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December 21, 2020

PARTIES OF RECORD

Re: Case No. 2020-00018

The attached management and operation audit report has been filed in the record of the above-referenced case. Pursuant to the procedural schedule, Grayson Rural Electric Cooperative Corporation will filed comments on or before January 6, 2021.

If you have any questions, please contact Nancy J. Vinsel, Assistant General Counsel, at nancy.vinsel@ky.gov.

Sincerely,

Linda C. Bridwell

Linda C. Bridwell, P.E.
Executive Director

njv

Attachment

Final Report

Focused Management and Operations Audit of Grayson Rural Electric Cooperative Corporation

Presented To:	**Presented by:**
Kentucky Public Service Commission	***The Liberty Consulting Group***

December 18, 2020

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I. Introduction

A. Background to this Engagement

The Kentucky Public Service Commission (Commission) sought proposals for consulting services required to perform a focused management and operations audit of Grayson Rural Electric Cooperative Corporation (Grayson RECC). Grayson RECC's headquarters are located in Grayson, Kentucky. The Commission selected The Liberty Consulting Group (Liberty) to perform this audit.

Significant Grayson RECC financial measures for 2019 included:

- $31.4 million in total electric operating revenues
- Net income of $2.2 million
- Return on net investment rate base of 0.52 percent.

Its test-year Times Interest Earned Ratio (TIER), excluding G&T Capital Credits, was 0.11 and its equity ratio was 20 percent. The Kentucky Public Service Commission's (Commission) Final Order of July 31, 2013, in Case No. 2012-00426 addressed concerns about Grayson RECC financial decisions and recommended pursuit of cost cutting measures. In proceedings addressing a subsequent Grayson RECC rate filing (Case No. 2018-00272), concerns about the sufficiency of Grayson RECC actions to address the Commission's order in Case No. 2012-00426 led to an order for a management audit of the cooperative. That audit produced a Final report in February 2020, with Action Plans finalized on April 6, 2020.

That management audit addressed overall board of director and management functions, financial management and strategic planning, but its scope did not include detailed examination of outside plant and infrastructure operations and management.

B. Grayson RECC Operating Characteristics

Operating as a not-for-profit rural electric distribution cooperative, member-owned Grayson RECC provides electricity services to some 15,294 member accounts (down from 15,320 recently). Its members span six eastern Kentucky counties, surrounded by four other cooperatives and Kentucky Power Company, an AEP investor-owned utility. Grayson RECC's accounts include only two industrial consumers - - each served by a separate 5,000 kVA transformer bank. Grayson RECC also provides outdoor lighting for a monthly charge. East Kentucky Power Cooperative, Inc., (EKPC) a generation and transmission cooperative, supplies power to the Grayson RECC and the 15 other distribution cooperatives that own EKPC.

EKPC provides wholesale electric service to Grayson RECC at 12.47/7.2 kV from 12 distribution substations including 36 substation transformers, which EKPC owns and maintains. EKPC bills Grayson RECC for wholesale power and for providing and maintaining the substations. EKPC works with Grayson RECC to coordinate substation overcurrent protection with feeder protective devices (line fuses and reclosers), under-frequency load shedding, and outage restoration. Grayson RECC maintenance lineworkers sometime read meters in the substations, and conduct substation and transmission switching for EKPC.

Grayson RECC provides service using 43 primary distribution circuits totaling 1,837 miles of 7.2/12 kV 1, 2, and 3-phase lines (including 49 miles of underground residential distribution cable) and 643 miles of 240/120 volt secondary circuits. Access to poles and lines along Rights Of Way (ROW) from roads is difficult for much of Grayson RECC's rural and heavily forested system. The fleet of trucks used to operate and maintain the system cannot gain direct access to well over half (about 1,285 miles) of Grayson RECC's primary circuits.

Management has installed circuit protective devices to minimize consumer exposure to faults. Multiple automatic circuit reclosers sectionalize mainline circuits over five miles long, and isolate more heavily loaded 3-phase lateral taps. All other taps are fused. A total of 119 multi-phase oil and electronic reclosers located on the main lines, and 218 oil circuit reclosers at the lateral taps operate. Three 3-phase, and eight 1-phase voltage regulators maintain proper voltage on long circuits. Grayson operates some circuits between 75 miles and 100 miles in length. Circuits over 50 miles create exposure to low voltage issues, depending on the size of the wire and the peak loads on the circuit.

C. Engagement Objectives and Scope

The Commission recently issued a Request for Proposal (RFP) seeking a management and operations audit focused on outside Grayson's RECC's plant and infrastructure. A detailed investigation of Grayson RECC's ability to plan for, construct, maintain and replace its outside plant comprised the overall scope of this audit. The scope of this examination includes engineering and construction practices and standards adherence, inspection, maintenance and repair, retirement, record keeping and reporting; workplace and workforce practices; inventory management and safety. The scope does not include the matters encompassed by the preceding audit, but does include an assessment of any failures by management to prioritize or fund projects to the detriment of safety or reliability.

The Commission selected Liberty to perform this focused management and operations audit. We conducted an audit that focused on the status and condition of outside plant and on the organizations, resources, systems, material and equipment, methods, practices, and activities employed to plan, design, engineer, construct, inspect, maintain, repair, and replace all outside plant. We addressed all components of this infrastructure. We examined conformity with applicable standards, good utility practice, Commission requirements, and member and public expectations. We considered how performance has contributed to reliability, cost effectiveness, and member and public safety. We sought to identify concrete and executable ways for Grayson RECC to improve its short- and long-run effectiveness and efficiency, identifying concrete recommendations for doing for enhancing reliability, costs, and safety.

D. Engagement Work Structure

We ensured a comprehensive and sufficiently detailed examination of all activities that contribute to reliability, costs, and safety associated with outside plant condition and operation by constructing a work plan addressing the following categories:

- *Capital Project Planning*
- *Annual O&M Work Planning*
- *Workplace Practices*
- *Engineering and Design*
- *O&M Work Management*
- *Inspection and Maintenance*
- *Capital Project Management*
- *Applied Technologies*
- *Vegetation Management*

- *Restoration and Retirement*
- *Reliability Programs*
- *Safety Training*
- *Inventory & Facilities Management*

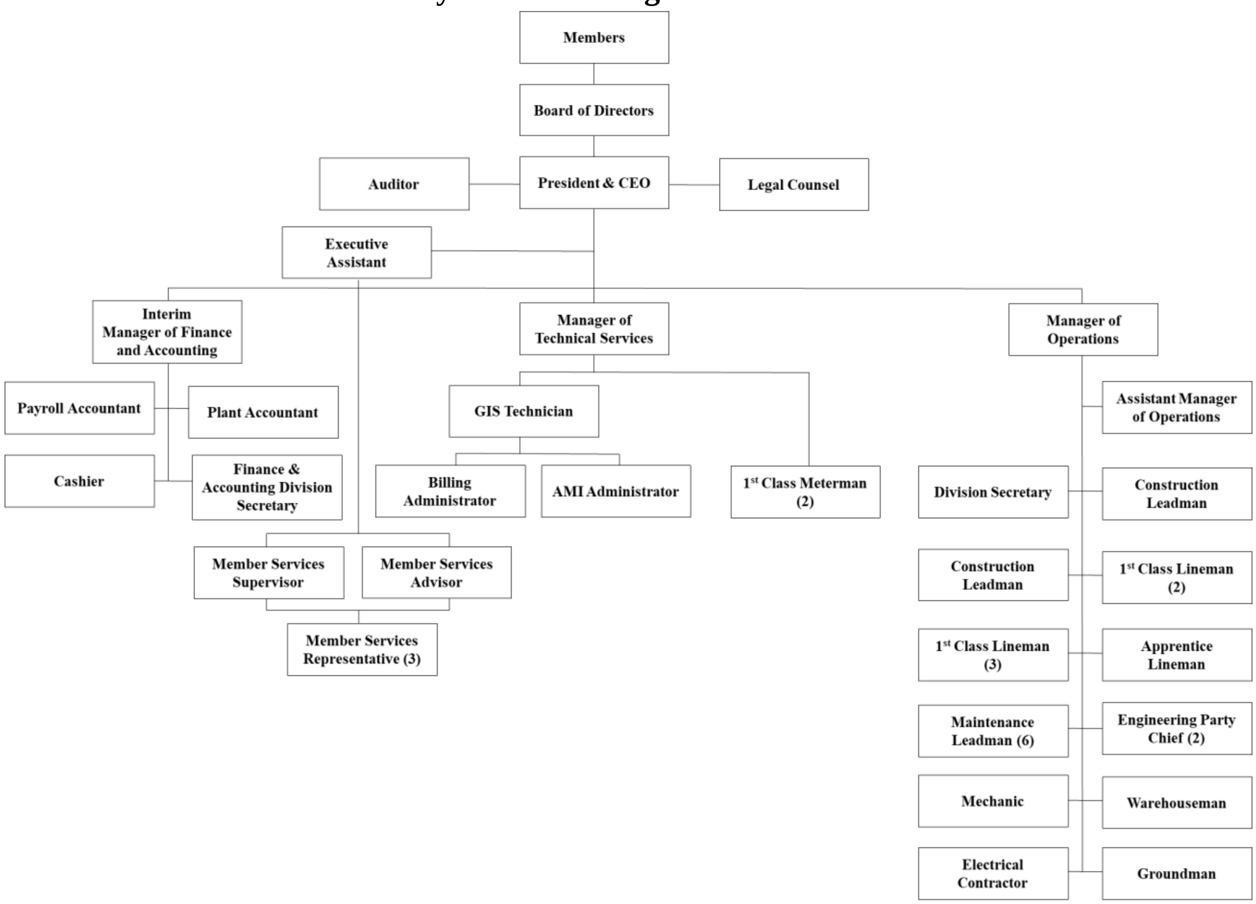
This report provides the results of our focused management and operations audit of Grayson RECC's outside plant. Management responded to 80 of our data requests, and its key personnel participated in an initial interview session (using video conferencing to respect COVID-19 limits) We then conducted a three-day inspection of outside plant facilities. This inspection included operations at the headquarters complex and about 300 miles of worst-performing circuits and their rights-of-way (ROWs). We visually examined equipment and vegetation conditions, observed pole replacement and tree removal, and witnessed management's use of its camera-mounted drone helicopter. We followed the three-day inspection activities with a day of in-person interviews with management to address inspection observations and to review information provided in data request responses and at the earlier, video-based group interview.

