

BEFORE THE CORPORATION COMMISSION OF OKLAHOMA

APPLICATION OF PUBLIC SERVICE COMPANY
OF OKLAHOMA, AN OKLAHOMA
CORPORATION, FOR AN ADJUSTMENT IN ITS
RATES AND CHARGES AND THE ELECTRIC
SERVICE RULES, REGULATIONS AND
CONDITIONS OF SERVICE FOR ELECTRIC
SERVICE IN THE STATE OF OKLAHOMA

CAUSE NO. PUD 201700151

RESPONSIVE TESTIMONY OF

DAVID J. GARRETT

FILED
SEP 21 2017

COURT CLERK'S OFFICE - OKC
CORPORATION COMMISSION
OF OKLAHOMA

PART II – DEPRECIATION

ON BEHALF OF
**OKLAHOMA INDUSTRIAL ENERGY CONSUMERS,
WAL-MART STORES EAST, LP, AND
SAM'S EAST, INC.**

IN RESPONSE TO THE DIRECT TESTIMONIES OF
JOHN J. SPANOS AND THOMAS J. MEEHAN

SEPTEMBER 21, 2017

TABLE OF CONTENTS

I.	INTRODUCTION	4
II.	EXECUTIVE SUMMARY	5
III.	LEGAL STANDARDS	12
IV.	ANALYTIC METHODS.....	14
V.	LIFE SPAN PROPERTY ANALYSIS	16
A.	Interim Retirement Analysis.....	17
B.	Terminal Net Salvage Analysis (Decommissioning Costs)	17
1.	Contingency Factor.....	22
2.	Escalation Factor	24
VI.	MASS PROPERTY ANALYSIS	26
A.	Service Life Estimates	27
B.	Detailed Analysis of Select Accounts.....	29
1.	Account 356 – Overhead Conductors and Devices	32
2.	Account 362 – Station Equipment.....	34
3.	Account 364 – Poles, Towers and Fixtures	37
4.	Account 366 – Underground Conduit.....	39
5.	Account 373 – Street Lighting and Signal Systems	41
6.	Account 390 – Structures and Improvements.....	45
VII.	ACCOUNT 303 – SOFTWARE	46
VIII.	CONCLUSION AND RECOMMENDATION	50

APPENDICES

Appendix A: The Depreciation System

Appendix B: Iowa Curves

Appendix C: Actuarial Analysis

LIST OF EXHIBITS

DJG-2-1	Curriculum Vitae
DJG-2-2	Summary Expense Adjustment (6-30-17 Plant)
DJG-2-3	Detailed Expense Adjustment (6-30-17 Plant)
DJG-2-4	Detailed Rate Comparison (12-31-16 Plant)
DJG-2-5	Depreciation Rate Development (12-31-16 Plant)
DJG-2-6	Weighted Net Salvage
DJG-2-7	Terminal Net Salvage
DJG-2-8	Diesel Allocations
DJG-2-9	Account 303 – Software Adjustment
DJG-2-10	Account 356 Curve Fitting
DJG-2-11	Account 362 Curve Fitting
DJG-2-12	Account 364 Curve Fitting
DJG-2-13	Account 366 Curve Fitting
DJG-2-14	Account 373 Curve Fitting
DJG-2-15	Account 390 Curve Fitting
DJG-2-16	Observed Life Tables and Iowa Curve Fitting
DJG-2-17	Remaining Life Development
DJG-2-18	Gannett Fleming 15-year Recommendation for Account 303 (Software)

INTRODUCTION

Q. State your name and occupation.

1 A. My name is David J. Garrett. I am a consultant specializing in public utility regulation. I
2 am the managing member of Resolve Utility Consulting, PLLC. I focus my practice on
3 the primary capital recovery mechanisms for public utility companies: cost of capital and
4 depreciation.

Q. Summarize your educational background and professional experience.

5 A. I received a B.B.A. degree with a major in Finance, an M.B.A. degree, and a Juris Doctor
6 degree from the University of Oklahoma. I worked in private legal practice for several
7 years before accepting a position as assistant general counsel at the Oklahoma Corporation
8 Commission in 2011. At the Oklahoma Commission, I worked in the Office of General
9 Counsel in regulatory proceedings. In 2012, I began working for the Public Utility
10 Division as a regulatory analyst providing testimony in regulatory proceedings. After
11 leaving the Oklahoma Commission, I formed Resolve Utility Consulting, PLLC, where I
12 have represented various consumer groups and state agencies in utility regulatory
13 proceedings, primarily in the areas of cost of capital and depreciation. I am a Certified
14 Depreciation Professional through the Society of Depreciation Professionals. I am also a
15 Certified Rate of Return Analyst through the Society of Utility and Regulatory Financial
16 Analysts. A more complete description of my qualifications and regulatory experience is
17 included in my curriculum vitae.¹

¹ Direct Exhibit DJG-2-1.

1
2
3
4
5
6
7
8
9
10

Q. On whose behalf are you testifying in this proceeding?

A. I am testifying on behalf of Oklahoma Industrial Energy Consumers ("OIEC") and Wal-Mart Stores East, LP, and Sam's East, Inc. (collectively, "Wal-Mart").

Q. Describe the purpose and scope of your testimony in this proceeding.

A. In this case I am testifying in response to the direct testimonies of four witnesses of Public Service Company of Oklahoma ("PSO" or the Company). Part I of my responsive testimony (a separate document) addresses the direct testimony of Pauline M. Ahern regarding general ratemaking theory and fair rate of return principles. Part II of my responsive testimony (this document) addresses the direct testimony of John J. Spanos regarding PSO's proposed depreciation rates, and it also addresses the direct testimony of Thomas J. Meehan regarding PSO's proposed decommissioning costs, which directly affects the Company's production net salvage and depreciation rates.

I. EXECUTIVE SUMMARY

Q. Summarize the key points of your testimony.

A. In this case, PSO is proposing a substantial increase to depreciation expense of about \$40 million. As demonstrated by the evidence presented in this testimony, it would not be reasonable to accept PSO's filed position regarding depreciation expense. PSO's proposed increase to depreciation expense is unreasonable due to several factors, which are summarized as follows:

11
12
13
14
15
16
17
18

- 1 1. In contradiction to the Commission's recent order in PSO's prior
2 rate case, PSO is proposing to add contingency and escalation
3 factors to the Company's terminal decommissioning costs, which
4 unreasonably increases the proposed depreciation expense for
5 PSO's production accounts.²

- 6 2. For several transmission, distribution, and general accounts, PSO is
7 proposing service lives that are shorter than those indicated by the
8 Company's historical retirement data, which results in unreasonably
9 high proposed depreciation rates for these accounts.

- 10 3. PSO chose to exclude a substantial account from its depreciation
11 study – Account 303 – which includes a balance of more than \$50
12 million for the Company's software systems. PSO is proposing an
13 amortization period of only five years, and has offered virtually no
14 support or justification for this position. PSO's own witness has
15 recommended amortization periods of up to 15 years for this
16 account.

17 For these reasons, it would not be reasonable to accept the Company's proposed increase
18 to depreciation expense. OIEC and Wal-Mart are proposing two options for adjustments
19 to PSO's proposed increase to depreciation expense, which are summarized as follows: (1)
20 Option One involves accepting portions of PSO's proposed rate increases for its production
21 accounts, as explained further below, while removing the escalation and contingency
22 factors from its proposed decommissioning costs, pursuant to the Commission's recent
23 order in PSO's prior rate case. In addition, the depreciation rates that were recently ordered
24 for PSO's transmission, distribution, and general accounts would stay the same. Finally,
25 Option One would also include OIEC and Wal-Mart's proposed adjustment to Account
26 303, since that issue was not addressed in PSO's prior rate case. Accepting Option One
27 would result in an increase to PSO's current depreciation expense of about \$9 million. (2)
28 Option Two involves changing PSO's currently-approved depreciation rates based on the

² Order No. 657877 p. 7, Cause No. PUD 201500208.

1 Company's proposal offered in this case with reasonable adjustments. Accepting Option
 2 Two would result in a substantial increase of about \$22 million to PSO's current
 3 depreciation expense. Option One is the preferable choice in this case. Although accepting
 4 Option One would result in a substantial increase in depreciation expense for PSO, it would
 5 also provide more relief to rate payers than Option Two, in light of the significant base rate
 6 increase proposed by PSO in this case. The impact to depreciation expense resulting from
 7 both options is illustrated below in the following tables.

**Figure 1:
 Option One: Accept Rate Increases to Production Plant**

Plant Function	Plant Balance 6/30/2017	PSO Proposal	OIEC Proposal	OIEC Adjustment
Intangible	\$ 51,158,691	\$ 10,002,988	\$ 5,009,816	\$ (4,993,173)
Production	1,562,178,971	59,052,499	53,223,445	(5,829,054)
Transmission	845,997,944	21,245,650	18,166,631	(3,079,019)
Distribution	2,389,887,504	78,220,567	65,282,209	(12,938,358)
General	169,512,415	5,952,814	3,730,822	(2,221,992)
Northeastern 4				(4,141,553)
Total	\$ 5,018,735,525	\$ 174,076,209	\$ 145,014,613	\$ (33,203,149)

8 Accepting Option One would increase PSO's current depreciation expense by about \$9
 9 million, and would be more reflective of the rates recently approved by the Commission.

**Figure 2:
 Option Two: Consider Rate Changes for All Accounts**

Plant Function	Plant Balance 6/30/2017	PSO Proposal	OIEC Proposal	OIEC Adjustment
Intangible	\$ 51,158,691	\$ 10,002,988	\$ 5,009,816	\$ (4,993,173)
Production	1,562,178,971	59,052,499	53,223,445	(5,829,054)
Transmission	845,997,944	21,245,650	20,568,389	(677,261)
Distribution	2,389,887,504	78,220,567	74,351,620	(3,868,947)
General	169,512,415	5,952,814	5,560,389	(392,425)
Northeastern 4				(4,141,553)
Total	\$ 5,018,735,525	\$ 174,076,209	\$ 158,315,350	\$ (19,902,412)

1 Accepting Option Two would result in a substantial increase of about \$22 million to PSO's
2 depreciation expense.

3 **Q. Why is it reasonable to adopt PSO's proposed rate increases for its production**
4 **accounts as contemplated under Option One?**

5 A. The depreciation rates for PSO's production accounts are determined under the life span
6 method, which seeks to recover the investments in each production plant over its estimated
7 life span. The basic formula to calculate these rates is dividing the original cost investments
8 in each plant by the plant's estimated service life. When the Company makes investments
9 in its production units between rate case, the numerator of the depreciation rate formula
10 increases due to increased costs, however, the denominator decreases as the plants move
11 toward their retirement dates. As a result, the depreciation rates must increase to recover
12 more costs over a shorter amount of time. Thus, to the extent that PSO's production plant
13 investments since its prior rate case are deemed prudent, the Company should be allowed
14 to recover those costs (less reasonable adjustments to terminal net salvage pursuant to the
15 Commission's prior order).

16 **Q. Why is Option One the better option in this case?**

17 A. Depreciation rates affect the timing of recovery for the Company's capital investments.
18 Due to the nature of how depreciation rates are estimated and developed, they usually do
19 not drastically change from year to year unless new information is available indicating
20 otherwise. The issue of depreciation rates was highly contested in PSO's most recent rate
21 case, and several witnesses representing various parties offered evidence and testimony in
22 support of their positions. Ultimately, the ALJ and the Commission rejected PSO's

1 proposal and chose to accept the rates proposed by PUD and OIEC. Specifically, the
2 Commission ordered:

3 The Commission adopts the distribution plant depreciation rates
4 recommended by PUD Witness David Garrett and the production plant and
5 transmission plant depreciation rates recommended by OIEC Witness Jack
6 Pous. With respect to general plant, the Commission adopts the
7 recommendations of David Garrett for life spans for salvage value.”³

8 These depreciation rates approved by the Commission have not even been in place for a
9 full year, yet PSO is proposing a substantial increase greater than \$40 million to
10 depreciation expense in this case, which represents a 35% increase. While Option One
11 would also result in an increase to depreciation expense, it would at least partially mitigate
12 the harmful financial impact to Oklahoma ratepayers while allowing the rates most recently
13 approved by the Commission to remain in effect for more than a mere calendar year.
14 Furthermore, Option One also considers two other important issues – the unreasonably
15 short amortization period for Account 303, and the recovery of Northeastern Unit 4 assets.

Q. Mr. Spanos states that some of the depreciation rates approved by the Commission in PSO’s last rate case are outside industry norms. Do you have any response to those assertions?

16 A. Yes. On page 7 of his direct testimony, Mr. Spanos states that some of the service lives
17 approved by the Commission in PSO’s last rate case exceed “the typical range of estimates
18 for other utilities.”⁴ In support of this assertion, Mr. Spanos provides a table showing what
19 he describes as an “industry range” for the accounts he discusses. However, these ranges
20 provided by Mr. Spanos are based on recommendations made by Gannett Fleming in other

³ Order No. 657877 p. 7, Cause No. PUD 201500208.

⁴ Direct Testimony of John J. Spanos, p. 7:3-4.

1 cases, and are not entirely based on service lives ordered in other jurisdictions. Of course,
2 as is often the case, the service lives proposed by utility witnesses such as Gannett Fleming
3 are often adjusted upward, which results in lower depreciation rates.

Q. Summarize the primary factors driving OIEC and Wal-Mart's adjustment.

4 A. As discussed above, it is OIEC and Wal-Mart's primary recommendation that the
5 Commission accept Option One as proposed above and in the attached exhibits.⁵ The
6 remainder of this testimony primarily focuses on factors driving the adjustments considered
7 in Option Two, though there is some overlap (e.g., adjustment to Account 303 – Software).
8 There are four primary factors driving OIEC and Wal-Mart's adjustments in this case.
9 These factors, along with their estimated dollar impact on the final adjustment are as
10 follows: (1) adjusting PSO's proposed depreciation rates on its production units by
11 removing the contingency and escalation factors from its proposed decommission costs
12 (\$5.8 million); (2) extending the proposed service lives for several of PSO's mass property
13 accounts (\$4.8 million); (3) extending the proposed service life of PSO's intangible
14 software account (\$5 million); and (4) removing the proposed depreciation expense
15 associated with Northeastern Unit 4.⁶

Q. Describe why it is important not to overestimate depreciation rates.

16 A. The issue of depreciation is essentially one of timing. Under the rate base rate of return
17 model, the utility is allowed to recover the original cost of its prudent investments required
18 to provide service. Depreciation systems are designed to allocate those costs in a

⁵ See specifically Exhibit DJG-2-3.

⁶ See responsive testimony of Mark E. Garrett.

1 systematic and rational manner – specifically, over the service life of the utility’s assets. If
2 depreciation rates are overestimated (i.e., service lives are underestimated), it encourages
3 economic inefficiency. Unlike competitive firms, regulated utility companies are not
4 always incentivized by natural market forces to make the most economically efficient
5 decisions. If a utility is allowed to recover the cost of an asset before the end of its useful
6 life, this could incentivize the utility to unnecessarily replace the asset in order to increase
7 rate base, which results in economic waste. Thus, from a public policy perspective, it is
8 preferable for regulators to ensure that assets are not depreciated before the end of their
9 true useful lives. While underestimating the useful lives of depreciable assets could
10 financially harm current ratepayers and encourage economic waste, unintentionally
11 overestimating depreciable lives (i.e., underestimating depreciation rates) does not harm
12 the Company. This is because if an asset’s life is overestimated, there are a variety of
13 measures that regulators can use to ensure the utility is not financially harmed. One such
14 measure would be the use of a regulatory asset account. In that case, the Company’s
15 original cost investment in these assets would remain in the Company’s rate base until they
16 are recovered. Moreover, since the Company’s awarded and earned returns on equity are
17 far above its true cost of equity, the Company’s shareholders further benefit from the excess
18 wealth transfer from ratepayers while these costs are in rate base. Thus, the process of
19 depreciation strives for a perfect match between actual and estimated useful life. When
20 these estimates are not exact, however, it is better that useful lives are overestimated rather
21 than underestimated.

II. LEGAL STANDARDS

Q. Discuss the standard by which regulated utilities are allowed to recover depreciation expense.

1 A. In *Lindheimer v. Illinois Bell Telephone Co.*, the U.S. Supreme Court stated that
2 “depreciation is the loss, not restored by current maintenance, which is due to all the factors
3 causing the ultimate retirement of the property. These factors embrace wear and tear,
4 decay, inadequacy, and obsolescence.”⁷ The *Lindheimer* Court also recognized that the
5 original cost of plant assets, rather than present value or some other measure, is the proper
6 basis for calculating depreciation expense.⁸ Moreover, the *Lindheimer* Court found:

[T]he company has the burden of making a convincing showing that the amounts it has charged to operating expenses for depreciation have not been excessive. That burden is not sustained by proof that its general accounting system has been correct. The calculations are mathematical, but the predictions underlying them are essentially matters of opinion.⁹

7 Thus, the Commission must ultimately determine if the Company has met its burden of
8 proof by making a convincing showing that its proposed depreciation rates are not
9 excessive.

⁷ *Lindheimer v. Illinois Bell Tel. Co.*, 292 U.S. 151, 167 (1934).

⁸ *Id.* (Referring to the straight-line method, the *Lindheimer* Court stated that “[a]ccording to the principle of this accounting practice, the loss is computed upon the actual cost of the property as entered upon the books, less the expected salvage, and the amount charged each year is one year’s pro rata share of the total amount.”). The original cost standard was reaffirmed by the Court in *Federal Power Commission v. Hope Natural Gas Co.*, 320 U.S. 591, 606 (1944). The *Hope* Court stated: “Moreover, this Court recognized in [*Lindheimer*], supra, the propriety of basing annual depreciation on cost. By such a procedure the utility is made whole and the integrity of its investment maintained. No more is required.”

⁹ *Id.* at 169 (emphasis added).

1 Q. **Should depreciation represent an allocated cost of capital to operation, rather than a**
2 **mechanism to determine loss of value?**

3 A. Yes. While the *Lindheimer* case and other early literature recognized depreciation as a
4 necessary expense, the language indicated that depreciation was primarily a mechanism to
5 determine loss of value.¹⁰ Adoption of this “value concept” would require annual
6 appraisals of extensive utility plant, and is thus not practical in this context. Rather, the
7 “cost allocation concept” recognizes that depreciation is a cost of providing service, and
8 that in addition to receiving a “return on” invested capital through the allowed rate of
9 return, a utility should also receive a “return of” its invested capital in the form of recovered
10 depreciation expense. The cost allocation concept also satisfies several fundamental
11 accounting principles, including verifiability, neutrality, and the matching principle.¹¹ The
definition of “depreciation accounting” published by the American Institute of Certified
Public Accountants (“AICPA”) properly reflects the cost allocation concept:

Depreciation accounting is a system of accounting that aims to distribute
cost or other basic value of tangible capital assets, less salvage (if any), over
the estimated useful life of the unit (which may be a group of assets) in a
systematic and rational manner. It is a process of allocation, not of
valuation.¹²

12 Thus, the concept of depreciation as “the allocation of cost has proven to be the most useful
13 and most widely used concept.”¹³

¹⁰ See Frank K. Wolf & W. Chester Fitch, *Depreciation Systems* 71 (Iowa State University Press 1994).

¹¹ National Association of Regulatory Utility Commissioners, *Public Utility Depreciation Practices* 12 (NARUC 1996).

¹² American Institute of Accountants, *Accounting Terminology Bulletins Number 1: Review and Résumé* 25 (American Institute of Accountants 1953).

¹³ Wolf *supra* n. 7, at 73.

III. ANALYTIC METHODS

Q. Discuss the definition and purpose of a depreciation system, as well as the depreciation system you employed for this project.

1 A. The legal standards set forth above do not mandate a specific procedure for conducting
2 depreciation analysis. These standards, however, direct that analysts use a system for
3 estimating depreciation rates that will result in the “systematic and rational” allocation of
4 capital recovery for the utility. Over the years, analysts have developed “depreciation
5 systems” designed to analyze grouped property in accordance with this standard. A
6 depreciation system may be defined by several primary parameters: 1) a method of
7 allocation; 2) a procedure for applying the method of allocation; 3) a technique of applying
8 the depreciation rate; and 4) a model for analyzing the characteristics of vintage property
9 groups.¹⁴ In this case, I used the straight-line method, the average life procedure, the
10 remaining life technique, and the broad group model; this system would be denoted as an
11 “SL-AL-RL-BG” system. This depreciation system conforms to the legal standards set
12 forth above, and is commonly used by depreciation analysts in regulatory proceedings. I
13 provide a more detailed discussion of depreciation system parameters, theories, and
14 equations in Appendix A.

