If the abnormal condition persists after a preset number of reclosures, then the circuit breaker remains or "locks out" in the open position. This process is referred to as "relaying to lockout".

The Float 12 kV circuit is connected to the network system through several network transformers, including a network transformer connected to Network Protector (NP) 20649. When the Float 12 kV PILC splice failed, the breaker (at Seabright substation) that protects the circuit detected the fault current and de-energized the circuit. In a radial system this would de-energize any transformer that is connected to the circuit. However, because in a network system all the secondary circuits are connected together and supplied by multiple feeders, the secondary side of the network transformer connected to the Float 12 kV circuit remained energized. This in turn caused the primary side of the network transformer to remain energized. Thus, the portion of the Float 12 kV conductor between the splice and the network transformer it connects to remained energized. Any current on this section of conductor will dissipate in the ground in the form of fault current (since the splice will be in direct contact with ground after it failed). The fault current in such a case is caused by backfeed current. Since the secondary side of the network transformer is still energized at 120/208V, and because the failed splice is grounded at effectively zero potential (voltage), current will naturally attempt to flow from the secondary side of the network transformer to the primary side through the conductor and through the splice, and dissipate in the ground, thus producing fault current.

In a properly configured and maintained network, this reverse current flow and fault current would not occur, preventing the cascading events of July 15, 2015. The relay of NP 20649 would sense that the initial voltage on the network transformer primary side was lost (when the breaker at Seabright substation opened and locked out) and would force the circuit breaker of NP 20649 to open, disconnecting its associated transformer from the secondary conductors. This would prevent any reverse current flow from the secondary side to the primary side, thereby preventing any backfed fault current into the primary feeder.

However, in this case, SED's investigation revealed that SCE had previously set NP 20649 in the manually closed position. This prevented NP 20649 from interrupting the flow of current into the primary side fault. The fault current originated from currents flowing on many of the secondary conductors of the network system, and because the failed splice was grounded, this provided a path that "drained" current from the secondary conductors. This overstressed the secondary conductors, caused them to overload and heat which damaged and burned their insulation. Continual feeding of the Float splice ground fault also likely caused that portion of the feeder conductor to overheat and burn. As a result, fires started in manhole numbers M5133091, M5133092, and M5133093, which contained the damaged secondary conductors. In addition, the fire also damaged other equipment as well as the Steam 12 kV PILC splice, contained in the same vault. SCE responded to the fire and decided to shut down the entire network in order to troubleshoot the cause of the fire and to allow the fire department to safely extinguish the fire.

B. July 15-20, 2015, Sequence of Events

The following is a sequence of events that describe SCE's response to the outage events and the effect of each event:

<u>July 15, 2015</u>

- 9:28AM – SCE crew transferred load from the Bow 12kV circuit (which was not a primary feeder circuit for the Long Beach network system), to the Float 12kV primary feeder circuit in order to isolate vault number V5408333 on the Bow 12 kV circuit for routine underground work. By transferring the load from the Bow 12 kV circuit to the Float 12 kV circuit, the load on the Float 12 kV circuit increased considerably.

- 3:07PM - A PILC splice in vault number V5134053 on the Float 12kV primary feeder circuit out of Seabright substation failed, causing the circuit to relay to lockout. This failure may have been due in part to the increased load from the load transfer.

- 3:32PM – A PILC splice on the Steam 12kV primary feeder circuit contained within the same underground vault as the aforementioned Float 12kV primary feeder circuit splice also failed, causing the Steam 12kV primary feeder circuit to relay to lockout.

- [redacted]

- 4:22PM – An SCE troubleman responded to the fire at 3rd Street and Chestnut Street and requested that the Cargo 12kV primary feeder circuit, a portion of which was in the manholes numbered M5133091, M5133092, and M5133093, be shut down to minimize damage to equipment, and create a safe condition for fire department personnel to extinguish the fire. The Cargo 12kV primary feeder circuit is subsequently shut down.

- 6:21PM – SCE Grid Operations proactively de-energized the Chestnut 12kV, Loop 12kV, and Tribune 12kV primary feeder circuits in an attempt to de-energize the entire network system to troubleshoot the problem. At this point, SCE believed that the entire network system was de-energized, but three primary feeder circuits – Afton 12kV, Dusk 12kV, and Hoback 12 kV remained energized. This was due to inaccurate maps of the network system that SCE Grid Operations was using at the time.

- Approximately 7:00PM – Customers report low voltage conditions in the areas around 9th Street and Pine Avenue. Additionally, secondary cables in manholes numbered M5132758 and M5132761 started to fail.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

Figure 7 below depicts the Long Beach 1 outages (the number of customers who were without power at different times and dates during the outages of July 15 to 20, 2015).

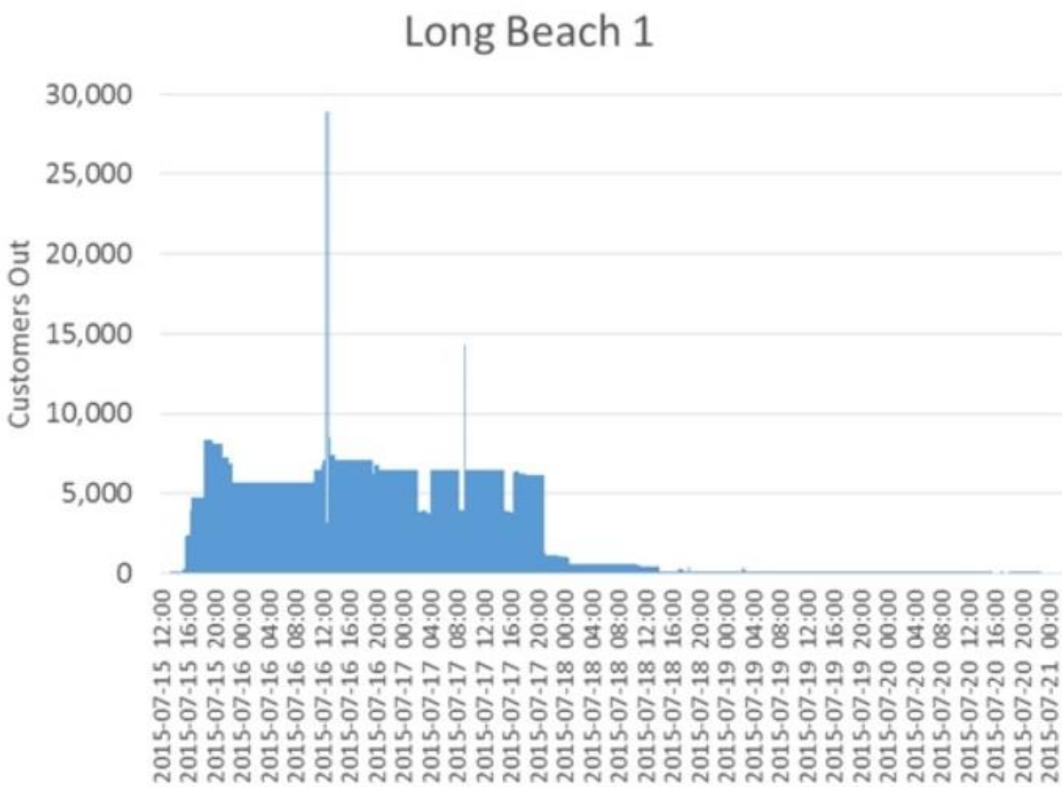

Figure 7: Number of customers out by date and time for July 15-20, 2015 outages. The large spikes in the customers out of power are due to SCE shutting off primary feeder circuits for troubleshooting purposes, causing outages to radial customers. The small customer outages after 20:00 hours on July 18, 2015, represent repairs and restoration activities for the final few customers. *Source: Davies Consulting.*

C. July 30, 2015-August 3, 2015 Outages Cause

At approximately 4:00PM on July 30, 2015, secondary conductors burned and failed in SCE vault number V5132757. The fire caused damage to sections of the Dusk and Hoback 12kV primary feeder circuits that were also in vault number V5132757, causing them to relay and lockout. In order to prevent the cascading failures experienced during the July 15-20 events and applying knowledge learned from the July 15-20 events, SCE Grid Operations proactively de-energized the State and Seabright substations. This action also consequently de-energized non-primary feeder circuits out of State and Seabright substations, in addition to de-energizing primary feeder circuits. At the peak of the outages, more than 17,500 customers were without power.

