FILED
July 2, 2019
INDIANA UTILITY
REGULATORY COMMISSION

STATE OF INDIANA

INDIANA UTILITY REGULATORY COMMISSION

PETITION OF DUKE ENERGY INDIANA, LLC PURSUANT TO IND. CODE §§ 8-1-2-42.7 AND 8-1-2-61, FOR (1) AUTHORITY TO MODIFY ITS RATES AND CHARGES FOR ELECTRIC UTILITY SERVICE THROUGH A STEP-IN OF NEW RATES AND CHARGES USING A FORECASTED TEST PERIOD; (2) APPROVAL OF NEW SCHEDULES OF RATES AND CHARGES, GENERAL RULES AND REGULATIONS, AND RIDERS; (3) APPROVAL OF A FEDERAL MANDATE CERTIFICATE UNDER IND. CODE § 8-1-8.4-1; (4) APPROVAL OF REVISED ELECTRIC DEPRECIATION RATES APPLICABLE TO ITS ELECTRIC PLANT IN SERVICE; (5) APPROVAL OF NECESSARY AND APPROPRIATE ACCOUNTING DEFERRAL RELIEF; AND (6) APPROVAL OF A REVENUE DECOUPLING MECHANISM FOR CERTAIN CUSTOMER CLASSES	)	**CAUSE NO. 45253**

VERIFIED DIRECT TESTIMONY
OF
TK CHRISTIE

On Behalf of Petitioner,
DUKE ENERGY INDIANA, LLC

Petitioner's Exhibit 27

July 2, 2019

DIRECT TESTIMONY OF TK CHRISTIE
DIRECTOR DISTRIBUTION VEGETATION MANAGEMENT
DUKE ENERGY BUSINESS SERVICES LLC
ON BEHALF OF DUKE ENERGY INDIANA, LLC
BEFORE THE INDIANA UTILITY REGULATORY COMMISSION

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is TK Christie, and my business address is 1000 East Main Street, Plainfield, Indiana.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed as Director Distribution Vegetation Management by Duke Energy Business Services, LLC, a service company subsidiary of Duke Energy Corporation, and a non-utility affiliate of Duke Energy Indiana, LLC ("Duke Energy Indiana," or "Company").

Q. PLEASE BRIEFLY DESCRIBE YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND.

A. I am a graduate of the University of South Florida with a Bachelor of Science in Industrial Engineering and a graduate of Webster University with a Master's in Business Administration. I have been in the electric utility industry for 23 years.

Q. PLEASE DESCRIBE YOUR DUTIES AND RESPONSIBILITIES AS DIRECTOR DISTRIBUTION VEGETATION MANAGEMENT.

A. As Director Distribution Vegetation Management, I am responsible for overseeing Duke Energy's Midwest distribution vegetation management activities for more than 34,000 miles of electric distribution lines across our service territories in

Indiana, Ohio, and Kentucky. In this capacity, I manage a staff of 14 employees, 8 of whom are International Society of Arboriculture ("ISA") certified arborists and have primary responsibility for distribution vegetation management in Duke Energy Indiana's service territory. I also serve as the primary jurisdictional leader responsible for overseeing our contractors who are performing distribution vegetation management. I ensure adherence to the contract strategy, terms and work plan execution to the Company's standards. I develop and monitor performance metrics and objectives in collaboration with contractors to ensure that our distribution vegetation management program is performed in accordance with Commission rules and regulations. I analyze budget and work plan status to ensure performance goals are on target. I also ensure consistent implementation of policies and procedures.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?

A. I will describe Duke Energy Indiana's current distribution vegetation management program, which focuses on both maintaining our existing rights-of-way and on hazard tree identification and removal outside of our rights-of-way. I will provide support for the Company's request for increased operating and maintenance expense to perform vegetation management on the Company's distribution system on an average of a five-year trim cycle. For purposes of my testimony, I will be discussing the vegetation management program for our distribution system. Duke

Energy Indiana witness Mr. Tim Abbott will discuss transmission vegetation management in his testimony.

Q. PLEASE SUMMARIZE DUKE ENERGY INDIANA'S PROPOSAL FOR ITS VEGETATION MANAGEMENT FOR 2020 AND BEYOND.

A. Duke Energy Indiana is requesting $49.4 million in ongoing costs for routine vegetation management to support a five-year trim cycle for its distribution system.

II. DUKE ENERGY INDIANA'S CURRENT VEGETATION MANAGEMENT PROGRAM

Q. PLEASE PROVIDE AN OVERVIEW OF DUKE ENERGY INDIANA'S VEGETATION MANAGEMENT PROGRAM.

A. Duke Energy Indiana's service territory covers 69 counties in north central, central and southern Indiana, and encompasses approximately 23,000 square miles. Duke Energy Indiana supplies electric service to approximately 840,000 residential, commercial and industrial customers over approximately 16,000 miles of distribution lines. Although some of our service territory is in cities and towns, the majority is in rural areas. Duke Energy Indiana's service territory also has two very different topographies, in terms of vegetation management. In the northern part of our service territory, it is flat and open and in the southern part of our service territory, there are hills and valleys and it is more heavily forested.

Q. WHAT IS THE COMPANY'S PHILOSOPHY TOWARDS VEGETATION MANAGEMENT?

A. The Company's approach towards vegetation management is to focus on customer safety and reliability in a cost-effective manner while utilizing industry best management practices. Duke Energy Indiana takes a proactive approach to its vegetation management program, which means we try to trim or remove trees and other vegetation that may cause problems before service is affected. Duke Energy Indiana's primary focus is to control the growth of incompatible vegetation along its electric lines. To control the growth around our distribution lines, we hire qualified personnel to monitor the condition of vegetation over, under and adjacent to our electric facilities. The Company also utilizes various vegetation control practices to reduce, manage or eliminate incompatible growth, such as the use of herbicides and mowing. The Company endeavors to perform maintenance on a five-year trim cycle; however, as will be discussed below, recent increases in contractor availability and costs have created challenges in meeting a five-year trim cycle.

The Company's philosophy is that the consistent implementation of industry accepted vegetation management practices reduces the likelihood of tree and power line conflicts, as well as service interruptions, and allows for the full utilization of the operating system. Work is performed in conformance with Indiana Utility Regulatory Commission rules, OSHA regulations, American National Standards Institute (ANSI) A300, ANSI Z133, Tree Care Industry Association's (formerly the National Arborist Association) standards, Dr. Shigo's *Field Guide for Qualified Line Clearance Tree Workers*, National Electrical

Safety Code, International Society of Arboriculture Best Management Practices, and all federal, state, county, and municipal laws, statutes, ordinances and regulations applicable to said work.

As will be discussed in Duke Energy Indiana witness Ms. Cicely Hart's testimony, 28.63% of all distribution-related outages were due to vegetation interference in 2018. Duke Energy Indiana knows that a strong vegetation management program is a key component to meet system reliability.

Q. BEYOND ROUTINE VEGETATION MANAGEMENT, WHAT OTHER ACTIVITIES IS DUKE ENERGY INDIANA ENGAGED IN TO ENSURE SYSTEM RELIABILITY?

A. To maintain safety and reliability, Duke Energy Indiana is engaged in a Hazard Tree Removal Program that is designed to remove trees that pose a potential danger to our distribution system. This program seeks to remove living and dead trees outside of the Company's right-of-way that pose a risk to our distribution system, including Ash trees, to counter the effects of the Emerald Ash Borer infestation. This focus on Ash tree removals will last approximately five years, from 2019 through 2024.

Q. WHAT IS DUKE ENERGY INDIANA'S CURRENT TRIM CYCLE FOR ITS DISTRIBUTION SYSTEM?

A. Although Duke Energy Indiana aspires to have a five-year trim cycle, recent challenges, as discussed below have resulted in a trim cycle closer to seven and a half years, which is the average of miles trimmed from 2014-2018. However, for the past two years, the average trim cycle has been closer to 16 years due to resource issues and increase in costs, as discussed below.

Q. AS PART OF ITS ROUTINE MAINTENANCE SCHEDULE, DESCRIBE THE RELIABILITY, SAFETY, AND OTHER CRITERIA USED IN DETERMINING WHETHER TREES AND VEGETATION REQUIRE TRIMMING.

A. Duke Energy Indiana has an integrated vegetation management program in which the Company uses foresters who are certified by the ISA to provide guidance and oversight to contractors who are pruning trees and clearing brush growth around, over and under power lines. In addition to the routine trim cycle, we perform periodic visual inspections to determine whether the Company's targeted 10 feet of clearance is maintained or requires additional attention in advance of the schedule. During routine vegetation maintenance, our employees and contractors are also identifying hazard trees that pose a risk and remove the affected trees once permissions are received. Our Hazard Tree Removal Program is another component of our integrated vegetation management plan.

Q. HOW MUCH IS CURRENTLY EMBEDDED IN RATES FOR DISTRIBUTION VEGETATION MANAGEMENT?

A. As approved in 2004 in Cause No. 42359, Duke Energy Indiana recovers approximately $13 million in operation and maintenance ("O&M") costs per year through its base rates. In addition to this amount, which represents routine vegetation management, the Company has been spending additional dollars associated with its Hazard Tree Removal Program.

Q. PLEASE SUMMARIZE THE AMOUNTS SPENT FOR DUKE ENERGY INDIANA'S VEGETATION MANAGEMENT PROGRAM FOR THE PAST FIVE YEARS AND THE MILES TRIMMED FOR EACH OF THOSE YEARS.

A. The table below shows the amount of spend and miles trimmed on the distribution system for the Company's routine vegetation management activities from 2014-2018 and what is planned for 2019-2021:

<u>Table 1</u>:

	2014 Actuals	**2015 Actuals**	**2016 Actuals**	**2017 Actuals**	**2018 Actuals**	**2019 Budget**	**2020 Forecast**	**2021 Forecast**
Miles	3,099.06	3,149.65	2,420.64	1,009.45	1,008.59	980	2,569	3,234
O&M Total Spend	$14.3M	$13.9M	$12.4M	$9.8M	$14.3M	$13.5M	$39M	$49.4M
Total Cost Per Mile	$ 4,614	$ 4,414	$5,123	$9,708	$14,178	$13,775	$15,181	$15,275

It is important to note that vegetation maintenance is only one part of our vegetation strategy. As discussed in more detail below, although we trimmed less miles in the last couple of years, we have turned our focus to the hazard tree program to remove dead and dying trees that also impact reliability of the system.

Q. PLEASE EXPLAIN THE CHALLENGES THAT DUKE ENERGY INDIANA HAS ENCOUNTERED WITH CONTRACTORS OVER THE PAST FEW YEARS.

A. Since 2016, Duke Energy Indiana has experienced a shortage of qualified vegetation management professionals across its service territory. Furthermore, contractors had difficulty attracting and retaining skilled workers, in a highly competitive labor market, resulting in increasingly higher contractor rates. As a result of the tightening labor market and qualified tree trimming professionals leaving the Midwest for higher wage states, Duke Energy Indiana has had difficulty attracting and retaining contractor crews.

Q. PLEASE EXPLAIN THE IMPACT OF THE CONTRACTOR SHORTAGE ON THE COMPANY'S VEGETATION MANAGEMENT PLAN.

A. Because the market for qualified contractor resources has become very competitive, Duke Energy Indiana has had to look outside the local region to meet our resource needs. The scarcity of the resources locally and the need to bring in qualified contractors from outside the territory has combined to result in significantly higher prices for critically important activities. Indeed, current, competitively bid prices for vegetation management resources are significantly higher than in years past. For example, the cost per mile for vegetation management activities in the Duke Energy Indiana service territory has risen from $4,614 in 2014 to $14,178 in 2018 (see table above) and is forecasted to increase in 2020 and beyond.

Q. WHAT STEPS HAS DUKE ENERGY INDIANA UNDERTAKEN TO MITIGATE THE IMPACTS OF THE CONTRACTOR SHORTAGE?

A. In the past two to three years, Duke Energy Indiana has partnered with its tree trimming contractors to formulate training for climbing crews to develop this skilled labor classification. In addition to training, we are paying higher rates to attract and retain a skilled workforce. We also meet with our contractors regularly to discuss their ability to retain qualified employees.

Q. ARE THERE OTHER FACTORS UNIQUE TO DUKE ENERGY INDIANA THAT HAVE COMPOUNDED CHALLENGES OVER THE LAST FIVE YEARS?

A. In addition to the contractor shortage, Duke Energy Indiana has encountered an Emerald Ash Borer ("EAB") infestation, that has required us to be more aggressive in our efforts to be proactive on our vegetation management activities. The Company's efforts to increase our Hazard Tree Program has challenged associated vegetation management resources and equipment.

III. THE HAZARD TREE REMOVAL PROGRAM

Q. PLEASE DESCRIBE THE HAZARD TREE REMOVAL PROGRAMS.

A. Because about a quarter of all distribution-related outages were due to vegetation interference in 2018, Duke Energy Indiana has begun an aggressive program to remove all hazard trees that are likely to cause a problem with Duke Energy Indiana's distribution system from outside the Company's right of way. The Company is in the process of addressing living trees that are diseased as well as dead trees that have the potential to impact Duke Energy Indiana's assets. As mentioned above, Duke Energy Indiana is also removing all Ash trees that are within 45 feet of the centerline of our overhead distribution lines.

In the beginning of 2019, Company personnel developed a workplan that targeted high risk trees using spatial identification technologies. Company personnel worked with contractors to prioritize removal of hazard and Ash trees by potential customer impact and highest threats to reliability. During 2019 and 2020, Duke Energy Indiana is targeting over 20,000 trees each year that are outside of our right of way. This work will continue for the foreseeable future.

There are two components to the Hazard Tree Program. First, when our contractors are performing routine maintenance, they are instructed to look outside the ten-foot clearance zone. If they identify trees that are infested with the Emerald Ash Borer or otherwise are a threat to our distribution lines, we will work with our customers to remove the tree.

The second component of this initiative occurs outside the normal trim cycle. The Company has retained "Hazard Tree Identifiers" or contractors whose sole job is to conduct visual inspections and identify hazard trees in our service territory. We have then divided our service territory into smaller territories and sought bids from contractors who will work with our customers to obtain permission to remove these trees before they have a chance to damage our system. Duke Energy Indiana awarded this work to three separate contractors, one of which had not done work for Duke Energy Indiana in the past, increasing the number of qualified contractors Duke Energy Indiana can rely on.

Q. WILL THIS BE AN ONGOING COMPONENT OF DUKE ENERGY INDIANA'S VEGETATION MANAGEMENT PROGRAM?

A. Yes, hazard tree identification and removal have been and will continue to be a component of our integrated vegetation management program.

IV. DUKE ENERGY INDIANA'S VEGETATION MANAGEMENT PROGRAM GOING FORWARD

Q. PLEASE DESCRIBE DUKE ENERGY INDIANA'S INTEGRATED VEGETATION MANAGEMENT PROGRAM.

A. To supplement our efforts of the Hazard Tree Removal Plan discussed above, the Company is targeting a five-year trim cycle.

Q. WHY DO YOU BELIEVE THAT A FIVE-YEAR AVERAGE TRIM CYCLE IS APPROPRIATE FOR DUKE ENERGY INDIANA?

A. In 2013, Duke Energy Indiana commissioned Environmental Consultants, Inc. ("ECI") out of Stoughton, Wisconsin to perform a regrowth analysis of tree-to-conductor contact by cycle length for the Duke Energy Indiana service territory. After the initial report, the Company requested a data validation to account for specific regrowth of species found in Duke Energy Indiana's service territory, which was completed on October 17, 2014. This study concluded: "The new data projections suggests that a five-year routine maintenance cycle (with a minimum 10-foot clearance specification at the time of pruning) is appropriate for the Duke Indiana distribution system when included as part of the overall IVM (integrated vegetation management) program." (page 20). See Petitioner's Exhibit 27-A (TKC).

Based on my experience and the conclusions of the ECI report, I believe that five years is the appropriate trim cycle for Duke Energy Indiana's service territory to provide safe and reliable service.

Q. PLEASE SUMMARIZE DUKE ENERGY INDIANA'S APPROACH TO VEGETATION MANAGEMENT FROM 2018-2021.

A. Duke Energy Indiana's plan includes a ramp up in Hazard tree removal primarily to address the EAB and it is increasing the routine maintenance over the next three years to achieve an average five-year vegetation trim cycle. Over the next two years, the Company will begin to shift some of the contractor resources from the Hazard Tree removal to routine vegetation management.

Q. WHAT IS DUKE ENERGY INDIANA'S REQUEST IN TERMS OF DOLLARS TO MEET A FIVE-YEAR TRIM CYCLE?

A. Currently, the Company is expecting to spend approximately $43 million in 2019 including both the routine vegetation maintenance and the Hazard Tree Removal Program. For the 2020 test year, Duke Energy Indiana plans to spend $69 million; this cost includes $30 million in capital costs for the Hazard Tree Removal Program and $39 million in costs for routine vegetation maintenance. Going forward, Duke Energy Indiana is requesting $49.4 million for ongoing vegetation maintenance. Additionally, in 2021 through 2024 Duke Energy Indiana is forecasting to spend $20 million annually in capital costs for its Hazard

Tree Program. See the table below for a summary of our overall vegetation program.

Table 2:

($ in Millions)	2018	2019	2020	2021
Routine Maintenance	$14	$13	$39	$49
Hazard Tree Removal	$11	$30	$30	$20
Total	**$25**	**$43**	**$69**	**$69**

Q. IF THE COMMISSION APPROVES $49 MILLION FOR ROUTINE VEGETATION MAINTENANCE GOING FORWARD, DO YOU BELIEVE THAT DUKE ENERGY INDIANA WILL BE ABLE TO MAINTAIN A FIVE-YEAR CYCLE, WHILE MAINTAINING SAFETY AND RELIABILITY?

A. Yes. Although it is difficult to predict future events, I believe that $49 million is necessary to sustain a five-year maintenance trim cycle while maintaining safe and reliable service to customers.

With the recent realignment of our contractor oversight model and increased partnership with vegetation suppliers, the Company has increased productivity. To augment our current contract workforce, Duke Energy Indiana has contracted with additional suppliers and diversified our contractor portfolio with local resources. Additionally, the focus on hazard tree removal will help ensure safe and reliable service.

V. CONCLUSION

Q. DO YOU BELIEVE THAT DUKE ENERGY INDIANA'S PROPOSAL AS OUTLINED IN YOUR TESTIMONY WILL ALLOW THE COMPANY TO CONTINUE TO PROVIDE SAFE AND RELIABLE SERVICE?