Q. Did Mr. Spanos use the same depreciation system that you used?

15 A. Yes.¹⁵ Therefore, the differences in our depreciation rate proposals are driven by different
16 service life and other parameter assumptions, rather by a difference in the depreciation
17 system.

¹⁴ See Wolf *supra* n. 7, at 70, 140.

¹⁵ See Direct Testimony of John J. Spanos, p. 14:1-6.

Q. Please describe the actuarial process you used to analyze the Company's depreciable property.

1 A. The study of retirement patterns of industrial property is derived from the actuarial process
2 used to study human mortality. Just as actuarial scientists study historical human mortality
3 data in order to predict how long a group of people will live, depreciation analysts study
4 historical plant data in order to estimate the average lives of property groups. The most
5 common actuarial method used by depreciation analysts is called the "retirement rate
6 method." In the retirement rate method, original property data, including additions,
7 retirements, transfers, and other transactions, are organized by vintage and transaction
8 year.¹⁶ The retirement rate method is ultimately used to develop an "observed life table,"
9 ("OLT") which shows the percentage of property surviving at each age interval. This
10 pattern of property retirement is described as a "survivor curve." The survivor curve
11 derived from the observed life table, however, must be fitted and smoothed with a complete
12 curve in order to determine the ultimate average life of the group.¹⁷ The most widely used
13 survivor curves for this curve-fitting process were developed at Iowa State University in
14 the early 1900s and are commonly known as the "Iowa curves."¹⁸ A more detailed
15 explanation of how the Iowa curves are used in the actuarial analysis of depreciable
16 property is set forth in Appendix C.

¹⁶ The "vintage" year refers to the year that a group of property was placed in service (aka "placement" year). The "transaction" year refers to the accounting year in which a property transaction occurred, such as an addition, retirement, or transfer (aka "experience" year).

¹⁷ See Appendix C for a more detailed discussion of the actuarial analysis used to determine the average lives of grouped industrial property.

¹⁸ See Appendix B for a more detailed discussion of the Iowa curves.

Q. Please describe the Company's depreciable assets in this case.

1 A. The Company's depreciable assets can be divided into two main groups: life span property
2 (i.e., production plant) and mass property (i.e., transmission and distribution plant). The
3 analytical process is slightly different for each type of property, as discussed further below.

IV. LIFE SPAN PROPERTY ANALYSIS

Q. Describe the approach to analyzing life span property.

4 A. For life span property, there are essentially three steps to the analytical process. First, I
5 reviewed the Company's proposed life spans for each of its production units and compared
6 them to life span estimates of other similar production units in other jurisdictions. Second,
7 I examined the Company's proposed interim retirement curves for each account in order to
8 assess the remaining lives and depreciation rates for each production unit. Finally, I
9 analyzed the weighted net salvage for each account, which involved reviewing the
10 Company's weighting of interim and terminal retirements for each production account, as
11 well as analyzing the Company's proposed interim and terminal net salvage rates.

Q. Describe life span property.

12 A. "Life span" property accounts usually consist of property within a production plant. The
13 assets within a production plant will be retired concurrently at the time the plant is retired,
14 regardless of their individual ages or remaining economic lives. For example, a production
15 plant will contain property from several accounts, such as structures, fuel holders, and
16 generators. When the plant is ultimately retired, all of the property associated with the
17 plant will be retired together, regardless of the age of each individual unit. Analysts often
18 use the analogy of a car to explain the treatment of life span property. Throughout the life

1 of a car, the owner will retire and replace various components, such as tires, belts, and
2 brakes. When the car reaches the end of its useful life and is finally retired, all of the car's
3 individual components are retired together. Some of the components may still have some
4 useful life remaining, but they are nonetheless retired along with the car. Thus, the various
5 accounts of life span property are scheduled to retire concurrently as of the production
6 unit's probable retirement date.

A. Interim Retirement Analysis

Q. Discuss the concept of interim retirements.

7 A. The individual components within a generating unit are retired and replaced throughout the
8 life of the unit. This retirement rate is measured by "interim" survivor curves. Thus, a
9 production plant's remaining life and depreciation rate are not only affected by the terminal
10 retirement date of the entire plant, but also by the retirement rate of the plant's individual
11 components, which are retired during the "interim" of the plant's useful life.

Q. Did you make any adjustments to the Company's proposed interim retirements?

12 A. No. I accepted the Company's proposed interim retirement curves as well as the
13 Company's proposed weighting of interim and terminal retirements because they are within
14 a reasonable range given the Company's data provided in this case.

B. Terminal Net Salvage Analysis (Decommissioning Costs)

Q. Describe terminal net salvage.

15 A. When a production plant reaches the end of its useful life, a utility may decide to
16 decommission the plant. In that case, the utility may sell some of the remaining assets.
17 The proceeds from this transaction are called "gross salvage." The corresponding expense

1 associated with decommissioning the plant is called "cost of removal." The term "net
2 salvage" equates to gross salvage less the cost of removal. When net salvage refers to
3 production plants, it is often called "terminal net salvage," because the transaction will
4 occur at the end of the plant's life.

Q. Describe how utilities estimate and justify the proposal of terminal net salvage recovery.

5 A. Typically, when a utility is requesting the recovery of a substantial amount of terminal net
6 salvage costs, it supports those costs with site-specific decommissioning studies. Terminal
7 net salvage costs are unlike other costs requested in a rate case. Specifically, while other
8 proposed costs might be based on a recent test year involving actual expenses incurred by
9 the utility, decommissioning costs are often estimated to occur many years or decades in
10 the future. Moreover, the utility may never even incur the decommissioning costs they are
11 proposing. For example, a utility may seek to recover \$10 million in a current rate case for
12 the complete demolition of a production plant to occur 10 years in the future. Thus, the
13 utility would be requesting an additional \$1 million per year in rates in addition to the other
14 depreciation costs associated with the plant. If instead, the utility decides to repower the
15 plant at a much lesser cost than a complete demolition, the utility would have recovered
16 millions of dollars from rate payers for costs that never occurred. Thus, decommissioning
17 costs are not as "known and measurable" as other costs proposed in a rate case.
18 Furthermore, decommissioning studies are often overestimated, as they usually do not
19 contemplate less expensive alternatives to complete demolition and often include
20 substantial contingency factors that arbitrarily increase the cost estimate, as is the case here.
21 Nonetheless, decommissioning studies provide some measurable basis upon which to

1 estimate the utility's terminal net salvage, and should be viewed as a minimum prerequisite
2 for any recovery of such costs.

3 **Q. Did PSO provide decommissioning studies in this case in support its proposed**
4 **terminal net salvage costs?**

5 A. Yes. The decommissioning studies were conducted by Sargent & Lundy and sponsored in
6 the direct testimony of Mr. Meehan.¹⁹

7 **Q. Are the decommissioning studies offered by PSO in this case similar to the studies**
8 **offered in the Company's prior rate case?**

9 A. Yes. In PSO's prior rate case, PSO offered decommissioning studies performed by Sargent
10 & Lundy ("S&L") and sponsored by Mr. Meehan, as the Company has in this case. Mr.
11 Meehan has also acknowledged that S&L "performed a similar demolition study in 2015"²⁰
In fact, Mr. Meehan refers to the decommissioning studies filed in this case as an "update"
to the studies filed in PSO's 2015 rate case.²¹

Q. In PSO's prior rate case, did the ALJ find that S&L had likely overestimated its
demolition cost proposals?

A. Yes. In PSO's prior rate case, the ALJ found that "it is likely that S&L has overestimated
the demolition cost."²²

¹⁹ See Direct Testimony of Thomas J. Meehan (decommissioning studies included in Exhibit TJM-3).

²⁰ Direct Testimony of Thomas J. Meehan, p. 7:12-13.

²¹ *Id.* at p.4:3.

²² Report and Recommendation of the Administrative Law Judge p. 164, filed May 31, 2016 in Cause No. PUD 201500208.

Q. Describe how the Company's proposed demolition costs are likely overestimated again in this case.

1 A. The assumptions relied upon in the Company's decommissioning studies generally include
2 a major demolition of the plants and returning the sites to an "industrial condition," which
3 would be suitable for development of an industrial facility. In other words, the
4 decommissioning studies do not consider the less costly alternatives, such as selling the
5 plants. In addition, the studies assume that none of the equipment will have a salvage value
6 in excess of the scrap value, and resale of equipment is not considered as a cost mitigation
7 factor. These are essentially the same assumptions and problems associated with the
8 similar demolition studies filed in PSO's prior rate case, which resulted in the ALJ finding
9 that PSO's demolition cost proposals were likely overestimated.

Q. Despite your concerns with the Company's decommissioning studies, are you recommending specific adjustments to PSO's proposed costs for labor, material, or indirect costs?

10 A. No. While as discussed above, PSO's decommissioning costs are likely overestimated
11 because they do not consider less costly alternatives and make other liberal assumptions, I
12 am not recommending specific adjustments to the Company's proposed costs for material,
13 labor, or other indirect costs. However, I think the Commission should take these factors
14 into account when considering my other adjustments to decommissioning costs and
15 terminal net salvage rates, as discussed further below.

Q. Do you agree with PSO's proposed decommissioning costs?

16 A. No. While I do not dispute the entirety of PSO's proposed decommissioning costs, there
17 are two important adjustments that should be made to these proposed costs: (1) removing

1 the contingency factor applied by Mr. Meehan; and (2) removing the escalation factor
2 applied by Mr. Spanos. Both adjustments are discussed further below.

Q. Were the escalation and contingency factors specifically addressed by the ALJ and Commission in PSO's prior rate case?

3 A. Yes. In PSO's prior rate case, the Company proposed the inclusion of escalation and
4 contingency factors in calculating PSO's terminal net salvage. In this case, the same
5 witnesses for PSO are essentially making the same proposals. However, in the prior case,
6 PUD and OIEC provided arguments against the escalation and contingency factors, and the
7 ALJ and Commission agreed that the escalation and contingency factors should be rejected.

8 First, in rejecting PSO's proposed escalation factor, the ALJ found as follows:

9 The ALJ adopts Staff witness Garrett's recommendation that the
10 Commission should deny the proposed escalation of demolition costs in this
11 case because (1) the escalated costs do not appear to be calculated in the
12 same manner as other calculations; (2) the Company did not offer any
13 testimony in support of the escalation factor; (3) an escalation factor that
14 does not consider any improvements in technology or economic efficiencies
15 likely overstates future costs; (4) it is inappropriate to apply an escalation
16 factor to demolition costs that are likely overstated; (5) asking ratepayers to
17 pay for future costs that may not occur, are not known and measurable
18 changes within the meaning of 17 O.S. § 284; and (6) the Commission has
19 not approved escalated demolition costs in previous cases.²³

20 Likewise, in rejecting PSO's proposed 15% contingency factors, the ALJ found as follows:

²³ Report and Recommendation of the Administrative Law Judge p. 164, filed May 31, 2016 in Cause No. PUD 201500208.

1 In its demolition cost study, S&L applied a 15% contingency factor to its
2 cost estimates, and a negative 15% contingency factor to its scrap metal
3 value estimates. The Company provides little justification for this
4 contingency factor other than the plants might experience uncertainties and
5 unplanned occurrences. This reasoning fails to consider the fact that certain
6 occurrences could reduce estimated costs.²⁴

7 PSO is essentially making the same arguments in this case as it did in its prior rate case
8 regarding the escalation and contingency factors. For the reasons outlined by the ALJ
9 above, as the reasons discussed in more detail below, the Commission should again reject
10 the inclusion of the escalation and contingency factors in determining PSO's appropriate
11 level of terminal net salvage.

1. Contingency Factor

Q. Describe the contingency factor applied by Mr. Meehan.

12 A. PSO's decommissioning studies include direct and indirect cost estimates to dismantle
13 PSO's generating facilities, which include labor, material, and scrap value estimates.²⁵
14 However, in addition to these cost estimates, Mr. Meehan applied a "15% contingency on
15 the labor, 15% contingency on material, a negative 15% contingency on scrap value and a
16 15% contingency on the indirect portions of the estimates."²⁶ These contingency factors
17 were applied to the cost estimates for each one of PSO's generating facilities, and add an
18 additional 15% of costs on top of the base dismantlement cost estimates (and reduce
19 positive scrap value by 15%).

²⁴ *Id.*

²⁵ See generally Exhibit TJM-3.

²⁶ Direct Testimony of Thomas J. Meehan, p. 15:17-20.

1 **Q. How much additional costs do these contingency factors add to the total decommissioning cost estimates?**

1 A. The total amount of the contingency factors is greater than \$22 million.²⁷

2 **Q. Do you agree that contingency factors should be included in the decommissioning cost estimates that are charged through rates?**

2 A. No. Mr. Meehan states that it is “common and expected standard industry practice to
3 include a positive contingency to account for the amount of detail, unknowns, and
4 uncertainties not included in a cost estimate.”²⁸ However, the issue the Commission should
5 consider is not whether contingency factors are standard industry practice among
6 contractors, but rather whether contingency factors should be charged to ratepayers. Mr.
7 Meehan’s argument in favor of the use contingency factors among contractors highlights
8 the exact reason why we should not include such contingency factors in ratemaking. That
9 is, contingency factors are included to account for “unknowns” and “uncertainties.” In a
10 ratemaking context, ratepayers should be not be charged for costs that are entirely
11 “unknown” by definition. Furthermore, these contingency factors fail to account for the
12 possibility that PSO’s proposed decommissioning costs might be overestimated (and scrap
13 value underestimated). For these reasons, it is not appropriate to include contingency
14 factors in future estimated decommissioning costs to be charged through current rates.

²⁷ See generally Exhibit TJM-3.

²⁸ *Id.* at 16:7-9.

1 **Q. Did the Commission allow the contingency factors in PSO's previous case?**

2 A. No. In PSO's previous rate case, the Commission adopted OIEC's proposed depreciation
3 rates for the Company's production accounts, which did not include the contingency
factors.²⁹

**Q. Do the depreciation rates you propose for PSO's production accounts exclude the
contingency factors?**

4 A. Yes. PSO's decommissioning costs affect the amounts of the net salvage and depreciation
5 rates for the Company's production accounts. The rates I propose for these accounts have
6 been calculated without inclusion of the contingency factors.³⁰

2. Escalation Factor

Q. Describe the cost escalation factor applied by Mr. Spanos.

7 A. To calculate his proposed net salvage rates for PSO's production accounts, Mr. Spanos
8 escalated the decommissioning cost estimates provided by Mr. Meehan by 2.5% each year
9 until the estimated retirement year for each generating facility.³¹

**Q. How much additional costs would the escalation factor add to PSO's proposed
decommissioning costs if approved?**

10 A. The escalation factor would add more than \$100 million to PSO's proposed
11 decommissioning costs.³²

²⁹ See Order No. 657877 entered in Cause No. PUD 201500208, p. 7.

³⁰ See Exhibit DJG-2-4 thru Exhibit DJG-2-7.

³¹ See Direct Testimony of John J. Spanos p. 23:1-2.

³² See Exhibit JSS-2 (depreciation study) p. VIII-6.

Q. Do you agree with Mr. Spanos's proposal to escalate the proposed decommissioning costs?

1 A. No. There are two important reasons the Commission should disallow the cost escalation
2 factor applied by Mr. Spanos. First, it is not appropriate to escalate a cost that is likely
3 overstated, is not known and measurable, and moreover, may never even occur as estimated
4 by the Company. The discussion presented above should lead us to question whether to
5 charge current ratepayers for future decommissioning costs at all, much less whether those
6 costs should be escalated. The second problem with the Company's cost escalation factor
7 is a technical one: It is not proper to charge current ratepayers for a future cost that has not
8 been discounted to present value. The "time value of money" concept is a cornerstone of
9 finance and valuation. For example, the DCF Model, which is used to estimate the cost of
10 equity, applies a growth rate to a company's dividends many years into the future.
11 However, that dividend stream is then discounted back to the current year by a discount
12 rate in order to arrive at the present value of an asset. Likewise, accounting for asset
13 retirement obligations involves escalating the present value of an estimated future cost, but
14 then the cost is discounted back to present value by a discount rate. In contrast to these
15 calculations, PSO proposes to escalate the present value of its decommissioning costs
16 decades into the future, and expects current ratepayers to pay the future value of these costs
17 with present-day dollars. This proposal completely disregards the elemental "time value
18 of money" principle. For these reasons, the Commission should exclude the escalation
19 factor applied by Mr. Spanos when determining appropriate net salvage and depreciation
20 rates for PSO's production accounts.

Q. **Did the Commission allow the escalation factor in PSO's previous case?**

1 A. No. In PSO's previous rate case, the Commission adopted OIEC's proposed depreciation
2 rates for the Company's production accounts, which did not include the escalation factor.³³
3

Q. **Do the depreciation rates you propose for PSO's production accounts exclude the escalation factor?**

4 A. Yes. PSO's decommissioning costs affect the amounts of the net salvage and depreciation
5 rates for the Company's production accounts. The rates I propose for these accounts have
6 been calculated without inclusion of the escalation factor.³⁴

V. MASS PROPERTY ANALYSIS

Q. **Describe mass property.**

7 A. Unlike life span property accounts, "mass" property accounts usually contain a large
8 number of small units that will not be retired concurrently. For example, poles, conductors,
9 transformers, and other transmission and distribution plant are usually classified as mass
10 property. Estimating the service life of any single unit contained in a mass account would
11 not require any actuarial analysis or curve-fitting techniques. Since we must develop a
12 single rate for an entire group of assets, however, actuarial analysis is required to calculate
13 the average remaining life of the group.

³³ See Order No. 657877 entered in Cause No. PUD 201500208, p. 7.

³⁴ See Exhibit DJG-2-4 thru Exhibit DJG-2-7.

1 **Q. How did you determine the depreciation rates for the mass property accounts?**

2 A. To develop depreciation rates for the Company's mass property accounts, I obtained the
3 Company's historical plant data to develop observed life tables for each account. I used
4 Iowa curves to smooth and complete the observed data to calculate the average remaining
5 life of each account. Finally, I analyzed the Company's proposed net salvage rates for each
6 mass account by reviewing the historical salvage data. After estimating the remaining life
7 and salvage rates for each account, I calculated the corresponding depreciation rates.
8 Further details about the actuarial analysis and curve-fitting techniques involved in this
process are presented in the attached appendices.

A. Service Life Estimates

9 **Q. Please describe your approach in estimating the service lives of mass property.**

10 A. I used all of the Company's property data and created an observed life table ("OLT") for
11 each account. The data points on the OLT can be plotted to form a curve (the "OLT
12 curve"). The OLT curve is not a theoretical curve, rather, it is actual observed data from
13 the Company's records that indicate the rate of retirement for each property group. An
14 OLT curve by itself, however, is rarely a smooth curve, and is often not a "complete" curve
15 (i.e., it does not end at zero percent surviving). In order to calculate average life (the area
16 under a curve), a complete survivor curve is needed. The Iowa curves are empirically-
17 derived curves based on the extensive studies of the actual mortality patterns of many
18 different types of industrial property. The curve-fitting process involves selecting the best
19 Iowa curve to fit the OLT curve. This can be accomplished through a combination of visual
20 and mathematical curve-fitting techniques, as well as professional judgment. The first step
of my approach to curve-fitting involves visually inspecting the OLT curve for any

1 irregularities. For example, if the “tail” end of the curve is erratic and shows a sharp decline
2 over a short period of time, it may indicate that this portion of the data is less reliable, as
3 further discussed below. After inspecting the OLT curve, I use a mathematical curve-
4 fitting technique which essentially involves measuring the distance between the OLT curve
5 and the selected Iowa curve in order to get an objective, mathematical assessment of how
6 well the curve fits. After selecting an Iowa curve, I observe the OLT curve along with the
7 Iowa curve on the same graph to determine how well the curve fits. I may repeat this
8 process several times for any given account to ensure that the most reasonable Iowa curve
9 is selected.

Q. Do you always select the mathematically best-fitting curve?

10 A. Not necessarily. Mathematical fitting is an important part of the curve-fitting process
11 because it promotes objective, unbiased results. While mathematical curve fitting is
12 important, however, it may not always yield the optimum result; therefore, it should not
13 necessarily be adopted without further analysis. In fact, for some of the accounts in this
14 case I selected Iowa curves that were not the mathematical best fit, and in every such
15 instance, this decision resulted in shorter curves (higher depreciation rates) being chosen,
16 as further illustrated below.