During the July 15-20 events, NP 28113, located in vault number V5132733, was set in the manual closed position with no relay installed. As explained previously, during those outages SCE proactively de-energized the Cargo 12kV primary feeder circuit in an effort to mitigate damage to the circuit components in manholes numbered M5133091, M5133092, and M5133093. However, because other feeder circuits were still energized, the secondary conductors of the network system were still energized. This caused current to backfeed onto the Cargo 12 kV primary circuit through NP 28113. As explained earlier, this will cause the secondary conductors to overload as the network system attempts to rebalance current flow in the secondary conductors. Additionally, as current is drawn away from the network due to backfeeding, voltage may dip in the network and currents may converge and add in single conductors. These factors caused secondary conductors to sustain damage, and this premature degradation ultimately caused the secondary conductors in V5132753 to fail and ignite, initiating the following events.

D. July 30, 2015-August 3, 2015 Sequence of Events

The following is a sequence of events that describe SCE's response to the outage events and the effect of each event:

[redacted]

- [redacted]

- [redacted]

- [redacted]

- [redacted]

- [redacted]

- [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Figure 8 below depicts Long Beach 2 outages (the number of customer who were without power at different times and dates during the outages of July 30 to August 3, 2015).

Figure 8: Number of customers out by date and time for July 30-August 3, 2015 outages. The small customer outages after 00:00 hours on August 1, 2015, represent repairs and restoration activities for the final few customers. *Source: Davies Consulting.*

V. SED Findings Pertaining to the Cause of the Outage

SED interviewed SCE staff on August 17, 2015; August 19, 2015; August 31, 2015; and October 13, 2015. Additionally, SED interviewed PG&E personnel on October 9, 2015 (SCE solicited advice from PG&E in troubleshooting and restoring the network system). SED also conducted field investigations and reviewed a large number of documents, records, and data provided by SCE. Based on these interviews, field investigations, and data reviews, SED concluded the following:

A. SCE Improperly Configured and Improperly Maintained Network Protectors

At the time of the July 15, 2015 outage, SCE had multiple network protectors that were improperly configured or missing critical components:

- Network protectors NP 20649 and NP 28113 in vaults V5134205 and V5132733, respectively, were set in the manually closed position without a relay installed.
  - NP 20649 was installed in V5134205 in December 17, 2007.
  - Sometime in 2008, the relay in NP 20649 was removed and the handle of NP 20649 was left in the manual open position. SCE could not provide an explanation of this action.
  - On October 15, 2010, an SCE Apparatus crew inspected NP 20649 and identified that NP 20649 was missing a relay. However, no follow-up or corrective action was taken.
  - On March 2, 2013, NP 20710 was installed in vault number V5132733.
  - On March 3, 2013, an SCE troubleman responded to low voltage calls in the areas and set NP 20710 in the manual closed position to address the low voltage calls.
  - On March 15, 2013, an SCE Apparatus crew was unable to inspect V5134205, which contained NP 20649, due to inaccessibility issues. The inspection was closed out, with no follow-up inspection.
  - On April 16, 2013, someone in SCE Distribution Apparatus discovered that NP 20710 would not close automatically and submitted a notification to replace NP 20710.
  - On July 31, 2014, a field crew from SCE’s Long Beach District replaced NP 20710 with a new network protector numbered NP 28113. NP 28113 did not come with a relay, and the field crew telephoned Distribution Apparatus that a relay still needed to be installed. An SAP (a software program that SCE uses to manage its workload and maintenance) notification was created, but did not have a specification notification for replacing or installing network protector relays. Instead, the notification was classified under “Special Programs.” NP 28113 was left in the manual closed position without a relay installed.

- On June 18, 2015, an SCE troubleman responded to a low voltage call around the areas of 3rd Street and Crystal Court, which was served by equipment in V5134205. The SCE troubleman discovered that NP 20649 was non-operational and set NP 20649 in the manual closed position to address the low voltage issues.
- On July 15, 2015, a PILC cable on the Float 12kV primary feeder circuit fails, causing the circuit to relay to lockout. Because NP 20649 (which was fed by the Float 12kV circuit) was in the manual closed position, the network system backfed onto the PILC cable failure.
- On July 15, 2015, SCE Grid Operations de-energized the Cargo 12kV primary feeder circuit, which fed NP 28113. However, because NP 28113 was in the manual closed position without a relay installed, it backfed onto the Cargo 12kV primary feeder circuit. This consequently stressed secondary conductors within manhole number M5132757, causing the insulation to degrade, contributing to the onset of the events starting on July 30, 2015.
- July 30, 2015 – Secondary cables in manhole number M5132757 failed and caught fire due to damage sustained during the July 15-20 events.

- At least two (2) network protectors were either set in the manual open position or found in the open position with a missing or inoperable relay.[9,10]
- At least six (6) network protectors, including NP 20649 and NP 28113, were missing a relay or configured incorrectly.[11]
- At least two (2) network protectors[12] were found in the manual closed position.

Leaving a network protector in the manual closed position is an unsafe condition as it can lead to backfeeding that can perpetuate primary feeder faults (as in the case of the Float 12kV splice failure) and overstress secondary network cables. Additionally, it is unsafe for workers who may enter a structure believing it is de-energized when, in fact, it is not. Ideally, network protectors should not be left in the manual closed position, and certainly

[redacted]

[10] A network protector that is set in the automatic position with an inoperable or missing relay is equivalent to a network protector set in the manual closed or manual open position. This is because of the absence or inability of a relay to send a signal to the network protector to open or close when conditions warrant.

[redacted]

not for an extended period of time. However, on July 15, 2015 SCE had at least one network protector that had been in a manual closed position without a relay in operation for more than several years.

Network protectors in the manual open position can lead to overstressed secondary cables on the network system. SCE's network system, regulated by sixty-two (62) network protectors, is designed to operate with all network protectors in the automatic setting, with an operational relay which will automatically determine whether the network protector breaker should be open or closed based on conditions in the network and on the primary feeder.[13]

As the number of network protectors that are set in the manual open position increases, fewer conductors are available to carry the load current in the network. As explained earlier, voltage in the system may dip and, as current in the network system rebalances itself in response, this may lead to secondary conductors carrying extra current and exceeding their rated ampacity, leading to overloading and failure.

Finally, without its relay installed or properly working, a network protector cannot operate for its intended purpose. Placing the protector in "automatic" will have no effect as the protector cannot automatically respond to network conditions without a relay.

B. SCE Failed to Maintain Adequate, Accurate, and Complete Network System Maps

Lack of accurate maps of its network system prevented SCE from properly de-energizing its entire network system during troubleshooting, which delayed restoration efforts and may have contributed to more damage on SCE's facilities.

