Classic Values, Innovative Advice

California Public Employees' Retirement System

Comprehensive Review of the 2017 Experience Study

Produced by Cheiron

November 2017

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Classic Values, Innovative Advice

November 27, 2017

Board of Administration
California Public Employees' Retirement System
Lincoln Plaza North
400 Q Street
Sacramento, CA 95811

Members of the Board:

The purpose of this report is to present our comprehensive review of the 1997 to 2015 experience study performed by the California Public Employees' Retirement System (CalPERS) Actuarial Office. Our analysis includes a review of the development of the price inflation, wage growth, and payroll growth assumptions. In addition, our analysis includes a replication of the calculation of actual decrements, exposures, raw rates, and the assessment of proposed rates for demographic assumptions.

If you have any questions about the report or would like additional information, please let us know.

Sincerely,
Cheiron

William R. Hallmark, ASA, EA, FCA, MAAA
Consulting Actuary

Anne Harper, FSA, EA, MAAA
Consulting Actuary

SECTION 1 – EXECUTIVE SUMMARY

Scope of Assignment

CalPERS recently completed its 1997-2015 demographic experience study. In addition, CalPERS is reviewing its economic assumptions. Under a Letter of Engagement issued pursuant to CalPERS Agreement No. 2013-6899, Cheiron, Inc. (Cheiron) was retained to perform a comprehensive review of the methodology and recommendations of this experience study.

We performed an independent study of the following economic assumptions and used our analysis to evaluate the recommendations of the Office of the Actuary:

- Price inflation,
- Wage growth, and
- Payroll growth.

Our comprehensive review of the demographic assumptions includes an independent determination of the actual decrements, exposures, and raw rates. In addition, we calculated the 90 percent confidence intervals around the raw rates and evaluated the proposed assumptions using three primary measures:

- The percentage of proposed rates that fall within the 90 percent confidence interval,
- The actual number of decrements compared to the expected number of decrements based on the proposed assumptions, and
- The r-squared statistic comparing the actual decrements to the expected decrements at each age or service year to evaluate the pattern of the assumption compared to the pattern of the experience.

Finally, we developed recommendations to improve the methodologies currently used by the Actuarial Office to develop assumptions. We reviewed the following demographic assumptions:

- Mortality rates,
- Retirement rates,
- Industrial disability rates,
- Non-industrial disability rates,
- Vested termination rates,
- Refund rates,
- Merit salary increases, and
- Family composition.

Key Findings and Recommendations

Based on our review of the 1997-2015 demographic experience study and the review of economic assumptions performed by the Actuarial Office, we believe the proposed assumptions are reasonable, appropriate, and were developed in accordance with generally accepted actuarial principles. However, there are some areas in which we believe the Actuarial Office should consider some adjustments to their methodologies to the valuations. In some cases, these changes could make a material difference to the valuations. However, we don't have sufficient data to determine how significant or insignificant they may be. We also suggest a number of technical improvements that we do not expect to materially change the valuation results.

Overall, we have been very impressed with the methodologies and procedures used by the Actuarial Office to manage a large amount of information and develop assumptions that reflect the unique variations of each group studied. The sheer number of assumptions set is daunting, and the accuracy of the variations for each group is impressive. As with any audit or peer review, the focus of our comments is on areas where some improvement can be made, but this focus should not take away from the overall evaluation of the outstanding work that has been performed.

SUMMARY OF ECONOMIC ASSUMPTION ANALYSIS

The specific economic assumptions analyzed in this report are price inflation, wage inflation, and payroll growth. Based on our independent analysis of these economic assumptions, we believe the recommendations to reduce price inflation to 2.5%, to maintain a real wage growth assumption of 0.25%, and to reduce the payroll growth assumption to 2.75% are reasonable and well-supported by the analysis.

SUMMARY OF DEMOGRAPHIC ASSUMPTION ANALYSIS

We concur with the vast majority of the demographic assumptions proposed by the Office of the Actuary. There are three general areas where we have recommendations:

- Mortality,
- Male and female differences for certain assumptions, and
- The fit or pattern of certain assumptions compared to the observed experience.

Mortality

Our recommendations on mortality have the potential to be the most material. In the last experience study, CalPERS took a significant step in its mortality assumption to project future improvements beyond the valuation date. Since that time, actuaries have become even more sophisticated in their analysis of mortality data and projections of future mortality improvement. Much of this development was spurred by the issuance of the RP-2014 mortality tables and the MP-2014 projection scale by the Society of Actuaries along with annual updates to that projection scale.

There are some important lessons from this recent analysis of mortality, many of which were known before, but the significance of some factors may not have been fully appreciated. There are two steps to the development of a mortality assumption. First, base tables are developed reflecting the current experience of the population. Then, the base tables are adjusted to anticipate future mortality improvements.

SECTION 1 – EXECUTIVE SUMMARY

Base Mortality Tables

In developing the base mortality tables, historically our analysis had focused on the number of people who died at each age during the period. That analysis produces a table that reflects a common understanding of mortality. However, when valuing a pension plan, it doesn't matter how long people are projected to live as much as how long the plan will have to continue paying a retirement benefit. Those may seem like the same concept, but the plan is affected more by how long someone with a relatively large retirement benefit lives than someone with a relatively small retirement benefit.

Mortality studies have consistently shown that people with higher incomes live longer than people with lower incomes. Since retirement benefits in CalPERS are based on final average salaries, higher income members also receive higher dollar amounts of benefits. Consequently, it is important for a pension plan to develop its mortality assumptions on a benefits-weighted basis. We understand, however, that the systems used by the Actuarial Office are not capable of developing the mortality analysis on a benefits-weighted basis. We also understand that this deficiency in system capability is planned to be corrected before the next experience study. In the meantime, however, we believe the difference between a headcount-weighted mortality assumption and a benefits-weighted mortality assumption is significant enough that the Actuarial Office should consider an adjustment to the proposed tables to estimate the impact.

In the RP-2014 tables, which were based on private plan data, the difference between the headcount-weighted table and the benefits-weighted table is significant. The male mortality rate in the benefits-weighted table at age 50 is more than 30% lower and the female rate is more than 45% lower than the rates in the headcount-weighted table. The differences between the tables gradually decrease as age increases until they reach similar rates between ages 90 and 100. Some have hypothesized that these differences in private plan data would not exist or be as significant in public plan data due to public plan members access to healthcare in retirement. However, our experience with public plans as well as the experience of many other actuarial firms, confirms a similar dynamic in public plans. The recently completed experience study for Oregon PERS, for example, found that a benefits-weighted analysis reduced their actual-to-expected ratios between 9% and 18% depending on the group, which means that retirees with larger benefits tend to live longer than those with smaller benefits. In California city and county plans, we have found a similar range of effects that varies depending on the covered population.

Projections of Mortality Improvement

Mortality has a long history of improvement, and we expect the improvements to continue in the future at some level. These projected improvements should be taken into account in the mortality assumption, preferably using a generational improvement scale. A generational mortality assumption essentially establishes a separate mortality table for each year of birth, recognizing that the probability of death at age 75, for example, of someone who is 75 today is greater than for someone who is 55 today and even greater than for someone who is 35 today.

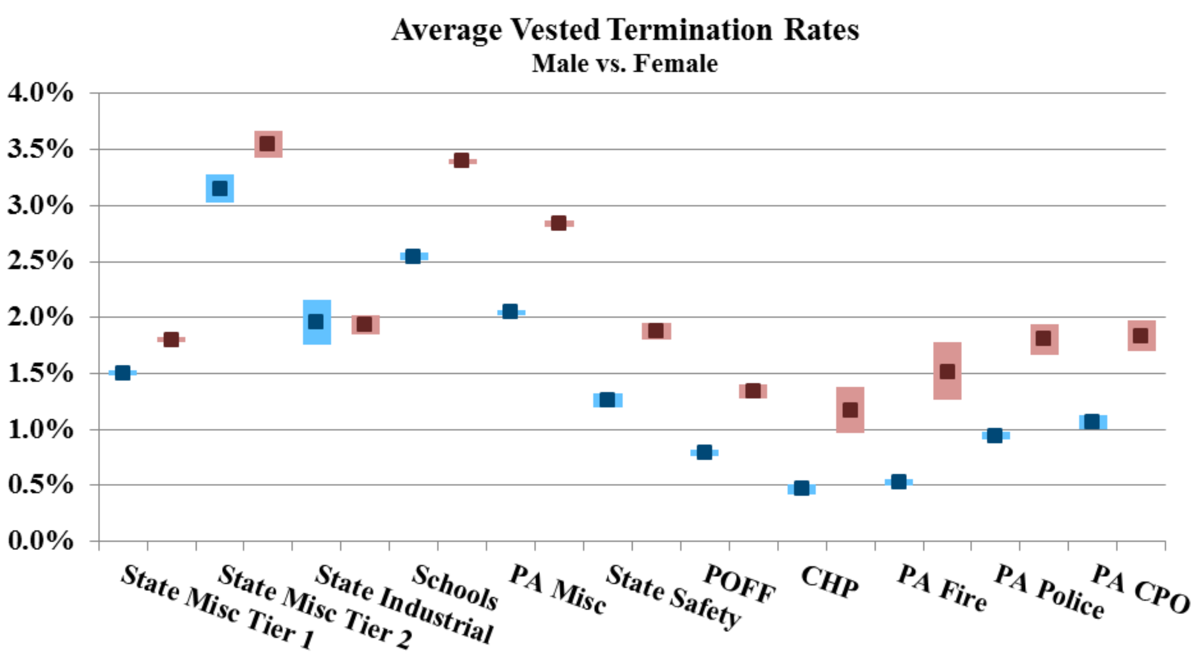
SECTION 1 – EXECUTIVE SUMMARY

While generational mortality is the best practice today, we understand that CalPERS's valuation system cannot use a generational mortality assumption. Consequently, the Actuarial Office develops a projection of the mortality rates to a fixed future date in order to estimate the liability that would be produced by a generational mortality table. The accuracy of this estimate changes with each valuation, with the demographics of each employer, and with changes in the discount rate. We have some technical comments about the methodology used to project the static table, but it is difficult to know how far the projection needs to be without actually running a valuation with a generational table. The projected static table proposed by the Actuarial Office appears to be reasonable for estimating the liability for benefits currently being paid that would be produced based on the generational mortality table.

Differences between Males and Females

In our analysis of the vested termination and industrial disability assumptions, we found that rates for females differed from rates for males for some groups and that there was credible data showing that the assumptions should not be the same for males and females as proposed by the Actuarial Office. For some of these groups, the number of females covered is low which may make the impact of having different assumptions on valuation results minimal, but the differences in rates are clear.

The chart below shows the average vested termination rate for males compared to females for the different groups studied. The dark blue squares represent the average vested termination rates observed for males and the dark red squares represent the average vested termination rates observed for females. The light blue and light red bars around the squares represent the range in which the average rate falls with 90 percent confidence.



SECTION 1 – EXECUTIVE SUMMARY

For most of the groups, there is no overlap between the bars, meaning that no single assumption can reasonably estimate both groups, and separate assumptions for males and females in these groups may be appropriate.

Over Emphasis on Actual-to-Expected Ratios

Finally, we found an overemphasis to fit the overall actual-to-expected (A/E) ratios when setting assumptions. In particular for retirement assumptions, this emphasis resulted in some assumptions not fitting the pattern of observed rates as well as they could. Actual-to-expected ratios are a very important metric to setting the proposed level of an assumption, but a rate that is too high for an age and service combination and another rate that is too low can offset each other and make the actual-to-expected ratio look perfect when the underlying assumptions for specific groups is not. When the Actuarial Office uses a Whitaker-Henderson graduation technique to fit the experience, the fit is usually pretty good although even in this case the technique can overweight points with limited experience, particularly if they are at the end of a service or age range. There are also assumptions for which the Whitaker-Henderson formulas are not suited and thus not used by the Actuarial Office. In these cases, we encourage the Actuarial Office to use other techniques to ensure a good fit, such as confidence intervals and the r-squared statistic.

The remainder of the report provides additional detail on our analysis and recommendations, including some technical suggestions for the next demographic experience study.

SECTION 2 – CERTIFICATION

The purpose of this report is to present the results of the comprehensive review of the 2017 CalPERS experience study. This report is for the use of CalPERS in selecting assumptions and in refining their methodologies for analyzing plan experience to set assumptions.

In preparing our report, we relied on information (some oral and some written) supplied by CalPERS. This information includes, but is not limited to, the plan provisions and member census data. We performed an informal examination of the obvious characteristics of the data for reasonableness and consistency in accordance with Actuarial Standard of Practice No. 23.

To the best of our knowledge, this report and its contents have been prepared in accordance with generally recognized and accepted actuarial principles and practices that are consistent with the Code of Professional Conduct and applicable Actuarial Standards of Practice set out by the Actuarial Standards Board. Furthermore, as credentialed actuaries, we meet the Qualification Standards of the American Academy of Actuaries to render the opinion contained in this report. This report does not address any contractual or legal issues. We are not attorneys and our firm does not provide any legal services or advice.

This report was prepared exclusively for CalPERS for the purpose described herein. Other users of this report are not intended users as defined in the Actuarial Standards of Practice, and Cheiron assumes no duty or liability to any other user.

William R. Hallmark, ASA, EA, FCA, MAAA
Consulting Actuary

Anne Harper, FSA, EA, MAAA
Consulting Actuary

SECTION 3 – ECONOMIC ASSUMPTIONS

ANALYSIS OF ECONOMIC ASSUMPTIONS

The economic assumptions used in actuarial valuations are intended to be long-term in nature, and should be both individually reasonable and consistent with each other. The specific assumptions reviewed in this report are:

- **Price inflation** – used indirectly as an underlying component of other economic assumptions.
- **Wage inflation** – across the board wage growth used to project benefits.
- **Payroll growth** – rate of growth in total payroll that is used to amortize the unfunded liability as a level percentage of expected payroll.

Our review of each of these assumptions, considered the following factors:

- Assumptions used by other similar large public sector pension plans,
- Historical data, and
- Expectations for the future.

The first two factors set a context, but the analysis is primarily driven by the last factor.

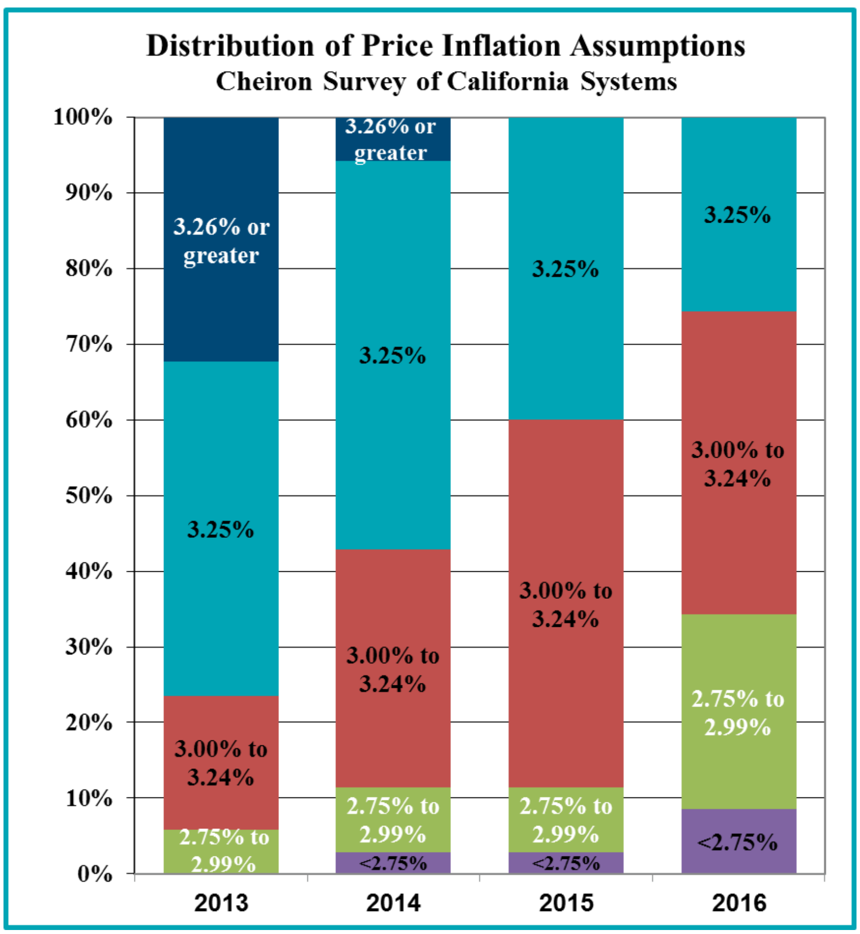
PRICE INFLATION

Long-term price inflation rates are the foundation of other economic assumptions. In a growing economy, wages and investments are expected to grow at the underlying inflation rate plus some additional real growth rate, whether it reflects productivity in terms of wages or risk premiums in terms of investments.

Survey Data

The Actuarial Office presented national survey information from the Public Plans Database. To supplement this information, Cheiron has compiled a survey of 35 public retirement systems in California and their economic assumptions over the last four years. The survey results in Chart III-1 illustrate a significant trend of systems reducing their inflation assumption. Most notably, the high-end of the assumption range decreased from 4.00% in the 2013 to 3.25% in 2016. Also, the percentage of plans using an assumption under 3.0% has increased from about 5 percent to about 35 percent.

Chart III-1

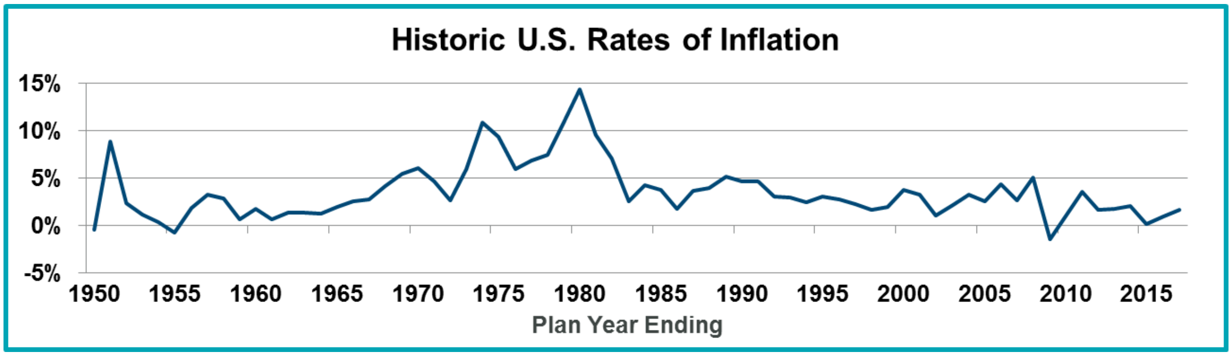


SECTION 3 – ECONOMIC ASSUMPTIONS
PRICE INFLATION

Historical Data

Chart III-2 below shows inflation for the U.S. for Plan year (ending June 30th) since 1950.

Chart III-2



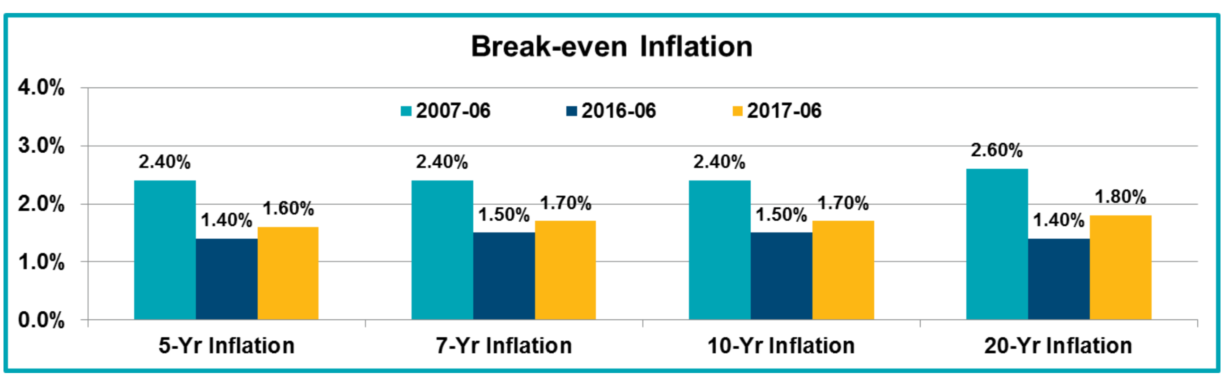
Source: Bureau of Labor Statistics, CPI-U, all items

Over the 50 years ending June, 2016, the geometric average inflation rate for the U.S. has been about 4.1%, but this average is heavily influenced by the high inflation rates in the 1970s and early 1980s. Over the last 30 years, the geometric average inflation rate has been 2.6%, and only about 1.6% over the past 10 years.

Future Expectations

A measure of the market consensus of expected future inflation rates is the difference in yields between conventional treasury bonds and Treasury Inflation-Protected Securities (TIPS) at the same maturity. Break-even inflation is the level of inflation needed for an investment in TIPS to "break even" with an investment in conventional treasury bonds of the same maturity. Chart III-3 shows the break-even inflation rate as of June 2007, 2016, and 2017. The break-even inflation rate for the last two years has been low across for all forecasted years between 1.40% - 1.80%.

Chart III-3



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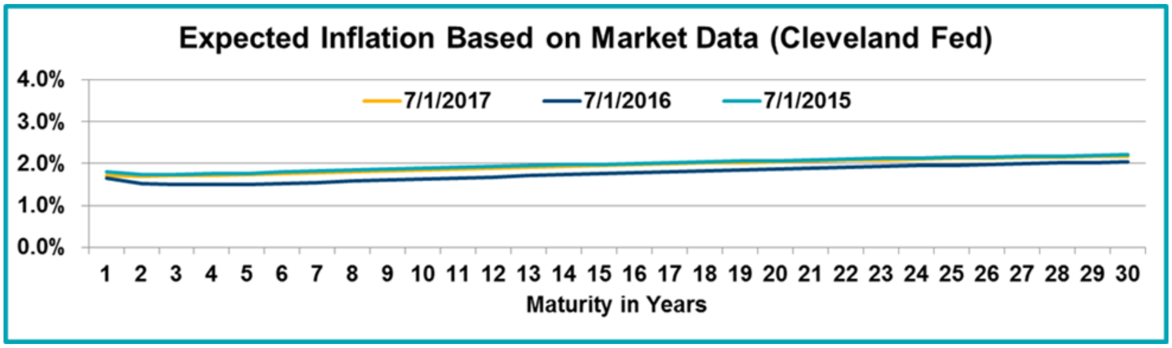
PRICE INFLATION

The Federal Reserve Bank of Cleveland publishes a forecast of inflation based primarily on this same data, as well as additional information such as inflation swaps and surveys of professional forecasters. Chart III-4 shows a summary of their published expectations for the last three years which are consistent with one another and forecast almost no volatility over the time period.

Chart III-4

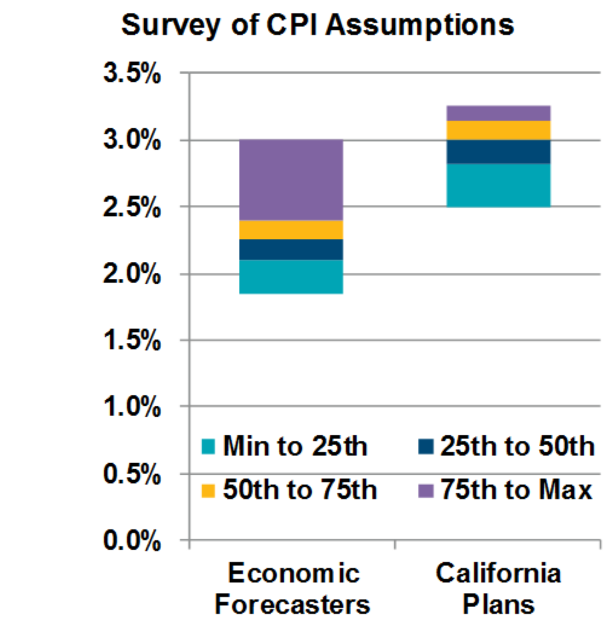


The Federal Reserve Bank of Philadelphia publishes a quarterly survey of professional economic forecasters. Chart III-5 on the next page shows the distribution of the professionals forecasts for average inflation over the next 10 years (2017-2026) compared to assumptions used by California public pension plans for the 2016-2017 valuations. It is important to note that pension plans' time horizon for inflation is much longer, usually 20-30 years, than the 10-year time horizon of the economic forecasters.

SECTION 3 – ECONOMIC ASSUMPTIONS

PRICE INFLATION

Chart III-5



	Economic Forecasters	California Plans
Minimum	1.84%	2.50%
25th Percentile	2.10%	2.81%
50th Percentile	2.25%	3.00%
75th Percentile	2.40%	3.15%
Maximum	3.00%	3.25%

Finally, investment consultants use underlying inflation assumptions to develop expectations of capital markets. Based on various California investment consultants and the 2017 Horizon Actuarial Services, LLC Survey of Capital Market Assumptions, the average short-term (approximately 10 years) and long-term (approximately 20 years) inflation assumptions were 2.2% and 2.6%, respectively.

Based on all of these considerations, we believe a reasonable range for long-term price inflation is between 2.00% and 3.00%. Therefore, the CalPERS' staff recommendation to reduce the inflation assumption from 2.75% to 2.50% is reasonable.

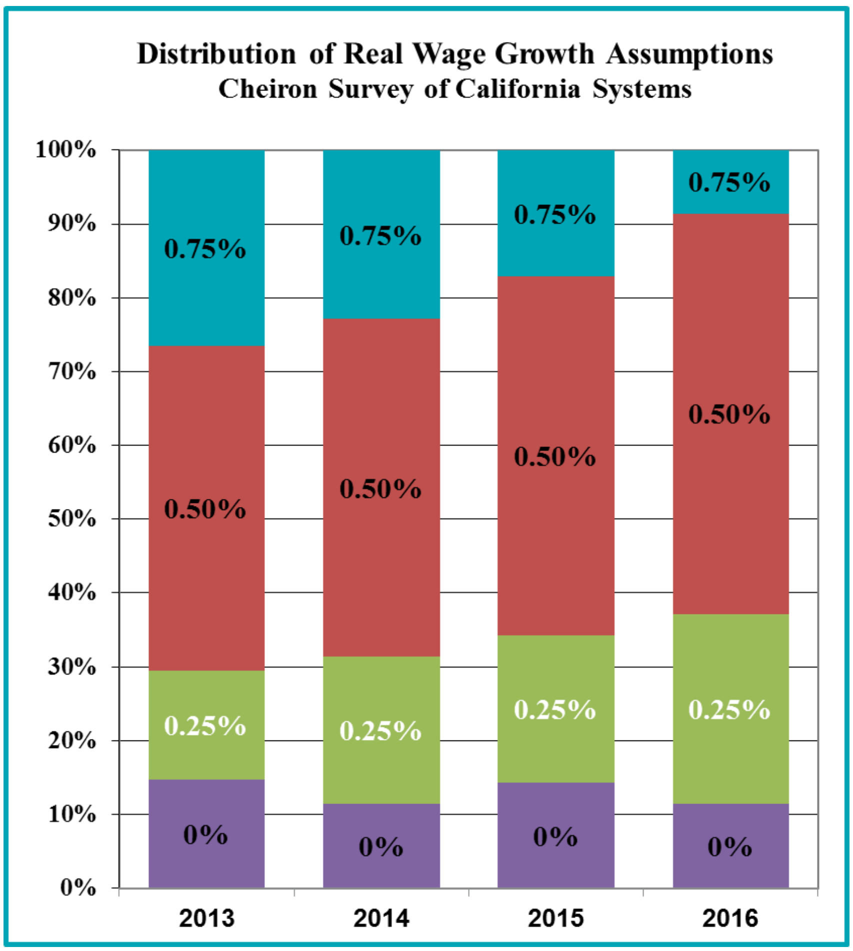
WAGE INFLATION/REAL WAGE GROWTH

Wage inflation can be thought of as the annual across-the-board increase in wages and is used in an actuarial valuation as the minimum expected salary increase for an individual. Wage inflation generally exceeds price inflation by some margin reflecting the history of increased purchasing power. This margin is also called real wage growth.

Survey Data

The results from Cheiron's survey of California Systems shown in Chart III-6 indicate a slight trend of systems to reduce their real wage growth assumption. About 25% of systems use the same real wage growth assumption as CalPERS.