Q. Should every portion of the OLT curve be given equal weight?

17 A. Not necessarily. Many analysts have observed that the points comprising the “tail end” of
18 the OLT curve may often have less analytical value than other portions of the curve.
19 “Points at the end of the curve are often based on fewer exposures and may be given less
20 weight than points based on larger samples. The weight placed on those points will depend

1 on the size of the exposures.”³⁵ In accordance with this standard, an analyst may decide to
2 truncate the tail end of the OLT curve at a certain percent of initial exposures, such as one
3 percent. Using this approach puts a greater emphasis on the most valuable portions of the
4 curve. For my analysis in this case, I not only considered the entirety of the OLT curve,
5 but also conducted further analyses that involved fitting Iowa curves to the most significant
6 part of the OLT curve for certain accounts. In other words, to verify the accuracy of my
7 curve selection, I narrowed the focus of my additional calculation to consider the top 99%
8 of the “exposures” (i.e., dollars exposed to retirement) and to eliminate the tail end of the
9 curve representing the bottom 1% of exposures.

B. Detailed Analysis of Select Accounts

Q. Discuss your analysis of material accounts.

10 A. My analysis in this case included a review of all the Company’s depreciable accounts. I
11 approached my analysis of all mass property accounts the same way using the methods
12 described in this testimony. For several accounts, however, I conducted additional
13 analysis. The selected accounts discussed in this section are those involving either a
14 significant amount of depreciation expense, or those that provide particularly good
15 illustrations of the differences in my curve selection process and the Company’s process.
16 For some of these accounts, I conducted additional analyses that included both visual and
17 mathematical curve fitting techniques not only for the entirety of the OLT curve, but also
18 for the most significant portion of the curve which includes the top 99% of the dollars
19 exposed to retirement, when applicable. By conducting additional analysis on the most

³⁵ Wolf *supra* n. 7, at 46.

1 significant portions of the OLT, I ensured that the Iowa curves I selected provide a good
2 fit to the Company's data.

Q. Discuss the general differences between your service life estimates and the Company's service life estimates for these accounts

3 A. While the Company and I used similar curve-fitting approaches in this case, the curves I
4 selected for these accounts provide a better mathematical fit to the observed data, and
5 provide a more reasonable and accurate representation of the mortality characteristics for
6 each account. In each of the following accounts, the Company has selected a curve that
7 underestimates the average remaining life of the assets in the account, which results in
8 unreasonably high depreciation rates. The analysis of each selected account is discussed
9 below.

Q. Are you persuaded by the opinions of PSO's employees and other contractors regarding their estimates of the future mortality characteristics of any of these accounts?

10 A. No. In his testimony, Mr. Spanos stated that he had discussions with Company
11 management and incorporated the information he received from these discussions in the
12 "interpretation and extrapolation of the statistical analyses."³⁶ This statement indicates that
13 discussions with Company personnel affected Mr. Spanos's interpretation of the
14 quantitative statistical analysis involved with remaining service live estimates. In
15 discovery, OIEC asked PSO the following question:

³⁶ Direct Testimony of John J. Spanos, p. 21:11-12.

Please specifically identify and describe any information obtained from any plant tour, field trip, or discussion with Company personnel, that would indicate that the average service lives of any life span or mass property would be shorter or longer than what is indicated by the retirement rate described by the Company's plant data.

1 In response, Mr. Spanos referred to PSO's response to data request AG 4-18, which
2 includes the information obtained from site visits and management meetings. However,
3 this response did not specifically identify any information that would lead me to deviate
4 from the results obtained through my statistical analysis. In other words, I did not see any
5 information in Mr. Spanos's site visit notes that would persuade me to deviate from the
6 remaining service lives indicated through analysis of PSO's historical property data in
7 combination with visual and mathematical Iowa curve-fitting techniques, especially for
8 accounts with sufficient retirement history and reliable observed survivor curves. In other
9 words, while I agree with Mr. Spanos that depreciation analysis is not strictly a
10 mathematical exercise, I did not incorporate any of the information provided by Mr. Spanos
11 that was obtained from discussions with Company personnel into my analysis for these
12 reasons. To the extent Mr. Spanos received valuable, relevant information from Company
13 personnel that would affect the statistical analysis in this case, it was not provided to the
14 other parties in response to their discovery requests. Therefore, the Commission should
15 give little weight to Mr. Spanos's professional judgment to the extent that judgment was
16 influenced by information that was not provided to other parties in the case in response to
17 their discovery requests. Furthermore, even if such information had been provided, I would
18 question the objectivity of the opinions rendered by employees of the applicant in this case,
19 especially when such opinions have a direct impact on a substantial component of the
20 Company's revenue requirement in this case. Therefore, in my opinion, the Commission

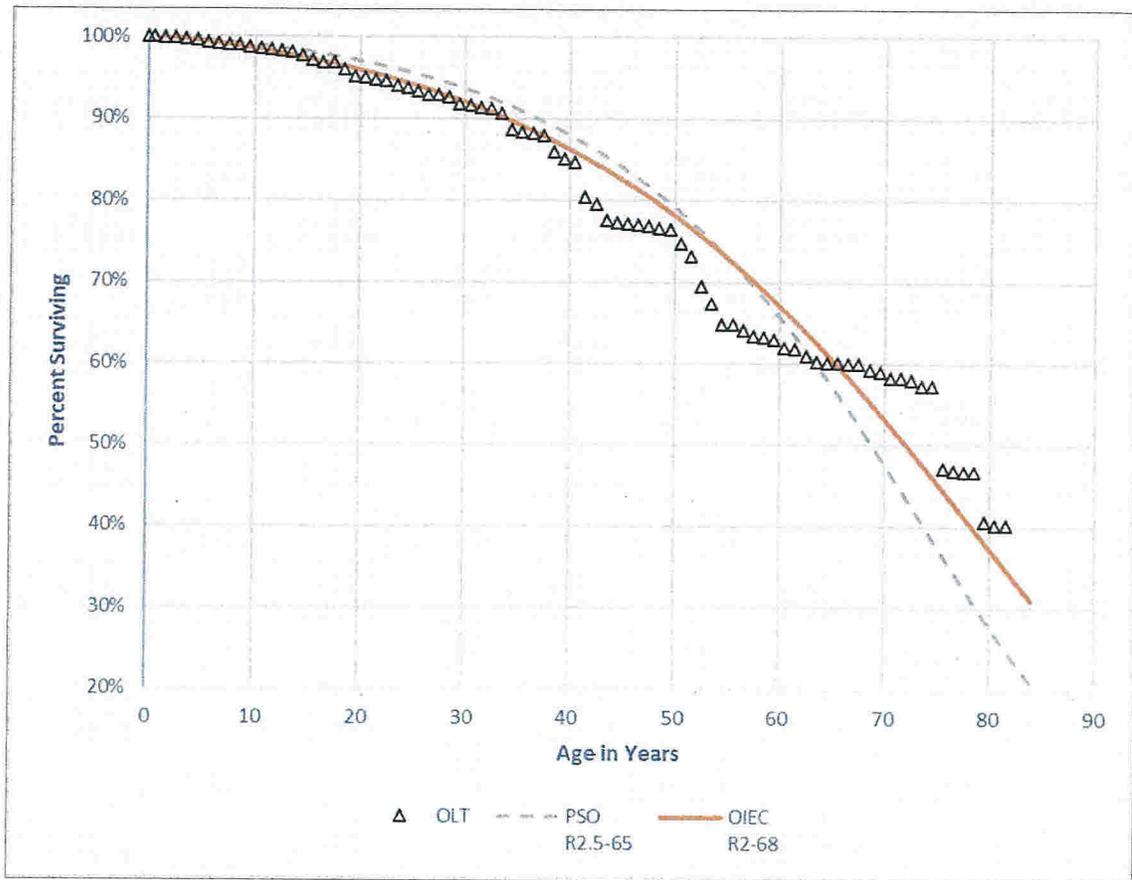
1 should give more weight to the statistical analysis provided by the depreciation experts in
2 this case than subjective elements of judgment, especially when there is sufficient data to
3 conduct such statistical analysis. This approach will promote more objective, unbiased,
4 and reasonable results.

1. Account 356 – Overhead Conductors and Devices

Q. Describe your service life estimate for this account, and compare it with the Company's estimate.

5 A. The OLT curve derived from PSO's historical property data for Account 356 is fairly
6 suitable for traditional Iowa curve fitting techniques and contains sufficient retirement
7 history. The Iowa curve I selected for this account is the R2-68 curve, and the curve the
8 Company selected is the R2.5-65 curve. The graph below shows these two curves
9 juxtaposed with the OLT curve.

**Figure 3:
Account 356 – Overhead Conductors and Devices**



1 Both of the selected Iowa curves are similar in shape and average life. PSO's R2.5-65
 2 curve is slightly steeper and shorter than the R2-68 curve. It is visually apparent that the
 3 R2-68 curve provides a better fit through the majority of the OLT curve, however, we can
 4 use mathematical curve-fitting techniques to measure which curve provides a better fit.

Q. Does your selected curve provide a better fit to the observed data?

5 A. Yes. The best mathematically-fitted curve is the one that minimizes the distance between
 6 the OLT curve and the Iowa curve, thus providing the closest fit. The "distance" between
 7 the curves is calculated using the "sum-of-squared differences" ("SSD") technique. The
 8 curve with the lower SSD represents the better mathematical fit. Specifically, the SSD for

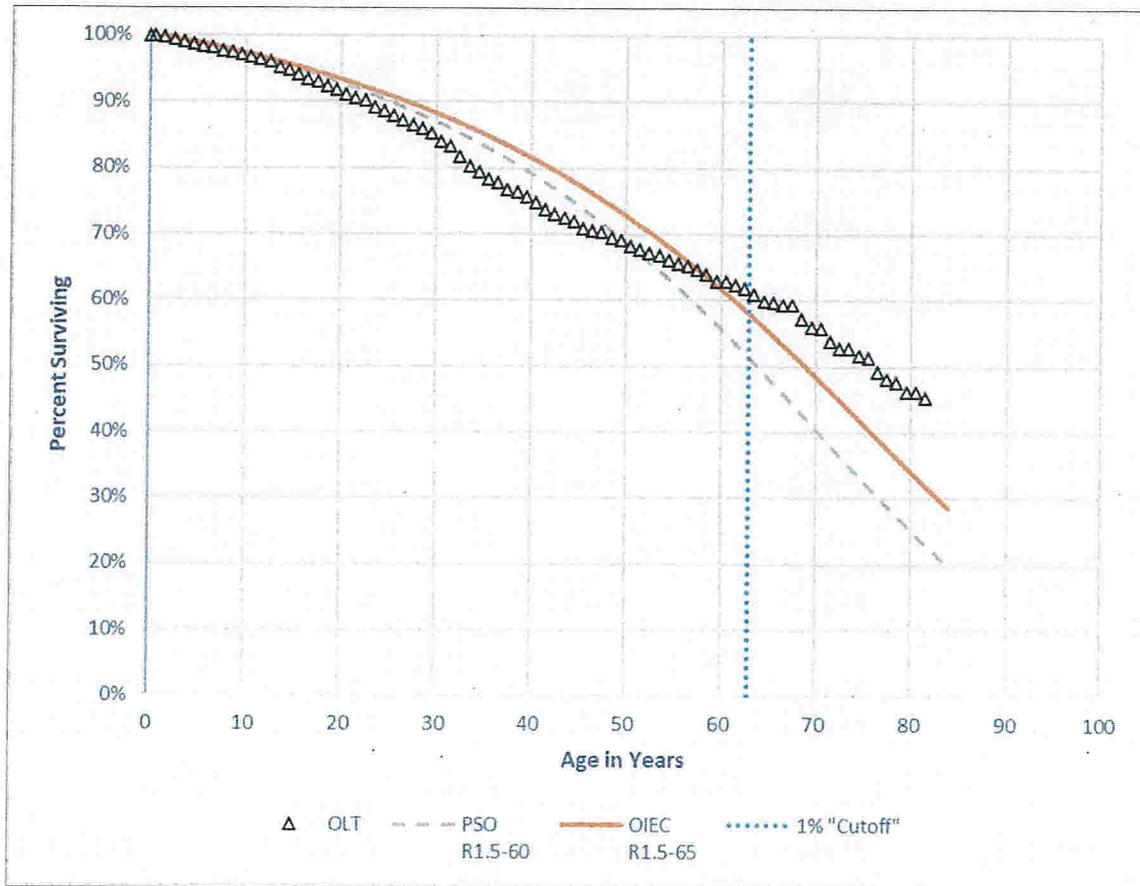
1 the Company's curve is 0.4361, while the SSD for the better-fitting R2-68 curve is only
2 0.1417. Thus, the curve I selected for this account provides a better fit to the OLT and
3 results in a more reasonable depreciation rate.

2. Account 362 – Station Equipment

Q. Describe your service life estimate for this account, and compare it with the Company's estimate.

4 **A.** For this account, I selected the R1.5-65 curve and the Company selected the R1.5-60 curve.
5 Thus, both curves selected are of the same "shape" or type. However, there is a difference
6 of five years for the average service life represented by the curves. The graph below shows
7 these two curves along with the OLT curve.

**Figure 4:
Account 362 – Station Equipment**



1 As shown in the graph, the R1.5-65 appears to provide a better overall fit to the OLT curve.
 2 The vertical dotted line represents the 1% “cutoff” that may be used as general benchmark
 3 to determine which portion of the “tail” end of the curve is statistically irrelevant. The data
 4 points to the right of the vertical line represent the less significant “tail” end of this
 5 particular OLT curve. As we can see, neither one of the Iowa curves attempts to fit to this
 6 tail end. However, the curve selected by the Company appears to drop too early around
 7 age 50, and does not fit to the relevant data points between ages 50 – 63, a significant 13-
 8 year period.

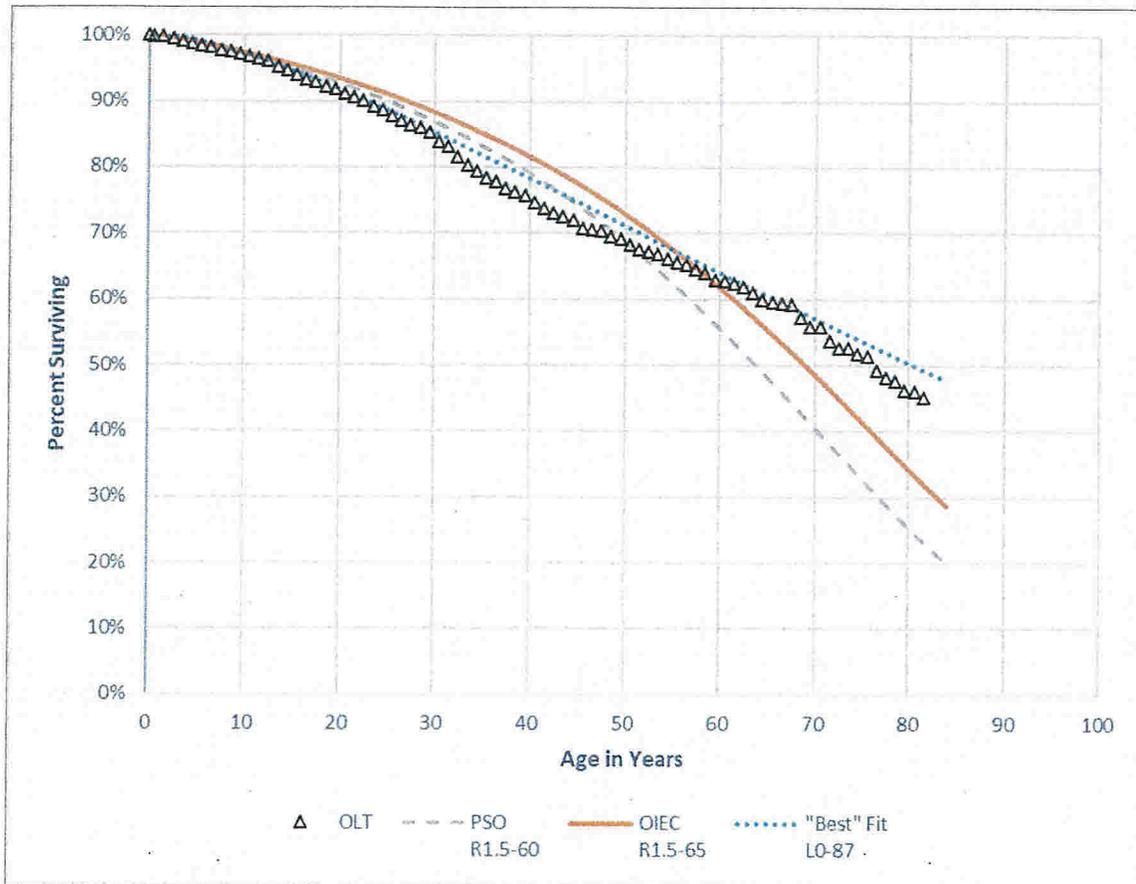
Q. Does your selected curve provide a better mathematical fit to the observed data than the Company's curve?

1 A. Yes. Once again, the Company's curve is too short, which understates the average service
2 life for this group of assets and overstates depreciation expense. This is true not only when
3 conducting curve-fitting techniques on the entire OLT curve for this account, but also when
4 considering the most statistically meaningful portion of the curve. As discussed above, the
5 "tail" end of certain OLT curves can have less statistical value because they represent an
6 insignificant amount of dollar exposures, as is the case here. All of the data points to the
7 right of the vertical dotted line in the graph above represent dollar exposures that are less
8 than one percent of beginning exposures in this account. Regardless, the R2.5-65 curve I
9 selected provides a better fit to the data under either scenario than the curve proposed by
10 the Company.³⁷

Q. Is the Iowa curve you selected for this account the best mathematically-fitting curve?

11 A. No. The best mathematically-fitting curve for this data set is the L0-87 curve. Selecting
12 this curve to calculate the service life for this account would result in a much lower
13 depreciation expense than the curve I selected. The graph below shows the two Iowa
14 curves discussed above, along with the L0-87 curve.

³⁷ Direct Exhibit DG 2-9.



1 The R1.5-65 curve represents the best mathematical fit to the most relevant portions of the
 2 OLT curve.

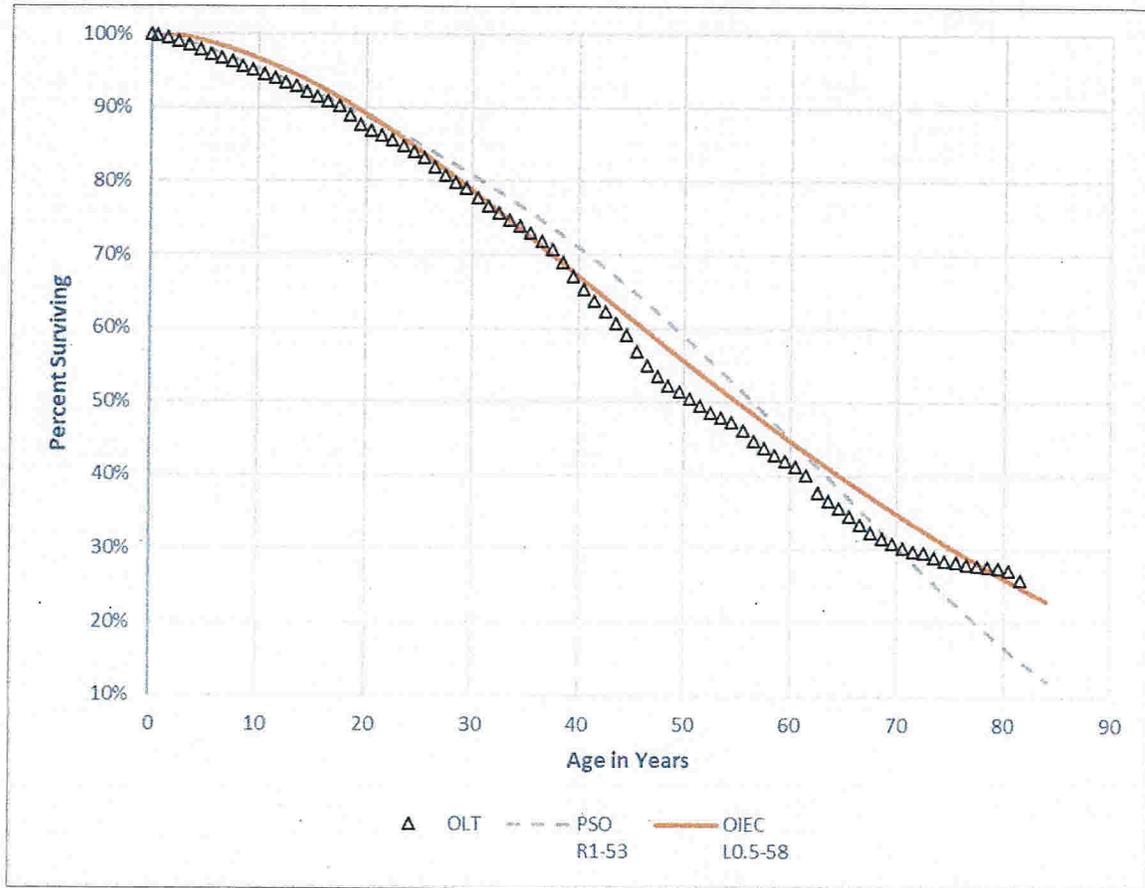
3. Account 364 – Poles, Towers and Fixtures

Q. Describe your service life estimate for this account, and compare it with the Company's estimate.

3 A. I selected the L0.5-58 curve for this account and the Company selected the R1-53 curve.
 4 Both curves are within a reasonable range for this account, but the L0.5-58 curve is superior
 5 because it provides a better fit to the observed data for this account, and therefore also
 6 provides a better estimate of the future retirement characteristics for this account. The
 7 retirement history in this account is ideal for curve fitting because the OLT curve goes

1 below 30% surviving and has a shape that is conducive to the Iowa curve-fitting process.
2 The graph below shows these two Iowa curves juxtaposed with the OLT curve.