A. Yes.

Q. ARE YOU FAMILIAR WITH PETITIONER'S EXHIBIT 27-A (TKC)?

A. Yes.

Q. DOES THIS CONCLUDE YOUR PREFILED DIRECT TESTIMONY?

A. Yes, it does.

Duke Energy Indiana Validation

Data Validation of Species Frequency and Growth Analysis by Region

Prepared for
Duke Energy
Plainfield, IN

October 17, 2014

Prepared by
Environmental Consultants, Inc.
520 Business Park Circle
Stoughton, WI 53589

Table of Contents

1.0 Introduction

Duke Energy engaged Environmental Consultants, Inc. (ECI) to perform a data validation of the regrowth data as presented in an earlier report entitled "*Duke Energy Indiana, Species Frequency and Growth Analysis by Region*" submitted in September of 2013. The regrowth tables presented in that report were subject to question concerning their validity in terms of tree-to-conductor contact by cycle length as compared to current clearances noted from anecdotal field observations. The report was suspected of overestimating the percentage contact by cycle length. ECI proposed a survey to statistically validate the current clearances to confirm the actual tree-to-conductor clearances by circuit last trim age. Comparing the average current clearance for each circuit age grouping to the percent contact tables in the previous report would serve as a basis for confirming their validity.

2.0 Methodology

2.1 Survey Design

Duke Energy Indiana is comprised of approximately 16,000 miles of overhead distribution line. Operationally, the distribution system is divided into five Vegetation Management Regions (Table 1).

Table 1. Duke Energy Indiana Regional Distribution Areas.

Region
Central - CIV
Eastern - EIV
Western - WIV
Northern - NIV
Southern - SIV

These regions were used in the initial report to stratify the data at a regional level. For the purposes of the validation survey, regions were not deemed crucial to the overall survey design. Survey sample points were selected randomly around the system with the overall intent to sample areas across as many circuits as possible with varying last trim dates.

Sample points were randomly selected using the pole asset information supplied by Duke Energy Indiana. Poles randomly selected were used as the starting point for each sample. Approximately 10 trees were surveyed at each sample location. Data collected during the validation survey on the Duke Energy Indiana overhead primary distribution system included the following items:

- Surveyor Name
- Utility
- Date Surveyed
- Time Surveyed
- Sample Number
- Region
- Feeder Number
- Last Trim Year
- Circuit Age
- Number of Phases
- Urban/Rural Designation
- Latitude
- Longitude
- Trim Type
- Tree Species
- Current Clearance to Conductor
- Clearance At Time of Original Prune
- Remarks

The distribution of the sample points are displayed in Figure 1 below.

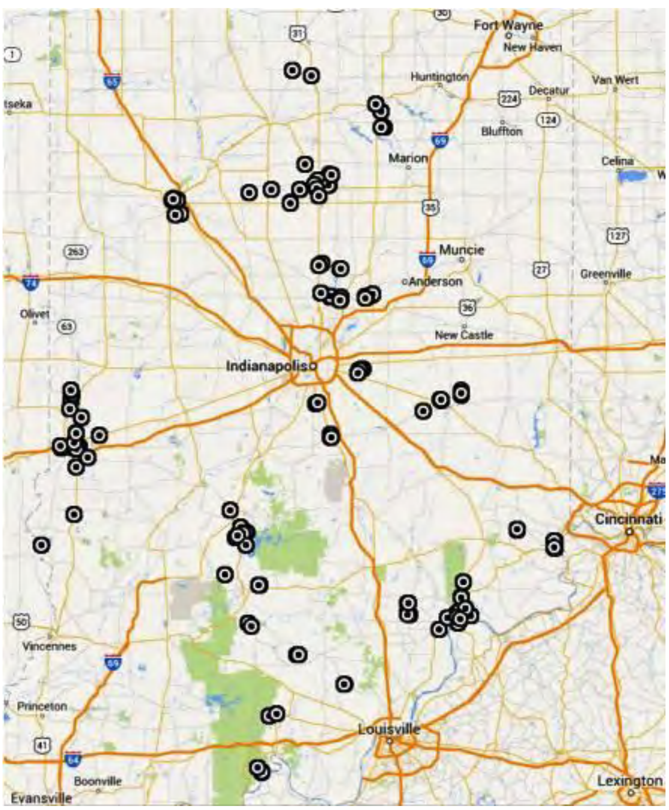

Figure 1. Distribution of ECI Sample Points.

THIS DOCUMENT CONTAINS INFORMATION THAT IS PROPRIETARY TO ECI AND DUKE ENERGY. REVIEW OR USE BY OTHER PARTIES IS PROHIBITED WITHOUT FIRST OBTAINING WRITTEN CONSENT FROM BOTH PARTIES.

3.0 Analysis

The data collected was used to analyze eight key factors that were determined to be potential causes of the discrepancy between the percentage contact by cycle length tables and the anecdotal field observations:

1. **Species Frequency** - To determine if there are potential errors in species frequency (when compared to the original survey) that may have contributed to overestimating tree-to-conductor contact due to the overuse of higher growth rate species in the regrowth simulation.
2. **Current Clearances** – To validate the actual current clearances to determine if current clearances are in-line with the expected clearances for the circuit age grouping as defined by the contact tables or if these clearances are more in-line with the anecdotal field observations as expressed by Duke Energy staff.
3. **Clearance at the Time of Initial Trimming** - To validate if the circuit clearances at the time of pruning meet the 10-foot clearance specification as defined by Duke Energy. This is important to confirm that the average clearance at the time of initial pruning is not a factor in reducing the current tree-to-conductor contact noted by the Duke Energy staff.
4. **Circuit Number Verification** - To determine if there were errors in the circuit number identification for each sample point that may have resulted in inaccurate years since last trim date.
5. **Trim Date Validation** - To determine if the trim history from the original survey is up-to-date and correct for calculating years since last trim date.
6. **Reactive Maintenance Expenditures** - To validate that the amount of reactive maintenance is minimal and would not significantly influence clearances observed.
7. **Regrowth Rates** - To determine if the regrowth data from the original survey is in-line with the regrowth calculated from the validation survey by using the difference between the clearance distance at initial pruning and the current clearance-to-conductor. Errors in the regrowth rates could contribute significantly to higher contact rates in the regrowth simulations.
8. **Growth Form** - To determine if species limb growth form (horizontal versus vertical growth) contributes to the variations in distance to conductor as noted through visual inspection when compared to the regrowth and percent contact tables.

4.0 Results

4.1 Species Frequency Validation

Table 2 presents the most common tree species and their relative frequency found during the original survey on the Duke Energy Indiana overhead distribution system by Region. Species type and frequency when coupled with regrowth rates are the main factors which influence future tree contact rates (described in section 3.2) for a given clearance distance at the time of maintenance. Table 3 present the most common tree species and relative frequency from the validation survey on the Duke Energy Indiana overhead distribution system by Region. There was minimal variation between the species frequency from the original survey and validation survey. When adjusting the species frequency for the ECI Tree Growth Simulator there was no significant influence on the projected tree-to-conductor contact percentages.

Table 2. Original Survey - Most Common Tree Species Frequency by Region.

Species	Central	Eastern	Northern	Southern	Western	System
Apple	0.5%	0.0%	1.9%	0.0%	0.0%	0.5%
Arborvitae	0.0%	0.0%	4.7%	0.0%	0.0%	1.0%
Ash, green	8.5%	10.4%	1.9%	5.5%	8.5%	6.9%
Basswood, American (linden)	1.5%	1.5%	1.9%	0.5%	0.0%	1.1%
Box-elder	3.5%	1.5%	1.9%	0.5%	0.0%	1.5%
Bradford Pear	0.0%	8.0%	1.4%	3.0%	0.0%	2.5%
Cherry, black	1.5%	1.5%	1.4%	3.0%	3.5%	2.2%
Cottonwood, eastern	3.0%	0.0%	1.4%	0.0%	0.5%	1.0%
Elm	0.5%	3.0%	3.8%	3.5%	4.0%	3.0%
Hackberry, common	9.5%	7.5%	4.3%	5.0%	4.0%	6.0%
Locust, black	2.0%	4.5%	0.0%	2.0%	4.0%	2.5%
Maple, Norway	4.0%	1.5%	4.3%	0.0%	0.0%	2.0%
Maple, red	1.5%	3.0%	2.4%	3.5%	0.5%	2.2%
Maple, silver	18.6%	17.9%	19.9%	18.4%	21.5%	19.3%
Maple, sugar	6.0%	7.0%	10.0%	3.0%	4.0%	6.0%
Mulberry	3.5%	3.5%	3.3%	11.9%	9.0%	6.2%
Oak, northern red	1.0%	0.5%	2.8%	3.5%	3.5%	2.3%
Oak, pin	0.5%	4.0%	1.4%	1.5%	3.0%	2.1%
Oak, shingle	0.0%	0.0%	2.4%	0.0%	0.0%	0.5%
Oak, white	2.0%	0.0%	1.9%	0.5%	1.5%	1.2%
Pine, eastern white	1.5%	3.0%	0.9%	7.0%	7.5%	4.0%
Pine, red	1.5%	3.5%	0.0%	0.0%	0.0%	1.0%
Redcedar, eastern	5.0%	0.5%	0.0%	1.5%	0.0%	1.4%
Sassafras	0.0%	1.0%	1.4%	2.5%	1.0%	1.2%
Spruce, blue	3.5%	0.0%	2.4%	3.0%	0.0%	1.8%
Spruce, Norway	0.0%	0.0%	2.4%	0.0%	0.5%	0.6%
Tuliptree (yellow-poplar)	3.0%	2.5%	1.4%	2.5%	1.5%	2.2%
Walnut, black	7.0%	4.0%	7.1%	6.0%	6.0%	6.0%
Other	10.9%	10.2%	11.4%	12.2%	16.0%	11.8%
Total:	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table 3. Validation Survey - Most Common Tree Species Frequency by Region.

Species	Central	Eastern	Northern	Southern	Western	System
Apple	2.6%	3.2%	2.6%	0.6%	1.1%	2.0%
Arborvitae	0.0%	0.0%	2.1%	0.0%	0.0%	0.4%
Ash, green	8.4%	6.3%	4.6%	3.9%	2.2%	5.1%
Basswood, American (linden)	2.1%	0.5%	0.0%	0.6%	0.6%	0.7%
Box-elder	0.0%	1.6%	1.0%	6.7%	8.3%	3.4%
Bradford Pear	0.0%	0.0%	0.0%	2.8%	1.7%	0.9%
Cherry, black	1.0%	6.3%	3.1%	10.0%	4.4%	4.9%
Cottonwood, eastern	2.1%	0.5%	1.0%	0.0%	0.0%	0.7%
Elm	4.2%	2.1%	1.0%	3.9%	6.1%	3.4%
Hackberry, common	15.7%	2.6%	6.2%	5.0%	4.4%	6.8%
Locust, black	1.0%	4.2%	0.5%	5.6%	1.1%	2.5%
Maple, Norway	3.1%	1.1%	1.5%	0.6%	0.6%	1.4%
Maple, red	0.0%	1.6%	0.0%	0.0%	0.0%	0.3%
Maple, silver	18.3%	20.5%	17.0%	6.7%	23.9%	17.3%
Maple, sugar	5.2%	4.7%	1.5%	8.9%	2.8%	4.6%
Mulberry	6.8%	0.0%	6.2%	2.2%	9.4%	4.9%
Oak, northern red	1.6%	5.3%	2.6%	0.6%	3.9%	2.8%
Oak, pin	0.5%	1.1%	1.5%	0.0%	0.6%	0.7%
Oak, shingle	0.0%	0.0%	0.5%	0.0%	1.1%	0.3%
Oak, white	1.0%	2.6%	3.1%	1.7%	0.0%	1.7%
Pine, eastern white	5.2%	10.0%	12.9%	7.8%	6.1%	8.4%
Pine, red	0.0%	0.0%	0.5%	0.6%	0.0%	0.2%
Redcedar, eastern	0.5%	1.6%	0.0%	8.9%	1.1%	2.4%
Sassafras	0.0%	2.6%	0.0%	1.1%	0.6%	0.9%
Spruce, blue	0.5%	0.0%	2.1%	0.0%	0.6%	0.6%
Spruce, Norway	0.0%	0.0%	3.1%	0.6%	2.8%	1.3%
Tuliptree (yellow-poplar)	2.6%	4.7%	1.0%	0.0%	0.6%	1.8%
Walnut, black	4.2%	4.2%	9.3%	7.8%	9.4%	7.0%
Other	13.4%	12.7%	15.1%	13.4%	6.6%	12.6%
Total:	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Regional tree characteristics are included in Table 4 to show how the distribution of trees relate to tree type (conifers vs. deciduous), geographical designation (rural, suburban, and rural), number of conductors (phases), and trim type (top-prunes, side-prunes, and overhang-prunes).

Of specific note in Table 4 is the lower percentage of coniferous trees across the system as when compared to Duke Energy Carolinas. That coupled with the higher percentage of trees in the urban and suburban classification, may point to the need for shorter cycle lengths. The higher than average percent of top trims in the Southern Region is also interesting. Top trims indicate trees left within the right-of-way and are most often a result of yard trees that are maintained as part of a homeowner's landscape. Topped trees tend to grow at a faster rate than side pruned trees and can result in the need for shorter cycles or a mid-cycle program.

Table 4. Characteristics of the Tree Species Sampled in the Species Frequency Study.

	Central	Eastern	Western	Northern	Southern	System
Species Type:						
% Coniferous	11%	7%	9%	7%	14%	10%
% Deciduous	89%	93%	91%	93%	86%	90%
Geographical Designation:						
% Agricultural	25%	10%	10%	29%	10%	17%
% Rural	0%	10%	20%	0%	15%	9%
% Suburban	45%	50%	15%	28%	10%	29%
% Urban	30%	30%	55%	43%	65%	45%
Number of Conductors:						
% Single-Phase	65%	65%	60%	62%	45%	59%
% Two-Phase	0%	0%	5%	0%	0%	1%
% Three-Phase	35%	35%	35%	38%	55%	40%
Trim Type:						
% Top Trims	15%	12%	22%	24%	29%	20%
% Side Trims	85%	88%	78%	76%	71%	80%

4.2 Current Clearances

During the validation survey ECI examined the current clearance (Table 5) to determine the validity of ECI Tree Growth Simulator projections for percent of trees in contact with conductors for various years since last trim. The validation survey confirmed Duke Energy Indiana concerns that the ECI Tree Growth Simulator contact projections were much higher than field observations.

Table 5. Observed Tree-to-Conductor Contact Percentages from Validation Survey.

Years Since Last Trimmed	Percent of Tree in Contact		
	Side Trim	Top Trim	System
1	0.0%	6.1%	2.4%
2	0.0%	12.9%	6.0%
3	3.6%	44.9%	18.9%
4	11.4%	40.9%	24.8%
5	24.7%	70.0%	41.5%
6	41.2%	60.0%	45.5%
7	61.5%	100.0%	70.6%

4.3 Clearance at the Time of Initial Trimming

In addition to examining current tree-to-conductor clearance, the clearance achieved at time of pruning was recorded to validate whether Duke Energy Indiana trimming specification were being met or if additional clearances were obtained on trimmed trees. The thought was that if additional clearances were achieved for the majority of trees trimmed this might explain the difference between ECI Tree Growth Simulator projections for 10 feet of clearance and field observations. Upon examination of the data collected during the validation survey, the clearance achieved at time of trimming is compliant with Duke Energy Indiana trimming specifications (Table 6).

Table 6. Clearance at the Time of Initial Trimming Observed during Validation Survey

Years Since Last Trimmed	Clearance At Time of Pruning		
	Side	Top	System
1	9.2	10.5	9.8
2	11.2	10.3	10.8
3	9.3	12.7	10.5
4	10.0	10.2	10.1
5	9.3	9.6	9.4
6	9.0	8.6	8.9
7	8.8	8.0	8.6
Average	9.7	10.6	10.1

4.4 Feeder Number Verification

Feeder number verification was performed to determine if errors had occurred when sample points were matched with the respective feeder number. Errors in feeder number identification may have resulted in inaccurate last trim dates and invalid sample grouping by years since last trim date. Duke Energy Indiana provided ECI with a system circuit map of the overhead distribution system that could be viewed using Google Earth. The GPS coordinates collected during the validation survey were used to populate sample point location in Google Earth. ECI then examined the location of each sample point to determine the closest circuit. Only one sample point was found with an incorrect feeder number. After correcting the feeder number for this sample, minimal change was observed in the percentage of tree-to-conductor contact for years since last trimmed age groups "1" and "3".

4.5 Trim Date Validation

Duke Energy Indiana records the date when scheduled maintenance occurs either on full circuit, backbone, or lateral segments. ECI used the circuit trim history to determine when schedule maintenance had occurred in the location of each sample point. Updated circuit trim history was requested for the validation survey to verify when a circuit was last trimmed and to make any adjustments to sample point information that was transferred from the original survey. Trim dates were found to be accurate.

4.6 Reactive Maintenance Expenditures Validation

Reactive maintenance is often used to address customer request, repetitive outages, operations departmental request, etc. ECI examined the historical vegetation management program budget to determine the amount spent on reactive maintenance to judge whether or not tree-to-conductor clearances observed during the validation survey could have been influenced by reactive maintenance. If reactive maintenance had occurred at a sample site, it would have resulted in increased tree-to-conductor clearance skewing the results to appear as though the trees were growing slower than estimated from the original survey. Historically Duke Energy Indiana spends less than 10% of the vegetation management program budget on reactive maintenance which is comparable to industry best management practices. While there is the potential that samples may be been located on sites where reactive maintenance occurred, ECI suspects this influence to be negligible.

4.7 Regrowth Data Validation

ECI validated the regrowth rates collected in the original survey against available state and regional regrowth data and found the regrowth rates to be accurate. In the original survey, sample sprouts were collected from previously pruned trees at various locations throughout each of the five defined regions.

In examining the growth forms of the most common tree species on the Duke Energy Indiana system, it became evident that their growth forms varied greatly from the growth forms of the tree species most common to the other Duke Energy operating companies (see Section 4.8 for more detail). ECI Tree Growth Simulator has a built-in assumption that side regrowth occurs at 90 degrees (i.e. horizontally) from the main trunk of the tree and does not account for any vertical orientation in side regrowth. After examining current clearances and clearance at time of trimming, it became evident that a directional growth factor would need to be applied to the side regrowth rates to account for non-horizontal growth. The directional growth factor is based upon the difference between current clearance and clearance at time of trimming in comparison to the regrowth rates from the original survey.