Chart III-6



SECTION 3 – ECONOMIC ASSUMPTIONS
WAGE INFLATION

Historical Data and Future Expectations

Over the past 25 years, mean real wage growth (as measured by the Social Security Administration) averaged 0.77% per year. However, over the same time period the increase in the median real wage was only 0.42% per year, as much of the growth in wages was clustered at the top end of the wage scale. Median real weekly non-farm wages have increased by only 0.21% from 1985-2015 and by 0.24% from 2005-2015, based on the Bureau of Labor Statistics (BLS) Current Population Survey.

Potential factors contributing to real wage growth include the presence of strong union representation in the collective bargaining process, competition in hiring among other similar employers, and regional factors – such as the local inflation index exceeding the national average, as has sometimes proven the case in parts of California. Also, historically the US as a whole witnessed 0.9% annual real growth in wages from 1970-2010, and the Social Security Administration projects real wage growth of 0.6% – 1.8% going forward in their projections. Finally, local governments across the United States have experienced some positive real wage growth over the past 10 years (0.6% per year, based on the BLS Quarterly Census of Employment and Wages).

However, governmental entities remain under financial stress, and other areas of employee compensation – most notably health care costs and pension contributions – have continued to increase faster than the CPI. The Social Security Administration noted in a recent report that the real wage differential has actually been negative (-0.2%) over the most recent economic cycle (2007-2013).

CalPERS' Staff's recommendation to maintain the real wage growth assumption of 0.25% is reasonable.

PAYROLL GROWTH

The payroll growth assumption is used as a parameter for the amortization method that determines how much amortization payments increase each year as a dollar amount. This parameter can range from 0% (level dollar amortization) to payroll growth. Most plans target contributions to be a level percentage of payroll, and consequently use payroll growth for the rate of increase in amortization payments.

If the covered population is stable, payroll growth should equal wage inflation (price inflation plus real wage growth), which is what most plans use for this purpose. However, as noted by the Actuarial Office, if the population declines, contributions are likely to increase as a percent of payroll. We have noticed an emerging trend to set the amortization payment growth rate lower than the expected payroll growth rate, and we appreciate the Actuarial Office's discussion of this possibility.

Based on the proposed recommendations to reduce the inflation assumption to 2.50% and maintain real wage growth at 0.25%, a 2.75% wage inflation assumption, CalPERS staff recommendation to reduce the amortization payment growth rate to 2.75% is reasonable.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS

Demographic assumptions are used to predict membership behavior, including rates of retirement, termination, disability, and mortality. These assumptions are based primarily on the historical experience of CalPERS, with some adjustments where future experience is expected to differ from historical experience (e.g., mortality improvement).

INTRODUCTION TO ANALYSIS OF DEMOGRAPHIC ASSUMPTIONS

Our analysis of the demographic assumptions begins with the census data we were provided. From the census data, we determined the number of actual decrements, the number of exposures and the raw rates for each separate assumption set by the Actuarial Office. We compared our independent calculations to the amounts calculated by the Actuarial Office.

Based on the number of decrements and exposures we developed from the census data, we calculated the 90 percent confidence interval for each assumption, which represents the range within which the true decrement rate during the experience study period fell with 90 percent confidence. Assumptions should generally fall within the 90 percent confidence interval of the observed experience. Confidence intervals vary in size based on the amount of experience observed for the particular rate. Where there is a lot of experience, the confidence interval will be relatively narrow and there is more certainty about the assumption. Where there is little experience, the confidence interval will cover a wide range indicating that a wide range of assumptions may be reasonable.

As a measure of the reasonableness of a set of assumed rates, we calculated the percentage of the assumed rates that were within the 90 percent confidence interval. Ideally, all of the rates would fall within the confidence interval, but often smoothing of rates from one age to the next results in some assumptions that fall outside the confidence interval. Any assumption change should increase the percentage of rates that fall within the confidence interval unless future experience is expected to be different than the experience during the period of study.

The second measure we used to assess the reasonableness of the assumption is the ratio of the actual number of decrements for each group compared to the expected number of decrements (A/E ratio or actual-to-expected ratio). If the assumption is perfect, this ratio will be 100 percent, and any recommended assumption change should move from the current A/E ratio towards 100 percent unless future experience is expected to be different than the experience during the period of study.

Finally, we calculate an r-squared statistic for each assumption. R-squared measures how well the pattern of the assumption fits the pattern of the actual data and can be thought of as the percentage of the variation in actual data explained by the assumption. Ideally, r-squared would equal 100 percent although this is never the case. Assumption changes generally should increase the r-squared compared to the current assumption making it closer to 100 percent unless the pattern of future decrements is expected to be different from the pattern experienced during the period of study.

MORTALITY RATES

Post-retirement mortality assumptions are developed separately by gender for healthy annuitants, non-industrially disabled annuitants, and industrially disabled annuitants. Pre-retirement mortality assumptions are also developed separately by gender, and separate rates are developed for industrial and non-industrial deaths.

Mortality assumptions are not developed separately for safety and non-safety groups. The Actuarial Office notes that prior studies determined that there were no material differences and the current study confirmed this finding. We have not been provided with the data to verify this confirmation, but we have no reason to doubt it. However, we would suggest that the final report include separate actual-to-expected ratios for safety and non-safety groups to demonstrate that there is no material difference. We believe this information will be particularly important given that the Society of Actuaries Retirement Plan Experience Committee will be publishing a mortality study for public plans, and we understand they are examining three job classifications: teachers, safety members, and miscellaneous members. If they come to a different conclusion than the Actuarial Office using nationwide data, it will be helpful to already have the CalPERS data reported.

Post-Retirement Base Tables

We understand that the Actuarial Office developed post-retirement mortality rates based on experience from June 30, 2012 through June 30, 2015. Raw rates were calculated based on the actual number of deaths during the period at each age from age 50 through age 109, and the raw rates were smoothed using a Whitaker-Henderson graduation. The table below shows the results of our analysis for ages 50 through 109.

Post-Retirement Mortality Base Rates						
	% in Confidence Interval		Actual-to-Expected Ratio		R-Squared	
	Current	Proposed	Current	Proposed	Current	Proposed
Service Retirement						
Male	36.8%	87.7%	89.1%	97.0%	99.4%	99.7%
Female	37.3%	86.4%	90.2%	97.7%	99.7%	99.8%
Non-Industrial Disability						
Male	75.5%	94.3%	89.4%	97.6%	92.0%	92.7%
Female	86.8%	96.2%	91.1%	97.8%	94.4%	94.8%
Industrial Disability						
Male	90.0%	98.0%	89.8%	102.7%	96.3%	96.3%
Female	100.0%	100.0%	80.9%	96.7%	56.4%	55.4%

The proposed base rates fall within the 90 percent confidence interval over 85% of the time, and significantly more often than the current base rates. The ideal actual-to-expected ratio is 100%, but it is more conservative if the mortality assumption produces an actual-to-expected ratio

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
MORTALITY RATES

greater than 100%.The actual-to-expected ratios for the proposed base rates are closer to 100% than the current assumption, although it isn't clear to us why they wouldn't be even closer to or slightly exceed 100%.

The r-squared statistic identifies how well the pattern of the assumption fits the pattern of the observed experience. Ideally, it would be 100%, and the proposed assumptions produce a high r-squared for the service retirement assumptions and a slightly lower r-squared for most of the other groups. The r-squared for female industrial disability mortality is particularly low, which as discussed below is likely due to the lack of sufficient data.

Benefits-Weighted Mortality Rates

For a pension plan, mortality rates are used to estimate how long the pension benefits will be paid, and mortality studies have found that mortality rates vary significantly based on income level. It is important to develop mortality rates on a benefits-weighted basis to the extent pension benefits vary based on income level and the plan includes members with a variety of income levels. Developing rates based on a headcount basis, as the Actuarial Office has, is likely to underestimate how long benefits will be paid and underestimate the liability of the pension plan. We understand that CalPERS's systems cannot analyze mortality experience on a benefits-weighted basis, and we were not provided the data necessary to perform such an analysis. We strongly encourage CalPERS to develop the capability to analyze mortality on a benefits-weighted basis, and in the interim to make an estimated adjustment.

The table on the next page shows the ratio of the headcount-weighted mortality rates to the benefits-weighted mortality rates from the RP-2014 mortality tables for healthy annuitants. The varying ratios by age indicate that the pattern of the mortality rates by age may be affected as well as the overall level of the mortality rates. These ratios reflect the population studied for the development of the RP-2014 tables which did not include any public plan experience. Consequently, these ratios may not accurately estimate the impact of benefits-weighting on the CalPERS population. If the Actuarial Office were to use these ratios to make the interim estimated adjustment, the rates calculated in the study would need to be divided by the factors shown in the table. If the Actuarial Office believes that the pattern for public plans will not be as significant as for private plans, the factors could be reduced for the purposes of an interim estimate.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS

MORTALITY RATES

RP-2014 Ratio of Headcount Rates to Benefits-Weighted Rates		
Age	Male	Female
50	131%	146%
55	122%	127%
60	119%	114%
65	116%	106%
70	113%	105%
75	111%	106%
80	109%	104%
85	107%	103%
90	103%	101%
95	101%	100%
100	100%	100%

As another example, Oregon PERS recently completed an experience study, and they compared actual-to-expected ratios on a headcount-weighted basis to those on a benefits-weighted basis. Depending on the group, the actual-to-expected ratio decreased from 9% to 18%. For example, the ratio for miscellaneous males was 104% on a headcount-weighted basis, but only 92% on a benefits-weighted basis.

In our experience with public plans, we have also found significant differences in the actual-to-expected ratios calculated on a headcount-weighted basis compared to a benefits-weighted basis. The amount of the difference seems to vary with the employee population, the base mortality table, and the mortality improvement projection scale. The Society of Actuaries' Retirement Plan Experience Committee is analyzing the impact of income on mortality rates and will likely publish their findings within the next 18 months. This study may provide better information on how to adjust the headcount-weighted rates, but may also raise the question of why some estimate of the impact was not already incorporated into the rates when studies have already shown that there is a significant difference on a benefits-weighted basis.

Credibility

There are very few pension plans that have sufficient experience to develop their own mortality tables. With actual mortality rates close to 0% for many ages, approximately 1,000 deaths are needed so that the 90 percent confidence interval does not range from the observed raw rate by

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
MORTALITY RATES

more than 5 percent.[1] When actual rates increase, as with significantly older ages, less experience is required to meet this standard of credibility. Note that the 1,000 death requirement for this level of credibility applies to each age at which a specific mortality rate is developed and not to the total number of deaths across all ages for which a mortality table is developed.

The table below shows the number of actual deaths by five-year age ranges in the CalPERS data for each post-retirement mortality table developed.

Actual CalPERS Deaths
June 30, 2012 to June 30, 2015

Age	Service Retirement		Non-Industrial Disability		Industrial Disability	
Range	Male	Female	Male	Female	Male	Female
50 - 54	77	69	50	80	32	12
55 - 59	352	309	120	120	72	18
60 - 64	949	826	188	196	141	35
65 - 69	1,611	1,537	245	235	281	27
70 - 74	2,004	1,952	242	226	294	29
75 - 79	2,584	2,869	202	219	328	14
80 - 84	3,526	4,130	226	221	291	11
85 - 89	3,998	5,885	194	217	218	11
90 - 94	3,423	6,188	113	192	87	6
95 +	1,420	3,614	30	75	22	2
Total	19,944	27,379	1,610	1,781	1,766	165

The number of deaths in each five-year age band would have to be at least 5,000 actual deaths to be considered fully credible experience at each age. Only female service retirement annuitants between the ages of 85 and 94 have sufficient experience to set a credible mortality rate for each age. If the data is grouped into five-year age bands as shown in the table, most of the bands for male and female service retirement annuitants have sufficient experience. For the younger ages, a larger age band may be needed. For the non-industrial and industrial disability experience, even the five-year age bands fall well short of the 1,000 deaths needed to set a credible mortality rate. The methodology used by the Actuarial Office that develops raw rates for each individual age based on limited experience for that age should be modified to ensure that mortality rates are set based on a credible level of experience.

One approach is to create age bands as shown above to group experience to credible levels. The mortality rate can be set for the group and then rates for each age can be developed by graduating

[1] See appendix 2 of the American Academy of Actuaries Practice Note, "Selecting and Documenting Mortality Assumptions for Pensions," for a discussion of the statistics behind this credibility measure. https://www.actuary.org/files/Mortality_PN_060515_0.pdf

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and interpolating between the groups. As long as the age bands are not too wide, a reasonable pattern can be interpolated between the age bands. This approach appears to be workable for the service retirement tables. In fact, the Actuarial Office could continue to use the current graduation methodology across all ages with the added condition that the weighted-average graduated rates for five-year age bands should fall within the 90 percent confidence interval for that five-year age band. Although the current proposed base rates mostly fall within or very close to the confidence interval, they fall outside of the confidence interval for the five-year age bands for 4 of the 12 bands for females and 2 of the 12 bands for males. For example, for males aged 50 through 54, there were 77 deaths on over 20,000 exposures. We calculated that the 90 percent confidence interval ranges from an average rate of 0.310% to 0.455%, but the weighted average proposed rate is 0.487%.

For the non-industrial and industrial disability tables, there isn't enough experience to apply this approach. Another approach would be to create a benchmark table based on CalPERS experience from June 30, 1997 through June 30, 2015. It appears that including all of these years in the study would provide sufficient data when combined with five-year age bands for the development of mortality rates for all groups except for female industrial disabilities. The difficulty with this approach is that mortality rates have been improving throughout this period and need to be adjusted from the central period of the study.

Using the table developed based on experience from 1997 through 2015 as a benchmark to define the pattern of rates from age to age, the more recent experience could be used to adjust the pattern as a whole by multiplying the rates by the actual-to-expected ratio calculated with reference to the benchmark rates.

One consequence of developing mortality rates with insufficient experience is that the pattern of resulting rates may not be very smooth. The charts below show the increase in the mortality rate from one age to the next for the CalPERS Industrial and Non-Industrial disability tables for males compared to the RP-2006 (RP-2014 without projection from 2006 to 2014) disability table for males. While the tables are expected to have different mortality rates, we would expect the pattern of change to be somewhat similar with gradual changes from age to age. In the first chart on the following page shows the difference in mortality rates for ages up to 75, both the RP-2006 and the CalPERS Non-Industrial Disability tables follow smooth, but slightly different patterns. The CalPERS Industrial Disability table, in contrast, has significant jumps in the rate of mortality change at ages 57 and 61.

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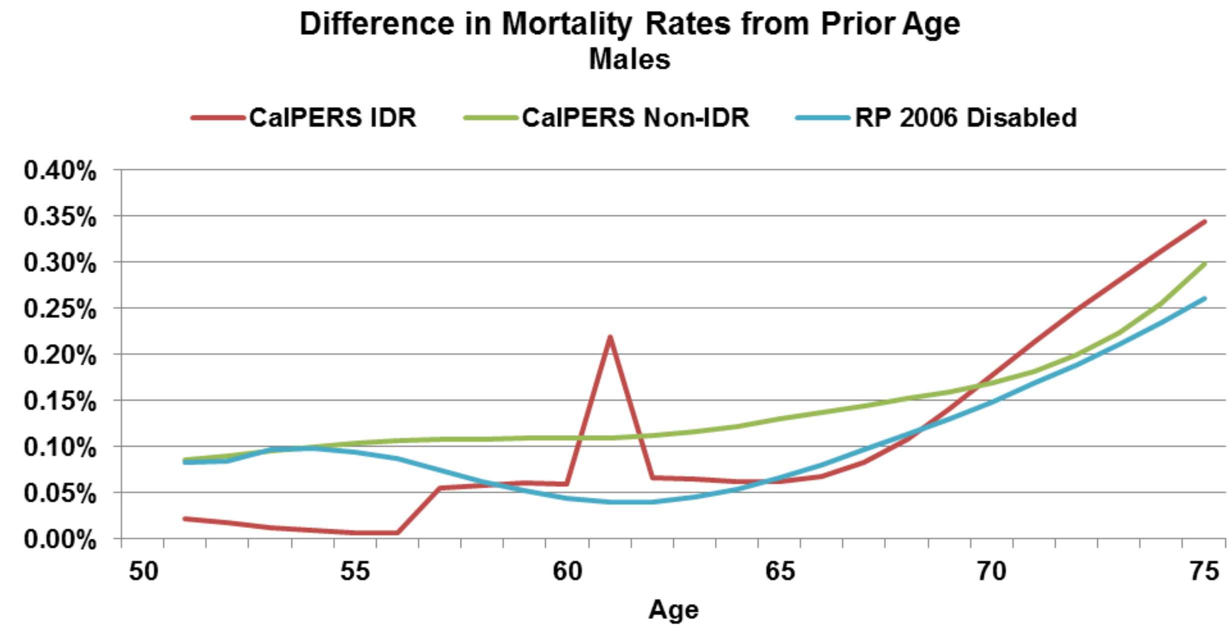

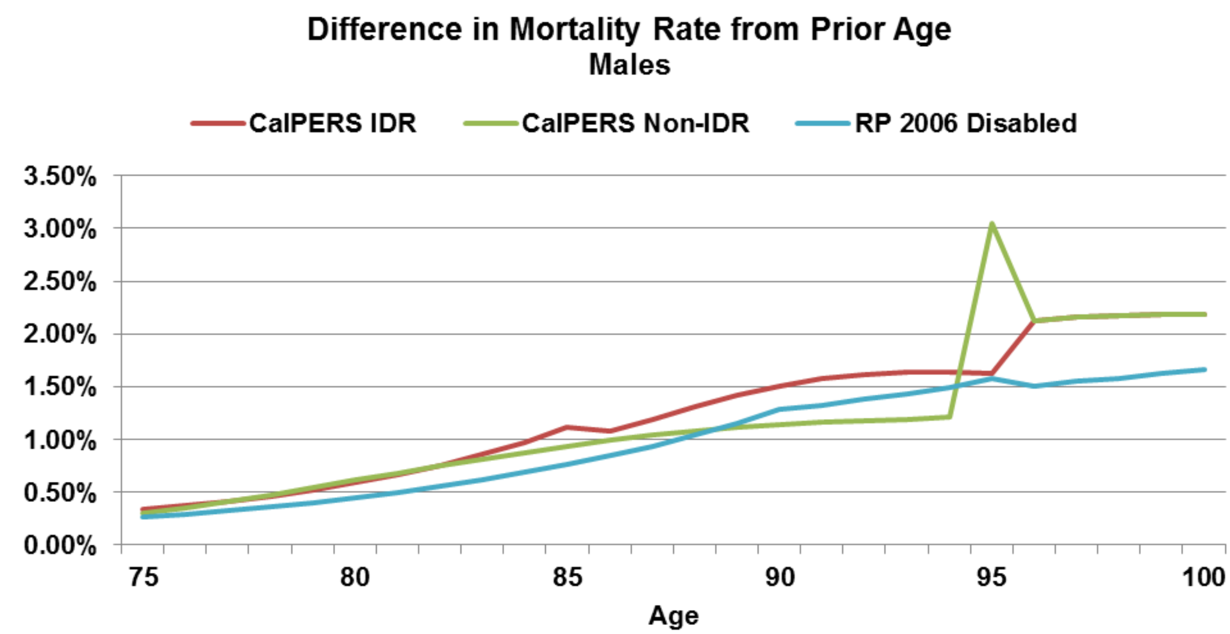

The second chart above shows the differences in mortality rates for ages 75 to 100. All three of the mortality tables have some noticeable adjustments in the rate of change, but the changes at age 95 for the CalPERS Non-Industrial table and at age 96 for the CalPERS Industrial table stand out. We believe that the sudden changes shown in these two charts as well as other sharp changes in the CalPERS tables are the result of the graduation methodology and the limited data to which it is applied.

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Pre-Retirement Base Tables

We understand that the Actuarial Office developed pre-retirement mortality rates based on experience from June 30, 2005 through June 30, 2015. For non-industrial mortality, raw rates were calculated based on the actual number of deaths during the period at each age from age 15 through age 80, and the raw rates were smoothed using a Whitaker-Henderson graduation. For industrial mortality, male and female data was combined and grouped into 10-year age bands. The table below shows the results of our analysis of the proposed assumptions for ages 20 through 80.

Pre-Retirement Mortality Base Rates						
	% in Confidence Interval		Actual-to-Expected Ratio		R-Squared	
	Current	Proposed	Current	Proposed	Current	Proposed
Non-Industrial						
Male	62.5%	92.5%	79.9%	97.9%	97.0%	97.3%
Female	45.0%	82.5%	75.9%	94.3%	97.6%	98.0%
Industrial	94.1%	88.2%	80.0%	101.1%	52.1%	51.9%

The proposed base rates fall within the 90 percent confidence interval over 80% of the time. However, given the limited data and the width of the confidence intervals, we would expect an even higher percentage, particularly for industrial mortality. The ideal actual-to-expected ratio is 100%, but it is more conservative if the mortality assumption produces an actual-to-expected ratio greater than 100%. The actual-to-expected ratios for the proposed base rates are closer to 100% than the current assumption, although it isn't clear to us why they wouldn't be even closer to or slightly exceed 100%.

The r-squared statistic identifies how well the pattern of the assumption fits the pattern of the observed experience. Ideally, it would be 100%, and the proposed assumptions produce a high r-squared for the non-industrial assumptions and a lower r-squared for the industrial assumptions where the data is very limited.

Credibility

As noted above, there are very few pension plans that have sufficient experience to develop their own mortality tables, particularly for pre-retirement ages. With actual mortality rates close to 0%, approximately 1,000 deaths are needed so that the 90 percent confidence interval does not range from the observed raw rate by more than 5 percent. The table on the next page shows the number of actual deaths by ten-year age ranges in the CalPERS data for each pre-retirement mortality table developed.

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Actual CalPERS Deaths				
Age	Non-Industrial		Industrial	
Range	Male	Female	Male	Female
20 - 29	46	16	7	0
30 - 39	117	93	31	1
40 - 49	328	291	71	3
50 - 59	710	770	20	0
60 - 69	533	506	3	3
70 - 79	118	104	0	0
Total	1,852	1,780	132	7

Even the ten-year age bands fall well short of the 1,000 deaths needed to set a credible mortality rate, and there are only 139 industrial deaths in the entire study. The methodology used by the Actuarial Office should be modified to ensure that mortality rates are set based on a credible level of experience.

For non-industrial pre-retirement mortality rates, we suggest that the Actuarial Office consider using a benchmark table such as the RP-2014 pre-retirement mortality rates. The rates in the benchmark table would first be adjusted by multiplying them by the actual-to-expected ratio based on CalPERS experience with reference to the benchmark table. Then, the fit could be tested by checking to make sure the adjusted rates fall within the 90 percent confidence intervals for CalPERS's experience for each 5 or 10-year age band.

For industrial pre-retirement mortality rates, there is no valid benchmark table of which we are aware. Consequently, the general approach the Actuarial Office has used is reasonable. We suggest that in addition to the steps already taken, the Actuarial Office should compute the 90 percent confidence interval for each of the age bands and ensure that the proposed rate falls within that confidence interval. The chart on the following page shows our calculation of the confidence intervals compared to the current and proposed assumptions.

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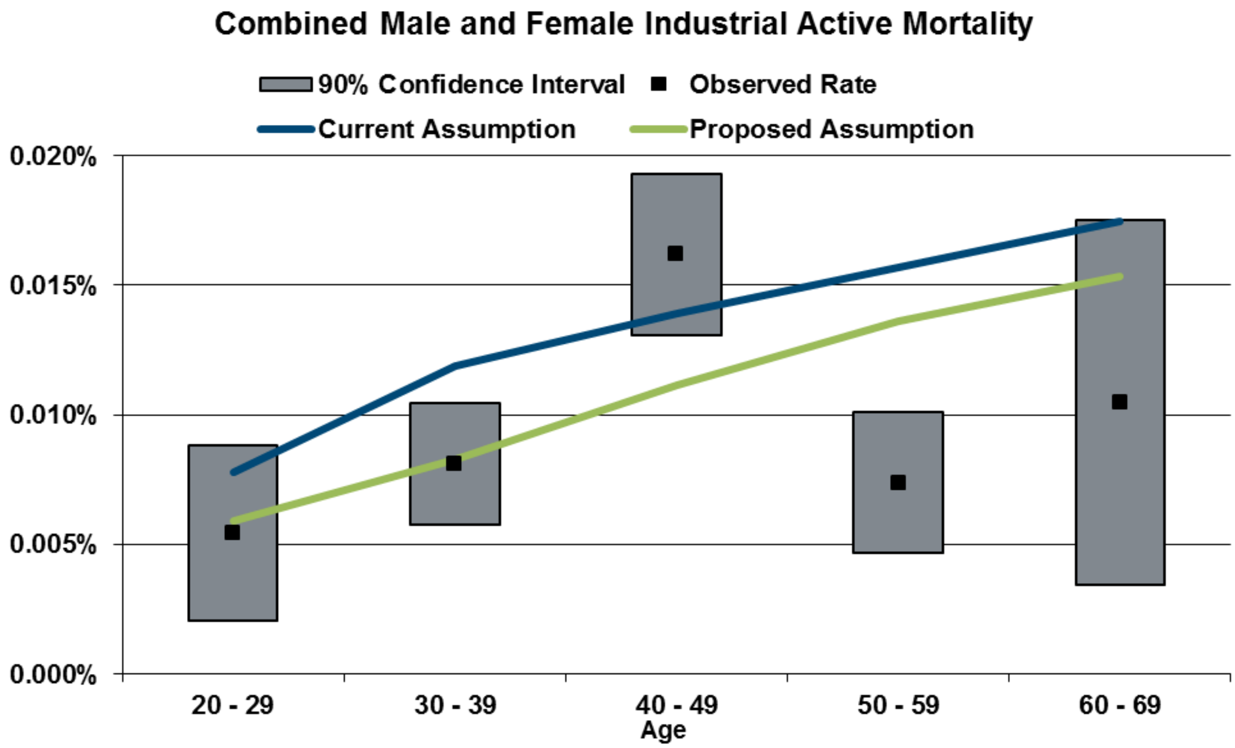

We note that the proposed assumption is below the confidence interval for ages 40 through 49 and above the confidence interval for ages 50 through 59. The Actuarial Office may want to consider whether this information warrants an adjustment to the proposed rates.

Mortality Projection Scale

There has been a long history of mortality improvement among pensioners in the U.S., and there is an expectation that mortality rates will continue to improve in the future. The Society of Actuaries has developed mortality improvement projection scales released annually based on three key concepts:

- Recently observed experience is the best predictor of future near-term mortality improvement rates.
- Long-term rates of mortality improvement should be based on "expert opinion" and analysis of longer-term mortality patterns.
- Near-term rates should transition smoothly into the assumed long-term mortality improvement rates over appropriately selected convergence periods.

While an in-depth analysis of the development and assumptions underlying these projection scales is beyond the scope of our analysis, it should be noted that two of the three concepts rely almost entirely on judgment about the uncertain future.

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Scale MP-2016 represented the Society's Retirement Plans Experience Committee's best estimate of future mortality improvement at the time this analysis was performed, but they note, given the uncertainty, that other appropriate parameters for their model would also provide a reasonable basis for projecting mortality. They provided an Excel tool for varying the parameters of their model to produce alternative mortality improvement projection scales. Best practice for developing an alternative projection scale would be to use this model and select alternative parameters, particularly for the convergence periods and long-term rates. Instead, the Actuarial Office has simply multiplied the MP-2016 scale by a factor of 0.9. This approach implies an adjustment to the long-term rates, no change to the convergence periods, and a disconnect with recently observed experience. There is volatility from year to year in the observed experience, so this disconnect may not be unreasonable. In aggregate, the proposed projection scale appears to be reasonable, but we suggest that in the future the Actuarial Office consider using the SOA's tool to develop alternative projection scales.

Generational Versus Static Assumption

Historically, CalPERS, like many other pension plans, has used a static mortality assumption. That is, the same mortality rates are used for all members regardless of their year of birth. Yet, with mortality improvements in the future, we expect that the mortality rate at age 70, for example, will be different for someone who is currently age 40 than it is for someone who is age 70 today. Under a typical static assumption, the rate used for age 70 would be somewhere between the current rate and projected future rates for younger members of the plan. As a result, older members are projected to live longer than they are really expected to live and younger members are projected to live shorter lives than they are really expected to live. It is hoped that on balance, the measure of liability matches the true expectations of longevity for each individual. Furthermore, with each experience study, it is expected that this balance will have to be adjusted to reflect the longer lifetimes of the new members.