Figure 5:
Account 364 – Poles, Towers and Fixtures



3 **Q. Does your selected curve provide a better mathematical fit to the observed data than**
4 **the Company's curve?**

3 A. Yes. Whether conducting the mathematical analysis on the entire OLT curve, or the OLT
4 curve less the "tail" end, the L0.5-58 curve provides a better mathematical fit. Specifically,

1 the SSD for the Company's curve is 0.1443, while the SSD for the L0.5-58 curve is 0.0263,
2 which means it is a closer fit to the observed data.³⁸

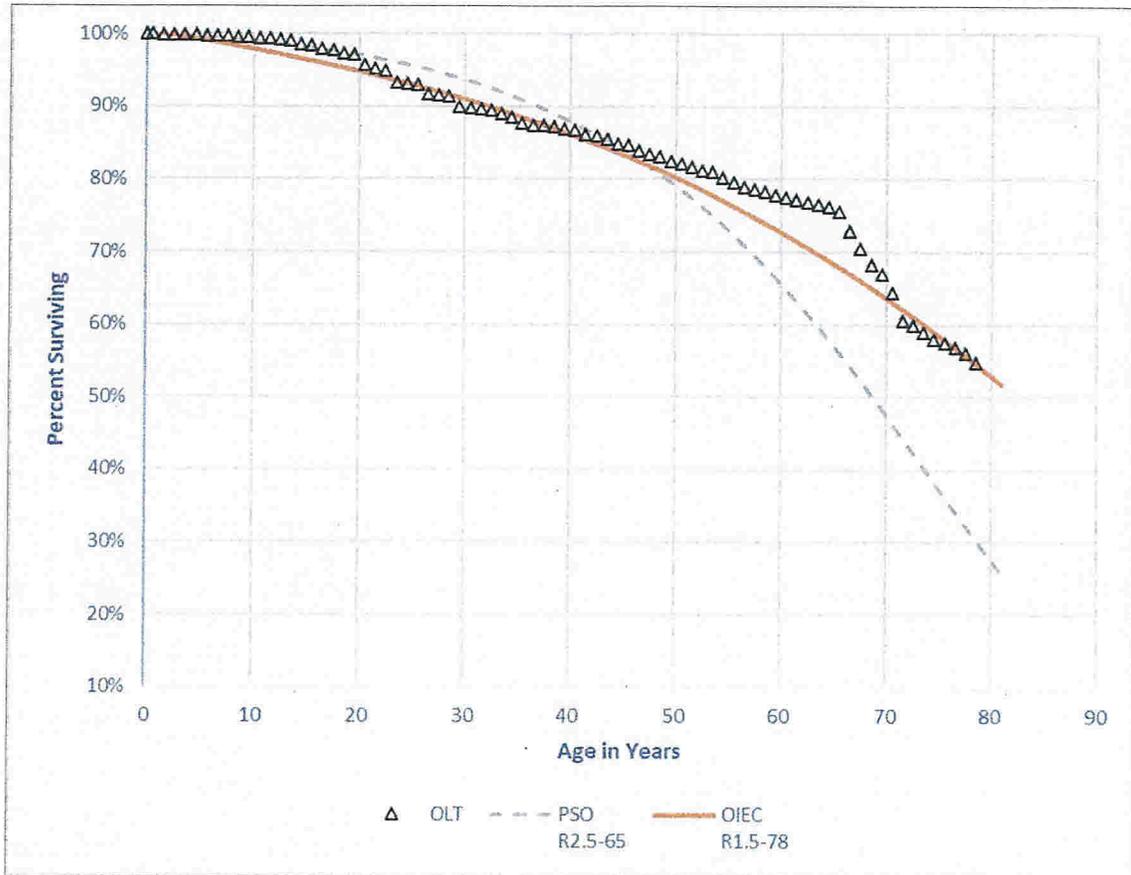
4. Account 366 – Underground Conduit

Q. Describe your service life estimate for this account, and compare it with the Company's estimate.

3 A. For Account 366, I selected the R1.5-78 curve and the Company selected the R2.5-65
4 curve. It is visually apparent that the R1.5-78 curve provides a better fit to the historical
5 data. The R2.5-65 curve selected by the Company is too short, which results in a shorter
6 service life estimate and higher depreciation rate. Specifically, the Company's curve
7 continues a sharp decline around the 45-year age interval, while the OLT curve follows a
8 more gradual decline, which is better represented by the R1.5-78 curve. The graph below
9 shows these two curves along with the OLT curve.

³⁸ Exhibit DJG-2-11.

**Figure 6:
Account 366 – Underground Conduit**



Q. Does your selected curve provide a better mathematical fit to the observed data than the Company's curve?

- 1 A. Yes. Whether conducting the mathematical analysis on the entire OLT curve, or the OLT
 2 curve less the "tail" end, the R1.5-78 curve provides a better mathematical fit. Specifically,
 3 the SSD for the Company's curve is 0.9821, while the SSD for the R1.5-78 curve is 0.0883,
 4 which means it is a closer fit to the observed data and results in a more reasonable
 5 depreciation rate for this account.³⁹

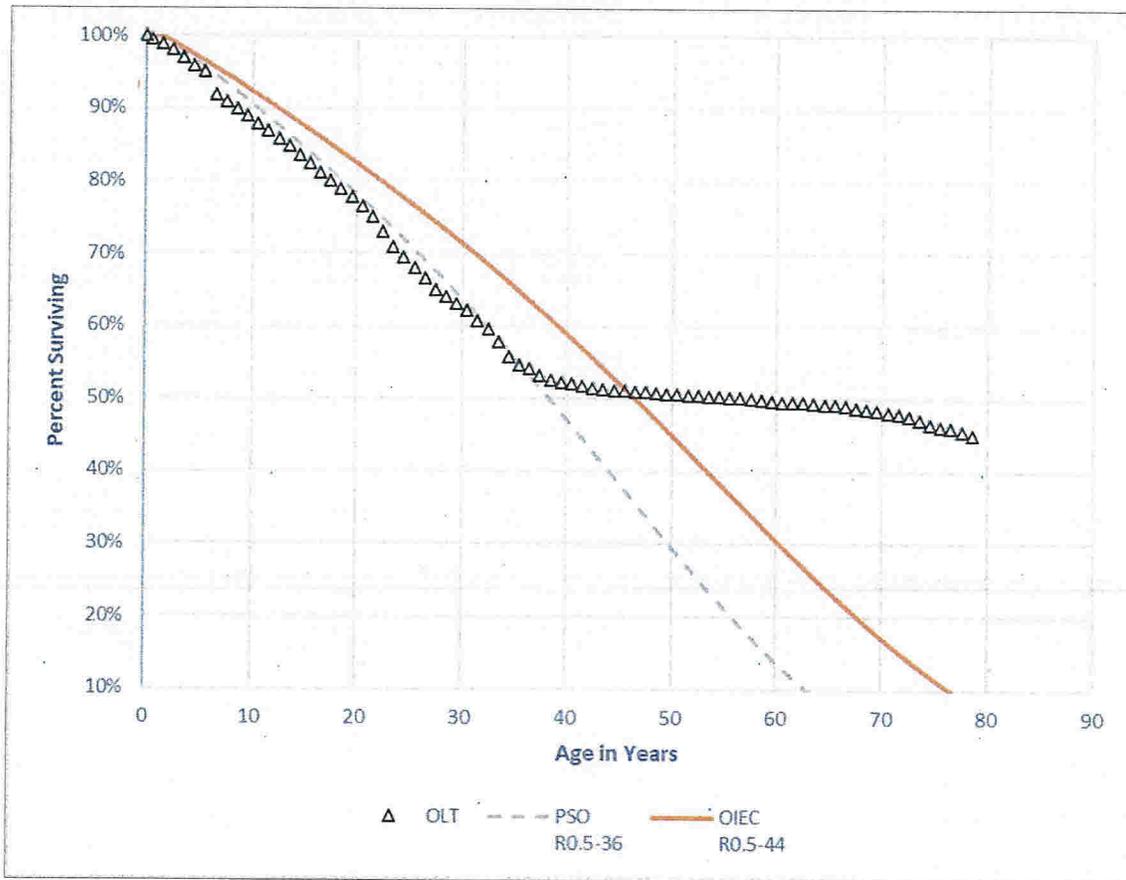
³⁹ Exhibit DJG-2-12.

5. Account 373 – Street Lighting and Signal Systems

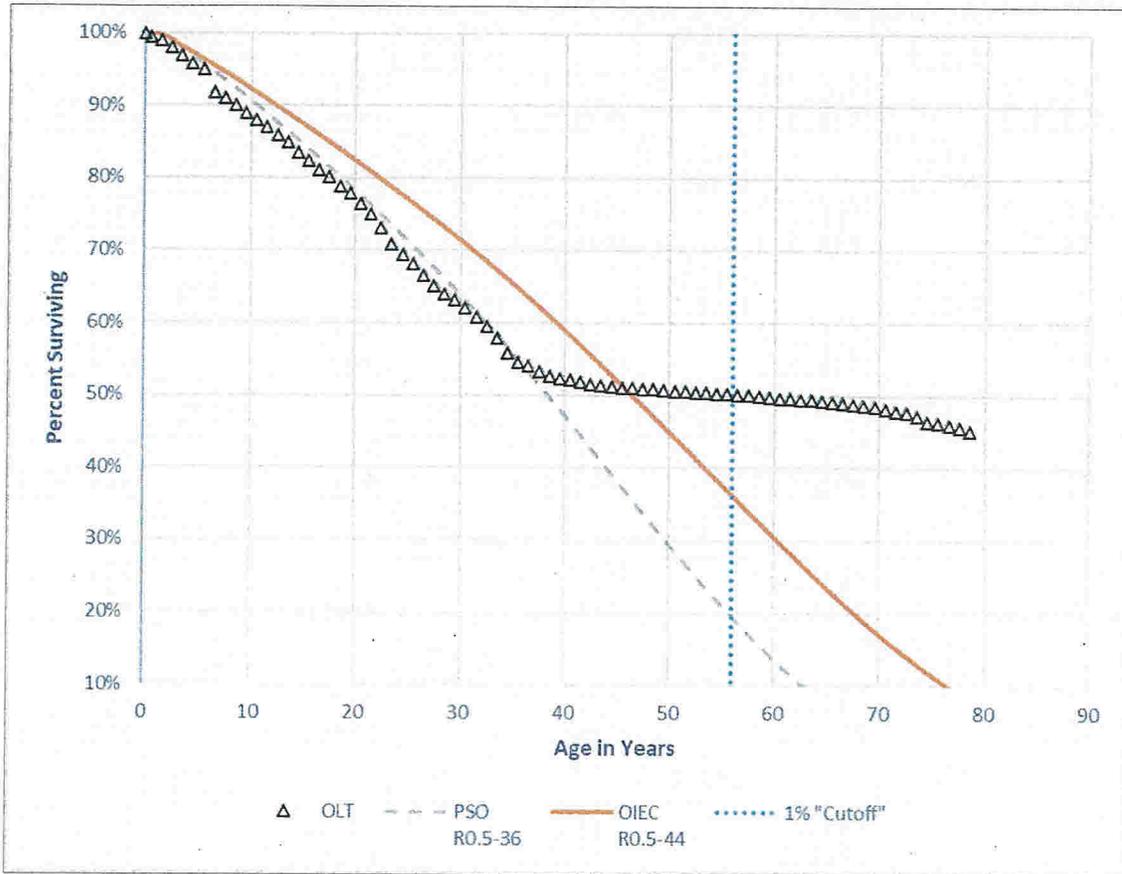
Q. Describe your service life estimate for this account, and compare it with the Company's estimate.

1 A. For Account 373, I selected the R0.5-44 curve and the Company selected the R0.5-36
2 curve. While both selected curves have the same shape, there is a different in average life
3 estimates of eight years. The Company's curve provides a good fit to the observed data up
4 to the 35-year age interval; however, it appears to ignore relevant historical data beyond
5 that point. The graph below shows these two curves along with the OLT curve.

**Figure 7:
Account 373 – Street Lighting and Signal Systems**



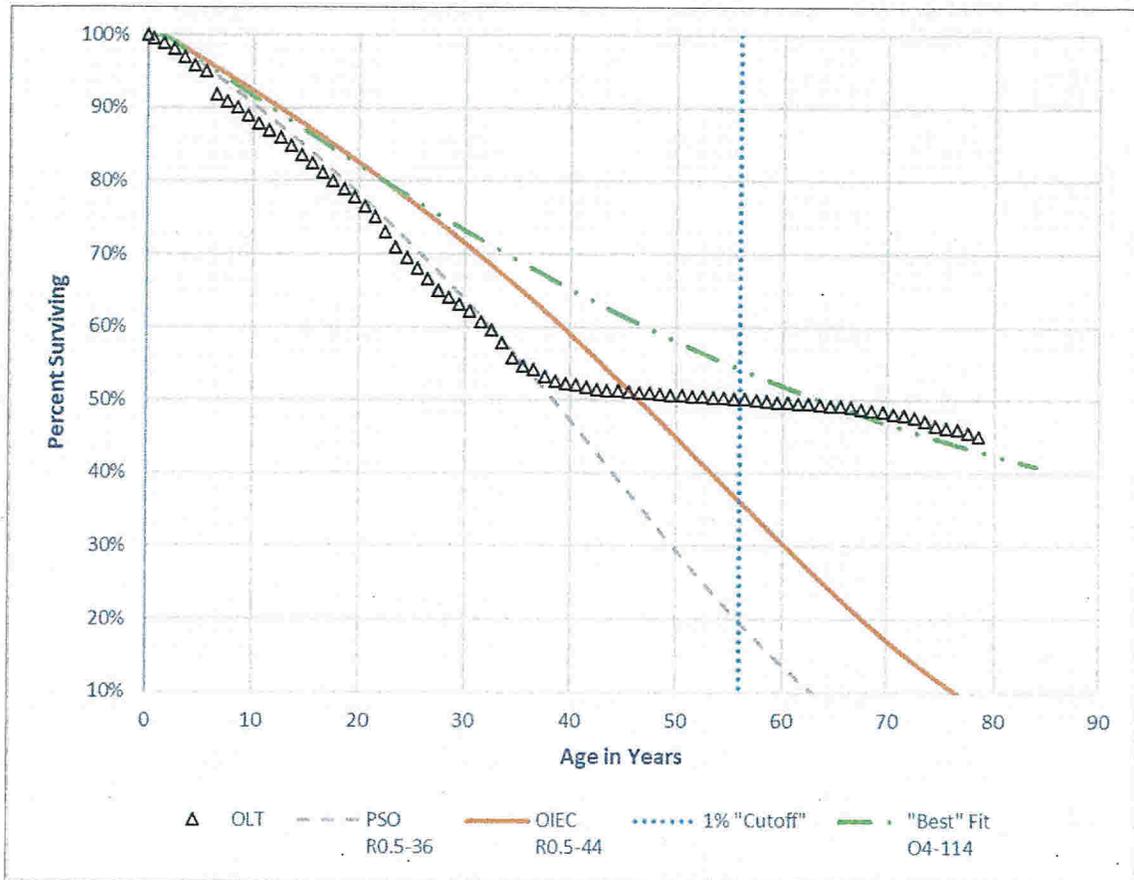
1 While it might be prudent to disregard the problematic “tail” end of the curve, the R0.5-36
 2 curve selected by the Company ignores large, relevant portions of the OLT curve. The
 3 graph below shows the same curves along with the 1% cutoff line as a benchmark.



4 As shown in this graph, the R0.5-36 curve selected by the Company seems to disregard a
 5 substantial 20 years of retirement data for this account – from age intervals 35 – 55. The
 6 R0.5-44 curve I selected represents a balance between the OLT curve pattern observed in
 7 the first 35 years and the pattern observed in the following 20 years.

8 **Q. Did you select the mathematically best-fitting curve for this account?**

9 **A.** No. The mathematically best fitting curve for this account and data band is the O4-114
 curve, which is shown in the graph below.



1 Selecting the O4-114 curve for this account would have resulted in a much lower
 2 depreciation rate recommendation.

3 **Q. Why did you not select the O4-114 curve for this account?**

4 A. Even though it is the mathematically best-fitting curve, I did not select the O4-114 curve
 5 for this account for several reasons. First, the OLT curve derived from the historical data
 6 for this account is less than ideal for strict mathematical curve-fitting techniques. In other
 7 words, the OLT curve does not represent a typical Iowa-type curve shape. Second, we do
 8 not typically observe "O" curve-type patterns for Account 373 among the data for other
 9 electric utilities. While I think it is best to focus on the data for the utility being analyzed
 rather than industry averages, when the historical data is not ideal for traditional curve-

1 fitting techniques, as is the case with this account, it can be instructive to consider the
2 results observed in the analysis of other utilities. Finally, the O4-114 curve is the “best”
3 mathematically fitting curve, in part, because it tracks the statistically problematic “tail-
4 end” of the OLT curve. Furthermore, while the O4-114 curve might provide the best
5 mathematical fit, it is clearly a poor fit from a visual curve-fitting standpoint, as it does not
6 track the entire middle-portion of the OLT curve. This account represents a good example
7 why it is important to conduct both visual and mathematical curve-fitting techniques in
8 actuarial analysis. In looking at the graph above, we see that the R0.5-44 curve I selected
9 for this account provides a good balance between the mathematically best-fitting curve
10 (which is problematic for the reasons discussed above) and the Company’s selected curve
11 (which is problematic because it ignores significant portions of relevant data).

