Executive Summary

I. Project Objective

The Liberty Consulting Group *(Liberty)* investigated Commonwealth Edison Company's *(ComEd's)* transmission, distribution, and related management systems to describe and evaluate those systems as they existed during the summer of 1999, compare ComEd's systems to good utility practices, report areas where ComEd's systems fell short of those good utility practices, and specify the actions needed to move ComEd to the higher standard. This is the first of a series of reports on the results of Liberty's investigation.

As a result of the outages that occurred in July and August of 1999, ComEd undertook many initiatives to improve its performance. The changes resulting from these initiatives were occurring during this investigation. It may be that ComEd is in the process of implementing some of the recommendations made in this report. In some cases, Liberty was aware of ComEd's current plans or actions, and mentioned them in this report. However, Liberty did not allow ComEd's current activities and plans to influence the content of this report. It was the intent of Liberty and the Illinois Commerce Commission Staff that this report will serve as the basis for a future investigation of ComEd's systems, after ComEd has had reasonable time to bring them up to the standards of good utility practice.

The Commission stated and Liberty adopted the following goals for the project:

1. evaluate ComEd's planning, procedures, and practices used to mitigate any deficient system performance;
2. evaluate ComEd's planning for and execution of emergency response and system restoration efforts;
3. evaluate ComEd's internal and external communications related to outages and service restoration;
4. evaluate ComEd's inspection, maintenance, replacement, and upgrading of equipment and overall transmission and distribution system;
5. evaluate ComEd's system performance compared to other major metropolitan service territories, detailing significant differences and similarities in system operation, planning, and design; and
6. evaluate ComEd's organizational and management structure and the adequacy of performance measures used to evaluate personnel and system reliability.

II. Scope

Liberty conducted this investigation of ComEd's transmission and distribution systems according to the Illinois Commerce Commission request for proposals and the subsequent contract between

Liberty and the Commission. The Commission Staff had developed two lists of questions for Liberty to answer: Energy Division, Engineering Department Questions for ComEd Outage Investigation and Distribution Reliability Review and Energy Division, Engineering Department Questions for ComEd Outage Transmission Reliability Review. The Commission Staff asked that Liberty examine two previous investigation reports and determine if ComEd had implemented the recommendations they contained: Report on the Investigation of the Electric Transmission and Distribution Reliability of the Commonwealth Edison Company, by Resource Management International, dated March 1992 and Investigation of Service Interruptions in the Commonwealth Edison System During the July 12-16, 1995 Heat Wave, by Failure Analysis Associates, dated November 28, 1995. The Commission Staff also asked Liberty to review two October 27, 1998, ComEd management presentations to the ICC, Statement of John W. Rowe and Paul McCoy Presentation to ICC on October 27, 1998, and determine if ComEd has performed the actions detailed therein. Finally, the Commission Staff asked Liberty to review the report on the July-August 1999 outages, when completed by Vantage Consulting, and identify any leads, findings, or recommendations appropriate for inclusion in Liberty's investigation.

III. Summary of Findings

A common theme that runs through the chapters of this report is that ComEd possessed good standards, policies, procedures, and practices, and good people to carry them out, but often failed to meets its own standards or follow its own procedures because it failed to budget enough money for necessary capital improvements and maintenance. Even ComEd's failures in the areas of load forecasting and planning can be traced to a corporate desire to minimize the money spent to improve the transmission and distribution system. In many aspects, ComEd was in a reactive mode of operation, often waiting for parts of it T&D systems to fail before taking any action and only attempting to improve the worst parts of its T&D systems.

This section is organized by report chapter and consists of short pieces of text taken from the body of this report to give the reader a sense of the content of each chapter. This is not a collection of Liberty's conclusions, which can be found at the end of each chapter, although the content is similar.

Chapter Two – T&D Organization: Liberty found that although ComEd had skilled personnel and adequate policies and procedures, its goals and objectives were dominated by cost control and failed to focus sufficiently on customer service and service reliability during the 1990s.

- Three transmission and distribution personnel reorganizations aimed at manpower and cost reduction caused inefficiencies and confusion throughout the 1990s.

- Customer satisfaction was no longer a stated ComEd goal after the 1992 reorganization.