In contrast, a generational mortality assumption uses a separate mortality table for each year of birth so that the mortality rate at age 70 of someone who is 40 today reflects 30 years of expected mortality improvement while the rate for someone who is currently age 70 does not. A generational assumption more accurately measures the liability associated with each individual. Also, when the next experience study is performed, there is an equal chance that mortality rates will need to be adjusted up or down. Consequently, the Society and others strongly recommend the use of generational mortality assumptions.

There have been two issues with adopting generational mortality. First, not all actuarial valuation systems were built to handle generational mortality. The Actuarial Office cited this as the reason they are not currently recommending generational mortality. We strongly urge CalPERS to modify its valuation system to handle generational mortality. Most valuation systems have already been updated.

Second, many plans base the definition of actuarial equivalence for calculating benefits in optional forms (and service purchases) on the mortality assumption used for the actuarial valuation. Using a generational table complicates these calculations, but many plans have now worked through these complications and administrative systems have been modified.

Given that the valuation system cannot use a generational mortality assumption, the Actuarial Office is recommending a 15-year projection to approximate the liability that a generational projection would produce. The central time of the data used to set the base mortality rates is January 1, 2014, so the 15-year projection would be to January 1, 2029, and we understand these rates would be used for the 2017, 2018, 2019, and 2020 valuations. The central date for these valuations is January 1, 2019, so on average the projection is 10 years beyond the valuation date.

The Actuarial Office provided us an analysis of life annuity factors for various ages of retirees under a generational assumption and under static assumptions with a 15-year and a 20-year projection. The analysis concluded that a 15-year projection would overstate the liability for retirees by 0.85% for females and 1.17% for males. There would be an offsetting understatement of the liability and normal cost for active members, so that in aggregate the Actuarial Office believes the 15-year projection is reasonable.

After replicating this analysis, we make the following observations and suggestions:

1. The static mortality rates provided by the Actuarial Office appear to reflect a 16-year projection instead of 15 years.
2. The life annuity factors under the generational table are based on ages attained in 2014. Since these tables are proposed to be used for 2017 through 2020 valuations, the factors should be based on ages attained in each of those years or 2019 could be used as a representative midpoint.
3. The life annuity factors were based on a discount rate of 7.375%, but we understand that the discount rate is being reduced over a few years to 7.0%. Consequently, we believe the analysis should be performed using a 7.0% discount rate.
4. The weights provided for each age are based on headcounts. To estimate the impact on liability, the weights should be based on benefit amounts instead. Given that wage inflation generally exceeds the COLA, we would expect more recent retirees to be weighted slightly more heavily.

When we adjusted the analysis to use ages attained in 2019 and a 7.0% discount rate, we found that the liability for retirees was overstated by 0.0% for females and 0.2% for males. We conclude that the 16-year projection provides a reasonable estimate of the liability that would be calculated using a generational table for benefits currently being paid. However, we do not believe there is a margin to make up for the additional projection that would be needed to reflect the liability and normal cost for active members.

Alternatives to Consider

There are two alternatives to the proposed method that the Office of the Actuary and the Board may want to consider. Both have advantages and disadvantages compared to the proposed methodology

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Separate retiree and active mortality tables

The first alternative is to adopt separate post-retirement mortality tables for actives and retirees with different projection periods. Since the liability for retirees has a lower duration, the projection period would be shorter and would reduce the measure of retiree liability compared to the proposed rates. At the same time, the projection period for active employees would be longer, reflecting the longer duration of the Actuarial Liability and normal cost for active members.

The advantage of this approach is that it would more accurately estimate the liability that would have been calculated with a generational mortality table for each employer in CalPERS. By adopting a single-post retirement mortality table as currently proposed, employers with a greater proportion of active employees are likely to experience actuarial losses.

The disadvantage of having two separate tables is the addition of a little more complexity. In addition, when a member actually retires, it would change the post-retirement mortality table used to value their benefits and create an actuarial gain.

Project to year of each valuation

Instead of projecting the table to the midpoint of the valuations, a second alternative to consider is to project a constant number of years beyond the valuation date. For example, for each valuation, a new mortality table could be used that is the same base table, but projected to 13 years beyond the valuation date. The advantages of this approach are:

- A shorter projection period for the first valuation requiring less of an immediate adjustment,
- Small adjustments each of the following years,
- A smaller expected adjustment when the next experience study is performed, and
- Better approximation in each valuation of the use of a generational mortality table.

The primary disadvantage is the additional complexity of changing the mortality table with each valuation, particularly because under current policy the valuation mortality is also used for member benefit calculations. Either the factors for member benefit calculations would need to be updated every year, or the factors would need to be based on a different mortality table than the valuation.

RETIREMENT RATES

This section analyzes the incidence of retirement by the age and service of the employee for the following groups:

- State Miscellaneous
- State Industrial
- State Safety
- Police Officers and Fire Fighters (POFF)
- California Highway Patrol (CHP)
- Schools
- Public Agency Miscellaneous (PA Misc)
    - 2.0% at 55 Formula
    - 2.0% at 60 Formula
    - 2.5% at 55 Formula
    - 2.7% at 55 Formula
    - 3.0% at 60 Formula
- Public Agency Fire (PA Fire)
    - 2.0% at 50 Formula
    - 2.0% at 55 Formula
    - 3.0% at 50 Formula
    - 3.0% at 55 Formula
- Public Agency Police and County Peace Officers (PA Police)
    - 2.0% at 50 Formula
    - 2.0% at 55 Formula
    - 3.0% at 50 Formula
    - 3.0% at 55 Formula

We analyzed the data for retirement ages 50 to the age at which CalPERS assumes 100% probability of retirement and service from 5 years to 49 years. The table on the following page compares the calculation of actual retirements, exposures, and the aggregate incidence rate for each group. For the State groups and Schools, the differences do not appear to be material. However, for all of the Public Agency groups, there are differences. We believe these differences are primarily due to the categorization of which retirement formula was applicable in which year as the decrements and exposures across all formulas are relatively close. In addition, we understand the Actuarial Office excluded data for employers immediately prior to and following a benefit formula change. Known upcoming changes in the benefit formula can have a significant impact on retirement rates, so we believe these exclusions were appropriate. However, we do not have the detailed information necessary to replicate these procedures.

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RETIREMENT RATES

Service Retirement Assumptions Comparison of Decrements and Exposures	CalPERS Data			Cheiron Data			Difference		
	Decrements	Exposures	Rate	Decrements	Exposures	Rate	Decrements	Exposures	Rate
State									
Miscellaneous	64,654	786,020	8.2%	64,843	768,341	8.4%	0.3%	-2.2%	0.2%
Industrial	3,472	42,009	8.3%	3,504	39,136	9.0%	0.9%	-6.8%	0.7%
Safety	8,837	104,079	8.5%	8,849	100,659	8.8%	0.1%	-3.3%	0.3%
POFF	16,081	114,338	14.1%	16,090	111,729	14.4%	0.1%	-2.3%	0.3%
CHP	2,236	11,786	19.0%	2,237	11,257	19.9%	0.0%	-4.5%	0.9%
Schools	88,049	1,247,491	7.1%	88,428	1,215,277	7.3%	0.4%	-2.6%	0.2%
Public Agency Misc									
2.0% at 55	30,426	363,395	8.4%	29,414	324,459	9.1%	-3.3%	-10.7%	0.7%
2.0% at 60	3,734	41,410	9.0%	4,416	50,614	8.7%	18.3%	22.2%	-0.3%
2.5% at 55	13,043	149,725	8.7%	14,852	159,783	9.3%	13.9%	6.7%	0.6%
2.7% at 55	16,181	170,887	9.5%	17,676	182,261	9.7%	9.2%	6.7%	0.2%
3.0% at 60	7,528	73,100	10.3%	7,661	88,111	8.7%	1.8%	20.5%	-1.6%
Total	70,912	798,518	8.9%	74,019	805,229	9.2%	4.4%	0.8%	0.3%
Public Agency Fire									
2.0% at 50	159	1,565	10.2%	339	4,159	8.2%	113.2%	165.8%	-2.0%
2.0% at 55	10	235	4.3%	10	319	3.1%	0.0%	35.8%	-1.1%
3.0% at 50	3,525	26,127	13.5%	3,490	14,518	24.0%	-1.0%	-44.4%	10.5%
3.0% at 55	927	8,463	11.0%	1,010	1,958	51.6%	9.0%	-76.9%	40.6%
Total	4,621	36,390	12.7%	4,849	20,954	23.1%	4.9%	-42.4%	10.4%
Public Agency Police									
2.0% at 50	630	5,879	10.7%	746	5,856	12.7%	18.4%	-0.4%	2.0%
2.0% at 55	54	673	8.0%	92	869	10.6%	70.4%	29.2%	2.6%
3.0% at 50	7,981	46,933	17.0%	7,894	45,008	17.5%	-1.1%	-4.1%	0.5%
3.0% at 55	807	7,084	11.4%	1,070	8,406	12.7%	32.6%	18.7%	1.3%
Total	9,472	60,569	15.6%	9,802	60,139	16.3%	3.5%	-0.7%	0.7%

Given the discrepancies, the remainder of our analysis on retirement rates is based on the actual retirements and exposures calculated by CalPERS.

Findings

The table on the next page compares three key statistics for the current assumptions, the proposed assumptions, and an assumption based on a mathematical formula. For the service retirement assumptions, the formula is a moving average with 25% weight on the prior age, 50% weight on the current age, and 25% weight on the next age. The formula has no professional judgment applied to the result as would normally be part of an assumption setting process.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
RETIREMENT RATES

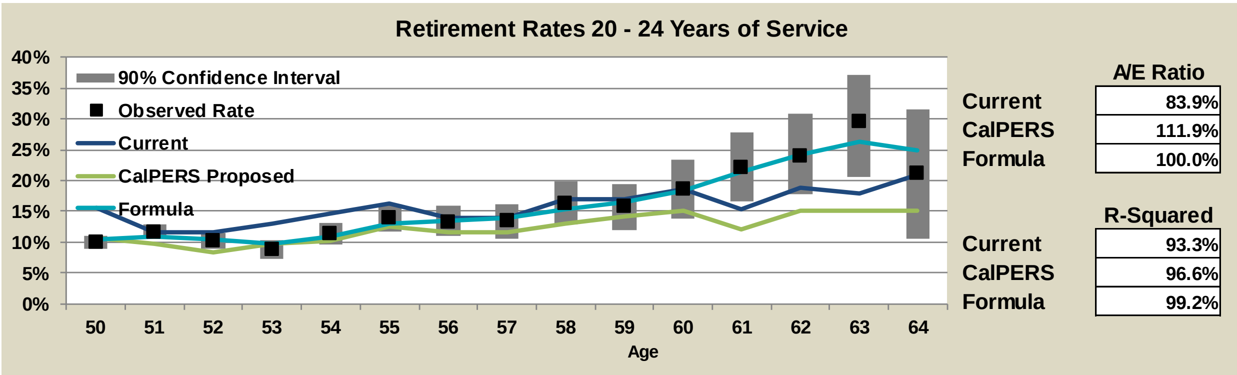
Service Retirement Assumptions Summary of Analysis	Proportion of Assumptions in Confidence Interval			Actual / Expected Ratio			R-Squared Statistic		
	Current	Proposed	Formula	Current	Proposed	Formula	Current	Proposed	Formula
State									
Miscellaneous	22%	40%	75%	87%	96%	100%	92%	98%	100%
Industrial	65%	77%	90%	98%	100%	101%	80%	88%	96%
Safety	56%	85%	93%	94%	99%	100%	84%	98%	98%
POFF	40%	66%	94%	110%	105%	100%	92%	100%	96%
CHP	71%	80%	87%	107%	102%	101%	97%	99%	96%
Schools	29%	33%	74%	84%	93%	100%	94%	96%	100%
Public Agency Misc									
2.0% at 55	46%	85%	90%	96%	99%	101%	91%	99%	99%
2.0% at 60	66%	87%	95%	115%	102%	100%	83%	95%	97%
2.5% at 55	50%	79%	95%	87%	97%	101%	84%	97%	99%
2.7% at 55	47%	78%	90%	88%	96%	101%	87%	98%	99%
3.0% at 60	61%	86%	95%	92%	98%	100%	89%	97%	98%
Public Agency Fire									
2.0% at 50	93%	93%	81%	113%	113%	100%	72%	72%	92%
2.0% at 55	100%	100%	40%	100%	100%	98%	0%	0%	66%
3.0% at 50	74%	74%	99%	100%	100%	100%	96%	96%	100%
3.0% at 55	81%	81%	90%	96%	96%	100%	86%	86%	99%
Public Agency Police									
2.0% at 50	74%	83%	94%	109%	101%	100%	55%	71%	93%
2.0% at 55	67%	98%	69%	50%	105%	100%	15%	20%	75%
3.0% at 50	50%	74%	96%	99%	108%	100%	98%	99%	100%
3.0% at 55	73%	88%	96%	118%	101%	101%	70%	90%	97%

The proportion of current or proposed rates that fall within the 90 percent confidence interval varies significantly, but for many of the groups, it is lower than we would expect. For most groups, this result is due to the weighting of the current assumptions in the Actuarial Office's analysis, which we will discuss below. For a few others, the proposed rates don't appear to follow the pattern of observed rates, or the pattern is set too high or too low. As an example, only 74% of the Public Agency Police 3.0% at age 50 assumptions fall within the confidence interval while 96% of the assumptions produced by the formula fall within the confidence interval.

The chart on the following page shows the information for Public Agency Police 3.0% at age 50 members with 20 through 24 years of service.[2] The raw observed rates are shown as black squares and the confidence intervals as gray bars around the black squares. The dark blue line represents the current assumption; the green line represents the proposed assumption; and, the teal line shows the assumption produced by the formula.

[2] Additional charts are shown in Appendix A.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
RETIREMENT RATES



The proposed rates are generally too low and don't appear to follow the pattern of increasing rates for older ages. The current assumption has a similar pattern, but the rates at the younger ages are too high.

The ideal actual-to-expected ratio is 100%, and the proposed assumptions for all the groups are relatively close to this target. Finally, we reviewed the r-squared statistic, which identifies how well the pattern of the assumption fits the pattern of the observed experience regardless of its level. Ideally, it would be 100%, but that is virtually impossible to achieve. The proposed assumptions produce relatively high r-squared statistics where there is significant data.

Blending the Current Assumption

The Actuarial Office indicated that it had developed the proposed assumptions for certain groups by blending the current assumptions with the actual experience. The most significant blending is for the Schools pool.

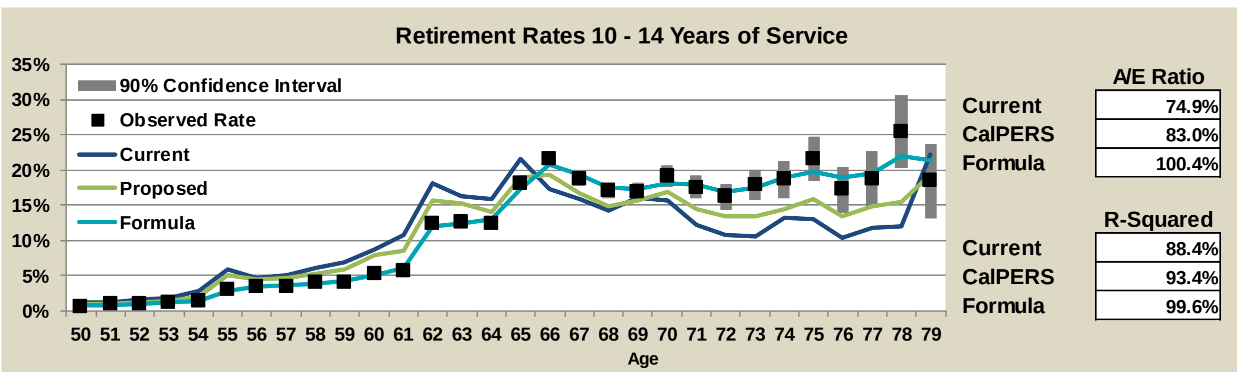
Blending is normally an important consideration as presumably the current assumption represents a prior period of experience. By blending the current assumption with the most recent experience, both periods of experience can be taken into account. Our first concern is that the blending in this case results in a double counting of the prior experience because it is already partially reflected in the data for this experience study. The current study is based on retirement experience from 2003 through 2015. In the prior study, retirement experience for the Schools pool was based on the years 2000 through 2011, and in the study where the current assumption was set, retirement experience for the Schools pool was based on the years 2000 through 2007. So, the years 2003 through 2007 have been included in the data for the last three experience studies. Additional years have been added, and this time, the years 2000 through 2002 were dropped. This methodology already provides a reasonable blending of recent and prior experience, so it doesn't seem necessary to also blend in the current assumption. If additional weight should be given to prior experience, the years 2000 through 2002 could be added back to the study.

An adjustment to the current experience may still be appropriate if there is a reason to believe that the experience during the period does not represent anticipated future experience either

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
RETIREMENT RATES

because there was something unusual during the period or something about the future is anticipated to be different. In this case, we understand that the Actuarial Office believes that the economic climate since the Great Recession may have influenced members to work longer and that this effect may be temporary. This hypothesis is plausible, but should be treated with some caution given the experience for the past eight years and that the hypothesized effect doesn't appear to have influenced other groups. As we understand it, School retirement rates actually increased from 2008 through 2011 before decreasing from 2012 through 2014 and then increasing again in 2015. There is clearly some uncertainty in future retirement rates given the annual volatility of the experience. However, it is not clear if the experience from 2003 through 2007 is a better predictor of future experience than the average over the period from 2003 through 2015. Even if the economic climate caused a change in retirement experience, the change may be permanent. Furthermore, the economic climate from 2003 through 2007 along with the retirement formula changes in 2000 may have also temporarily affected retirement rates.

The chart below shows the information for Schools pool members with 10 to 14 years of service: a group with over 300,000 exposures. The raw observed rates are shown as black squares and the confidence intervals as gray bars around the black squares. The dark blue line represents the current assumption; the green line represents the proposed assumption; and, the teal line shows the assumption produced by the formula.



It is clear from the chart that the retirement rates prior to age 65 have declined since the current assumption was set, and the retirement rates after age 65 have increased. If the hypothesis proposed by the Actuarial Office is correct, it explains the reduction in rates prior to age 65, but doesn't explain the increase after age 65 or why that increase would revert to a lower level. We are comfortable with rates prior to age 65 remaining higher than the current level of experience while retirement behavior is monitored for a possible return to prior rates, but suggest that the rates for ages greater than 65 should reflect the experience of the last 12 years.

INDUSTRIAL DISABILITY RATES

This section analyzes the incidence of industrial disability by the age and gender of the employee for the following groups:

- State Industrial
- State Safety
- Police Officers and Fire Fighters (POFF)
- California Highway Patrol (CHP)
- Public Agency Fire (PA Fire)
- Public Agency Police (PA Police)
- Public Agency County Peace Officers (PA CPO)

We analyzed the data for ages 25 through 70. The table below compares the calculation of actual industrial disabilities, exposures, and the aggregate incidence rate for each group by gender. The differences do not appear to be material.

Industrial Disability Data Comparison									
	CalPERS Data			Cheiron Data			Difference		
Group	Actual	Exposures	Rate	Actual	Exposures	Rate	Actual	Exposures	Rate
State Industrial									
Male	7	17,738	0.04%	8	15,247	0.05%	14%	-14%	0.01%
Female	20	80,943	0.02%	22	73,126	0.03%	10%	-10%	0.01%
State Safety									
Male	491	114,507	0.43%	492	124,905	0.39%	0%	9%	-0.03%
Female	567	115,137	0.49%	569	130,645	0.44%	0%	13%	-0.06%
POFF									
Male	1,821	345,622	0.53%	1,828	337,921	0.54%	0%	-2%	0.01%
Female	775	75,382	1.03%	777	73,245	1.06%	0%	-3%	0.03%
CHP									
Male	366	65,364	0.56%	366	64,268	0.57%	0%	-2%	0.01%
Female	72	5,728	1.26%	72	5,609	1.28%	0%	-2%	0.03%
PA Fire									
Male	1,098	142,194	0.77%	1,103	136,621	0.81%	0%	-4%	0.04%
Female	60	5,563	1.08%	60	5,432	1.10%	0%	-2%	0.03%
PA Police									
Male	2,513	221,403	1.14%	2,521	208,247	1.21%	0%	-6%	0.08%
Female	462	25,249	1.83%	463	23,629	1.96%	0%	-6%	0.13%
PA CPO									
Male	395	76,732	0.51%	395	72,871	0.54%	0%	-5%	0.03%
Female	158	26,367	0.60%	158	24,920	0.63%	0%	-5%	0.03%

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS

INDUSTRIAL DISABILITY RATES

Findings

The table below compares three key statistics for the current assumptions, the proposed assumptions, and an assumption based on a mathematical formula. For the industrial disability assumptions, the formula uses a Whitaker-Henderson graduation of the raw rates much like the Actuarial Office uses to develop mortality assumptions. The formula has no professional judgment applied to the result as would normally be part of an assumption setting process.

Industrial Disability Assumptions

	Proportion in Confidence Interval			Actual / Expected Ratio			R-Squared Statistic		
Group	**Current**	**Proposed**	**Formula**	**Current**	**Proposed**	**Formula**	**Current**	**Proposed**	**Formula**
State Industrial									
Male	98%	98%	76%	133%	133%	90%	0%	0%	16%
Female	100%	100%	100%	78%	78%	98%	21%	21%	24%
State Safety									
Male	63%	63%	91%	72%	72%	100%	79%	79%	83%
Female	85%	85%	98%	91%	91%	100%	79%	79%	85%
POFF									
Male	61%	61%	87%	80%	80%	99%	90%	90%	93%
Female	57%	57%	96%	151%	151%	100%	87%	87%	92%
CHP									
Male	61%	61%	85%	59%	59%	99%	84%	84%	83%
Female	89%	89%	93%	140%	140%	99%	37%	37%	49%
PA Fire									
Male	63%	76%	80%	77%	103%	99%	89%	89%	94%
Female	91%	96%	100%	137%	183%	100%	32%	32%	63%
PA Police									
Male	63%	63%	67%	87%	87%	99%	96%	96%	88%
Female	61%	61%	93%	166%	166%	98%	83%	83%	92%
PA CPO									
Male	85%	85%	89%	87%	87%	99%	76%	76%	77%
Female	91%	91%	93%	107%	107%	99%	65%	65%	68%

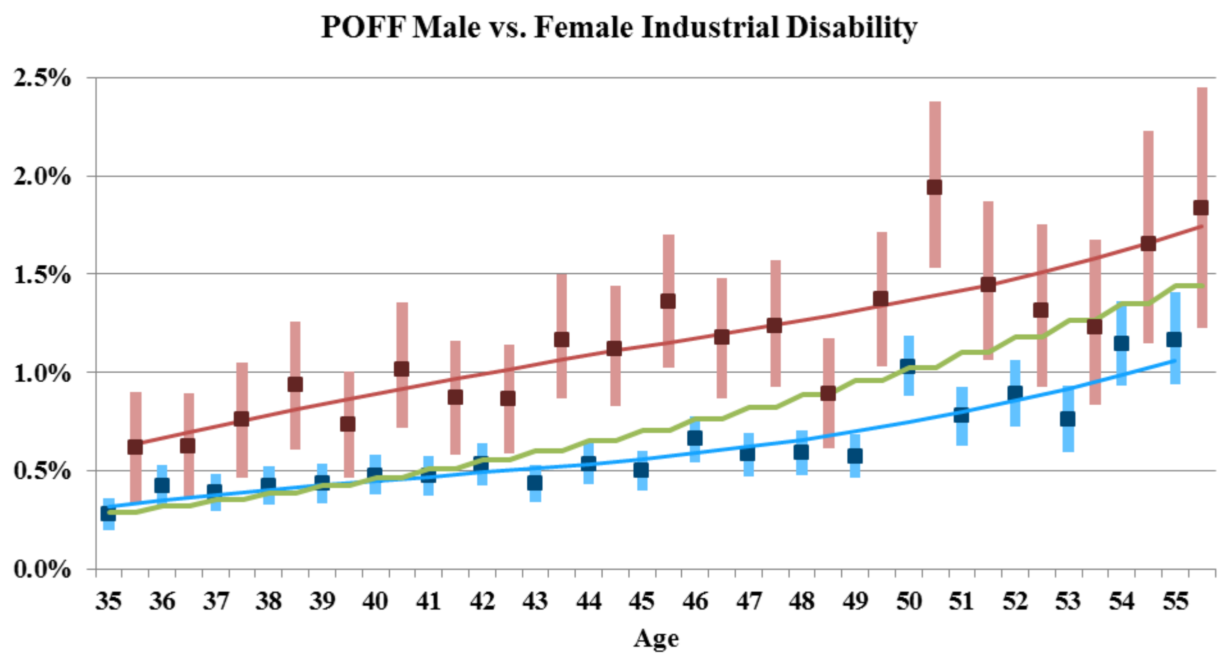
The proportion of current or proposed rates that fall within the 90 percent confidence interval is not as high as we would expect, particularly for the groups with a significant number of exposures. For example, POFF has over 400,000 exposures, but the current and proposed assumptions only fall within the confidence interval 61% of the time for males and 57% of the time for females. In contrast, the formula rates fall within the confidence interval 87% of the time for males and 96% of the time for females.

The ideal actual-to-expected ratio is 100%, but it is more conservative if the industrial disability assumption produces an actual-to-expected ratio less than 100%. The Actuarial Office sets identical industrial disability rates for males and females, but the observed rates for some of the groups are clearly different as shown by the actual-to-expected ratios. For some groups, the female actual-to-expected ratio is far in excess of 100%, indicating that there are many more

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
INDUSTRIAL DISABILITY RATES

industrial disabilities than assumed and contributing to actuarial losses. There may not be sufficient female experience in all cases to develop different assumptions (e.g., CHP), but in those cases the percentage of female rates in the confidence interval should be high because if there is so little data the confidence interval will be very wide. For other groups, the difference is significant and there is sufficient data to set a separate assumption. POFF, for example, has more female data than CHP has male and female data.

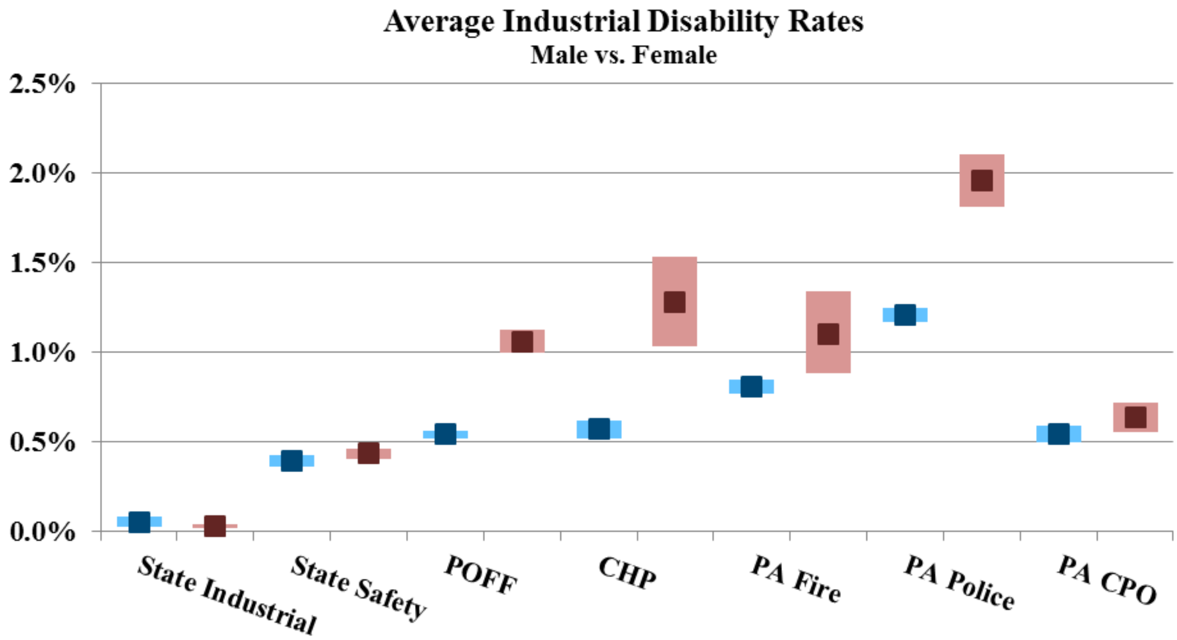
The chart below shows the analysis of POFF industrial disability rates for females and males. The dark red and blue squares represent the raw observed rates for females and males respectively. The floating light red and light blue bars represent the 90 percent confidence intervals around the raw rates. The green line represents the current and proposed assumption. The red and blue lines represent the formula assumptions for females and males.