II. Findings

A. Organization

The President and CEO of Grayson RECC has overall responsibility for a staff organized into four departments and consisting of 40 employees - - down from 44 in 2018. None of the eliminated positions worked in the infrastructure planning, engineering, and design or field operations positions that formed the focus of our examination. We focused on two organizations: Technical Services and its 6 positions, and Operations and its 22 positions, including 14 lineworkers.

Grayson RECC Organization Chart



The Operations Department has responsibility for:

- Job engineering
- Preparation of work and service orders
- Line construction, inspection, and maintenance
- Dispatch and outage response
- Warehouse and vehicles
- Safety and safety equipment maintenance.

The Technical Services Department has responsibility for meter installation and maintenance and a number of systems and equipment types directly related to infrastructure design, operation, and maintenance. It also has responsibility for other systems, such as IT generally, billing and communications, on which we did not focus.

Other organizations, which fell outside the scope of our examination and which employed the remainder of the 40-member Grayson RECC staffing, perform finance, accounting, and member services functions.

The Manager of Operations:

- Plans and schedules weekly and daily work activities of the two line construction crews and any on-going contractor work
- Monitors the work of the six maintenance lineworkers, one located in each of the six service areas
- Oversees an Assistant Manager of Operations, who plans and supervises the ROW vegetation spraying and tree trimming work, and fills in for the Operations Manager when needed
- Supervises two engineering party chiefs, also called "staking engineers."

Grayson RECC does not employ a full-time professional engineer, but does use the services of an outside, part-time professional engineer, who also works for other cooperatives. His primary function is to inspect, with the engineering party chiefs, completed line projects for compliance, as required by the Rural Utility Service (RUS). The part-time engineer also:

- Conducts load and arc flash studies
- Provides technical support to the engineering party chiefs
- Assists with long-term year capital projects planning
- Provides sealed drawings and specifications where required (*e.g.*, for projects involving state and federal highways).

The part-time engineer will retire at the end of the 2020. Grayson RECC will need a replacement experienced with RUS requirements. Management reported that it is seeking short term a contracted professional engineer, and is analyzing the benefits of hiring a professional engineer on a full- or part-time basis, or sharing one with another cooperative as a permanent solution.

Grayson RECC uses Leidos, a large, well-known, engineering firm (Leidos) for its large capital projects. Leidos has worked with many other investor- and member-owned electricity providers, including a number in Kentucky.

B. Capital Project Budgeting and Management

We found the capital project planning procedures and activities appropriate in meeting the needs of a small electricity distribution entity. The Grayson RECC circuits have experienced low loads across the system, mitigating the need to address growth-induced limits. The highest 2019 peak circuit loading amounted to only about half of the involved line's capability. There has been no material level of overall load growth. One source of potential growth, a planned aluminum rolling mill operation does not appear likely to occur. The next table summarizes non-coincident peak loads since the winter of 2014/2015.

Non-Coincident Winter Peak Loads

Winter	MW
2014/2015	86.039
2015/2016	65.541
2016/2017	60.599
2017/2018	74.502
2018/2019	72.638

Management annually conducts a capital project planning process whose evaluations span up to six future years. Internal staff, the part-time engineer, and an RUS representative contribute to the identification of possible circuit loading and voltage violations. This group also reviews reliability issues based on outage reports, reliability indices, and inspection reports. The staff and the part-time engineer determine project scopes and estimated costs, and then prioritize them based on need levels.

After identification, capital projects undergo a prioritization process that considers the operating issues they address. Management prepares initial project cost estimates based on historical costs and the expertise of its outside engineering firm Leidos in the case of larger projects. That outside firm, which other Kentucky member-owned providers use, brings to bear its knowledge of pertinent costs trends and developments, addressing changes in contract labor and material (poles, for example) costs. The outside firm's services include estimate development and refinement, project engineering, and preparations of construction solicitations. Grayson's Manager of Operations oversees contractor performance of project work.

The engineering party chiefs perform much of the pre-construction staking work required, with the outside engineering firm doing so indicated by project size or limits on in-house availability. Project material purchasing occurs internally. Grayson RECC also contracts with an outside line contractor for some capital project construction, generally using a unit pricing approach. The Manager of Operations conducts weekly reviews of ongoing projects, determining which are completion priorities when required. Weather conditions are the usual cause of completion delays.

An inquiry about project cost variances identified only one (the Stark Conversion) experiencing a substantial overrun - - reported by management as approaching $500,000 over budgeted costs. Work began in October of 2015 under a budget of $576,870, with completion in December of 2017 at a cost of $1,076,390. Initial plans contemplated replacement of an old, cross county line along the line's already-existing ROW. Access difficulties for construction and eventually for maintenance caused a change to a roadside location going around, rather than through a heavily wooded valley involved, producing a significantly longer length, resulting in the higher costs.

The next table shows capital budgets and expenditures since 2015. Advanced Metering Infrastructure (AMI) installation expenditures of $3.96 million accounted for the large anomaly in spending in 2019. Annual expenditures after accounting for this anomaly have remained fairly stable since 2016, with actual spending running consistently below budgets. Line extensions costs have been moderate and dropping, costing roughly $700 thousand through 2018 on average, but now at less than $500 thousand.

Capital Spending - - 2015-2020

Year	Budget	Actual	AMI Meter System	Line Extension
2015	$5,64 8,780	$4,941,738		$748,710
2016	$4,853,234	$3,925,846		$634,763
2017	$4,512,042	$3,352,967		$759,878
2018	$4,894.215	$3,694,784		$666,053
2019	$5,913,773	$6,658,513	$3,960,399	$461,385
2020YTD	$4,826,085	$1,877,547	$201,989	$436,577

Our review of the capital plans through 2024 disclosed the following major elements:

- New Construction, which includes line replacements, about 92 miles of new overhead, and about 5 miles of underground construction
- Line conversions of about 16 line miles on 8 circuits - - increasing conductor size or converting single phase to 2 or 3 phase
- New underground and overhead transformers, new and replacement meters, underground and overhead service drops, and sectionalizing equipment, new line voltage regulators, conductor replacement, and pole replacements
- Other distribution items, including security lighting and AMI.

Capital Budgets Through 2024

Description	2000/2021	2021/2022	2022/2023	2023/2024
New Construction - UG and OH Lines	$638,582	$664,161	$690,633	$718,271
Line Conversions	$230,000	$631,600	$535,392	$725,537
Poles, transformers, meters, service drops, sectionalizing equipment, regulators, conductor	$2,826,257	$2,498,228	$2,593,711	$2,682,334
Other Items – security lights and AMI	369,248	383,570	398,326	413,950
Totals	4,064,087	4,177,759	4,218,062	4,540,092

We also found that management has applied appropriate methods and practices for managing its capital projects, which, tend to be very much smaller than those required of larger electric operations. Facilities above the distribution level fall under the responsibility of EKPC. As noted earlier, Grayson RECC uses its outside engineering firm to provide engineering and estimating services. The firm also prepares solicitations seeking bids for construction work to be performed by outside resources. Grayson RECC's Operations Manager then oversees construction work.

C. Equipment Status and Condition

We examined system status and conditions, which comprised a specific element of RFP focus, through a three-day inspection process, supported by information gleaned from data request responses and interviews with management. Locations visited included main office, operations office, garage, and warehouse facilities, a crew work site, a vegetation work site, and about 300 miles of worst performing circuits. We focused particularly on pole and line condition, visible defects, and vegetation clearances.

Grayson RECC conducts administrative, billing, consumer service, technical services, operations, garage, and warehouse activities in a multi-building complex located at 109 Bagby Park Street, in Grayson, Kentucky. We inspected all facilities and observed ongoing activities at the complex. Activities proceeded in an orderly way in well-organized and maintained facilities, using equipment showing no visible indication of poor maintenance or malfunction. Operations vehicles observed appeared in good working condition. By morning start time, a warehouse operator had arrayed materials required for crew use from a well-organized warehouse for field crews. Those crews departed without delay.

Over the three days, we visually inspected the Low Gap 2, Elliottville 3, Leon 2, and Mazie 1, 2, and 3 circuits and parts of other circuits. We selected these circuits randomly from management's worst-performing circuits list; *i.e.*, those whose SAIFI or SAIDI reliability measures fall below average performance for the previous five years We observed no deficiencies and saw no line equipment showing signs of extreme age or inadequate maintenance. We observed only one location where tree limbs touched a line. However, a number of cross-county ROWs will require vegetation control very soon. Our inspection disclosed sound, well-maintained circuit equipment, exhibiting conditions one would expect following installation, operation, and maintenance in manners consistent with good utility practice.

Major components of distribution equipment are long-lived, making it common to find a substantial amount of aging equipment in use on the circuits that cooperatives use to deliver service. We did not find excessive aging or other deficiencies in the line equipment we examined. Tree clearances were generally acceptable, with a few locations, however, near the point of requiring trimming soon. We discuss later the sufficiency of annual vegetation management expenditures to support the treatment cycle that Grayson RECC has established.

We saw no concerns about pole condition. Management reported that it has replaced many of poles that had reached 30 years of age. We found that about 5,000 of its 35,000 poles are older than 30 years, not counting those with indeterminate age.