ECI revised the original regrowth rates for the most common tree species on the Duke Indiana distribution system based on the calculated growth correction factor (see Section 4.8 for more detail). The revised growth rates, which reflect horizontal limb growth, are presented in Figure 2 and Figure 3.

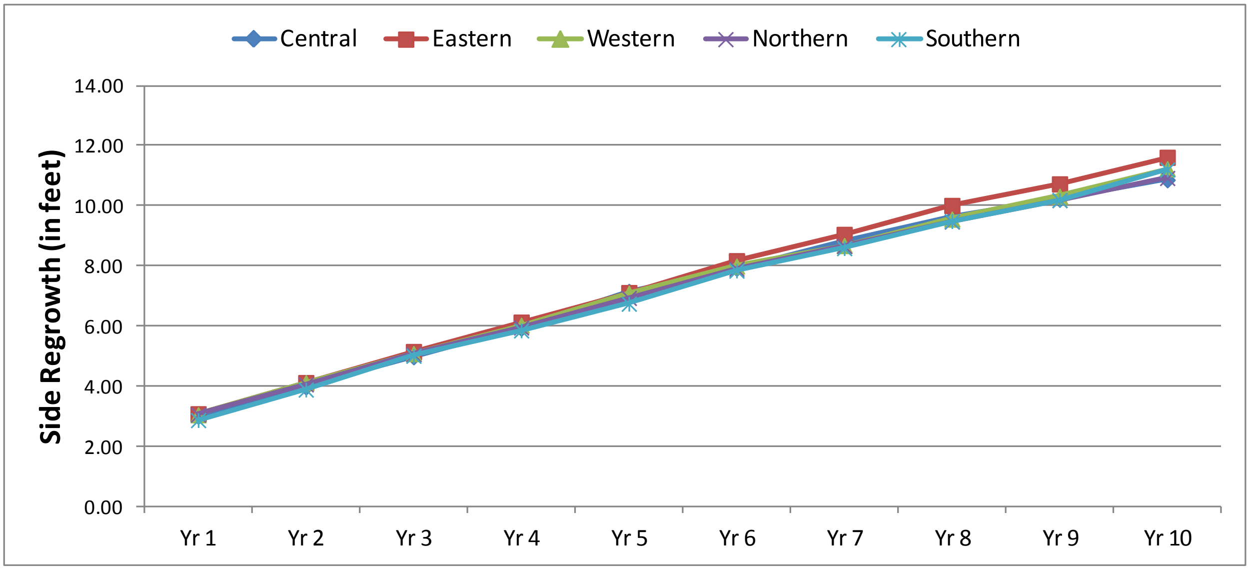

Figure 2. Mean Regrowth Rates of Side-Pruned Trees by Region with Growth Correction Factor.

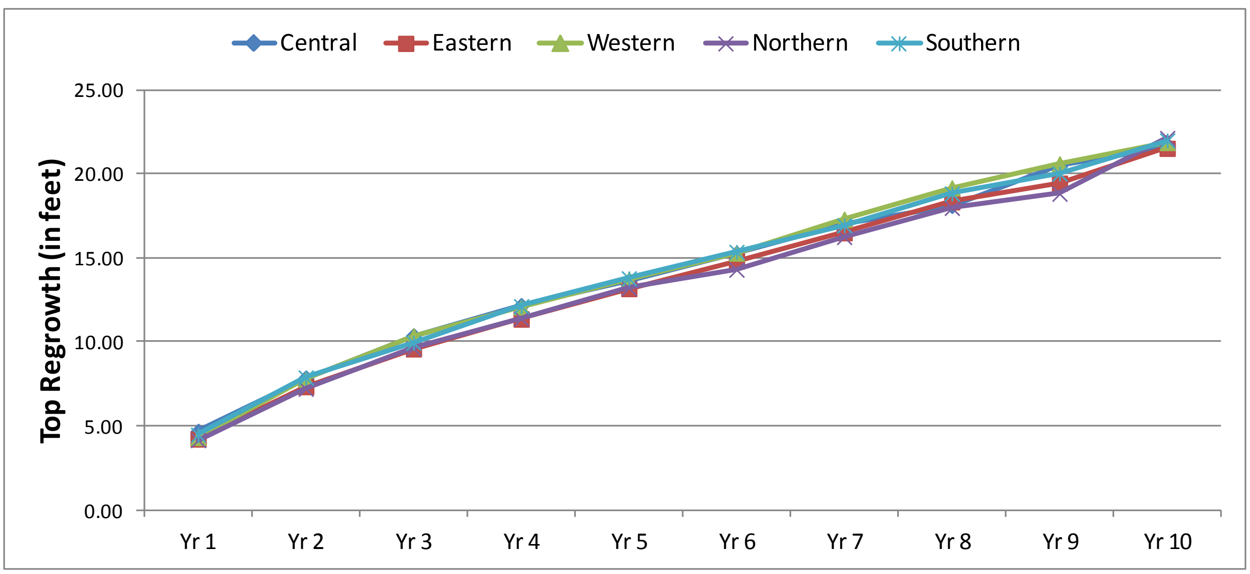

Figure 3. Mean Regrowth Rates of Top-Pruned Trees by Region with Growth Correction Factor.

Regrowth rates can fluctuate based on a variety of factors including species, genetic traits, soil, rainfall, past maintenance practices and other factors. Tables 7, 9, 11, 13, and 15 are a re-print the results of the ECI Tree Growth Simulator for each region using data from the original survey. Each table shows the average tree contact by cycle length that can be expected across the system for varying pruning clearances. Additional tree contact charts summarized at the system level can be found in Appendix B.

After applying the directional growth factors for each species, the data was re-analyzed using the ECI Tree Growth Simulator and the results are presented in Tables 8, 10, 12, 14, 16, and Appendix B. The results in these tables closely match the field observations reported by Duke Energy Indiana personnel and ECI's validation survey. The directional growth factor was not applied to average top regrowth rates because field observation supports that top regrowth has very little to no horizontal orientation. The original data is not invalid however, and should be treated as worse case scenarios for tree-to-conductor contact.

Table 7. Central Region - Original Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	90.0	93.8	95.4	96.5	97.1	97.5	97.8	98.1	98.2	98.4	98.5	98.6	98.7	98.7	98.8
3	78.3	83.6	86.8	89.1	90.8	92.2	93.2	94.0	94.6	95.1	95.4	95.7	96.0	96.3	96.5
4	62.5	73.0	78.7	82.1	84.4	86.3	87.8	89.1	90.2	91.1	91.8	92.5	93.0	93.5	93.8
5	44.6	60.6	69.3	74.6	78.0	80.5	82.3	84.0	85.5	86.7	87.8	88.7	89.5	90.2	90.7
6	26.1	46.2	`58.3	65.5	70.3	73.8	76.3	78.4	80.0	81.4	82.7	83.9	84.9	85.9	86.7
7	13.4	34.5	48.5	57.4	63.4	67.7	70.8	73.4	75.4	77.1	78.5	79.9	81.1	82.2	83.1
8	6.3	23.9	38.4	48.7	56.0	61.2	65.0	68.1	70.5	72.4	74.2	75.8	77.2	78.4	79.5
9	3.2	15.8	29.4	40.5	48.8	54.9	59.4	62.9	65.6	67.9	69.8	71.7	73.2	74.6	75.8
10	1.5	10.3	21.8	32.8	41.5	48.3	53.4	57.4	60.5	63.1	65.3	67.4	69.1	70.7	72.1
11	0.4	6.2	15.7	25.9	34.3	41.4	47.0	51.6	55.1	58.0	60.6	62.9	64.8	66.5	68.1
12		3.8	10.8	19.5	27.3	34.7	40.8	45.6	49.5	52.8	55.7	58.2	60.3	62.2	64.0
13		1.8	6.4	13.2	20.4	27.6	33.9	39.1	43.4	47.1	50.3	53.1	55.5	57.6	59.6
14		1.0	3.7	8.3	14.3	21.1	27.5	32.7	37.3	41.3	44.9	48.1	50.7	53.0	55.2
15			2.2	5.7	10.5	16.3	22.4	27.4	32.1	36.3	40.1	43.4	46.2	48.7	51.0

Table 8. Central Region – Revised Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	73.9	78.5	95.0	80.8	96.9	81.8	82.2	82.5	82.9	83.1	83.3	98.7	83.6	83.7	83.7
3	55.4	65.1	83.3	72.9	89.3	76.3	77.5	78.4	79.3	79.8	80.2	95.4	81.0	81.3	81.5
4	38.7	49.2	68.5	62.6	79.1	68.8	70.9	72.6	74.0	75.0	75.9	90.7	77.3	77.9	78.2
5	25.7	33.7	51.0	50.0	66.4	59.6	62.7	65.2	67.2	68.8	70.2	84.4	72.4	73.3	73.9
6	16.4	22.2	35.7	37.5	52.7	49.5	53.7	57.0	59.7	61.8	63.7	77.1	66.7	67.9	68.8
7	8.7	14.1	24.0	26.5	39.5	39.0	43.9	47.9	51.4	54.0	56.4	68.9	60.2	61.7	63.0
8	4.3	10.2	15.6	18.2	28.4	29.4	34.4	38.8	42.8	45.9	48.7	60.3	53.3	55.2	56.7
9	1.9	6.1	10.1	12.5	20.2	21.7	26.5	30.9	34.9	38.3	41.4	52.0	46.6	48.7	50.5
10	0.8	3.6	6.7	8.6	14.6	16.2	20.4	24.4	28.3	31.6	34.8	44.3	40.2	42.6	44.7
11	0.2	2.1	4.5	6.1	10.4	11.9	15.4	19.0	22.5	25.7	28.7	37.2	34.3	36.8	39.0
12	0.1	1.2	3.0	4.4	7.6	8.8	11.7	14.8	17.9	20.7	23.6	31.0	29.1	31.6	33.9
13		0.7	2.0	3.1	5.6	6.6	8.9	11.5	14.1	16.7	19.4	25.8	24.6	27.1	29.3
14		0.3	1.2	2.1	4.1	5.0	6.8	9.0	11.2	13.5	15.9	21.5	20.8	23.1	25.3
15		0.2	0.7	1.7	3.1	3.8	5.2	7.0	8.9	10.8	12.9	17.7	17.4	19.6	21.7

Table 9. Eastern Region - Original Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances**.**

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	91.5	94.7	96.2	97.1	97.6	98.0	98.2	98.4	98.6	98.7	98.8	98.9	98.9	99.0	99.0
3	80.3	85.5	88.7	90.8	92.4	93.6	94.4	95.1	95.6	96.0	96.3	96.6	96.8	97.0	97.2
4	64.7	74.9	80.5	84.0	86.4	88.2	89.6	90.8	91.7	92.5	93.1	93.6	94.1	94.5	94.8
5	45.1	61.5	70.5	76.0	79.5	82.2	84.1	85.7	87.1	88.2	89.2	90.0	90.8	91.4	91.9
6	26.4	46.8	59.2	66.8	71.8	75.4	78.1	80.3	82.0	83.4	84.7	85.8	86.7	87.6	88.3
7	13.6	34.2	48.6	58.0	64.3	69.0	72.4	75.1	77.2	79.0	80.5	81.8	83.0	84.1	85.0
8	6.1	22.9	38.1	48.9	56.6	62.1	66.3	69.6	72.2	74.3	76.2	77.8	79.2	80.4	81.4
9	2.6	14.6	29.0	40.6	49.0	55.5	60.3	64.1	67.1	69.6	71.8	73.6	75.2	76.6	77.9
10	1.0	9.1	21.0	32.5	41.5	48.6	54.1	58.5	61.9	64.7	67.1	69.3	71.1	72.7	74.1
11	0.4	5.3	15.0	25.3	34.0	41.5	47.5	52.4	56.3	59.4	62.2	64.6	66.6	68.4	70.1
12		3.2	10.5	18.9	27.2	34.8	41.1	46.3	50.6	54.1	57.2	59.9	62.1	64.2	66.0
13		1.5	6.4	13.3	20.8	28.0	34.4	39.9	44.5	48.4	51.8	54.8	57.3	59.6	61.7
14		0.7	3.4	8.5	14.7	21.6	28.0	33.5	38.4	42.6	46.3	49.5	52.3	54.8	57.1
15			1.9	5.6	10.4	16.3	22.4	27.8	32.8	37.2	41.1	44.6	47.6	50.3	52.7

Table 10. Eastern Region – Revised Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	76.4	80.9	95.3	83.2	97.1	84.1	84.5	84.8	85.2	85.3	85.5	98.8	85.8	86.0	85.9
3	57.8	67.5	83.9	75.3	89.7	78.7	79.9	80.7	81.6	82.1	82.5	95.6	83.3	83.6	83.7
4	40.3	51.1	68.9	64.7	79.5	71.1	73.1	74.8	76.2	77.2	78.1	90.9	79.5	80.0	80.4
5	26.6	35.1	51.5	51.8	66.8	61.6	64.8	67.2	69.3	70.9	72.3	84.7	74.5	75.4	76.0
6	16.9	23.0	35.9	38.8	53.0	51.1	55.4	58.8	61.6	63.7	65.6	77.4	68.6	69.9	70.8
7	8.7	14.5	24.2	27.4	39.7	40.2	45.3	49.5	52.9	55.7	58.1	69.3	62.0	63.6	64.8
8	4.2	10.2	15.7	18.8	28.6	30.4	35.6	40.1	44.1	47.3	50.2	60.6	54.9	56.8	58.4
9	1.9	6.1	10.2	12.9	20.3	22.4	27.3	31.8	36.0	39.5	42.6	52.2	48.0	50.1	52.0
10	0.8	3.4	6.6	8.9	14.5	16.6	20.9	25.0	29.1	32.5	35.7	44.4	41.4	43.8	45.9
11	0.2	2.0	4.5	6.2	10.4	12.2	15.9	19.5	23.2	26.4	29.6	37.4	35.4	38.0	40.2
12	0.1	1.2	3.0	4.5	7.6	9.1	12.1	15.2	18.5	21.4	24.4	31.3	30.1	32.7	35.0
13	0.1	0.7	2.0	3.2	5.6	6.8	9.2	11.9	14.6	17.3	20.1	26.1	25.4	28.0	30.3
14		0.3	1.2	2.1	4.1	5.1	7.0	9.2	11.5	13.9	16.4	21.6	21.4	23.9	26.1
15		0.2	0.7	1.6	3.0	3.8	5.3	7.1	9.1	11.1	13.3	17.8	17.9	20.2	22.4

Table 11. Western Region - Original Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	92.6	95.3	96.7	97.4	97.9	98.2	98.5	98.7	98.8	98.9	99.0	99.0	99.1	99.2	99.2
3	81.2	86.9	90.1	92.2	93.6	94.6	95.3	95.9	96.3	96.6	96.9	97.1	97.3	97.5	97.7
4	64.4	75.6	81.5	85.2	87.7	89.5	90.8	91.9	92.7	93.4	93.9	94.4	94.8	95.1	95.4
5	45.9	62.2	71.4	77.1	80.9	83.6	85.5	87.1	88.3	89.4	90.3	91.0	91.6	92.2	92.7
6	27.2	47.5	59.9	67.8	73.1	76.9	79.6	81.8	83.5	84.9	86.1	87.1	88.0	88.8	89.5
7	14.6	35.0	49.4	59.0	65.6	70.4	73.9	76.7	78.9	80.6	82.1	83.4	84.5	85.4	86.3
8	6.7	24.4	39.4	50.0	57.8	63.4	67.7	71.1	73.8	76.0	77.8	79.4	80.7	81.9	82.9
9	2.6	15.7	30.0	41.4	50.0	56.5	61.5	65.4	68.6	71.2	73.3	75.2	76.8	78.2	79.4
10	0.9	10.2	22.3	33.5	42.5	49.6	55.2	59.6	63.3	66.2	68.7	70.9	72.7	74.3	75.7
11	0.3	6.2	15.9	26.2	35.2	42.6	48.7	53.6	57.7	61.1	63.9	66.3	68.4	70.3	71.8
12	0.2	3.6	10.9	19.7	28.2	35.6	42.0	47.3	51.8	55.5	58.7	61.4	63.8	65.9	67.7
13	0.1	1.9	7.0	14.3	21.9	29.0	35.4	40.9	45.7	49.8	53.3	56.3	59.0	61.3	63.3
14		0.9	4.3	9.8	16.1	22.7	29.0	34.6	39.7	44.0	47.7	51.1	53.9	56.5	58.7
15			2.4	6.3	11.4	17.2	23.1	28.6	33.7	38.2	42.2	45.7	48.8	51.6	54.0

Table 12. Western Region – Revised Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	80.0	84.6	95.3	87.2	97.1	88.2	88.5	88.8	89.2	89.3	89.5	98.8	89.7	89.8	89.9
3	60.8	70.7	84.0	79.1	89.9	82.6	83.8	84.6	85.4	85.9	86.4	95.6	87.1	87.4	87.6
4	42.5	53.7	69.1	68.0	79.6	74.6	76.8	78.5	79.9	80.9	81.8	91.0	83.2	83.7	84.1
5	28.1	37.1	51.8	54.5	66.9	64.7	68.0	70.5	72.6	74.3	75.7	84.8	78.0	78.8	79.5
6	17.4	24.2	36.0	40.7	52.9	53.5	58.0	61.5	64.4	66.6	68.6	77.4	71.7	73.0	74.0
7	9.1	15.2	24.2	28.8	39.7	42.1	47.4	51.8	55.4	58.2	60.8	69.3	64.8	66.4	67.8
8	4.4	10.4	15.9	19.9	28.6	31.9	37.3	42.0	46.1	49.5	52.5	60.6	57.4	59.4	61.0
9	2.0	6.2	10.3	13.5	20.2	23.4	28.5	33.1	37.4	41.1	44.4	52.0	49.9	52.2	54.2
10	0.7	3.5	6.8	9.3	14.4	17.3	21.7	26.0	30.1	33.8	37.2	44.2	43.1	45.6	47.8
11	0.2	2.1	4.6	6.5	10.3	12.7	16.4	20.1	23.9	27.4	30.7	37.2	36.8	39.4	41.8
12	0.1	1.2	3.0	4.6	7.5	9.4	12.4	15.6	18.9	22.1	25.2	31.0	31.1	33.8	36.3
13	0.1	0.7	2.0	3.3	5.5	6.9	9.3	12.1	14.8	17.7	20.6	25.7	26.2	28.8	31.3
14		0.3	1.2	2.2	4.0	5.2	7.1	9.4	11.7	14.2	16.8	21.2	22.0	24.5	26.9
15		0.2	0.7	1.6	2.9	3.9	5.4	7.2	9.2	11.4	13.6	17.5	18.4	20.8	23.1