Note that the green line representing the proposed assumption tends to be below the female rates and confidence intervals while it is mostly above the male rates and confidence intervals after age 42. Many of the confidence intervals for females and males do not even overlap. For example, the bottom of the confidence interval at age 45 for a female is just over 1.0%, but the top of the confidence interval for a male at age 45 is only about 0.6%. There is no single rate that could be assumed that would fall in both confidence intervals. This separation indicates that different assumptions for males and females would be appropriate.

For POFF, there appears to be sufficient female data to set a reasonable assumption. For some of the other groups there is less female data, but the level of incidence is clearly different than the male level of incidence. The chart on the next page shows the average industrial disability rate for males and females in each group as well as the associated confidence interval.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
INDUSTRIAL DISABILITY RATES



Based on the differences shown, it may be appropriate to set different assumptions by gender for POFF, CHP, PA Fire, and PA Police.[3] Where there is insufficient data to set a female assumption based solely on female data, the Actuarial Office may want to consider adding an adjustment to the male assumptions or referencing the female experience from another similar group.

Finally, we reviewed the r-squared statistic, which identifies how well the pattern of the assumption fits the pattern of the observed experience. Ideally, it would be 100%, and the proposed assumptions produce a reasonable r-squared where there is significant data. The pattern can be difficult to discern when there isn't very much data (e.g., State Industrial).

[3] Charts showing male and female experience by age can be found in Appendix B.

NON-INDUSTRIAL DISABILITY RATES

This section analyzes the incidence of non-industrial disability by the age and gender of the employee for the following groups:

- State Miscellaneous Tier 1
- State Miscellaneous Tier 2
- State Industrial
- Schools
- Public Agency Miscellaneous (PA Misc)
- State Safety
- Police Officers and Fire Fighters (POFF)
- California Highway Patrol (CHP)
- Public Agency Fire (PA Fire)
- Public Agency Police (PA Police)
- Public Agency County Peace Officers (PA CPO)

We analyzed the data for ages 25 through 75. The table on the following page compares the calculation of actual industrial disabilities, exposures, and the aggregate incidence rate for each group by gender. For most groups, the differences do not appear to be material.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
NON-INDUSTRIAL DISABILITY RATES

Non-Industrial Disability Assumptions									
	CalPERS Data			Cheiron Data			Difference		
Group	Actual	Exposures	Rate	Actual	Exposures	Rate	Actual	Exposures	Rate
State Miscellaneous Tier 1									
Male	890	509,599	0.175%	894	497,862	0.180%	100%	98%	0.005%
Female	1,622	640,183	0.253%	1,633	625,154	0.261%	101%	98%	0.008%
State Miscellaneous Tier 2									
Male	70	31,312	0.224%	71	29,066	0.244%	101%	93%	0.021%
Female	153	39,403	0.388%	153	36,306	0.421%	100%	92%	0.033%
State Industrial									
Male	44	12,766	0.345%	48	11,255	0.426%	109%	88%	0.082%
Female	278	63,154	0.440%	279	58,078	0.480%	100%	92%	0.040%
Schools									
Male	1,086	540,943	0.201%	1,088	527,130	0.206%	100%	97%	0.006%
Female	1,769	1,228,280	0.144%	1,779	1,196,093	0.149%	101%	97%	0.005%
PA Misc									
Male	844	694,309	0.122%	845	641,426	0.132%	100%	92%	0.010%
Female	925	728,593	0.127%	935	663,654	0.141%	101%	91%	0.014%
State Safety									
Male	237	112,165	0.211%	241	107,186	0.225%	102%	96%	0.014%
Female	185	93,770	0.197%	186	89,587	0.208%	101%	96%	0.010%
POFF									
Male	265	389,174	0.068%	266	384,661	0.069%	100%	99%	0.001%
Female	97	91,641	0.106%	99	89,849	0.110%	102%	98%	0.004%
CHP									
Male	8	78,729	0.010%	8	77,688	0.010%	100%	99%	0.000%
Female	2	7,628	0.026%	2	7,474	0.027%	100%	98%	0.001%
PA Fire									
Male	41	172,876	0.024%	41	167,712	0.024%	100%	97%	0.001%
Female	3	6,268	0.048%	3	6,145	0.049%	100%	98%	0.001%
PA Police									
Male	100	259,832	0.038%	100	248,126	0.040%	100%	95%	0.002%
Female	22	27,010	0.081%	22	25,639	0.086%	100%	95%	0.004%
PA CPO									
Male	66	83,556	0.079%	67	79,094	0.085%	102%	95%	0.006%
Female	40	27,330	0.146%	40	25,729	0.155%	100%	94%	0.009%

Findings

The table on the next page compares three key statistics for the current assumptions, the proposed assumptions, and an assumption based on a mathematical formula. For the non-industrial disability assumptions, the formula uses a Whitaker-Henderson graduation of the raw rates much like the Actuarial Office uses to develop mortality assumptions. The formula has no professional judgment applied to the result as would normally be part of an assumption setting process.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
NON-INDUSTRIAL DISABILITY RATES

Non-Industrial Disability Assumptions									
	Proportion in Confidence Interval			Actual / Expected Ratio			R-Squared Statistic		
Group	Current	Proposed	Formula	Current	Proposed	Formula	Current	Proposed	Formula
State Miscellaneous Tier 1									
Male	82%	82%	88%	92%	92%	100%	90%	90%	93%
Female	71%	71%	84%	89%	89%	100%	92%	92%	92%
State Miscellaneous Tier 2									
Male	76%	92%	80%	52%	103%	100%	41%	51%	49%
Female	75%	100%	96%	55%	111%	99%	65%	82%	82%
State Industrial									
Male	90%	92%	78%	69%	77%	99%	25%	23%	32%
Female	90%	94%	94%	85%	92%	99%	79%	78%	83%
Schools									
Male	67%	92%	98%	76%	108%	100%	95%	95%	95%
Female	90%	94%	98%	91%	105%	100%	99%	99%	98%
PA Misc									
Male	67%	92%	90%	74%	100%	100%	94%	94%	94%
Female	76%	96%	94%	86%	101%	100%	95%	95%	95%
State Safety									
Male	94%	94%	94%	91%	91%	100%	78%	78%	82%
Female	86%	86%	82%	94%	94%	100%	57%	57%	68%
POFF									
Male	92%	92%	96%	98%	98%	100%	76%	76%	81%
Female	90%	90%	96%	158%	158%	100%	48%	48%	61%
CHP									
Male	100%	100%	98%	48%	48%	99%	14%	14%	21%
Female	100%	100%	82%	123%	123%	99%	4%	4%	12%
PA Fire									
Male	88%	88%	80%	73%	73%	99%	15%	15%	47%
Female	100%	100%	82%	191%	191%	97%	0%	0%	18%
PA Police									
Male	82%	82%	96%	77%	77%	99%	43%	43%	63%
Female	92%	92%	96%	187%	187%	98%	14%	14%	33%
PA CPO									
Male	94%	94%	94%	96%	96%	100%	52%	52%	56%
Female	94%	94%	88%	180%	180%	99%	40%	40%	53%

The proportion of current or proposed rates that fall within the 90 percent confidence interval is high for all groups except State Miscellaneous Tier 2 where the data differences are driving the results. When new assumptions have been proposed; the percentage of rates within the confidence interval has increased, indicating that the proposed assumption is an improvement.

The ideal actual-to-expected ratio is 100%, but it is more conservative if the non-industrial disability assumption produces an actual-to-expected ratio less than 100%. For most groups, the actual-to-expected ratios are near or somewhat below 100%. The groups that are over 100% are primarily groups for which there is little data and the percentage of rates within the confidence interval is high, so we believe these are reasonable assumptions. Likewise for Schools, we would not have reduced the assumption as much as the Actuarial Office did, but with over 90 percent of the proposed rates within the confidence interval, the proposed assumption is still reasonable.[4]

Finally, we reviewed the r-squared statistic, which identifies how well the pattern of the assumption fits the pattern of the observed experience. Ideally, it would be 100%, but that is virtually impossible to achieve. The proposed assumptions produce a reasonable r-squared where there is significant data. The pattern can be difficult to discern when there isn't very much data (e.g., CHP).

[4] Sample charts showing experience by age group can be found in Appendix C.

VESTED TERMINATION RATES

This section analyzes the incidence of vested termination by the age, service, and gender of the employee for the following groups:

- State Miscellaneous Tier 1
- State Miscellaneous Tier 2
- State Industrial
- Schools
- Public Agency Miscellaneous (PA Misc)
- State Safety
- Police Officers and Fire Fighters (POFF)
- California Highway Patrol (CHP)
- Public Agency Fire (PA Fire)
- Public Agency Police (PA Police)
- Public Agency County Peace Officers (PA CPO)

We analyzed the data for entry ages 20 through 49 and service from 5 years to 29 years. The table on the following page compares the calculation of actual vested terminations, exposures, and the aggregate incidence rate for each group by gender. For most groups, the differences do not appear to be material. However, there are a few groups where the differences would affect the average vested termination rate by 20 to 45 basis points.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS

VESTED TERMINATION RATES

Vested Termination Assumptions

Comparison of Decrements and Exposures

	CalPERS Data			Cheiron Data			Difference		
	Decrements	Exposures	Rate	Decrements	Exposures	Rate	Decrements	Exposures	Rate
State Misc Tier 1									
Male	7,819	548,437	1.43%	9,271	616,195	1.50%	119%	112%	0.08%
Female	11,983	701,577	1.71%	14,299	793,745	1.80%	119%	113%	0.09%
State Misc Tier 2									
Male	790	42,564	1.86%	717	32,811	2.19%	91%	77%	0.33%
Female	1,364	60,700	2.25%	1,213	45,350	2.67%	89%	75%	0.43%
State Industrial									
Male	216	14,350	1.51%	260	13,278	1.96%	120%	93%	0.45%
Female	1,271	74,870	1.70%	1,427	73,736	1.94%	112%	98%	0.24%
Schools									
Male	11,279	607,535	1.86%	10,000	648,154	1.54%	89%	107%	-0.31%
Female	29,507	1,422,343	2.07%	26,825	1,473,354	1.82%	91%	104%	-0.25%
PA Misc									
Male	14,770	790,742	1.87%	16,472	806,322	2.04%	112%	102%	0.17%
Female	20,777	856,308	2.43%	23,763	836,917	2.84%	114%	98%	0.41%
State Safety									
Male	1,050	88,765	1.18%	1,153	91,522	1.26%	110%	103%	0.08%
Female	1,340	76,593	1.75%	1,490	79,365	1.88%	111%	104%	0.13%
POFF									
Male	2,462	348,908	0.71%	2,966	375,418	0.79%	120%	108%	0.08%
Female	1,053	83,539	1.26%	1,182	88,559	1.33%	112%	106%	0.07%
CHP									
Male	334	67,671	0.49%	354	75,991	0.47%	106%	112%	-0.03%
Female	84	6,769	1.24%	87	7,443	1.17%	104%	110%	-0.07%
PA Fire									
Male	721	138,697	0.52%	849	159,777	0.53%	118%	115%	0.01%
Female	84	5,782	1.45%	92	6,087	1.51%	110%	105%	0.06%
PA Police									
Male	2,096	225,078	0.93%	2,272	240,875	0.94%	108%	107%	0.01%
Female	433	25,040	1.73%	460	25,464	1.81%	106%	102%	0.08%
PA CPO									
Male	756	73,660	1.03%	809	76,129	1.06%	107%	103%	0.04%
Female	430	25,184	1.71%	463	25,263	1.83%	108%	100%	0.13%

Findings

The table on the next page compares three key statistics for the current assumptions, the proposed assumptions, and an assumption based on a mathematical formula. For the vested termination assumptions, the formula uses a Whitaker-Henderson graduation of the raw rates much like the Actuarial Office uses to develop mortality assumptions. The formula has no professional judgment applied to the result as would normally be part of an assumption setting process.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
VESTED TERMINATION RATES

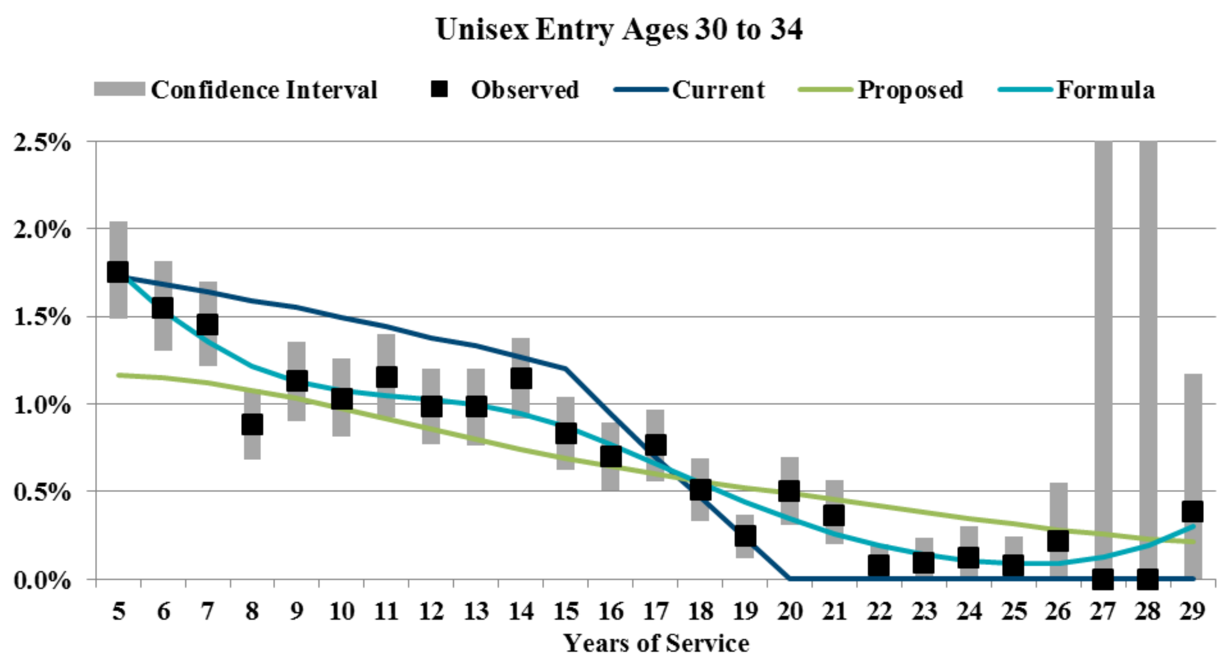
Vested Termination Assumptions Summary of Analysis	Proportion in Confidence Interval			Actual / Expected Ratio			R-Squared Statistic		
	Current	Proposed	Formula	Current	Proposed	Formula	Current	Proposed	Formula
State Misc Tier 1									
Male	23%	73%	93%	105%	110%	100%	84%	98%	99%
Female	27%	51%	94%	116%	128%	100%	83%	98%	99%
State Misc Tier 2									
Male	68%	83%	97%	112%	109%	100%	78%	82%	94%
Female	73%	75%	97%	123%	135%	100%	89%	87%	96%
State Industrial									
Male	91%	91%	97%	136%	136%	100%	60%	60%	78%
Female	69%	69%	96%	117%	117%	100%	81%	81%	95%
Schools									
Male	8%	53%	89%	59%	82%	100%	27%	69%	98%
Female	9%	26%	91%	86%	91%	100%	25%	48%	99%
PA Misc									
Male	13%	63%	95%	94%	108%	100%	78%	98%	100%
Female	21%	28%	93%	122%	139%	100%	85%	98%	100%
State Safety									
Male	53%	78%	95%	85%	100%	100%	66%	79%	92%
Female	65%	74%	97%	106%	141%	100%	79%	85%	97%
POFF									
Male	50%	65%	91%	79%	101%	100%	85%	87%	97%
Female	83%	73%	95%	133%	171%	100%	87%	88%	96%
CHP									
Male	86%	95%	91%	75%	89%	100%	80%	83%	89%
Female	96%	95%	87%	190%	234%	100%	51%	56%	80%
PA Fire									
Male	78%	91%	90%	88%	104%	100%	85%	86%	91%
Female	97%	97%	85%	219%	264%	99%	40%	43%	58%
PA Police									
Male	81%	81%	93%	104%	104%	100%	94%	94%	98%
Female	87%	87%	87%	177%	177%	100%	86%	86%	92%
PA CPO									
Male	75%	91%	95%	77%	95%	100%	88%	91%	96%
Female	93%	91%	91%	125%	155%	100%	88%	90%	94%

The proportion of proposed rates that fall within the 90 percent confidence interval is generally high, but for some of the groups, it is lower than we would expect. In some cases (e.g., Schools), it may be driven by differences in our data, and in others, it is due to the difference between male and female rates as discussed below. However, there are some cases where the proposed assumptions don't appear to reflect the pattern in the data.

As an example, the chart on the following page shows the information for POFF male and female members with entry ages 30 through 34. The raw observed rates are shown as black squares and the confidence intervals as gray bars around the black squares. The dark blue line

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
VESTED TERMINATION RATES

represents the current assumption; the green line represents the proposed assumption; and, the teal line shows the assumption produced by the formula.[5]

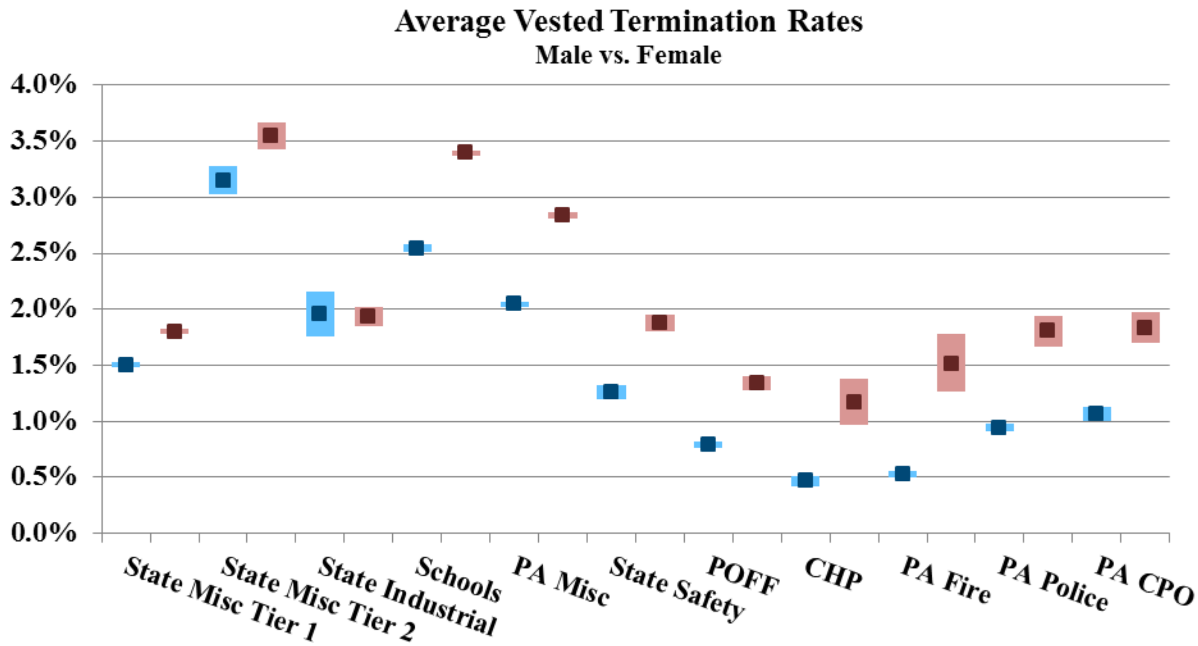


The proposed rates appear too low for less than 8 years of service and too high for more than 22 years of service, perhaps over correcting for the current assumption. While the high rates for those with many years of service may tend to understate the liability, we do not believe the net impact is likely to be significant. Nevertheless, we would encourage the Actuarial Office to improve their methodology for setting these assumptions to more accurately reflect the pattern of rates.

The ideal actual-to-expected ratio is 100%, but it is more conservative if the vested termination assumption produces an actual-to-expected ratio greater than 100%. The Actuarial Office sets identical vested termination rates for males and females, but the observed rates for some of the groups are clearly different as shown by the actual-to-expected ratios. The chart on the next page shows the average vested termination rate for males and females in each group as well as the associated confidence interval. The dark red and blue squares represent the weighted-average observed rates for females and males, respectively. The floating light red and light blue bars represent the 90 percent confidence intervals around the observed rates.

[5] Additional charts can be found in Appendix D.

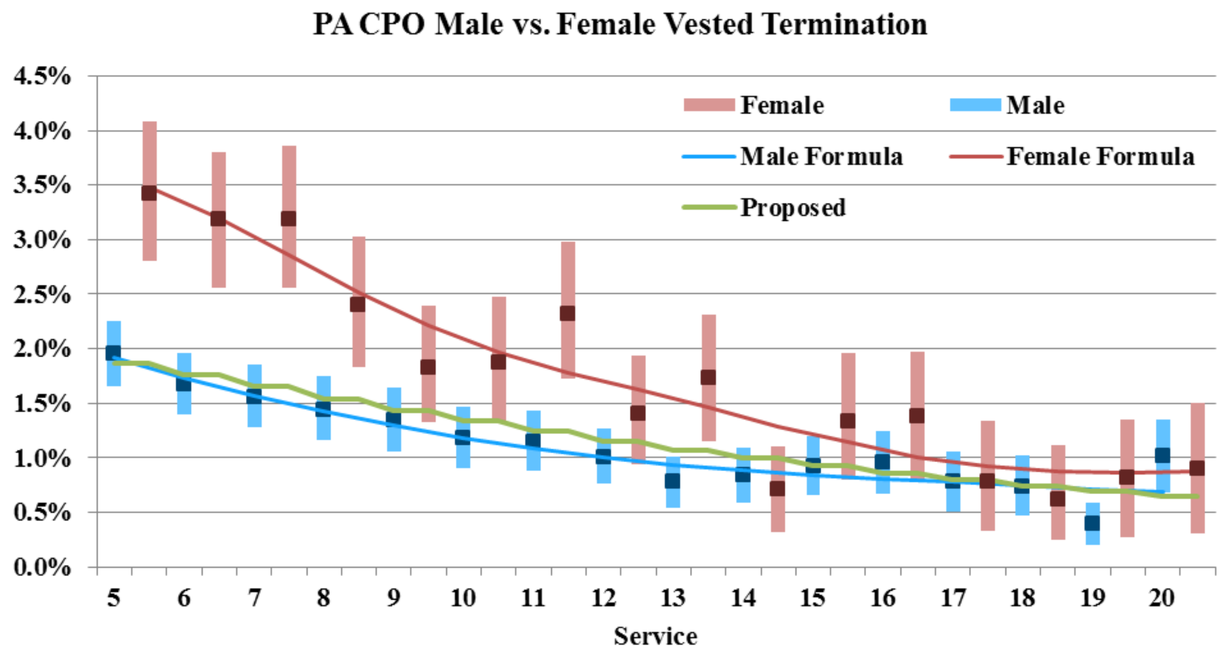
SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
VESTED TERMINATION RATES



For almost all of the groups, there is a clear separation between the male and female rates. There may not be sufficient female experience in all cases to develop different assumptions (e.g., CHP), so the Actuarial Office may want to consider adding an adjustment to the male assumptions or referencing the female experience from another similar group to set the female assumption. For other groups, the difference is significant and there is sufficient data to set a separate assumption.

The chart on the following page show the analysis of Public Agency CPO vested termination rates for females and males at entry ages from 20 through 49. The green line represents the proposed assumption. The red and blue lines represent the formula assumptions for females and males.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
VESTED TERMINATION RATES



Note that the green line representing the proposed assumption tends to be below the female rates and confidence intervals for the early years of service. In the early years of service, many of the confidence intervals for females and males do not even overlap. There is no single rate that could be assumed that would fall in both confidence intervals. This separation indicates that different assumptions for males and females would be appropriate. Between 14 and 20 years of service, however, the male and female rates converge and a single unisex assumption may be appropriate.

Finally, we reviewed the r-squared statistic, which identifies how well the pattern of the assumption fits the pattern of the observed experience. Ideally, it would be 100%, but that is virtually impossible to achieve. The proposed assumptions do not always produce as high of an r-squared as we would expect. Developing separate rates for males and females that fall within the confidence intervals will likely help the r-squared statistic as well.

REFUND RATES

This section analyzes the incidence of refunds by the age, service, and gender of the employee for the following groups:

- State Miscellaneous Tier 1
- State Miscellaneous Tier 2
- State Industrial
- Schools
- Public Agency Miscellaneous (PA Misc)
- State Safety
- Police Officers and Fire Fighters (POFF)
- California Highway Patrol (CHP)
- Public Agency Fire (PA Fire)
- Public Agency Police (PA Police)
- Public Agency County Peace Officers (PA CPO)

We analyzed the data for entry ages 20 through 49 and service from 0 years to 24 years. The table on the following page compares the calculation of actual refunds, exposures, and the aggregate refund rate for each group by gender. For all non-safety groups and State Safety, the differences affect the average refund rate by at least 20 basis points. For State Miscellaneous Tier 2, the differences are clearly material. We believe these differences are due to criteria such as service for part time members and the treatment of members with exit dates prior to June 30, 2000.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
REFUND RATES

Refund Assumptions

Comparison of Decrements and Exposures

	CalPERS Data			Cheiron Data			Difference		
	Decrements	Exposures	Rate	Decrements	Exposures	Rate	Decrements	Exposures	Rate
State Misc Tier 1									
Male	18,116	743,756	2.44%	16,853	854,379	1.97%	93%	115%	-0.46%
Female	24,534	946,413	2.59%	22,565	1,126,895	2.00%	92%	119%	-0.59%
State Misc Tier 2									
Male	5,383	122,829	4.38%	1,298	62,933	2.06%	24%	51%	-2.32%
Female	7,171	162,471	4.41%	1,495	83,605	1.79%	21%	51%	-2.63%
State Industrial									
Male	388	20,050	1.94%	378	16,541	2.29%	97%	82%	0.35%
Female	1,721	99,626	1.73%	1,621	89,208	1.82%	94%	90%	0.09%
Schools									
Male	47,033	947,419	4.96%	47,364	911,440	5.20%	101%	96%	0.23%
Female	117,283	2,423,647	4.84%	119,553	2,310,540	5.17%	102%	95%	0.34%
PA Misc									
Male	37,734	1,132,563	3.33%	36,138	1,020,215	3.54%	96%	90%	0.21%
Female	57,152	1,301,258	4.39%	54,275	1,158,569	4.68%	95%	89%	0.29%
State Safety									
Male	2,633	121,959	2.16%	2,558	141,444	1.81%	97%	116%	-0.35%
Female	4,246	119,040	3.57%	4,150	150,282	2.76%	98%	126%	-0.81%
POFF									
Male	7,317	461,322	1.59%	6,768	458,599	1.48%	92%	99%	-0.11%
Female	1,803	106,136	1.70%	1,662	104,507	1.59%	92%	98%	-0.11%
CHP									
Male	269	84,649	0.32%	266	84,193	0.32%	99%	99%	0.00%
Female	23	7,797	0.29%	22	7,685	0.29%	96%	99%	-0.01%
PA Fire									
Male	1,718	176,802	0.97%	1,706	171,387	1.00%	99%	97%	0.02%
Female	124	7,501	1.65%	124	7,287	1.70%	100%	97%	0.05%
PA Police									
Male	3,705	289,129	1.28%	3,666	274,053	1.34%	99%	95%	0.06%
Female	611	33,709	1.81%	602	31,708	1.90%	99%	94%	0.09%
PA CPO									
Male	1,869	101,751	1.84%	1,832	95,706	1.91%	98%	94%	0.08%
Female	957	35,912	2.66%	926	33,594	2.76%	97%	94%	0.09%

Given the discrepancies, the remainder of our analysis on refund rates is based on the actual refunds and exposures calculated by CalPERS.