At the start of the July 15th outage, SCE field personnel had incomplete and inaccurate maps of the Long Beach secondary network system. Specifically, the field map did not contain all the primary feeder circuits of the network system. The maps available to SCE's Grid Operations on July 15 only contained seven (7) of the 12kV primary feeder circuits (Float, Steam, Cargo, Chestnut, Ocean, Loop, and Tribune). Three primary feeder circuits (Afton, Dusk, and Hoback) were not on the map. This missing information complicated and prolonged restoration efforts during the July 15-20th events, as SCE would de-energize the seven primary feeders on the map under the impression that the whole network was de-energized.

C. SCE Lacks Adequate Training on the Network System

[redacted]

[13] A network system can operate with some network protectors in the manual closed or manual open position for a very limited period of time, but a network system operates optimally with all network protectors in the automatic position with a properly functioning relay.

[redacted][14]

[redacted]

D. SCE Lacks Adequate Methods to Capture Network Protector Field Findings and to Communicate this Information Between Various Groups in SCE

Prior to the events of July 15-20, SCE's methods to capture field findings on the network protectors and to transfer that information to different groups within SCE were inadequate. Sometime in 2008, SCE adopted a new database system (SAP) to capture, store, and manage inspection information. This system did not have an adequate method to capture information pertaining to network protectors. For example, findings regarding network protectors would be classified as "Special Program" with no additional explanation of the problem or indication that it was related to the network system.

In addition, SCE would often rely on telephone calls to notify repair crews of maintenance orders on network protectors rather than using the automated system. As a result, critical information regarding the status of network protectors was unable to be passed on to various groups within SCE, causing them to neglect critical repairs. One such instance is when NP 20649 was set and left in manual open in 2008; since SAP did not adequately capture this information it did not reach the SCE Apparatus Group for proper reconfiguration.

E. SCE Does Not Perform Testing on its Network Transformers

[redacted]

[redacted]

[14] Tribal knowledge is unwritten or undocumented information that is known by only a few individuals or small group of people within a company, but is critical to the overall quality or operation of a product or system.

[redacted]

[redacted]

F. SCE Conducts Insufficient Inspections of Network Protectors

[redacted] SED believes that keeping the network protector on an annual inspection frequency would increase the probability that critical network protector issues would be captured and corrected more expeditiously.[redacted]

G. SCE's Lack of Knowledge of its Own System Led to Complications in Restoring the Network System

SCE encountered several major complications during the restoration of the network system:

- At numerous instances during the outages and restoration efforts, primary feeder circuits, which served the network system and radial system, were unintentionally or intentionally de-energized. As a result, customers who are served by the radial system lost power each time the primary feeder circuit was de-energized.
- SCE did not have an established protocol for identifying and isolating major problems on the network system. [redacted]

[redacted]

[redacted]

[redacted]

- During the outages, SCE solicited the help of Con Edison (in New York) and Pacific Gas and Electric Company (PG&E).
    - PG&E manages a network system in San Francisco significantly larger than SCE's Long Beach network system. SCE requested copies of PG&E's standards for isolating issues on the network system. SED believes that this is indicative that SCE did not have extensive knowledge on how to restore the Long Beach network system in the event of a major failure.

H. SCE Demonstrated Complacency in Maintaining the Long Beach Network System

SED interviewed PG&E personnel on October 9, 2015. During this interview, the PG&E personnel indicated that managers of network systems must remain vigilant because it is easy for a utility or a group managing a network system to become complacent in the operation and maintenance of the network system, in part due to the general reliability of network systems. SED believes that SCE was complacent in its operation and maintenance of the Long Beach network system. During interviews, multiple SCE employees strongly expressed and reiterated that problems are unlikely to occur due to the reliability of the Long Beach network system, and that the last major outage on the network system was in 1959.

SCE's complacency in maintaining the Long Beach network system was due, in part, to the very redundancy in the system which made it so reliable for many years. SCE does not have this luxury in management of its radial network, given that most failures on the radial system immediately result in loss of power to customers, requiring immediate attention by SCE. Many problems on the radial system are visible to customers, inspectors, and regulators, whereas problems on the network system may go undetected for years.

I. SCE Lacked a Defined Management Structure for the Long Beach Network System

[redacted]
Additionally, SED could not identify a singular principal entity that was responsible for maintaining the network system.

J. SCE Failed to Ensure Proper Workmanship on PILC Splices

[redacted]

[redacted]

[redacted]

[redacted]

K. SCE Failed to Properly Address Employee Warnings and Implement Internal Recommendations Related to the Secondary Network System Maintenance Problems

[redacted]

Finally, SCE also reported that a 2011 SCE internal presentation identified multiple problems in its secondary network system.[17] Although SCE performed corrective action for some of the findings, it failed to complete corrective action for others.

SED believes that the findings listed above may be indicative of a corporate culture issue in which concerns from field personnel are not given adequate consideration by lower to mid-level management at SCE, and internal recommendations are not fully implemented.

L. SCE Lacks a Proper Method for Evaluating Ampacity Ratings - Transferal of the Bow 12kV Circuit Load to the Float 12kV Primary Feeder Circuit

Although a single, specific cause of failure of the Float 12kV PILC splice has not been identified, SED believes that the transfer of the Bow 12kV non-primary circuit feeder load to the Float 12kV primary circuit feeder load contributed to the failure of the Float 12kV PILC splice. On July 15, 2015 at 9:28AM, approximately five and a half hours before the Float 12kV PILC splice failed, SCE transferred the Bow 12kV circuit load to

[17] SCE, *Performance Review Long Beach Network Outage, p. 33*

the Float 12kV circuit in order to isolate vault number V5408333 to replace an underground gas switch. [redacted]

[redacted]

Resistive heating (also known as Joule Heating) is proportional to the square of the amount of current.[18] As such, when current on the Float 12kV circuit increased approximately nine fold (30 amps to 270 amps) heating of the conductor would have increased by more than 80 times. This heating is not immediate, but increases exponentially over time, and may accelerate with any cable degradation. As mentioned above, the IMCORP report identified an air pocket around the insulating tubing. If there were any other installation defects present in the Float 12kC PILC splice, these defects, in conjunction with the increased resistive heating, could lead to premature failure of the Float 12kV splice.

M. SCE Failed to Correct or Replace Deteriorated Equipment and Cables throughout the Network System

On July 31, 2015, SED engineers entered several vaults containing network system equipment and observed multiple instances of leaking and deteriorating conductors. [redacted]

N. SCE Failed to Fully Utilize Network Protector Automation and Communication Capabilities

[redacted]

[18] As a mathematical formula, the relationship between heat and current may be expressed as $H \alpha I^2$, where "H" represents heat and "I" represents current in a conductor.

VI. Non-Secondary Network System Outages During the Summer and Fall of 2015

In addition to the outages on the secondary network system, the City of Long Beach experienced a number of other unrelated unplanned outages on the radial system during the summer and early fall months of 2015. In order to determine if these outages indicate significant problems in SCE's maintenance outside the secondary network system, SED requested a list of all unplanned outages affecting over 50 customers for over one hour in the City of Long Beach, for the months of July to November 2015. SCE compiled a listing including the outage date, time, location, duration and cause. A review of the information shows that most of these outages occurred during the high temperature, high load summer months, when utility distribution systems are typically stressed. The outages tapered off as the weather cooled.

[redacted]

[redacted]

SED consistently emphasizes the importance of effective root cause analysis, failure trending, infrared and advanced testing, predictive maintenance, and other modern inspection and maintenance program to the utilities, in an attempt to reduce all unplanned outages on distribution facilities. In addition, SED conducts regular audits, incident and outage investigation, analysis and special investigations to ensure compliance with Commission requirements.

[redacted] [redacted]

VII. Historical Reliability Statistics of the Long Beach District

SCE's Long Beach District typically enjoys high reliability when compared to reliability in SCE's overall service territory. The Long Beach secondary network in particular has performed reliably in the past, and has not experienced a major outage since the 1950s.

