

# Missouri Department of Transportation and Highway Patrol Employees' Retirement System (MPERS)

5-Year Experience Study

July 1, 2017 Through June 30, 2022



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February 15, 2023

Retirement Board  
Missouri Department of Transportation  
and Highway Patrol Employees' Retirement System  
1913 William Street  
Jefferson City, Missouri 65102-1930

Dear Board Members:

Presented in this report are the results of an Experience Study of the Missouri Department of Transportation and Highway Patrol Employees' Retirement System (MPERS). The study was conducted for the purpose of reviewing and, where necessary, updating the assumptions used in the actuarial valuation model.

The investigation was based upon the statistical data furnished for annual active member and retired life actuarial valuations during the period **July 1, 2017 to June 30, 2022**. A file-matching technique was utilized to track individual member activity from one year to the next.

This report is divided into the following sections:

- A) Background
  - The actuarial valuation model and the need for actuarial assumptions
  - A sensitive model – why assumptions need to be reviewed
- B) Comments and Recommendations
- C) Economic Activity
  - Inflation and Real Wage Growth
  - Investment Return
- D) Active Decrement Activity – Actual vs. Expected
  - Withdrawals
  - Disability
  - Retirement
  - Pay Increase Assumptions
- E) Mortality
- F) Actuarial Methods and Miscellaneous and Technical Assumptions
- G) Comprehensive Listing of Demographic Assumptions

The investigation was carried out using generally accepted actuarial principles and techniques in accordance with standards of practice prescribed by the Actuarial Standards Board. We believe that the recommended actuarial assumptions contained in this report will produce valuation results which, in the aggregate, are reasonable and in compliance with local, State and federal laws.

This report should not be relied on for any purpose other than that described above. It was prepared at the request of the Board and is intended for use by the Retirement System and those designated or approved by the Board. This report may be provided to parties other than the System only in its entirety and only with the permission of the Board. GRS is not responsible for unauthorized use of this report.

This report was prepared using our proprietary valuation model and related software which, in our professional judgment, has the capability to provide results that are consistent with the purposes of the valuation and has no material limitations or known weaknesses. We performed tests to ensure that the model reasonably represents that which is intended to be modeled.

The signing actuaries are independent of the plan sponsor.

Heidi G. Barry and Jamal Adora are Members of the American Academy of Actuaries (MAAA) and meet the Qualification Standards of the American Academy of Actuaries to render the actuarial opinions contained herein.

Respectfully submitted,  
Gabriel, Roeder, Smith & Company



Heidi G. Barry, ASA, FCA, MAAA



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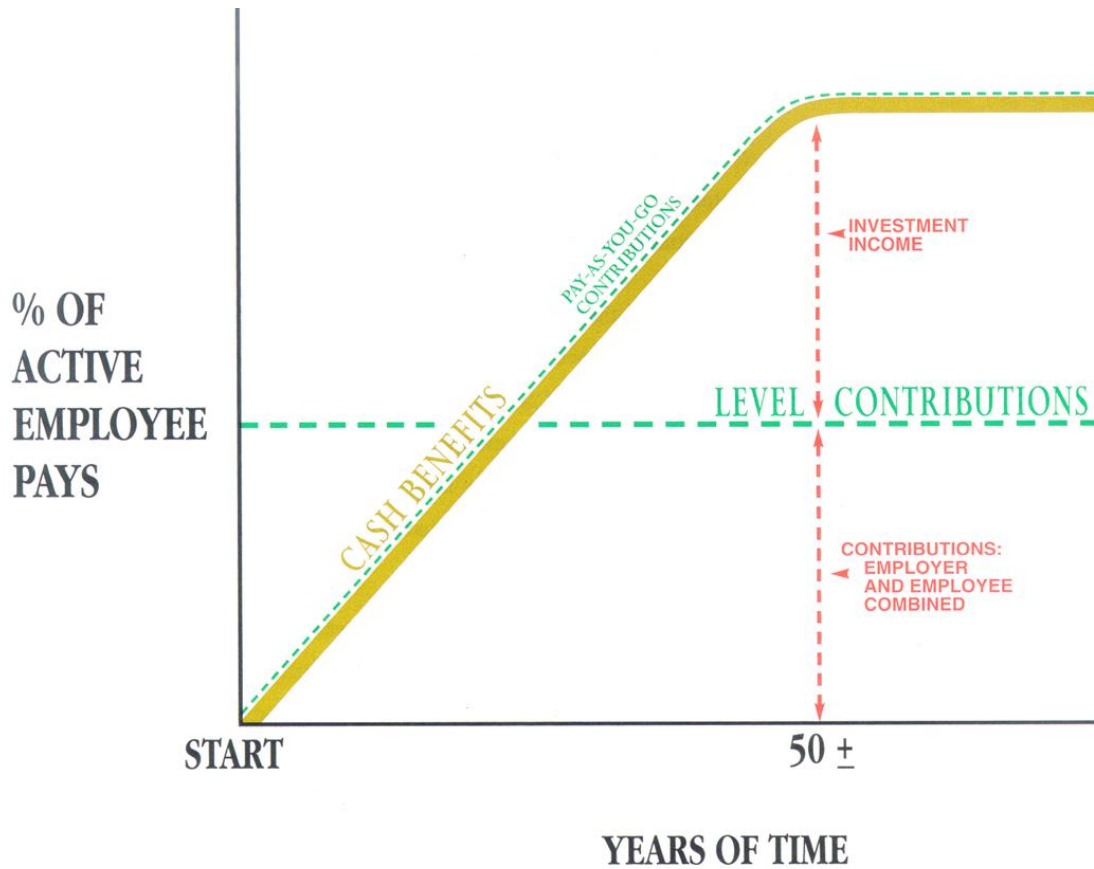


## **SECTION A**

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### **BACKGROUND**

# Actuarial Valuation Model and the Need for Actuarial Assumptions



When a pension plan is first implemented the cash demands are nil because there are no retired members. As the plan ages, the cash demands begin to grow as more and more members retire. If a plan follows the pay-as-you-go principle, the following will happen (see illustration above):

- Cash contributions will slightly exceed the cash benefits (because of administrative expenses).
- Contributions will start very low and continue to escalate as a percent of active member payroll until the plan matures, generally over a period of 50 or more years.
- Benefits currently accruing will become a financial obligation for future generations.
- The entire cost of the benefits currently accruing will be paid in the future.

# Actuarial Valuation Model and the Need for Actuarial Assumptions

Many plans, including MPERS, finance their obligations in a different manner: Pre-funding with level percent of payroll contributions (illustrated by the level line in the graph on the previous page). Under this arrangement the following is expected to occur:

- Cash contributions exceed cash demands in the early years of a plan, thereby building a pool of assets.
- The pool of assets generates investment income which will ultimately pay for a significant portion of the benefit obligation.
- Contributions are able to remain approximately level (as a percent of payroll) creating intergenerational equity.
- Cash demand (or benefit payments) will ultimately exceed the employer and employee contributions (the difference is paid for by investment income on the pool of assets).

The key to this second financing arrangement is the level percent of payroll contribution. This contribution is computed by the means of an actuarial valuation which is essentially a mathematical model. The mathematical model is necessary in a defined benefit plan because there are “knowns” and “unknowns” which must be evaluated before the level contribution rate can be determined.

The “knowns” are:

- Participants in the plan.
- The demographic characteristics of each active and inactive member (i.e., age, sex, salary, service, etc.).
- The demographic characteristics of each retired member and beneficiary (i.e., age, sex, benefit, form of payment, etc.).
- The conditions and characteristics of the plan (i.e., type and amount of benefits payable, eligibility for benefits, length of time benefit is payable, etc.).
- The current purchasing power of a dollar.
- The value of the pool of assets.
- How the pool of assets is invested.

# Actuarial Valuation Model and the Need for Actuarial Assumptions

The “unknowns” are:

- Who will retire and at what age, service and final average earnings?
- Who will quit before becoming vested?
- Who will quit and be entitled to a future vested benefit?
- Who will become disabled?
- How long will members and their beneficiaries live (before and after retirement)?
- What is the future purchasing power of the dollar (future inflation)?
- How much income will the pool of assets generate?

The valuation model takes the “knowns,” incorporates assumptions about the “unknowns” and develops the estimated cost of the plan for the current members. This cost is then financed using an actuarial cost method to determine the level contribution requirement.

Because future experience cannot be predicted with certainty, the costs can only be estimated. The model is revisited annually to re-determine the cost estimates based upon experience which has already occurred and assumptions about future experience.



## Sensitive Model – Why Assumptions Need to Be Reviewed

When System experience deviates from expected experience, a gain or loss is generated. This gain or loss is then amortized over a period of future years and applied as an offset or addition to the normal cost contribution. Over time, it is expected that the gains and losses will offset each other. If they do not, then one or more of the actuarial assumptions may need to be modified to reflect actual emerging experience.

If the assumptions are too conservative (the estimated cost of the plan is too high) then the computed contribution rate will decrease over time. If the assumptions are too liberal (the estimated cost of the plan is too low) then the computed contribution rate will increase over time. In either case, this is not consistent with the level percent of payroll principle to establish contributions that will, over time, remain approximately level as a percent of payroll.

In addition, *each* assumption should represent a reasonable estimate of future experience. Even though a package of assumptions may produce results which are reasonable, it is important that each component of the package reflect actual expected experience. Estimated costs of benefit changes, for example, are highly dependent upon specific assumptions.

The actuarial assumptions are intended to be the best estimate of future experience of the System when they are adopted, but conditions change over time. In addition, our understanding of the conditions affecting plan activity changes (even if the conditions themselves are not changing). It is for these reasons, and the desire to keep the computed contribution rate as level as possible, that the actuarial assumptions should be reviewed periodically and adjusted to reflect basic experience trends -- **but not random year-to-year fluctuations.**

### Selecting Demographic Assumptions

Guidance regarding the selection of demographic assumptions for measuring pension obligations is provided by Actuarial Standards of Practice (ASOP) No. 35. The standard requires that the selected demographic assumptions be reasonable reflections of future experience. While past demographic experience is generally a good indicator of future demographic experience, the ASOP cautions the actuary not to give undue weight to past experience or experience that is not sufficiently credible.