Table 13. Northern Region - Original Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	91.6	94.7	96.2	97.1	97.7	98.0	98.3	98.5	98.6	98.8	98.8	98.9	99.0	99.1	99.1
3	80.6	86.0	89.2	91.4	92.9	94.0	94.8	95.5	95.9	96.3	96.6	96.8	97.1	97.2	97.4
4	63.5	74.7	80.4	84.2	86.7	88.6	90.0	91.1	92.0	92.8	93.4	93.9	94.3	94.7	95.0
5	44.5	61.2	70.4	76.0	79.8	82.5	84.5	86.2	87.5	88.6	89.5	90.3	91.0	91.6	92.1
6	26.1	46.6	59.1	66.8	72.1	75.9	78.6	80.8	82.6	84.0	85.2	86.3	87.2	88.1	88.8
7	13.3	33.7	48.3	57.9	64.5	69.3	72.8	75.6	77.8	79.6	81.1	82.4	83.6	84.6	85.5
8	5.7	23.1	38.0	48.9	56.7	62.4	66.6	70.0	72.7	74.9	76.7	78.4	79.7	80.9	82.0
9	2.2	14.8	29.0	40.5	49.1	55.6	60.6	64.5	67.6	70.2	72.4	74.2	75.8	77.2	78.5
10	0.9	9.7	21.3	32.7	41.7	48.8	54.4	58.8	62.4	65.3	67.8	69.9	71.8	73.4	74.8
11	0.4	6.0	14.9	25.1	34.0	41.6	47.7	52.6	56.7	60.0	62.8	65.2	67.3	69.2	70.8
12	0.2	3.6	10.3	18.7	27.1	34.6	40.9	46.2	50.7	54.4	57.5	60.3	62.7	64.8	66.6
13	0.1	1.8	6.4	13.2	20.7	27.8	34.2	39.8	44.6	48.7	52.1	55.2	57.8	60.1	62.2
14		0.9	3.8	8.9	15.0	21.6	27.9	33.5	38.5	42.8	46.6	49.9	52.7	55.3	57.6
15		0.4	2.1	5.7	10.6	16.3	22.2	27.7	32.8	37.3	41.2	44.7	47.8	50.6	53.0

Table 14. Northern Region – Revised Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	77.9	82.4	95.3	84.8	97.1	85.8	86.2	86.5	86.8	87.0	87.2	98.7	87.5	87.6	87.6
3	59.2	68.9	84.0	76.9	89.8	80.4	81.5	82.4	83.2	83.7	84.1	95.6	84.9	85.1	85.3
4	41.4	52.3	69.0	66.0	79.5	72.5	74.6	76.3	77.7	78.7	79.6	90.9	81.0	81.5	81.9
5	27.2	36.0	51.6	52.9	66.8	62.8	66.0	68.5	70.6	72.2	73.7	84.7	75.9	76.8	77.4
6	17.2	23.5	36.0	39.6	52.9	52.1	56.4	59.8	62.7	64.8	66.7	77.3	69.9	71.1	72.1
7	8.9	14.7	24.2	28.0	39.7	41.0	46.1	50.4	53.9	56.7	59.1	69.2	63.1	64.7	66.0
8	4.3	10.2	15.7	19.3	28.6	31.0	36.3	40.9	44.9	48.2	51.1	60.6	55.9	57.8	59.4
9	1.9	6.1	10.3	13.2	20.3	22.9	27.9	32.4	36.6	40.2	43.4	52.1	48.8	51.0	52.9
10	0.7	3.4	6.6	9.0	14.5	16.9	21.3	25.4	29.5	33.0	36.3	44.3	42.0	44.5	46.7
11	0.2	2.0	4.5	6.3	10.4	12.4	16.1	19.8	23.5	26.8	30.1	37.3	35.9	38.5	40.8
12	0.1	1.2	2.9	4.5	7.5	9.2	12.2	15.4	18.6	21.6	24.7	31.2	30.5	33.1	35.5
13	0.1	0.7	1.9	3.2	5.5	6.8	9.2	11.9	14.7	17.4	20.2	25.9	25.7	28.3	30.7
14		0.3	1.2	2.1	4.0	5.1	7.0	9.2	11.6	14.0	16.5	21.4	21.6	24.1	26.4
15		0.2	0.7	1.6	2.9	3.8	5.3	7.1	9.1	11.2	13.4	17.6	18.0	20.4	22.6

Table 15. Southern Region - Original Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	91.9	94.8	96.3	97.1	97.7	98.0	98.3	98.5	98.6	98.8	98.8	98.9	99.0	99.1	99.1
3	80.7	86.1	89.3	91.4	93.0	94.1	94.9	95.5	95.9	96.3	96.6	96.9	97.1	97.3	97.4
4	63.8	74.9	80.6	84.3	86.8	88.7	90.1	91.2	92.1	92.8	93.4	93.9	94.4	94.7	95.1
5	45.0	61.5	70.6	76.2	80.0	82.7	84.7	86.3	87.6	88.7	89.6	90.4	91.1	91.7	92.2
6	26.5	46.9	59.3	67.1	72.3	76.1	78.8	81.0	82.7	84.1	85.3	86.4	87.3	88.1	88.9
7	14.0	34.4	48.8	58.2	64.8	69.6	73.1	75.9	78.0	79.8	81.3	82.6	83.7	84.7	85.6
8	6.3	23.9	38.7	49.4	57.1	62.7	67.0	70.3	73.0	75.2	77.0	78.6	79.9	81.1	82.1
9	2.6	15.4	29.6	41.0	49.6	56.0	60.9	64.8	67.9	70.5	72.6	74.5	76.0	77.4	78.6
10	1.0	10.2	22.0	33.2	42.2	49.2	54.7	59.1	62.7	65.6	68.0	70.2	72.0	73.6	75.0
11	0.4	6.2	15.5	25.7	34.6	42.0	48.1	53.0	57.0	60.3	63.1	65.5	67.6	69.5	71.1
12	0.2	3.7	10.6	19.2	27.6	35.1	41.4	46.6	51.1	54.8	57.9	60.6	63.0	65.1	66.9
13	0.1	1.9	6.8	13.8	21.3	28.4	34.8	40.3	45.1	49.1	52.6	55.6	58.2	60.5	62.6
14		0.9	4.0	9.3	15.5	22.1	28.4	34.0	39.0	43.3	47.0	50.3	53.2	55.8	58.0
15		0.4	2.2	6.0	11.0	16.8	22.6	28.2	33.2	37.7	41.6	45.1	48.2	51.0	53.4

Table 16. Southern Region – Revised Estimated Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances with Directional Correction Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	78.9	83.5	95.2	86.0	97.0	87.1	87.5	87.8	88.1	88.2	88.4	98.7	88.7	88.8	88.8
3	59.8	69.7	83.8	78.0	89.7	81.5	82.7	83.5	84.3	84.9	85.3	95.6	86.1	86.3	86.5
4	41.8	52.9	68.9	66.9	79.4	73.5	75.7	77.4	78.8	79.8	80.7	90.9	82.2	82.7	83.1
5	27.5	36.4	51.6	53.6	66.7	63.7	67.0	69.5	71.6	73.3	74.7	84.6	77.0	77.8	78.5
6	17.3	23.9	36.0	40.1	52.8	52.7	57.2	60.6	63.5	65.7	67.7	77.3	70.8	72.0	73.0
7	9.1	15.0	24.2	28.4	39.6	41.5	46.8	51.0	54.6	57.4	59.9	69.1	63.9	65.5	66.9
8	4.4	10.3	15.8	19.6	28.5	31.4	36.8	41.4	45.5	48.9	51.8	60.5	56.6	58.6	60.2
9	2.0	6.1	10.3	13.3	20.2	23.1	28.1	32.7	36.9	40.5	43.8	51.9	49.3	51.5	53.5
10	0.7	3.5	6.7	9.2	14.4	17.1	21.5	25.6	29.8	33.3	36.7	44.2	42.5	45.0	47.2
11	0.2	2.0	4.5	6.5	10.3	12.6	16.2	19.9	23.7	27.0	30.4	37.1	36.3	38.9	41.3
12	0.1	1.2	3.0	4.6	7.5	9.3	12.3	15.5	18.8	21.8	24.9	31.0	30.8	33.4	35.8
13	0.1	0.7	1.9	3.2	5.4	6.9	9.2	12.0	14.7	17.6	20.4	25.7	25.9	28.5	30.9
14		0.3	1.1	2.1	4.0	5.2	7.0	9.3	11.6	14.1	16.6	21.2	21.7	24.3	26.6
15		0.2	0.7	1.6	2.9	3.8	5.3	7.2	9.1	11.3	13.5	17.5	18.2	20.6	22.8

Clearance at time of pruning is a key factor in determining the optimal cycle strategy. More importantly, the tree contractor's ability to consistently clear to the established standards will determine if established cycles can be maintained.

Figures 4 through 7 provide a view of trees in contact with the conductors on an average Duke Energy Indiana circuit after pruning, based on current average growth rates. Note that the potential for a tree related event increases the longer a tree remains in contact with the energized conductor. Studies have shown that tree outage events increase on trees in contact for multiple years due to several factors, including: trees in contact have grown through the conductor, increasing the chances of low impedance faults from touching two or more conductors; and increases in stem diameters provide a better fault path.

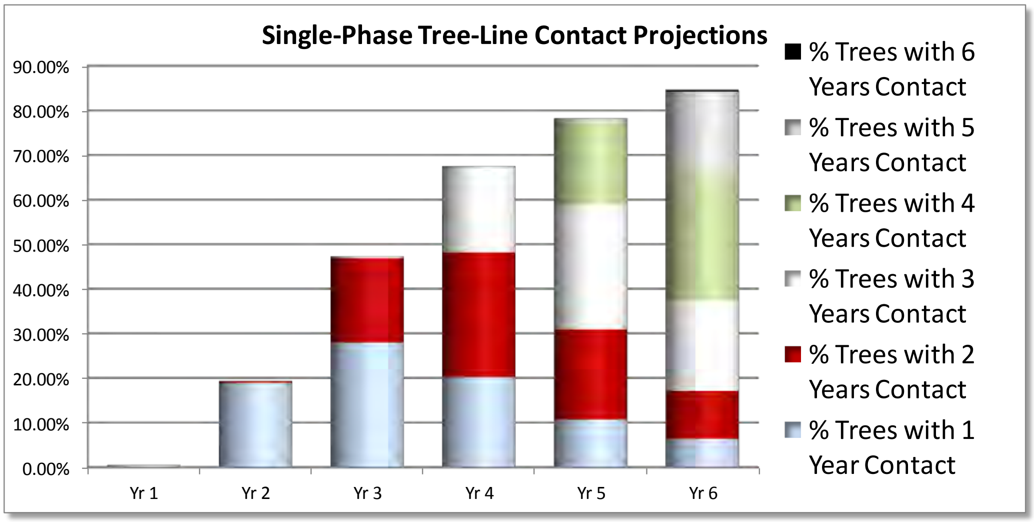

Figure 4. Original projected tree contact at the time of pruning by year with 10 feet initial clearance (single-phase system).

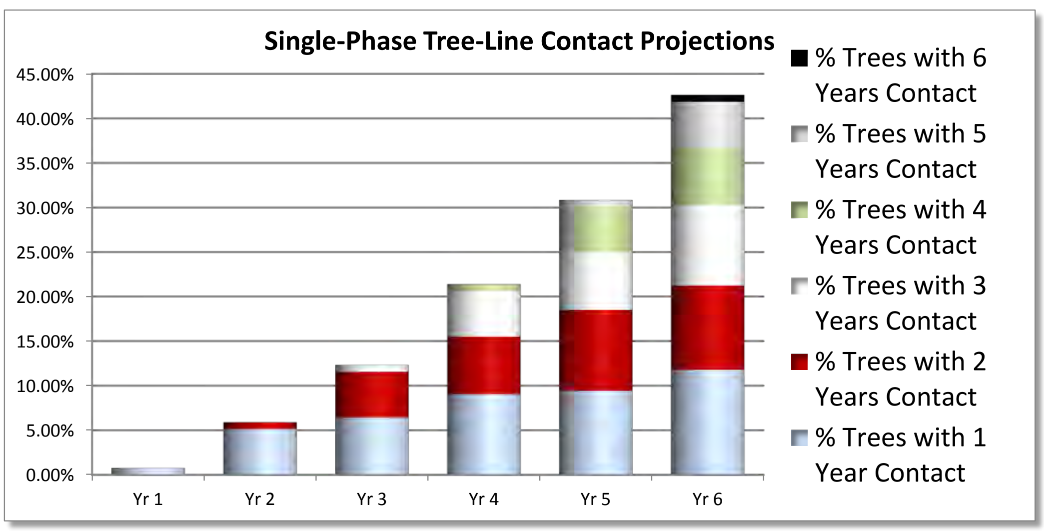

Figure 5. Revised projected tree contact at the time of pruning by year with 10 feet initial clearance with the directional growth factor applied (single-phase system).

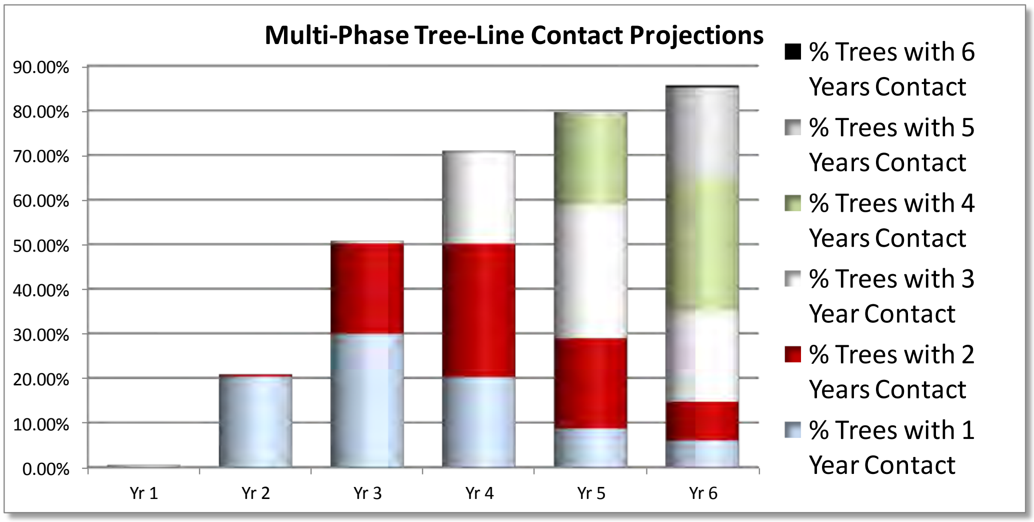

Figure 6. Original projected tree contact at the time of pruning by year with 10 feet initial clearance (multi-phase system).

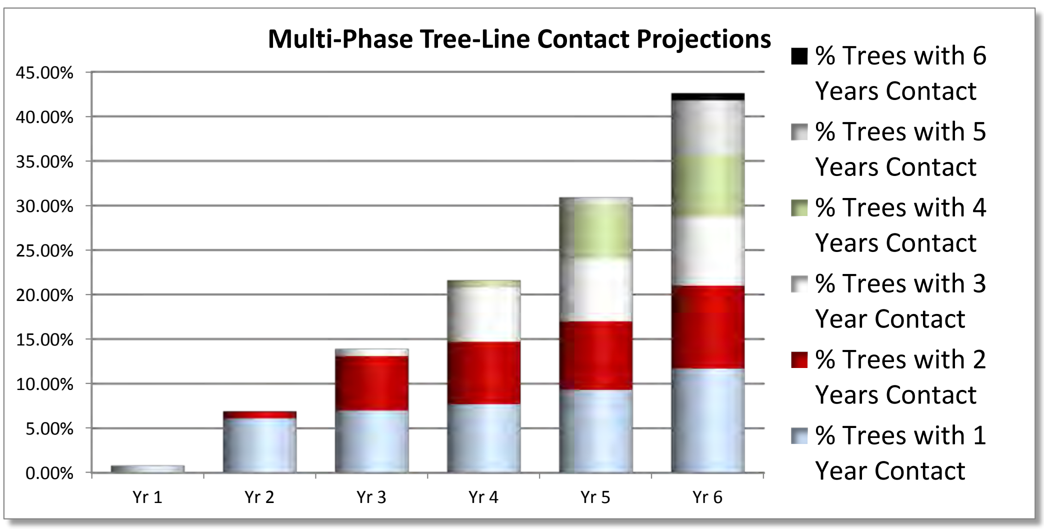

Figure 7. Revised projected tree contact at the time of pruning by year with 10 feet initial clearance with the directional growth factor applied (multi-phase system).

4.8 Growth Form Validation

Typically, tree limbs grow out from the main stem following one of two growth forms: horizontal, whereas the limbs tend to grow straight out to the side; or vertical, whereas limbs tend to grow out and up at angles of 45 degrees or more. While most trees will exhibit some of both growth forms, it is well documented that certain tree species will more closely follow one or the other growth forms. Silver maples and elms tend to have a more vertical orientation, whereas oak and pine tree species have more horizontal orientation in limb growth (Figure 8).

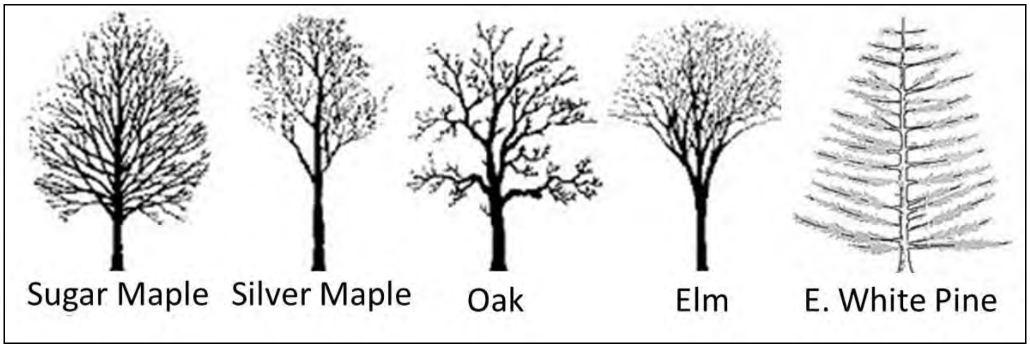

Figure 8. Examples of structural limb growth form for five different species to depict the general direction of limb growth.