SED looked at SCE's Long Beach District reliability using industry standard reliability metrics – System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), and Customer Average Interruption Duration Index (CAIDI).

SAIDI measures the number of hours of power outage for an average customer over a time period.

SAIFI measures the average number of times an average customer experiences an outage during a time period.

CAIDI measures the average amount of time a customer is out of power for a specific outage.

Lower numbers are preferable for all metrics.

Long Beach is one of SCE's more reliable districts, likely due in part to the reliability of the secondary network. In 2014 the Long Beach District recorded a SAIDI of 66.23 compared to a system-wide metric of 112.18, and in 2013 recorded a SAIDI of 75.83 compared to the system-wide metric of 108.13.[20] Long Beach has typically been at least the second best performing district in SCE's service territory for the past 5 years.

Aside from minor variation from year to year, the three major investor owned utilities (IOUs) in the state exhibit comparable reliability. Annual reliability reports for the major IOUs are publicly available on the CPUC website. [21]

[redacted]:

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[20] https://www.sce.com/nrc/reliability/reports/county/santabarbaracounty_district_5.pdf. Note that these metrics are for a full year.

[21] http://www.cpuc.ca.gov/General.aspx?id=4529

[redacted].

	[redacted]

As shown above, in July 2015, excluding the major network outages, the Long Beach District outperforms SCE system-wide in both SAIDI and SAIFI. System-wide, SCE reported a spike in SAIDI during July, no doubt partially attributed to the Long Beach outages and the generally hot, high load condition in the SCE service area during that month. The system-wide statistics return to a more acceptable level in August. Given the huge disparities caused by the network outages, these statistics, while not entirely dispositive, do not by themselves point to major neglect of the maintenance, inspection, and operations of SCE facilities in its entire service territory.

[redacted]

[23] General Order 166, Standard 12, Section A. *Restoration Performance Benchmark for a Measured Event.*

[redacted]

VIII. SCE Emergency Response

A. Overview

In addition to technical problems in the downtown Long Beach secondary network and SCE's maintenance and inspection activities in the Long Beach District, SED examined SCE's emergency response during the 2015 Long Beach outages.

Following the 2011 windstorms in the Los Angeles area, SED conducted a similar investigation of SCE's emergency response planning and implementation, and issued several recommendations for improvement. While SCE has addressed many of the recommendations from the 2011 windstorm report,[25] most specifically through improvements in its Incident Command System (ICS), some specific problems remain, and became evident during the recent Long Beach outages.

These problems include inadequate restoration time estimates and protocols for communicating restoration activities to customers, failure to appropriately use all available communication methods with customers, difficulty for Long Beach first responders to obtain specific operational information, and inadequate risk assessment and preparation for localized incidents such as the Long Beach outages. A number of these problems were exacerbated by SCE's lack of knowledge in network system restoration protocols, which made it difficult for SCE to predict restoration time.

Long Beach experienced no injuries or major property damage as an immediate result of these outages.[26] SED notes that the City of Long Beach had developed an ICS of its own prior to these events, as well as an active Community Emergency Response Team which provided invaluable assistance during the outages. Without the assistance of Long Beach officials, first responders, and the cooperation of Long Beach residents and business customers, the outcome could have been worse.

B. Independent Consultant (Davies) Report and SED Investigation

In addition to a technical causal analysis, SCE's independent consultant, Davies Consulting (Davies), also examined SCE's emergency response to the Long Beach incident. SCE also prepared its own technical Root Cause Evaluation (RCE).

Davies conducted a comprehensive examination of SCE's emergency response, and issued recommendations in several areas, including improvements to the implementation of the emergency command structure, improved communications with the public and first responders, and better use of technology tools during the outages.

---

[25] SED's windstorm report is Attachment 2 to the Order Instituting Investigation (I.) 14-03-004.

[26] One apartment fire was reportedly caused by the use of candles.

In general SED agrees with Davies' recommendations (see Attachment A), which can be found in the public Davies report.[27] SED also generally agrees with SCE's internal recommendations from its RCE (see Attachment B).

Although SED also looked comprehensively at SCE's emergency planning, and reviews SCE's full emergency plan annually under the provisions of CPUC General Order 166, SED focused its investigation on specific shortcomings mentioned by City of Long Beach staff, first responders, and residents during public meetings. SED also examined issues SCE failed to address since the 2011 windstorm.

SED will not rehash all deficiencies identified by Davies, but will discuss some of the most significant programmatic shortcomings SED identified in SCE's emergency response planning and implementation. This includes some issues identified by Davies as well as some additional problems discovered by SED.

C. SED Findings Pertaining to SCE Emergency Response

<u>Problems with Incident Command System Deployment</u>

A primary SED recommendation following the 2011 windstorm was that SCE fully develop an ICS based on Federal Emergency Management Agency (FEMA) National Incident Management System (NIMS) protocols. ICS is a standard emergency management construct for "the combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure."[28] SCE had implemented a nascent ICS in 2011, and has since improved its ICS, but still has some distance to go in its efforts to achieve a fully developed and mature ICS.

SCE's current Corporate Emergency Response Plan is based on an ICS structure. SCE's "Watch Team" within its Business Resiliency Group monitors its service territory for possible emergency situations requiring implementation of an Incident Management Team (IMT). The Business Resiliency Duty Manager uses special tools including Complexity Analysis to determine the severity and potential impact of threats or events. SCE will then develop an appropriate Incident Action Plan.

Both SED and Davies found problems in SCE's ICS. To characterize the most significant issue, SCE's emergency response was hampered due to SCE's initial failure in recognizing the severity of the Long Beach emergency, and SCE's subsequent difficulty appropriately scaling and implementing a response to the Long Beach network outage within an ICS structure. This, combined with SCE's limited knowledge of the difficulty in restoration of a network system appears to have led SCE to improperly classify the July 15 outages at first. This caused some delays in standing up its IMT.

27

http://newsroom.edison.com/internal_redirect/cms.ipressroom.com.s3.amazonaws.com/166/files/201510/Report%20on%20the%20SCE%20Long%20Beach%20Outage.pdf

28 ICS Glossary, FEMA Emergency Management Institute

According to Long Beach officials and residents, SCE's response improved as the July 15 outage extended past one day, and also improved for the July 30 outage.

When the July 15th outage occurred, SCE did not fully activate its IMT until July 16, and never fully implemented its Incident Support Team. Long Beach city officials complained that SCE took too long to send representatives, particularly authoritative representatives, to Long Beach's emergency operations centers. Because of this, Long Beach first responders lacked important information and Long Beach city officials were unable to fully answer questions from residents. Davies points out that SCE did not utilize its Mobile Command Center vehicle and established geographically separated command posts. SED agrees that these are serious problems that SCE should address to prevent future recurrences.

Davies identified potential areas for improvement of SCE's ICS, recommending that SCE change its incident complexity analysis process to consider all appropriate factors, improve use of the IMT, use rosters for company emergency response teams, activate its Mobile Command unit,[29] better plan for command and control locations, and improve collaboration with local agencies. SED identified similar issues and agrees that these actions will likely improve the effectiveness of SCE's emergency response as a whole.

Specific Problems with SCE Emergency Response to Long Beach Outages

In addition to the cross-cutting problems identified above, SED identified several problems specific to the response to the July 2015 outages. Some of these issues appear to be recurring problems with SCE's incident response.

SCE Needs Better Knowledge of Customers and Areas to Effectively Plan for Emergency Response

Many downtown Long Beach residents, including some elderly residents in high rise apartments, receive electricity from the secondary network under "master meter" agreements. Under master meter agreements, building owners purchase electricity from the utility and resell it to their tenants.