Q. Does your selected curve provide a better mathematical fit to the observed data than the Company’s curve?

12 A. Yes. Whether conducting the mathematical analysis on the entire OLT curve, or the OLT
13 curve less the “tail” end, the R0.5-44 curve provides a better mathematical fit than the
14 Company’s curve. Specifically, the SSD for the Company’s curve is 5.8492, while the
15 SSD for the R0.5-44 curve is 2.8982.⁴⁰

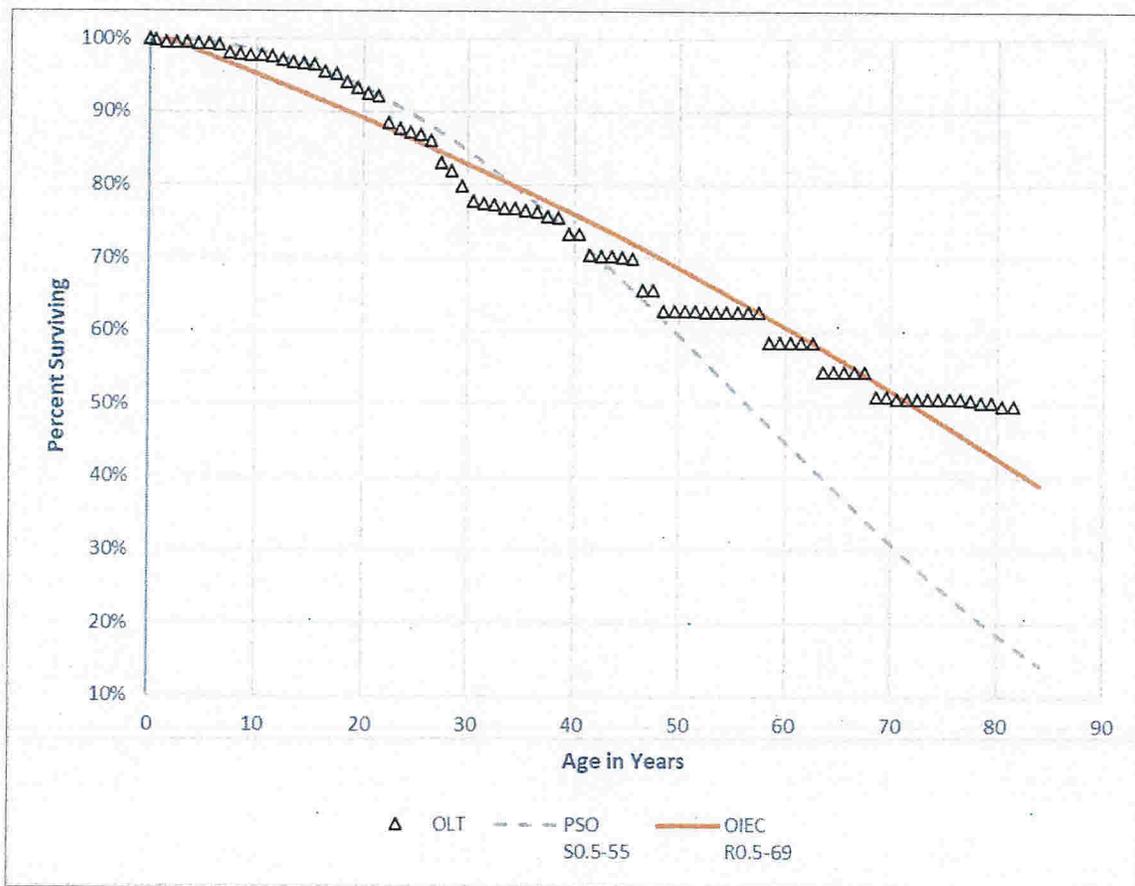
⁴⁰ Exhibit DJG-2-13.

6. Account 390 – Structures and Improvements

Q. Describe your service life estimate for this account, and compare it with the Company's estimate.

1 A. The Iowa curve I selected for this account is the R0.5-69 curve, and the curve the Company
2 selected is the S0.5-55 curve. The graph below shows these two curves juxtaposed with
3 the OLT curve.

Figure 8:
Account 390 – Structures and Improvements



4 As with the other accounts discussed above, the curve selected by the Company for this
5 account is too short, which results in an underestimated service life and overestimated
6 depreciation rate and expense. A visual observation shows that the R0.5-69 curve provides
7 a better fit to the observed data than the Company's curve.

Q. Does your selected curve provide a better fit to the observed data?

1 A. Yes. The SSD for the Company's curve is 1.5882, while the SSD for the better-fitting
2 R0.5-69 curve is only 0.1048. Thus, the curve I selected for this account provides a better
3 fit to the OLT and results in a more reasonable depreciation rate.

VI. ACCOUNT 303 – SOFTWARE

Q. Describe the Company's position regarding Account 303.

4 A. Account 303 includes the Company's software systems. At December 31, 2016, there was
5 a balance of \$51.2 million in this account. Even though this account is the largest of the
6 Company's amortized accounts, PSO chose not to include it in the depreciation study or
7 provide any testimony in support of the five-year proposed amortization period. A five-
8 year amortization period for this account results in an amortization expense of more than
9 \$10 million.⁴¹

Q. Has PSO met its burden of proof regarding the amortization period for Account 303?

10 A. No. The Company does not appear to have provided any support for the proposed five-
11 year amortization period for this account. Account 303 has a balance of more than \$50
12 million, which is significant, and should have been supported by evidence in this filing.
13 Furthermore, Account 303 is often included in depreciation studies for other utilities, along
14 with specific information regarding the annual balances and accruals associated with the
15 account, and specific calculations regarding the proposed amortization rate.⁴² However,

⁴¹ Schedule I-4_ Proposed.

⁴² See e.g., Direct Testimony of John J. Spanos, Exhibit JJS-2, filed December 18, 2015 in Cause No. PUD 201500273 (OG&E's 2015 rate case).

1 PSO failed to provide any such information for Account 303 in this case. As discussed
2 above, the Supreme Court has clearly held that the utility bears the burden of making a
3 “convincing showing” that its proposed depreciation rates are not excessive.⁴³ As further
4 discussed below, there is evidence suggesting that the assets in this account could last up
5 to 20 years.

Q. Do you agree with the Company’s proposal regarding this account?

6 A. No. By choosing a five-year amortization period for Account 303, the Company is
7 suggesting that its software programs will last only five years, on average, which results in
8 an excessive proposed expense level. While a five-year service life estimate might be
9 appropriate for basic consumer software systems, it is insufficient to accurately describe
10 the service life of major software systems. Unlike basic consumer software systems, large
11 enterprise software systems can be customized to the specific needs of the company. These
12 modular systems require substantial upfront engineering costs along with periodic
13 maintenance and support fees to ensure that the system performs reliably over a long period
14 of time. For example, many utility companies rely on Enterprise Resource Planning
15 (“ERP”) systems comprising a suite of modular applications that collect and integrate data
16 from different facets of the firm.

⁴³ *Lindheimer v. Illinois Bell Tel. Co.*, 292 U.S. 151, 167 (1934).

Q. Are you aware of service life estimates of Enterprise Resource Planning systems of 20 years or more?

1 A. Yes. ERP systems are designed to provide long term solutions to companies. SAP is one
2 of several providers of ERP systems.⁴⁴ According to a report by CGI Consulting Services,
3 SAP systems can last 25 – 30 years.⁴⁵ Given the extremely high installation costs for these
4 complex systems as well as the annual maintenance fees, it is not surprising that companies
5 using ERP systems would demand that the systems last longer than 10 years.

Q. Have utility companies recognized that their ERP systems can last at least 20 years?

6 A. Yes. Florida Power & Light (“FP&L”) is one of many utilities that utilize ERP systems.
7 In 2011, FP&L implemented SAP’s ERP system to replace its previous accounting
8 system.⁴⁶ FP&L had previously amortized its software over a five-year period. FP&L,
9 however, requested that the amortization period be extended to 20 years in order to reflect
10 the much longer lifespan of the new ERP system.⁴⁷ Kim Ousdahl, FP&L’s Vice President,
11 Controller and Chief Accounting Officer, gave the following testimony regarding FP&L’s
12 software account:

⁴⁴ SAP ERP is enterprise resource planning software developed by the German company SAP SE.

⁴⁵ *Taking the Long View to SAP Value*, CGI, “Enlightened Managed Services Series,” CGI Group Inc. 2011 p. 2.

⁴⁶ Petition for Rate Increase by Florida Power & Light Company, Docket No. 120015-EI, Testimony & Exhibits of Kim Ousdahl. p. 14.

⁴⁷ *Id.*

In 2011, the Company implemented a new general ledger accounting system (SAP) to replace its legacy system. . . . FPL's policy for accounting for new software requires . . . amortization on a straight-line basis over a period of five years, which is the current amortization period approved for this account. The Company is requesting to extend the amortization period of this system from five to twenty years in order to more appropriately recognize the longer benefit period expected from this major business system.⁴⁸

1 While a 10-year average life may have been appropriate for older, more basic software
2 systems, it does not reflect the much longer service life of newer, more complex systems.

Q. Has PSO's depreciation witness recommended amortization periods up to 15 years for Account 303 in other depreciation studies?

3 A. Yes. Although Gannett Fleming did not include Account 303 in the depreciation study in
4 this case, it has recommended amortization periods of up to 15 years for this account in
5 other cases.⁴⁹

Q. Are you recommending that the Company extend the service life of its software account to 15 or 20 years?

6 A. No. Although it would not be unreasonable to consider a 15 or 20-year amortization period
7 for the assets in Account 303, I am recommending a more conservative 10-year
8 amortization period for this account in the interest of reasonableness. I have calculated the
9 amortization expense adjustment for this Account under a 10-year amortization period,
10 which results in an adjustment in amortization expense of \$4.9 million.⁵⁰

⁴⁸ *Id.*

⁴⁹ See Petition of NSTAR Electric Company and Western Massachusetts Electric Company each d/b/a Eversource Energy for Approval of an Increase in Base Distribution Rates for Electric Service Pursuant to G.L. c. 164 § 94 and 220 C.M.R. § 500, Exhibit ES-JJS-6, relevant portions attached hereto as Exhibit DJG-2-17.

⁵⁰ See Exhibit DJG-2-8.

VII. CONCLUSION AND RECOMMENDATION

Q. Summarize the key points of your testimony.

1 A. In this case, PSO is proposing an increase in depreciation expense in excess of \$40 million
2 despite the fact that the depreciation rates ordered by the Commission have been in effect
3 for less than one year. It is clear that PSO's position cannot be accepted and that reasonable
4 adjustments must be considered. OIEC and Wal-Mart propose two options for the
5 Commission to consider in determining the level of depreciation expense to be authorized
6 in this proceeding. Option One involves accepting portions of PSO's proposed rate
7 increases for its production accounts, while removing the escalation and contingency
8 factors from its proposed decommissioning costs, pursuant to the Commission's recent
9 order in PSO's prior rate case. Option One would also adopt the depreciation rates recently
10 ordered for PSO's transmission, distribution, and general accounts. Option Two involves
11 changing PSO's currently-approved depreciation rates based on the Company's proposal
12 in this case with reasonable modifications. Adopting Option Two would result in a
13 substantial increase of about \$22 million to PSO's current depreciation expense, while
14 accepting Option One would result in an increase of about \$9 million. Option One is
15 preferable because although it would result in a substantial increase in depreciation
16 expense, it would also provide more relief to rate payers in light of the significant base rate
17 increase proposed by PSO in this case.

Q. What is OIEC and Wal-Mart's recommendation to the Commission with regard to PSO's proposed depreciation rates?

18 A. OIEC and Wal-Mart recommend the Commission adopt the proposed depreciation rates
19 presented under Option One (See Exhibit DJG-2-3). Should the Commission not adopt

1 this recommendation, OIEC and Wal-Mart recommend the Commission adopt the
2 depreciation rates proposed under Option Two (See Exhibit DJG-2-3).

3 **Q. Does this conclude your testimony?**

4 A. Yes, including any exhibits, appendices, and other items attached hereto. I reserve the right
5 to supplement this testimony as needed with any additional information that has been
requested from the Company but not yet provided.

Respectfully Submitted,



David J. Garrett
Resolve Utility Consulting, PLLC
100 Park Avenue, Suite 700
Oklahoma City, OK 73102
dgarrett@resolveuc.com
(405) 249-1050

APPENDIX A:
THE DEPRECIATION SYSTEM

A depreciation accounting system may be thought of as a dynamic system in which estimates of life and salvage are inputs to the system, and the accumulated depreciation account is a measure of the state of the system at any given time.⁵¹ The primary objective of the depreciation system is the timely recovery of capital. The process for calculating the annual accruals is determined by the factors required to define the system. A depreciation system should be defined by four primary factors: 1) a method of allocation; 2) a procedure for applying the method of allocation to a group of property; 3) a technique for applying the depreciation rate; and 4) a model for analyzing the characteristics of vintage groups comprising a continuous property group.⁵² The figure below illustrates the basic concept of a depreciation system and includes some of the available parameters.⁵³

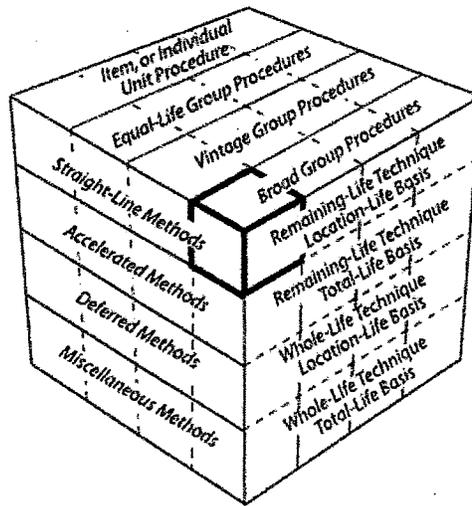
There are hundreds of potential combinations of methods, procedures, techniques, and models, but in practice, analysts use only a few combinations. Ultimately, the system selected must result in the systematic and rational allocation of capital recovery for the utility. Each of the four primary factors defining the parameters of a depreciation system is discussed further below.

⁵¹ Wolf *supra* n. 7, at 69-70.

⁵² *Id.* at 70, 139-40.

⁵³ Edison Electric Institute, *Introduction to Depreciation* (inside cover) (EEI April 2013). Some definitions of the terms shown in this diagram are not consistent among depreciation practitioners and literature due to the fact that depreciation analysis is a relatively small and fragmented field. This diagram simply illustrates the some of the available parameters of a depreciation system.

**Figure 9:
The Depreciation System Cube**



1. Allocation Methods

The “method” refers to the pattern of depreciation in relation to the accounting periods. The method most commonly used in the regulatory context is the “straight-line method” – a type of age-life method in which the depreciable cost of plant is charged in equal amounts to each accounting period over the service life of plant.⁵⁴ Because group depreciation rates and plant balances often change, the amount of the annual accrual rarely remains the same, even when the straight-line method is employed.⁵⁵ The basic formula for the straight-line method is as follows:⁵⁶

⁵⁴ NARUC *supra* n. 8, at 56.

⁵⁵ *Id.*

⁵⁶ *Id.*

**Equation 1:
Straight-Line Accrual**

$$\text{Annual Accrual} = \frac{\text{Gross Plant} - \text{Net Salvage}}{\text{Service Life}}$$

Gross plant is a known amount from the utility's records, while both net salvage and service life must be estimated in order to calculate the annual accrual. The straight-line method differs from accelerated methods of recovery, such as the "sum-of-the-years-digits" method and the "declining balance" method. Accelerated methods are primarily used for tax purposes and are rarely used in the regulatory context for determining annual accruals.⁵⁷ In practice, the annual accrual is expressed as a rate which is applied to the original cost of plant in order to determine the annual accrual in dollars. The formula for determining the straight-line rate is as follows:⁵⁸

**Equation 2:
Straight-Line Rate**

$$\text{Depreciation Rate \%} = \frac{100 - \text{Net Salvage \%}}{\text{Service Life}}$$

2. Grouping Procedures

The "procedure" refers to the way the allocation method is applied through subdividing the total property into groups.⁵⁹ While single units may be analyzed for depreciation, a group plan of depreciation is particularly adaptable to utility property. Employing a grouping procedure allows for a composite application of depreciation rates to groups of similar property, rather than excessively conducting calculations for each unit. Whereas an individual unit of property has a

⁵⁷ *Id.* at 57.

⁵⁸ *Id.* at 56.

⁵⁹ *Wolf supra* n. 7, at 74-75.

single life, a group of property displays a dispersion of lives and the life characteristics of the group must be described statistically.⁶⁰ When analyzing mass property categories, it is important that each group contains homogenous units of plant that are used in the same general manner throughout the plant and operated under the same general conditions.⁶¹

The “average life” and “equal life” grouping procedures are the two most common. In the average life procedure, a constant annual accrual rate based on the average life of all property in the group is applied to the surviving property. While property having shorter lives than the group average will not be fully depreciated, and likewise, property having longer lives than the group average will be over-depreciated, the ultimate result is that the group will be fully depreciated by the time of the final retirement.⁶² Thus, the average life procedure treats each unit as though its life is equal to the average life of the group. In contrast, the equal life procedure treats each unit in the group as though its life was known.⁶³ Under the equal life procedure the property is divided into subgroups that each has a common life.⁶⁴

3. Application Techniques

The third factor of a depreciation system is the “technique” for applying the depreciation rate. There are two commonly used techniques: “whole life” and “remaining life.” The whole life technique applies the depreciation rate on the estimated average service life of group, while the remaining life technique seeks to recover undepreciated costs over the remaining life of the plant.⁶⁵

⁶⁰ *Id.* at 74.

⁶¹ NARUC *supra* n. 8, at 61-62.

⁶² *See Wolf supra* n. 7, at 74-75.

⁶³ *Id.* at 75.

⁶⁴ *Id.*

⁶⁵ NARUC *supra* n. 8, at 63-64.

In choosing the application technique, consideration should be given to the proper level of the accumulated depreciation account. Depreciation accrual rates are calculated using estimates of service life and salvage. Periodically these estimates must be revised due to changing conditions, which cause the accumulated depreciation account to be higher or lower than necessary. Unless some corrective action is taken, the annual accruals will not equal the original cost of the plant at the time of final retirement.⁶⁶ Analysts can calculate the level of imbalance in the accumulated depreciation account by determining the “calculated accumulated depreciation,” (a.k.a. “theoretical reserve” and referred to in these appendices as “CAD”). The CAD is the calculated balance that would be in the accumulated depreciation account at a point in time using current depreciation parameters.⁶⁷ An imbalance exists when the actual accumulated depreciation account does not equal the CAD. The choice of application technique will affect how the imbalance is dealt with.

Use of the whole life technique requires that an adjustment be made to accumulated depreciation after calculation of the CAD. The adjustment can be made in a lump sum or over a period of time. With use of the remaining life technique, however, adjustments to accumulated depreciation are amortized over the remaining life of the property and are automatically included in the annual accrual.⁶⁸ This is one reason that the remaining life technique is popular among practitioners and regulators. The basic formula for the remaining life technique is as follows:⁶⁹

⁶⁶ Wolf *supra* n. 7, at 83.

⁶⁷ NARUC *supra* n. 8, at 325.

⁶⁸ NARUC *supra* n. 8, at 65 (“The desirability of using the remaining life technique is that any necessary adjustments of [accumulated depreciation] . . . are accrued automatically over the remaining life of the property. Once commenced, adjustments to the depreciation reserve, outside of those inherent in the remaining life rate would require regulatory approval.”).

⁶⁹ *Id.* at 64.

**Equation 3:
Remaining Life Accrual**

$$\text{Annual Accrual} = \frac{\text{Gross Plant} - \text{Accumulated Depreciation} - \text{Net Salvage}}{\text{Average Remaining Life}}$$

The remaining life accrual formula is similar to the basic straight-line accrual formula above with two notable exceptions. First, the numerator has an additional factor in the remaining life formula: the accumulated depreciation. Second, the denominator is “average remaining life” instead of “average life.” Essentially, the future accrual of plant (gross plant less accumulated depreciation) is allocated over the remaining life of plant. Thus, the adjustment to accumulated depreciation is “automatic” in the sense that it is built into the remaining life calculation.⁷⁰

4. Analysis Model

The fourth parameter of a depreciation system, the “model,” relates to the way of viewing the life and salvage characteristics of the vintage groups that have been combined to form a continuous property group for depreciation purposes.⁷¹ A continuous property group is created when vintage groups are combined to form a common group. Over time, the characteristics of the property may change, but the continuous property group will continue. The two analysis models used among practitioners, the “broad group” and the “vintage group,” are two ways of viewing the life and salvage characteristics of the vintage groups that have been combined to form a continuous property group.

The broad group model views the continuous property group as a collection of vintage groups that each has the same life and salvage characteristics. Thus, a single survivor curve and a

⁷⁰ Wolf *supra* n. 7, at 178.

⁷¹ See Wolf *supra* n. 7, at 139 (I added the term “model” to distinguish this fourth depreciation system parameter from the other three parameters).

single salvage schedule are chosen to describe all the vintages in the continuous property group. In contrast, the vintage group model views the continuous property group as a collection of vintage groups that may have different life and salvage characteristics. Typically, there is not a significant difference between vintage group and broad group results unless vintages within the applicable property group experienced dramatically different retirement levels than anticipated in the overall estimated life for the group. For this reason, many analysts utilize the broad group procedure because it is more efficient.