- In 1995, two-thirds of the ComEd's management compensation incentive plan stressed cost reduction.

- The 1997 incentive goals for Transmission and Distribution Operations had only one quantitative goal, which was a measure of operations and maintenance expense per customer.

Chapter Three – T&D Budgeting: Liberty found that during most of the 1990s, ComEd exercised cost control and reduction policies that resulted in less than adequate funding for transmission and distribution. It is likely that a root cause of many of the service interruptions experienced by ComEd's customers in recent years relates to this less than adequate funding.

- ComEd's transmission and distribution capital and operations and maintenance expenditures declined during the period 1992 through 1998. The share of ComEd's corporate capital budget spent on transmission and distribution also declined during this period. These declines were the result of ComEd's conscious and concerted efforts to reduce costs.

- ComEd's capital spending for transmission and distribution from 1991 through 1999 was $225 million less than ComEd's cumulative budgeted amounts for that period.

- Less than $200 million of the additional $307 million in capital expenditures that ComEd announced in late 1998 in response to worsening transmission and distribution performance was actually targeted for reliability projects.

- On a per-customer basis, ComEd's operations and maintenance expenses for transmission and distribution declined from 1991 through 1997 and were below the median of a large group of comparison utilities.

Chapter Four – Assessment and Reporting of System Reliability Information: Liberty found that ComEd did not effectively use reliability information to help provide better service to its customers.

- Of the 46,000 service interruptions that ComEd reported to the Commission for calendar year 1998, ComEd classified 8,418 of the interruptions, more than 18 percent, as having an "Unknown" origin. Once ComEd closed an outage report, it made no attempt to change the cause code, even if better information about the outage became known. Therefore, ComEd did not analyze nearly one in five of the interruptions experienced by its customers after the restoration activities.

- In 1990, an audit completed for the ICC recommended that ComEd should continue to implement customer-based outage reporting and develop milestones for achieving results

and measuring progress against these results. In 1995, another audit completed for the ICC recommended that ComEd should complete the software to compute customer-based reliability indices. ComEd's 1994, 1995, 1996, and 1997 Reliability Performance Reports to the ICC noted that the new computer system designed to track individual customer interruptions was in the process of being completed. However, as of June 1999, ComEd's system still required manual intervention to assess the number of customers affected by some outages.

- The timing of many of ComEd's initiatives to improve its assessment and use of reliability information coincided with a year of particularly poor performance and increased regulatory scrutiny and requirements. The impetus to improve did not come from within ComEd, but rather was from external factors. The problem with that type of motivation for change is that it may not be deep-seated and long-lasting.

- Even when serious problems became apparent, ComEd's initial approach seemed to have been to throw money at the problems rather than implementing a smart and effective program. ComEd did not take reasonable steps to ensure that it collected consistent and accurate reliability information. ComEd did little, if any, outage follow-up investigative work. The company was not timely in its development of the interruption reporting system that was widely recognized as necessary for effectively using reliability information. ComEd's organization was not conducive to good input from reliability engineers to planning and maintenance. Without the information and without the communications, there is little reason to believe that reliability influenced ComEd's system decisions.

Chapter Five – Distribution System Planning: Liberty found that while ComEd's organization of the planning function was reasonable, ComEd did not use reasonable, conservative assumptions in making peak electrical load estimates and did not adequately reinforce its distribution system.

- When ComEd experienced capital budget restrictions, it increased the maximum loading it allowed on transformers and feeders. When combined with serious understatement of possible peak-load conditions caused by ComEd's use of an "average" peak-day, this practice simply created an additional burden that ComEd's electric system could not bear under the pressure of severe hot weather.

- ComEd used a four-hour moving average temperature of 93°F as its base peak-day planning temperature. However, Liberty learned that since the year 1928 the median daily peak temperature during July has been 96 degrees. The highest five-day average of daily maximum temperatures during the 1928-1999 period was 99.8 degrees, nearly seven degrees hotter than the temperature ComEd used for planning purposes.