D. Conformity with Standards

Grayson RECC designs its distribution system to RUS specifications, which in some ways prove more stringent than those required by the National Electrical Safety Code (NESC). For example, management double grounds all equipment poles, and uses double cross arms on mainlines. Grayson RECC operates some quite lengthy (close to 100 miles) main and lateral tap lines.

We found fusing or protection with automated reclosers on all lateral taps we viewed. Installation of voltage regulators and capacitors on long lines maintain required voltages for consumers at the end of those lines. Grayson RECC has installed downstream automatic reclosers on nearly all circuits to limit outage exposure for many consumers. Moreover, most circuits can be tied to other circuits by opening sectionalizer switches and

Five Longest Circuits

Substation	Circuit	Miles
Elloittville	Circuit 3	98.60
Mazie	Circuit 2	93.34
Warnok	Circuit 4	80.65
Airport Rd	Circuit 1	78.46
Newfoundland	Circuit 1	75.19

closing the switch that ties two circuits together; that tying permits transfer of some consumer loads to another circuit during extended line outages. Some remote, isolated circuits are not close enough to others to make circuit ties feasible. Grayson RECC's light circuit loadings, which distinguishes it from many operations we have examined, enhance the capability to perform load transfers. The accompanying table lists the five longest circuits, including laterals.

Grayson RECC's circuits have 40 feet wide ROWs, providing 20 feet on either side of the centerline. Our field inspections showed that long sections of many circuits are "cross-county," within heavily wooded and mountainous areas located at substantial distances from roads, with access difficult - - sometimes impossible for derrick-digger trucks and bucket trucks. Management estimates that 1,285 miles of primary line (about 70 percent of its total line miles) traverses off-road ROWs inaccessible to trucks. This terrain makes line repairs, pole replacements, line rebuilds, and vegetation spraying and tree trimming and removal much more time consuming. Line workers must use climbers (climbing hooks), rather than bucket trucks, for access to pole tops. These conditions contribute to higher customer interruption durations, classically measured in the industry by the index termed "CAIDI" (Customer Average Interruption Duration Index).

$$\text{CAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customer interruptions}}$$

E. Comparative Costs

Grayson RECC member costs are high in comparison with 18 other Kentucky member-owned cooperatives. Grayson RECC has the highest distribution operations and maintenance cost per consumer. Customer numbers and density have a direct bearing on this metric here, as we have found generally in the industry. Grayson RECC has the 2nd lowest number of members in total and the lowest member density, measured in members per mile of line. It also has the 2nd highest number of employees per member. Moving from customer numbers to miles of line makes a significant difference. Measuring on a per mile of line basis takes Grayson RECC costs to nearly the average.

F. Reliability

We compared reliability metrics among member-owned Kentucky electricity providers, using information reported to the Commission. The latest information available for comparison among these operations comes from 2018. The age of the data and the need to consider unique circumstances of each of the data providers warrants caution in drawing firm conclusions about the quality of the performance of any of them. Nevertheless, the data does provide an indication of how performance differs. Utilities themselves generally make similar comparisons - - indicating that, if not determinative, such data proves at least interesting.

The data showed that Grayson RECC had the second highest frequency and the third longest duration of outages. SAIFI (System Average Interruption Frequency Index) provided the basis for comparing frequency. It depicts how often the average customer experiences a sustained interruption over a given time period. CAIDI (Customer Average Interruption Duration Index) provided the basis for one comparison of duration. The industry uses it as one proxy for average restoration time. SAIDI (System Average Interruption Duration Index) provided the other basis for duration comparison. It depicts the average outage duration for each customer served. The next table shows the comparisons using these three measures, which exclude the impacts of major events, such as large storms.

Kentucky Cooperative Reliability Indices: 2018

Entity	SAIDI	SAIFI	CAIDI	Entity	SAIDI	SAIFI	CAIDI
Big Sandy	448.790	3.770	119.042	Jackson Purchase	122.816	1.379	89.062
Blue Grass Energy	157.133	1.118	140.548	Kenergy	107.300	1.590	67.484
Clark Energy (KY)	133.142	1.157	115.075	Meade County	118.250	1.290	91.667
Cumberland Valley	296.598	2.644	112.178	Nolin	65.131	1.056	61.677
Farmers (KY)	82.380	0.894	92.148	Owen	108.000	1.060	101.887
Fleming-Mason	125.400	0.873	143.643	Salt River	93.500	0.976	95.799
Grayson	**378.400**	**3.030**	**124.884**	Shelby	118.560	1.250	94.848
Inter County	123.340	1.140	108.193	South Kentucky	287.834	2.187	131.611
Jackson	270.100	2.222	121.557	Taylor County	86.900	1.300	66.846

Off-ROW trees that fall into lines contribute materially to Grayson RECC's outage measures. Its high numbers of off-road circuits (traversing wooded, mountainous territory) often prevent use of derrick-digger and bucket trucks, thus extending outage durations.

We also found very high variability in the reliability measures of the individual Grayson RECC circuits., SAIFI varied among the overhead circuits in 2019, producing a range of between about 0.3 and 7.0 in outages per end user. This variability can be partially contributed to the differences in miles of exposure among the circuits. CAIDI varied between 62 and 223 minutes per outage, and SAIDI from 16 to 770 outage minutes per consumer. The next table shows the Grayson RECC system averages for 2015 through 2019. System reliability has remained reasonably steady same since 2015.

Grayson RECC Reliability - - 2015-2019

Year	**SAIFI** (#)	**CAIDI** (minutes)	**SAIDI** (minutes)
2015	3.1	135	424
2016	3.2	136	440
2017	3.7	148	545
2018	3.0	125	378
2019	2.6	147	381

Management identifies its worst performing circuits each year. The engineering party chiefs analyze them to identify remediation work consisting of: (a) O&M activities, such as installing animal guards or trimming trees, or (b) capital work, such as replacing line sections. We did not find, however, a true programmatic approach to ensuring completion of the work, assessing its results, or applying lessons learned in the future. Attention to these circuits takes the same forms and cycles that apply to regular corrective maintenance work, and management does not prepare reports detailing what it did to investigate and to correct issues causing the poor performance of the previous year's worst performing feeders.

Management did, however, provide in its 2019 Electric Distribution Utility Annual Reliability Report to the Commission a list of the circuits performing worse than the five-year SAIFI and CAIDI averages. Up to 50 percent of outages on these circuits (27 percent of systemwide outages) resulted from "tree failure-off ROW." Management reported that a majority of the fallen trees as living. A particularly wet 2019 appears to have exposed even healthy trees to higher numbers of falls. Management, however, has stated an intention to address off-ROW hazard trees in its inspections. Off-ROW hazard tree removal poses stakeholder (property owner, local government, other interest groups) management issues for all utilities, making such removal difficult to accomplish.

Small animal contact formed another contributor to 2019 outages. Equipment failure and tree contact contributed to relatively few cases. Management has begun to install squirrel guards where outages have been caused by them. Tree growth between clearing cycles (limb contact) did not prove a large outage cause, providing one indicator of the effectiveness of the use of wide ROWs and tree trimming and brush removal activities. The tables below indicate the top 95 percent of outage causes in 2018 and in 2019.

Top 95 Percent of 2018 and 2019 Outage Causes

Cause	2018		2019	
	Events	Percent of Total	Events	Percent of Total
Tree failure off ROW	285	19.6	394	27.0
Small animals and birds	282	19.4	292	20.0
Maintenance	204	14.1	194	13.3
Cause unknown	128	8.8	116	8.0
Lightning	70	4.8	72	4.9
Decay/age of material/equipment	73	5.0	69	4.7
Tree failure from overhang or dead tree			57	3.9
Other	59	4.1	55	3.8
Material or equipment fault/failure	69	4.7	49	3.4
Wind, not trees	16	1.1	36	2.5
Construction	20	1.4	26	1.8
Tree growth	21	1.4	25	1.7
Weather, other	55	3.8		
Customer caused	17	1.2		
Public, other	15	1.0		

Grayson RECC reported that it has been working with its maintenance lineworkers to reduce the numbers of outage causes listed as "unknown." Our review of 2019's worst-performing circuits, generally found unknown causes at low levels, except for one circuit, 21 percent of whose outages had unknown causes.

Outages incurred when circuits are taken out of service to permit maintenance work (classified as "Maintenance" outages) caused over 13 percent of 2019 outages. Distribution system operators cannot eliminate such outages, but can minimize them by working on a circuit while it remains energized. Grayson RECC's contractor performs such "hot line" work; for example, in transferring energized conductors. Some Grayson RECC lineworkers have received training to work safely on energized lines, but management does not use them to do so. However, recognizing that hot-line work can save work time, and reduce outages and contractor costs. Management has stated an intention to perform more hot-line work.

Other electricity distributors commonly pay special focus on and often create programs dedicated to worst-performing circuits. We did not find at Grayson RECC a range of programs specifically dedicated to (versus generally supportive of) reliability-improvement. Management identifies the circuits whose reliability performance proves worse than average for the preceding five years. Management investigates the causes of the poor reliability and replaces under-performing devices and conductor, or installs animal protectors to improve reliability of a circuit. Grayson RECC as noted, does, however incorporate significant reliability-enhancing features into its circuits. These features include fusing of all lateral taps or protection with automatic circuit reclosers. Most mainlines also have downstream automatic reclosers to accommodate automatic fault isolation.

Establishing and maintaining an effective cycle for vegetation management activities also comprises a central element in ensuring reliability. Management's expenditures on vegetation management have not been sufficient to permit it to do the work needed to keep pace with the eight-year cycle it has adopted, as we describe later.

G. Planning and Managing O&M Activities

Management uses appropriate means for planning operations and maintenance work, both short- and long-term. The means it employs conform to the scale and scope of its programs, which are comparatively smaller and less complicated, given the types and numbers of the equipment and systems Grayson RECC operates. Management uses four-year budgets to address the longer term, recasting these budgets annually during sessions that address both capital and O&M needs.