APPENDIX B:**IOWA CURVES**

Early work in the analysis of the service life of industrial property was based on models that described the life characteristics of human populations.⁷² This explains why the word “mortality” is often used in the context of depreciation analysis. In fact, a group of property installed during the same accounting period is analogous to a group of humans born during the same calendar year. Each period the group will incur a certain fraction of deaths / retirements until there are no survivors. Describing this pattern of mortality is part of actuarial analysis, and is regularly used by insurance companies to determine life insurance premiums. The pattern of mortality may be described by several mathematical functions, particularly the survivor curve and frequency curve. Each curve may be derived from the other so that if one curve is known, the other may be obtained. A survivor curve is a graph of the percent of units remaining in service expressed as a function of age.⁷³ A frequency curve is a graph of the frequency of retirements as a function of age. Several types of survivor and frequency curves are illustrated in the figures below.

1. Development

The survivor curves used by analysts today were developed over several decades from extensive analysis of utility and industrial property. In 1931 Edwin Kurtz and Robley Winfrey used extensive data from a range of 65 industrial property groups to create survivor curves representing the life characteristics of each group of property.⁷⁴ They generalized the 65 curves

⁷² Wolf *supra* n. 7, at 276.

⁷³ *Id.* at 23.

⁷⁴ *Id.* at 34.

into 13 survivor curve types and published their results in *Bulletin 103: Life Characteristics of Physical Property*. The 13 type curves were designed to be used as valuable aids in forecasting probable future service lives of industrial property. Over the next few years, Winfrey continued gathering additional data, particularly from public utility property, and expanded the examined property groups from 65 to 176.⁷⁵ This resulted in 5 additional survivor curve types for a total of 18 curves. In 1935, Winfrey published *Bulletin 125: Statistical Analysis of Industrial Property Retirements*. According to Winfrey, “[t]he 18 type curves are expected to represent quite well all survivor curves commonly encountered in utility and industrial practices.”⁷⁶ These curves are known as the “Iowa curves” and are used extensively in depreciation analysis in order to obtain the average service lives of property groups. (Use of Iowa curves in actuarial analysis is further discussed in Appendix C.)

In 1942, Winfrey published *Bulletin 155: Depreciation of Group Properties*. In Bulletin 155, Winfrey made some slight revisions to a few of the 18 curve types, and published the equations, tables of the percent surviving, and probable life of each curve at five-percent intervals.⁷⁷ Rather than using the original formulas, analysts typically rely on the published tables containing the percentages surviving. This is because absent knowledge of the integration technique applied to each age interval, it is not possible to recreate the exact original published table values. In the 1970s, John Russo collected data from over 2,000 property accounts reflecting observations during the period 1965 – 1975 as part of his Ph.D. dissertation at Iowa State. Russo

⁷⁵ *Id.*

⁷⁶ Robley Winfrey, *Bulletin 125: Statistical Analyses of Industrial Property Retirements* 85, Vol. XXXIV, No. 23 (Iowa State College of Agriculture and Mechanic Arts 1935).

⁷⁷ Robley Winfrey, *Bulletin 155: Depreciation of Group Properties* 121-28, Vol. XLI, No. 1 (The Iowa State College Bulletin 1942); *see also* Wolf *supra* n. 7, at 305-38 (publishing the percent surviving for each Iowa curve, including “O” type curve, at one percent intervals).

essentially repeated Winfrey's data collection, testing, and analysis methods used to develop the original Iowa curves, except that Russo studied industrial property in service several decades after Winfrey published the original Iowa curves. Russo drew three major conclusions from his research:⁷⁸

1. No evidence was found to conclude that the Iowa curve set, as it stands, is not a valid system of standard curves;
2. No evidence was found to conclude that new curve shapes could be produced at this time that would add to the validity of the Iowa curve set; and
3. No evidence was found to suggest that the number of curves within the Iowa curve set should be reduced.

Prior to Russo's study, some had criticized the Iowa curves as being potentially obsolete because their development was rooted in the study of industrial property in existence during the early 1900s. Russo's research, however, negated this criticism by confirming that the Iowa curves represent a sufficiently wide range of life patterns, and that though technology will change over time, the underlying patterns of retirements remain constant and can be adequately described by the Iowa curves.⁷⁹

Over the years, several more curve types have been added to Winfrey's 18 Iowa curves. In 1967, Harold Cowles added four origin-modal curves. In addition, a square curve is sometimes used to depict retirements which are all planned to occur at a given age. Finally, analysts commonly rely on several "half curves" derived from the original Iowa curves. Thus, the term "Iowa curves" could be said to describe up to 31 standardized survivor curves.

⁷⁸ See Wolf *supra* n. 7, at 37.

⁷⁹ *Id.*

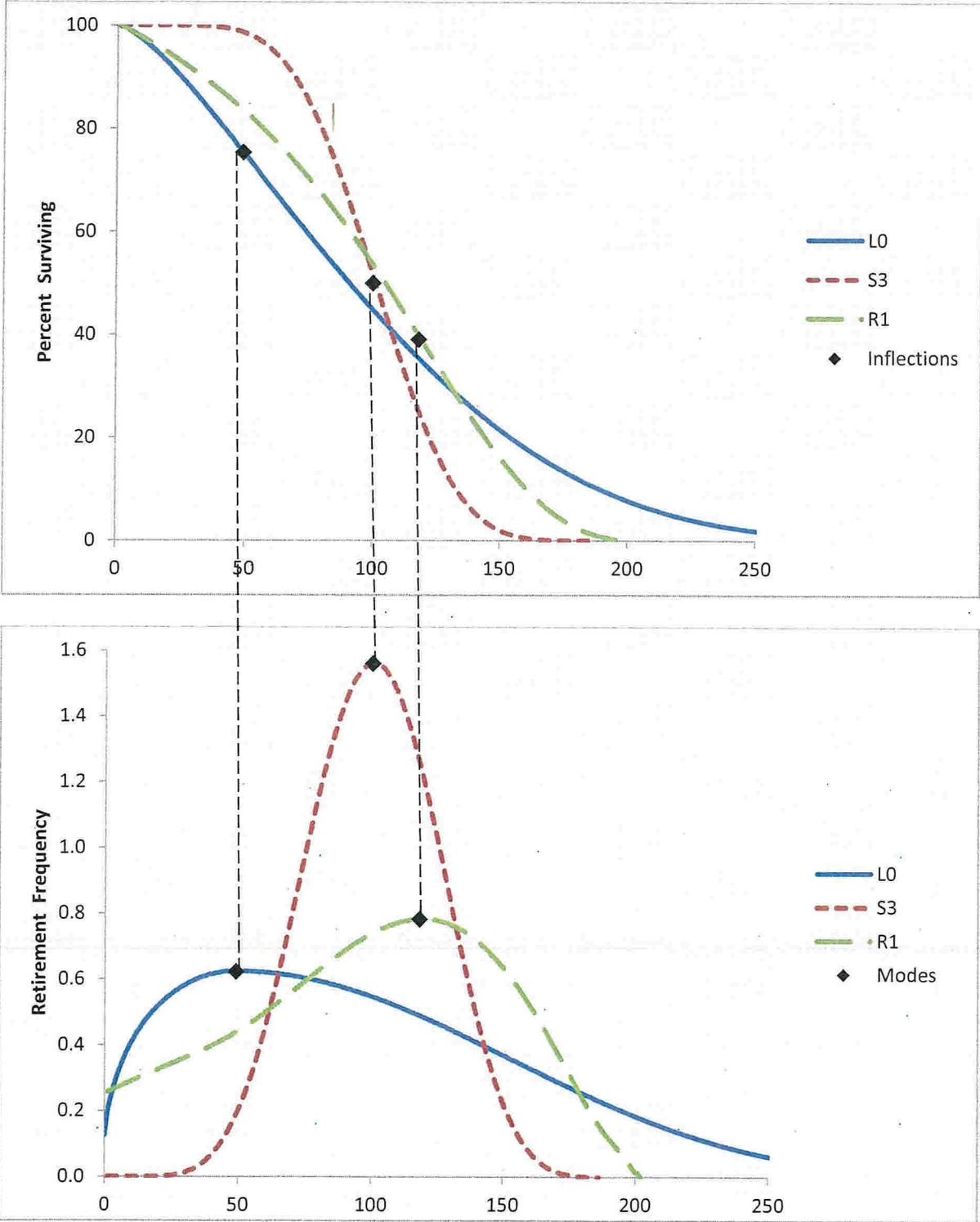
2. Classification

The Iowa curves are classified by three variables: modal location, average life, and variation of life. First, the mode is the percent life that results in the highest point of the frequency curve and the “inflection point” on the survivor curve. The modal age is the age at which the greatest rate of retirement occurs. As illustrated in the figure below, the modes appear at the steepest point of each survivor curve in the top graph, as well as the highest point of each corresponding frequency curve in the bottom graph.

The classification of the survivor curves was made according to whether the mode of the retirement frequency curves was to the left, to the right, or coincident with average service life. There are three modal “families” of curves: six left modal curves (L0, L1, L2, L3, L4, L5); five right modal curves (R1, R2, R3, R4, R5); and seven symmetrical curves (S0, S1, S2, S3, S4, S5, S6).⁸⁰ In the figure below, one curve from each family is shown: L0, S3 and R1, with average life at 100 on the x-axis. It is clear from the graphs that the modes for the L0 and R1 curves appear to the left and right of average life respectively, while the S3 mode is coincident with average life.

⁸⁰ In 1967, Harold A. Cowles added four origin-modal curves known as “O type” curves. There are also several “half” curves and a square curve, so the total amount of survivor curves commonly called “Iowa” curves is about 31 (see NARUC supra n. 8, at 68).

Figure 10:
Modal Age Illustration



The second Iowa curve classification variable is average life. The Iowa curves were designed using a single parameter of age expressed as a percent of average life instead of actual age. This was necessary in order for the curves to be of practical value. As Winfrey notes:

Since the location of a particular survivor on a graph is affected by both its span in years and the shape of the curve, it is difficult to classify a group of curves unless one of these variables can be controlled. This is easily done by expressing the age in percent of average life.”⁸¹

Because age is expressed in terms of percent of average life, any particular Iowa curve type can be modified to forecast property groups with various average lives.

The third variable, variation of life, is represented by the numbers next to each letter. A lower number (e.g., L1) indicates a relatively low mode, large variation, and large maximum life; a higher number (e.g., L5) indicates a relatively high mode, small variation, and small maximum life. All three classification variables – modal location, average life, and variation of life – are used to describe each Iowa curve. For example, a 13-L1 Iowa curve describes a group of property with a 13-year average life, with the greatest number of retirements occurring before (or to the left of) the average life, and a relatively low mode. The graphs below show these 18 survivor curves, organized by modal family.

⁸¹ Winfrey, *Bulletin 125: Statistical Analyses of Industrial Property Retirements* 60, Vol. XXXIV, No. 23 (Iowa State College of Agriculture and Mechanic Arts 1935).

Figure 11:
Type L Survivor and Frequency Curves

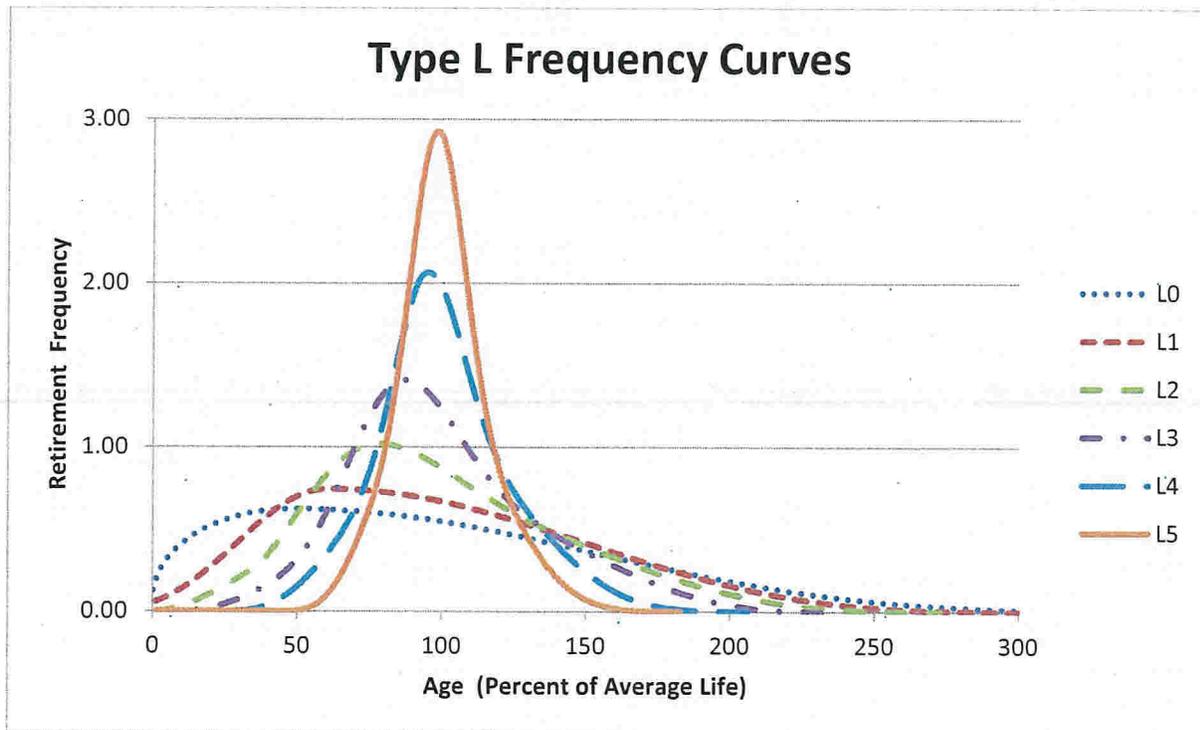
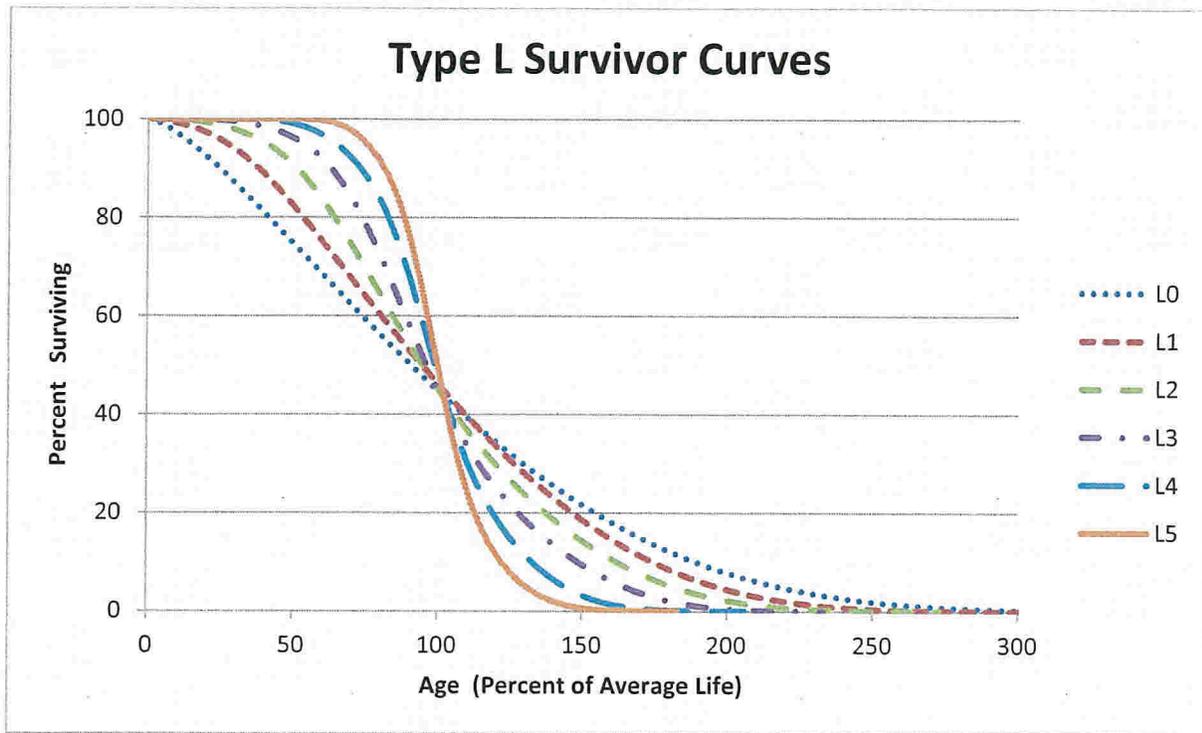