In this case, SCE initially characterized this outage based on the number of "customers" out, which may have understated the actual number of residents suffering from the outages, since one "customer" might actually represent many electricity users (for example, an entire apartment building might be one customer, but represent many residents). Long Beach first responders also indicated this confusion in terminology presented some issues during the outages.

Identifying unique characteristics of various portions of its service area prior to outages, and incorporating this knowledge into its emergency planning process would allow SCE to more effectively respond to outages. SCE would necessarily treat outages in urban

[29] SCE owns large vehicles outfitted for use in an emergency. These vehicles can be strategically located for logistic planning, and are well suited for use by an IMT.

high rise areas differently than outages in primarily business areas, outages in forested rural areas, or outages in suburban areas.

For example, during the 2011 windstorm, large numbers of trees and other vegetation impeded restoration efforts. Had SCE identified the vegetation issues in this area prior to the 2011 windstorm it might have been able to plan more effectively.

Similarly, the Long Beach outages provided unique challenges. The Long Beach outages affected a significant number of elderly and immobile residents in multi-story buildings. Many of these residents rely on elevators to leave and return to their dwellings. Concerns of such residents are different than the concerns of the typical suburban customer. These people may need more face to face assistance, different types of communication activities, and emergency generators earlier than other customers.

SED recommends that SCE consider specific issues and difficulties presented by various neighborhoods or areas in its service territory as it conducts its emergency planning.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[30] In general, G.O.166 applies only to very large scale outages affecting over 10% of a utility's service territory. Most provisions of G.O.166 would not apply to the Long Beach outages.

[redacted]

[redacted]

Problems Communicating Operational Activities to First Responders and City Officials

Although SCE liaisons and other personnel began communicating with Long Beach first responders early during the July outages, Long Beach City officials (in particular Deputy Fire Chief Rich Brandt) related that during the July 15 outages, often the available SCE staff did not have specific operational information and in some cases did not communicate specific operational activities to first responders.[32] This was also a specific problem SED identified during the 2011 windstorms.

In the case of the Long Beach outages, part of the problem arose because SCE was not always certain of the potential effects of its restoration processes on the secondary network or the rest of its radial system in the Long Beach district. SCE found that restoring power to one area might trigger a vault fire in another area. To a certain extent, at the beginning of its restoration process, SCE was operating partly by "trial and error," and was therefore unable to pass on operational information about which it was uncertain.

In other cases SCE apparently possessed information but for various reasons failed to pass it on to first responders. For example, during the outages SCE was often required to de-energize large portions of its radial network to perform work on the secondary network. This caused temporary, large scale outages of up to 30,000 customers. In most of these instances SCE stated that it informed first responders beforehand. However, in some instances it did not, presenting a security concern for first responders.

SCE Mobile Application Tool

SCE has recently developed a mobile application for use by state and local government. This application was not deployed during the outages. SED concurs with Davies that this application "is an important tool" but will not replace SCE's current liaison process.[33]

---

[31] In early 2016, SCE began holding emergency plan review meetings pursuant to Public Utilities Code Section 768.6. SED staff attended one of these meetings on March 25, 2016.

[32] Long Beach officials did comment that SCE field crews were responsive and effective in their immediate response to the hazardous vault fires, and assisted in making the vaults electrically safe for firefighters.

[33] Davies Consulting. *Independent Report. Evaluation of the July 2015 Long Beach Network Outages.* P71.

SED recommends that SCE develop plans to ensure that it constantly provides all important and relevant information, including operational information to local officials and first responders.

Problems Communicating with the Public - Restoration Time Estimates

SED reviewed anecdotal evidence[34] that suggests customers expect a few basic items from their electrical provider:

- They expect their power to stay on and in the event of outages they expect the power to be restored quickly,
- In the event the utility cannot restore the power quickly, they expect to be informed frequently and accurately as to when the power will be restored and at a bare minimum the activities the utility is taking to restore the power,
- If they cannot receive accurate restoration time estimates, at a minimum they expect frequent communication to know the utility is present and involved, and
- They appreciate emergency assistance for extended outages and to be safe during the outages.

Inaccurate restoration time estimates and insufficient communication with the public regarding restoration efforts were highlighted as major issues during SCE's emergency response to the 2011 windstorms. Again, these same areas remained problematic during the 2015 Long Beach outages, as mentioned in the Davies Report as well as by residents in public fora.

The primary problem in both the windstorm and the Long Beach outages was that SCE was completely unable to accurately estimate restoration time for the grid, and in particular the secondary network. To remedy this, SCE must improve its awareness and knowledge of the network system. In addition, better automation and metering of its network protectors, as well as use of smart meters (Advanced Metering Infrastructure – AMI), SCE's Energy Management and SCE's Outage Management Systems should also assist SCE in this effort.

During outages, frequent communications with the public are essential. SCE should provide the best and most accurate restoration estimates available. Overly conservative estimates are preferable to overly optimistic estimates. If SCE cannot provide estimates, it should at the very least inform the public of what it is doing and that it understands their concern. More is better in these instances. Formalized plans which allow some leeway are preferable to either rigid communication guidelines or fully ad-hoc decisions on communications.

[34] "Anecdotal evidence" includes comments from customers during townhall meetings, and council meetings, during the Long Beach outages and windstorm incidents, as well as historical comments during various SED customer complaint investigations.

SED recommends that, to the extent possible, SCE should improve and formalize both its methodology for making restoration estimates and communicating the estimates (or lack thereof) to the public.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Beach downtown outages, it should be possible to plan and carry out adequate face-to-face customer contact.

SCE has no comprehensive "reverse 911" system, although it has been expanding telephone notification of planned outages to certain customers and businesses. Additionally, SCE has studied the possibility of partnering with local municipalities in order to utilize existing reverse 911 systems on a shared basis, but it currently has no specific plans in this area.

Despite the modern technology and multiple available communications channels, residents still complained that they lacked information during the outages. Many residents, in both the 2011 windstorm and the Long Beach outages, went so far as to recommend using police cars with loudspeakers to announce outage related information from the streets.

SED recommends that SCE performs a specific, comprehensive review of its existing communication methodologies, and research all potential additional communication methodologies to develop a more effective baseline communication policy, and to "think outside the box" as far as communications during outages is concerned.

[redacted]

[redacted] These generators provided power to several hundred residents. Given the hot temperatures during these outages, and the nature of the customers and residents in the area, SED believes SCE could have deployed these generators sooner.

SED recommends that SCE thoroughly review its policy for deploying generators in emergency situations, and implement a policy that allows it to provide generators/temporary power as soon as feasible to affected customers.

<u>Other Areas of Interest Related to Emergency Response</u>

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

IX. SCE Response to the Long Beach Outages

On September 1, 2015, SED sent SCE a letter ordering SCE to conduct several corrective actions, summarized below:

- Perform a detailed inspection of all underground facilities that are part of the Long Beach secondary network system. These facilities include, but are not limited to network protectors, mole limiters, lead conductors, and splices. The inspections are to verify proper working conditions and proper settings.
- Confirm the ventilation system of vaults and other underground structures that require ventilation in the City of Long Beach District is working properly.
- Confirm that the manhole and vault covers of underground structures in the City of Long Beach are properly tethered and secured in the event of an underground vault explosion.
- Confirm that transformers serving the Long Beach area are properly rated to meet customer demand during peak times.
- Inspect and confirm safe and reliable operation of the circuit(s) supplying power to the Port of Long Beach, and any SPOT networks serving a large customer in the City of Long Beach.[35]

On September 30, 2015, SCE responded to SED's letter, indicating that they performed the following corrective actions, summarized below:

- After the July 15 outage, SCE inspected 329 underground structures, including 303 underground structures that were part of the Long Beach secondary network system. The inspections included inspections of the underground structures, equipment contained within the structure, underground cables and their components, splices, network protectors, and mole limiters, and verifying proper configuration of network protectors.
- As part of the above-mentioned inspections, SCE created notifications to repair or replace equipment requiring corrective action, including underground blowers used for ventilation.
- Moving forward, SCE will commence inspecting underground structures that do not contain equipment such as underground switches or transformers.
- Following the events of July 15-20, SCE has commenced performing additional tests on substation circuit breakers for primary feeder circuits connected to the Long Beach secondary network system.