In the Duke Carolina Regrowth Study, the six most dominate tree species were oak (21.6 percent), loblolly pine (13.4 percent), sweetgum (9.4 percent), red maple (9.0 percent), yellow-poplar (8.8 percent) and Eastern white pine (6.2 percent). Four out of six of these tree species demonstrate a horizontal side regrowth form. In the Duke Florida Regrowth Study, the six most dominate tree species were oaks (34.0 percent), camphor tree (6.0 percent), slash pine (5 percent), Eastern red cedar (4.0 percent), loblolly pine (3.0 percent) and red maple (3.0 percent). Five out of six of these tree species demonstrate a horizontal side regrowth form. For the Duke Indiana Regrowth Study, four out six of the most common tree species exhibit a vertical orientation in regrowth of side limbs. Therefore, the vertical orientation had a greater influence on the original regrowth study for Indiana and minimal influence for the Duke Carolina and Florida Regrowth Studies.

As part of this study to validate the original regrowth study, ECI collected additional spatial data to determine the accuracy of the original cycle contact percentage tables. Distance to conductor and distance at time of pruning by species was used to analyze the relationship between limb regrowth and visual field conditions in terms of distance to conductor. The results supported the growth form theory as the primary causal agent for the discrepancy. Using silver maple (*Acer saccharinum*) as an example, which comprises 17.3 percent of the total tree species on the Duke Indiana system, the regrowth table (Table 17 in Appendix A) shows the average regrowth rate at year six to be 188.54 inches (or 15.7 feet). It stands to reason then, that at 10 foot of clearance at the time of pruning, after six years you could expect the average silver maple to be through and past the conductors by 5.7 feet! However, since silver maple exhibits a vertical limb growth form pattern, the limbs do not grow directly towards the line making the horizontal growth a function and subject to the Pythagorean Theorem. ECI compared the average regrowth rate (the 188.54 inches) to the average horizontal distance from the trunk of the tree to the limb tips and determined that on average, silver maple limbs attach at a 54 degree angle. Hence, the true average horizontal growth distance for silver maple can be calculated as 109.78 inches in six years.

ECI reviewed the common tree species on the Duke Indiana system using the same methodology as stated above to re-project the average side horizontal regrowth rates. These projections were used in the Growth Simulator to produce revised cycle contact percentage tables (see Tables 8, 10, 12, 14 and 16 in Section 4.7, and Tables 20, 22, 24, 26, 28, and 30 in Appendix B) adjusted for directional growth form. The results yield cycle lengths and contact percentages that are more consistent with field observations.

4.9 Conclusion

ECI's field validation survey confirmed that the anecdotal field observations of average tree-to-conductor clearance is accurate and does indeed vary significantly from the original Regrowth Simulator estimates of percentage tree contact by cycle length projections. Several potential causal agents that may have contributed to this discrepancy were explored. ECI found no errors related to species identification or frequency. In addition, ECI excluded regrowth rate errors, excessive average clearances at time of pruning, significant circuit number or last prune date errors, and excluded excessive reactive maintenance expenditures as potential contributors. However, in the analysis of the validation survey data, ECI noted significant differences in limb regrowth measurements versus the horizontal protrusion of the limb in relation to the conductors. In essence, ECI found that the regrowth of the limb is not always representative of the estimated clearance to conductor due to the vertical orientation of limb growth on certain species.

ECI's Growth Simulator projects contact percentages assuming horizontal growth. Regrowth as measured in the field is obtained by measuring internodal growth along the axis of the stem and does not account for vertical inclination. ECI has determined that species growth form must be considered in order to secure an accurate picture of tree-to-conductor contact at varying maintenance cycles. However, the original estimates still retain some value if viewed as the "worst case" scenario and may have some significance in potential contact due to ice loading or storm conditions that may cause the limbs to sway in a more horizontal position.

ECI revised the percent contact charts and regrowth rates to reflect species specific directional growth form. The revised estimates match field observations when the directional growth factor is applied. The new data projections suggests that a five-year routine maintenance cycle (with a minimum 10 foot clearance specification at the time of pruning) is appropriate for the Duke Indiana distribution system when included as part of the overall IVM (integrated vegetation management) program.

5.0 Appendix A – Mean Species Regrowth and Standard Deviations

Table 17. Original Mean Annual Growth Rate Table for the trees on the Duke Energy Indiana distribution system from original regrowth study.

			Mean Annual Growth (in inches)														
Species Code	**Type of Growth**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
ACNE	**Side**	**Mean**	48.42	80.58	107.67	132.08	155.75	178.75	201.75	224.75	247.75	270.75	293.75	316.75	339.75	362.75	385.75
		Std. Dev.	18.80	19.33	25.43	33.60	43.85	55.65	67.89	80.36	92.96	105.66	118.43	131.23	144.07	156.93	169.81
	Top	**Mean**	75.33	106.78	137.89	171.00	204.78	238.89	273.00	307.11	341.22	375.33	409.44	443.56	477.67	511.78	545.89
		Std. Dev.	25.29	28.63	36.43	46.69	56.53	66.10	75.81	85.60	95.47	105.38	115.32	125.29	135.28	145.28	155.30
ACPL	**Side**	**Mean**	22.19	42.57	59.48	76.67	90.19	95.55	91.81	92.62	93.43	94.24	95.05	95.86	96.67	97.48	98.29
		Std. Dev.	16.44	20.93	25.43	30.11	35.73	35.09	74.44	114.40	155.70	197.50	239.54	281.71	323.97	366.27	408.61
	Top	**Mean**	37.45	68.23	95.59	119.77	142.27	164.50	186.73	208.95	231.18	253.41	275.64	297.86	320.09	342.32	364.55
		Std. Dev.	26.64	35.20	43.08	50.40	59.00	67.90	78.29	89.64	101.64	114.08	126.83	139.81	152.95	166.22	179.60
ACRU	**Side**	**Mean**	46.20	74.30	110.60	135.80	146.70	166.70	186.70	206.70	226.70	246.70	266.70	286.70	306.70	326.70	346.70
		Std. Dev.	15.65	19.58	30.03	32.45	35.22	38.08	42.95	49.25	56.49	64.36	72.65	81.24	90.04	98.99	108.06
	Top	**Mean**	72.07	108.33	137.27	160.27	174.60	186.87	199.13	211.40	223.67	235.93	248.20	260.47	272.73	285.00	297.27
		Std. Dev.	15.45	21.50	27.35	30.91	34.74	36.93	40.18	44.25	48.94	54.10	59.59	65.34	71.28	77.37	83.57
ACSA	**Side**	**Mean**	59.51	99.95	130.37	153.41	172.37	188.54	204.71	220.88	237.05	253.22	269.39	285.56	301.73	317.90	334.07
		Std. Dev.	22.83	34.93	36.54	39.06	42.23	44.71	48.66	53.77	59.73	66.31	73.36	80.74	88.38	96.20	104.18
	Top	**Mean**	58.92	98.92	133.75	158.33	175.92	196.42	216.92	237.42	257.92	278.42	298.92	319.42	339.92	360.42	380.92
		Std. Dev.	26.38	30.12	28.27	29.04	31.96	37.51	45.80	55.63	66.32	77.50	89.01	100.71	112.56	124.51	136.54
ACSU	**Side**	**Mean**	45.53	76.16	102.16	122.74	139.63	151.05	162.47	173.89	185.32	196.74	208.16	219.58	231.00	242.42	253.84
		Std. Dev.	14.82	26.35	26.98	27.92	30.27	30.01	31.33	34.05	37.87	42.49	47.68	53.27	59.16	65.25	71.50
	Top	**Mean**	37.88	68.38	101.63	121.38	133.38	146.50	159.63	172.75	185.88	199.00	212.13	225.25	238.38	251.50	264.63
		Std. Dev.	10.25	14.66	23.54	19.58	22.19	19.07	16.78	15.67	16.01	17.71	20.43	23.83	27.66	31.75	36.03
CEOC	**Side**	**Mean**	49.67	80.89	110.00	131.78	148.56	172.11	195.67	219.22	242.78	266.33	289.89	313.44	337.00	360.56	384.11
		Std. Dev.	19.54	27.55	31.83	33.35	30.19	30.95	37.65	47.86	59.80	72.63	85.95	99.56	113.36	127.28	141.30
	Top	**Mean**	61.00	98.27	130.55	148.82	166.45	185.55	204.64	223.73	242.82	261.91	281.00	300.09	319.18	338.27	357.36
		Std. Dev.	20.30	25.99	24.49	26.25	29.39	35.37	44.51	55.25	66.83	78.88	91.22	103.74	116.38	129.11	141.90
FRPE	**Side**	**Mean**	42.95	73.21	98.95	120.11	136.05	150.84	165.63	180.42	195.21	210.00	224.79	239.58	254.37	269.16	283.95
		Std. Dev.	17.62	21.93	28.93	32.70	34.28	36.71	39.91	43.70	47.94	52.53	57.39	62.44	67.65	72.98	78.41
	Top	**Mean**	47.38	84.38	109.50	136.63	153.13	169.50	185.88	202.25	218.63	235.00	251.38	267.75	284.13	300.50	316.88
		Std. Dev.	26.98	26.52	27.09	30.70	27.17	26.00	28.07	32.78	39.18	46.58	54.58	62.95	71.56	80.32	89.21
JUNI	**Side**	**Mean**	50.79	80.93	110.93	136.36	151.07	166.86	182.64	198.43	214.21	230.00	245.79	261.57	277.36	293.14	308.93
		Std. Dev.	24.45	29.83	34.75	39.64	42.95	47.29	53.76	61.69	70.58	80.13	90.11	100.41	110.93	121.62	132.43
	Top	**Mean**	69.25	113.25	160.38	197.75	231.13	262.00	292.88	323.75	354.63	385.50	416.38	447.25	478.13	509.00	539.88
		Std. Dev.	34.47	41.09	48.25	54.46	68.44	88.53	110.12	132.48	155.28	178.34	201.58	224.94	248.39	271.91	295.47
JUVI	**Side**	**Mean**	11.42	20.58	30.50	38.42	44.92	52.75	60.58	68.42	76.25	84.08	91.92	99.75	107.58	115.42	123.25
		Std. Dev.	6.16	10.01	15.64	17.34	19.52	20.54	21.78	23.19	24.75	26.42	28.20	30.06	31.99	33.97	36.00
	Top	**Mean**	15.69	32.00	43.63	54.63	62.06	71.19	80.31	89.44	98.56	107.69	116.81	125.94	135.06	144.19	153.31
		Std. Dev.	5.13	8.89	11.42	14.99	17.91	18.09	18.73	19.77	21.15	22.83	24.73	26.80	29.02	31.35	33.77
LITU	**Side**	**Mean**	42.29	71.43	95.88	116.72	128.48	141.97	155.45	168.93	182.41	195.90	209.38	222.86	236.34	249.83	263.31
		Std. Dev.	12.26	14.65	18.97	23.63	24.10	26.19	29.85	34.58	40.01	45.88	52.05	58.42	64.93	71.55	78.24
	Top	**Mean**	78.91	122.36	152.18	185.64	205.82	230.36	254.91	279.45	304.00	328.55	353.09	377.64	402.18	426.73	451.27
		Std. Dev.	25.80	33.31	34.54	39.20	38.85	44.11	50.61	57.92	65.77	74.00	82.48	91.16	99.97	108.89	117.88
MASP	**Side**	**Mean**	18.80	45.40	62.00	72.60	83.60	92.20	100.80	109.40	118.00	126.60	135.20	143.80	152.40	161.00	169.60
		Std. Dev.	11.73	10.90	13.82	14.26	12.86	9.73	7.19	6.02	6.96	9.40	12.48	15.83	19.32	22.88	26.48
	Top	**Mean**	27.20	48.20	64.60	80.20	97.20	110.40	123.60	136.80	150.00	163.20	176.40	189.60	202.80	216.00	229.20
		Std. Dev.	10.47	19.87	26.67	34.08	32.91	31.12	29.96	29.52	29.83	30.87	32.55	34.80	37.51	40.59	43.96
MOSP	**Side**	**Mean**	47.38	77.31	102.54	128.54	151.77	170.62	189.46	208.31	227.15	246.00	264.85	283.69	302.54	321.38	340.23
		Std. Dev.	20.49	24.60	24.54	26.14	22.86	25.98	33.97	44.28	55.63	67.50	79.65	91.98	104.42	116.93	129.50
	Top	**Mean**	53.95	84.74	110.37	133.95	152.89	172.21	191.53	210.84	230.16	249.47	268.79	288.11	307.42	326.74	346.05
		Std. Dev.	30.92	38.03	39.41	42.78	48.02	47.36	48.83	52.23	57.23	63.46	70.58	78.35	86.60	95.20	104.07
PIAB	**Side**	**Mean**	6.50	14.30	21.90	30.10	39.80	46.90	54.00	61.10	68.20	75.30	82.40	89.50	96.60	103.70	110.80
		Std. Dev.	3.37	7.44	11.80	16.67	20.37	21.89	23.59	25.44	27.40	29.45	31.58	33.77	36.00	38.28	40.59
	Top	**Mean**	16.07	27.67	39.87	52.13	65.33	77.87	90.40	102.93	115.47	128.00	140.53	153.07	165.60	178.13	190.67
		Std. Dev.	12.15	13.74	16.40	19.32	23.15	25.85	29.12	32.80	36.75	40.91	45.21	49.62	54.11	58.67	63.27
PIPU	**Side**	**Mean**	7.18	13.45	18.45	23.36	28.27	33.18	38.09	43.00	47.91	52.82	57.73	62.64	67.55	72.45	77.36
		Std. Dev.	2.23	3.39	5.43	6.25	6.13	5.81	5.80	6.12	6.70	7.49	8.44	9.49	10.61	11.79	13.01
	Top	**Mean**	12.55	24.18	37.09	48.45	58.82	69.73	80.64	91.55	102.45	113.36	124.27	135.18	146.09	157.00	167.91
		Std. Dev.	4.18	5.02	7.96	10.29	11.43	13.30	15.65	18.29	21.13	24.08	27.11	30.20	33.32	36.48	39.66
PIRE	**Side**	**Mean**	7.44	15.78	23.11	29.00	35.44	40.44	45.44	50.44	55.44	60.44	65.44	70.44	75.44	80.44	85.44
		Std. Dev.	2.96	4.63	5.80	6.89	7.80	9.38	11.22	13.19	15.26	17.38	19.54	21.73	23.93	26.15	28.39
	Top	**Mean**	6.82	15.27	24.64	36.00	47.36	58.91	70.45	82.00	93.55	105.09	116.64	128.18	139.73	151.27	162.82
		Std. Dev.	1.72	3.69	7.20	11.45	16.91	19.76	23.24	27.13	31.26	35.56	39.97	44.46	49.00	53.58	58.20
PIST	**Side**	**Mean**	19.18	35.18	51.91	64.91	82.09	98.82	115.55	132.27	149.00	165.73	182.45	199.18	215.91	232.64	249.36
		Std. Dev.	7.43	11.51	15.23	18.66	21.22	25.25	31.07	37.85	45.17	52.80	60.63	68.58	76.62	84.73	92.88
	Top	**Mean**	21.79	40.71	56.79	80.50	101.93	123.14	144.36	165.57	186.79	208.00	229.21	250.43	271.64	292.86	314.07
		Std. Dev.	9.78	15.23	23.44	28.72	30.91	34.54	38.72	43.31	48.17	53.24	58.47	63.81	69.24	74.74	80.29
PODE	**Side**	**Mean**	46.27	80.82	109.55	136.18	158.55	184.09	209.64	235.18	260.73	286.27	311.82	337.36	362.91	388.45	414.00
		Std. Dev.	18.47	22.71	22.25	24.60	22.71	28.63	38.77	50.66	63.31	76.36	89.62	103.01	116.50	130.04	143.63
	Top	**Mean**	66.00	108.70	142.20	174.60	207.00	239.40	271.80	304.20	336.60	369.00	401.40	433.80	466.20	498.60	531.00
		Std. Dev.	24.73	36.24	49.89	62.29	76.51	91.72	107.49	123.61	139.96	156.46	173.08	189.78	206.55	223.36	240.21
PRSE	**Side**	**Mean**	52.70	87.80	122.60	148.10	167.70	188.00	208.30	228.60	248.90	269.20	289.50	309.80	330.10	350.40	370.70
		Std. Dev.	19.58	27.78	34.61	38.16	44.15	53.59	64.51	76.27	88.55	101.15	113.97	126.94	140.02	153.19	166.41
	Top	**Mean**	59.93	103.64	136.14	168.71	199.57	229.64	259.71	289.79	319.86	349.93	380.00	410.07	440.14	470.21	500.29
		Std. Dev.	26.08	31.86	40.81	49.81	60.33	70.63	82.37	95.03	108.29	121.94	135.88	150.01	164.30	178.70	193.18
PYCA	**Side**	**Mean**	31.18	53.47	82.00	109.24	134.59	159.29	184.00	208.71	233.41	258.12	282.82	307.53	332.24	356.94	381.65
		Std. Dev.	18.56	28.34	40.01	42.31	47.26	54.56	63.65	73.88	84.83	96.26	108.02	120.01	132.16	144.44	156.82
	Top	**Mean**	49.27	83.55	114.59	139.91	159.27	175.91	192.55	209.18	225.82	242.45	259.09	275.73	292.36	309.00	325.64
		Std. Dev.	19.39	28.64	36.74	46.55	48.21	53.21	59.16	65.80	72.95	80.46	88.25	96.25	104.41	112.69	121.08
QUAL	**Side**	**Mean**	25.33	46.21	67.67	86.17	101.50	115.96	130.42	144.88	159.33	173.79	188.25	202.71	217.17	231.63	246.08
		Std. Dev.	9.86	13.48	15.22	16.21	17.13	19.69	23.94	29.13	34.86	40.89	47.11	53.45	59.88	66.37	72.91
	Top	**Mean**	35.63	64.53	88.63	114.16	137.11	158.05	179.00	199.95	220.89	241.84	262.79	283.74	304.68	325.63	346.58
		Std. Dev.	10.38	14.87	17.62	24.15	24.64	27.09	30.49	34.57	39.11	43.98	49.07	54.32	59.69	65.16	70.69