- After the July 1999 events, ComEd changed its base peak-day planning temperature from 93 degrees to 99 degrees, but 99 degrees may not be adequate. Because electric energy has become a life-essential service, designing the electric system to sustain loads that may be imposed on it, even just occasionally, is a necessity. The maximum temperature recorded at Chicago-Midway was 107 degrees in June of 1934. The second highest day on record was 106 degrees in July 1995 followed by 104 degrees in June 1988 and July 1999. In fact, a temperature of 104 degrees or more has been experienced in 5 of the 73 years recorded. Simplistically, this suggests a 1 in 15 year probability that ComEd's electric system will be subjected to a temperature of 104 degrees or more.

- ComEd's temperature adjustment method did not adequately recognize all weather-related issues. During both hot and cold temperature excursions, there is an accumulating effect created by structural masses increasing in temperature during hot weather and cooling in cold weather. This phenomenon causes peak demands and load factors to increase in each subsequent hot or cold day. Therefore, the actual observed peak load will increase for each consecutive day for a given peak daily temperature. Actual load charts from ComEd's system demonstrate this phenomenon, but ComEd's did not adjust its electric peak load forecasts to account for it.

- When planning main feeders, ComEd's planners attempted to include feeder-to-feeder ties to provide alternate feed possibilities for both emergency and normal operational switching. ComEd did not give its planners defined reliability criteria for determining capacity, frequency, or timing of the ties between feeders. Instead, ComEd left those criteria to the discretion of each planner.

- ComEd's practice was to design its distribution feeders to operate at 100 percent of capacity. In years when capital budget restrictions were more restrictive, ComEd increased the normal operating maximum to 105 percent or even 110 percent of capacity. During the July 1999 events, the load on many of ComEd's feeders was more than 110 percent of capacity. During the July 1999 events, ComEd could not switch some customer loads from damaged feeders to feeders that were not affected by the outages because those unaffected feeders were already overloaded.

- The combination of the 110 percent equipment overload standard with the 93 degree peak-day design temperature made system failures inevitable. This combination virtually ensured that the system would frequently operate above its capacity ratings and equipment would deteriorate and fail.

- ComEd operated some of its equipment above normal thermal limits. This policy led to failures sooner than would otherwise be the case. To manage these potential events effectively, it is necessary for ComEd to monitor, record, and accumulate the excesses, or loss-of-life events on major equipment such as large transformers and main feeder elements.

Liberty found that ComEd did not formally monitor and document its equipment for loss-of-life events.

- ComEd allowed the load on its transformers and feeders to increase considerably over the past ten years. To the extent that increased load increased the frequency or duration of events that caused ComEd's equipment to operate above normal ratings, the probability of failures has increased correspondingly.

Chapter Six – Distribution System Design: Liberty found that ComEd's distribution design standards and design review process were consistent with good engineering and utility practices. ComEd's distribution design provided the necessary qualities for the provision of durable and reliable service.

Chapter Seven – Distribution System Protection: Liberty found that ComEd performed reasonably well in most aspects of distribution system protection. However, ComEd's testing and maintenance of protection relays was inadequate, and ComEd did not always follow its distribution system protection standards.

- In 1995 a task force of ComEd employees made five recommendations for changes to ComEd's system protection. Liberty agreed with three of the task force's recommendations, but ComEd did not fully implement any of them.

- ComEd's distribution protection practices within substations were reasonable, but not so for ComEd's practices outside substations. ComEd's Distribution Protection Standards required fusing of lateral taps off main distribution feeders, however, ComEd did not follow its standard and did not fuse these taps. Unfused taps decreased the reliability of ComEd's distribution system.

- ComEd's distribution protection standards contained requirements to install line reclosers on distribution feeders that were too long to allow substation relays to detect faults near the end of the feeder. ComEd did not consistently apply this standard. Doing so could have improved service reliability.

- Before 1998, ComEd's distribution relay testing interval was 10 years for major maintenance. In 1998, ComEd lengthened the interval to 14 years and to 21 years if a relay operated automatically during the period. Liberty judges 14 years between significant relay tests to be too long. Most utilities test their relays on a one-year to five-year interval. When a relay fails to operate properly, damage to the distribution system may increase and interruptions of service to customers may lengthen.

- ComEd operated many of its distribution substation transformers connected in parallel. Parallel operation results in larger fault currents on substation buses and on distribution feeders when a fault occurs. In the past, ComEd has attempted to limit fault current by installing neutral inductors in its substations, but ComEd recently decided to stop installing neutral inductors. The magnitude of fault current can affect the amount of damage done to distribution equipment and cables. Parallel operation of distribution substation transformers could make cable basement fires more likely.