ASOP No. 35 defines a reasonable demographic assumption in section 3.3.5 of the standard. That section is replicated below:

**3.2.5 Select a Reasonable Assumption**—The actuary should select reasonable demographic assumptions. For this purpose, an assumption is reasonable if it has the following characteristics:

- a. it is appropriate for the purpose of the measurement;
- b. it reflects the actuary's professional judgment;
- c. it takes into account current and historical data that is relevant to selecting the assumption for the measurement date, to the extent such relevant data is reasonably available;
- d. it reflects the actuary's estimate of future experience, the actuary's observation of the estimates inherent in market data (if any), or a combination thereof; and
- e. it is expected to have no significant bias (i.e., it is not significantly optimistic or pessimistic), except when provisions for adverse deviation or plan provisions that are difficult to measure are included (as discussed in section 3.10.1) or when alternative assumptions are used for the assessment of risk, in accordance with ASOP No. 51, Assessment and Disclosure of Risk Associated with Measuring Pension Obligations and Determining Pension Plan Contributions.



## Selecting Economic Assumptions

Guidance regarding the selection of economic assumptions for measuring pension obligations is provided by Actuarial Standards of Practice (ASOP) No. 27. The standard requires that the selected economic assumptions be consistent with each other. That is, the selection of the investment return assumption should be consistent with the selection of the wage inflation and price inflation assumptions.

ASOP No. 27 defines a reasonable economic assumption in section 3.6. This section is replicated below:

**3.6 Selecting a Reasonable Assumption**—The actuary should select reasonable economic assumptions. For this purpose, an assumption is reasonable if it has the following characteristics:

- a. it is appropriate for the purpose of the measurement;
- b. it reflects the actuary's professional judgment;
- c. it takes into account current and historical data that is relevant to selecting the assumption for the measurement date, to the extent such relevant data is reasonably available;
- d. it reflects the actuary's estimate of future experience, the actuary's observation of the estimates inherent in market data (if any), or a combination thereof; and
- e. it is expected to have no significant bias (i.e., it is not significantly optimistic or pessimistic), except when provisions for adverse deviation or plan provisions that are difficult to measure are included (as discussed in section 3.5.1) or when alternative assumptions are used for the assessment of risk, in accordance with ASOP No. 51, *Assessment and Disclosure of Risk Associated with Measuring Pension Obligations and Determining Pension Plan Contributions*.

**3.6.1 Reasonable Assumption Based on Future Experience or Market Data**—The actuary should develop a reasonable economic assumption based on the actuary's estimate of future experience, the actuary's observation of the estimates inherent in market data, or a combination thereof. Examples of how the actuary may observe estimates inherent in market data include the following:

- a. comparing yields on inflation-indexed bonds to yields on equivalent non-inflation-indexed bonds as a part of estimating the market's expectation of future inflation;
- b. comparing yields on bonds of different credit quality to determine market credit spreads;
- c. observing yields on U.S. Treasury debt of various maturities to determine a yield curve free of credit risk; and
- d. examining annuity prices to estimate the market price to settle pension obligations.

The items listed above, as well as other market observations or prices, include estimates of future experience as well as other considerations. For example, the difference in yields between inflation-linked and non-inflation-linked bonds may include premiums for liquidity and future inflation risk in addition to an estimate of future inflation. The actuary may want to adjust estimates based on observations to reflect the various risk premiums and other factors (such as supply and demand for tradable bond or debt securities) that might be reflected in market pricing.

**3.6.2 Range of Reasonable Assumptions**—Due to the uncertain nature of the items for which assumptions are selected, the actuary may consider several different assumptions reasonable for a given measurement. Different actuaries will apply different professional judgment and may choose different reasonable assumptions. As a result, a range of reasonable assumptions may develop, both for an individual actuary and across actuarial practice.



## Selecting Economic Assumptions

**3.6.2 Combined Effect of Assumption** – The actuary should select assumptions (both demographic assumptions selected in accordance with ASOP No. 35 and economic assumptions selected in accordance with this standard) such that the combined effect of the assumptions selected by the actuary is expected to have no significant bias (i.e., it is not significantly optimistic or pessimistic) except when provisions for adverse deviation are included or when alternative assumptions are used for the assessment of risk, in accordance with ASOP No. 51.

For example, the actuary may have decided not to make any assumption with regard to four different types of future events, each of which alone is immaterial. However, the effect of omitting assumptions for all four types of future events may be a material understatement or overstatement of the measurement results. In these circumstances, the assumptions should be revised.

## **SECTION B**

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### **COMMENTS AND RECOMMENDATIONS**

## Summary of Findings Non-Uniformed

Description	Current Experience Study			Last Experience Study
	General Direction of Change in Rates	General Direction of Long-Term Cost Change	General Direction of Short-Term Employer Contribution Change	General Direction of Change in Rates
Age-based withdrawal (5 or more years of service)	Increase	Decrease	Decrease	Increase
Service-based withdrawal (less than 5 years of service)	Increase	Decrease	Decrease	Neutral for males Increase for females
Disability	Decrease	Decrease	Decrease	Increase
Normal retirement	Decrease for males Decrease for females	Decrease	Decrease	Decrease for males Neutral for females
Early (reduced) retirement	Decrease for males Decrease for females	Decrease	Decrease	Decrease for males Increase for females
Healthy Post-retirement mortality	Increase for males Decrease for females	Decrease	Decrease	Neutral
Disabled mortality	Decrease	Increase	Increase	Decrease
Pre-retirement mortality	Increase	Increase	Increase	Increase
Merit and seniority pay increases	Neutral	Neutral	Neutral	Decrease

## Summary of Findings Uniformed

Description	Current Experience Study			Last Experience Study
	General Direction of Change in Rates	General Direction of Long-Term Cost Change	General Direction of Short-Term Employer Contribution Change	General Direction of Change in Rates
Age-based withdrawal (5 or more years of service)	Increase	Decrease	Decrease	Decrease
Service-based withdrawal (less than 5 years of service)	Increase	Decrease	Decrease	Decrease
Disability	Neutral	Neutral	Neutral	Increase
Normal retirement	Increase	Increase	Increase	Increase
Healthy Post-retirement mortality	Neutral	Neutral	Neutral	Neutral
Disabled mortality	Decrease	Increase	Increase	Decrease
Pre-retirement mortality	Increase	Increase	Increase	Increase
Merit and seniority pay increases	Increase	Increase	Increase	Decrease

## Summary of Decrement Assumptions

**Background:** In general, recent patterns of non-economic activity (rates of withdrawal, disability, death, retirement, and merit and seniority pay increases) tend to be reliable predictors of future experience. However, past activity will also contain anomalies (or special circumstances) that cannot be assumed to replicate in the future. The actuary attempts to identify and remove these anomalies before creating recommended rates. The goal is to identify long-term trends in activity and move the rates toward those trends as a result of the periodic investigations. In establishing our recommendations, we have considered the results of the prior study, as well as the observed trends from this study.

Experience was studied separately for Uniformed members and Non-Uniformed members. For the Non-Uniformed members, the experience was further broken down between male and female members. Male and female experience was studied in aggregate for the Uniformed group since it is over 95% male.

Our first step was to look at liability gains and losses over the measurement period. The table below suggests that the current set of assumptions has generated small liability gains overall during the measurement period.

Liability Gain/(Loss) for Year				Percent of Beginning of Year Liability
	Non-Uniform	Uniform	Total	
2017/2018	\$ 22,662,692	\$ 14,182,587	\$ 36,845,279	1.0%
2018/2019	(2,577,290)	2,569,194	(8,096)	0.0%
2019/2020	(1,779,005)	3,471,605	1,692,600	0.0%
2020/2021	35,634,675	(5,623,816)	30,010,859	0.7%
2021/2022	(20,867,764)	3,992,015	(16,875,749)	-0.4%
Total	\$ 33,073,308	\$ 18,591,585	\$ 51,664,893	

**Rates of Withdrawals:** Withdrawals from service were studied separately for members with less than five years of service and members with five or more years of service. Actual experience was above expectations for both Uniformed members and Non-Uniformed members. The rates were adjusted to more closely track experience.

**Disability:** Observed rates of disability are close to the assumed rates for Uniformed members and lower than assumed for Non-Uniformed members. The recommended rates were decreased for Non-Uniformed members to more closely track experience. We recommend no change to the Uniformed rates.

**Normal Retirement:** Actual experience was above expectations for Uniformed members and below expectations for Non-Uniformed members. Rates were adjusted accordingly to more closely track experience.

**Early Retirement:** Experience indicated fewer early retirements than assumed for males and females. The recommended rates were adjusted accordingly.



## Summary of Decrement Assumptions (Concluded)

**Post-Retirement Healthy Mortality Rates** are used to measure the probabilities of members dying after retirement. The rates currently in use are the RP-2014 Healthy Annuitant Mortality tables projected to 2022 using projection scale MP-2017. The RP-2014 tables were based on a study by the Society of Actuaries (SOA) on the mortality experience of uninsured private retirement plans in the United States. Since the last experience study, the SOA has released the Pub-2010 tables which are based on the mortality experience of public retirement plans in the United States. The Pub-2010 tables include distinct tables for General, Teachers, and Public Safety job classifications. Consistent with the job classification used to create the Pub-2010 tables, we are recommending one set of tables for Non-Uniform and a different set for Uniform. Specifically, we recommend these tables be updated to the Pub-2010 General, Healthy Retiree, Amount-Weighted, Below-Median Income tables for males and females for Non-Uniformed members. We recommend these tables be updated to the Pub-2010 Public Safety Healthy Retiree, Amount-Weighted, tables for males and females for Uniformed members. The proposed assumptions are adjusted for mortality improvement back to the observation period base year of 2010 and then projected generationally from 2010 to 2019 using scale MP-2021 and 90% of scale MP-2021 for years following 2019. The assumptions include a margin for future mortality improvements and will result in higher computed liabilities and contributions. These are the newest tables and projection scales released by the Society of Actuaries and better account for the mortality improvements of coming generations.

**Post-Retirement Disabled Mortality Rates.** The rates currently in use for disabled lives are the RP-2014 Disabled Retiree Annuitant Mortality tables projected to 2022 using projection scale MP-2017. We recommend these tables be updated to the Pub-2010 General Disabled Retiree, Amount-Weighted tables for males and females for Non-Uniformed members. We recommend these tables be updated to the Pub-2010 Public Safety Disabled Retiree, Amount-Weighted tables for males and females for Uniformed members. The proposed assumptions are adjusted for mortality improvement back to the observation period base year of 2010 and then projected generationally from 2010 to 2019 using scale MP-2021 and 90% of scale MP-2021 for years following 2019. The assumptions include a margin for future mortality improvements and will result in higher computed liabilities and contributions.