[35] A SPOT network is a network transformer and network protector pair that typically serves a single, "large" customer. For example, a SPOT network may serve a large apartment building or an industrial complex.

- SCE tethered 287 underground structures in the Long Beach secondary network system.

[redacted]

- [redacted]

- SCE appointed a single “owner” of the Long Beach secondary network system. The Long Beach Distribution Business Line District Manager became the single point of contact for work on the Long Beach Secondary Network.

[redacted]

[redacted].

X. Violations

A. General Order 128, Rule 17.1, *Design, Construction, and Maintenance*

Rule 17.1 states the following:

> *Electrical supply and communication systems shall be designed, constructed, and maintained for their intended use, regard being given to the conditions under which they are to be operated, to enable the furnishing of safe, proper, and adequate service.*
>
> *For all particulars not specified in these rules, design, construction, and maintenance should be done in accordance with accepted good practice for the given local conditions known at the time by those responsible for the design, construction, or maintenance of [the] communication or supply lines and equipment.*
>
> *All work performed on public streets and highways shall be done in such a manner that the operations of other utilities and the convenience of the public will be interfered with as little as possible and no conditions unusually dangerous to workmen, pedestrians or others shall be established at any time.*

SCE violated General Order 128, Rule 17.1 in the following instances:

- Network protectors are designed to be installed and maintained in the "automatic" position in order to fulfill their intended purpose to prevent backfeeding onto the primary feeder circuits (a network protector in the automatic position will allow it to automatically "open" or "close" based on conditions that are discussed earlier in this report). Additionally, network protectors must be installed with a functioning relay in order for a network protector to be able to operate automatically. SCE did not design and install or maintain the network protectors listed below for their intended use:

  NP 20649, NP 28113, were set in the "manual closed" position instead of automatic position (which is the correct position to set network protectors).

  NP 20638, NP 20649, NP 25505, NP 25509, NP 30397, and NP 28113 were without a relay installed or with an improperly configured relay:

- As identified in the IMCORP analysis, the Float and Steam 12kV splices were constructed with major deviations from manufacturer recommended installation procedures that introduced conductive paths on areas on the splices intended for non-conductive paths. As such, the splice was not constructed, operated, and maintained as intended.

- [redacted]

[redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

B. General Order 128, Rule 17.2, *Inspection*

Rule 17.2 states the following:

> *Systems shall be inspected by the operator frequently and thoroughly for the purpose of insuring that they are in good condition and in conformance with all applicable requirements of these rules[.]*

Sometime in 2010, a UDI crew inspected vault number 5134205, which contained NP 20649, and did not open and check NP 20649 to verify that it was set properly (NP 20649 was in service in the manual open position without a relay installed at the time). Three years later on March 15, 2013, an SCE Apparatus crew was unable to complete an inspection of network protector NP 20649 due to inaccessibility issues (construction in the area). The inspection was closed out, and a follow up inspection was not conducted. SCE is in violation of General Order 128, Rule 17.2, for not conducting and completing a thorough inspection of NP 20649.

C. General Order 128, Rule 33.6-A, *Accessibility*

Rule 33.6-A states the following:

> *Cables and conductors in manholes, handholes, permanent cable trenches, or other similar enclosures shall be reasonably accessible to workmen and working space shall be available at all times.*

[redacted]

D. Public Utilities Code Section 768.6

PU Code Section 768.6 states in part the following:

> *"(3) Every two years, in order to update and improve that electrical corporation's emergency and disaster preparedness plan, an electrical corporation providing service in California shall invite appropriate representatives of every city, county, or city and county within that electrical corporation's service area to meet with, and provide consultation to, the electrical corporation…*
>
> *(c) A meeting pursuant to subdivision (b) shall be noticed and shall be conducted in a public meeting that allows for the participation of appropriate representatives of counties and cities within the electrical corporation's service area…(3) An electrical corporation shall notify the commission of the date, time, and location of a meeting pursuant to subdivision (b).*
>
> *(d) An electrical corporation shall conduct a meeting pursuant to subdivision (b) no later than April 1, 2013, and every two years thereafter.*
>
> *(e) An electrical corporation shall memorialize a meeting pursuant to subdivision (b), and shall submit its records of the meeting to the commission."*

In 2015 SCE was required to hold emergency planning meeting with the public. SCE was required to notify stakeholders of these meetings, inform the Commission of the meetings, hold the meetings, and memorialize the meetings and then report on the meetings to the Commission.

SED's investigation revealed that SCE did not hold specific meetings pursuant to PU Code Section 768.6, and did not notify the Commission of these meetings or submit copies of records of these meetings to the Commission. SCE did not fully comply with the specific requirements of Section 768.6, therefore SED finds that SCE is in violation of Section 768.6. SED notes that SCE has committed to maintaining full compliance with this regulation in the future.

E. CPUC Decision 14-08-009

CPUC Decision (D.) 14-08-009 states, in part:

> *The following settlements … are approved as reasonable in light of the record, consistent with law and Commission precedent, and in the public interest: …*
> *(b) 2011 Windstorm Settlement Agreement Between the Safety and Enforcement Division of the California Public Utilities Commission and Southern California Edison Company.*

The approved 2011 Windstorm Settlement Agreement, which is Attachment A to D.14-08-009, states in its Section 3(C)(4):

To the extent not already completed, SCE agrees to implement all of the recommendations in the SED windstorm report.

SCE has addressed many of the recommendations in the SED windstorm report. However, SED finds that SCE failed to implement the following recommendation on page 15 of the report:

SCE should ensure it provides accurate estimated restoration time to its customers.

The need for SCE to provide accurate estimated restoration times was a central issue in the windstorm OII. In reaching their $8 million financial settlement in that proceeding, parties included $3.5 million because SCE communicated inaccurate restoration times to customers.[36] However, as described in Section VIII above, SCE still was unable to provide accurate restoration time estimates during the 2015 Long Beach outages. Therefore, SED concludes that SCE is in violation of D.14-08-009 because it has failed to implement this recommendation in the SED windstorm report.

F. Public Utilities Code Section 451

Public Utilities Code Section 451 states the following:

All charges demanded or received by any public utility, or by any two or more public utilities, for any product or commodity furnished or to be furnished or any service rendered or to be rendered shall be just and reasonable. Every unjust or unreasonable charge demanded or received for such product or commodity or service is unlawful.

Every public utility shall furnish and maintain such adequate, efficient, just, and reasonable service, instrumentalities, equipment, and facilities, including telephone facilities, as defined in Section 54.1 of the Civil Code, as are necessary to promote the safety, health, comfort, and convenience of its patrons, employees, and the public.

All rules made by a public utility affecting or pertaining to its charges or service to the public shall be just and reasonable.

SCE receives funding for operations and maintenance in every General Rate Case to maintain and furnish adequate, efficient, just, and reasonable service, instrumentalities, equipment and facilities throughout its system. This includes the Long Beach secondary network.