- Parallel operation of ComEd's distribution transformers has exposed transformers to every fault that occurs on the feeders connected to both transformers, theoretically this has doubled the number of faults each transformer has endured and has shortened the life of the transformers.

Chapter Eight – T&D Lightning Protection: Liberty found that lightning-related equipment outages affected ComEd's distribution system reliability significantly. While ComEd provided good lightning protection for parts of its transmission and distribution systems, there are improvements that ComEd should make. For example, and contrary to good utility practices, ComEd did not provide direct-stroke lightning protection on all of its substations.

- Lightning accounted for about half of the weather-related interruptions experienced by ComEd's customers in 1998, a year that ComEd said included an unprecedented ice storm in March and an extreme wind storm with hurricane force winds in November. Without those two unusual storms, the percentage of interruptions caused by lightning would have been even higher.

- The average duration of interruptions caused by lightning in 1998 was 373 minutes (6 hours, 13 minutes), while the average duration of interruptions for all causes was 274 minutes (4 hours, 34 minutes).

- ComEd constructed its 34 kV lines with overhead static wires for lightning protection until recently. When ComEd built its Marengo TSS123 to Harvard SS318 line, it replaced the overhead static wires with lightning arresters. This change may not have been good for reliability. Between May 1998 and July 1999, the line experienced 22 outages, 18 of which were caused by lightning. This is a significant number of lightning outages for a 34 kV line or any other line.

- ComEd did not use shield wires to provide direct-stroke lightning protection to some 138 kV substations and all substations at voltages below 138 kV. Direct-stroke protection of substations is almost a universal utility practice, which ComEd did not meet.

- ComEd did not provide lightning arrester protection at terminals of underground transmission cables.

- ComEd did not provide lightning arrester protection at the secondary terminals of distribution substation transformers.

Chapter Nine – Distribution System Operations and Maintenance: Liberty found that although ComEd's Distribution Dispatch Center and the dispatchers' practices were consistent with most good utility practices, there were factors that limited the ability of the dispatchers to fully monitor and control distribution systems. ComEd's distribution system lacked the capacity to serve customers' loads during extreme conditions and so system operations could not cope with simultaneous problems. Liberty also found some deficiencies in ComEd's distribution maintenance organization and performance, including a very large backlog of maintenance actions, and therefore some aspects of ComEd's maintenance practices were not consistent with good utility practices.

- ComEd's planning and upgrade practices created some challenges for the operations group. Since ComEd allowed its planned equipment and feeder loading to go up to and in excess of 100 percent of ComEd's ratings, and with several load relief projects behind schedule, the operations group was occasionally forced (for example when equipment failed) to decide whether to overload equipment, or shed load. However, ComEd did not have clearly defined load shedding guidelines for the load dispatchers.

- ComEd provided its dispatchers with summer load data and lists of potential summer problem areas too late for the dispatchers to be properly informed of system loading conditions.

- ComEd did not monitor transformer and cable temperatures to determine if equipment required revised ratings and reduced loadings.

- Liberty found that ComEd's emergency dispatching procedures did not meet good utility practice because of repair procedure delays and a lack of priority for restoring service to customers. ComEd did not have procedures that placed a priority on picking up interrupted customers from other circuits, or using portable generators or transformers. Crew callout procedures caused average interruption times to go from about two hours to about eight hours if a repair crew was needed.

- ComEd's maintenance expense per customer declined after 1992 and did not returned to the 1992 level until 1998, when ComEd experienced an unusual number of storms.

- Liberty found several shortcomings in ComEd's distribution system preventive maintenance practices in the areas of content, diagnostic testing, frequency, and performance and concluded that it did not meet good utility practices.

- In the summer of 1999, ComEd had a backlog of 79,000 maintenance items, many of which exceeded ComEd's policy for completing maintenance actions in at least twelve months. At the same time, ComEd was using its distribution personnel to perform work on equipment and facilities that did not belong to ComEd.