The two engineering party chiefs, both former lineworkers, design smaller jobs (those not designed by the outside engineering firm), and the six maintenance lineworkers prepare service orders, when they observe line defects, a warehouse operator ensures materials readiness, and the manager of operations has responsibility for scheduling and marshalling crew resources at the job sites. Extensive experience with the terrain and distribution system permits the Operations Manager to prepare and manage to reasonably firm estimates of job durations for these projects. Management does not use specific performance metrics to gauge work efficiency, but the small organization and the limits on the type of work involved allow for prompt identification and resolution of job completion issues. Close coordination among the engineering party chiefs, operations manager, and crews support these efforts. An engineering party chief, confirmed subsequently by the part-time engineer, verifies work quality and compliance with specifications and guidance applicable to each job.

H. Field Operations

1. O&M Costs

The next table shows O&M costs since 2014. Annual costs have remained flat, as compared with an annual growth rate of about 4.5 percent in budgeted costs over this period.

Grayson RECC's Distribution O&M Costs

Year	Budget	Spend
2014	$4,357,400	$5,194,566
2015	$4,699,220	$4,294,808
2016	$4,916,280	$4,763,172
2017	$5,172,780	$4,724,770
2018	$5,261,854	$5,033,533
2019	$5,083,165	$4,272,053
2020 to date	$3,708,449	$3,453,553
2020 projected	$5,562,683	$5,141,120

2. Resources

By any measure, Grayson RECC comprises a small utility operation. It does not have the size or scale to support the more complex, function-differentiated organizations that larger utilities can economically deploy. The Operations organization operates under good practices for similarly sized electricity distribution operations. The Operations department, supported by Technical Services, has responsibility for maintaining outside plant. Distribution circuits make up that plant, which consists of poles and hardware, transformers, automatic circuit reclosers, capacitors, and voltage regulators.

Grayson RECC employs a lean management structure consistent with the size and nature of its operations. Key positions pertinent to our examination include the President and CEO, the Manager of Operations, the Manager of Technical Services, and a GIS (Geographic Information System) Technician. As we find typical of similar operations, they have extensive levels of experience in public power, more than ample experience in distribution operations, and typical academic backgrounds. The management team also includes an experienced Manager of Finance & Accounting (interim).

Grayson RECC's field operations resources consist of maintenance lineworkers (first responders) and construction lineworkers (who perform both construction and maintenance work). Our field inspections, interviews, and document reviews found their work practices effective and safe. The two construction line crews work primarily on replacing poles. Moreover, we did not find management's method for determining when poles need replacement sound. We discuss later a change that may reduce the number of poles replaced annually. That change has implications for staffing needs.

Grayson RECC's two construction crews each use a derrick-digger line construction truck and a large bucket truck. The derrick-digger trucks can also carry several poles, obviating the need for a pole trailer. The crews also have access to in-house and contractor-provided off-road vehicles. Each of the six maintenance lineworkers have a small bucket truck. Grayson RECC replaces the derrick-digger trucks every 8-9 years and the bucket truck chasses every 6 years. Management reuses bucket mechanisms twice before replacing them.

The six maintenance lineworkers:

- Respond to outages and technical customer concerns
- Conduct minor line and service wire repairs that require only one lineworker
- Assist meter personnel
- Trim small limbs encroaching on wires or transformers
- Conduct walking inspections of each circuit in their areas every two years for condition and tree issues
- Inspect pad mount transformers every 6 months.

Management assigns each maintenance lineworker to designated areas. They prepare service orders when they conduct repairs. Upon identifying a circuit deficiency whose remediation requires a larger, line crew, they report the deficiency and send photographs to the engineering party chiefs. The chiefs then design the repairs, and prepare service orders that include lists of the required materials.

The two Grayson RECC line crews each employ four lineworkers, and one adds a groundman. Their responsibilities include replacing poles, installing new service connections, repairing or replacing switches, reclosers, and conductors, and retiring obsolete equipment.

3. Field Labor Costs

We found the costs of Grayson's lineworkers high. On average, a maintenance lineworker cost about $160,000 in 2019, with construction crew lineworkers costing about $146,000. The average loaded cost, which includes all benefits runs to about nearly $63 per hour for regular time. Costs for contractor-provided lineworkers run about 10 percent higher. The next table shows 2018 and 2019 personnel costs in these categories.

2018 and 2019 Line worker Costs

Area	2018				2019			
Maintenance	**Regular**	**OT**	**Benefits**	**Total**	**Regular**	**OT**	**Benefits**	**Total**
Total	$483,408	$139,853	$305,8370	$929,098	$487,571	$131,602	$338,184	$957,357
Average	$80,568	$23,309	$50,9732	$154,850	$81,262	$21,934	$56,364	$159,560
Construction	**Regular**	**OT**	**Benefits**	**Total**	**Regular**	**OT**	**Benefits**	**Total**
Total	$611,725	$165,038	$351,897	$1,128,660	$617,469	$145,196	$404,953	$1,167,61
Average	$76,465	$20,630	$43,987	$141,083	$77,184	$18,150	$50,619	$145,952

Maintenance lineworkers serve as Grayson RECC's first responders; construction lineworkers have responsibility for conducting system construction and maintenance work. The following table shows overtime hours since 2018. Overtime levels have fallen the past two years. In 2019, assuming 30,750 regular time hours per year for the 15 line workers (including the groundman), overtime averaged about 13 percent of regular time hours.

2018 Through 2020 Line Maintenance Overtime Hours

Year	OT Hours	
	Through Sept.	***Year End***
2018	4,877	6,314
2019	3,973	5,448
2020	3,270	--

Grayson RECC has not been charged with overtime hours for construction work since 2017.

I. Field Practices

1. Management Oversight

At the beginning of each week, the Manager of Operations prepares and plans work to be completed and provides the service orders to the service, crew, and contractor resource who will perform them. The manager addresses emergent work requiring resource shifts by redirecting resources as needed. The manager's many years of experience in the service territory gives him the knowledge necessary for estimating job durations. The manager conducts random job site visits each week, and reviews work status and progress with the Grayson CEO at least monthly.

2. Inspection and Maintenance

We found management's inspection of distribution circuits and performance of corrective maintenance generally appropriate, given the nature of its distribution-focused system, size, and location. For a comparatively small operation, it applies criteria, resources, and methods reasonably supportive of sound management of its infrastructure assets. However, management does not employ a ground-line, wood-pole testing program in determining which wood poles to retire and replace. For a system like Grayson RECC's, pole inspection, maintenance, and replacement command considerable shares of both O&M and capital expenditures.

The construction line crews replace bad line equipment, such as bad cutout switches, but by far most corrective maintenance work involves replacing poles. Other than its vegetation management program, management has no line equipment requiring preventive maintenance. Management addresses voltage regulator and automatic recloser malfunctions as corrective maintenance by exchanging them with a new or repaired unit. Grayson RECC uses two transformer companies to rebuild damaged or defective voltage regulators and oil circuit reclosers.

The six maintenance lineworkers inspect the circuits portions in their areas, including lateral tap lines, on two-year cycles. They also inspect Grayson RECC's 96 pad-mounted transformers every six months. The maintenance lineworkers record findings on line inspection forms. The division secretary enters the data on an Excel spreadsheet and verifies when circuit inspections have been completed. To provide a visual aid for tracking circuit inspection completions, the maintenance lineworkers mark up a circuit one-line map located in the office. Grayson RECC's inspections of circuits and pad-mount transformers have occurred in numbers consistent with established cycles, as the next table shows.

Circuit and Pad Mount Transformer Inspections

Equipment	Circuits	Transformers
Number	43	96
Cycle	2 Years	6 Months
Inspections Required	***22***	***196***
Inspections Performed		
2016	18	174
2017	23	175
2018	18	200
2019	23	210
2020YTD	12	221

When a maintenance lineworker finds pole, line, or hardware defects, or other areas of concern, such as tree contact, he or she determines whether the corrective action is high priority (emergency) or a low priority issue and creates a service order to correct the issue. The Operations Manager and division secretary monitor the progress of the inspections, as well as completion of the corrective maintenance service orders. The Operations Manager reviews all service orders for completions every three months. Nearly all corrective maintenance orders are completed during the current year.

3. Restoration and Retirement

Management has for some time operated and proposed to continue a large pole replacement program. We observed no poles exhibiting poor condition during our visual inspections. However, system records show a substantial number of unknown or plus-40-year age, as the next table demonstrates.

Distribution of Pole Ages

Total	0-9 years	10-19	20-29	30-39	40 plus	Unknown
35,347	5,846	6,975	7,302	3,374	1,902	9,948

The next table shows that management has replaced poles at a 1 to 1.5 percent rate per year, covering 3,996 poles (11 percent of total pole numbers) since 2010. These replacements have cost $13.6 million - - on average about $3,400 per pole.

Annual Pole Replacements

Year	Number	Capital Cost
2010	414	$1,156,633
2011	484	$1,341,517
2012	483	$1,551,332
2013	361	$1,093,612
2014	431	$1,484,318
2015	347	$1,255,755

2016	369	$1,225,100
2017	295	$1,121,156
2018	354	$1,464,174
2019	270	$1,207,057
2020YTD	188	$740,722
Totals	**3996**	**13,641,378**

The pole replacement budget through 2024 targets 1,300 poles at a cost of $5.9 million total and $4,500 per pole.

Pole Replacement Budgets

Year	Pole Budget
2000/2021	$1,394,900
2021/2022	$1,450,475
2022/2023	$1,508,850
2023/2024	$1,569,100

Before 2018, the last known pole testing (as opposed to just inspecting and sounding) occurred in the early 1990s. Grayson RECC used a professional pole inspector to test 100 poles on 10 circuits on 2018. Given the costs of contractor use, management uses its maintenance lineworkers to conduct visual inspections and sound tests (thumping with a hammer) while conducting cyclical inspections that include all poles every two years.