**Pre-Retirement Mortality Rates.** The rates currently in use for active lives are the RP-2014 Employee Mortality Table projected to 2022 using projection scale MP-2017 and multiplied by a factor of 65%. We recommend these tables be updated to the Pub-2010 General, Employee, Amount-Weighted, Below-Median Income tables for males and females for Non-Uniformed members. We recommend these tables be updated to the Pub-2010 Public Safety Employee, Amount-Weighted, tables for males and females for Uniformed members. The proposed assumptions are adjusted for mortality improvement back to the observation period base year of 2010 and then projected generationally from 2010 to 2019 using scale MP-2021 and 90% of scale MP-2021 for years following 2019. The assumptions include a margin for future mortality improvements and will result in higher computed liabilities and contributions.

More detail concerning proposed mortality assumptions can be found in **Section E**.

**Pay Increase Rate (Merit and Longevity Portion).** For Non-Uniform, small and mostly offsetting changes were made to the rates to more closely track experience. For Uniform, the experience over the last 5-years did not always provide a clear pattern at each service year. In order to have a better pattern at each service year, we extended the pay increase study for Uniform from 5-years to 10-years. Ultimately, for Uniform we decreased the rates for early service years and increased them for later service years to more closely track experience.

**Complete listings of all assumptions are in Sections F and G.**





## Summary of Decrement Experience

### Aggregate Summary of Active Decrements Experienced Between 2017 and 2022

Decrement Risk Area	Actual	Expected	
		Present	Proposed
<b><u>Withdrawal - Total</u></b>			
Uniform	147	79	113
Non-Uniform			
Male	1,835	1,284	1,531
Female	554	389	459
<b><u>Withdrawal - Service 5 &amp; Up</u></b>			
Uniform	100	38	70
Non-Uniform			
Male	613	377	472
Female	267	178	210
<b><u>Disability</u></b>			
Uniform	4	6	6
Non-Uniform	68	80	75
<b><u>Normal Retirement</u></b>			
Uniform	192	167	179
Non-Uniform			
Male	745	883	815
Female	292	341	327
<b><u>Early Retirement</u></b>			
Non-Uniform			
Male	58	84	72
Female	16	22	19

## Active Member Data Reconciliation

### Uniformed Members

Valuation Year	Active Members Beginning of Year	Retired	Disabled	Died	Vested Terminated	Non-Vested Terminated	New	Active Members End of Year
2018	1,264	28	1	0	15	15	26	1,231
2019	1,231	40	3	1	25	11	60	1,211
2020	1,211	39	0	1	13	12	58	1,204
2021	1,204	41	0	1	10	11	60	1,201
2022	1,201	44	0	1	20	15	61	1,182
2023	1,182							
5-year	7,293	192	4	4	83	64	265	7,211
Expected		167	6	4	38	41		

### Non-Uniformed Members

Valuation Year	Active Members Beginning of Year	Retired	Disabled	Died	Vested Terminated	Non-Vested Terminated	New	Active Members End of Year
2018	6,192	200	13	8	120	299	608	6,160
2019	6,160	192	17	11	121	347	738	6,210
2020	6,210	224	14	12	140	308	639	6,151
2021	6,151	221	8	6	126	293	521	6,018
2022	6,018	291	17	17	203	439	641	5,692
2023	5,692							
5-year	30,731	1,128	69	54	710	1,686	3,147	30,231
Expected		1,330	68	25	555	1,118		



# Economic Recommendations

**Economic Assumptions.** When it comes to economic assumptions, there is no best single combination of assumptions. We are guided by the Actuarial Standards of Practice in developing recommendations we believe to be reasonable. At this time, we believe that the current set of economic assumptions (6.50% interest; 3.00% wage inflation) are reasonable. However, we recommend further review of the assumptions in the Spring. More detail on the analysis of the current assumptions using capital market assumption models can be found on **pages C-5 through C-8.**

We suggest maintaining the wage inflation (and price inflation) assumption for future years. Further information on recent trends regarding inflation can be found on **pages C-2 through C-4.**

Administrative expenses are currently added as a load to the normal cost. The load is based on actual administrative expenses for the preceding year. We do not recommend a change to this method.

The credited interest on member contributions is currently assumed to be 3.0%. We recommend maintaining this assumption.

Given past experience and current economic trends, we recommend the following sets of alternative assumptions be taken into consideration:

	<b>Current Assumptions</b>
<b>Investment Return</b>	6.50%
<b>Wage Inflation</b>	3.00%
<b>Real Rate of Return (over wage)</b>	3.50%
<b>Price Inflation</b>	2.25%
<b>Real Rate of Return (over price)</b>	4.25%

## Other Recommendations

**Actuarial Value of Assets:** The asset valuation method is a three-year smoothed market value method in which assumed investment return is recognized immediately each year and differences between actual and assumed investment return are phased-in over a closed three-year period. This asset valuation method is intended to give recognition to the long-term accuracy of market values while filtering out and dampening short term market swings. We do not recommend a change to this method.

**Amortization Policy:**

*Permanent Policy:* The total contribution will be based on normal cost plus a 13-year amortization of unfunded actuarial accrued liabilities. The amortization period is a closed 13-year period starting July 1, 2023.

*Temporary Accelerated Policy:* The total contribution is based on normal cost plus a 2-year amortization period for unfunded retiree liabilities and a 17-year amortization period for other unfunded liabilities. Both amortization periods are closed periods starting July 1, 2023.

This temporary accelerated policy was adopted by the Retirement Board on September 17, 2009 and will remain in effect until such time as the retiree liability becomes 100% funded or the permanent policy produces a higher contribution rate.

In September 2014, the Board adopted a contribution stabilization reserve fund from experience gains in an effort to keep the employer contribution rate at or near 58%, in the near term. In February 2015, the Board established a maximum of \$250 million in the contribution stabilization reserve fund. The contribution stabilization reserve fund is expected to result in the fund becoming more than 100% funded by the end of the amortization period, if experience is exactly as assumed.

Given that the temporary policy is set to expire, we feel that it is time to consider whether or not a change in the amortization policy is needed. Some alternative policies for consideration include:

- 1) The current unfunded liability will be amortized over the remaining permanent policy period of 13 years (12 years in the 2023 valuation). Any new gains and losses will be amortized over a closed 20-year period. We refer to this as layered amortization.
- 2) Adopting a layered amortization approach for future gains and losses. The current unfunded liability will be amortized over the remaining permanent policy period of 20 years (20 years in the 2023 valuation). Any new gains and losses will be amortized over a closed 20-year period.
- 3) Reset the amortization period to a closed 20-year period beginning in the 2023 valuation. Discussions will continue prior to the next experience study where we will again recommend adopting a layered amortization approach. Please note, resetting the amortization period frequently is not recommended. The goal of the System is to fund its unfunded actuarial accrued liabilities at 100%. Use of an open or frequent resetting of the amortization period is not conducive to this goal.

## Other Recommendations

**Load for unused sick leave:** Currently Normal and Early retirement benefits for Closed and Year 2000 Plans are increased by 3.75% for Uniformed members and 2.6% for Non-Uniformed members to account for the inclusion of unused sick leave in the calculation of Average Pay. The table below is based on the members who have retired over the last 5 years:

Member Group	Number	Average Service Years	Average Unused Sick Leave Years*	Ratio
Uniformed - Closed and Y2K	196	32.3	1.18	3.64%
MoDOT - Closed and Y2K	927	28.1	0.58	2.08%
Civilian Patrol - Closed and Y2K	186	27.6	0.49	1.77%
Uniformed - 2011	0	0.0	0.00	
MoDOT - 2011	28	7.2	0.16	2.23%
Civilian Patrol - 2011	11	7.1	0.13	1.78%

\* Based on crediting 1 month of service for every 168 hours of unused sick leave.

We do not think that it is appropriate to give full credibility to the sick leave experience in the past 5 years. Based on our review, we recommend that the load for unused sick leave for Non-Uniformed members of the Closed and Year 2000 plans be decreased to 2.3%. This review supports continued use of the current loads for Uniformed members of the Closed and Year 2000 Plans at the current assumption of 3.75%.

Year 2011 Tier Normal and Early retirement benefits are increased by 1.5% for Uniformed members and 1.0% for Non-Uniformed members to account for the inclusion of unused sick leave in the calculation of Average Pay. Based on our review, the Year 2011 Tier experience for Non-Uniformed members appears to be in line with the experience for Non-Uniformed members of the Closed and Year 2000 plans. We recommend that the load be increased to 2.3% for Year 2011 Tier Non-Uniformed members. While there is no actual experience for Year 2011 Tier Uniform members, given that the trend for Year 2011 Tier Non-Uniform members appears to be consistent with Closed and Year 2000 Non-Uniform members we have assumed that Year 2011 Tier Uniformed members will trend close to Closed and Year 2000 Uniform members. We recommend that the load be increased to 3.75% for Year 2011 Tier Uniformed members.

**Load for end of career increases in compensation:** Additionally, we have looked into the load for end of career increases in compensation. There is currently no load for this activity. In past experience studies, it was determined that this activity does not occur with any frequency that would merit modeling in the valuation. For this experience study, we looked at the expected versus actual new retiree liabilities in the past 5 years. The table below shows the aggregate results. The table below indicates that new retiree benefits have generally been as expected for Non-Uniform members and higher than expected for Uniform members. As a result, we recommend adding a 2% load for end of career increases in compensation for Closed and Year 2000 plan Uniform members.

Group	(\$ millions)		%
	Expected Reserve Transfer	Actual Reserve Transfer	Difference
Uniformed	\$202.7	\$210.5	3.9%
Non-Uniformed	\$424.5	\$424.8	0.1%



## Other Recommendations

**Optional forms of payment:** Reduction factors for the Y2K plan are codified in the statute. Factors for the closed plan are adopted by the Board. We reviewed these factors and find them to be actuarially equivalent within reasonable tolerances, based on the current economic assumptions. These factors will get reviewed one final time after the Board formally adopts a new set of economic assumptions and a load may be added, if warranted. Such a load is not expected to be greater than 1% -2%.

**Marriage Assumption:** The current assumption is that 90% of active members are married for the death-in-service benefit. MPERS Staff has provided additional information regarding active member deaths in the valuation data beginning in 2018. Based on the data provided about 85% of active member deaths have a surviving spouse. The current assumption of 90% continues to appear reasonable and we recommend no change. It is also assumed that 100% of future Closed plan retirees are married for the automatic 50% survivor benefit. The new Closed plan retirees in the 2022 data were reviewed and the majority were reported as having a spouse. In addition, the Missouri statute allows members who marry after retirement to elect a joint and survivor benefit upon marriage. The current assumption of 100% continues to appear reasonable and we recommend no change.

**Deferred and Active members eligible for Closed and Y2K plan benefits:** Closed plan members are able to elect Y2K benefits at retirement. We assume they will elect a Closed plan benefit. Although there may be increases or decreases in liabilities for individual members based on the election of Y2K benefits, in aggregate, we do not believe that these elections will result in a cost to the system. We will continue to monitor the liabilities for Closed plan members and may update this assumption as experience emerges.