- In a 1992 report to the ICC, RMI recommended that ComEd develop more detailed plans and budgets to prioritize maintenance work and create a system-wide program for tracking backlogs. RMI warned that without such efforts, a "very large backlog of work" would develop. RMI also recommended that ComEd analyze maintenance programs for their expected effect on reliability and determine the costs necessary so that these programs could be prioritized. Liberty found that ComEd's efforts to meet these recommendations were ineffective or nonexistent.

- ComEd was inspecting poles on an eight-year cycle. The number of backlogged maintenance items shows that an eight-year cycle is too long.

Chapter Ten – Distribution System Conditions: Liberty found that ComEd built its distribution system using engineering, construction, and material standards consistent with practices of other utilities. However, ComEd did not have programs in place to identify and replace or refurbish equipment that had aged and had been overloaded such that its expected life had been reduced. Liberty also found that ComEd had allowed its distribution system to become heavily loaded and had not properly maintained the physical condition of distribution equipment.

- Age should not be the only factor for determining when a cable should be replaced. However, if a utility has not kept track of conditions like overloads and faults, then there comes a time when good utility practice requires a utility to replace cables (and other equipment) or provide back-up capacity so that system reliability will not suffer. Liberty assessed the age of circuits at the Northwest(1) substation and found that twelve of the circuits were over 60 years old and seven of the circuits were over 70 years old. Without any other information available, ComEd should have either replaced many of these circuits or substantially reduced the load and dependence on them long before the summer of 1999.

- ComEd had an engineering standard for determining when distribution transformers were overloaded. However, ComEd's data indicated that it had over 10,000 distribution transformers with loads in excess of 150 percent of their nameplate rating. In fact, ComEd's data showed 431 distribution transformers with loads in excess of 1,000 percent of nameplate rating. Since loads of this size would cause catastrophic failure of the

transformers, and since ComEd's data did not indicate failures in this manner or in these numbers, Liberty concluded that ComEd's transformer load data was not accurate. It is apparent to Liberty that ComEd did not have the reliable data it needed to follow its standard.

- ComEd consistently projected loads on distribution circuits to be above 90 percent of their normal rating. Loading circuits to this level did not allow ComEd to transfer load during system emergencies without overloading the circuits. For example, Liberty found 18 circuits in Chicago that were overloaded by up to 156 percent of their emergency rating in 1999.

- Following the July and August outages in 1999, ComEd inspected 626 of its 4,472 distribution circuits and found 6,460 problems. This inspection showed that ComEd's distribution system was not in a good state of repair and ComEd's prior inspections had failed to assess the physical condition of the distribution system.

Chapter Eleven – Substations: Liberty found that while most aspects of ComEd's substation designs were good, substation maintenance and the organizational structure responsible for maintaining and testing substation equipment was not consistent with good utility practices.

- While the construction skills of ComEd's substation mechanics were impressive, their maintenance skills were not. Liberty observed ComEd mechanics performing 12kV circuit breaker maintenance at the Kingsbury-Ohio substation. The mechanics did not have a copy of their work procedures, did not perform any tests to verify the electrical integrity of the breaker, used an improper lubricant, and exposed spare circuit breakers to damp outdoor air. This lack of following good utility practice indicated either the need for additional training or better technical supervision.

- ComEd did not have substation test crews specially trained and equipped to perform the more complicated acceptance and maintenance tests required by the work procedures. When available, the System Shop's electricians were called to perform special power-factor and circuit breaker motion analysis tests. The number of test sets (one of each) and qualified shop electricians (2-3 for each test set) to operate the test sets was insufficient. A nearby utility about one-half the size of ComEd had several substation test crews, power-factor insulation test sets, and circuit breaker motion analyzers.

- In July 1999, ComEd employed 509 substation mechanics. ComEd sometimes used these mechanics for non-ComEd projects. During the period of January 1998 to August 1999, ComEd pursued the sale of electrical construction and maintenance services, and provided engineering and skilled labor to perform construction, maintenance, or repair work for about 200 non-ComEd projects. Of these, about 120 projects used ComEd linemen and substation mechanics. While some of these projects were important to the reliable operation of

ComEd's system, the practice of using ComEd's mechanics and electricians for outside work, during a period when ComEd's maintenance backlog was significant, was not consistent with good utility practices.