Figure 12:
Type S Survivor and Frequency Curves

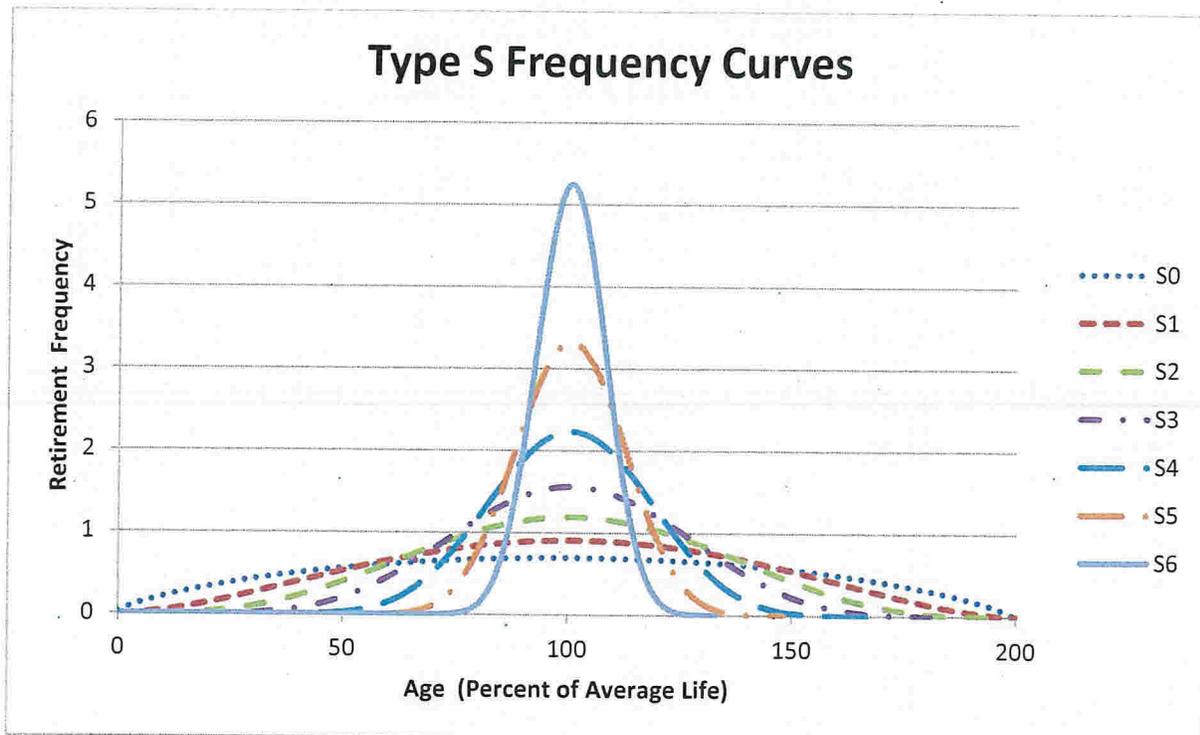
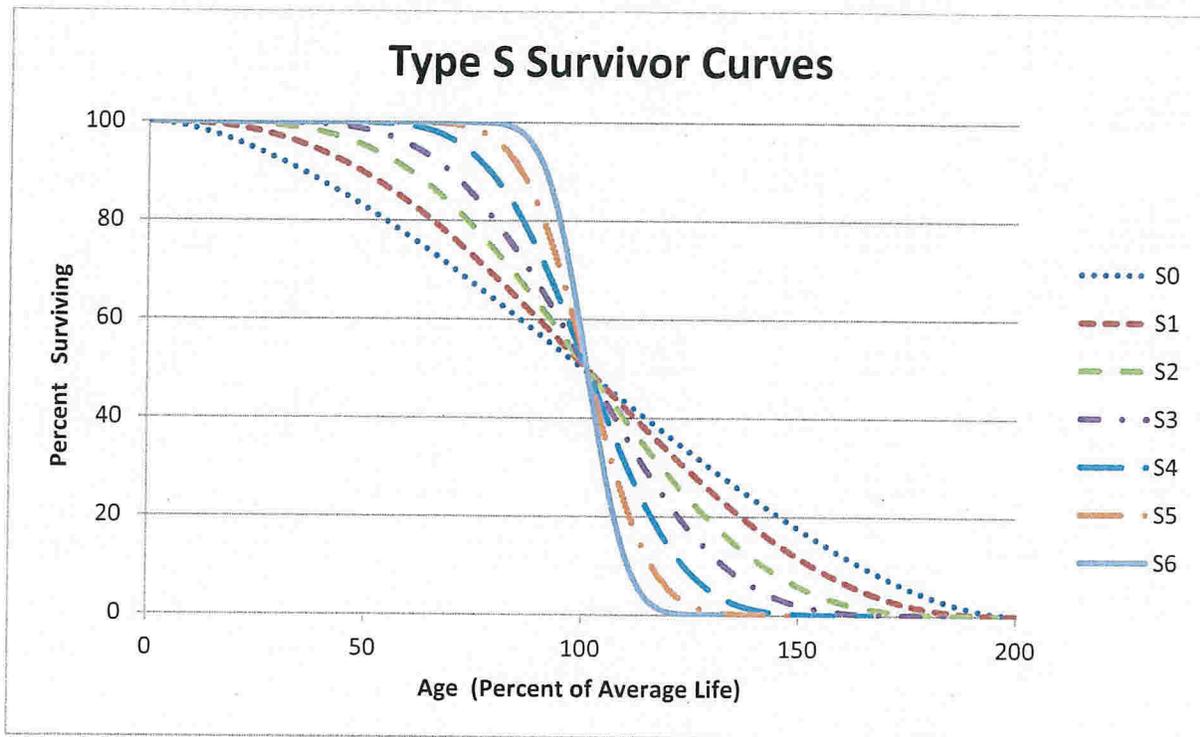
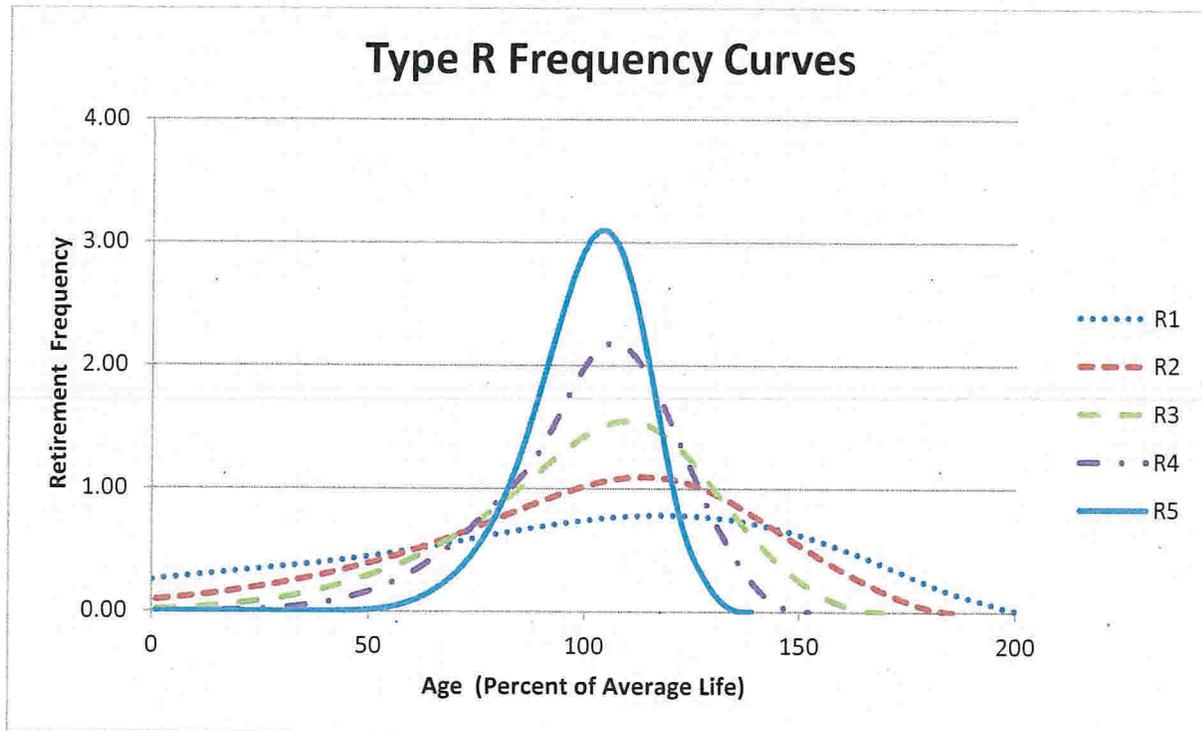
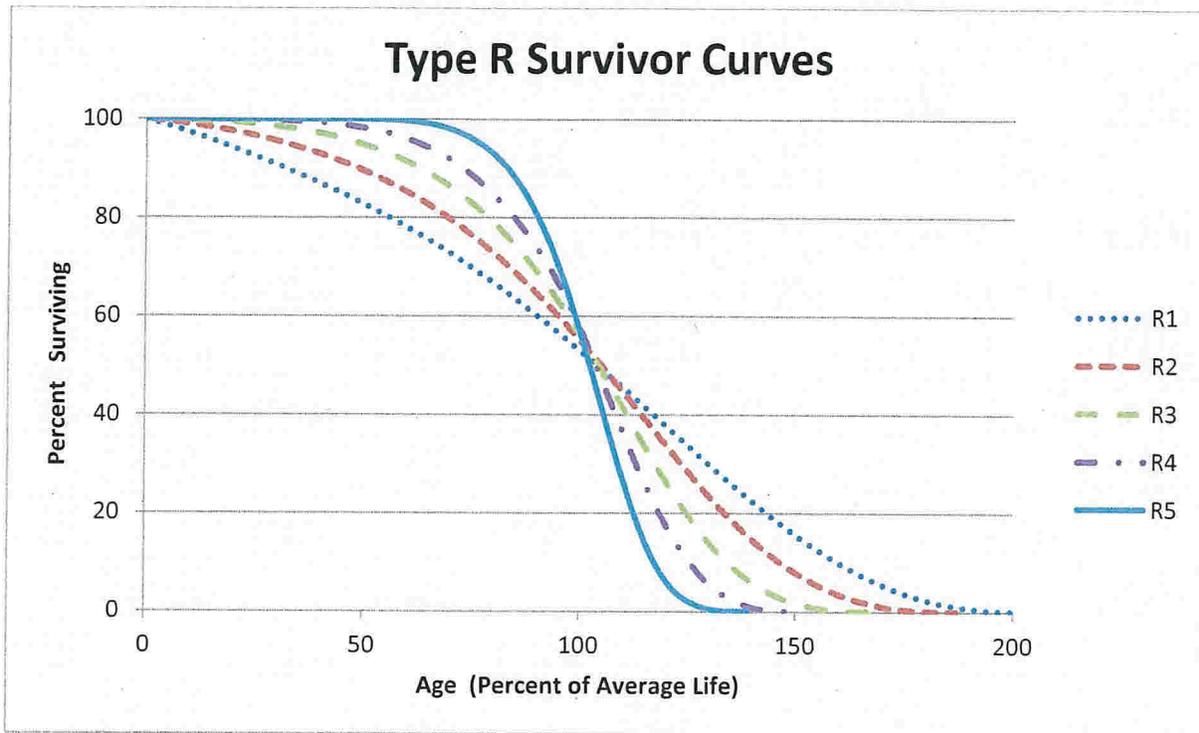


Figure 13:
Type R Survivor and Frequency Curves



As shown in the graphs above, the modes for the L family frequency curves occur to the left of average life (100% on the x-axis), while the S family modes occur at the average, and the R family modes occur after the average.

3. Types of Lives

Several other important statistical analyses and types of lives may be derived from an Iowa curve. These include: 1) average life; 2) realized life; 3) remaining life; and 4) probable life. The figure below illustrates these concepts. It shows the frequency curve, survivor curve, and probable life curve. Age M_x on the x-axis represents the modal age, while age AL_x represents the average age. Thus, this figure illustrates an “L type” Iowa curve since the mode occurs before the average.⁸²

First, average life is the area under the survivor curve from age zero to maximum life. Because the survivor curve is measured in percent, the area under the curve must be divided by 100% to convert it from percent-years to years. The formula for average life is as follows:⁸³

**Equation 4:
Average Life**

$$\text{Average Life} = \frac{\text{Area Under Survivor Curve from Age 0 to Max Life}}{100\%}$$

Thus, average life may not be determined without a complete survivor curve. Many property groups being analyzed will not have experienced full retirement. This results in a “stub” survivor curve. Iowa curves are used to extend stub curves to maximum life in order for the average life calculation to be made (see Appendix C).

⁸² From age zero to age M_x on the survivor curve, it could be said that the percent surviving from this property group is decreasing at an increasing rate. Conversely, from point M_x to maximum on the survivor curve, the percent surviving is decreasing at a decreasing rate.

⁸³ See NARUC *supra* n. 8, at 71.

Realized life is similar to average life, except that realized life is the average years of service experienced to date from the vintage's original installations.⁸⁴ As shown in the figure below, realized life is the area under the survivor curve from zero to age RL_x . Likewise, unrealized life is the area under the survivor curve from age RL_x to maximum life. Thus, it could be said that average life equals realized life plus unrealized life.

Average remaining life represents the future years of service expected from the surviving property.⁸⁵ Remaining life is sometimes referred to as "average remaining life" and "life expectancy." To calculate average remaining life at age x , the area under the estimated future portion of the survivor curve is divided by the percent surviving at age x (denoted S_x). Thus, the average remaining life formula is:

**Equation 5:
Average Remaining Life**

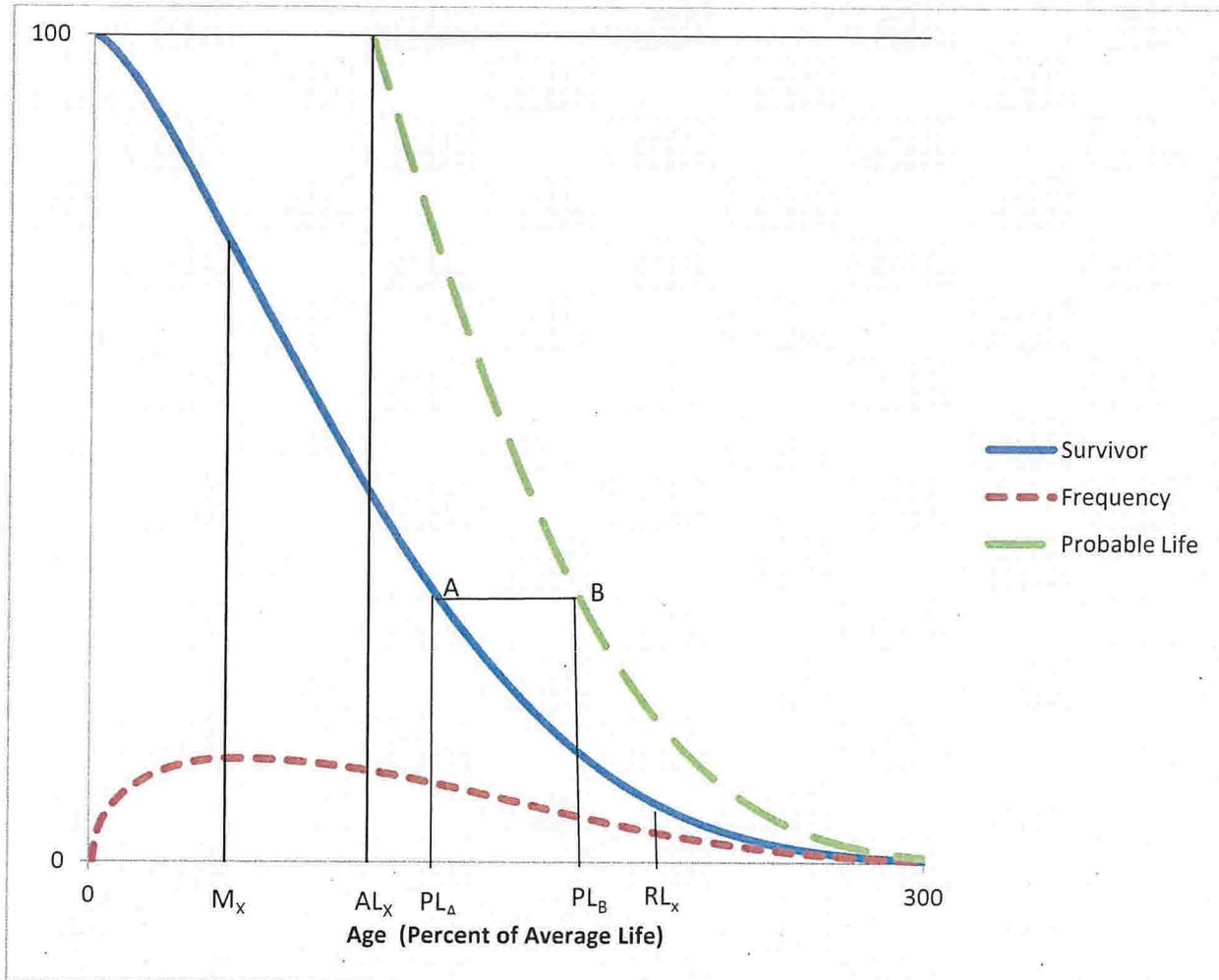
$$\text{Average Remaining Life} = \frac{\text{Area Under Survivor Curve from Age } x \text{ to Max Life}}{S_x}$$

It is necessary to determine average remaining life in order to calculate the annual accrual under the remaining life technique.

⁸⁴ *Id.* at 73.

⁸⁵ *Id.* at 74.

**Figure 14:
Iowa Curve Derivations**



Finally, the probable life may also be determined from the Iowa curve. The probable life of a property group is the total life expectancy of the property surviving at any age and is equal to the remaining life plus the current age.⁸⁶ The probable life is also illustrated in this figure. The probable life at age PL_A is the age at point PL_B . Thus, to read the probable life at age PL_A , see the corresponding point on the survivor curve above at point “A,” then horizontally to point “B” on

⁸⁶ Wolf *supra* n. 7, at 28.

the probable life curve, and back down to the age corresponding to point "B." It is no coincidence that the vertical line from AL_x connects at the top of the probable life curve. This is because at age zero, probable life equals average life.

APPENDIX C: ACTUARIAL ANALYSIS

Actuarial science is a discipline that applies various statistical methods to assess risk probabilities and other related functions. Actuaries often study human mortality. The results from historical mortality data are used to predict how long similar groups of people who are alive will live today. Insurance companies rely on actuarial analysis in determining premiums for life insurance policies.

The study of human mortality is analogous to estimating service lives of industrial property groups. While some humans die solely from chance, most deaths are related to age; that is, death rates generally increase as age increases. Similarly, physical plant is also subject to forces of retirement. These forces include physical, functional, and contingent factors, as shown in the table below.⁸⁷

**Figure 15:
Forces of Retirement**

<u>Physical Factors</u>	<u>Functional Factors</u>	<u>Contingent Factors</u>
Wear and tear Decay or deterioration Action of the elements	Inadequacy Obsolescence Changes in technology Regulations Managerial discretion	Casualties or disasters Extraordinary obsolescence

While actuaries study historical mortality data in order to predict how long a group of people will live, depreciation analysts must look at a utility's historical data in order to estimate the average lives of property groups. A utility's historical data is often contained in the Continuing Property Records ("CPR"). Generally, a CPR should contain 1) an inventory of property record

⁸⁷ NARUC *supra* n. 8, at 14-15.

units; 2) the association of costs with such units; and 3) the dates of installation and removal of plant. Since actuarial analysis includes the examination of historical data to forecast future retirements, the historical data used in the analysis should not contain events that are anomalous or unlikely to recur.⁸⁸ Historical data is used in the retirement rate actuarial method, which is discussed further below.

The Retirement Rate Method

There are several systematic actuarial methods that use historical data in order to calculating observed survivor curves for property groups. Of these methods, the retirement rate method is superior, and is widely employed by depreciation analysts.⁸⁹ The retirement rate method is ultimately used to develop an observed survivor curve, which can be fitted with an Iowa curve discussed in Appendix B in order to forecast average life. The observed survivor curve is calculated by using an observed life table (“OLT”). The figures below illustrate how the OLT is developed. First, historical property data are organized in a matrix format, with placement years on the left forming rows, and experience years on the top forming columns. The placement year (a.k.a. “vintage year” or “installation year”) is the year of placement of a group of property. The experience year (a.k.a. “activity year”) refers to the accounting data for a particular calendar year. The two matrices below use aged data – that is, data for which the dates of placements, retirements, transfers, and other transactions are known. Without aged data, the retirement rate actuarial method may not be employed. The first matrix is the exposure matrix, which shows the exposures

⁸⁸ *Id.* at 112-13.

⁸⁹ Anson Marston, Robley Winfrey & Jean C. Hempstead, *Engineering Valuation and Depreciation* 154 (2nd ed., McGraw-Hill Book Company, Inc. 1953).

at the beginning of each year.⁹⁰ An exposure is simply the depreciable property subject to retirement during a period. The second matrix is the retirement matrix, which shows the annual retirements during each year. Each matrix covers placement years 2003–2015, and experience years 2008–2015. In the exposure matrix, the number in the 2009 experience column and the 2003 placement row is \$192,000. This means at the beginning of 2012, there was \$192,000 still exposed to retirement from the vintage group placed in 2003. Likewise, in the retirement matrix, \$19,000 of the dollars invested in 2003 was retired during 2012.

**Figure 16:
Exposure Matrix**

Placement Years	Experience Years							Total at Start of Age Interval	Age Interval	
	Exposures at January 1 of Each Year (Dollars in 000's)									
	2008	2009	2010	2011	2012	2013	2014	2015		
2003	261	245	228	211	192	173	152	131	131	11.5 - 12.5
2004	267	252	236	220	202	184	165	145	297	10.5 - 11.5
2005	304	291	277	263	248	232	216	198	536	9.5 - 10.5
2006	345	334	322	310	298	284	270	255	847	8.5 - 9.5
2007	367	357	347	335	324	312	299	286	1,201	7.5 - 8.5
2008	375	366	357	347	336	325	314	302	1,581	6.5 - 7.5
2009		377	366	356	346	336	327	319	1,986	5.5 - 6.5
2010			381	369	358	347	336	327	2,404	4.5 - 5.5
2011				386	372	359	346	334	2,559	3.5 - 4.5
2012					395	380	366	352	2,722	2.5 - 3.5
2013						401	385	370	2,866	1.5 - 2.5
2014							410	393	2,998	0.5 - 1.5
2015								416	3,141	0.0 - 0.5
Total	1919	2222	2514	2796	3070	3333	3586	3827	23,268	

⁹⁰ Technically, the last numbers in each column are “gross additions” rather than exposures. Gross additions do not include adjustments and transfers applicable to plant placed in a previous year. Once retirements, adjustments, and transfers are factored in, the balance at the beginning of the next account period is called an “exposure” rather than an addition.

**Figure 17:
Retirement Matrix**

Placement Years	Experience Years								Total During Age Interval	Age Interval
	Retirements During the Year (Dollars in 000's)									
	2008	2009	2010	2011	2012	2013	2014	2015		
2003	16	17	18	19	19	20	21	23	23	11.5 - 12.5
2004	15	16	17	17	18	19	20	21	43	10.5 - 11.5
2005	13	14	14	15	16	17	17	18	59	9.5 - 10.5
2006	11	12	12	13	13	14	15	15	71	8.5 - 9.5
2007	10	11	11	12	12	13	13	14	82	7.5 - 8.5
2008	9	9	10	10	11	11	12	13	91	6.5 - 7.5
2009		11	10	10	9	9	9	8	95	5.5 - 6.5
2010			12	11	11	10	10	9	100	4.5 - 5.5
2011				14	13	13	12	11	93	3.5 - 4.5
2012					15	14	14	13	91	2.5 - 3.5
2013						16	15	14	93	1.5 - 2.5
2014							17	16	100	0.5 - 1.5
2015								18	112	0.0 - 0.5
Total	74	89	104	121	139	157	175	194	1,052	

These matrices help visualize how exposure and retirement data are calculated for each age interval. An age interval is typically one year. A common convention is to assume that any unit installed during the year is installed in the middle of the calendar year (i.e., July 1st). This convention is called the “half-year convention” and effectively assumes that all units are installed uniformly during the year.⁹¹ Adoption of the half-year convention leads to age intervals of 0-0.5 years, 0.5-1.5 years, etc., as shown in the matrices.