**Load for potential survivor benefits of future disabled members:** We currently increase the liabilities for future disabled members by 50% to account for survivor benefits for members that die prior to normal retirement commencement. We do not otherwise model this benefit for future disabled members. Based on our modelling using the updated mortality assumptions recommended in this report, we recommend lowering the load to 25%.

**Load for survivor benefits of current self-insured disability retirants:** Survivor benefits for current self-insured disability members are currently modeled by increasing the liabilities by 12%. For these members that are eligible for Y2K benefits, the average years remaining to retirement eligibility in 2017 was 1.3 years. In 2022 more than 80% of the self-insured disability retirants are eligible for Y2K retirement. As a result, we recommend no change to the 12% load. Note that this is a closed group of members and the liabilities for this group are not material.

**Load for survivor benefits for future deferred members:** The liabilities for future deferred Closed and Year 2000 plan members are currently increased by 2% to account for potential survivor benefits payable if the member dies during the deferred period. We recommend increasing the load to 3%. The rationale for this load is based on the associated liabilities for the current deferred members. We have otherwise not modeled this benefit for future deferred members. 2011 Tier participants are not eligible for this benefit and, therefore, there is no load.

**Gainful employment offset for \$90 per month special benefit:** The current assumption is that 30% of the \$90 per month special benefit for future Uniformed Closed plan retirees is offset by gainful employment. This assumption is immaterial and we are not recommending a change to the assumption.



## Other Recommendations

**Forfeiture of deferred benefits:** MPERS Staff has provided additional information regarding 2011 Tier active member terminations in the valuation data beginning in 2018. These members may elect to withdraw their contributions in lieu of a future benefit. The data indicates that less than 4% of members elect to forfeit their deferred benefit. We recommend no change to the current assumption that 0% of 2011 Tier members will elect to forfeit their benefit. We will continue to monitor this assumption and may recommend changes as more experience continues to emerge.

**Liabilities for transfers and rehires:** We have studied the impact on the plan due to new liabilities from transfers and rehires. Based on the current funding policy, we do not believe that this experience has a material effect on the plan. Therefore, we are not recommending a load to account for such experience.

# Valuation Results

## Contribution Calculation Comparison

	Decrement and Present Economic Assumptions	Proposed Decrement Assumptions		
		Present Economic#		
	Temporary Policy	Temporary Policy	Permanent Policy	Reset Policy
Amortization Policy*	2 years	2 years	13 years	20 years
Retired Unfunded Liabilities	17 years	17 years	13 years	20 years
Other Unfunded Liabilities				
<b>Economic Assumptions</b>				
Investment Return	6.50 %	6.50 %	6.50 %	6.50 %
Wage Inflation	3.00 %	3.00 %	3.00 %	3.00 %
Spread on Wages	3.50 %	3.50 %	3.50 %	3.50 %
Price Inflation	2.25 %	2.25 %	2.25 %	2.25 %
COLA	1.80 %	1.80 %	1.80 %	1.80 %
<b>Non-Uniformed Group</b>				
<b>Employer Contributions for</b>				
Normal Cost	9.080 %	8.410 %	8.410 %	8.410 %
Unfunded Actuarial Accrued Liability (UAAL)	26.446 %	26.840 %	33.013 %	23.864 %
Disability Insurance	0.475 %	0.475 %	0.475 %	0.475 %
Administrative Expenses	1.380 %	1.380 %	1.380 %	1.380 %
<b>Total Computed Employer Contribution Without Contribution Stabilization Reserve Fund</b>	<b>37.381 %</b>	<b>37.105 %</b>	<b>43.278 %</b>	<b>34.129 %</b>
Utilization of Contribution Stabilization Reserve Fund	20.619 %	20.895 %	8.977 %	6.197 %
<b>Total Computed Employer Contribution With Contribution Stabilization Reserve Fund</b>	<b>58.000 %</b>	<b>58.000 %</b>	<b>52.255 %</b>	<b>40.326 %</b>
Active UAAL (\$ millions)	957.6	968.0	968.0	968.0
Retiree UAAL (\$ millions)	74.5	79.5	79.5	79.5
<b>Uniformed Group</b>				
<b>Employer Contributions for</b>				
Normal Cost	16.740 %	17.600 %	17.600 %	17.600 %
Unfunded Actuarial Accrued Liability (UAAL)	37.504 %	39.463 %	48.538 %	35.087 %
Disability Insurance	0.475 %	0.475 %	0.475 %	0.475 %
Administrative Expenses	1.380 %	1.380 %	1.380 %	1.380 %
<b>Total Computed Employer Contribution Without Contribution Stabilization Reserve Fund</b>	<b>56.099 %</b>	<b>58.918 %</b>	<b>67.993 %</b>	<b>54.542 %</b>
Utilization of Contribution Stabilization Reserve Fund	1.901 %	0.000 %	0.000 %	0.898 %
<b>Total Computed Employer Contribution With Contribution Stabilization Reserve Fund</b>	<b>58.000 %</b>	<b>58.918 %</b>	<b>67.993 %</b>	<b>55.440 %</b>
Active UAAL (\$ millions)	452.9	474.0	474.0	474.0
Retiree UAAL (\$ millions)	0.0	0.0	0.0	0.0
<b>MPERS Totals</b>				
Combined Employer Contribution Rate	58.000 %	58.230 %	56.197 %	44.112 %
Projected Dollar Contributions (\$ millions)	219.5	220.3	212.4	166.6
Total UAAL (\$ millions)	1,485.1	1,521.5	1,521.5	1,521.5
Contribution Stabilization Reserve Fund (\$ millions)	170.7	148.2	250.0	250.0
<b>Total Amount Financed (\$ millions)</b>	<b>1,655.8</b>	<b>1,669.7</b>	<b>1,771.5</b>	<b>1,771.5</b>
<b>MPERS Funded Status</b>	<b>66.33 %</b>	<b>65.79 %</b>	<b>65.79 %</b>	<b>65.79 %</b>

# Reflects proposed demographic assumptions and is for illustrative purposes only. Nominal rates of return for these alternates are outside the recommended range.

\* The amortization of the UAAL under all scenarios was performed using the temporary funding policy which results in a larger combined MPERS contribution than the permanent policy after utilizing the contribution stabilization reserve fund.





# Test Case Review

The chart below shows a list of activity resulting in benefit payments for members of MPERS. For the next experience study, we intend to review additional test cases related to a different decrement.

	Test cases reviewed for study ending in 2017
For members that are active:	
Active to normal retirement	
Active to early retirement	
Active to vested deferred	
Active non-duty death prior to retirement	
Active duty death prior to retirement	
Active to disabled	
Purchase of service	
Active transfer within MPERS (e.g. Uniform to Non-Uniform)	
Active portability (e.g. MPERS to MOSERS)	
For members that are retired	
Retired change in spouse	
Retired death after retirement	
Retired to active	
For members that are disabled	
Disabled to retired	
Disabled to active	
Disabled death prior to retirement	
For members that are vested deferred	
Vested deferred to retired	2022
Vested deferred death prior to retirement	
Vested deferred to active (internal)	
Vested deferred to external transfer	
Purchase of service	

For each scenario above, test cases are requested for the following, when applicable:

- Closed, Year 2000, and 2011 Tier plans
- Uniform and Non-Uniform
- For participants in the Closed plan, calculations of Year 2000 benefits
- Calculations for various forms of payments
- Active members electing BackDROP

While not a typical part of an experience study, we have added this test to the process to check for potential changes in administration or benefit conditions that may not have been identified in the annual valuation process. The intent is to look at members who have had a status change during the year and compare how we modeled that status change (before it happened) to how it actually occurred in order to identify any changes in programming that might be appropriate.

This process did not identify any needed changes in modeling this year.



## **SECTION C**

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### **ECONOMIC ACTIVITY**

## Economic Assumptions

Economic assumptions include long-term rates of investment return (net of investment expenses based upon a passive investment strategy; sometimes net of administrative expenses), price inflation, wage inflation (the across-the-board portion of salary increases) and a payroll growth assumption. Unlike demographic activities, economic activities do not lend themselves to analysis solely on the basis of internal historical patterns because both salary increases and investment return are affected more by external forces; namely inflation (both wage and price), general productivity changes and the local economic environment which defy accurate long-term prediction. Estimates of economic activities are generally selected on the basis of the expectations in an inflation-free environment and then both long-term rates of investment return and wage inflation are increased by some provision for long-term price inflation.

Sources considered in the analysis of the price inflation assumption included:

- Congressional Budget Office; 5-year and 10-year annual averages;
- Federal Reserve Bank of Philadelphia quarterly survey of Society of Professional Forecasters; 5-year and 10-year annual averages;
- Federal Reserve Bank of Cleveland Inflation Expectations; 10-year, 20-year and 30-year expectations;
- Federal Reserve Bank of St. Louis Breakeven Inflation Rates; 10-year, 20-year and 30-year periods;
- U.S Department of the Treasury Breakeven Inflation Rates; 10-year, 20-year, 30-year, 50-year and 100-year periods;
- Social Security 2022 Trustees Report; and
- Future capital market expectations of firms that GRS monitors through our proprietary Capital Market Assumptions Modeler (CMAM). In general, capital market expectations were provided covering a 10-year period. In addition, six of the twelve firms provided capital market expectations over a 20-year to 30-year period.

Sources considered in the analysis of the investment return assumption included:

- Future capital market expectations of the firms included in the 2022 version of the GRS CMAM

Sources considered in the analysis of the wage inflation and payroll growth assumptions included:

- Historical observations of national inflation statistics (both price and wage)

## Price Inflation

Many of the economic assumptions are developed using a building block method which depends on price inflation. Below we show forward looking price inflation forecasts from several different sources.

<b>Forward-Looking Price Inflation Forecasts<sup>a</sup></b>	
<b>Congressional Budget Office<sup>b</sup></b> 5-Year Annual Average 10-Year Annual Average	3.23% 2.81%
<b>Federal Reserve Bank of Philadelphia<sup>c</sup></b> 5-Year Annual Average 10-Year Annual Average	3.75% 2.95%
<b>Federal Reserve Bank of Cleveland<sup>d</sup></b> 10-Year Expectation 20-Year Expectation 30-Year Expectation	2.22% 2.29% 2.37%
<b>Federal Reserve Bank of St. Louis<sup>e</sup></b> 10-Year Breakeven Inflation 20-Year Breakeven Inflation 30-Year Breakeven Inflation	2.26% 2.50% 2.26%
<b>U.S. Department of the Treasury<sup>f</sup></b> 10-Year Breakeven Inflation 20-Year Breakeven Inflation 30-Year Breakeven Inflation 50-Year Breakeven Inflation 100-Year Breakeven Inflation	2.07% 2.40% 2.21% 2.34% 2.44%
<b>Social Security Trustees<sup>g</sup></b> Ultimate Intermediate Assumption	2.40%

<sup>a</sup>End of the Fourth Quarter, 2022. Version 2023-02-09 by Gabriel, Roeder, Smith & Company.