Circumstances like internal voids, caused by fungus and insects, if sufficiently large, cause wood poles to lose strength, risking failure. These sources of failure are, unlike other typical problems (*e.g.*, split pole tops and cross arms) are not visible to inspectors, or can be missed by sounding. Pole replacement comprises an important issue in optimizing reliability and costs for operators like Grayson RECC. We do not believe that management approaches pole replacement in a sufficiently analytical way, creating a likelihood that some poles undergo replacement before the ends of their useful lives. The maintenance lineworkers identify deteriorated poles by thumping (sounding) with a hammer or by visual inspection, particularly of pole tops. Lineworkers in the industry commonly use pole thumping and inspecting for splits and pole top damage to ensure that a pole is safe to climb. These methods, however, do not by themselves provide a sound basis for measuring pole strength for purposes of identifying need for replacement.

The much more common practice in the industry relies upon performing "ground-line testing and treating" performed by specialized pole testing contractors. That testing procedure involves boring the pole below and above ground line, followed by insertion of a device that measures remaining internal shell thickness. The testing part of the procedure uses a process that provides more definitive evidence of the need for pole replacement or bracing due to failure to meet National Electrical Safety Code (NESC) strength guidelines (using shell thickness as a criterion). Even poles found to be at less than acceptable strength can sometimes be rendered serviceable for some time by bracing, in lieu of replacement. This measurement then drives a determination of pole strength. The treatment aspect of this procedure involves wrapping the pole below ground and filling the bore holes and any voids in a pole with fungicide and insecticide. This treatment extends pole life.

Common practice underground-line testing procedure involves testing of wood poles 20 years or more old, with repetition every 10 years. Were Grayson RECC to institute such a program, its GIS data will allow a reasonably comprehensive program start; *e.g.*, by testing in the first year ten percent of its 20+ year old poles, starting with the oldest.

4. Vegetation Management

The Assistant Manager of Operations has responsibility for managing vegetation work. Management does not use the services of a certified arborist to assist with its vegetation management program, or to help it identify off-ROW hazard trees. Such trees contributed about 27 percent (50 percent on one circuit) to Grayson RECC's CAIDI recently. An arborist would provide added expertise in tailoring treatment cycles and targeting areas for hot-spot treatment to complement regularly cycled vegetation work. An arborist working on a part-time basis would cost about $280 per day of work. A local contractor performs Spring and Fall brush spraying and tree trimming. Other contractors perform hot-spot trimming and tree removal.

Management historically did not employ a regular cycle for vegetation management. It began in 2000 to employ an eight-year cycle, augmented by hot spot trimming to address fast-growth locations and tree encroachment. Management has been spending about $1.7 million each year on vegetation management. Its budget for 2020 conforms to that general level of spending, but actual expenditures this year have run substantially below budget. Moreover, management reports that maintaining an eight-year cycle requires annual expenditures of about $2.4 million, making annual expenditures of $1.7 about 70 percent of required levels. A five-year cycle would require annual expenditures of about $3.9 million - - more than twice the normal Grayson RECC level. The next table shows annual vegetation management costs. Management reports that it cannot break these total costs down into tree trimming, tree removal, and spraying categories.

Vegetation Management Costs and Resources

Year	Budget	Spending	Crews (#)
2014	$1,746,488	$1,838,633	11
2015	$1,574,666	$1,569,576	11
2016	$1,638,093	$1,684,139	11
2017	$1,712,133	$1,653,689	11
2018	$1,713,539	$1,639,764	11
2019	$1,720,230	$1,791,097	11
2020*	$1,810,693	$1,099,876	10

**Through mid-October*

About half of Grayson RECC's line mileage traverses densely wooded terrain, Management cleared about 64 line miles under its circuit cut program in 2019, bush-hogged about 65 miles, removed 14,043 trees, and trimmed 9,334 yard trees. Vegetation work consists largely of cutting and spraying shrubs within the ROW and removing trees within and outside the ROWs. On-ROW brush undergoes cutting under the eight-year cycle, with herbicide applied after one year and again after four. Management uses dormant herbicide in the winter months and foliar herbicide in the summer months. Use of 40-foot ROW widths means that most tree work involves cutting encroaching limbs in yard trees. Observations by maintenance lineworkers during their periodic and daily circuit inspections and from outage reports identify tree limb encroachment close or in contact with lines. Upon identification of a trimming need, management dispatches a tree crew to conduct required trimming.

The next photos highlight the accessibility issues that management must account for in performing vegetation and other line inspection and maintenance work.

The two-year pole inspection cycle includes assessment of vegetation condition and management needs. Additionally, the six maintenance lineworkers, as “owners” of the circuits in their operating areas, are regularly making visual observations and reporting to the Assistant Manager (responsible for vegetation management) any issues encountered. Overall, as our inspections demonstrated, Grayson RECC circuits generally showed conditions indicating that management has been applying good utility practice to prevent interruptions due to vegetation incursion. We did observe, however, that management has reduced vegetation management spending thus far in 2020. That funding reduction produced expenditures not consistent with maintaining its eight-year cycle for ROW vegetation trimming, treatment and tree removal. We observed instances where attention will be needed to vegetation management imminently, underscoring the importance of continuing expenditures at levels consistent with adhering to the planned cycle, and to continue removing hazard trees.

Overall, our observations indicate that the eight-year cycle, augmented with hot spot trimming, has overall produced ROW conditions consistent with maintaining service continuity. Management’s use of 40-feet ROWs makes most vegetation management a matter of controlling undergrowth, rather than trimming and removing trees. Most tree trimming occurs on trees in yards or near (but outside) the ROWs. Falling trees located outside the ROW have had the biggest effect on CAIDI. Management does remove obvious off-ROW hazard trees, but, like all distribution system operators regularly faces opposition and denial of permission to do so.

5. *Workplace Practices*

Our observations in the field indicated close and direct relationships between the Grayson RECC’s CEO, manager of operations, engineering party chiefs, maintenance lineworkers, and line crews. We observed an appropriate focus on safe work performance, and productive work execution.

Management provides appropriate training to field workers, and verifies that work performed satisfies quality requirements.

Our field inspection activities included unannounced observation of two pole changeouts. We found the crews efficient in performing the work. We observed the tailgate safety meeting and we found notably strong use of safety bucket truck safety procedures, use of personal protective equipment, and precautions to ensure de-energization and grounding of the switched out section of line involved.

6. Outage Dispatch

The Manager of Operations supervises the division secretary, who has primarily responsibility for dispatching maintenance lineworkers to respond to outages during business hours. During business hours, in-house employees dispatch the maintenance lineworker assigned to that area to address the outage. If necessary, maintenance lineworkers request (via cell phone or 2-way radio) the dispatcher to call for assistance from another maintenance lineworker, or from a construction crew in the area, if the outage is large. During after hours, outage calls are directed to the Cooperative Response Center (CRC), who then dispatches the appropriate maintenance lineworker, who then calls the manager of operations if additional assistance is needed.

J. Engineering

Grayson RECC uses a single, part-time engineer under contract and, where required, an outside professional engineering firm for capital projects involving its larger circuits. We found the structure and level of resources used appropriate given the size and nature of the work involved. We also found that management employs RUS and NESC guidelines to control designs. The two engineering party chiefs provide individual job designs for line crews performing the work. These chiefs perform site inspections of completed jobs. The part-time professional engineer also conducts load studies and arc flash studies and assists the engineering party chiefs with design issues; and assists with the capital project planning process.

The next table shows that engineering costs have remained both low and stable. These costs divide between two firms. All Grayson RECC engineering costs were Distribution Services Solutions for professional engineering services and Leidos for project engineering services.

Year	DSS $				Leidos			
	O&M		Capital		O&M		Capital	
	Budget	*Actual*	*Budget*	*Actual*	*Budget*	*Actual*	*Budget*	*Actual*
2015	$2,500	$0	$10,000	$9,243	$0	$1,820	$0	$0
2016	$2,500	$7,805	$10,000	$12,680	$0	$0	$61,363	$45,069
2017	$5,000	$9,598	$10,000	$9,411	$0	$1,521	$0	$0
2018	$5,000	$375	$10,000	$9,748	$0	$0	$0	$0
2019	$5,000	$3,325	$10,000	$13,184	$0	$0	$38,000	$34,600
2020 YTD	$5,000	$175	$10,000	$7,798	$0	$0	$30,000	$0

K. Use of Technology

Particularly for its comparatively very small size, Grayson RECC incorporates substantial technology into its system and into supporting those who operate and maintain it. It does not, in contrast to most larger electric distribution entities make use of Supervisory Control and Data Acquisition (SCADA) systems or equipment. SCADA systems monitor and control substations, transformers and other electrical assets. A SCADA system could reduce CAIDI; *e.g.*, by reducing truck time, but we did not find substantial reason to conclude that substantial SCADA investments have the potential to prove cost effective for Grayson RECC. A SCADA system would require the installation of compatible reclosers, remote terminal units, a communication system, and a console for machine interface.

Nevertheless, Grayson RECC has, for its size, made notable use of modern electronic aids to support its operations. It employs an Outage Management System (OMS), Geographic Information System (GIS), Advanced Meter Infrastructure (AMI), and tablet computers in the field. It also employs a drone and camera (secured for $1,500) to support close inspection and photographing of pole tops and vegetation intrusion. Such systems and equipment become less prevalent among smaller operations, who have lower user numbers over which to spread their costs. We find them useful in providing timely and accurate outage response, accurate plant recordkeeping, and job design assistance.

Technical Services has responsibility for managing the technologies that support infrastructure management and operation. The group has suitable skills and experience for developing and ensuring the effective application of systems and tools. A Technical Services Manager supervises the GIS technician and two meter specialists. The GIS technician also manages the Billing System Administrator and the AMI System Administrator, and provides drone inspection service to others.