Findings

The table on the next page compares three key statistics for the current assumptions, the proposed assumptions, and an assumption based on a mathematical formula. For the refund assumptions, the formula uses a Whitaker-Henderson graduation of the raw rates much like the Actuarial Office uses to develop mortality assumptions. The formula has no professional judgment applied to the result as would normally be part of an assumption setting process.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
REFUND RATES

Refund Assumptions
Summary of Analysis

	Proportion in Confidence Interval			Actual / Expected Ratio			R-Squared Statistic		
	Current	Proposed	Formula	Current	Proposed	Formula	Current	Proposed	Formula
State Misc Tier 1									
Male	31%	74%	72%	75%	97%	100%	96%	99%	98%
Female	29%	67%	72%	81%	106%	100%	98%	100%	99%
State Misc Tier 2									
Male	15%	15%	81%	86%	86%	100%	96%	96%	98%
Female	21%	21%	87%	93%	93%	100%	98%	98%	99%
State Industrial									
Male	93%	93%	75%	122%	103%	100%	93%	94%	92%
Female	85%	86%	77%	123%	104%	100%	94%	93%	95%
Schools									
Male	53%	67%	79%	111%	98%	100%	97%	98%	98%
Female	28%	62%	73%	114%	103%	100%	91%	98%	99%
PA Misc									
Male	47%	47%	67%	85%	85%	100%	97%	97%	98%
Female	51%	51%	61%	102%	102%	100%	97%	97%	99%
State Safety									
Male	79%	76%	85%	97%	90%	100%	95%	96%	98%
Female	71%	75%	87%	126%	115%	100%	98%	99%	99%
POFF									
Male	62%	62%	84%	105%	105%	100%	87%	87%	98%
Female	77%	77%	78%	127%	127%	100%	80%	80%	96%
CHP									
Male	91%	95%	67%	75%	102%	100%	65%	83%	93%
Female	99%	99%	65%	85%	131%	97%	54%	78%	81%
PA Fire									
Male	88%	87%	73%	107%	100%	100%	90%	97%	98%
Female	95%	97%	65%	171%	158%	98%	91%	97%	95%
PA Police									
Male	67%	67%	69%	105%	105%	100%	95%	95%	97%
Female	91%	91%	71%	133%	133%	100%	94%	94%	96%
PA CPO									
Male	81%	91%	83%	85%	89%	100%	96%	97%	97%
Female	93%	95%	81%	115%	120%	100%	97%	97%	97%

The proportion of current or proposed rates that fall within the 90 percent confidence interval is high for most groups with some notable exceptions. To the extent these variations are due to a conservative bias with respect to the probability of a member taking a refund, it may be prudent. Refund assumptions can be very powerful, and over-estimating the number of refunds, particularly for older, longer service members can significantly understate the liability of the plan.

The ideal actual-to-expected ratio is 100%, but given the power of the refund assumption, we believe it is prudent to err on the side of ratios greater than 100%, particularly for members with more years of service. For most groups, the actual-to-expected ratios are near or above 100%. We suggest taking a closer look at the groups that are not and considering a reduction in the assumed refund rates. We note that the proposed assumptions include small probabilities of members taking a refund even after 20 or 30 years of service. We suggest phasing the refund assumption to 0% somewhere between 10 and 15 years of service.[6]

Finally, we reviewed the r-squared statistic, which identifies how well the pattern of the assumption fits the pattern of the observed experience. Ideally, it would be 100%, but that is virtually impossible to achieve. All of the proposed assumptions produce a high r-squared.

[6] Sample charts showing the experience by years of service are shown in Appendix E.

MERIT SALARY INCREASES

The merit salary scale is used to project salary increases in addition to the across-the-board wage inflation assumption of 2.75 percent. The Office of the Actuary uses a logarithmic model to separately graduate the data observations during the first 8 years of service and 9 or more years of service. Some adjustments are made to smooth the connection between the models and to fit the ultimate rate selected.

The methodology used and assumptions proposed in the experience study are reasonable. We have two technical comments we suggest be considered for the next experience study, but we do not believe it would materially change the conclusions of the current experience study.

Technical Comments

Averaging Methodology

In combining multiple years of experience for the study, CalPERS staff weighted the experience for each year by the number of people present in each of those years for that particular group and entry age-service combination. Instead, the combination for different years should be weighted based on salary as it is in determining the average increase for an individual year.

The Actuarial Liability for a given group is largely proportional to salary. Determining the average for multiple years by weighting by count gives the same weight to the salary increase for a low-paid member as it does for a high-paid member. However, the liability being measured is much more sensitive to the salary increase for the high-paid member.

To illustrate, consider the following simple example with two scenarios.

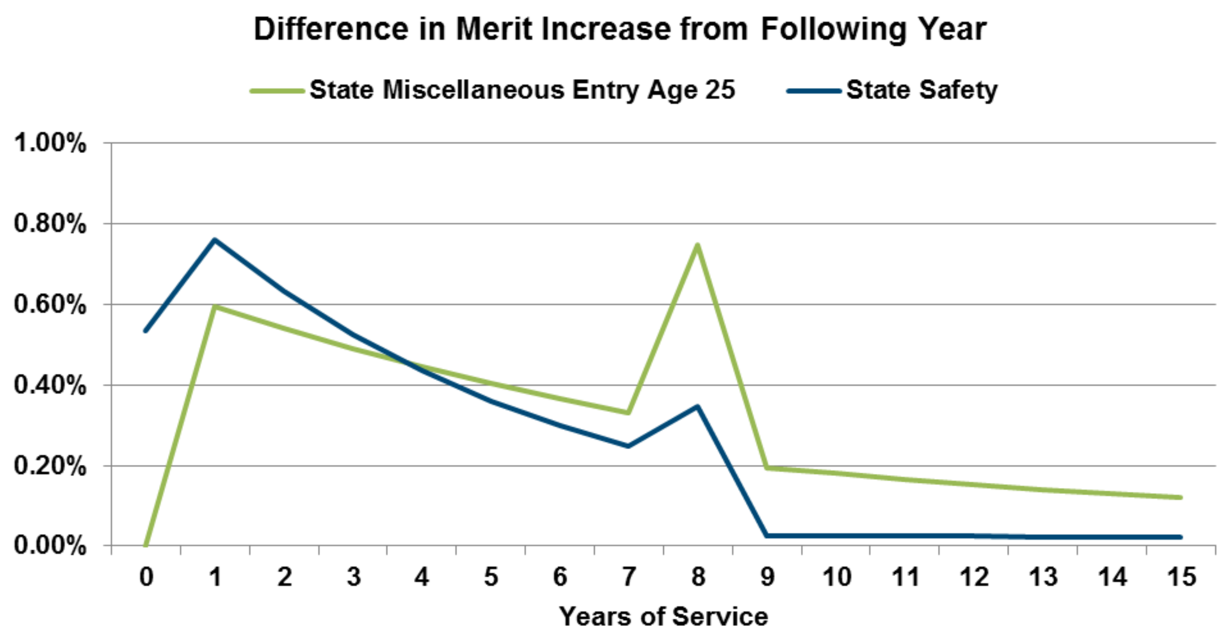
		Pay Increase	
	Salary	Scenario 1	Scenario 2
High-Paid Member	$200,000	10%	0%
Low-Paid Member	$20,000	0%	10%

In Scenario 1, the high-paid member receives a 10% increase in pay while the low-paid member receives no pay increase. In Scenario 2, the low-paid member receives the 10% increase while the high-paid member receives no increase. In both cases, the average weighted by count is a 5% increase, which would result in a projection of total salary for both members of $231,000 ($200,000 x 1.05 + $20,000 x 1.05). In Scenario 1, however, actual pay would increase to $240,000 ($200,000 x 1.10 + $20,000 x 1.00), which is a 9% increase. In Scenario 2, actual pay would only increase to $222,000 ($200,000 x 1.00 + $20,000 x 1.10), which is a 0.9% increase.

SECTION 4 – DEMOGRAPHIC ASSUMPTIONS
MERIT SALARY INCREASES

In the study, there are usually more than two members being averaged and the disparity in pay is not as extreme as in the example, so differences are likely to be much smaller. Nevertheless, a systemic bias could emerge (with a weighting toward lower-paid employees), so we suggest that this methodology be changed in future experience studies. We made this same recommendation in our review of the prior study, but it does not appear that the methodology changed.

Our second technical comment is that the transition of rates from the logarithmic model covering the first eight years of service to the logarithmic model covering the remaining years of service is not always smooth. The chart below shows two examples: State Miscellaneous members with an entry age of 25 and State Safety members. The amount shown in the chart for each year is the difference between the merit scale for that year and the following year. For example, the amount shown for 0 years of service is the merit scale for 0 years of service minus the merit scale for 1 year of service. This is a measure of the rate of change in the merit scale.



In both of these examples, the rate of decrease in the merit scale spikes at the point the two logarithmic models are joined. For most groups, the adjustment at the point the models are joined is not as significant.[7] We suggest that a methodology be adopted to smooth this transition over a few years of service.

[7] Charts for additional groups are shown in Appendix F.

FAMILY COMPOSITION

Probability of Marriage

We understand that many of the plans administered by CalPERS include either a 25 percent or a 50 percent post-retirement survivor allowance benefit. In order to properly value those plans, the Actuarial Office applies an assumption as to the probability of a member being married at the time of retirement. The assumptions developed by the Actuarial Office appear to be reasonable. However, we have three suggestions for their consideration.

First, the data used appears to include members who retired quite a while ago. To make sure the probabilities are capturing any changes over time, we suggest that the analysis should also be performed on members who retired in the last four or five years.

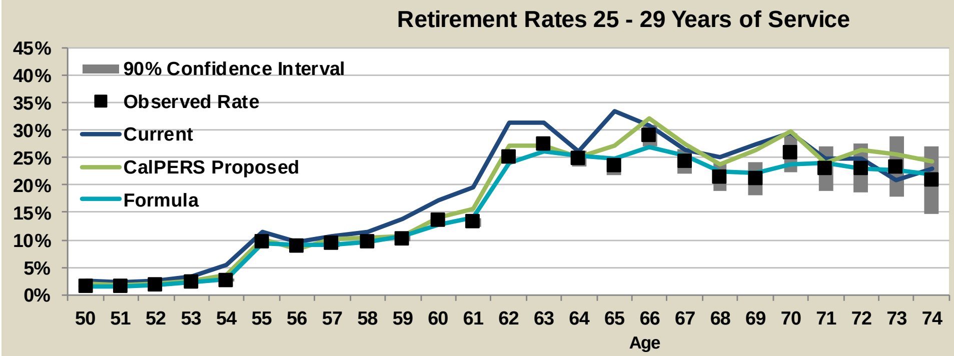
Second, in some systems we have found the marriage rates at retirement for males and females to be different. The analysis should produce the rates separately for males and females even if ultimately the decision is to use the same rate for both.

Finally, since this assumption is only used for plans with an automatic post-retirement survivor allowance benefit, the analysis should check the probability of marriage at retirement just for these plans in case there is any selection bias in which plans have that benefit.

In addition to the probability of marriage, the Actuarial Office also estimates the age difference between the retiree and his or her spouse. The differences between groups do not appear to be significant, and the Actuarial Office recommends retaining the current assumption that males are three years older than females. This assumption is reasonable, but the Actuarial Office may also consider if it should separate the assumption between male and female retirees. While in aggregate males are three years older than their female spouses, it appears that female retirees are only two years younger than their male spouses.

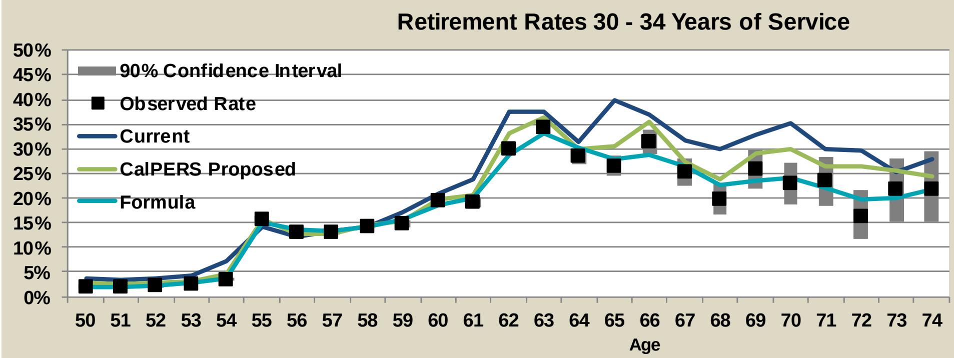
APPENDIX A – SAMPLE RETIREMENT RATE ANALYSES

State Miscellaneous Tier 1



A/E Ratio	
Current	79.4%
Proposed	92.0%
Formula	100.0%

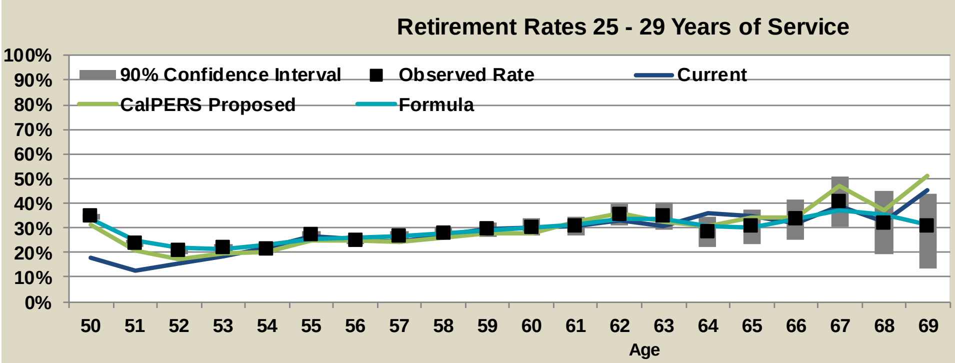
R-Squared	
Current	96.6%
Proposed	99.4%
Formula	99.5%



A/E Ratio	
Current	87.8%
Proposed	96.2%
Formula	99.7%

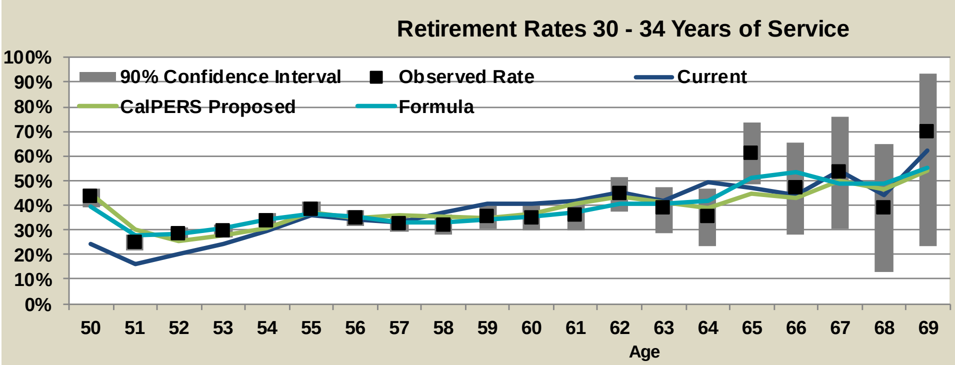
R-Squared	
Current	95.8%
Proposed	99.6%
Formula	99.7%

State POFF



A/E Ratio	
Current	129.1%
CalPERS	109.7%
Formula	99.9%

R-Squared	
Current	88.7%
CalPERS	99.8%
Formula	99.7%



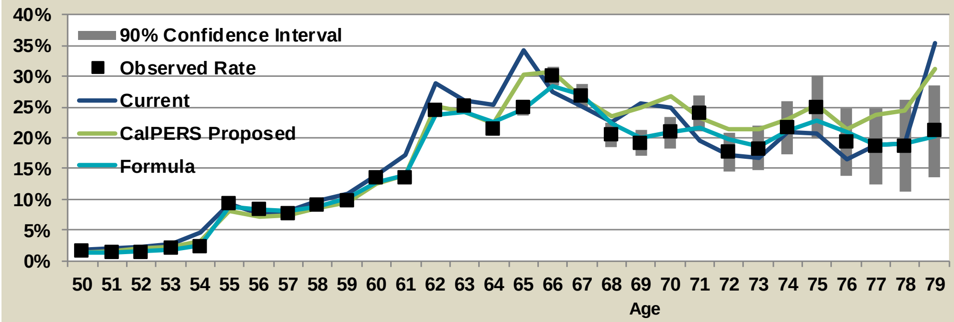
A/E Ratio	
Current	111.3%
CalPERS	100.2%
Formula	100.3%

R-Squared	
Current	92.8%
CalPERS	98.6%
Formula	99.5%

APPENDIX A – SAMPLE RETIREMENT RATE ANALYSES

Schools

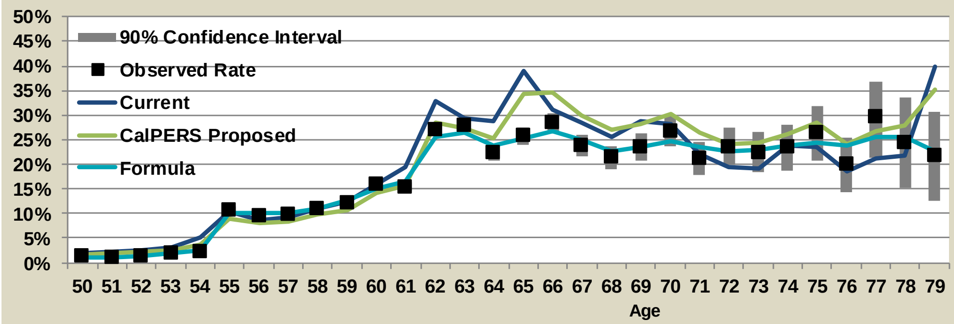
Retirement Rates 25 - 29 Years of Service



	A/E Ratio
Current	89.2%
CalPERS	98.3%
Formula	100.2%

	R-Squared
Current	97.3%
CalPERS	98.7%
Formula	99.7%

Retirement Rates 30 - 34 Years of Service

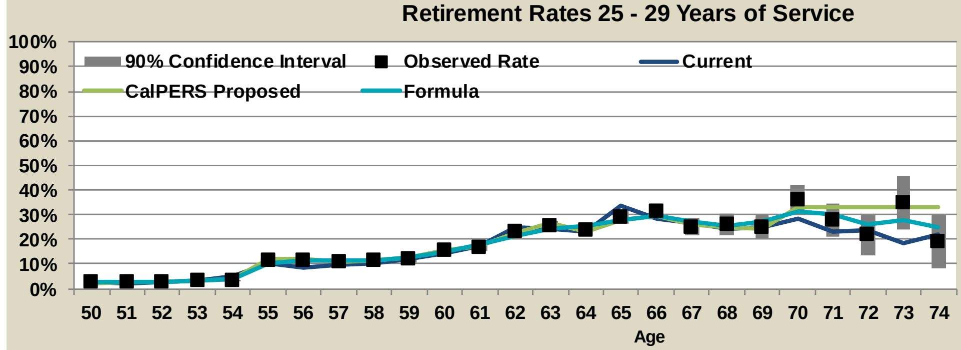


	A/E Ratio
Current	88.4%
CalPERS	96.8%
Formula	100.3%

	R-Squared
Current	94.8%
CalPERS	95.7%
Formula	99.5%

Public Agency Miscellaneous 2.0% @ 55

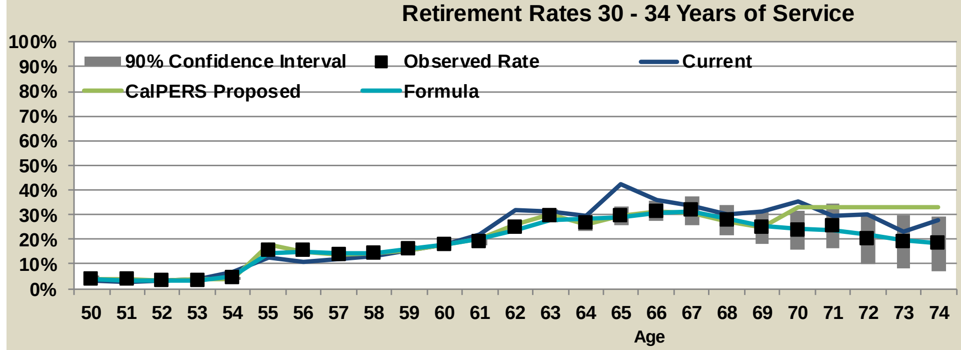
Retirement Rates 25 - 29 Years of Service



	A/E Ratio
Current	103.2%
CalPERS	98.6%
Formula	100.6%

	R-Squared
Current	94.7%
CalPERS	99.6%
Formula	99.2%

Retirement Rates 30 - 34 Years of Service

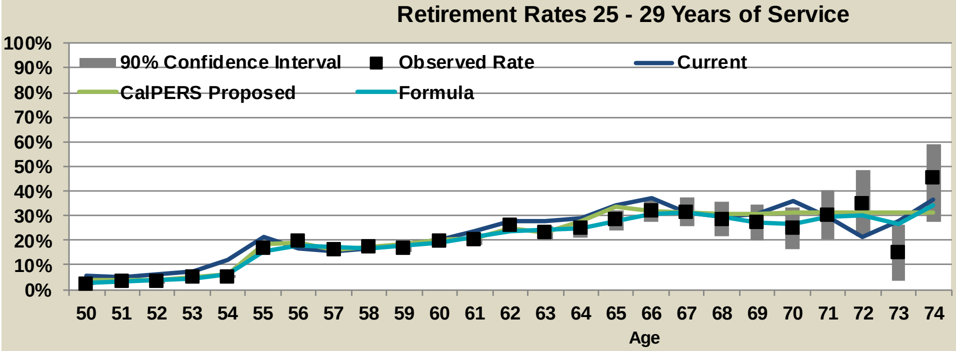


	A/E Ratio
Current	100.2%
CalPERS	98.0%
Formula	100.5%

	R-Squared
Current	92.6%
CalPERS	99.3%
Formula	99.6%

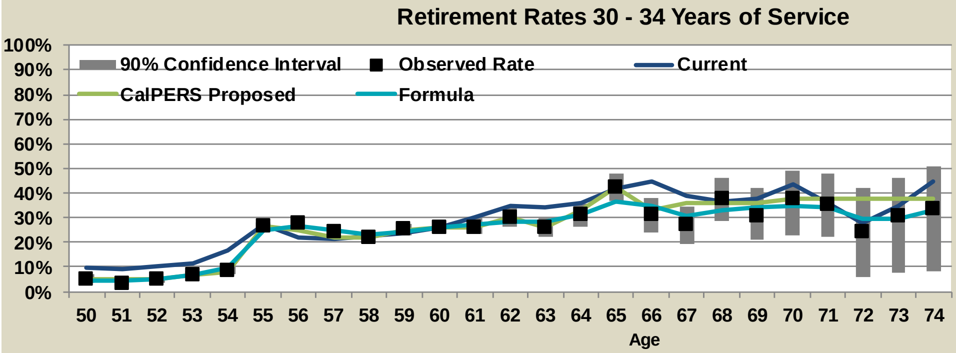
APPENDIX A – SAMPLE RETIREMENT RATE ANALYSES

Public Agency Miscellaneous 2.7% @ 55



A/E Ratio	
Current	84.0%
CalPERS	93.6%
Formula	100.9%

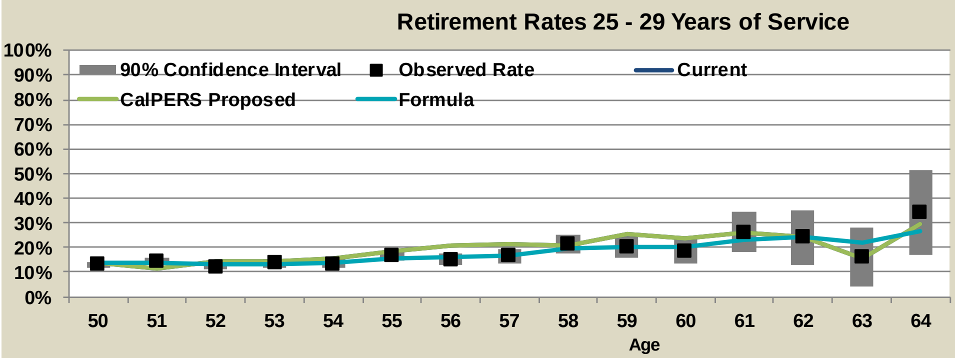
R-Squared	
Current	87.4%
CalPERS	98.6%
Formula	98.9%



A/E Ratio	
Current	90.3%
CalPERS	101.8%
Formula	100.4%

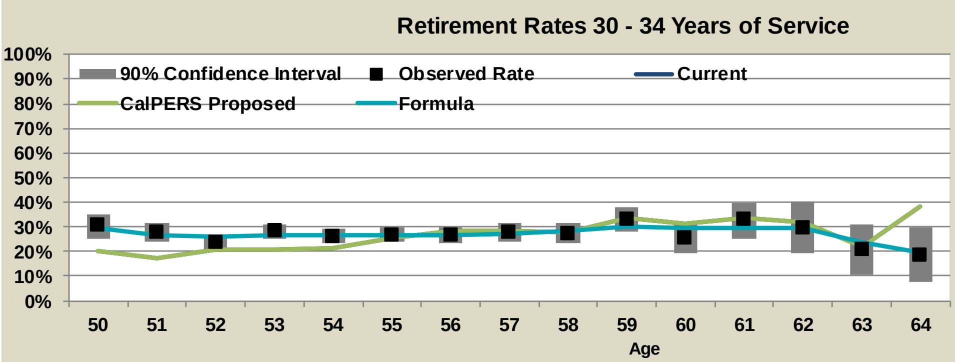
R-Squared	
Current	91.7%
CalPERS	99.5%
Formula	99.5%

Public Agency Fire 3.0% @ 50



A/E Ratio	
Current	92.5%
CalPERS	92.5%
Formula	100.1%

R-Squared	
Current	94.5%
CalPERS	94.5%
Formula	99.3%



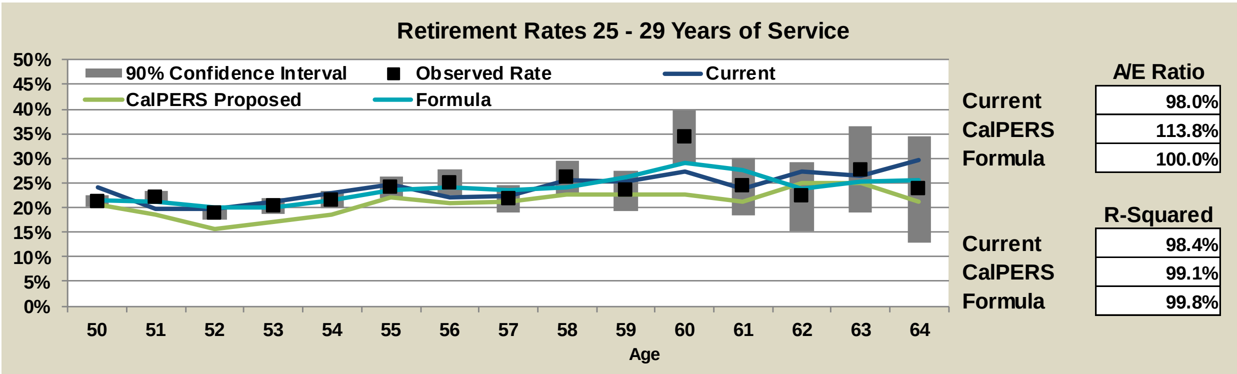
A/E Ratio	
Current	110.7%
CalPERS	110.7%
Formula	100.1%

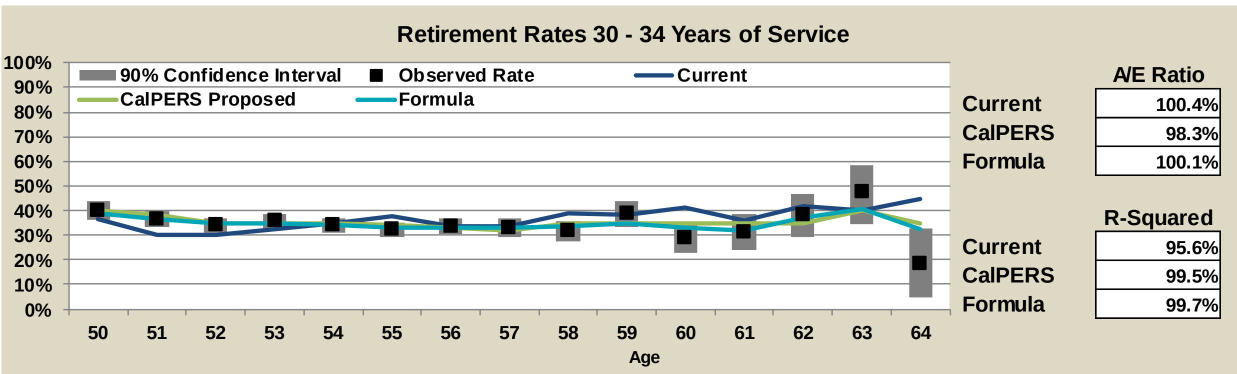
R-Squared	
Current	90.9%
CalPERS	90.9%
Formula	99.1%