<sup>b</sup>The Budget and Economic Outlook: 2022 to 2032, Release Date: May 2022, Consumer Price Index (CPI-U), Percentage Change from Year to Year, 5-Year Annual Average (2022 - 2026), 10-Year Annual Average (2022 - 2031).

<sup>c</sup>Fourth Quarter 2022 Survey of Professional Forecasters, Release Date: November 14, 2022, Headline CPI, Annualized Percentage Points, 5-Year Annual Average (2022 - 2026), 10-Year Annual Average (2022 - 2031).

<sup>d</sup>Inflation Expectations, Model output date: December 1, 2022.

<sup>e</sup>The breakeven inflation rate represents a measure of expected inflation derived from X-Year Treasury Constant Maturity Securities and X-Year Treasury Inflation-Indexed Constant Maturity Securities. Observation date: December, 2022.

<sup>f</sup>The Treasury Breakeven Inflation (TBI) Curve, Monthly Average Rates, December, 2022.

<sup>g</sup>The 2022 Annual Report of The Board of Trustees of The Federal Old-Age And Survivors Insurance and Federal Disability Insurance Trust Funds, June 2, 2022, Long-range (75-year) assumptions, Intermediate, Consumer Price Index (CPI-W), for 2026 and later.



## Price Inflation

We reviewed the forward-looking inflation assumptions used by the twelve independent investment firms that work with public sector plans. These are shown later in the report. The samples from these firms ranged from 2.26% to 3.10%, with an average of 2.53%.

The current price inflation assumption is 2.25%. **As a result of our analysis, we recommend maintaining a price inflation assumption in a range between 2.25% and 2.75%.**

## Wage Inflation

Wage inflation consists of two components: 1) a portion due to pure price inflation (i.e., increases due to changes in the CPI); and 2) increases in average salary levels in excess of pure price inflation (i.e., increases due to changes in productivity levels, supply and demand in the labor market and other macroeconomic factors).

The current wage inflation assumption is 3.0%.

We are generally comfortable with the wage inflation assumption exceeding the price inflation by 0.5% to 1.0%.

The table below shows the difference between the increase in National Average Wage Index and price inflation over various periods, ending December 2021:

Periods Ending December 2021	Difference Between Increase in National Average Wage Index and CPI
Last five (5) years	1.6%
Last ten (10) years	1.4%
Last fifteen (15) years	0.9%
Last twenty (20) years	0.8%
Last twenty-five (25) years	1.2%
Last thirty (30) years	1.1%

**We recommend maintaining a wage inflation assumption of 3.00%.** However, if the Board were to consider increasing the price inflation assumption to 2.50%, it would be reasonable to increase the wage growth assumption to 3.25%.

# Forward-Looking Economic Assumptions

## Capital Market Assumption Modeler

The analysis of the investment return assumption in this report is based on forward-looking measures of expected investment return outcomes for the asset classes in the System’s current investment policy. For purposes of this analysis, we have analyzed the System’s investment policy with the capital market assumptions from twelve nationally recognized investment advisors.

Our analysis is based on the GRS Capital Market Assumption Modeler (CMAM). Because GRS is a benefits consulting firm and does not develop or maintain our own capital market expectations, we request and monitor forward-looking expectations developed by several major investment advisory firms. We update our CMAM on an annual basis. The capital market assumptions in the 2022 CMAM are from the following investment firms (in alphabetical order): Aon Hewitt, Blackrock, BNY Mellon, Callan, Cambridge, JPMorgan, Meketa, Mercer, NEPC, RVK, Verus, and Wilshire. We believe that the benefit of performing this analysis using multiple investment advisory firms is to recognize the uncertain nature of the items affecting the selection of the investment return assumption. While there may be differences in asset classes, investment horizons, inflation assumptions, treatment of investment expenses, excess manager performance (i.e., alpha), etc., we have attempted to align the various assumption sets from the different investment advisors to be as consistent as possible.

To the best of our ability, we have adapted the System’s investment policy to fit with the advisors’ assumptions adjusting for these known differences in assumptions and methodology. In the following charts, to the extent possible all returns are net of passive investment expenses and have no assumption for excess manager performance (alpha) in excess of active management fees.

For purposes of this analysis, we have been provided with the following asset allocation from System staff:

Asset Class	Target Allocation
Cash	0.0%
U.S. Stock - Large Cap	20.3%
U.S. Stock - Small Cap	2.7%
International Equity	12.0%
Emerging Markets Equity	5.0%
U.S. Corporate Bonds	9.0%
Government Bonds	13.5%
High Yield	7.5%
Real Estate	20.0%
Private Equity	10.0%
Total	100.0%

# Forward-Looking Economic Assumptions

## Capital Market Assumption Modeler

The arithmetic expected return developed from the policy asset allocation is shown in the table below. The CMAM begins with the nominal expected return from each consultant (Column 2), takes out each consultant’s price inflation assumption (Column 3) to arrive at the real return (Column 4). We then incorporate the actuary’s price inflation assumption of 2.25% (Column 5) to get the expected nominal return (Column 6). Note that this return has not yet been adjusted for risk or “volatility drag.” We have shown the standard deviation of returns as one measure of the investment risk (Column 8).

The average arithmetic return from the last three years of CMAMs are shown at the bottom of the table for reference.

Investment Consultant	Investment Consultant Expected Nominal Return	Investment Consultant Inflation Assumption	Expected Real Return (2)-(3)	Actuary Inflation Assumption	Expected Nominal Return (4)+(5)	Investment Expenses	Expected Nominal Return Net of Expenses (6)-(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	5.33%	3.00%	2.33%	2.25%	4.58%	0.00%	4.58%
2	5.77%	2.60%	3.17%	2.25%	5.42%	0.00%	5.42%
3	5.61%	2.40%	3.21%	2.25%	5.46%	0.00%	5.46%
4	5.74%	2.31%	3.43%	2.25%	5.68%	0.00%	5.68%
5	5.82%	2.50%	3.32%	2.25%	5.57%	0.00%	5.57%
6	5.74%	2.31%	3.43%	2.25%	5.68%	0.00%	5.68%
7	6.46%	2.64%	3.82%	2.25%	6.07%	0.00%	6.07%
8	6.20%	2.50%	3.70%	2.25%	5.95%	0.00%	5.95%
9	6.23%	2.41%	3.83%	2.25%	6.08%	0.00%	6.08%
10	6.40%	2.26%	4.14%	2.25%	6.39%	0.00%	6.39%
11	6.62%	2.29%	4.33%	2.25%	6.58%	0.00%	6.58%
12	7.58%	3.10%	4.48%	2.25%	6.73%	0.00%	6.73%
<b>Average</b>	<b>6.12%</b>	<b>2.53%</b>	<b>3.60%</b>	<b>2.25%</b>	<b>5.85%</b>	<b>0.00%</b>	<b>5.85%</b>
<b>Average from last 3 CMAMs</b>							<b>6.16%</b>



# Forward-Looking Economic Assumptions

## Capital Market Assumption Modeler

We then compare the probabilities of achieving returns over a 20-year horizon. We compute the 40th, 50th, and 60th percentiles of returns as well as the probability of achieving the current assumption of 6.50% over a 20-year horizon. Alternative probabilities are shown for various assumed rates of return for comparison. Note that the investment horizon for most of the capital market assumption sets is between 5 and 10 years. For purposes of this analysis, no adjustment has been made to return expectations for 20 years.

Investment Consultant	Distribution of 20-Year Average Geometric Net Nominal Return			Probability of Exceeding 6.50%	Probability of Exceeding 6.25%	Probability of Exceeding 6.00%
	40th	50th	60th			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	3.58%	4.13%	4.68%	13.95%	16.61%	19.59%
2	4.01%	4.70%	5.40%	25.80%	28.77%	31.91%
3	4.17%	4.82%	5.48%	25.90%	29.09%	32.45%
4	4.40%	5.05%	5.70%	28.73%	32.09%	35.61%
5	4.53%	5.10%	5.66%	26.65%	30.40%	34.38%
6	4.68%	5.23%	5.78%	28.07%	32.02%	36.19%
7	4.66%	5.35%	6.05%	33.86%	37.23%	40.71%
8	4.74%	5.37%	6.00%	32.46%	36.13%	39.94%
9	4.86%	5.49%	6.12%	34.27%	38.00%	41.87%
10	5.03%	5.71%	6.39%	38.43%	42.01%	45.68%
11	5.24%	5.91%	6.59%	41.28%	44.97%	48.71%
12	5.48%	6.12%	6.77%	44.07%	47.97%	51.90%
<b>Average</b>	<b>4.62%</b>	<b>5.25%</b>	<b>5.88%</b>	<b>31.12%</b>	<b>34.61%</b>	<b>38.24%</b>
<b>Average from last 3 CMAMs</b>	<b>5.56%</b>					
<b>Current CMAM average over 20- to 30-year</b>	<b>6.30%</b>					

The 50th percentile return is also the geometric average return net of investment expenses (this is a characteristic of the lognormal distribution which is the most common distribution used to model investment returns). This is the expected return adjusted for volatility drag and is a reasonable rate of return for purposes of the valuation.

The preferred investment return assumption in the actuarial community is the forward-looking expected geometric return (i.e., 50th percentile). Based upon the average of each of the investment firms' expectations, this would lead to an investment return assumption of 5.25% using the policy allocation. A less preferred investment return assumption, but still reasonable assumption, is the forward-looking expected arithmetic return (i.e., expected nominal return). Based on the average of each of the investment firms' expectations, this would lead to an investment return assumption of 5.85% using the policy allocation.

## Forward-Looking Economic Assumptions

So as not to overreact to short term outlooks, we next broaden our analysis to consider the three-year average of our CMAM results (consistent with past analyses). Based on the 3-year average CMAM, an assumption that falls between 5.56% and 6.16% would be reasonable. The long-term geometric average is 6.30%.

The forward-looking expectations of several investment firms are updated in our model year over year. The CMAM results from the past several years of expectations are shown below (assuming 2.25% price inflation). Please note the participating investment consultants may vary from one year to the next.