Given that the fires, exploding vaults, and lengthy outages in Long Beach fail to promote the safety, health, comfort, and convenience of its patrons, employees and the public, and that these conditions can be traced to SCE's maintenance and operations, SED concludes that SCE violated Public Utilities Code, Section 451.

[36] D.14-08-009, mimeo. pp. 12-13.

XI. SED Recommendations

In addition to the recommendations identified in SCE's Root Cause Evaluation report and those in the independent Davies report, SED makes the following recommendations:

A. Recommendations Relating to the Network System Outages

Revisions to the Network Protector Training Class

SED recommends that SCE make several major improvements to its network protector training class. At minimum, SCE should make the following changes:

- Groups outside of the Apparatus Group that deal with the network system (e.g., SCE troublemen) should also be required to take the training class.
- Network protector class should be amended to place a greater emphasis on the proper configuration of the network relays and the hazardous consequences of leaving a network protector in the manual closed position. Doing so will reduce the occurrence of complacency in maintaining and operating the network system.
- Regularly update training material to ensure that the information is accurate and up to date.

Develop a Protocol for a More Accurate Ampacity Determination

As identified earlier, transferring the Bow 12kV load to the Float 12kV primary circuit may have accelerated the failure of the Float 12kV PILC splice. SCE's load transferal protocols currently do not take into consideration a reduction in current carrying capacity due to degradation sustained to conductors and splices over their service life. SED recommends that SCE consider developing a protocol for more accurately determining the ampacity of a circuit, rather than relying on a nominal ampacity of a circuit.

Ensure Proper Ventilation

SCE should ensure that blowers and ventilation in underground structures are in optimal condition to remove any combustible gases from the structure and aid in cooling any equipment in the structure.

Fire Prevention and Mitigation

As part of equipment installation on underground structures, SCE should investigate methods to prevent fires in vaults from starting and spreading.

Mounting and Racking of Equipment

SCE should develop standards for the appropriate mounting and racking of equipment and cables in underground structures to ensure that at all times access to equipment by SCE field personnel is not impeded.

Understanding of Network Protectors

SCE should ensure that SCE personnel tasked with installing, operating, maintaining, and inspecting network protectors are aware that all network protectors need to have a functional controlling relay and be placed in an automatic position to function as intended.

Audits of the Secondary Network

SCE should conduct and document periodic audits and condition assessments of the secondary network, and perform follow-up maintenance as necessary.

Equipment Upgrades

SCE should complete automation and telemetry upgrades to all network protectors.

Maps and Diagrams

SCE should institute programs to ensure network maps and diagrams are consistently reviewed for accuracy and accurately reflect state of the network.

System Models

SCE should develop load flow models for the network and methodologies for utilizing real time data from network protectors to monitor the network and to aid in restoration of the network.

Network Protector Relays

SCE should ensure that network protectors are never installed without relays and are always tested immediately after installation.

Manual Closed Policy

SCE should develop a policy on when and for how long network protectors can be set in manual open and manual closed positions.

Spare Parts

SCE should maintain an adequate supply of replacement parts for the network.

Maintenance Management

SCE should develop effective maintenance management processes for the network including effective electronic database forms for entering field findings for the network.

Manufacturer Recommendations

At a minimum, SCE should follow all recommendations found in instruction manuals or data sheets for maintenance and testing of network system equipment (i.e. network transformers, network protectors, etc.)

Testing

SCE should develop effective testing protocols for network protectors and network transformers.

Single Entity Management

SCE should identify a single entity responsible for oversight of the network and coordinating efforts of all groups working on the network.

Risk Management

SCE should utilize all available data for predictive maintenance and effective risk management for the secondary network including assessment of the condition of conductors, transformers, protectors and all components of the network. For effective risk management, SCE should identify all possible threats and risks, assess the severity of those risks, develop a plan to mitigate those risks, implement that plan and track it to completion. Risk assessment should be an ongoing process.

Repair Priority

SCE should prioritize repairs on the secondary network to ensure work is completed in a timely manner without unduly stressing the system.

Real Time Monitoring

SCE should develop a program to ensure that the current state of the network is known in real time. From this program SCE should develop a regular report on the state of the network.

Benchmarking

SCE should participate in regular network benchmarking efforts with other utilities.

Addressing Staff Concerns

SCE should encourage its employees to report any concerns with the condition of the network and ensure that those concerns are addressed at the appropriate level.

Inspection Practices

SCE should ensure inspection practices cover all areas of the network, including inspecting manhole tethers regularly.

Splice Construction

SCE should improve oversight and training for splice construction.

B. Recommendations Relating to SCE's Emergency Response During the Network System Outages

To improve its emergency response SED recommends that SCE:

- Review its policy for deploying generators in emergency situations, and implement a policy that allows it to provide generators/temporary power as soon as feasible to affected customers.
- Perform a specific, comprehensive review of its communication methodologies during various types of outages to arrive at a baseline policy and to "think outside the box" as far as communications during outages is concerned.
- Ensure that all medically sensitive customers, particularly those in master metered residences, are aware of and properly enrolled in its Medical Baseline program.
- Improve and formalize both its methodology for making restoration estimates and communicating the estimates (or lack thereof) to the public.
- Develop plans to ensure that it constantly provides all important and relevant information, including operational information, to local officials and first responders.
- Include consideration of the specific issues and difficulties presented by various neighborhoods or areas in its service territory as it conducts its emergency planning.
- Specifically invite Long Beach city officials to participate in General Order 166 exercises and any other emergency planning activities and exercises.

C. Recommendations Relating to SCE Corporate Culture

The July 2015 Long Beach outages exposed some cultural problems in SCE's management of the Long Beach network, which could potentially extend outside of the network.

Davies also identified cultural issues in its report, primarily related to emergency response and communication with external stakeholders.[37] SED found corporate issues related to internal communications, risk assessment, training and transmission of institutional knowledge.

SED found that:

- Prior to the Long Beach outages, SCE's apparatus group employees expressed concerns to their management about the maintenance and inspection practices for the network protectors, and other SCE transmission and distribution employees expressed concern over lack of training for the fabrication of Poly to PILC splices. Apparently SCE never addressed these concerns.
- Although SCE conducted risk assessment for the secondary network as part of its distribution system risk assessment for its rate cases, it appears that SCE's risk assessment for the network system was inadequate. For example, although SCE is performing cable assessment in other districts, it did not perform these assessments on the Long Beach secondary network. An adequate risk assessment requires an organization to consider all available data, and in addition to "think outside the box." As is seen in the Long Beach outages, simply looking at overall reliability is insufficient.
- In 2011 SCE prepared a report based on an apparent risk evaluation of the secondary network system. This report warned of catastrophic failure of the entire network system in the event of the failure of important components. Many of the problems identified in the report mirror the findings of this report, including inadequate knowledge of the system and multiple problems with the network protectors. SCE made some changes based on the report recommendations, but failed to follow through with a comprehensive corrective action plan.
- SCE's training practices for the secondary network were insufficient. Additionally, an inordinate amount of training is performed through informal channels. SED is unsure if this extends to other training in SCE, but SCE should ensure that it develops appropriate formal training when necessary and captures institutional knowledge from retiring employees for dissemination through the company.

[37] Davies. P 78.
http://newsroom.edison.com/internal_redirect/cms.ipressroom.com.s3.amazonaws.com/166/files/201510/Report%20on%20the%20SCE%20Long%20Beach%20Outage.pdf

To improve its corporate culture, SED recommends that SCE:

- Develop programs and practices to capture and address employee concerns regarding maintenance and testing of its facilities, and to ensure that the appropriate corrective actions are taken,
- Further develop and improve its emergency response protocols and ICS implementation companywide, including the adoption of recommendations of Davies consulting and the recommendations contained in this report,
- Review its risk management practices to ensure that SCE identifies and assesses all potential risks to its system, develops comprehensive plans to mitigate those risks, implements those plans and tracks the plans to completion,
- Establish programs to capture institutional knowledge and translate this information to formal training programs where appropriate, and
- Continuously review its training activities, not only related to the secondary network system but for all elements of its business.