The purpose of the matrices is to calculate the totals for each age interval, which are shown in the second column from the right in each matrix. This column is calculated by adding each number from the corresponding age interval in the matrix. For example, in the exposure matrix, the total amount of exposures at the beginning of the 8.5-9.5 age interval is \$847,000. This number was calculated by adding the numbers shown on the “stairs” to the left (192+184+216+255=847). The same calculation is applied to each number in the column. The amounts retired during the year

⁹¹ Wolf *supra* n. 7, at 22.

in the retirements matrix affect the exposures at the beginning of each year in the exposures matrix. For example, the amount exposed to retirement in 2008 from the 2003 vintage is \$261,000. The amount retired during 2008 from the 2003 vintage is \$16,000. Thus, the amount exposed to retirement in 2009 from the 2003 vintage is \$245,000 ($\$261,000 - \$16,000$). The company's property records may contain other transactions which affect the property, including sales, transfers, and adjusting entries. Although these transactions are not shown in the matrices above, they would nonetheless affect the amount exposed to retirement at the beginning of each year.

The totaled amounts for each age interval in both matrices are used to form the exposure and retirement columns in the OLT, as shown in the chart below. This chart also shows the retirement ratio and the survivor ratio for each age interval. The retirement ratio for an age interval is the ratio of retirements during the interval to the property exposed to retirement at the beginning of the interval. The retirement ratio represents the probability that the property surviving at the beginning of an age interval will be retired during the interval. The survivor ratio is simply the complement to the retirement ratio ($1 - \text{retirement ratio}$). The survivor ratio represents the probability that the property surviving at the beginning of an age interval will survive to the next age interval.

**Figure 18:
Observed Life Table**

Age at Start of Interval	Exposures at Start of Age Interval	Retirements During Age Interval	Retirement Ratio	Survivor Ratio	Percent Surviving at Start of Age Interval
A	B	C	D = C/B	E = 1 - D	F
0.0	3,141	112	0.036	0.964	100.00
0.5	2,998	100	0.033	0.967	96.43
1.5	2,866	93	0.032	0.968	93.21
2.5	2,722	91	0.033	0.967	90.19
3.5	2,559	93	0.037	0.963	87.19
4.5	2,404	100	0.042	0.958	84.01
5.5	1,986	95	0.048	0.952	80.50
6.5	1,581	91	0.058	0.942	76.67
7.5	1,201	82	0.068	0.932	72.26
8.5	847	71	0.084	0.916	67.31
9.5	536	59	0.110	0.890	61.63
10.5	297	43	0.143	0.857	54.87
11.5	131	23	0.172	0.828	47.01
Total	23,268	1,052			38.91

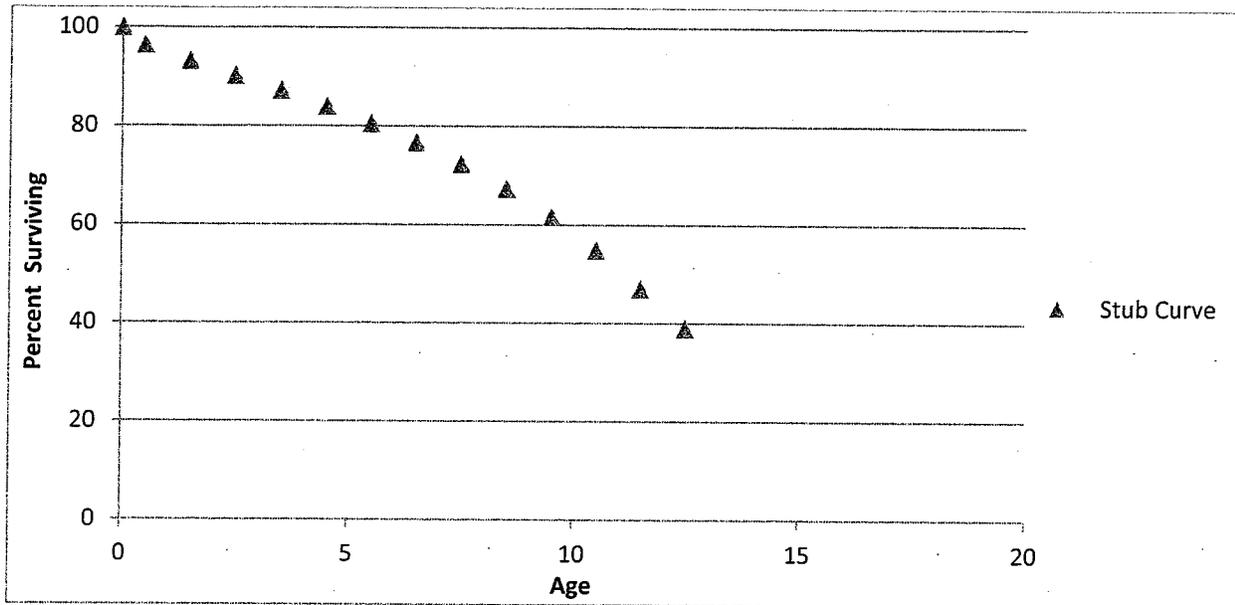
Column F on the right shows the percentages surviving at the beginning of each age interval. This column starts at 100% surviving. Each consecutive number below is calculated by multiplying the percent surviving from the previous age interval by the corresponding survivor ratio for that age interval. For example, the percent surviving at the start of age interval 1.5 is 93.21%, which was calculated by multiplying the percent surviving for age interval 0.5 (96.43%) by the survivor ratio for age interval 0.5 (0.967)⁹².

The percentages surviving in Column F are the numbers that are used to form the original survivor curve. This particular curve starts at 100% surviving and ends at 38.91% surviving. An

⁹² Multiplying 96.43 by 0.967 does not equal 93.21 exactly due to rounding.

observed survivor curve such as this that does not reach zero percent surviving is called a “stub” curve. The figure below illustrates the stub survivor curve derived from the OLT table above.

**Figure 19:
Original “Stub” Survivor Curve**



The matrices used to develop the basic OLT and stub survivor curve provide a basic illustration of the retirement rate method in that only a few placement and experience years were used. In reality, analysts may have several decades of aged property data to analyze. In that case, it may be useful to use a technique called “banding” in order to identify trends in the data.

Banding

The forces of retirement and characteristics of industrial property are constantly changing. A depreciation analyst may examine the magnitude of these changes. Analysts often use a technique called “banding” to assist with this process. Banding refers to the merging of several years of data into a single data set for further analysis, and it is a common technique associated

with the retirement rate method.⁹³ There are three primary benefits of using bands in depreciation analysis:

1. Increasing the sample size. In statistical analyses, the larger the sample size in relation to the body of total data, the greater the reliability of the result;
2. Smooth the observed data. Generally, the data obtained from a single activity or vintage year will not produce an observed life table that can be easily fit; and
3. Identify trends. By looking at successive bands, the analyst may identify broad trends in the data that may be useful in projecting the future life characteristics of the property.⁹⁴

Two common types of banding methods are the “placement band” method and the “experience band” method.” A placement band, as the name implies, isolates selected placement years for analysis. The figure below illustrates the same exposure matrix shown above, except that only the placement years 2005-2008 are considered in calculating the total exposures at the beginning of each age interval.

⁹³ NARUC *supra* n. 8, at 113.

⁹⁴ *Id.*

**Figure 20:
Placement Bands**

Placement Years	Experience Years								Total at Start of Age Interval	Age Interval
	Exposures at January 1 of Each Year (Dollars in 000's)									
	2008	2009	2010	2011	2012	2013	2014	2015		
2003	261	245	228	211	192	173	152	131		11.5 - 12.5
2004	267	252	236	220	202	184	165	145		10.5 - 11.5
2005	304	291	277	263	248	232	216	198	198	9.5 - 10.5
2006	345	334	322	310	298	284	270	255	471	8.5 - 9.5
2007	367	357	347	335	324	312	299	286	788	7.5 - 8.5
2008	375	366	357	347	336	325	314	302	1,133	6.5 - 7.5
2009		377	366	356	346	336	327	319	1,186	5.5 - 6.5
2010			381	369	358	347	336	327	1,237	4.5 - 5.5
2011				386	372	359	346	334	1,285	3.5 - 4.5
2012					395	380	366	352	1,331	2.5 - 3.5
2013						401	385	370	1,059	1.5 - 2.5
2014							410	393	733	0.5 - 1.5
2015								416	375	0.0 - 0.5
Total	1919	2222	2514	2796	3070	3333	3586	3827	9,796	

The shaded cells within the placement band equal the total exposures at the beginning of age interval 4.5–5.5 (\$1,237). The same placement band would be used for the retirement matrix covering the same placement years of 2005 – 2008. This of course would result in a different OLT and original stub survivor curve than those that were calculated above without the restriction of a placement band.

Analysts often use placement bands for comparing the survivor characteristics of properties with different physical characteristics.⁹⁵ Placement bands allow analysts to isolate the effects of changes in technology and materials that occur in successive generations of plant. For example, if in 2005 an electric utility began placing transmission poles with a special chemical treatment that extended the service lives of the poles, an analyst could use placement bands to isolate and analyze the effect of that change in the property group's physical characteristics. While placement bands are very useful in depreciation analysis, they also possess an intrinsic dilemma. A

⁹⁵ Wolf *supra* n. 7, at 182.

fundamental characteristic of placement bands is that they yield fairly complete survivor curves for older vintages. However, with newer vintages, which are arguably more valuable for forecasting, placement bands yield shorter survivor curves. Longer “stub” curves are considered more valuable for forecasting average life. Thus, an analyst must select a band width broad enough to provide confidence in the reliability of the resulting curve fit, yet narrow enough so that an emerging trend may be observed.⁹⁶

Analysts also use “experience bands.” Experience bands show the composite retirement history for all vintages during a select set of activity years. The figure below shows the same data presented in the previous exposure matrices, except that the experience band from 2011 – 2013 is isolated, resulting in different interval totals.

**Figure 21:
Experience Bands**

Placement Years	Experience Years								Total at Start of Age Interval	Age Interval
	Exposures at January 1 of Each Year (Dollars in 000's)									
	2008	2009	2010	2011	2012	2013	2014	2015		
2003	261	245	228	211	192	173	152	131		11.5 - 12.5
2004	267	252	236	220	202	184	165	145		10.5 - 11.5
2005	304	291	277	263	248	232	216	198	173	9.5 - 10.5
2006	345	334	322	310	298	284	270	255	376	8.5 - 9.5
2007	367	357	347	335	324	312	299	286	645	7.5 - 8.5
2008	375	366	357	347	336	325	314	302	752	6.5 - 7.5
2009		377	366	356	346	336	327	319	872	5.5 - 6.5
2010			381	369	358	347	336	327	959	4.5 - 5.5
2011				386	372	359	346	334	1,008	3.5 - 4.5
2012					395	380	366	352	1,039	2.5 - 3.5
2013						401	385	370	1,072	1.5 - 2.5
2014							410	393	1,121	0.5 - 1.5
2015								416	1,182	0.0 - 0.5
Total	1919	2222	2514	2796	3070	3333	3586	3827	9,199	

The shaded cells within the experience band equal the total exposures at the beginning of age interval 4.5–5.5 (\$1,237). The same experience band would be used for the retirement matrix

⁹⁶ NARUC *supra* n. 8, at 114.

covering the same experience years of 2011 – 2013. This of course would result in a different OLT and original stub survivor than if the band had not been used. Analysts often use experience bands to isolate and analyze the effects of an operating environment over time.⁹⁷ Likewise, the use of experience bands allows analysis of the effects of an unusual environmental event. For example, if an unusually severe ice storm occurred in 2013, destruction from that storm would affect an electric utility's line transformers of all ages. That is, each of the line transformers from each placement year would be affected, including those recently installed in 2012, as well as those installed in 2003. Using experience bands, an analyst could isolate or even eliminate the 2013 experience year from the analysis. In contrast, a placement band would not effectively isolate the ice storm's effect on life characteristics. Rather, the placement band would show an unusually large rate of retirement during 2013, making it more difficult to accurately fit the data with a smooth Iowa curve. Experience bands tend to yield the most complete stub curves for recent bands because they have the greatest number of vintages included. Longer stub curves are better for forecasting. The experience bands, however, may also result in more erratic retirement dispersion making the curve fitting process more difficult.

Depreciation analysts must use professional judgment in determining the types of bands to use and the band widths. In practice, analysts may use various combinations of placement and experience bands in order to increase the data sample size, identify trends and changes in life characteristics, and isolate unusual events. Regardless of which bands are used, observed survivor curves in depreciation analysis rarely reach zero percent. This is because, as seen in the OLT above, relatively newer vintage groups have not yet been fully retired at the time the property is

⁹⁷ *Id.*

studied. An analyst could confine the analysis to older, fully retired vintage groups in order to get complete survivor curves, but such analysis would ignore some the property currently in service and would arguably not provide an accurate description of life characteristics for current plant in service. Because a complete curve is necessary to calculate the average life of the property group, however, curve fitting techniques using Iowa curves or other standardized curves may be employed in order to complete the stub curve.

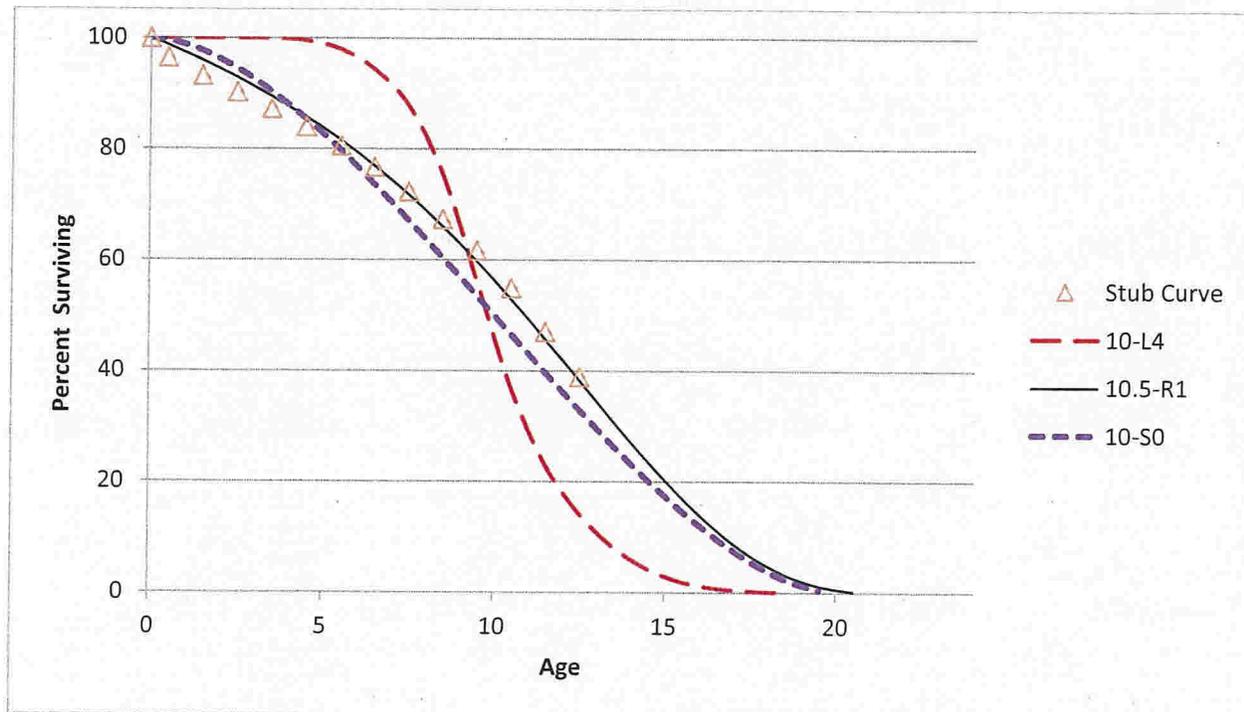
Curve Fitting

Depreciation analysts typically use the survivor curve rather than the frequency curve to fit the observed stub curves. The most commonly used generalized survivor curves used in the curve fitting process are the Iowa curves discussed above. As Wolf notes, if “the Iowa curves are adopted as a model, an underlying assumption is that the process describing the retirement pattern is one of the 22 [or more] processes described by the Iowa curves.”⁹⁸

Curve fitting may be done through visual matching or mathematical matching. In visual curve fitting, the analyst visually examines the plotted data to make an initial judgment about the Iowa curves that may be a good fit. The figure below illustrates the stub survivor curve shown above. It also shows three different Iowa curves: the 10-L4, the 10.5-R1, and the 10-S0. Visually, it is clear that the 10.5-R1 curve is a better fit than the other two curves.

⁹⁸ Wolf *supra* n. 7, at 46 (22 curves includes Winfrey’s 18 original curves plus Cowles’s four “O” type curves).

**Figure 22:
Visual Curve Fitting**



In mathematical fitting, the least squares method is used to calculate the best fit. This mathematical method would be excessively time consuming if done by hand. With the use of modern computer software however, mathematical fitting is an efficient and useful process. The typical logic for a computer program, as well as the software employed for the analysis in this testimony is as follows:

First (an Iowa curve) curve is arbitrarily selected. . . . If the observed curve is a stub curve, . . . calculate the area under the curve and up to the age at final data point. Call this area the realized life. Then systematically vary the average life of the theoretical survivor curve and calculate its realized life at the age corresponding to the study date. This trial and error procedure ends when you find an average life such that the realized life of the theoretical curve equals the realized life of the observed curve. Call this the average life.

Once the average life is found, calculate the difference between each percent surviving point on the observed survivor curve and the corresponding point on the Iowa curve. Square each difference and sum them. The sum of squares is used as a measure of goodness of fit for that particular Iowa type curve. This procedure is

repeated for the remaining 21 Iowa type curves. The “best fit” is declared to be the type of curve that minimizes the sum of differences squared.⁹⁹

Mathematical fitting requires less judgment from the analyst, and is thus less subjective.

Blind reliance on mathematical fitting, however, may lead to poor estimates. Thus, analysts should employ both mathematical and visual curve fitting in reaching their final estimates. This way, analysts may utilize the objective nature of mathematical fitting while still employing professional judgment. As Wolf notes: “The results of mathematical curve fitting serve as a guide for the analyst and speed the visual fitting process. But the results of the mathematical fitting should be checked visually and the final determination of the best fit be made by the analyst.”¹⁰⁰

In the graph above, visual fitting was sufficient to determine that the 10.5-R1 Iowa curve was a better fit than the 10-L4 and the 10-S0 curves. Using the sum of least squares method, mathematical fitting confirms the same result. In the chart below, the percentages surviving from the OLT that formed the original stub curve are shown in the left column, while the corresponding percentages surviving for each age interval are shown for the three Iowa curves. The right portion of the chart shows the differences between the points on each Iowa curve and the stub curve. These differences are summed at the bottom. Curve 10.5-R1 is the best fit because the sum of the squared differences for this curve is less than the same sum of the other two curves. Curve 10-L4 is the worst fit, which was also confirmed visually.

⁹⁹ Wolf *supra* n. 7, at 47.

¹⁰⁰ *Id.* at 48.

**Figure 23:
Mathematical Fitting**

Age Interval	Stub Curve	Iowa Curves			Squared Differences		
		10-L4	10-S0	10.5-R1	10-L4	10-S0	10.5-R1
0.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0
0.5	96.4	100.0	99.7	98.7	12.7	10.3	5.3
1.5	93.2	100.0	97.7	96.0	46.1	19.8	7.6
2.5	90.2	100.0	94.4	92.9	96.2	18.0	7.2
3.5	87.2	100.0	90.2	89.5	162.9	9.3	5.2
4.5	84.0	99.5	85.3	85.7	239.9	1.6	2.9
5.5	80.5	97.9	79.7	81.6	301.1	0.7	1.2
6.5	76.7	94.2	73.6	77.0	308.5	9.5	0.1
7.5	72.3	87.6	67.1	71.8	235.2	26.5	0.2
8.5	67.3	75.2	60.4	66.1	62.7	48.2	1.6
9.5	61.6	56.0	53.5	59.7	31.4	66.6	3.6
10.5	54.9	36.8	46.5	52.9	325.4	69.6	3.9
11.5	47.0	23.1	39.6	45.7	572.6	54.4	1.8
12.5	38.9	14.2	32.9	38.2	609.6	36.2	0.4
SUM					3004.2	371.0	41.0