CALIFORNIA PUBLIC EMPLOYEES' RETIREMENT SYSTEM
COMPREHENSIVE REVIEW OF THE 2017 EXPERIENCE STUDY

APPENDIX A – SAMPLE RETIREMENT RATE ANALYSES

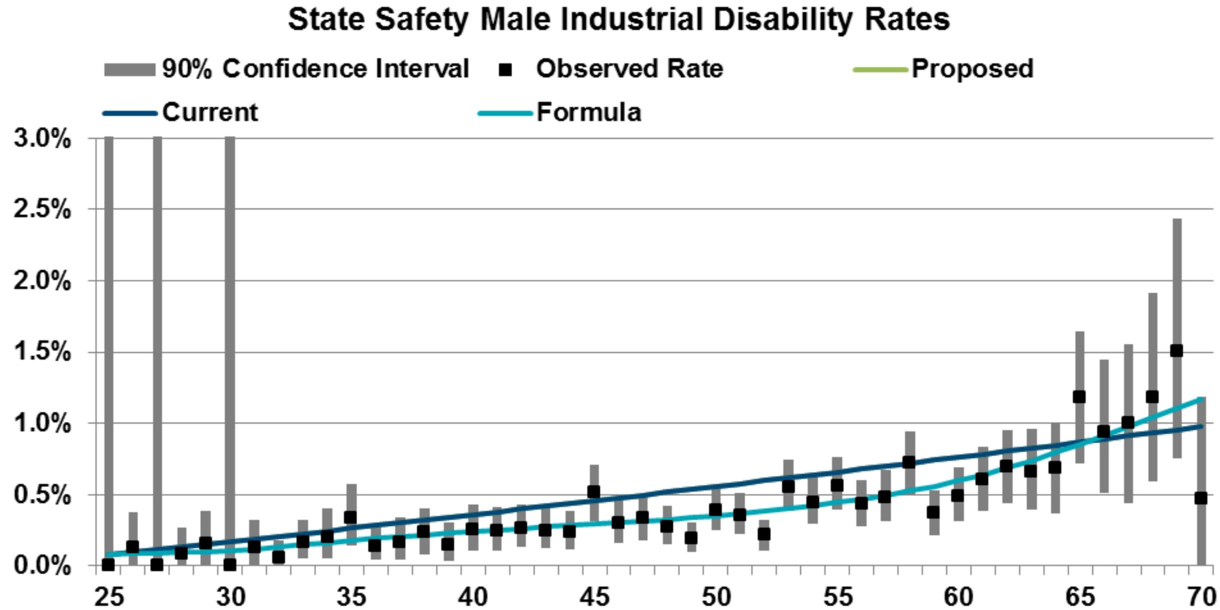
Public Agency Police 3.0% @ 50

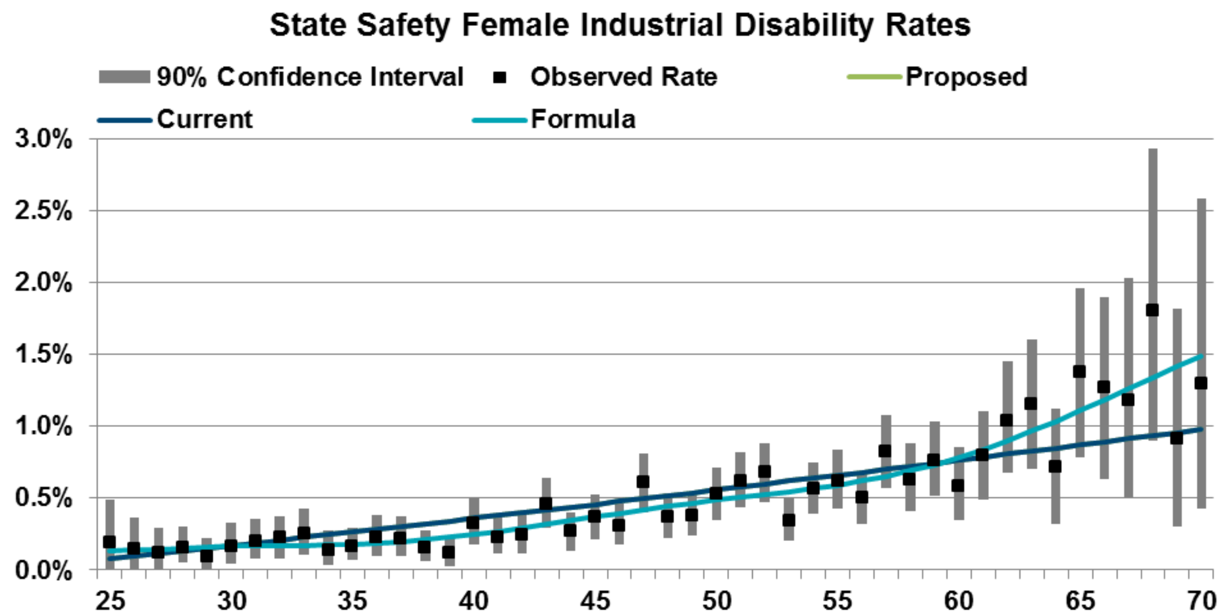




APPENDIX B – SAMPLE INDUSTRIAL DISABILITY ANALYSES

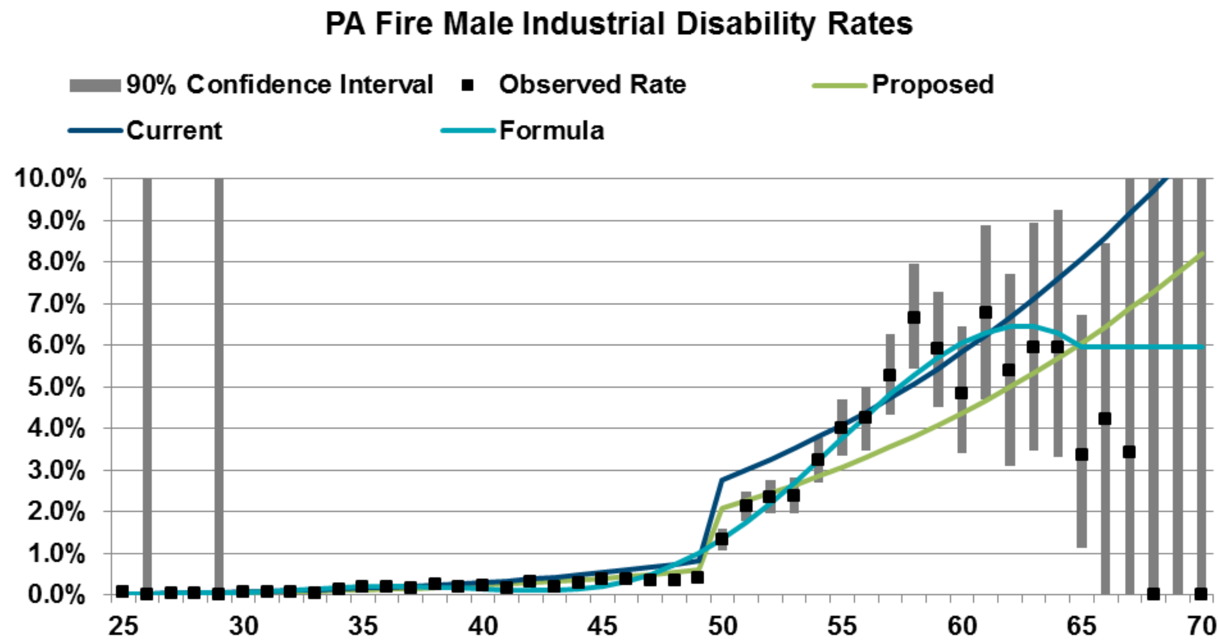
State Safety

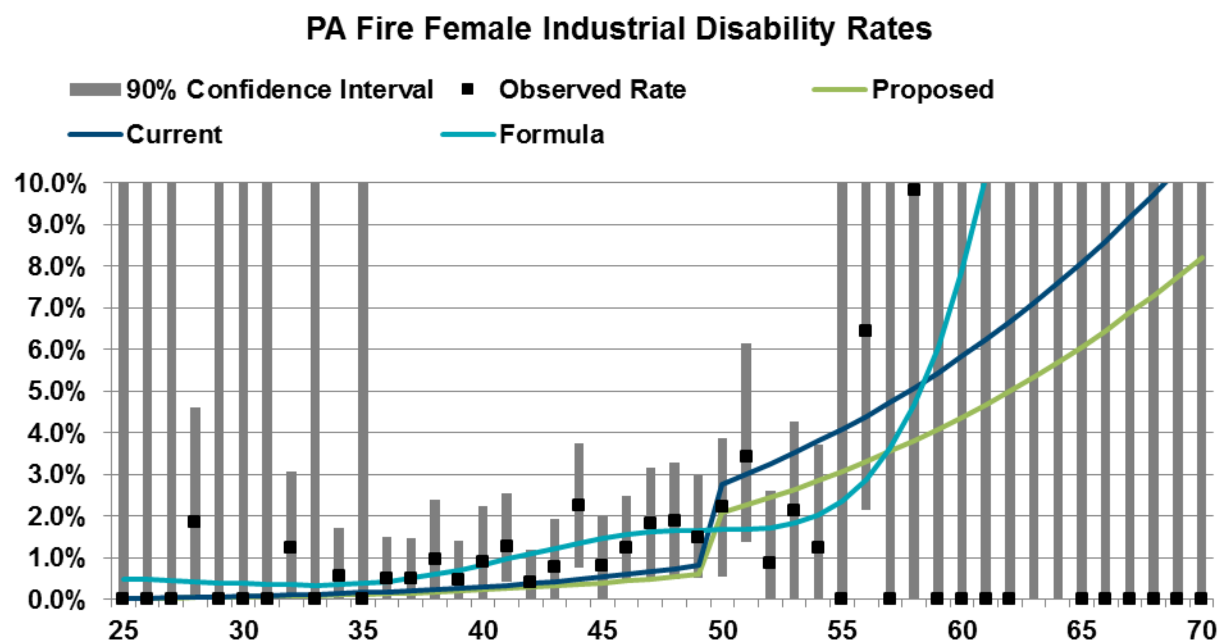




APPENDIX B – SAMPLE INDUSTRIAL DISABILITY ANALYSES

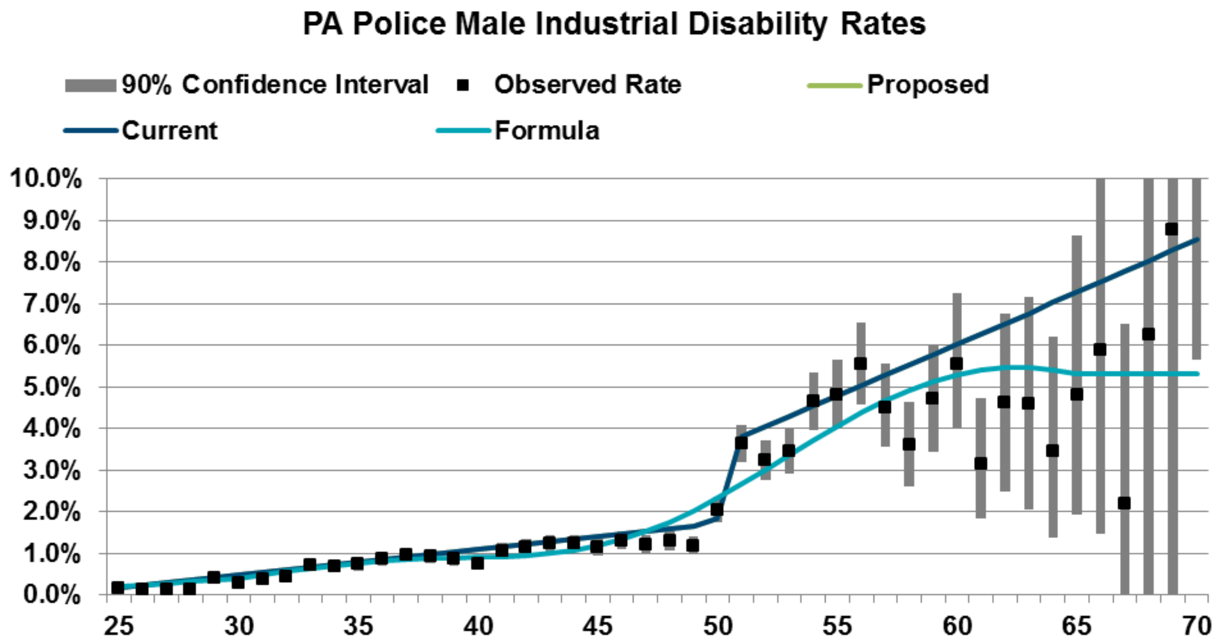
Public Agency Fire

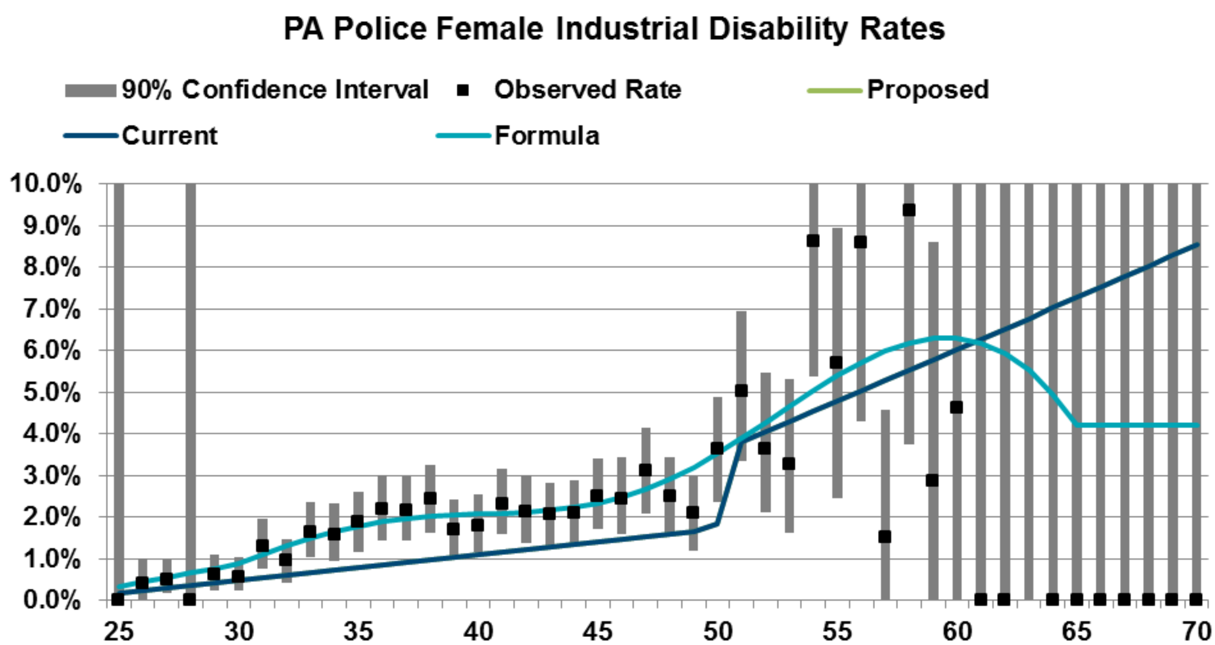




APPENDIX B – SAMPLE INDUSTRIAL DISABILITY ANALYSES

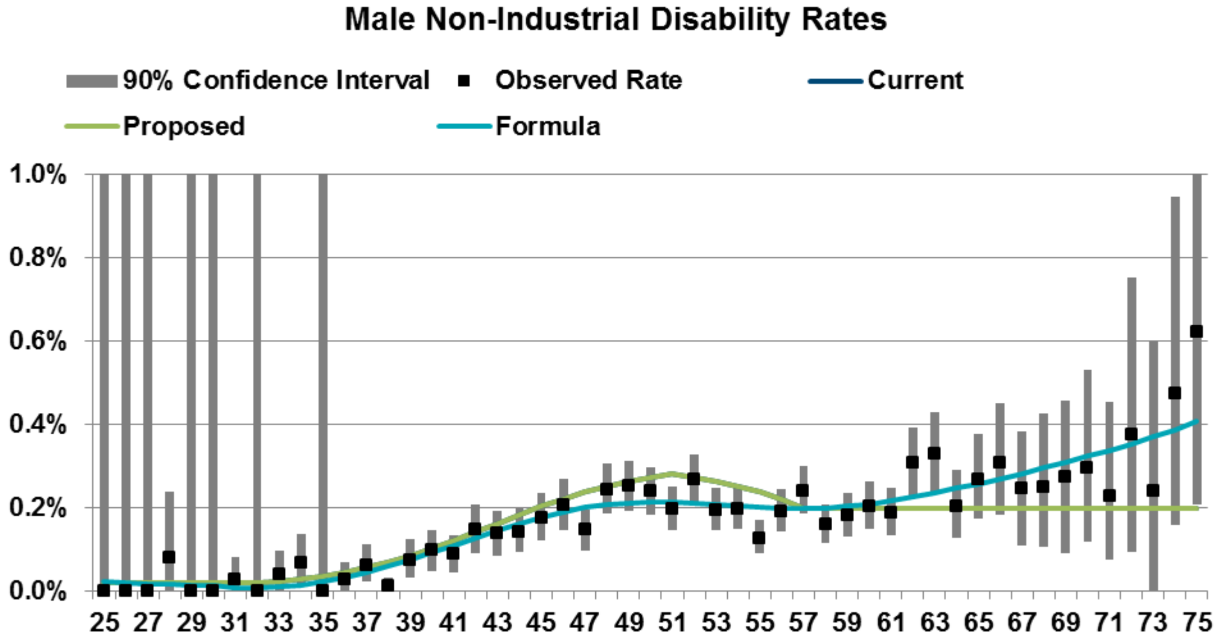
Public Agency Police

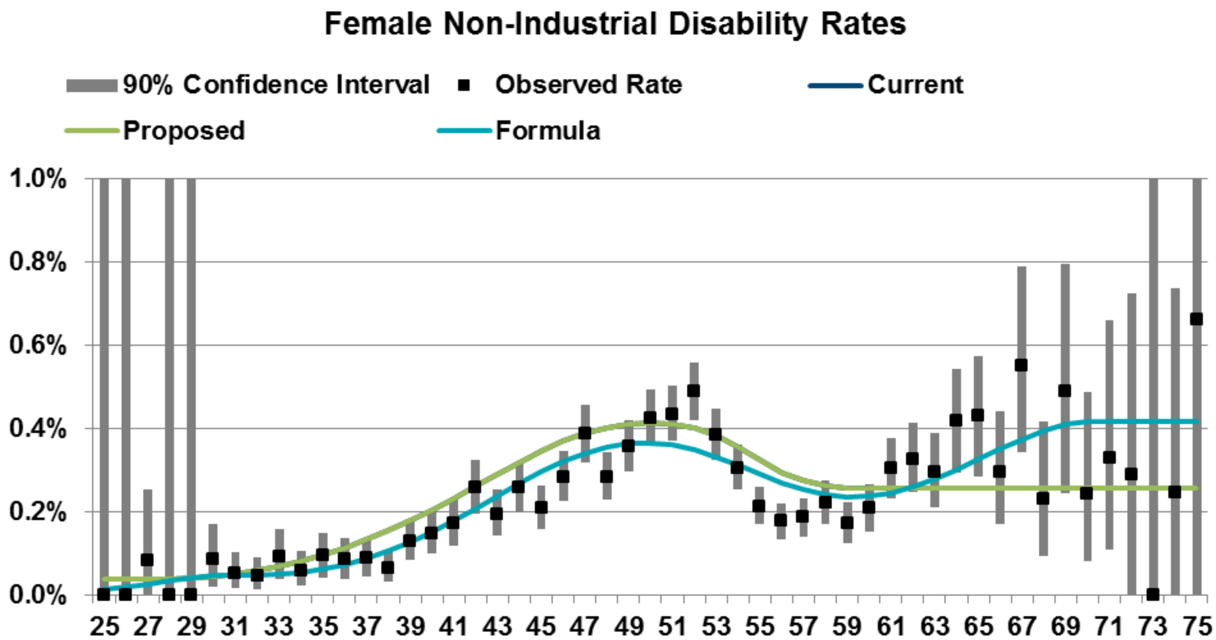




APPENDIX C – SAMPLE NON-INDUSTRIAL DISABILITY ANALYSES

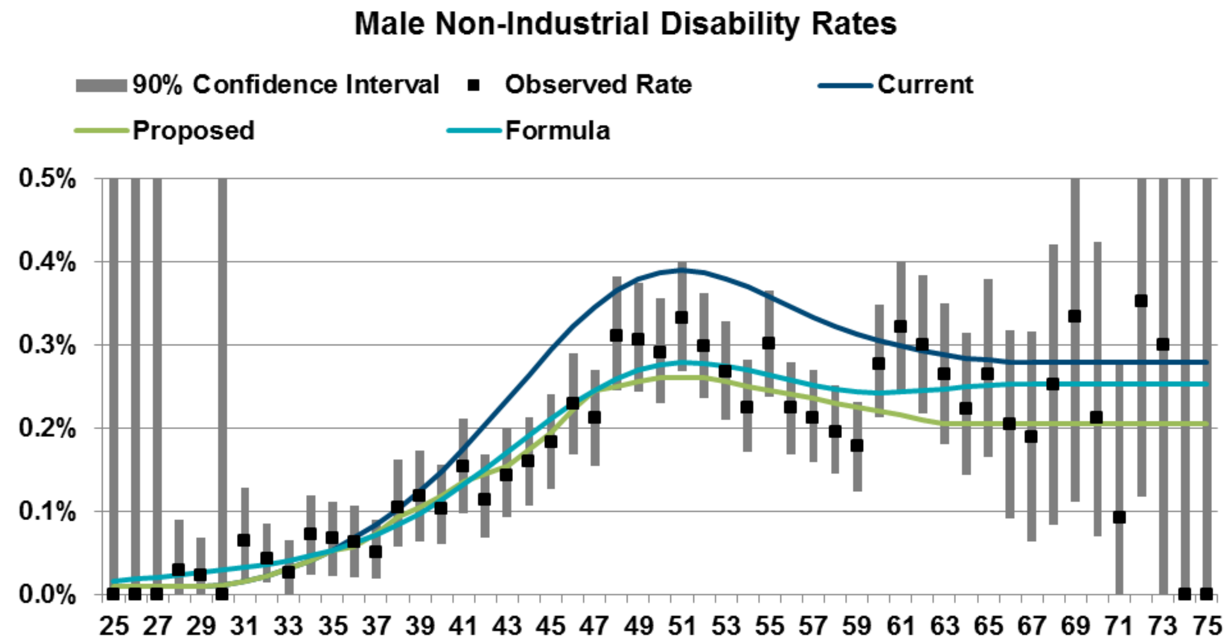
State Miscellaneous Tier 1

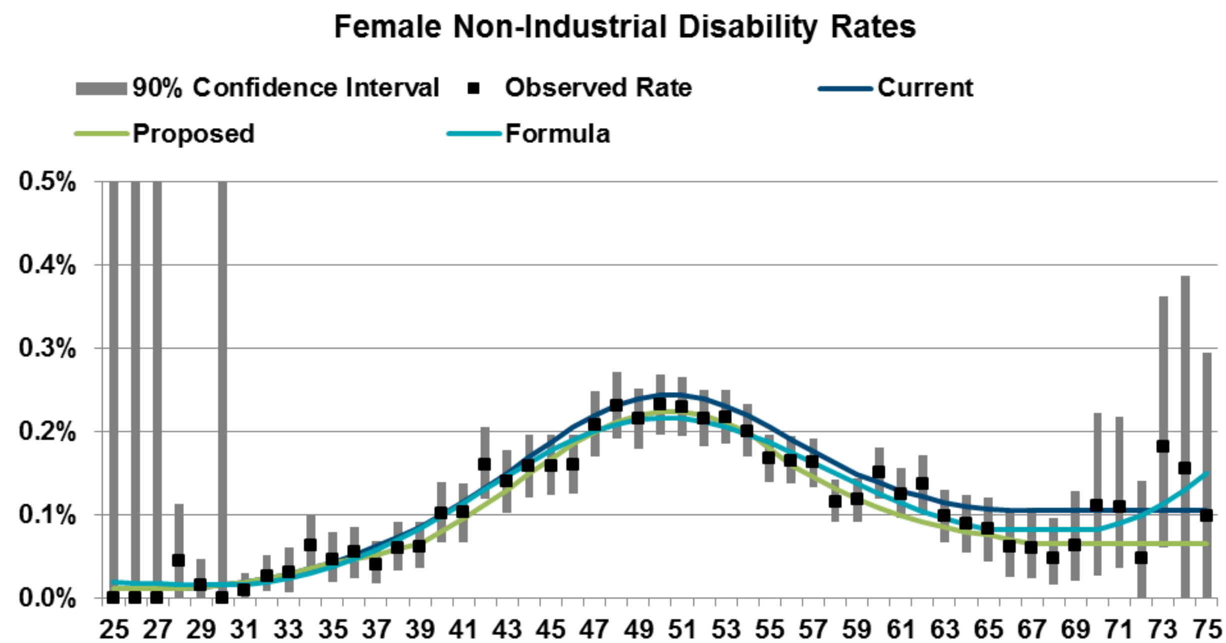