ATTACHMENT A
DAVIES REPORT RECOMMENDATIONS

Corporate Culture Recommendations

Number	Recommendation	Value	Ease of Implementation	Implementation Timeframe
CC-1	Fully Endorse and Communicate the Emergency Management Vision and Guiding Principles	High	Easy	Immediate
CC-2	Assign Individuals with Broad Experience to Incident Leadership	High	Moderate	Immediate
CC-3	Continue to Champion a Cooperative and Transparent Relationship with its External Stakeholders	High	Moderate	Critical

Information Technology and Operational Technology Recommendations

Number	Recommendation	Value	Ease of Implementation	Implementation Timeframe
ITOT-1	Ensure that Network Outages are Part of the Design Basis in the Next Release of OMS	Low	Difficult	Long-term
ITOT-2	Update the AMI Capabilities for the Networked Area (at a minimum)	High	Difficult	Long-term
ITOT-3	Update the AMI Capabilities for the entire SCE Service Territory	High	Difficult	Long(er)-term
ITOT-4	Work with External Stakeholders to Affirm the LPA Application’s	High	Moderate	Short Term

	Usefulness and Update as Necessary			

Communications Recommendations

Number	Recommendation	Value	Ease of Implementation	Implementation Timeframe
COM-1	Develop a Comprehensive Crisis Communications Plan, Plan Framework, Modules, and Associated Processes to Address Hazards, Threats, and Risks that SCE Faces	High	Difficult	Mid-term
COM-2	Enhance the One Voice Process to Account for Different Stakeholder Needs	High	Difficult	Mid-term
COM-3	In Developing the Communications Strategy, Consider the Need to Provide Stakeholders and Response Partners with Information Beyond "Confirmed Facts"	Moderate	Easy	Short-term
COM-4	Formalize the Information Sharing and Vetting Process and Implement a Database/Portal	High	Difficult	Mid-term
COM-5	Enhance Executive Distribution Lists to Ensure Executives are Apprised of the Incident Situation and Response Progress	Moderate	Easy	Short-term

COM-6	Enhance Process for Developing and Releasing ERTs	Moderate	Moderate	Mid-term
COM-7	Assess Communication and Partnership Preparedness and Response Models	High	Moderate	Immediate

Incident Response and Management Recommendations

Number	**Recommendation**	**Value**	**Ease of Implementation**	**Implementation Timeframe**
IRM-1	Enhance the Incident Complexity Analysis Process	High	Moderate	Immediate
IRM-2	Where the IMT is Required, SCE Should Not Rely on Remote Activation	High	Easy	Complete
IRM-3	Use Rosters and Streamline Shifts	High	Easy	Immediate
IRM-4	Establish Accountability for Preparedness and Response Role Activation	Moderate	Moderate	Mid-term
IRM-5	Consider Limitations of Existing Command And Control Locations; Activate the Company's Available Mobile Command Centers During Significant Incidents	Moderate	Easy	Immediate
IRM-6	Collaborate with Local Agencies to Support Communities Affected by Incidents	High	Moderate	Long-term
IRM - 7	Assign responsibility for determining level of response to	High	Moderate	Critical

	Business Resiliency organization			

Emergency Planning and Preparedness Recommendations

Number	Recommendation	Value	Ease of Implementation	Implementation Timeframe
EPP-1	Support and Enhance Business Resiliency Efforts	High	Easy	Immediate
EPP-2	ICS Maturity Model and 'Typed' Teams	High	Moderate	Mid-term
EPP-3	Implement ICS more fully	High	Difficult	Long-term
EPP-4	Expand On-call Incident Management Teams and Move Toward a More Mature ICS Model	High	Easy	Immediate
EPP-5	Create Plan Framework	High	Easy	Immediate
EPP-6	Develop an Underground Network Restoration Process or Annex	High	Difficult	Long-term
EPP-7	Train and Exercise In-Breadth	High	Moderate	Mid-term
EPP-8	Review Current Levels of Service During Response and Update Capabilities or Expectations	High	Difficult	Immediate

Underground Network Recommendations

Number	Recommendation	Value	Ease of Implementation	Implementation Timeframe
UNO-1	Network Training and Certification	High	Difficult	Long-term

UNO-2	Develop a Secondary Network Model	High	Difficult	Long-term
UNO-3	Develop a Network Contingency Plan	Moderate	Easy	Mid-term
UNO-4	Report Voltage Exceptions for the Network	High	Easy	Immediate
UNO-5	Improve Network Modeling Capabilities	Moderate	Easy	Immediate
UNO-6	Complete all Planned Maintenance in Off-Peak Season	High	Easy	Immediate
UNO-7	Continue the Underground Network	High	Easy	Immediate

ATTACHMENT B

SCE's INTERNAL RECOMMENDATIONS

LESSONS LEARNED	CORRECTIVE ACTION
The SCE crew closed out the network protector inspection with no actions taken and did not return to complete the work request.	Conduct an All Hands meeting with Distribution Apparatus Crew members to review lessons learned of the Long Beach outage events specifically addressing not closing out equipment inspections with no actions taken, documenting deficiencies in SAP, and notifying Distribution Apparatus supervision of inaccessibility to underground structures and rescheduling the equipment inspection.
There was a lack of consistent, updated mapping and no formal mapping process for network map corrections of the Long Beach secondary network.	Update Long Beach Downtown secondary network map with the results of the Network Protector detailed inspections, Long Beach secondary network underground structure inspections, and repairs made from both July 15th and July 30th events. Improve the process for all mapping updates for Long Beach secondary network to ensure they are submitted through Western Mapping Office at Lighthipe.
There was limited automation and remote monitoring capability of network protector's status within the Long Beach secondary network.	Install radio, antennas, and monitoring equipment on all Long Beach Network Protectors. Develop and implement an Outage Management System (OMS) graphic interface to monitor secondary load on secondary networks.
After removal of asbestos fire/arc proofing insulation, alternative methods for insulating primary circuit cables were not sought.	Install fire protection wrap on cable splices.
A model of the Long Beach secondary network did not exist.	Create a computerized model of the secondary network for normal operation and contingencies.
There was a lack of adequate knowledge of the vulnerabilities and operational importance of the network protectors, NP relays, and secondary network system. This lack of knowledge resulted in network protectors being placed in service that were not able to perform their intended function due to missing NP relays.	Instruct SCE crews on the installation and maintenance procedures for addressing network protectors including periodic refresher training.
There was no standard design configuration of primary circuitry for the Long Beach secondary network, which included a combination of radial system and secondary network.	Develop and implement design configuration and planning criteria for secondary network distribution system. This includes configuration of primary circuitry, and loading criteria.
There were insufficient work processes and organizational structure to support continuous operation of the Long Beach secondary network,	Develop a specific organizational structure that is dedicated to the Long Beach secondary network. Become a participating member of a utility industry network forum such as at the Electric Power Research Institute to obtain lessons learned and best practices for secondary network

	design, construction, and maintenance. Initiate changes and corrective actions as identified.
The work management process was not adequately established to ensure that NP relays were ordered, tracked, and installed prior to placing a network protector in service. This includes an inadequate process established for capturing missing NP relays.	Develop a work management process to ensure proper handling of network protectors and associated relays. Establish a process to ensure all newly installed Network Protectors without the necessary components are physically tagged as "Out of Service" and a Notification that will prioritize the installation of a NP relay and/or other components is generated.