<b>Investment Return With Policy Allocation</b>		
<b>CMAM Year</b>	<b>Mean</b>	<b>Median</b>
2015	6.73%	6.15%
2016	7.13%	6.55%
2017	6.59%	6.03%
2018	6.53%	5.94%
2019	7.02%	6.44%
2020	6.54%	5.96%
2021	6.07%	5.46%
2022	5.85%	5.25%

We also examined the January 2023 Capital Market expectations of NEPC, the System’s investment consultant. NEPC’s 10-year expected return is 6.88% based on the Plan’s target investment policy.

We believe the current investment return assumption of 6.5% continues to be reasonable provided more weight is placed on NEPC’s analysis and GRS’ long-term expectation. Our 2023 Capital Market Assumption Model will be available later in the year. It is expected that the 2023 CMAM will be higher than the 2022 CMAM, potentially in the range of a 0.50% to 1.00% increase. Since using the 2023 Capital Market Assumption Model is expected to result in a large change to this analysis, we recommend waiting until that model is available before making any decisions regarding the economic assumptions.

## SECTION D

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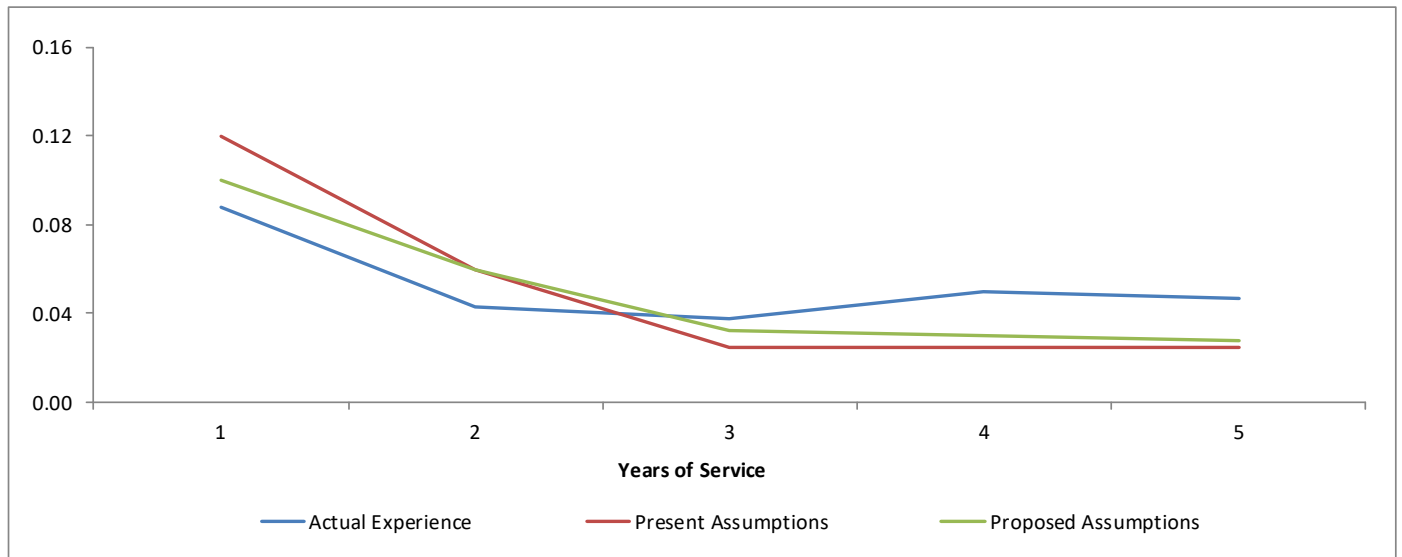
### ACTIVE DECREMENT ACTIVITY – ACTUAL VS. EXPECTED

# Uniformed Members Service-Based Withdrawal Experience

## Withdrawals with Less Than 5 Years of Service

There were 47 withdrawals and 975 years of exposure included in the service-based withdrawal investigation. Withdrawals are separations from active member status for a reason other than disability, death, or retirement.

Years of Service	Life Years Exposure	Number of Withdrawals			Withdrawal Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
1	91	8	11	9	0.0879	0.1200	0.1000
2	234	10	14	14	0.0427	0.0600	0.0600
3	214	8	5	7	0.0374	0.0250	0.0325
4	221	11	6	7	0.0498	0.0250	0.0300
5	215	10	5	6	0.0465	0.0250	0.0275
Totals	975	47	41	43	0.0482	0.0421	0.0441

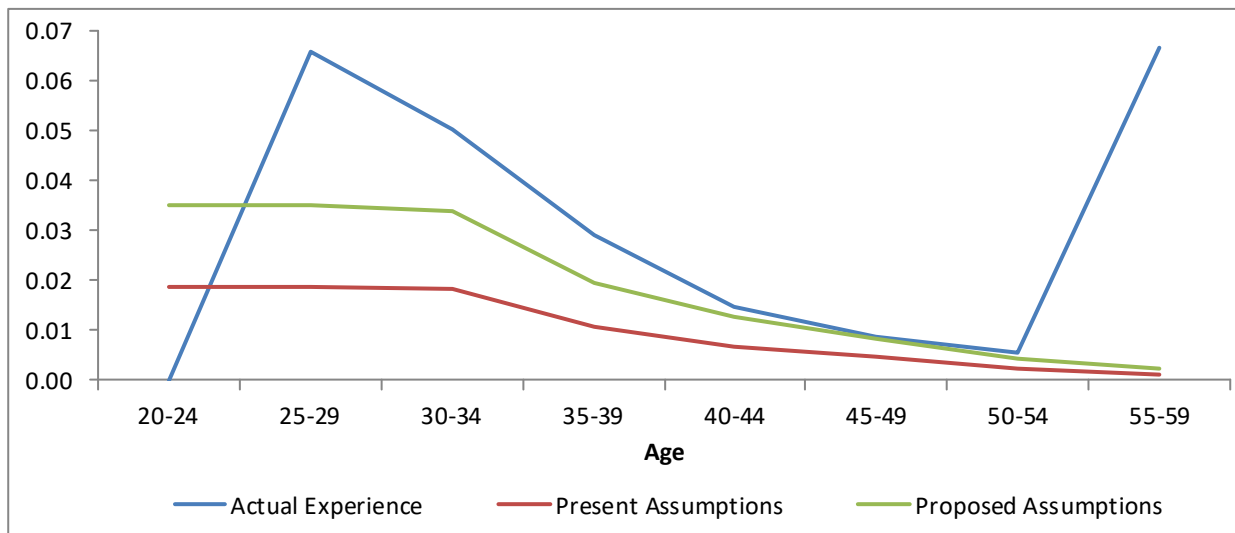


# Uniformed Members Age-Based Withdrawal Experience

## Withdrawals with 5 or More Years of Service

There were 100 withdrawals and 4,417 years of exposure included in the age-based withdrawal investigation. Withdrawals are separations from active member status for a reason other than disability, death, or retirement.

Age	Life Years Exposure	Number of Withdrawals			Withdrawal Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
20-24	-	-	-	-	N/A	0.0189	0.0351
25-29	213	14	4	7	0.0657	0.0189	0.0351
30-34	758	38	13	24	0.0501	0.0183	0.0339
35-39	723	21	8	14	0.0290	0.0106	0.0197
40-44	823	12	6	11	0.0146	0.0069	0.0128
45-49	1,145	10	5	10	0.0087	0.0046	0.0085
50-54	740	4	2	4	0.0054	0.0023	0.0043
55-59	15	1	-	-	0.0667	0.0013	0.0024
Totals	4,417	100	38	70	0.0226	0.0086	0.0158

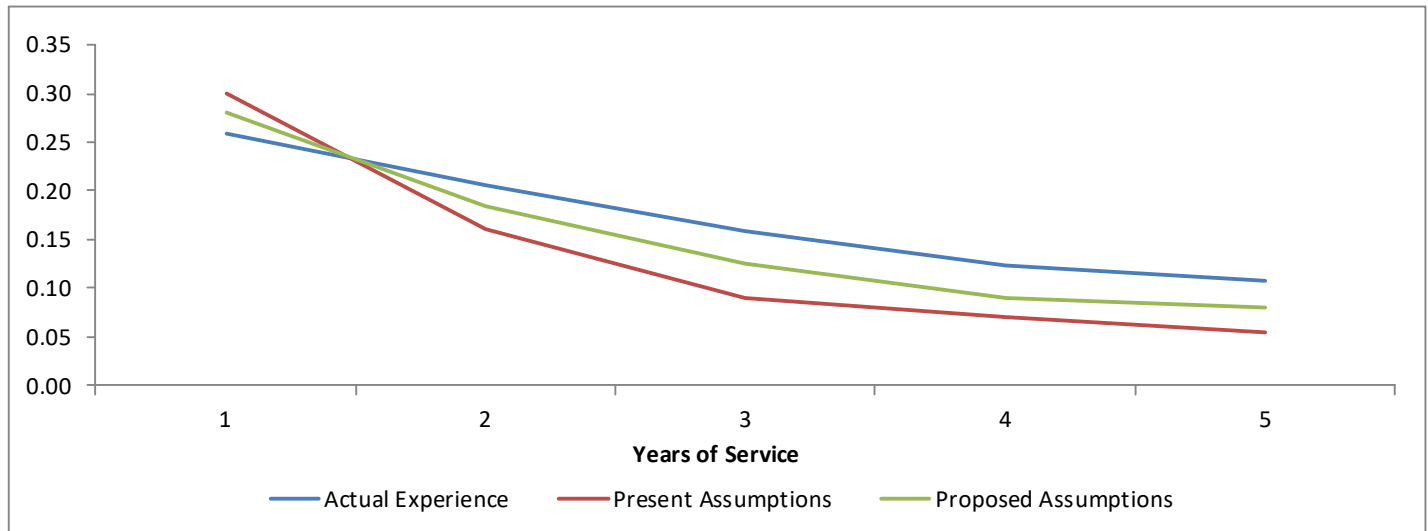


# Non-Uniformed Males Service-Based Withdrawal Experience

## Withdrawals with Less Than 5 Years of Service

There were 1,222 withdrawals and 7,251 years of exposure included in the male service-based withdrawal investigation. Withdrawals are separations from active member status for a reason other than disability, death, or retirement.