APPENDIX C – SAMPLE NON-INDUSTRIAL DISABILITY ANALYSES

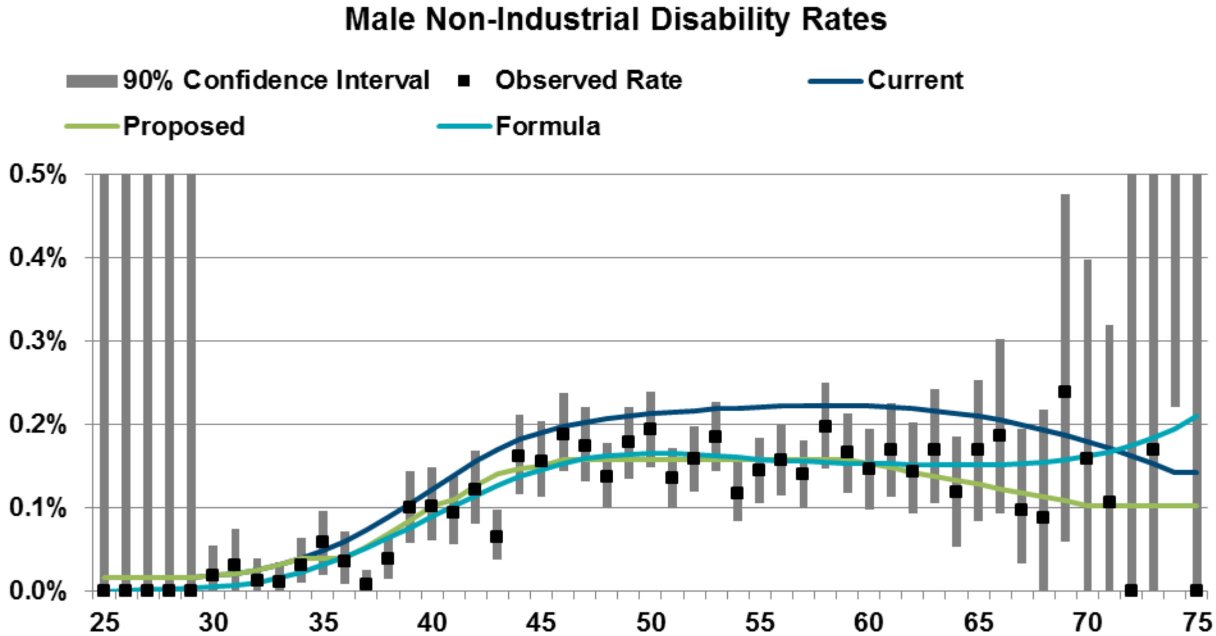
Schools

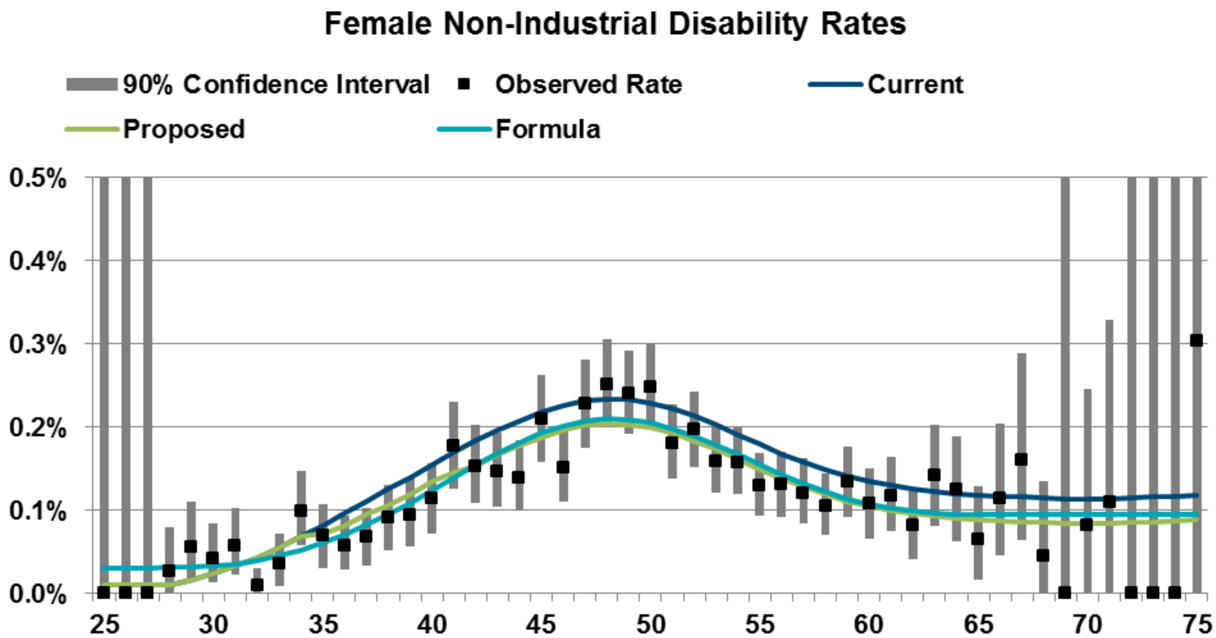




APPENDIX C – SAMPLE NON-INDUSTRIAL DISABILITY ANALYSES

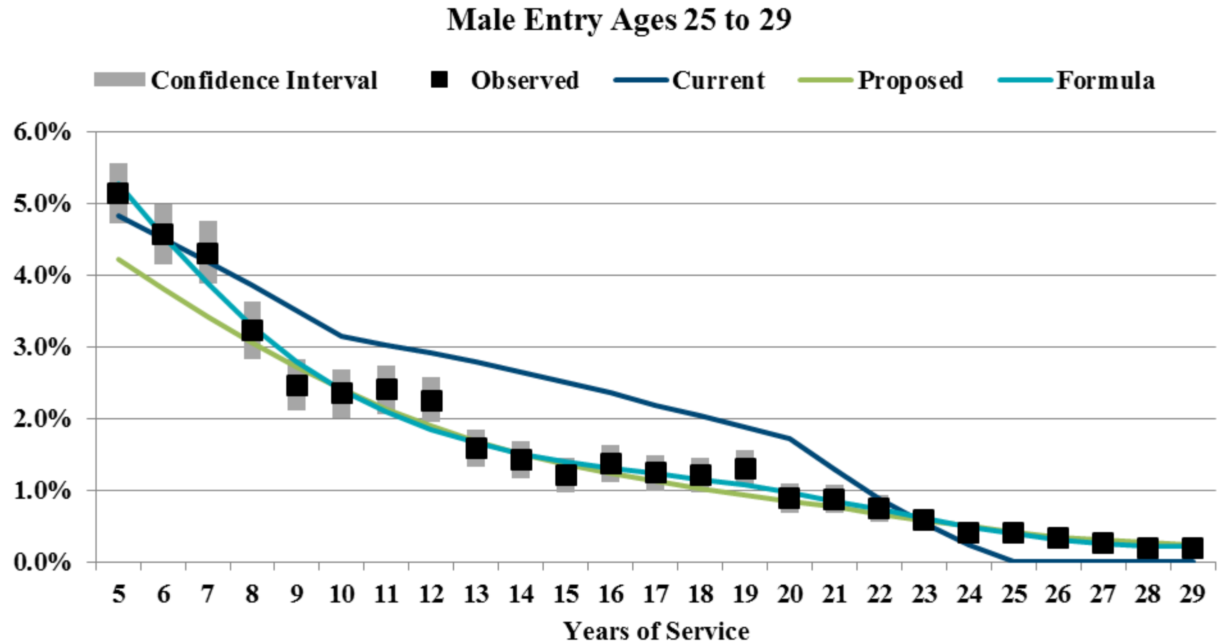
Public Agency Miscellaneous

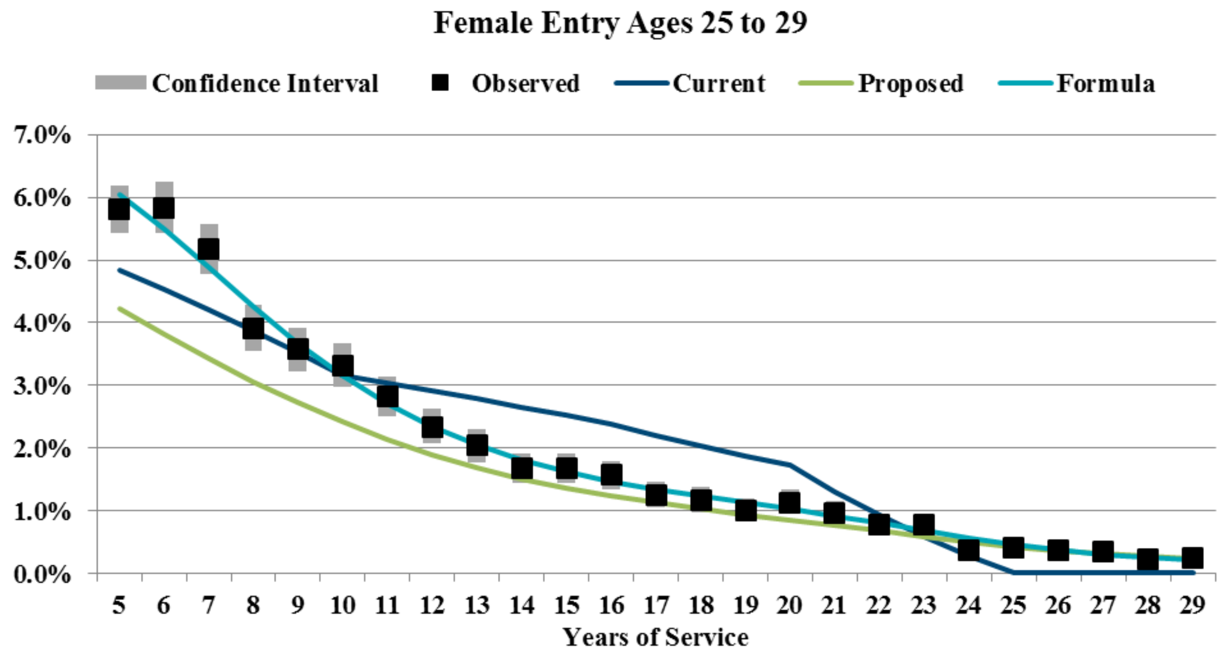




APPENDIX D – SAMPLE VESTED TERMINATION ANALYSES

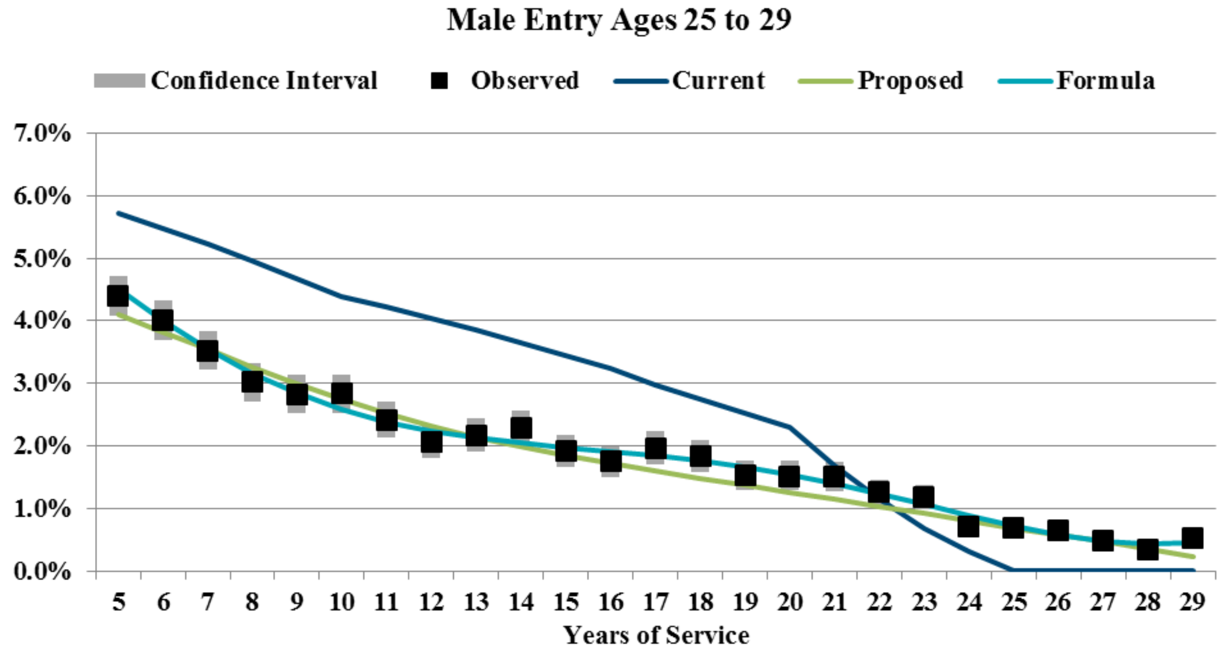
State Miscellaneous Tier 1

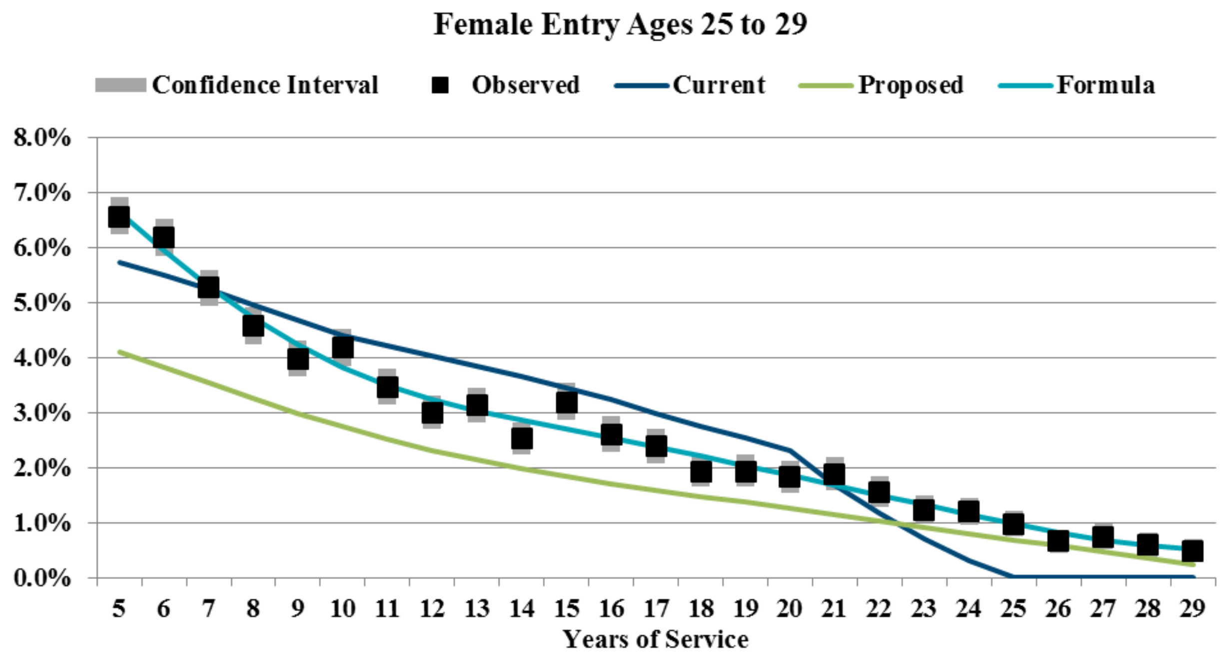




APPENDIX D – SAMPLE VESTED TERMINATION ANALYSES

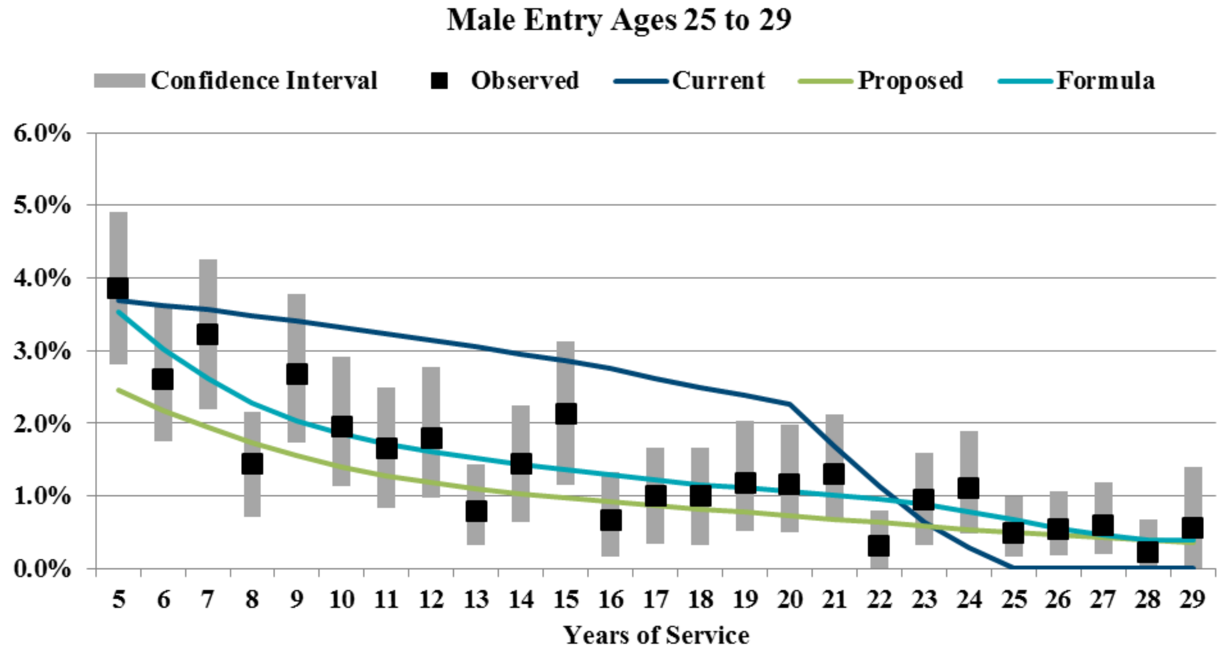
Public Agency Miscellaneous

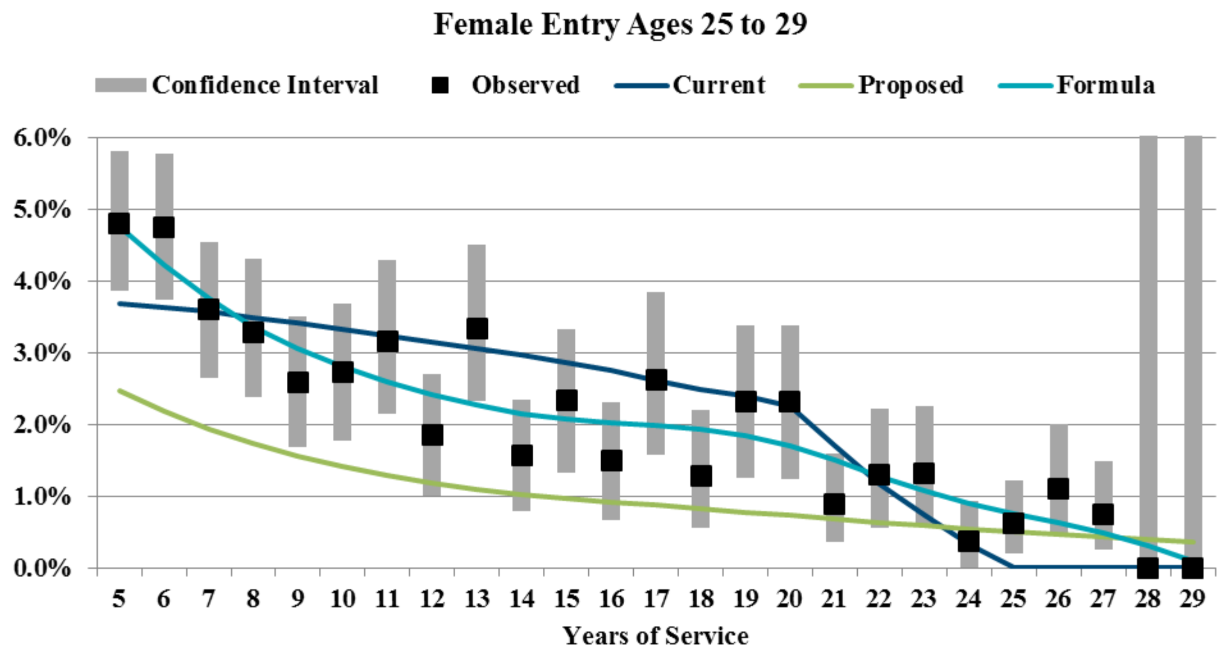




APPENDIX D – SAMPLE VESTED TERMINATION ANALYSES

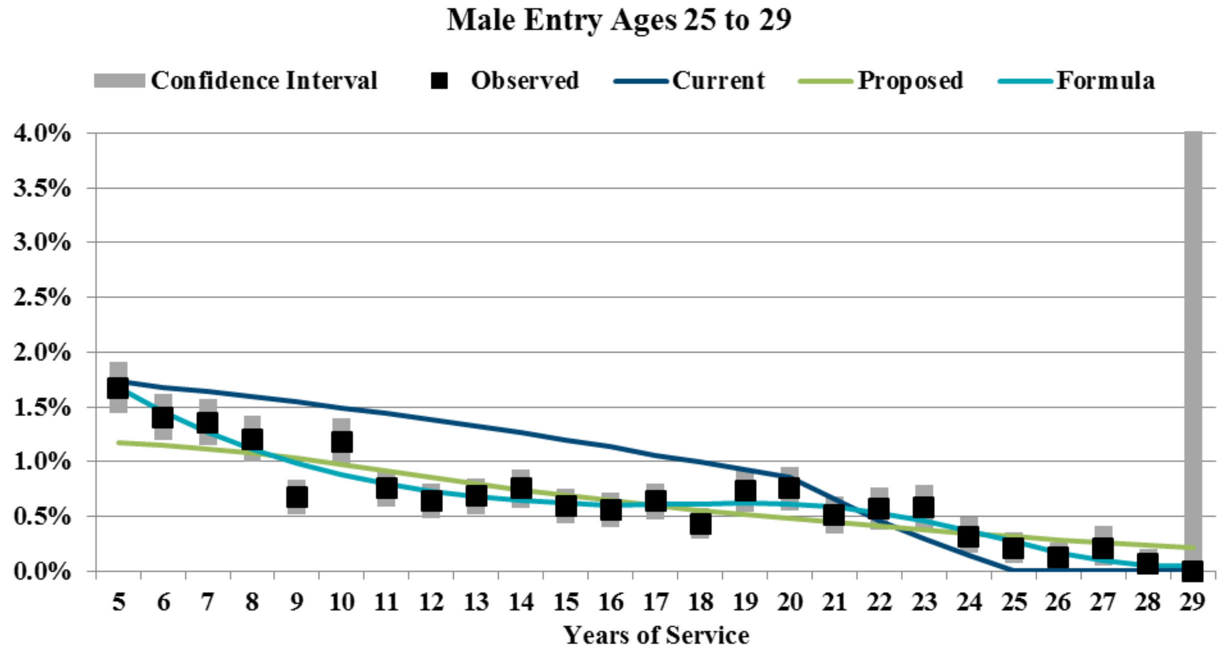
State Safety

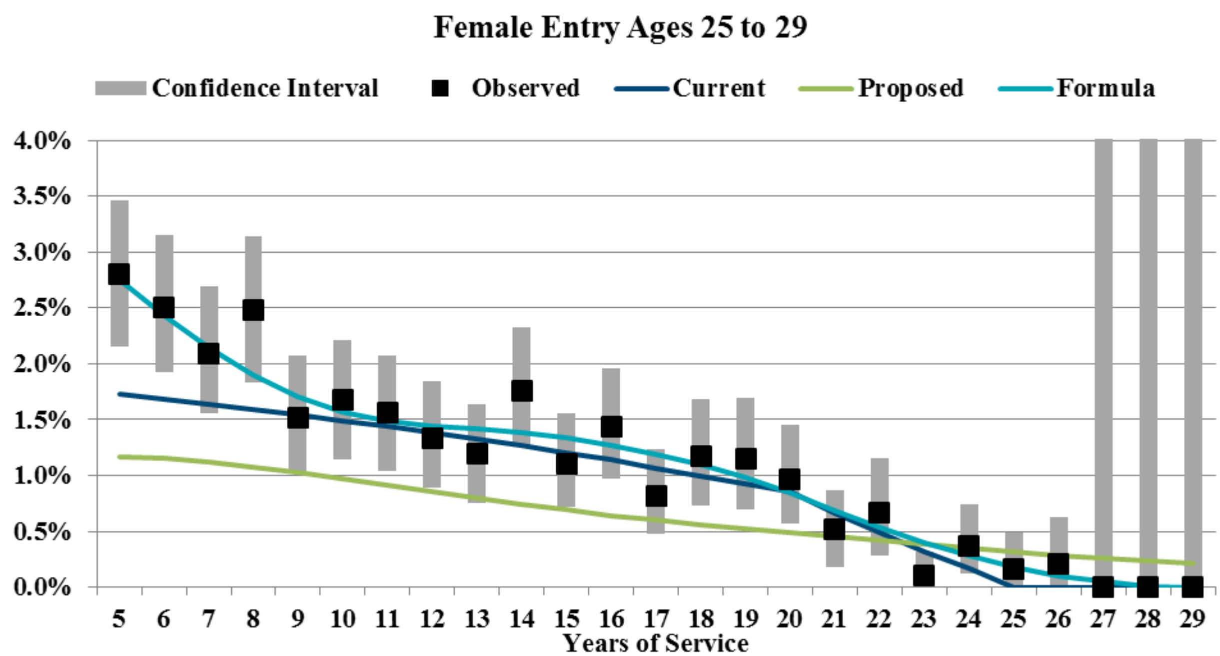




APPENDIX D – SAMPLE VESTED TERMINATION ANALYSES

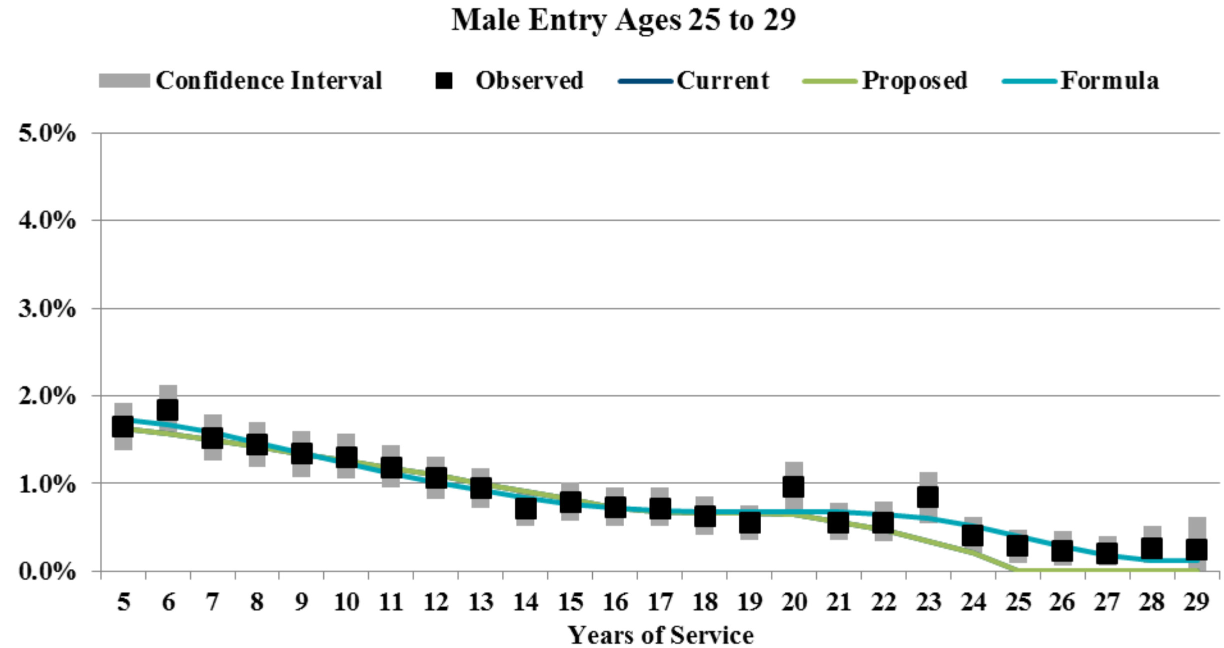
POFF

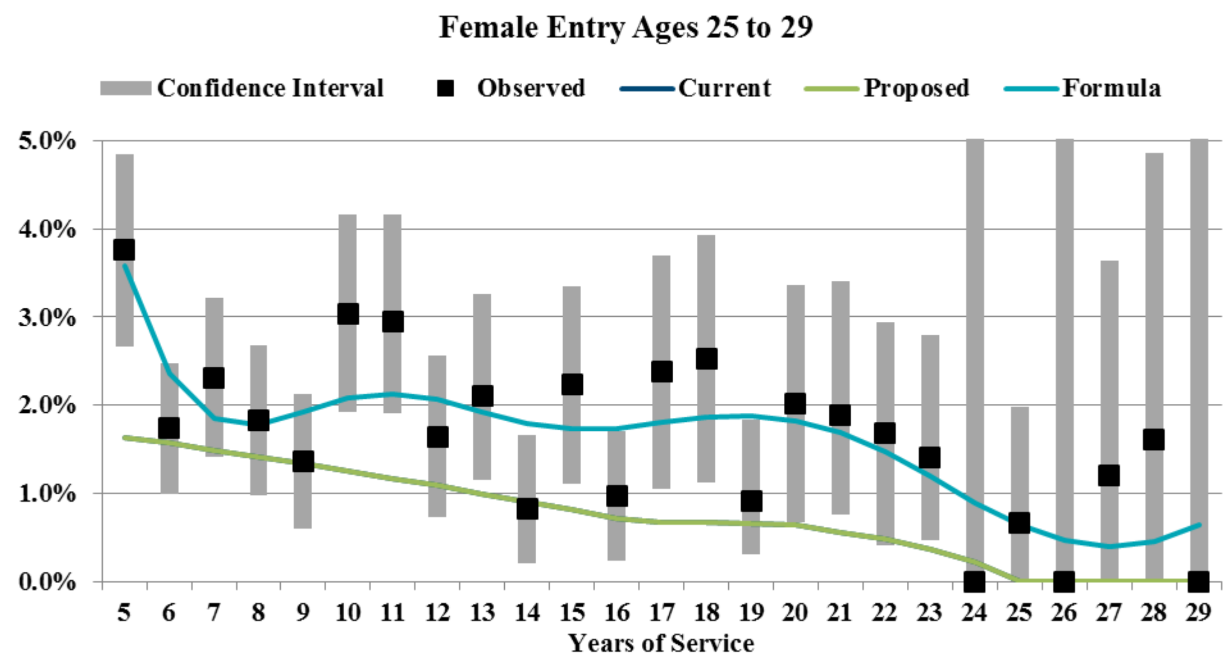