Grayson RECC operates a modern OMS with semi-integrated GIS mapping. The OMS cost a total of $90,708 to install and requires $18,232 annually for support. Management backs up daily the OMS server on-site, and backs up the data again every night to a backup server located in Lexington.

A GIS export process helps management prepare updated, but modified GIS map data for export to the OMS. Management has eliminated paper maps, integrating its GIS map data with tablet computers provided to each service persons, construction crew lead, meter person, and engineering party chief.

The OMS system provides outage tracking. Primarily, outages are identified by members calling into the system, which determines the outage location, predicts the outage device, and the number of consumers affected. Management installed the current OMS in 2011, employing Milsoft Utility Solution's "DisSpatch," and Milsoft provided annual upgrades under an annual service agreement. The OMS obtained better outage prediction capability when management imported its GIS Maps into the OMS during a 2018 upgrade. Using queried OMS data, management identifies affected end users when planning outages, in order to facilitate advance notice to them.

Management is now working with Landis+Gyr (its AMI vendor) and Milsoft to get the meter-OMS interface able to allow the new AMI meters to be pinged, to verify if a meter is energized, during and after an outage. This capability, for example, will help to ensure that all consumers are back in service before repair crews leave an area. Linking the AMI to the OMS will support identification of members out of service without telephoning them.

The GIS and tablet computers provide system maps showing to first responders and others, information such as customer address, meters, pole numbers, transformer sizes, conductor information, line distances, among other information. Users also have access to Google maps to quickly determine best travel routes. Maintenance lineworkers, crew leaders, and engineering party chiefs use cameras in the tablets to record pole, conductor, and transformer repairs, replacements, and other information, along with noting vegetation in ROW conditions and issues. The GIS system can store such data, which can also be sent to others for required corrective actions. Saved photographs help engineering party chiefs prepare repair service orders. Pulling a photo, for example, can provide knowledge of pole conditions and equipment without traveling to it.

Newly installed AMI capability attaches to the meters of nearly all members, replacing an obsolete automatic meter reading system. This capability has improved reliable meter reading capability and allowed remote meter connects and disconnects. AMI functionality also allows management to "ping" meters to determine whether energized or not. This capability has particular value in restoration after major outage events. It reduces requirements to contact consumers by phone to verify outage status or reconnection. Integrating this capability with the operation of the OMS, can occur if later determined to be cost effective.

Management has also secured at nominal cost a drone with a camera, which allows close views of pole tops, conductors, and hardware. The drone particularly facilitates inspection of the long stretches of off-road ROWs. It eases determining clearance distances material to assessing tree trimming needs. Grayson RECC also employs a 2-way radio network system owned by EKPC and maintained by a company located in Lexington.

L. Inventory Management and Purchasing

The Manager of Operations supervises the one warehouse operator. A separate vehicle mechanic also reports to the Manager of Operations. The warehouse operator and vehicle mechanic can support each other as required. Our visual inspection of the warehouse found it well-organized.

We found well-structured and supportive organizations, resources, and methods for making and tracking purchases required to support infrastructure construction, operation, inspection, maintenance, and replacement. A purchasing agent and the warehouse operator work together to manage, track, and charge accounts when procuring materials and inventory. As material is needed, the warehouse operator develops a list and forwards it to the purchasing agent. The purchasing agent, with assistance from the warehouse operator, creates a purchase order and orders the material. Upon delivery of the material, the warehouse operator checks off the material and receipts it electronically to the purchase order. After confirmation of receipt, the purchasing agent completes the purchase order and prepares a voucher for payment. An information system (UPN) using bar codes adjusts the inventory of each item as the material is received and paid.

The information system maintains a running total of material in the warehouse. Job prints control materials issuance. Management initiates jobs through the UPN system. The staking software then generates a list used to reconcile actual material use. At job completion, accounting staff performs further reconciliations and, using UPN, categorizes costs as capital or O&M. As job material is checked out, inventory is reduced, based on the material pick list. Any adjustments from the print is corrected by the engineering party chief and the warehouse operator to ensure that the unused material is issued back into stock. Minor material is issued as it is distributed from shelf to a bin. Shelf stock is maintained and tracked through UPN using bar codes; bin inventory is managed and tracked visually. Plant accounting annually reviews all warehouse records for accuracy, and works with others to eliminate any errors. Charging an item to the wrong job or account is a typical issue corrected.

Obsolete inventory is retired through the warehouse operator and the plant accountant. When obsolete material is to be retired, the warehouse operator completes an adjustment sheet prepared for by the plant accountant, listing the material and count. It will be sent to the plant accountant for removal from inventory. Disposal costs are based on bids received.

Management purchases poles from one vendor and voltage regulators, conductor, and reclosers each from two or three vendors. To ensure best pricing, management requests new bids for the supply of these items, including price, delivery, and availability. United Utility Supply (UUS) supplies pole-mount transformers, which include a 10-year manufacturer's warranty. Transformers failing during the warranty period undergo analysis to determine whether to be replaced or repaired. Those failing beyond 10 years go to the Solomon Corporation or to MS TN Transformers for an assessment of whether to repair or replace.

Management determines equipment end of life from line, pole, and pad mount transformer inspection programs. It determines conductor end of life based on historical outage data and maintenance lineworker familiarity with the line section involved.

The next table provides the value of warehouse inventory.. Transformers, reclosers, capacitors, and regulators are considered as special equipment because they are capitalized when received.

Warehouse Values

Year	Materials & Hardware	Conductor	Transformers
2018	$1,48,571	$58,891	$81,014
2019	$732,654	$58,033	$51,841
2020YTD	$293,991	$68,214	$50,120

Warehouse inventory undergoes an annual adjustment, based on work with the engineering party chiefs and the Manager of Operations. Crews occasionally report the sizes of poles used incorrectly, and do not account for unused conductors and some other equipment. The table below indicates calculation of under-and over-reporting of inventory, with corresponding adjustments. The remainder is unaccounted for. Recent unaccounted for inventory amounts have been minimal. Grayson expects inventory turnover of about 2.0 each year. The large increase in inventory in 2019 resulted from purchase of large amounts of AMI equipment.

Inventory Adjustments

Year	$ Over	$ Under	Difference	Adjustments	Average	Beg	Purchases	Ending	Turnover
2010	$26,372	$12,848	$13,525	$39,221	$421,703	$265,284	$783,303	$265,826	1.86
2011	$22,748	$11,419	$11,328	$34,167	$325,145	$265,826	$657,919	$259,856	2.04
2012	$23,213	$15,602	$7,610	$38,816	$259,830	$259,856	$489,767	$173,020	2.22
2013	$11,520	$4,511	$7,010	$16,031	$255,209	$173,020	$622,738	$204,295	2.32
2014	$9,384	$7,070	$2,315	$16,454	$277,261	$204,295	$571,268	$252,233	1.89
2015	$7,341	$6,012	$1,329	$13,354	$289,732	$251,910	$535,641	$197,271	2.04
2016	$18,718	$24,935	-$6,218	$43,653	$424,672	$197,271	$829,882	$242,456	1.85
2017	$14,5420	$14,460	$82	$29,002	$284,684	$242,456	$672,841	$457,389	1.61
2018	$13,624	$10,889	$2,734	$24,513	$259,754	$241,539	$594,312	$258,653	2.22
2019	$10,473	$8,937	$1,536	$19,410	$959,600	$258,653	$1,801,656	$1,397,883	0.69
2020YTD	$4,496	$5,589	-$1,092	$10,085	$877,333	$1,397,883	$488,358	$379,903	1.72

M. Vehicles

The next table shows initial capital costs and 2019 O&M maintenance costs for the truck fleet. Maintenance costs for Grayson RECC's trucks are substantial. A full-time mechanic services and repairs the trucks and passenger vehicles. Management has not compared in an analytical fashion its internal costs to those it might obtain by contracting vehicle maintenance to local garages, because Management has cited past concerns about longer vehicle downtimes and less than satisfactory repairs when using outside services in the past.

Truck Fleet Costs

Vehicle	Purchased	Capital Cost	2019 O&M
North Crew Derrick-Digger	2012	$230,938	$45,215
South Crew Derrick-Digger	2010	$210,324	$22,566
North Construction Crew Line Bucket Truck	2015	$170,496	$47,243
South Construction Crew Bucket Truck	2016	$193,083	$56,699
Spare Derrick-Bucket Truck	2012	$85,326	$27,275
No. 1 Maintenance Bucket Truck	2020	$115,187	$0
No. 2 Maintenance Bucket Truck	2019	$129,379	$19,123
No. 3 Maintenance Bucket Truck	2018	$124,583	$37,149
No. 4 Maintenance Bucket Truck	2017	$120,312	$43,556
No. 5 Maintenance Bucket Truck	2014	$107,994	$46,142
No. 6 Maintenance Bucket Truck	2014	$113,155	$42,286
Truck #130 Maintenance Bucket Truck	2013	$113,155	$38,237
Total Costs		**$1,733,932**	**$425,491**

N. Training and Safety

We found field worker training in work methods and processes and safety generally appropriate. No more common measurement in the industry exists than safety incident reporting. For at least ten years, Grayson RECC has experienced no accidents involving climbing, using a bucket, and electrical contact. Grayson RECC has not had a reportable electrical injury since at least 2010. OSHA reported incidents for the latest two-year period available included only three other minor, non-electrical injuries.

Grayson RECC employs a four-year apprentice program founded on the National Utility Service (NUS) apprentice training program - - certified by the Kentucky Department of Labor. The apprentice training program addresses core training and development needs in a manner commensurate with practice as similar entities. Line construction journeymen provide apprentices on-the-job training in line construction methods, use of climbers, use of bucket and derrick-digger trucks, all applicable safety procedures, and personal protective equipment use.