Years of Service	Life Years Exposure	Number of Withdrawals			Withdrawal Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
1	890	231	267	249	0.2596	0.3000	0.2800
2	2,003	413	320	371	0.2062	0.1600	0.1850
3	1,674	267	151	209	0.1595	0.0900	0.1250
4	1,462	180	102	132	0.1231	0.0700	0.0900
5	1,222	131	67	98	0.1072	0.0550	0.0800
Totals	7,251	1,222	907	1,059	0.1685	0.1251	0.1460

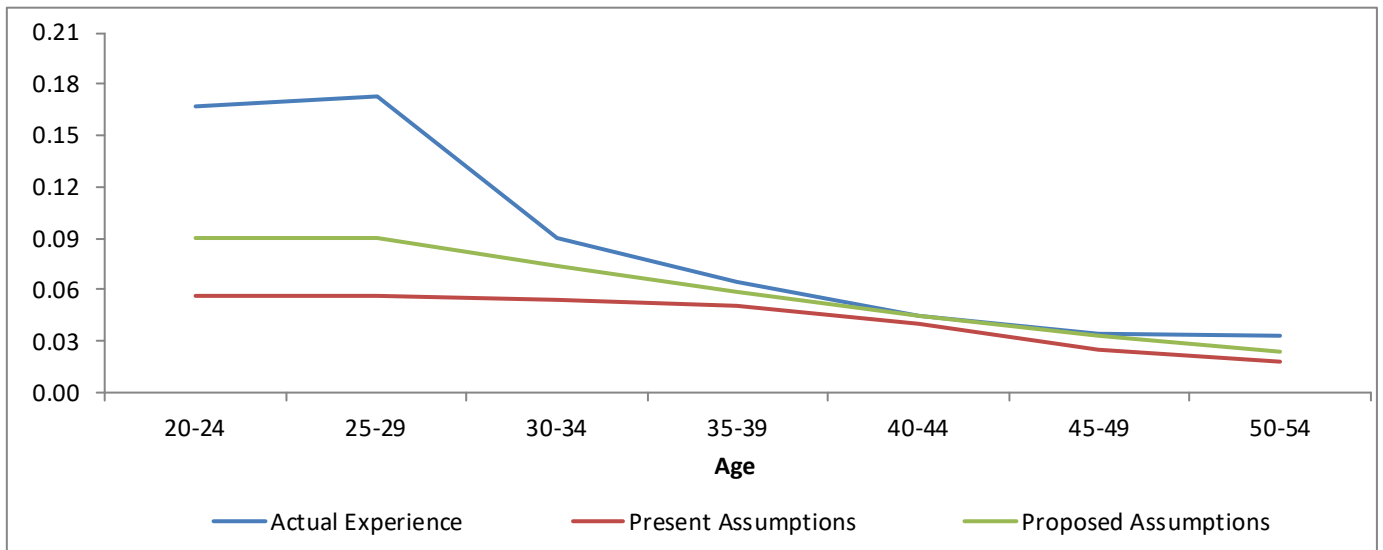


# Non-Uniformed Males Age-Based Withdrawal Experience

## Withdrawals with 5 or More Years of Service

There were 613 withdrawals and 11,471 years of exposure included in the male age-based withdrawal investigation. Withdrawals are separations from active member status for a reason other than disability, death, or retirement.

Age	Life Years Exposure	Number of Withdrawals			Withdrawal Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
20-24	6	1	-	1	0.1667	0.0560	0.0904
25-29	300	52	17	26	0.1733	0.0560	0.0904
30-34	959	86	52	70	0.0897	0.0546	0.0741
35-39	1,715	110	87	100	0.0641	0.0511	0.0589
40-44	2,263	102	91	102	0.0451	0.0406	0.0451
45-49	2,783	96	70	93	0.0345	0.0252	0.0334
50-54	2,633	86	49	65	0.0327	0.0182	0.0243
55-59	721	53	10	14	0.0735	0.0140	0.0183
60 & Up	91	27	1	1	0.2967	0.0140	0.0158
Totals	11,471	613	377	472	0.0534	0.0329	0.0411
Totals from 30 - 54	10,353	480	349	430	0.0464	0.0337	0.0415

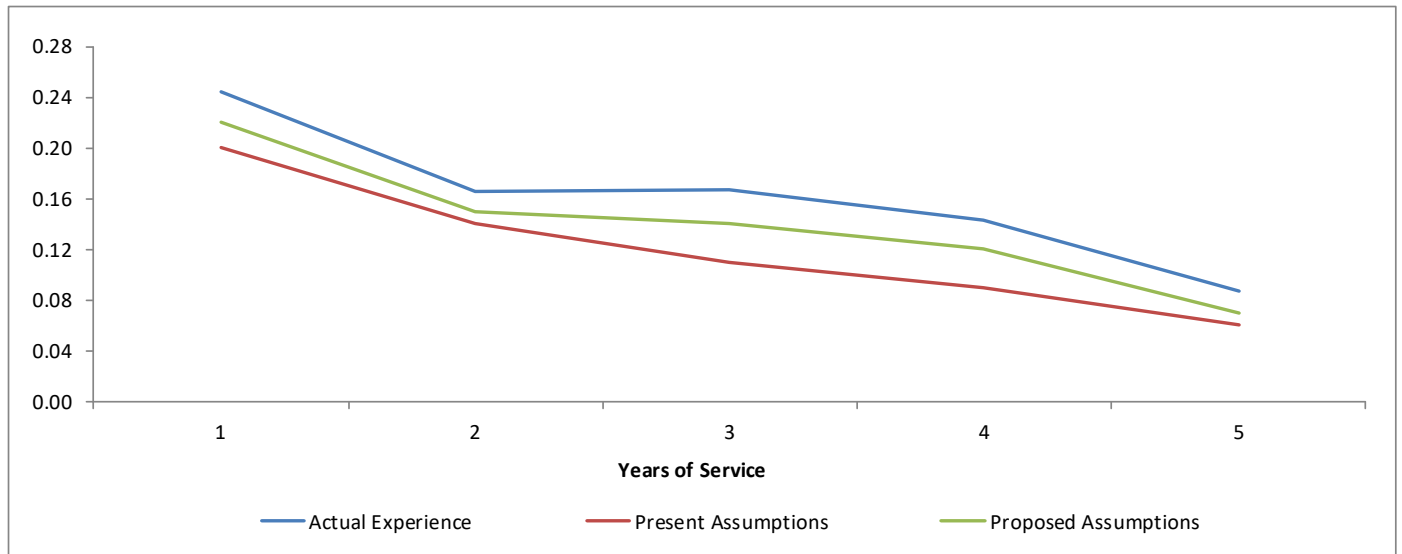


# Non-Uniformed Females Service-Based Withdrawal Experience

## Withdrawals with Less Than 5 Years of Service

There were 287 withdrawals and 1,840 years of exposure included in the female service-based withdrawal investigation. Withdrawals are separations from active member status for a reason other than disability, death, or retirement.

Years of Service	Life Years Exposure	Number of Withdrawals			Withdrawal Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
1	221	54	44	49	0.2443	0.2000	0.2200
2	477	79	67	72	0.1656	0.1400	0.1500
3	412	69	45	58	0.1675	0.1100	0.1400
4	376	54	34	45	0.1436	0.0900	0.1200
5	354	31	21	25	0.0876	0.0600	0.0700
Totals	1,840	287	211	249	0.1560	0.1147	0.1353



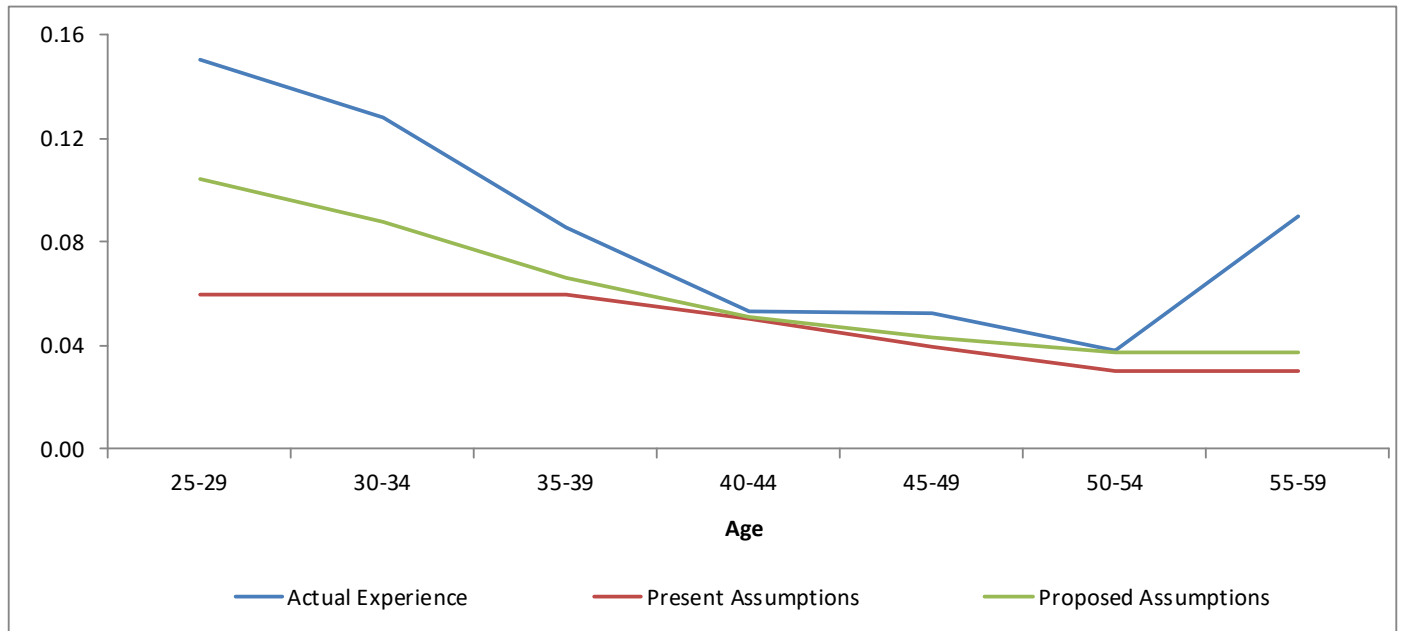


# Non-Uniformed Females Age-Based Withdrawal Experience

## Withdrawals with 5 or More Years of Service

There were 267 withdrawals and 3,972 years of exposure included in the female age-based withdrawal investigation. Withdrawals are separations from active member status for a reason other than disability, death, or retirement.