			Mean Annual Growth (in inches)														
Species Code	**Type of Growth**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
QUIM	**Side**	**Mean**	44.20	67.90	91.90	116.40	134.00	146.90	159.80	172.70	185.60	198.50	211.40	224.30	237.20	250.10	263.00
		Std. Dev.	21.12	30.22	33.45	40.32	40.68	40.48	41.03	42.32	44.28	46.82	49.85	53.30	57.08	61.13	65.41
	Top	**Mean**	35.10	64.10	86.70	114.40	132.00	153.30	174.60	195.90	217.20	238.50	259.80	281.10	302.40	323.70	345.00
		Std. Dev.	15.81	20.14	22.89	20.35	20.08	21.41	24.98	30.01	35.89	42.26	48.93	55.80	62.80	69.89	77.04
QUPA	**Side**	**Mean**	36.41	63.05	86.95	107.05	125.64	142.32	159.00	175.68	192.36	209.05	225.73	242.41	259.09	275.77	292.45
		Std. Dev.	16.32	21.16	24.23	28.18	31.03	33.87	37.93	42.85	48.38	54.34	60.59	67.05	73.67	80.41	87.24
	Top	**Mean**	37.00	68.00	89.18	121.45	139.60	131.18	135.45	139.73	144.00	148.27	152.55	156.82	161.09	165.36	169.64
		Std. Dev.	12.41	18.30	40.09	34.75	37.79	101.24	150.94	201.64	252.74	304.04	355.45	406.92	458.45	510.00	561.58
QURU	**Side**	**Mean**	33.82	56.53	77.71	97.94	114.35	126.00	137.65	149.29	160.94	172.59	184.24	195.88	207.53	219.18	230.82
		Std. Dev.	21.08	27.86	31.84	38.94	40.46	41.39	42.88	44.87	47.31	50.13	53.27	56.67	60.29	64.10	68.06
	Top	**Mean**	34.82	63.55	86.00	114.00	133.45	153.27	173.09	192.91	212.73	232.55	252.36	272.18	292.00	311.82	331.64
		Std. Dev.	15.03	19.19	21.84	19.35	19.65	20.31	24.22	30.15	37.14	44.69	52.56	60.64	68.84	77.13	85.48
ROPS	**Side**	**Mean**	45.09	77.64	111.45	136.18	155.64	176.55	197.45	218.36	239.27	260.18	281.09	302.00	322.91	343.82	364.73
		Std. Dev.	22.91	30.92	39.03	43.38	45.11	47.27	50.69	55.16	60.44	66.33	72.68	79.40	86.38	93.57	100.93
	Top	**Mean**	54.36	96.73	126.91	152.82	174.45	192.55	210.64	228.73	246.82	264.91	283.00	301.09	319.18	337.27	355.36
		Std. Dev.	21.01	34.46	33.74	27.91	25.45	26.81	30.33	35.37	41.39	48.01	55.01	62.28	69.72	77.29	84.95
SAAL	**Side**	**Mean**	47.67	86.00	114.33	131.33	148.67	165.00	181.33	197.67	214.00	230.33	246.67	263.00	279.33	295.67	312.00
		Std. Dev.	11.02	9.17	17.93	11.15	7.37	9.85	17.62	26.35	35.34	44.43	53.58	62.75	71.93	81.13	90.34
	Top	**Mean**	93.91	132.55	169.36	198.82	223.45	255.82	288.18	320.55	352.91	385.27	417.64	450.00	482.36	514.73	547.09
		Std. Dev.	17.01	22.17	27.21	30.72	34.57	35.12	39.63	46.98	56.07	66.17	76.90	88.02	99.40	110.96	122.66
THSP	**Side**	**Mean**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Top	**Mean**	31.80	52.00	71.90	94.90	116.00	133.50	151.00	168.50	186.00	203.50	221.00	238.50	256.00	273.50	291.00
		Std. Dev.	13.13	20.48	27.74	35.40	40.62	46.91	53.55	60.41	67.42	74.55	81.76	89.04	96.36	103.72	111.11
TIAM	**Side**	**Mean**	42.80	68.20	92.00	109.40	123.50	137.10	150.70	164.30	177.90	191.50	205.10	218.70	232.30	245.90	259.50
		Std. Dev.	15.10	21.59	20.25	20.58	21.51	24.29	28.81	34.39	40.60	47.18	54.00	60.98	68.08	75.25	82.48
	Top	**Mean**	37.88	68.38	101.63	121.38	133.38	146.50	159.63	172.75	185.88	199.00	212.13	225.25	238.38	251.50	264.63
		Std. Dev.	10.25	14.66	23.54	19.58	22.19	19.07	16.78	15.67	16.01	17.71	20.43	23.83	27.66	31.75	36.03
ULSP	**Side**	**Mean**	46.53	80.67	111.67	137.53	159.87	181.07	202.27	223.47	244.67	265.87	287.07	308.27	329.47	350.67	371.87
		Std. Dev.	20.68	33.12	42.64	44.23	45.85	50.70	56.82	63.85	71.52	79.64	88.09	96.78	105.66	114.67	123.80
	Top	**Mean**	62.00	98.00	127.90	145.40	161.80	177.00	192.20	207.40	222.60	237.80	253.00	268.20	283.40	298.60	313.80
		Std. Dev.	18.26	22.90	31.50	33.80	36.71	39.65	43.34	47.59	52.27	57.27	62.52	67.96	73.55	79.25	85.05

DUKE SPECIES CODES

Common Name	Code	Latin Name
Apple	Masp	*Malus* spp.
Arborvitae	Thsp	*Thuja* spp.
Ash, green	Frpe	*Fraxinus pennsylvanica*
Basswood, American (linden)	Tiam	*Tilia americana*
Box-elder	Acne	*Acer negundo*
Cherry, black	Prse	*Prunus serotina*
Cottonwood, eastern	Pode	*Populus deltoides*
Elm	Ulsp	*Ulmus* spp.
Hackberry, common	Ceoc	*Celtis occidentalis*
Locust, black	Rops	*Robinia pseudoacacia*
Maple, Norway	Acpl	*Acer platanoides*
Maple, red	Acru	*Acer rubrum*
Maple, silver	Acsa	*Acer saccharinum*
Maple, sugar	Acsu	*Acer saccharum*
Mulberry	Mosp	*Morus spp.*
Oak, northern red	Quru	*Quercus rubra*
Oak, pin	Qupa	*Quercus palustris*
Oak, shingle	Quim	*Quercus imbricaria*
Oak, white	Qual	*Quercus alba*
Pear, Bradford	Pyca	*Pyrus calleryana*
Pine, eastern white	Pist	*Pinus strobus*
Pine, red	Pire	*Pinus resinosa*
Redcedar, eastern	Juvi	*Juniperus virginiana*
Sassafras	Saal	*Sassafras albidum*
Spruce, blue	Pipu	*Picea pungens*
Spruce, Norway	Piab	*Picea abies*
Tuliptree (yellow-poplar)	Litu	*Liriodendron*
Walnut, black	Juni	*Juglans nigra*

Table 18. Revised Mean Annual Growth Rate Table for the trees on the Duke Energy Indiana distribution with directional growth factor.

			Mean Annual Growth (in inches)														
Species Code	**Type of Growth**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
ACNE	**Side**	**Mean**	19.20	42.40	65.60	88.80	112.00	135.20	152.60	169.99	187.39	204.79	222.18	239.58	256.97	274.37	291.77
		Std. Dev.	7.45	10.17	15.49	22.59	31.53	42.09	51.35	60.78	70.31	79.92	89.57	99.26	108.97	118.69	128.43
	Top	**Mean**	75.33	106.78	137.89	171.00	204.78	238.89	273.00	307.11	341.22	375.33	409.44	443.56	477.67	511.78	545.89
		Std. Dev.	25.29	28.63	36.43	46.69	56.53	66.10	75.81	85.60	95.47	105.38	115.32	125.29	135.28	145.28	155.30
ACPL	**Side**	**Mean**	22.19	42.57	59.48	76.67	90.19	101.33	112.48	123.62	134.76	145.90	157.05	168.19	179.33	190.48	201.62
		Std. Dev.	16.44	20.93	25.43	30.11	35.73	43.27	51.26	59.52	67.95	76.50	85.13	93.82	102.55	111.31	120.10
	Top	**Mean**	26.53	50.27	73.40	91.20	108.00	125.20	142.40	159.60	176.80	194.00	211.20	228.40	245.60	262.80	280.00
		Std. Dev.	14.63	20.92	29.57	30.37	33.08	35.27	39.35	44.81	51.21	58.24	65.70	73.45	81.42	89.54	97.78
ACRU	**Side**	**Mean**	32.33	52.00	77.41	95.04	102.67	116.67	130.66	144.66	158.66	172.66	186.65	200.65	214.65	228.65	242.64
		Std. Dev.	10.95	13.71	21.02	22.71	24.65	26.65	30.06	34.47	39.53	45.04	50.85	56.86	63.01	69.28	75.63
	Top	**Mean**	72.07	108.33	137.27	160.27	174.60	186.87	199.13	211.40	223.67	235.93	248.20	260.47	272.73	285.00	297.27
		Std. Dev.	15.45	21.50	27.35	30.91	34.74	36.93	40.18	44.25	48.94	54.10	59.59	65.34	71.28	77.37	83.57
ACSA	**Side**	**Mean**	55.94	66.71	77.48	88.24	99.01	109.78	119.19	128.61	138.03	147.44	156.86	166.27	175.69	185.10	194.52
		Std. Dev.	21.46	23.31	21.72	22.47	24.26	26.03	28.33	31.31	34.78	38.61	42.71	47.01	51.46	56.02	60.66
	Top	**Mean**	58.92	98.92	133.75	158.33	175.92	196.42	216.92	237.42	257.92	278.42	298.92	319.42	339.92	360.42	380.92
		Std. Dev.	26.38	30.12	28.27	29.04	31.96	37.51	45.80	55.63	66.32	77.50	89.01	100.71	112.56	124.51	136.54
ACSU	**Side**	**Mean**	24.17	35.74	47.31	58.89	70.46	82.03	88.23	94.43	100.64	106.84	113.04	119.24	125.44	131.65	137.85
		Std. Dev.	7.87	12.37	12.50	13.40	15.27	16.29	17.01	18.49	20.56	23.07	25.89	28.93	32.13	35.43	38.83
	Top	**Mean**	37.88	68.38	101.63	121.38	133.38	146.50	159.63	172.75	185.88	199.00	212.13	225.25	238.38	251.50	264.63
		Std. Dev.	10.25	14.66	23.54	19.58	22.19	19.07	16.78	15.67	16.01	17.71	20.43	23.83	27.66	31.75	36.03
CEOC	**Side**	**Mean**	41.82	48.80	55.78	62.76	69.75	76.73	87.23	97.73	108.23	118.73	129.23	139.73	150.23	160.74	171.24
		Std. Dev.	16.45	16.62	16.14	15.89	14.17	13.80	16.78	21.33	26.66	32.38	38.31	44.38	50.53	56.74	62.99
	Top	**Mean**	61.00	98.27	130.55	148.82	166.45	185.55	204.64	223.73	242.82	261.91	281.00	300.09	319.18	338.27	357.36
		Std. Dev.	20.30	25.99	24.49	26.25	29.39	35.37	44.51	55.25	66.83	78.88	91.22	103.74	116.38	129.11	141.90
CASP	**Side**	**Mean**	49.00	81.38	106.63	124.38	133.50	140.88	148.25	155.63	163.00	170.38	177.75	185.13	192.50	199.88	207.25
		Std. Dev.	17.35	30.90	39.94	45.46	45.09	45.74	46.91	48.55	50.62	53.07	55.84	58.90	62.20	65.70	69.37
	Top	**Mean**	50.00	92.00	124.00	145.00	162.00	169.00	176.00	183.00	190.00	197.00	204.00	211.00	218.00	225.00	232.00
		Std. Dev.	1.00	2.00	3.00	5.00	5.00	5.00	4.00	8.00	11.00	3.00	4.00	2.00	8.00	6.00	10.00
FRAX	**Side**	**Mean**	34.52	42.24	49.97	57.70	65.42	73.15	80.32	87.49	94.67	101.84	109.01	116.18	123.36	130.53	137.70
		Std. Dev.	14.16	12.65	14.61	15.71	16.48	17.80	19.35	21.19	23.25	25.48	27.83	30.28	32.81	35.39	38.02
	Top	**Mean**	47.38	84.38	109.50	136.63	153.13	169.50	185.88	202.25	218.63	235.00	251.38	267.75	284.13	300.50	316.88
		Std. Dev.	26.98	26.52	27.09	30.70	27.17	26.00	28.07	32.78	39.18	46.58	54.58	62.95	71.56	80.32	89.21
FRPE	**Side**	**Mean**	42.95	73.21	98.95	120.11	136.05	150.84	165.63	180.42	195.21	210.00	224.79	239.58	254.37	269.16	283.95
		Std. Dev.	17.62	21.93	28.93	32.70	34.28	36.71	39.91	43.70	47.94	52.53	57.39	62.44	67.65	72.98	78.41
	Top	**Mean**	47.38	84.38	109.50	136.63	153.13	169.50	185.88	202.25	218.63	235.00	251.38	267.75	284.13	300.50	316.88
		Std. Dev.	26.98	26.52	27.09	30.70	27.17	26.00	28.07	32.78	39.18	46.58	54.58	62.95	71.56	80.32	89.21
JUNI	**Side**	**Mean**	11.90	28.88	45.85	62.82	79.79	96.76	105.92	115.07	124.22	133.38	142.53	151.69	160.84	170.00	179.15
		Std. Dev.	5.73	10.64	14.36	18.26	22.68	27.42	31.18	35.77	40.93	46.47	52.26	58.23	64.33	70.53	76.80
	Top	**Mean**	69.25	113.25	160.38	197.75	231.13	262.00	292.88	323.75	354.63	385.50	416.38	447.25	478.13	509.00	539.88
		Std. Dev.	34.47	41.09	48.25	54.46	68.44	88.53	110.12	132.48	155.28	178.34	201.58	224.94	248.39	271.91	295.47
JUVI	**Side**	**Mean**	11.42	20.58	30.50	38.42	44.92	52.75	60.58	68.42	76.25	84.08	91.92	99.75	107.58	115.42	123.25
		Std. Dev.	6.16	10.01	15.64	17.34	19.52	20.54	21.78	23.19	24.75	26.42	28.20	30.06	31.99	33.97	36.00
	Top	**Mean**	15.69	32.00	43.63	54.63	62.06	71.19	80.31	89.44	98.56	107.69	116.81	125.94	135.06	144.19	153.31
		Std. Dev.	5.13	8.89	11.42	14.99	17.91	18.09	18.73	19.77	21.15	22.83	24.73	26.80	29.02	31.35	33.77
LITU	**Side**	**Mean**	21.96	42.72	63.48	84.24	105.00	125.76	137.70	149.65	161.59	173.53	185.48	197.42	209.37	221.31	233.25
		Std. Dev.	6.36	8.76	12.56	17.06	19.69	23.20	26.44	30.63	35.44	40.64	46.10	51.75	57.52	63.38	69.31
	Top	**Mean**	78.91	122.36	152.18	185.64	205.82	230.36	254.91	279.45	304.00	328.55	353.09	377.64	402.18	426.73	451.27
		Std. Dev.	25.80	33.31	34.54	39.20	38.85	44.11	50.61	57.92	65.77	74.00	82.48	91.16	99.97	108.89	117.88
MASP	**Side**	**Mean**	18.80	45.40	62.00	72.60	83.60	92.20	100.80	109.40	118.00	126.60	135.20	143.80	152.40	161.00	169.60
		Std. Dev.	11.73	10.90	13.82	14.26	12.86	9.73	7.19	6.02	6.96	9.40	12.48	15.83	19.32	22.88	26.48
	Top	**Mean**	27.20	48.20	64.60	80.20	97.20	110.40	123.60	136.80	150.00	163.20	176.40	189.60	202.80	216.00	229.20
		Std. Dev.	10.47	19.87	26.67	34.08	32.91	31.12	29.96	29.52	29.83	30.87	32.55	34.80	37.51	40.59	43.96
MOSP	**Side**	**Mean**	24.33	39.69	52.65	66.00	77.93	87.61	97.28	106.96	116.64	126.31	135.99	145.67	155.34	165.02	174.70
		Std. Dev.	10.52	12.63	12.60	13.42	11.74	13.34	17.44	22.74	28.56	34.66	40.90	47.23	53.61	60.04	66.50
	Top	**Mean**	53.95	84.74	110.37	133.95	152.89	172.21	191.53	210.84	230.16	249.47	268.79	288.11	307.42	326.74	346.05
		Std. Dev.	30.92	38.03	39.41	42.78	48.02	47.36	48.83	52.23	57.23	63.46	70.58	78.35	86.60	95.20	104.07
PIAB	**Side**	**Mean**	6.50	14.30	21.90	30.10	39.80	46.90	54.00	61.10	68.20	75.30	82.40	89.50	96.60	103.70	110.80
		Std. Dev.	3.37	7.44	11.80	16.67	20.37	21.89	23.59	25.44	27.40	29.45	31.58	33.77	36.00	38.28	40.59
	Top	**Mean**	16.07	27.67	39.87	52.13	65.33	77.87	90.40	102.93	115.47	128.00	140.53	153.07	165.60	178.13	190.67
		Std. Dev.	12.15	13.74	16.40	19.32	23.15	25.85	29.12	32.80	36.75	40.91	45.21	49.62	54.11	58.67	63.27
PIPU	**Side**	**Mean**	7.18	13.45	18.45	23.36	28.27	33.18	38.09	43.00	47.91	52.82	57.73	62.64	67.55	72.45	77.36
		Std. Dev.	2.23	3.39	5.43	6.25	6.13	5.81	5.80	6.12	6.70	7.49	8.44	9.49	10.61	11.79	13.01
	Top	**Mean**	12.55	24.18	37.09	48.45	58.82	69.73	80.64	91.55	102.45	113.36	124.27	135.18	146.09	157.00	167.91
		Std. Dev.	4.18	5.02	7.96	10.29	11.43	13.30	15.65	18.29	21.13	24.08	27.11	30.20	33.32	36.48	39.66
PIRE	**Side**	**Mean**	7.44	15.78	23.11	29.00	35.44	40.44	45.44	50.44	55.44	60.44	65.44	70.44	75.44	80.44	85.44
		Std. Dev.	2.96	4.63	5.80	6.89	7.80	9.38	11.22	13.19	15.26	17.38	19.54	21.73	23.93	26.15	28.39
	Top	**Mean**	6.82	15.27	24.64	36.00	47.36	58.91	70.45	82.00	93.55	105.09	116.64	128.18	139.73	151.27	162.82
		Std. Dev.	1.72	3.69	7.20	11.45	16.91	19.76	23.24	27.13	31.26	35.56	39.97	44.46	49.00	53.58	58.20
PIST	**Side**	**Mean**	19.18	35.18	51.91	64.91	82.09	98.82	115.55	132.27	149.00	165.73	182.45	199.18	215.91	232.64	249.36
		Std. Dev.	7.43	11.51	15.23	18.66	21.22	25.25	31.07	37.85	45.17	52.80	60.63	68.58	76.62	84.73	92.88
	Top	**Mean**	21.79	40.71	56.79	80.50	101.93	123.14	144.36	165.57	186.79	208.00	229.21	250.43	271.64	292.86	314.07
		Std. Dev.	9.78	15.23	23.44	28.72	30.91	34.54	38.72	43.31	48.17	53.24	58.47	63.81	69.24	74.74	80.29
PODE	**Side**	**Mean**	46.27	80.82	109.55	136.18	158.55	184.09	209.64	235.18	260.73	286.27	311.82	337.36	362.91	388.45	414.00
		Std. Dev.	18.47	22.71	22.25	24.60	22.71	28.63	38.77	50.66	63.31	76.36	89.62	103.01	116.50	130.04	143.63
	Top	**Mean**	66.00	108.70	142.20	174.60	207.00	239.40	271.80	304.20	336.60	369.00	401.40	433.80	466.20	498.60	531.00
		Std. Dev.	24.73	36.24	49.89	62.29	76.51	91.72	107.49	123.61	139.96	156.46	173.08	189.78	206.55	223.36	240.21
PRSE	**Side**	**Mean**	13.20	32.20	51.20	70.20	89.20	108.20	119.88	131.57	143.25	154.93	166.62	178.30	189.98	201.67	213.35
		Std. Dev.	4.91	10.19	14.45	18.09	23.49	30.84	37.13	43.90	50.96	58.22	65.60	73.06	80.59	88.16	95.77
	Top	**Mean**	59.93	103.64	136.14	168.71	199.57	229.64	259.71	289.79	319.86	349.93	380.00	410.07	440.14	470.21	500.29
		Std. Dev.	26.08	31.86	40.81	49.81	60.33	70.63	82.37	95.03	108.29	121.94	135.88	150.01	164.30	178.70	193.18