Management supplements those core efforts with annual work practice training for field forces. EKPC provides annual substation operation and restoration training. Line workers participate in workshops hosted by the Kentucky Association of Electrical Cooperatives. Examples include hot line and underground schools.

Line workers attend weekly safety meetings, receive annual pole top safety training, and participate in an on-line safety training program. Procedures require tailgate safety meeting before commencement of all jobs. Training includes access to online safety training provided by the Kentucky Association of Electric Cooperatives, several in-person training classes, and monthly safety training meetings. Grayson RECC has adopted the American Public Power safety manual. Line workers participate in bucket truck and pole top rescue, CPR, and first aid training.

Grayson RECC annually hosts safety training with area first responders. The statewide association provides a safety trailer and demonstration with emergency training, with the ability for first responders to ask questions. Grayson also utilizes its social media and Kentucky Living magazine to promote and provide safety information to its members.

O. Emergency and Disaster Response

We reviewed Grayson RECC's disaster and emergency planning, finding it appropriate to the scope and scale of its operations. for a small COOP utility.

Grayson RECC has a Disaster Recovery Plan that sets forth responsibilities and measures for resuming operations after loss of the use of its main building and OMS following fires, tornados, or other major events. The warehouse/garage has been set up to operate as a backup location. Should it too prove unusable or inaccessible, three temporary locations outside the territory have been designated. The Cooperative Response Center (CRC) would dispatch Grayson RECC's lineworkers and take outage calls; and personnel needing OMS access would do gain it remotely through CRC. Grayson Management would coordinate with United Technologies a cloud-based system to use the phone system offsite. Grayson RECC's CIS/GIS system, keeps a near real time backup of Grayson RECC's system in Atlanta. As soon as a remote server can be created, or as soon as management could obtain a physical server, the backup system can be used. The remaining applications could be used through Netgain (Grayson RECC's IT service company) and a remote backup service.

Grayson RECC has an emergency response plan (ERP), indicating how to contact the team of employees required to respond to a major outage event and who will gather damage data. Based on that damage data, the manager of operations determines the number of outside line crews that will be needed to repair the damage caused by the storm, in a timely and cost-effective way. Grayson RECC hasn't needed to use crews from other COOPs in the last few years. However, Grayson RECC reported when other COOP crews were requested, Grayson RECC crews and the other crews worked together without any issues reported.

The ERP includes the necessary elements for working through an emergency, such as a storm that substantially damages much of the electric system. It describes when the plan should be used, provides general information, and lists priorities, emergency phone numbers, emergency duties, contacts with the state, communities, and county emergency agencies. It describes the process for securing mutual assistance from contractors and from the Kentucky Association of Electric Cooperatives, and others. Grayson RECC participated in a Tornado drill this spring with all employees responding to their designated areas. Every January, Grayson RECC participates with the local gas companies to discuss actions in case of a gas related accident.

III. Conclusions

1. Our field inspections disclosed well-maintained and appropriately designed circuits consistent with Rural Utility Service (RUS) design specifications, and making appropriate use of voltage regulators, automatic circuit reclosers, fusing, and animal protection.

Grayson RECC has designed its distribution system according to RUS specifications, which exceed National Electrical Safety Code requirements in some cases. Examples include use of double grounding and double cross arms on some facilities. Management has maintained the distribution system appropriately.

We inspected some of the COOP's worst performing circuits and ROWs. We found them in good condition, with, however, ROW clearing needed soon in some locations. The observed condition of the distribution circuits indicates that they can provide reliable service if Grayson RECC continues its current inspection and corrective maintain practices. However, management has reduced vegetation management spending to a level that, if continued, is likely to reduce reliability because of increases in vegetation-caused outages.

Some of the mainlines and lateral tap lines are lengthy (close to 100 miles). Management has addressed the needs imposed by its system through measures that include fusing lateral taps, employing automate reclosers, installing voltage regulators and capacitors, installing downstream automatic reclosers, and enabling circuit tying. Management has taken measures to enable load transfers where required to maintain service, an approach made effective given the low loads on the circuits.

2. Grayson RECC's operations organizations and methods provide for a logical alignment of functions and resources, and support effective and efficient operation.

The Operations organization includes the Manager and the Assistant Manager of Operations, 2 engineering chiefs, 10-11 vegetation management contractor crews, 6 maintenance lineworkers, and two 4-person construction line crews. The maintenance lineworkers address distribution facility ROW conditions in assigned areas. Workers, crew leaders, and management have sufficient access to job information to plan, schedule, and record completion of work activities.

3. The technical services group effectively applies and manages technologies of types and levels consistent with the needs and resources of a small utility operation.

A Technical Services group keeps a reasonable range of technologies available for use in operating and managing the system. Systems and equipment available include the Outage Management System (OMS), the Geographic Information System (GIS), the Advance Meter Infrastructure (AMI), and tablet computers, all of which provide technological support commensurate with system needs and the costs of providing them.

4. Grayson RECC develops long-term and conducts weekly O&M work planning in a manner that effectively and efficiently meets its needs.

Grayson plans its long-term O&M budgets four years out during its annual O&M and capital budgeting meetings. The engineering chiefs and maintenance lineworkers prepare service orders, the warehouse operator ensures materials readiness, and the manager of operations provides for scheduling and marshalling of crews. Management does not use KPIs (key performance indicators), but the scale of its operations make close work among engineering chiefs, operations manager, and crews sufficient to monitor work progress and completion sufficiently. The quality of and compliance to RUS specifications for every job is verified by the engineering chiefs, and later by the professional engineer.

5. Capital planning processes and activities provide a sound framework for addressing Grayson RECC's needs timely and effectively.

Grayson RECC annually conducts capital project planning for up to six years. The process appropriately engages internal staff, the part-time professional engineer, and the RUS representative in identifying system needs and projects to address them. This group undertakes reviews of outage reports, reliability indices, and inspection reports. Identified projects undergo prioritization based on operating criticality and urgency. A small utility operation, Grayson RECC makes appropriate use of a large, reputable engineering firm with significant experience in the region and with member-owned operations. The firm engineers and estimates large jobs; a contractor constructs, them, and the internal operations oversees and monitors their execution.

6. The engineering organization, resources, methods, and costs are effective.

The engineering chiefs provide the RUS-based job designs for the line crews, and they inspect all completed jobs, which the part-time professional engineer then verifies. The professional engineer also conducts load and arc flash studies, assists the engineering chiefs with design issues; and participates in the capital project planning process.

7. The emergency response and disaster recovery plans adequately address planning for and response to major events, provide for backup locations and systems, and are supported by outreach to ensure that first responders understand how to interact with Grayson RECC during emergency conditions.

Management has addressed the requirement to guide resources in responding to major emergencies, including wide-spread outages. The emergency plan makes clear when the emergency organization comes into existence, provides general guidance, and lists priorities, emergency phone numbers, emergency duties, contacts with the state, communities, and county emergency agencies. It also provides clear measures for securing mutual assistance from outside resources.

The Disaster Recovery Plan provides management sound and comprehensive guidance for responding to loss of main building and key system use, following major events. Suitable backup locations have been identified and prepared. Alternative access to key systems (*e.g.*, servers, OMS and the customer system) and telecommunications have been addressed.

8. Purchasing and warehousing operations and methods are efficient and effective.

Management tracks running totals of warehoused material and equipment, monitors turnover, and reconciles warehouse inventory each year. The UPN system supports accurate tracking and charging to the proper accounts. Periodic bids secure material and equipment, with market solicitations made when signaled by price or other changes in existing supply arrangements. Management secures quotes for all major equipment and materials and specialty items.

9. Field work practices are effective and are consistent with good utility practice.

Our observation of workplace sites showed a cooperative, safe, and productive environment and practices in the office and in the field. The CEO, the Manager of Operations, the engineering chiefs, the maintenance lineworkers, and the line crews exhibited a relaxed but effective relationship. Management provides appropriate training to lineworkers, and verifies the quality of all work performed. Our field inspection activities included unannounced observation of pole changeouts. We found the crews efficient and efficient in performing the work, and attentive to ensuring safety and personal protective equipment use.

10. The Outage Management System and outage response methods are sound.

The OMS provides outage tracking, determining locations, predicting devices involved, and estimating numbers of users affected. Management enhanced OMS capability by importing GIS maps into OMS in 2018. The AMI system helps during an outage and the following restoration work by identifying any unrestored members.

The division secretary dispatches maintenance lineworkers to outage locations during business hours. The lineworkers can secure assistance in responding via cell phones or 2-way radio. After-hours outage calls get directed to the remote Cooperative Response Center (CRC) for dispatch of a maintenance lineworker.

11. Management has appropriately designed, conducted, and kept pace with its programs for circuit and pad mount transformer inspection maintenance.

Except for not conducting ground-line pole testing, Grayson inspects and performs corrective maintenance appropriately and timely, using two-year cycles for distribution circuits and six-month cycles for the nearly 100 pad-mounted transformers. Inspection findings are appropriately recorded, lead to work lists and schedules, and undergo completion verification. Lineworkers markup a wall map in the office to provide a visual reflection of circuit inspection completion.

The two engineering chiefs use inspection results and outage reports to plan larger repair and pole and transformer change-out jobs. They inspect and stake job sites and prepare drawings and lists of materials required. They work with the warehouse operator to ensure that crews have materials ready at the beginning of each day. The engineers also monitor job progress and consistence with drawings through field inspections. Random job visits by manager of operations assess crew efficiency and safety procedures compliance.

12. Grayson RECC's work and safety practices have been effective.

Lineworkers get appropriate safety training during the course of the apprenticeship program, augmented by continuing work practice training. Weekly safety meetings, annual pole top safety training, and an on-line safety training program also re-emphasize, refresh, and augment more formal safety training. Tailgate safety meetings precede commencement of all jobs. No reportable electrical or fall injuries have occurred for a decade or more.