- ComEd used contractors to perform a few specialized maintenance procedures in substations, but did not use contractors to perform any other substation maintenance. Not using quality substation maintenance contractors, when the substation maintenance was significantly backlogged, was not consistent with good utility practices.

- According to ComEd's study, if the summer peak temperatures in 2000 match those experienced in 1999, the loading on about 30 percent of the TSS and TDC transformers and 16 percent of the feeders will exceed ComEd's normal rating. A few of the transformers will exceed 120 percent of the normal rating if temperature conditions are matched. This expected and very possible loading is the result of ComEd's inadequate planning.

- ComEd rated its transmission substation and distribution substation transformers to be operated at 128 percent of nameplate rating for normal summer loads, 155 percent of nameplate rating for ten days (producing an 85°C rise for the top oil temperature) during an emergency, and 170 percent for two hours to allow for switching. Other utilities also have a practice of allowing occasional overloading that results in reduced transformer life. However, ComEd could not provide a convincing justification for the ratings it chose to use. ComEd's transformer ratings are slightly excessive when compared to the guidelines contained in IEEE standards.

- ComEd was not able to complete some scheduled substation upgrades, such as at LaSalle and Northwest Substations, in timely fashion. The delays in completing substation upgrade work jeopardized reliable electric service.

- The ComEd substation maintenance programs lacked sufficient budgeting, supervision, or manpower to complete maintenance on a timely basis. In August 1999, ComEd had a backlog of about 5,200 substation corrective maintenance tasks and 20,000 preventive maintenance tasks. Such backlogs are not consistent with good utility practices.

- Although ComEd's maintenance program manuals indicated that tests were to be performed on substation equipment, Liberty found no evidence to show that the tests were actually performed.

- ComEd decreased substation maintenance expenditures from about $45 million in 1991 to about $15 million in 1998. From January 1988 to July 1999, transmission substation and distribution substation circuit breakers failed to operate at a rate of about 75 per year. Transformer failures in transmission substations and distribution substations totaled 85 from 1992 to 1999. This large number of failures was excessive.

IV. Summary of Recommendations

At the end of each chapter of this report are recommendations relating to the subject matter of the chapter. This section is a collection of those recommendations. Each recommendation is identified with a number that shows both the chapter from which it is taken and the recommendation number within the chapter.

Two-1 Expedite the transition from the interim organization to a permanent T&D Operations organization. Some organizational improvements should be made.

Three-1 ComEd should dedicate the necessary funds to maintain and improve the reliability of its T&D systems.

Four-1 ComEd should demonstrate, and the ICC may choose to independently confirm, that the company is effectively using reliability information.

Five-1 ComEd should change the way it uses hot summer temperatures to plan for peak electrical loads.

Five-2 ComEd should implement a "First Contingency" criterion for its distribution feeder design process.

Five-3 ComEd should develop a "Remaining Life" data base and review process that includes recording of overloading events, replacement plans, and a double contingency design under certain circumstances.

Five-4 ComEd should establish an annual, formalized, objective review of the distribution load forecast processes that quantifies the assumptions and the accuracy of the forecast for each projected year.

Five-5 ComEd should formalize distribution planning guidelines for determining when load relief should begin for circuits and transformers. In addition, ComEd should develop a formalized procedure for producing its annual five-year load forecast and budget review.

Five-6 ComEd should move from its SAS-based feeder forecast program to a state-of-the-art forecast computer environment.

Six-1 ComEd should review or correct several specific items in its Engineering Standard Practices and cable rating program.

Six-2 ComEd should review and correct as necessary its Load Ratings Book.

Seven-1 ComEd should reduce the testing interval for distribution system protection relays and develop a program to catch up on the backlog of relay testing that has developed.

Seven-2 ComEd should implement a program to install fuses on all laterals and taps in accordance with the ComEd Standards.

Seven-3 ComEd should develop a formalized procedure to replace old and obsolete feeder protection relays with microprocessor-based relays.

Seven-4 ComEd should review its system and install reclosers on feeder taps in accordance with its standards on the basis of load and at the midpoint on lines that have a length of 5 miles or more.

Seven-5 ComEd should evaluate the application of neutral grounding inductors on large distribution power transformers and apply neutral inductors on each 12kV distribution power transformer rated 40 MVA and above.

Seven-6 ComEd should provide the regional TISs with a common technical manager.