			Mean Annual Growth (in inches)														
Species Code	**Type of Growth**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
PYCA	**Side**	**Mean**	25.40	44.53	69.27	96.67	122.13	147.20	172.27	197.33	222.40	247.47	272.53	297.60	322.67	347.73	372.80
		Std. Dev.	9.47	13.22	18.78	24.65	33.75	45.49	58.10	71.13	84.38	97.76	111.22	124.74	138.30	151.89	165.51
	Top	**Mean**	39.67	67.60	93.87	113.73	133.07	148.20	163.33	178.47	193.60	208.73	223.87	239.00	254.13	269.27	284.40
		Std. Dev.	11.91	16.74	20.74	21.80	25.68	31.16	38.11	45.86	54.06	62.54	71.21	79.99	88.86	97.79	106.77
QUAL	**Side**	**Mean**	25.33	46.21	67.67	86.17	101.50	115.96	130.42	144.88	159.33	173.79	188.25	202.71	217.17	231.63	246.08
		Std. Dev.	9.86	13.48	15.22	16.21	17.13	19.69	23.94	29.13	34.86	40.89	47.11	53.45	59.88	66.37	72.91
	Top	**Mean**	35.63	64.53	88.63	114.16	137.11	158.05	179.00	199.95	220.89	241.84	262.79	283.74	304.68	325.63	346.58
		Std. Dev.	10.38	14.87	17.62	24.15	24.64	27.09	30.49	34.57	39.11	43.98	49.07	54.32	59.69	65.16	70.69
QUIM	**Side**	**Mean**	44.20	67.90	91.90	116.40	134.00	146.90	159.80	172.70	185.60	198.50	211.40	224.30	237.20	250.10	263.00
		Std. Dev.	21.12	30.22	33.45	40.32	40.68	40.48	41.03	42.32	44.28	46.82	49.85	53.30	57.08	61.13	65.41
	Top	**Mean**	35.10	64.10	86.70	114.40	132.00	153.30	174.60	195.90	217.20	238.50	259.80	281.10	302.40	323.70	345.00
		Std. Dev.	15.81	20.14	22.89	20.35	20.08	21.41	24.98	30.01	35.89	42.26	48.93	55.80	62.80	69.89	77.04
QUPA	**Side**	**Mean**	28.57	49.47	68.23	84.00	98.59	111.68	124.77	137.86	150.95	164.04	177.13	190.22	203.31	216.40	229.49
		Std. Dev.	12.81	16.61	19.01	22.11	24.35	26.58	29.76	33.63	37.97	42.64	47.54	52.61	57.81	63.10	68.46
	Top	**Mean**	37.00	68.00	89.18	121.45	126.91	131.18	135.45	139.73	144.00	148.27	152.55	156.82	161.09	165.36	169.64
		Std. Dev.	12.41	18.30	40.09	34.75	55.29	101.24	150.94	201.64	252.74	304.04	355.45	406.92	458.45	510.00	561.58
QURU	**Side**	**Mean**	22.27	31.95	41.63	51.31	60.99	70.67	77.20	83.73	90.26	96.80	103.33	109.86	116.39	122.92	129.46
		Std. Dev.	13.88	15.75	17.06	20.40	21.58	23.21	24.05	25.17	26.53	28.11	29.87	31.78	33.81	35.95	38.17
	Top	**Mean**	34.82	63.55	86.00	114.00	133.45	153.27	173.09	192.91	212.73	232.55	252.36	272.18	292.00	311.82	331.64
		Std. Dev.	15.03	19.19	21.84	19.35	19.65	20.31	24.22	30.15	37.14	44.69	52.56	60.64	68.84	77.13	85.48
ROPS	**Side**	**Mean**	31.79	54.73	78.57	96.00	109.71	124.45	139.19	153.93	168.67	183.41	198.15	212.89	227.63	242.37	257.11
		Std. Dev.	16.15	21.80	27.51	30.58	31.80	33.32	35.74	38.88	42.60	46.76	51.24	55.97	60.89	65.96	71.15
	Top	**Mean**	54.36	96.73	126.91	152.82	174.45	192.55	210.64	228.73	246.82	264.91	283.00	301.09	319.18	337.27	355.36
		Std. Dev.	21.01	34.46	33.74	27.91	25.45	26.81	30.33	35.37	41.39	48.01	55.01	62.28	69.72	77.29	84.95
SAAL	**Side**	**Mean**	47.67	86.00	114.33	131.33	148.67	165.00	181.33	197.67	214.00	230.33	246.67	263.00	279.33	295.67	312.00
		Std. Dev.	11.02	9.17	17.93	11.15	7.37	9.85	17.62	26.35	35.34	44.43	53.58	62.75	71.93	81.13	90.34
	Top	**Mean**	93.91	132.55	169.36	198.82	223.45	255.82	288.18	320.55	352.91	385.27	417.64	450.00	482.36	514.73	547.09
		Std. Dev.	17.01	22.17	27.21	30.72	34.57	35.12	39.63	46.98	56.07	66.17	76.90	88.02	99.40	110.96	122.66
THSP	**Side**	**Mean**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Std. Dev.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Top	**Mean**	31.80	52.00	71.90	94.90	116.00	133.50	151.00	168.50	186.00	203.50	221.00	238.50	256.00	273.50	291.00
		Std. Dev.	13.13	20.48	27.74	35.40	40.62	46.91	53.55	60.41	67.42	74.55	81.76	89.04	96.36	103.72	111.11
TIAM	**Side**	**Mean**	42.80	68.20	92.00	109.40	123.50	137.10	150.70	164.30	177.90	191.50	205.10	218.70	232.30	245.90	259.50
		Std. Dev.	15.10	21.59	20.25	20.58	21.51	24.29	28.81	34.39	40.60	47.18	54.00	60.98	68.08	75.25	82.48
	Top	**Mean**	37.88	68.38	101.63	121.38	133.38	146.50	159.63	172.75	185.88	199.00	212.13	225.25	238.38	251.50	264.63
		Std. Dev.	10.25	14.66	23.54	19.58	22.19	19.07	16.78	15.67	16.01	17.71	20.43	23.83	27.66	31.75	36.03
ULSP	**Side**	**Mean**	37.59	46.98	56.37	65.76	75.15	84.54	94.44	104.34	114.23	124.13	134.03	143.93	153.83	163.73	173.62
		Std. Dev.	16.70	19.29	21.52	21.15	21.55	23.67	26.53	29.81	33.39	37.18	41.13	45.19	49.33	53.54	57.80
	Top	**Mean**	62.00	98.00	127.90	145.40	161.80	177.00	192.20	207.40	222.60	237.80	253.00	268.20	283.40	298.60	313.80
		Std. Dev.	18.26	22.90	31.50	33.80	36.71	39.65	43.34	47.59	52.27	57.27	62.52	67.96	73.55	79.25	85.05

DUKE SPECIES CODES

Common Name	Code	Latin Name
Apple	Masp	*Malus* spp.
Arborvitae	Thsp	*Thuja* spp.
Ash, green	Frpe	*Fraxinus pennsylvanica*
Ash spp.	Frax	*Fraxinus Spp.*
Basswood, American (linden)	Tiam	*Tilia americana*
Box-elder	Acne	*Acer negundo*
Catalpa, northern	Casp	*Catalpa speciosa*
Cherry, black	Prse	*Prunus serotina*
Cottonwood, eastern	Pode	*Populus deltoides*
Elm	Ulsp	*Ulmus* spp.
Hackberry, common	Ceoc	*Celtis occidentalis*
Locust, black	Rops	*Robinia pseudoacacia*
Maple, Norway	Acpl	*Acer platanoides*
Maple, red	Acru	*Acer rubrum*
Maple, silver	Acsa	*Acer saccharinum*
Maple, sugar	Acsu	*Acer saccharum*
Mulberry	Mosp	*Morus spp.*
Oak, northern red	Quru	*Quercus rubra*
Oak, pin	Qupa	*Quercus palustris*
Oak, shingle	Quim	*Quercus imbricaria*
Oak, white	Qual	*Quercus alba*
Pear, Bradford	Pyca	*Pyrus calleryana*
Pine, eastern white	Pist	*Pinus strobus*
Pine, red	Pire	*Pinus resinosa*
Redcedar, eastern	Juvi	*Juniperus virginiana*
Sassafras	Saal	*Sassafras albidum*
Spruce, blue	Pipu	*Picea pungens*

DUKE SPECIES CODES

Common Name	Code	Latin Name
Spruce, Norway	Piab	*Picea abies*
Tuliptree (yellow-poplar)	Litu	*Liriodendron*
Walnut, black	Juni	*Juglans nigra*

6.0 Appendix B – Other Tree Contact Table Scenarios

Table 19. Urban – Original Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Urban** Designated Trees Only.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	92.9	95.6	96.9	97.6	98.0	98.3	98.5	98.7	98.8	98.9	99.0	99.1	99.1	99.2	99.2
3	81.8	87.7	90.8	92.7	94.0	95.0	95.6	96.1	96.5	96.8	97.1	97.3	97.5	97.6	97.8
4	65.9	77.0	82.8	86.3	88.6	90.2	91.4	92.4	93.2	93.8	94.3	94.7	95.1	95.4	95.7
5	47.1	63.5	72.5	78.1	81.8	84.3	86.2	87.6	88.8	89.8	90.6	91.4	92.0	92.5	92.9
6	28.7	48.8	61.1	68.8	74.0	77.7	80.4	82.4	84.1	85.4	86.6	87.5	88.4	89.1	89.8
7	15.1	35.6	50.1	59.7	66.2	71.0	74.5	77.2	79.3	81.0	82.5	83.7	84.8	85.7	86.5
8	6.9	24.7	39.9	50.7	58.4	64.1	68.4	71.7	74.3	76.5	78.3	79.8	81.1	82.2	83.2
9	2.5	15.9	30.6	42.1	50.6	57.1	62.1	66.0	69.2	71.8	73.9	75.7	77.3	78.6	79.8
10	0.9	10.2	22.8	34.2	43.2	50.2	55.8	60.3	63.9	66.8	69.3	71.4	73.2	74.8	76.2
11	0.3	6.2	16.3	26.7	35.7	43.2	49.3	54.2	58.3	61.6	64.4	66.8	68.9	70.7	72.3
12	0.2	3.6	11.3	20.2	28.8	36.3	42.7	47.9	52.4	56.1	59.2	62.0	64.4	66.4	68.2
13	0.1	1.9	7.2	14.6	22.3	29.5	35.9	41.4	46.2	50.3	53.7	56.8	59.4	61.7	63.7
14	0.1	0.9	4.3	10.0	16.4	23.2	29.5	35.1	40.1	44.4	48.1	51.4	54.3	56.9	59.1
15		0.5	2.4	6.5	11.8	17.7	23.6	29.0	34.1	38.6	42.6	46.1	49.3	52.0	54.5

Table 20. Urban – Revised Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Urban** Designated Trees Only with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	82.7	87.2	95.4	89.9	97.2	90.9	91.3	91.5	91.8	92.0	92.1	98.8	92.4	92.5	92.5
3	62.6	72.9	84.1	81.6	89.9	85.2	86.3	87.2	88.0	88.5	88.9	95.7	89.7	89.9	90.1
4	43.6	55.3	69.1	70.2	79.7	77.0	79.2	80.9	82.3	83.4	84.3	91.0	85.7	86.2	86.6
5	28.8	38.1	51.8	56.3	67.0	66.8	70.2	72.8	74.9	76.6	78.1	84.9	80.3	81.2	81.9
6	17.7	24.9	35.9	41.8	52.9	55.1	59.7	63.4	66.3	68.7	70.7	77.5	73.9	75.1	76.2
7	9.4	15.6	24.0	29.6	39.6	43.4	48.8	53.3	57.0	60.0	62.6	69.3	66.7	68.4	69.8
8	4.5	10.3	15.8	20.4	28.6	32.8	38.4	43.3	47.5	51.0	54.1	60.7	59.1	61.1	62.9
9	2.0	6.1	10.2	13.8	20.1	24.1	29.3	34.1	38.5	42.3	45.8	52.1	51.4	53.8	55.9
10	0.7	3.4	6.7	9.5	14.3	17.8	22.3	26.7	31.0	34.8	38.3	44.4	44.4	47.0	49.3
11	0.3	2.0	4.5	6.6	10.2	13.0	16.8	20.7	24.6	28.1	31.6	37.2	37.8	40.6	43.0
12	0.1	1.2	3.0	4.7	7.4	9.6	12.7	16.0	19.4	22.7	26.0	31.1	32.0	34.8	37.4
13	0.1	0.6	2.0	3.3	5.4	7.1	9.5	12.3	15.2	18.2	21.2	25.7	26.9	29.7	32.2
14	0.1	0.3	1.2	2.3	4.0	5.3	7.3	9.5	12.0	14.6	17.2	21.2	22.6	25.2	27.7
15	0.1	0.2	0.7	1.6	2.9	4.0	5.5	7.3	9.4	11.7	14.0	17.5	18.9	21.4	23.8

Table 21. Suburban – Original Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Suburban** Designated Trees Only.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	92.7	95.5	96.8	97.5	98.0	98.3	98.5	98.7	98.8	98.9	99.0	99.0	99.1	99.1	99.2
3	81.0	87.3	90.5	92.5	93.8	94.8	95.5	96.0	96.4	96.8	97.0	97.2	97.4	97.6	97.7
4	64.6	76.1	82.1	85.8	88.2	89.9	91.2	92.2	93.0	93.6	94.2	94.6	95.0	95.3	95.6
5	46.1	62.6	71.9	77.6	81.3	84.0	85.9	87.4	88.7	89.7	90.5	91.2	91.9	92.4	92.8
6	27.7	47.9	60.3	68.2	73.5	77.3	80.0	82.2	83.9	85.2	86.4	87.4	88.3	89.0	89.7
7	14.5	34.9	49.4	59.0	65.6	70.5	74.1	76.8	79.1	80.8	82.3	83.6	84.6	85.6	86.4
8	6.5	24.1	39.2	50.0	57.7	63.5	67.9	71.3	74.0	76.2	78.0	79.6	80.9	82.0	83.1
9	2.5	15.6	30.0	41.4	50.0	56.5	61.6	65.6	68.8	71.4	73.6	75.4	77.0	78.4	79.6
10	0.9	9.9	22.2	33.5	42.4	49.6	55.2	59.7	63.4	66.4	68.9	71.1	72.9	74.5	75.9
11	0.3	6.0	15.8	26.1	35.1	42.5	48.7	53.6	57.7	61.2	64.0	66.4	68.6	70.4	72.0
12	0.2	3.5	10.9	19.7	28.2	35.6	42.0	47.3	51.8	55.6	58.8	61.5	63.9	66.0	67.9
13	0.1	1.9	6.9	14.1	21.7	28.9	35.2	40.8	45.6	49.8	53.3	56.3	59.0	61.3	63.4
14	0.1	0.9	4.2	9.7	16.0	22.6	28.9	34.5	39.5	43.9	47.7	51.0	53.9	56.5	58.8
15		0.4	2.4	6.3	11.4	17.2	23.0	28.5	33.5	38.1	42.1	45.6	48.8	51.6	54.1

Table 22. Suburban – Revised Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Suburban** Designated Trees Only with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	82.1	86.7	95.4	89.4	97.2	90.4	90.7	91.0	91.3	91.5	91.6	98.8	91.9	92.0	92.0
3	62.2	72.4	84.1	81.1	90.0	84.7	85.9	86.8	87.5	88.0	88.5	95.7	89.2	89.5	89.6
4	43.6	55.1	69.2	69.8	79.8	76.6	78.8	80.5	81.9	83.0	83.8	91.1	85.2	85.8	86.2
5	28.7	38.0	51.9	56.0	67.1	66.4	69.8	72.4	74.5	76.2	77.7	84.9	79.9	80.8	81.5
6	17.6	24.8	36.0	41.6	52.9	54.8	59.4	63.0	66.0	68.3	70.3	77.5	73.5	74.8	75.8
7	9.3	15.6	24.2	29.5	39.6	43.1	48.6	53.0	56.7	59.7	62.3	69.3	66.4	68.0	69.4
8	4.4	10.4	15.9	20.3	28.6	32.7	38.2	43.1	47.3	50.7	53.8	60.7	58.8	60.8	62.6
9	1.9	6.2	10.3	13.8	20.1	24.0	29.1	33.9	38.3	42.1	45.5	52.1	51.1	53.5	55.6
10	0.7	3.5	6.7	9.4	14.3	17.7	22.2	26.5	30.8	34.5	38.0	44.3	44.1	46.7	49.0
11	0.2	2.0	4.5	6.6	10.2	12.9	16.7	20.5	24.4	27.9	31.4	37.2	37.6	40.3	42.8
12	0.1	1.2	3.0	4.7	7.4	9.6	12.6	15.9	19.2	22.5	25.8	31.0	31.8	34.6	37.1
13	0.1	0.7	2.0	3.3	5.4	7.0	9.4	12.2	15.1	18.0	21.0	25.6	26.7	29.4	32.0
14	0.1	0.3	1.2	2.3	4.0	5.3	7.2	9.4	11.9	14.5	17.1	21.2	22.4	25.0	27.5
15	0.1	0.2	0.7	1.6	2.9	3.9	5.4	7.3	9.3	11.6	13.9	17.5	18.8	21.2	23.6