13. An opportunity exists to reduce outages from fallen trees and to increase the use of hot-line maintenance. *(See Recommendations #1, 2, and 3)*

Grayson RECC's performance as measured against industry-typical reliability metrics is comparably low. The large numbers of fallen off-ROW trees it experiences help diminish its reliability performance and its low use of hot-line work requires outages for many maintenance activities. A high proportion of line inaccessible by truck also contributes to outage lengths at Grayson RECC.

Spending more to address off-ROW hazard trees matching activities and expenditures to a well-developed vegetation management cycle offers material opportunities for improving reliability performance. Management does not use the services of a professional arborist to assist in directing removal, clearing, and other management activity where it can produce the greatest benefit for the dollars spent.

14. Management regularly addresses its worst-performing circuits, but not in a sufficiently programmatic manner. (*See Recommendation #4*)

Management does not focus on reporting and assessing the effectiveness of work conducted to improve the reliability of its worst-performing circuits. It does address them regularly, but it is not using the increasingly prevalent practice of analyzing in a sufficiently structured way the before and after cost and performance data useful in identifying most effective measures for the money spent.

15. The number of outage causes listed as "unknown" impairs the outage cause visibility needed to optimize efforts to improve reliability. (*See Recommendation # 5)*

Management has been working with its maintenance lineworkers to reduce the number of outage causes listed as "unknown." For the system, about 8 percent of outages causes were listed as unknown in 2019, but at least one circuit had 21 percent of unknown causes.

16. Grayson line worker overtime costs are high *(Recommendation No. 6)*

Grayson RECC lineworkers worked 3,973 overtime hours in 2019, for a total cost of approximately $270,000 for overtime maintenance work. Rates have fallen some recently, but remain at a comparatively high percentage of regular hours.

17. The lack of a ground-line pole testing and treating program calls into question whether management is making optimum pole replacement decisions. (*See Recommendations #7 and 8)*

A common utility practice plans replacement of wood poles when they have lost 50 percent of their original strength. Ground line inspection and testing comprises the only reliable way to determine pole strength quantitatively. The process also includes injection and wrapping measures designed to extend expected pole life to 60 years or more. Grayson RECC uses the significantly less accurate method of sounding (thumping with a hammer) poles to detect internal voids, conducted as part of its two-year circuit inspection cycle. We do not consider this procedure effective in determining when to replace poles.

The lack of applying a sounder approach for determining when poles have become sufficiently deteriorated to require replacement means that management may be replacing poles unnecessarily, or not addressing poles that should be replaced.

A companion issue arises from the large number of poles (about one-third of the total) of indeterminate age.

IV. Recommendations

1. Conduct trial retention of an arborist to assist with the vegetation management program. *(See Conclusion #13)*

Fallen off-ROW trees contribute up to 50 percent of Grayson RECC circuit outages. Management should contract with an arborist, experienced in vegetation management for electric utilities, to assist it in determining the most cost effective practices generally, and to provide expertise in identifying and removing likely off-ROW hazard trees. It is not clear that a full-time arborist is required or that even-part time services are necessary for more than an interim period. It would be beneficial for management to contact other regional companies to assess the possibilities of a lending or sharing approach. Within two years, it should become clear whether the expected value justifies continuing use of an arborist, or whether knowledge transfer to internal staff has been sufficient.

The primary goal is reliability improvement, rather than cost reduction. However, reducing outage incidents creates the possibility for generating savings, especially in reducing overtime costs. Grayson estimates that the cost of an arborist is $35 per hour, or $280 per day. Management should arrange for the start of an arborist, either hired or made available for consultation by a larger regional electric utility, by April 2021. The arborist should identify recommendations to improve the effectiveness of Grayson RECC's vegetation management program and provide guidance on removing hazard trees.

2. Increase vegetation management activities sufficiently to meet the requirements of the eight-year cycle and implement an off-ROW hazard tree removal program. *(See Conclusion #13)*

Tree and brush contact has not contributed substantially to outages, indicating vegetation management brush and tree trimming effectiveness in past years. However, management decreased vegetation management spending in 2020. Resulting levels of expenditures will not support completion of work on the 8-year cycle that has been used. Moreover, increased work in removing off-ROW hazard trees is in order. Off-ROW living hazard trees are the primary cause of outages. A formal off-ROW hazard tree removal program should be implemented, focused on most effectively identifying and removing those trees that are most likely to fall into lines. Management needs to examine, with the assistance of the arborist, its cycles and increased hazard tree removal, to ensure that it will optimize expenditures, without unnecessarily increasing them.

The goal is reliability improvement, rather than cost reduction. Restoring expenditure levels reduced in 2020 will add costs. A moderate increase in costs for maintaining vegetation management and for removing more hazard tress will result, but should be mitigated somewhat by reduced hot spot trimming. Management estimates that it needs to spend $2.4 million per year (from $1.7 million) to maintain an 8-year cycle and to remove hazard trees A redesigned base program employing the experience of an arborist will better inform future vegetation management activities and associated costs. Whatever amounts are spent will be better directed at the vegetation-related drivers of interruptions, thus improving reliability, or at least maintaining it at a lower cost.

3. **Increase the use of "hot-line" work by internal lineworkers to reduce outages taken to perform maintenance activities.** *(See Conclusion #13)*

Management lists "Maintenance" as the cause for about 13 percent of CAIDI. Management trained some line workers in methods, procedures, and safety practices required to work with energized lines. Management should extend training to all its line workers to permit all to practice hot-line work. This measure would improve CAIDI and would reduce costs for contractors, who now normally perform hot-line work on the system.

The goal is to improve CAIDI, but implementation could produce a small reduction in contractor costs. Additional training should be the only cost for using all of Grayson line workers to work on energized circuits. Management should train and prepare all lineworkers for hotline work, and begin conducting hotline work by Spring 2021.

4. **Provide a structured program for conducting and documenting work activities addressing the previous year's worst performing circuit work, including follow up inspections and corrective maintenance conducted, and estimated or actual reliability improvements.** *(See Conclusion #14)*

Structured, highly visible worst-circuit programs have become common in optimizing efforts to enhance reliability performance. To ensure that the causes of outages on these circuits are addressed and that expenditures in doing so are optimized, management should annually catalogue its efforts and costs to investigate the causes of outages, the corrective actions taken, and the actual or estimated reliability improvements (either by avoided customer interruptions and numbers of customers interrupted each year, or by improvements in SAIFI and CAIDI) for each of the previous year's worst performing circuits.

The primary goal is to improve the reliability of worst performing circuits, but adoption of the recommendation has the ability to provide better reliability improvement for dollars spent. Adopting and implementing the program should involve no material cost. Management should by January 2021, begin documenting all identified causes of outages occurring for the previous year's worst performing circuits, document corrective actions and costs applied during the year, and estimate the reliability improvement resulting those corrective actions.

5. **Conduct a structured annual training program for properly identifying outages and require reporting intended to reduce "unknown" as the cause of outages.** *(See Conclusion #15)*

Management should formalize its training for identifying causes so that the engineering chiefs and the manager of operations can address the causes of outages. The goal is to improve reliability. Implementation will require only nominal costs. By the end of the first quarter of 2021, management should be operating a formal outage-cause identification training program encouraging and preparing all lineworkers to investigate all outage causes. The training should give them sufficient ability to identify outage causes and an understanding of the importance of accurate outage data.

6. **Evaluate and take actions to optimize lineworker overtime levels, considering the need to support maintenance of reliability performance.** *(See Conclusion #16)*

All lineworker overtime has been charged to maintenance work only since 2017. Much maintenance overtime likely results from addressing off-hours outages and restoring power to end users. However, management should identify where outage restorations could be delayed, or when temporary restorations can made, so that the appropriate repairs could be made during regular time hours; and anywhere else overtime for maintenance activities can be reduced or eliminated. This study should include considerations for CAIDI consequences of these actions.

Before a fuller understanding of the drivers of overtime levels, savings estimates are speculative. However, the recommendation will lead to a determination of how to best manage use overtime as part of the resource mix employed. The analysis should involve no material incremental costs. Management should complete by March 2021 a study of overtime drivers with conclusions about where lineworker overtime hours can be reduced in the future, without substantially affecting reliability.

7. **Engage, initially on a trial basis, a professional ground-line pole testing and treating contractor.** *(See Conclusion #17)*

Management currently depends on its maintenance lineworkers to judge pole strength condition by sounding (thumping with a hammer) and visual inspection. This method for deciding when to replace poles has given way more and more to use of pole testing that also digs down 18 inches, bores the poles below and above the ground line to identify hollow areas, measures the thickness of the pole shell, applies fungicide and/or insecticide, and wraps the poles below ground level. These activities are based on NESC pole strength requirements and provide a sounder basis for determining pole strength and quality. For at least two years, management should provide for such a program - - testing each year 1/10th of all poles either more than 20 years old or of indeterminate age.

Reducing the rate of pole replacement can produce material savings by requiring fewer construction lineworkers. Management estimated, based on conducting ground-line inspection on about 2,253 poles each year (1/10 of all poles known to be older than 20 years old, plus those poles with unknown age) that the annual cost would be in the range from $90,000 for the ground-line inspection plus fungicide to about $126,000 if insecticide was included. This cost may be reduced if Grayson RECC is able to determine the age of its poles of unknown age. Management should institute a trial pole ground-line testing program by April 1, 2021.

8. **Investigate the ages of poles with unknown ages.** *(Conclusion #17)*

The number of wood poles known to be over 30 years is not large, but management does not know the age of almost a third of its poles due to label fading. Management should endeavor to determine the age of the poles of unknown age. A program that reduces this number substantially may produce a reduction in the numbers of poles tested each year. Researching pole age should not produce material marginal costs. If research does not provide management with pole ages by April 1, 2021, then ground-line pole testing should include the provision of age estimates.

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