APPENDIX D – SAMPLE VESTED TERMINATION ANALYSES

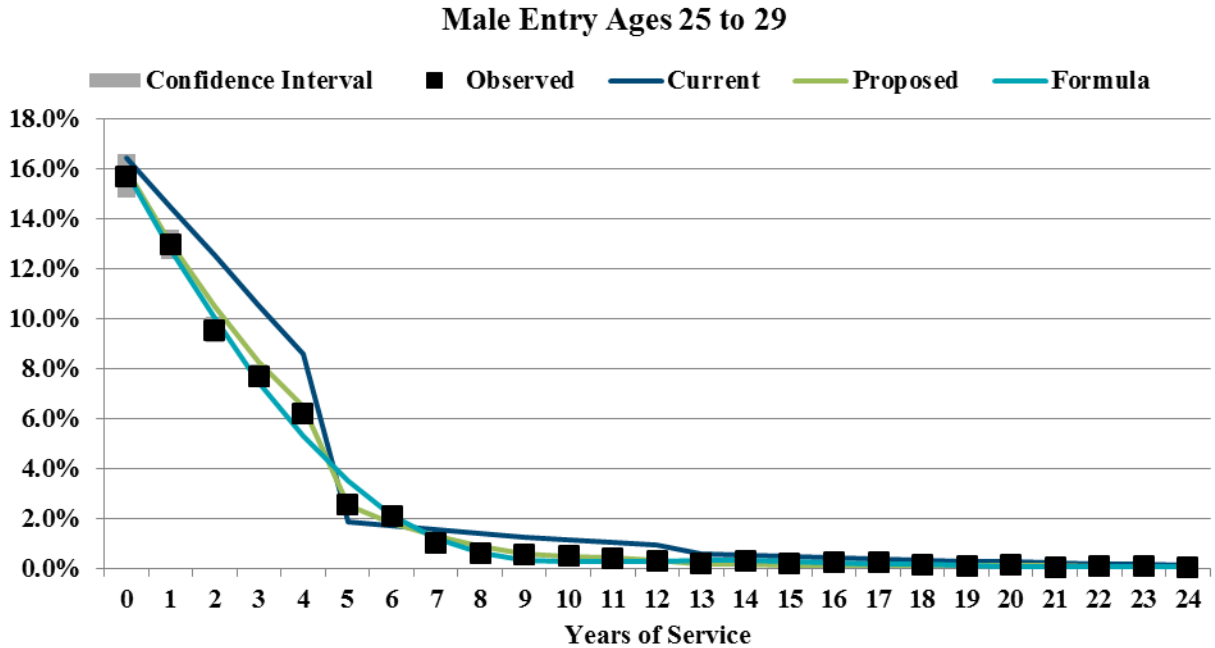
Public Agency Police

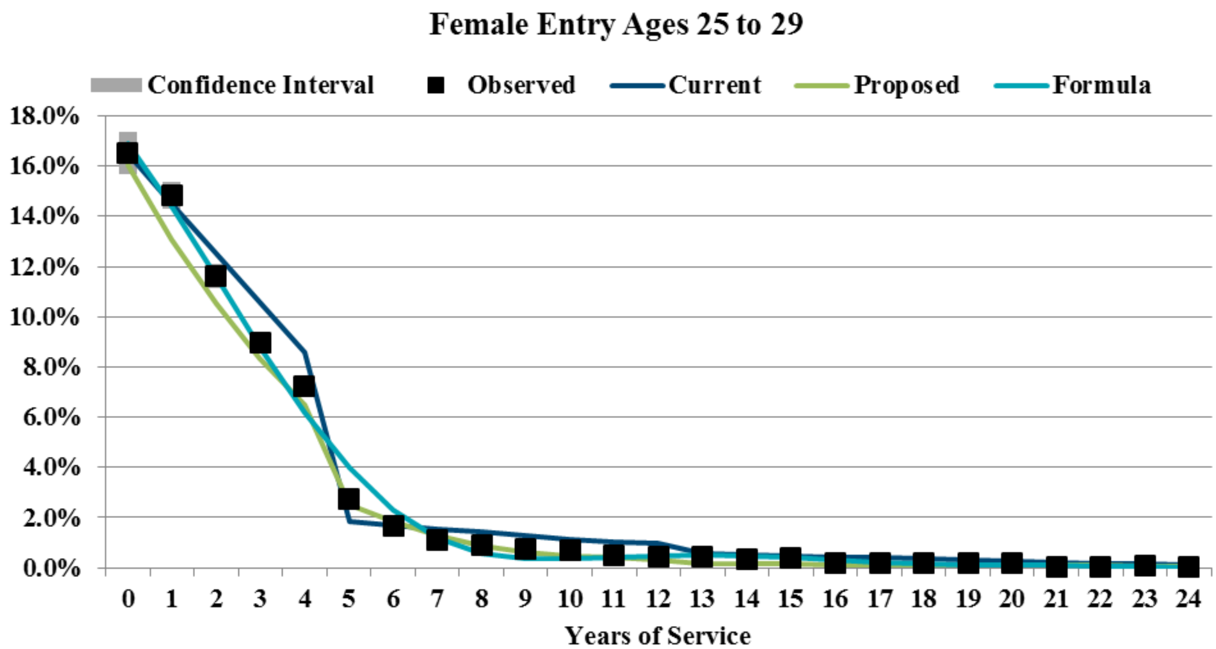




APPENDIX E – SAMPLE REFUND ANALYSES

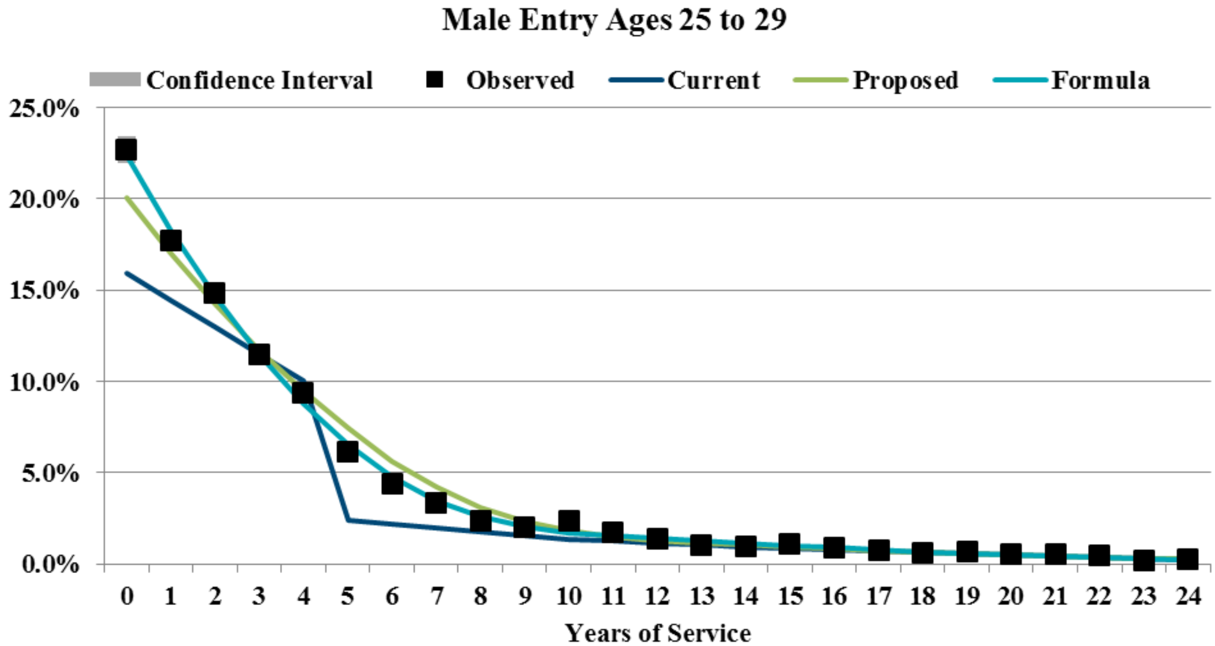
State Miscellaneous Tier 1

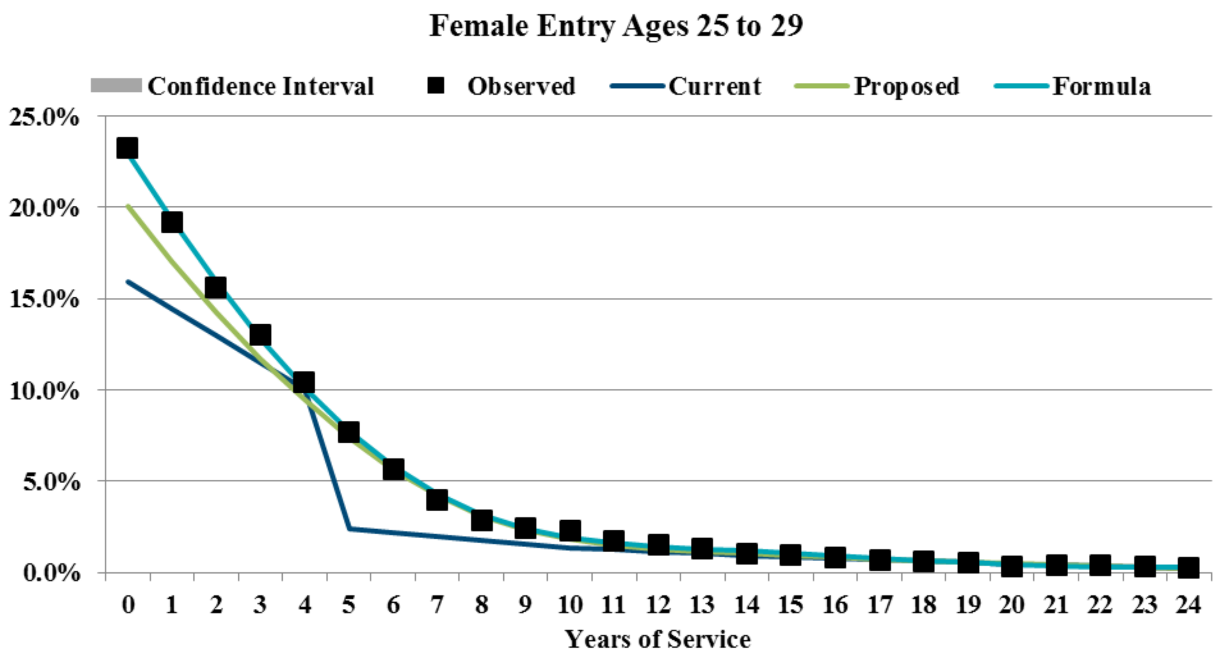




APPENDIX E – SAMPLE REFUND ANALYSES

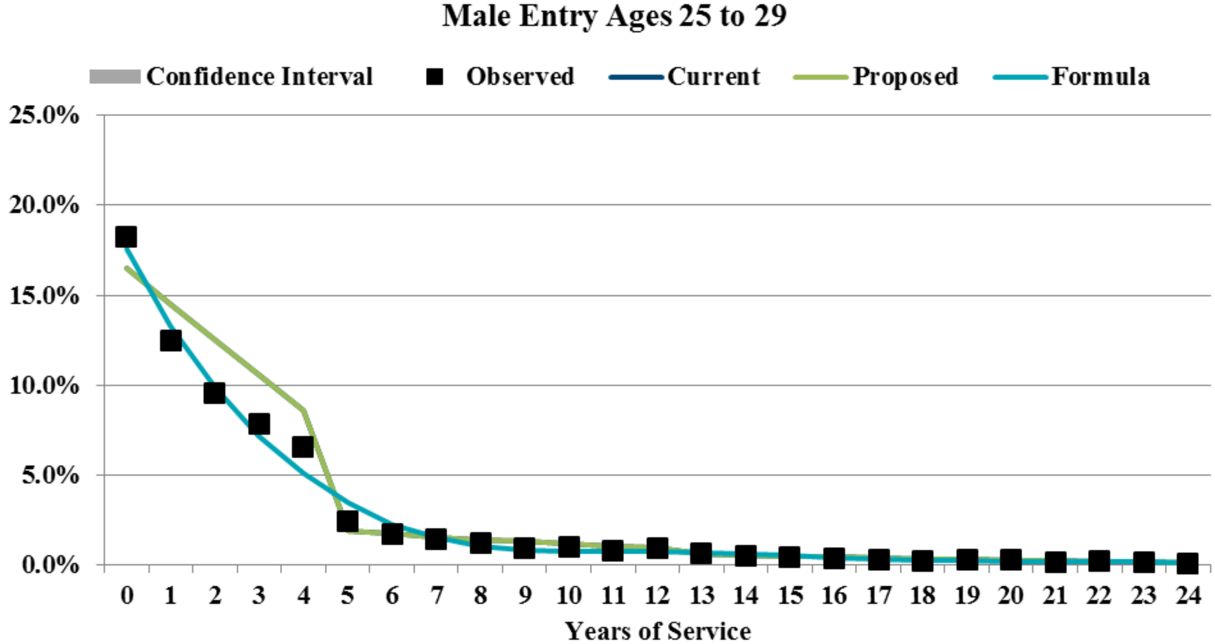
Schools

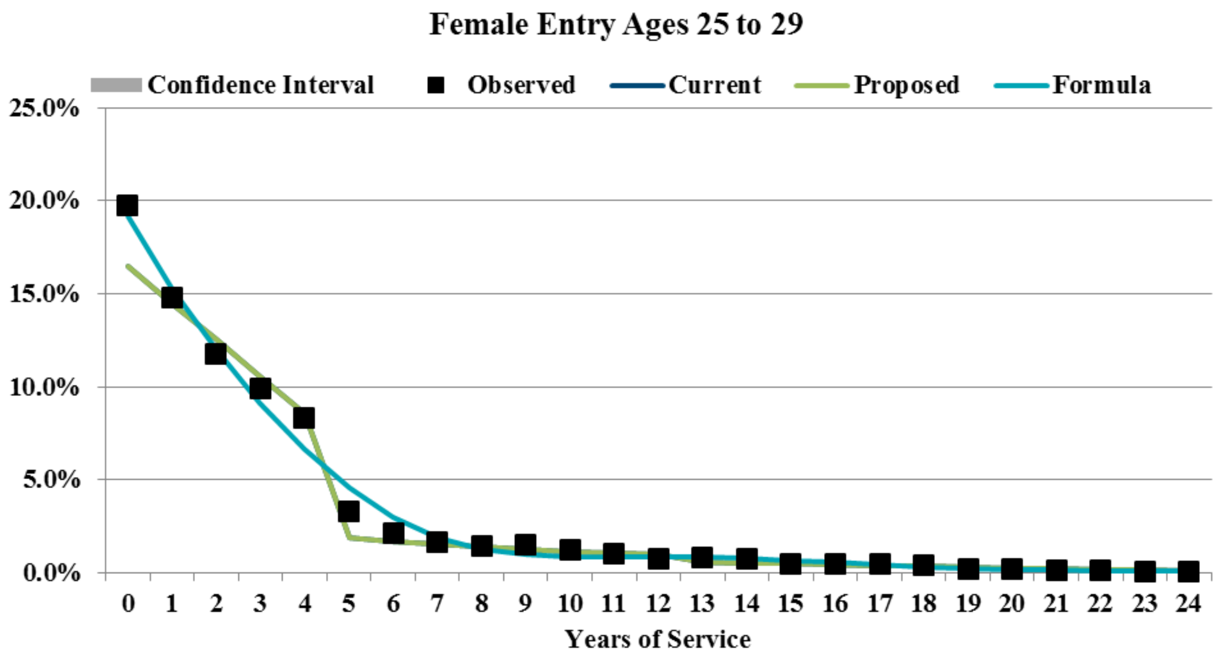




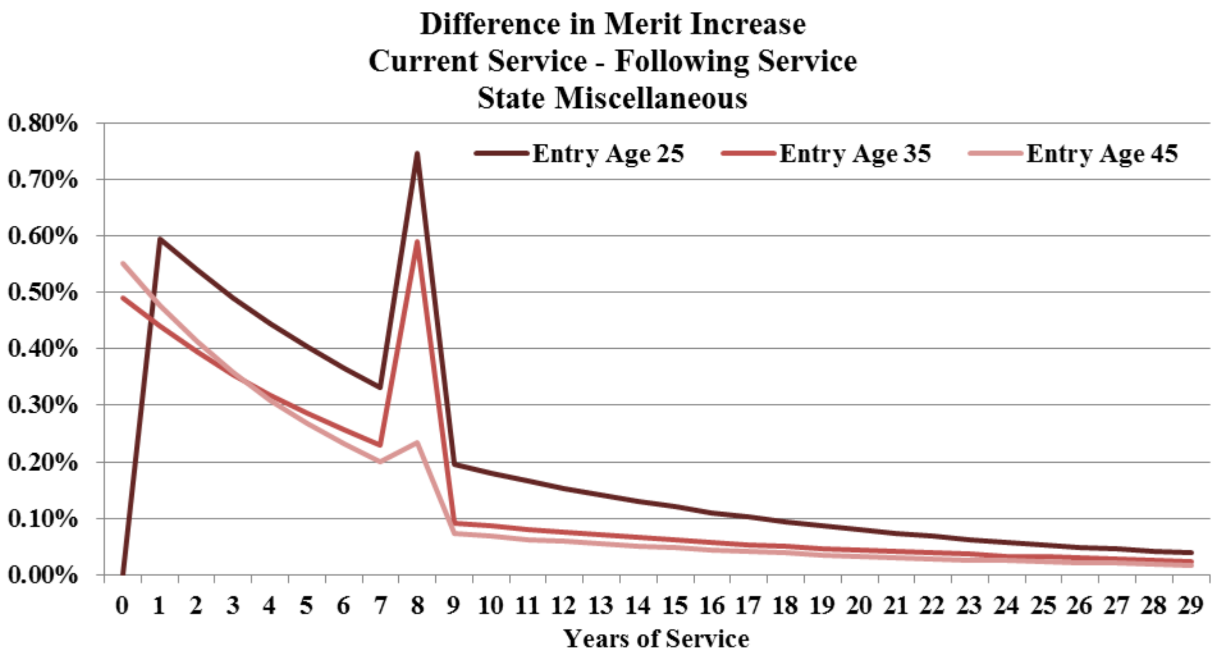
APPENDIX E – SAMPLE REFUND ANALYSES

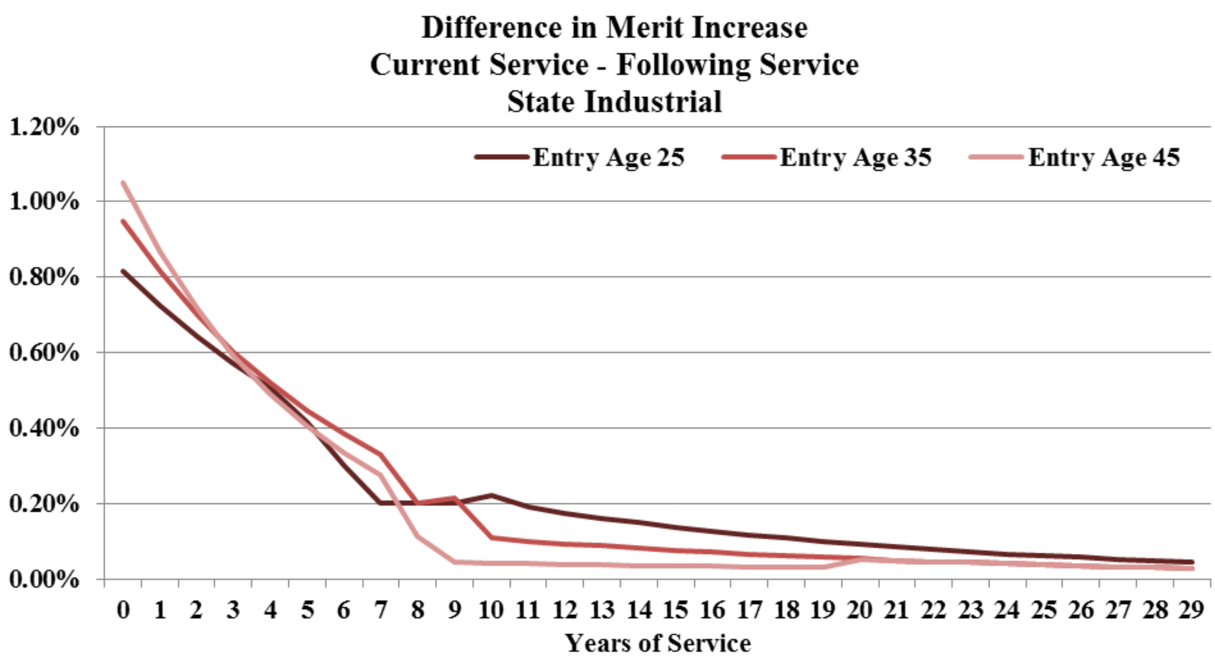
Public Agency Miscellaneous



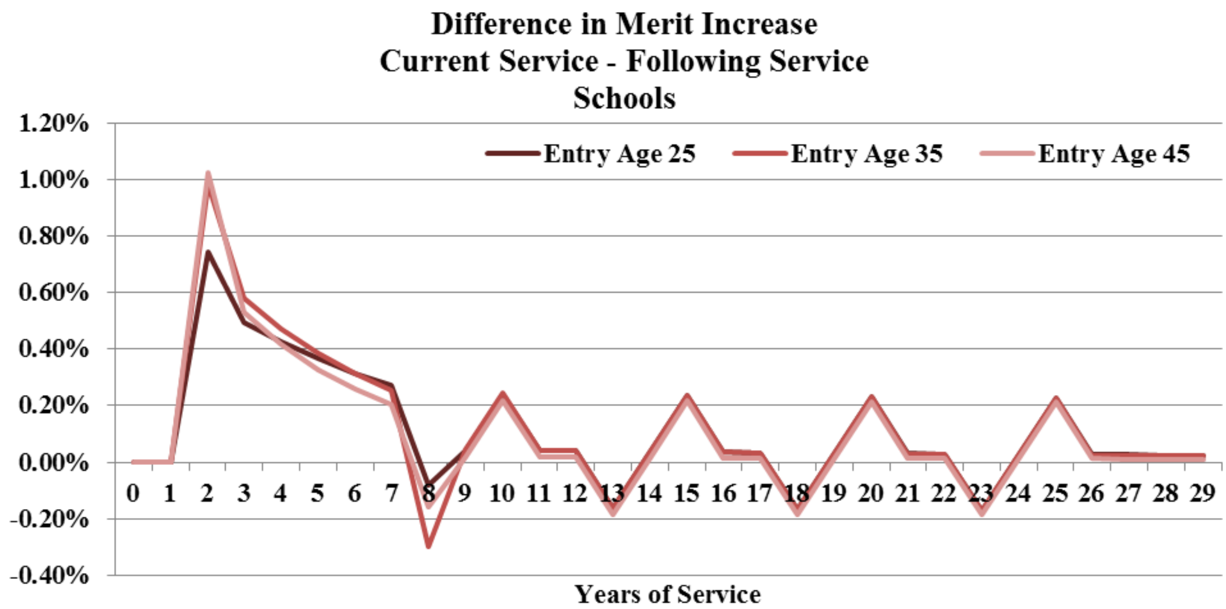


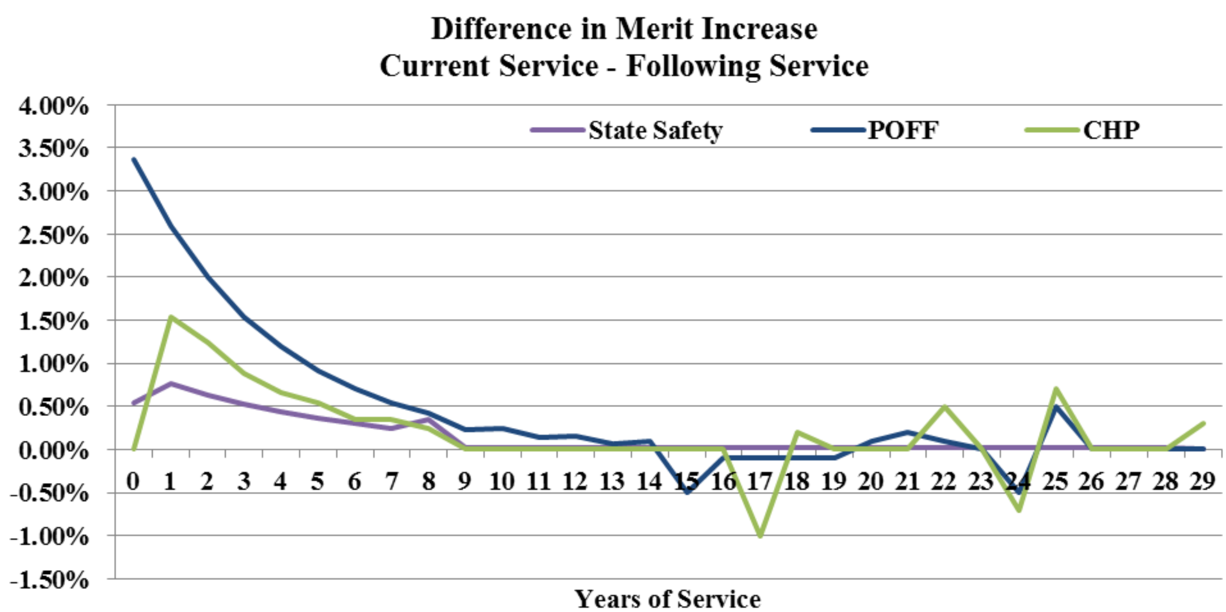
APPENDIX F – SAMPLE MERIT SCALE ANALYSES



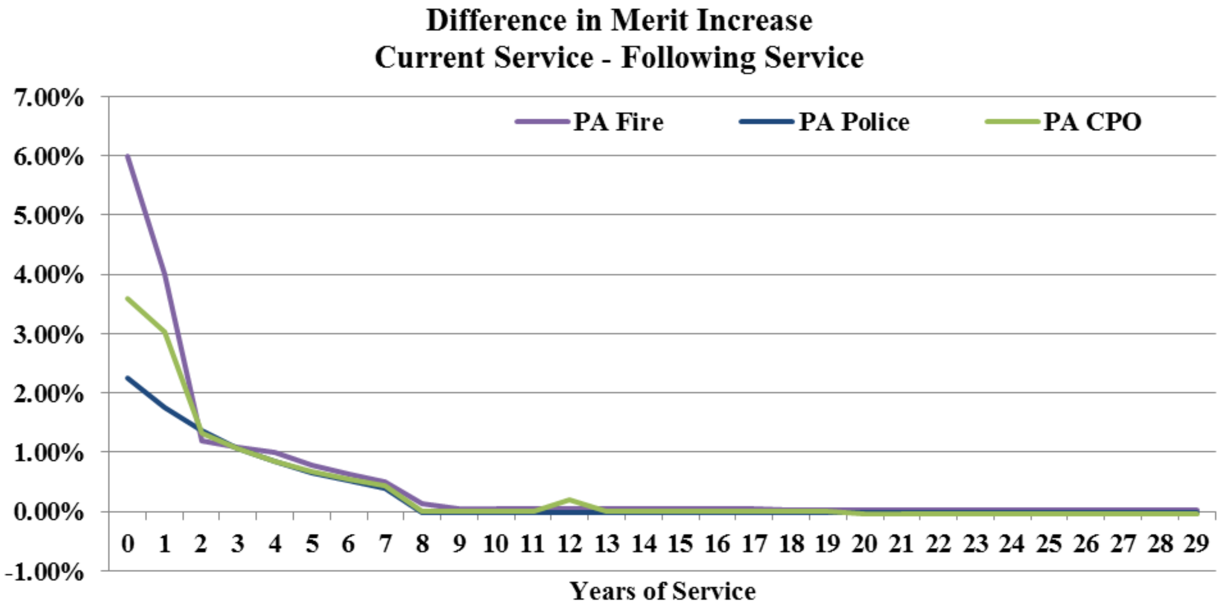


APPENDIX F – SAMPLE MERIT SCALE ANALYSES





APPENDIX F – SAMPLE MERIT SCALE ANALYSES



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Classic Values, Innovative Advice