Table 23. Rural – Original Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Rural** Designated Trees Only.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	92.7	95.4	96.7	97.5	97.9	98.3	98.5	98.7	98.8	98.9	99.0	99.0	99.1	99.1	99.2
3	80.8	87.1	90.4	92.4	93.8	94.8	95.5	96.0	96.4	96.7	97.0	97.2	97.4	97.6	97.7
4	63.9	75.6	81.8	85.5	88.0	89.8	91.1	92.1	92.9	93.6	94.1	94.5	94.9	95.3	95.5
5	45.5	62.2	71.5	77.3	81.1	83.8	85.8	87.3	88.6	89.6	90.5	91.2	91.8	92.4	92.8
6	27.2	47.5	59.9	67.9	73.2	77.1	79.9	82.1	83.8	85.2	86.3	87.3	88.2	89.0	89.6
7	14.2	34.6	49.0	58.6	65.4	70.3	73.9	76.7	78.9	80.7	82.2	83.5	84.6	85.6	86.4
8	6.3	23.8	38.8	49.6	57.4	63.2	67.6	71.1	73.8	76.0	77.9	79.4	80.8	82.0	83.0
9	2.5	15.4	29.7	41.0	49.7	56.2	61.4	65.3	68.6	71.2	73.4	75.3	76.9	78.3	79.5
10	0.9	9.8	21.9	33.1	42.1	49.2	54.9	59.4	63.2	66.2	68.7	70.9	72.8	74.4	75.8
11	0.3	5.9	15.5	25.8	34.7	42.2	48.3	53.3	57.5	60.9	63.8	66.2	68.4	70.3	71.9
12	0.2	3.4	10.7	19.4	27.8	35.2	41.6	46.9	51.5	55.3	58.5	61.3	63.7	65.9	67.7
13	0.1	1.8	6.8	13.9	21.4	28.5	34.9	40.5	45.4	49.5	53.0	56.1	58.8	61.1	63.2
14	0.1	0.9	4.2	9.6	15.8	22.3	28.6	34.2	39.3	43.7	47.4	50.8	53.7	56.3	58.6
15		0.4	2.4	6.2	11.2	16.9	22.7	28.2	33.2	37.8	41.8	45.4	48.6	51.4	53.9

Table 24. Rural – Revised Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Rural** Designated Trees Only with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	81.6	86.1	95.4	88.7	97.2	89.8	90.1	90.4	90.7	90.9	91.0	98.8	91.3	91.4	91.4
3	62.0	72.0	84.2	80.6	90.0	84.2	85.3	86.2	87.0	87.5	87.9	95.7	88.6	88.9	89.1
4	43.6	54.9	69.3	69.4	79.9	76.2	78.3	80.0	81.4	82.5	83.3	91.1	84.7	85.3	85.6
5	28.6	37.8	51.9	55.6	67.1	66.0	69.4	72.0	74.1	75.8	77.2	85.0	79.4	80.3	81.0
6	17.5	24.6	36.0	41.4	52.9	54.5	59.1	62.7	65.6	67.9	69.9	77.5	73.1	74.3	75.4
7	9.1	15.5	24.2	29.3	39.6	42.9	48.3	52.7	56.4	59.3	61.9	69.4	66.0	67.6	69.0
8	4.4	10.4	15.9	20.2	28.6	32.5	38.0	42.8	47.0	50.4	53.5	60.7	58.4	60.5	62.2
9	1.9	6.2	10.3	13.7	20.1	23.8	29.0	33.7	38.0	41.8	45.2	52.1	50.8	53.2	55.2
10	0.7	3.5	6.8	9.4	14.3	17.6	22.1	26.4	30.6	34.3	37.8	44.3	43.8	46.4	48.7
11	0.2	2.0	4.5	6.6	10.2	12.8	16.6	20.4	24.2	27.8	31.2	37.2	37.4	40.1	42.5
12	0.1	1.2	3.0	4.7	7.4	9.5	12.5	15.7	19.1	22.3	25.6	31.0	31.6	34.4	36.9
13	0.1	0.7	2.0	3.3	5.4	7.0	9.4	12.1	15.0	17.9	20.8	25.6	26.5	29.2	31.8
14		0.3	1.2	2.3	4.0	5.3	7.1	9.4	11.8	14.4	17.0	21.2	22.3	24.9	27.3
15		0.1	0.7	1.6	2.9	3.9	5.4	7.2	9.3	11.5	13.7	17.4	18.6	21.0	23.4

Table 25. Agricultural – Original Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Agricultural** Designated Trees Only.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	92.4	95.2	96.6	97.4	97.9	98.2	98.4	98.6	98.8	98.9	98.9	99.0	99.1	99.1	99.2
3	80.5	86.8	90.1	92.2	93.6	94.6	95.3	95.9	96.3	96.6	96.9	97.1	97.3	97.5	97.7
4	63.8	75.3	81.4	85.3	87.7	89.5	90.9	91.9	92.7	93.4	94.0	94.4	94.8	95.2	95.5
5	45.4	61.9	71.2	77.0	80.8	83.6	85.5	87.1	88.4	89.4	90.3	91.0	91.7	92.2	92.7
6	27.1	47.2	59.7	67.6	73.0	76.8	79.6	81.8	83.5	84.9	86.1	87.1	88.0	88.8	89.5
7	14.5	34.6	49.0	58.5	65.2	70.1	73.7	76.5	78.7	80.5	82.0	83.3	84.4	85.4	86.2
8	6.6	24.1	39.0	49.6	57.4	63.2	67.5	71.0	73.7	75.9	77.7	79.3	80.7	81.8	82.8
9	2.6	15.5	29.8	41.0	49.6	56.2	61.2	65.2	68.4	71.1	73.2	75.1	76.7	78.1	79.3
10	0.9	10.0	22.0	33.2	42.1	49.2	54.9	59.4	63.1	66.1	68.6	70.7	72.6	74.2	75.6
11	0.3	6.1	15.6	25.9	34.8	42.2	48.4	53.3	57.4	60.9	63.7	66.2	68.3	70.1	71.7
12	0.2	3.5	10.8	19.5	28.0	35.3	41.7	47.0	51.5	55.3	58.5	61.3	63.7	65.8	67.6
13	0.1	1.9	6.9	14.0	21.6	28.6	35.0	40.6	45.4	49.5	53.0	56.1	58.7	61.1	63.1
14	0.1	0.9	4.2	9.7	16.0	22.5	28.7	34.4	39.4	43.7	47.5	50.8	53.7	56.3	58.6
15		0.4	2.4	6.3	11.3	17.0	22.8	28.3	33.3	37.9	41.8	45.4	48.6	51.3	53.8

Table 26. Agricultural – Revised Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Agricultural** Designated Trees Only with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	80.8	85.4	95.3	88.0	97.1	89.0	89.4	89.7	90.0	90.1	90.3	98.8	90.6	90.7	90.7
3	61.5	71.5	84.1	79.9	90.0	83.5	84.6	85.5	86.3	86.8	87.2	95.7	87.9	88.2	88.4
4	43.1	54.4	69.2	68.8	79.8	75.5	77.6	79.3	80.7	81.8	82.6	91.1	84.0	84.6	84.9
5	28.3	37.4	51.9	55.2	67.1	65.5	68.8	71.3	73.5	75.1	76.6	84.9	78.8	79.7	80.3
6	17.4	24.4	36.1	41.1	53.0	54.1	58.6	62.2	65.1	67.3	69.3	77.5	72.5	73.7	74.8
7	9.1	15.4	24.3	29.2	39.7	42.6	48.0	52.3	56.0	58.9	61.4	69.4	65.5	67.1	68.5
8	4.4	10.4	16.0	20.1	28.7	32.3	37.8	42.5	46.7	50.1	53.1	60.8	58.0	60.0	61.7
9	2.0	6.3	10.4	13.7	20.3	23.7	28.9	33.5	37.9	41.6	45.0	52.2	50.5	52.8	54.9
10	0.7	3.5	6.8	9.4	14.4	17.5	22.0	26.3	30.5	34.2	37.6	44.4	43.6	46.1	48.4
11	0.2	2.1	4.5	6.6	10.3	12.8	16.6	20.4	24.2	27.7	31.1	37.3	37.2	39.8	42.2
12	0.1	1.2	3.0	4.7	7.5	9.5	12.5	15.8	19.1	22.3	25.5	31.1	31.5	34.2	36.7
13	0.1	0.7	2.0	3.3	5.5	7.0	9.4	12.1	15.0	17.9	20.8	25.7	26.4	29.1	31.6
14		0.3	1.2	2.2	4.0	5.3	7.2	9.4	11.8	14.3	16.9	21.3	22.2	24.8	27.2
15		0.1	0.7	1.7	2.9	3.9	5.4	7.3	9.3	11.5	13.7	17.5	18.6	21.0	23.3

Table 27. Multi-Phase – Original Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Multi-Phase** Designated Trees Only.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	91.7	94.9	96.3	97.1	97.6	98.0	98.2	98.4	98.6	98.7	98.8	98.9	99.0	99.1	99.1
3	82.3	87.2	90.1	92.0	93.4	94.4	95.2	95.8	96.2	96.6	96.9	97.1	97.3	97.5	97.6
4	67.5	76.8	82.3	85.6	87.9	89.5	90.8	91.9	92.7	93.5	94.0	94.5	94.9	95.2	95.5
5	46.8	63.3	72.0	77.6	81.2	83.8	85.7	87.2	88.5	89.6	90.5	91.2	91.8	92.4	92.8
6	29.5	50.8	62.0	69.4	74.4	78.0	80.6	82.6	84.2	85.5	86.6	87.6	88.4	89.2	89.8
7	15.6	37.5	51.2	60.5	66.7	71.3	74.7	77.3	79.4	81.1	82.5	83.6	84.7	85.6	86.4
8	7.1	26.4	41.2	52.1	59.4	64.8	69.0	72.2	74.7	76.8	78.5	79.9	81.2	82.2	83.2
9	2.4	17.2	32.0	43.8	52.0	58.3	63.2	67.0	70.1	72.5	74.5	76.2	77.7	78.9	80.0
10	0.5	10.7	24.0	35.7	44.5	51.4	56.9	61.1	64.7	67.5	69.8	71.8	73.6	75.1	76.4
11	0.2	6.7	17.9	28.7	37.5	44.8	50.8	55.6	59.5	62.7	65.4	67.6	69.7	71.4	72.9
12		3.5	12.4	22.1	30.4	37.8	44.3	49.4	53.7	57.3	60.3	62.7	65.1	67.1	68.8
13		1.9	8.3	16.2	24.0	31.2	37.9	43.3	48.0	51.9	55.1	57.9	60.5	62.7	64.7
14		0.9	4.9	11.0	17.8	24.6	31.2	36.7	41.7	45.8	49.4	52.5	55.4	57.9	60.0
15		0.2	2.7	7.0	12.6	18.6	24.9	30.5	35.6	39.9	43.8	47.2	50.4	53.1	55.4

Table 28. Multi-Phase – Revised Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Multi-Phase** Designated Trees Only with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	87.6	92.6	94.8	96.0	96.8	97.3	97.7	98.0	98.2	98.3	98.5	98.6	98.7	98.7	98.8
3	63.9	76.0	82.4	86.2	88.7	90.6	91.9	92.9	93.7	94.3	94.8	95.2	95.5	95.8	96.0
4	44.6	57.7	68.0	74.5	79.0	82.1	84.5	86.3	87.8	89.0	89.9	90.7	91.4	91.9	92.5
5	30.1	39.6	50.9	59.9	66.4	71.3	74.8	77.6	79.8	81.7	83.3	84.5	85.6	86.5	87.4
6	20.0	26.3	35.9	45.1	52.8	59.3	64.2	67.9	71.0	73.4	75.6	77.4	79.0	80.3	81.5
7	10.6	17.0	24.1	32.2	39.9	46.9	52.7	57.4	61.2	64.3	67.0	69.3	71.3	73.0	74.6
8	5.4	10.5	15.8	22.3	28.9	35.3	41.3	46.5	51.0	54.7	58.0	60.8	63.3	65.4	67.3
9	2.1	5.9	10.3	15.0	20.1	25.7	31.3	36.6	41.5	45.7	49.2	52.4	55.2	57.7	59.9
10	0.8	3.9	7.2	10.8	14.8	19.5	24.3	29.3	34.0	38.1	41.7	45.1	48.0	50.8	53.2
11	0.3	2.6	4.9	7.5	10.5	14.3	18.5	22.8	27.0	30.9	34.5	37.9	41.1	44.0	46.6
12		1.6	3.1	5.4	7.8	10.8	14.3	17.9	21.5	25.1	28.5	31.9	35.0	37.9	40.6
13		1.0	2.2	3.8	5.7	8.0	10.7	13.8	16.9	20.2	23.4	26.5	29.5	32.4	35.1
14		0.3	1.5	2.7	4.4	6.3	8.5	11.1	13.7	16.7	19.5	22.4	25.3	28.1	30.8
15		0.2	0.9	1.8	3.1	4.6	6.5	8.7	11.0	13.6	16.1	18.8	21.5	24.2	26.8

Table 29. Single-Phase – Original Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Single-Phase** Designated Trees Only.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	92.3	95.4	96.7	97.4	97.8	98.2	98.4	98.6	98.7	98.8	98.9	99.0	99.1	99.1	99.2
3	81.4	87.4	90.4	92.4	93.7	94.7	95.4	95.9	96.4	96.7	97.0	97.2	97.4	97.5	97.7
4	66.9	76.7	82.4	86.0	88.2	89.9	91.1	92.1	92.9	93.6	94.1	94.6	95.0	95.3	95.6
5	47.1	63.3	72.1	77.7	81.4	84.0	85.8	87.3	88.5	89.6	90.4	91.2	91.8	92.3	92.8
6	28.4	48.8	60.5	68.2	73.5	77.2	79.9	82.0	83.6	85.0	86.1	87.1	88.0	88.8	89.4
7	14.6	35.1	49.2	58.8	65.4	70.2	73.8	76.4	78.6	80.4	81.8	83.1	84.1	85.1	86.0
8	6.6	24.2	39.2	50.1	57.7	63.4	67.7	71.0	73.7	75.9	77.7	79.2	80.5	81.6	82.6
9	2.1	15.6	30.0	41.6	50.1	56.5	61.6	65.5	68.6	71.2	73.4	75.1	76.7	78.0	79.2
10	0.5	9.9	22.4	33.7	42.6	49.6	55.2	59.6	63.1	66.1	68.6	70.7	72.5	74.1	75.5
11	0.2	5.9	16.1	26.2	34.9	42.3	48.5	53.4	57.4	60.8	63.6	66.0	68.1	69.9	71.5
12		3.5	11.2	19.9	28.0	35.4	41.9	47.2	51.6	55.3	58.4	61.1	63.5	65.5	67.3
13		1.8	7.2	14.3	21.6	28.8	35.4	40.9	45.6	49.6	53.1	56.1	58.7	61.0	63.0
14		1.0	4.3	9.7	15.8	22.1	28.6	34.2	39.1	43.4	47.2	50.4	53.3	55.9	58.1
15		0.4	2.5	6.2	11.2	16.6	22.6	28.1	33.2	37.7	41.8	45.2	48.4	51.2	53.6

Table 30. Single-Phase – Revised Estimated Average System Tree/Conductor Contact by Cycle Length for Varying Pruning Clearances for **Single-Phase** Designated Trees Only with Directional Growth Factor.

Clearance (feet)	1-Yr. Cycle	2-Yr. Cycle	3-Yr. Cycle	4-Yr. Cycle	5-Yr. Cycle	6-Yr. Cycle	7-Yr. Cycle	8-Yr. Cycle	9-Yr. Cycle	10-Yr. Cycle	11-Yr. Cycle	12-Yr. Cycle	13-Yr. Cycle	14-Yr. Cycle	15-Yr. Cycle
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	88.4	92.8	94.9	96.1	96.9	97.4	97.7	98.0	98.2	98.4	98.5	98.6	98.7	98.8	98.9
3	65.5	76.8	82.8	86.5	89.0	90.7	92.0	93.0	93.8	94.4	94.9	95.3	95.6	95.9	96.1
4	44.7	57.5	67.4	73.9	78.4	81.6	84.1	86.0	87.5	88.6	89.6	90.4	91.1	91.7	92.2
5	29.0	38.9	50.0	59.0	65.7	70.6	74.3	77.1	79.3	81.3	82.9	84.2	85.3	86.2	87.1
6	18.3	25.2	34.7	44.1	52.0	58.5	63.4	67.3	70.4	72.9	75.1	76.9	78.5	79.9	81.1
7	9.4	15.8	23.1	31.0	38.8	45.9	51.7	56.5	60.4	63.6	66.4	68.8	70.8	72.5	74.1
8	4.7	9.5	14.9	21.1	27.7	34.5	40.5	45.7	50.2	54.0	57.3	60.2	62.7	64.8	66.7
9	2.1	5.7	9.6	14.5	19.7	25.4	31.0	36.1	40.9	45.1	48.8	52.0	54.8	57.2	59.5
10	0.8	3.3	6.3	10.1	14.2	19.0	23.9	28.6	33.2	37.3	41.0	44.5	47.4	50.1	52.6
11	0.2	2.1	4.3	7.0	10.1	13.9	17.9	22.0	26.3	30.2	33.9	37.4	40.5	43.3	46.0
12		1.1	2.7	4.9	7.3	10.1	13.5	17.0	20.7	24.2	27.7	31.1	34.2	37.1	39.9
13		0.6	1.8	3.4	5.3	7.4	10.0	13.0	16.1	19.4	22.6	25.9	28.8	31.6	34.4
14		0.3	1.1	2.3	3.9	5.6	7.6	10.1	12.8	15.6	18.5	21.5	24.3	27.0	29.8
15		0.2	0.7	1.6	2.9	4.2	5.8	7.8	10.0	12.5	15.0	17.8	20.4	23.0	25.6

VERIFICATION

I hereby verify under the penalties of perjury that the foregoing representations are true to the best of my knowledge, information and belief.

Signed: T.K. Christie

TK Christie

Dated: 7/2/2019