Seven-7 ComEd should replace incandescent indicating lamps with LED type lamps.

Eight-1 ComEd should use to its full potential the available technology that locates lightning strokes in relation to its T&D system.

Eight-2 ComEd should discontinue the use its new 34 kV line lightning protection design until it can explain the high outage rate on the 34 kV line in the Northwestern Region.

Eight-3 ComEd should install shielding in all new substations to provide direct-stroke lightning protection. Furthermore, ComEd should review all existing substations and develop a program to provide direct-stroke protection where economically feasible.

Eight-4 ComEd should investigate its practice of not grounding the shield wires of all transmission lines to the substation ground grids.

Eight-5 ComEd should provide lightning protection for underground transmission lines.

Eight-6 ComEd should specify lightning arresters on the 12 kV and 34 kV secondary windings for all new power distribution transformers .

Nine-1 The distribution planning department should provide summer loading data and possible operating problems to the dispatchers during the previous winter.

Nine-2 ComEd's dispatchers should be monitoring, via SCADA and PI-historian software, transformer and cable temperatures, at least where over-temperature conditions may exist.

Nine-3 ComEd should plan to install remote monitoring of network protectors.

Nine-4 ComEd should have procedures that (1) allow troublemen and operators to perform repairs more often, and (2) provide quick access to repair crews.

Nine-5 ComEd should prepare procedures that encourage troublemen and crews to restore service to customers before and during equipment repair procedures.

Nine-6 ComEd should accelerate the implementation of the digital mapping (CEGIS) of their equipment and have it integrated into the interruption location software.

Nine-7 The distribution construction and maintenance organization should be separated from the substation group.

Nine-8 ComEd should reduce and prioritize the maintenance backlog.

Nine-9 ComEd should integrate the various databases used to track distribution equipment, construction, and maintenance.

Nine-10 ComEd should increase the frequency of the pole inspection program, which includes 25 specific items to inspect and other items to upgrade, to every four years.

Nine-11 ComEd should expand the maintenance testing of cables to include all priority cables.

Nine-12 ComEd should expand the distribution equipment inspection program.

Ten-1 ComEd should develop proactive programs to track the age, loading, and physical condition of its distribution system so that repairs, refurbishment, and replacements can take place before system failures occur.

Ten-2 ComEd must not allow the physical condition of its distribution system to deteriorate to a condition like that which was discovered in the Fall of 1999.

Ten-3 ComEd should improve the accuracy of the system used to track distribution system transformer loading.

Eleven-1 ComEd should improve the organization responsible for substation construction and maintenance.

Eleven-2 ComEd should promote accountability and responsibility for substation maintenance.

Eleven- 3 ComEd should review and upgrade as necessary the substation training programs for substation mechanics

Eleven- 4 ComEd should only perform work on non-ComEd equipment when that work is critical to the reliability of ComEd's system.

Eleven-5 ComEd should use outside contractors for substation maintenance to reduce the maintenance backlog.

Eleven-6 ComEd should complete upgrade work that is planned.

Eleven-7 ComEd should improve the RELAP program.

Eleven-8 ComEd should de-rate transformers to allow a planning margin that will minimize overloading of transformers.

Eleven-9 ComEd should increase the median peak summer temperature used for loading calculations on substations. (Refer to Chapter Five on Distribution System Planning.)

Eleven-10 ComEd should determine acceptable transformer loss-of-life.

Eleven-11 ComEd should have a formal, technical review made of its transformer loading criteria.

Eleven-12 ComEd should take action to relieve overloading on TSS and TDC transformers and cables on the basis of realistic temperature predictions.

Eleven-13 ComEd should monitor transformer "hot spot" temperatures when operating near summer normal ratings.

Eleven-14 ComEd should maintain thermal load records for substation transformers.

Eleven-15 ComEd should conduct tests whenever a substation transformer experiences a temperature alarm.

Eleven-16 ComEd should intensify testing and maintenance for transformers that may be heavily loaded.

Eleven-17 ComEd should reduce the substation maintenance backlog.

Eleven-18 ComEd should establish substation test crews.

Eleven-19 ComEd should consider having Substation Maintenance Programs reviewed by others.

Eleven-20 ComEd should evaluate all available cable testing procedures.