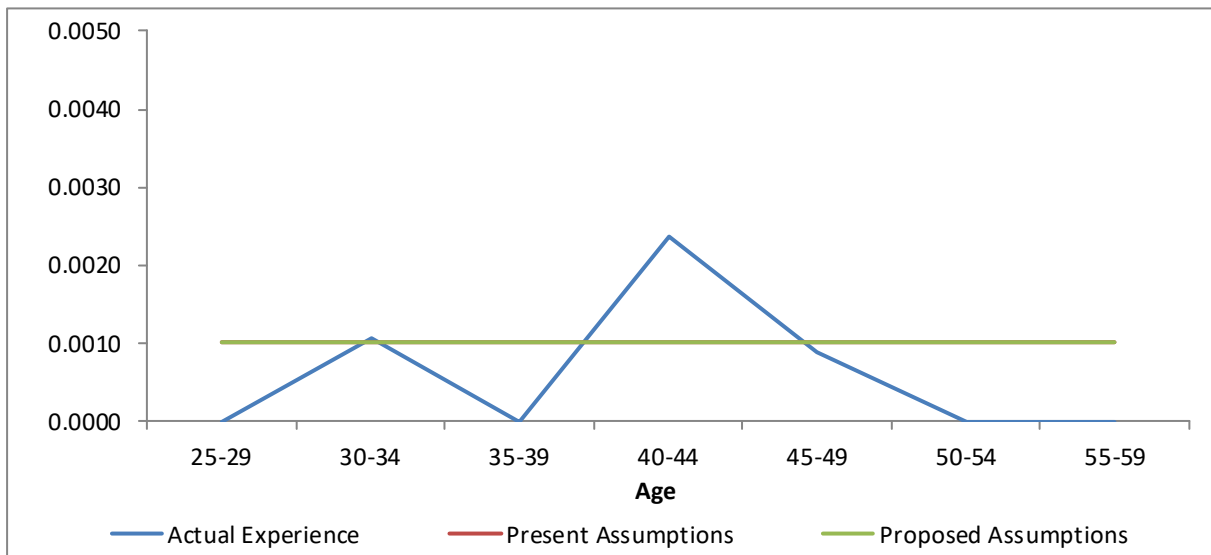
Age	Life Years Exposure	Number of Withdrawals			Withdrawal Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
20-24	-	-	-	-	N/A	0.0600	0.1040
25-29	113	17	7	11	0.1504	0.0600	0.1040
30-34	413	53	25	36	0.1283	0.0600	0.0878
35-39	605	52	36	40	0.0860	0.0600	0.0663
40-44	788	42	40	41	0.0533	0.0505	0.0514
45-49	951	50	37	41	0.0526	0.0392	0.0429
50-54	902	34	27	34	0.0377	0.0300	0.0371
55-59	167	15	5	6	0.0898	0.0300	0.0371
60 & Up	33	4	1	1	0.1212	0.0300	0.0371
Totals	3,972	267	178	210	0.0672	0.0448	0.0529



# Uniformed Members Disability Experience

There were 4 disability benefit claims reported for the 5-year period and 5,216 years of exposure.

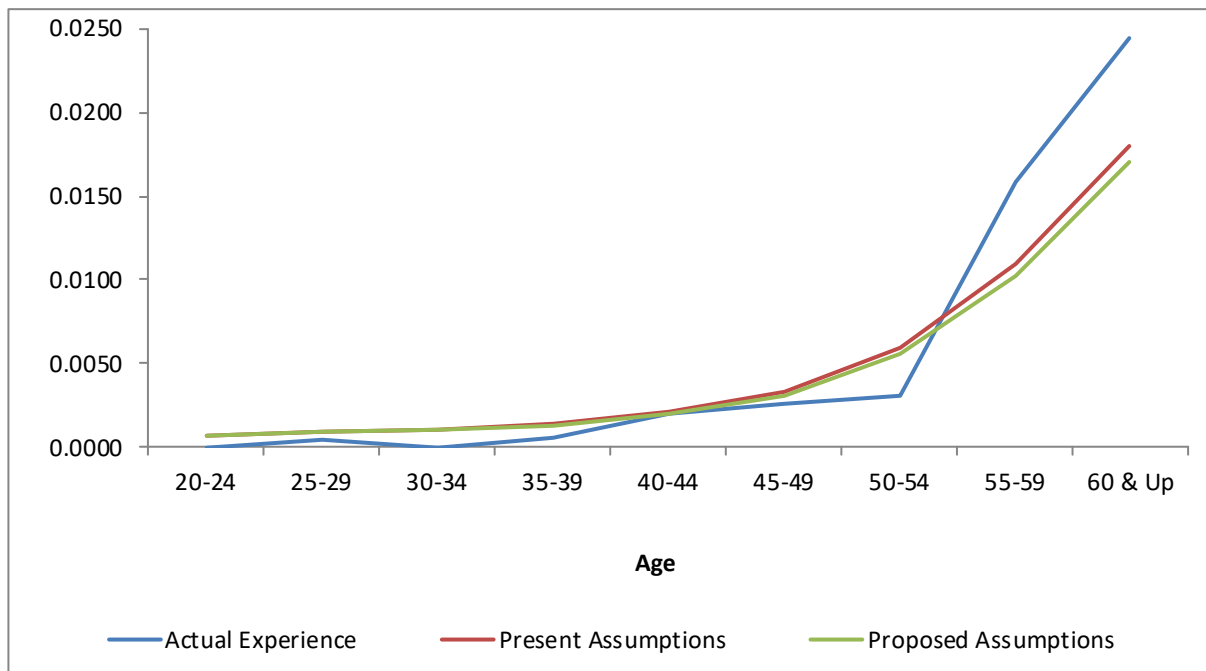
Age	Life Years Exposure	Number of Disabilities			Disability Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
25-29	749	-	1	1	0.0000	0.0010	0.0010
30-34	946	1	1	1	0.0011	0.0010	0.0010
35-39	776	-	1	1	0.0000	0.0010	0.0010
40-44	841	2	1	1	0.0024	0.0010	0.0010
45-49	1,148	1	1	1	0.0009	0.0010	0.0010
50-54	741	-	1	1	0.0000	0.0010	0.0010
55-59	15	-	-	-	0.0000	0.0010	0.0010
Totals	5,216	4	6	6	0.0008	0.0012	0.0012



## Non-Uniformed Members Disability Experience

There were 68 disability benefit claims reported for the 5-year period and 24,462 years of exposure.

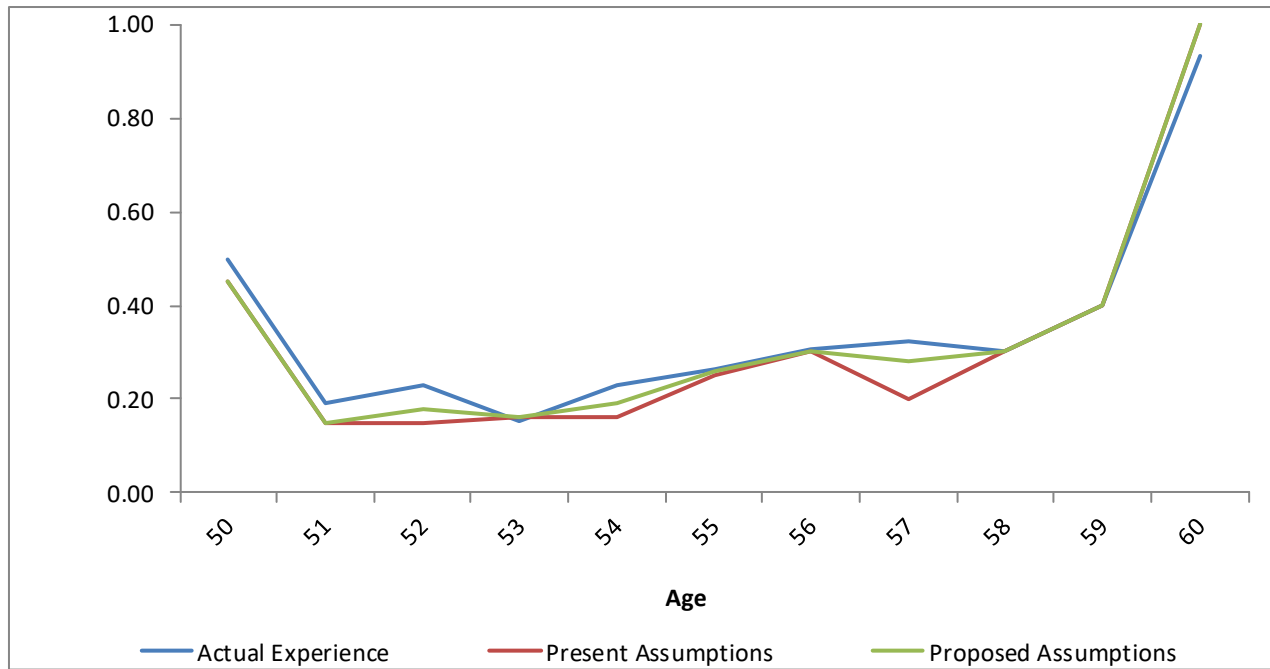
Age	Life Years Exposure	Number of Disabilities			Disability Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
20-24	951	-	1	1	0.0000	0.0007	0.0007
25-29	2,636	1	2	2	0.0004	0.0009	0.0009
30-34	2,886	-	3	3	0.0000	0.0011	0.0010
35-39	3,451	2	5	4	0.0006	0.0014	0.0013
40-44	3,938	8	8	8	0.0020	0.0021	0.0020
45-49	4,566	12	15	14	0.0026	0.0032	0.0031
50-54	4,209	13	25	23	0.0031	0.0059	0.0056
55-59	1,456	23	15	14	0.0158	0.0109	0.0103
60 & Up	369	9	6	6	0.0244	0.0180	0.0170
Totals	24,462	68	80	75	0.0028	0.0025	0.0031



# Uniformed Members Closed and Year 2000 Plans Age & Service Normal Retirement Experience

There were 192 age and service unreduced retirements and 719 life years of exposure (exposure includes active members eligible for unreduced retirement) in the retirement investigation.

Age	Life Years Exposure	Number of Retirements			Retirement Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
50	2	1	1	1	0.5000	0.4500	0.4500
51	37	7	6	6	0.1892	0.1500	0.1500
52	92	21	14	17	0.2283	0.1500	0.1800
53	105	16	17	17	0.1524	0.1600	0.1600
54	117	27	19	22	0.2308	0.1600	0.1900
55	128	34	32	33	0.2656	0.2500	0.2600
56	91	28	27	27	0.3077	0.3000	0.3000
57	62	20	12	17	0.3226	0.2000	0.2800
58	40	12	12	12	0.3000	0.3000	0.3000
59	30	12	12	12	0.4000	0.4000	0.4000
60	15	14	15	15	0.9333	1.0000	1.0000
Totals	719	192	167	179	0.2670	0.2323	0.2490



# Uniformed Members 2011 Tier Plan Age & Service Normal Retirement Experience

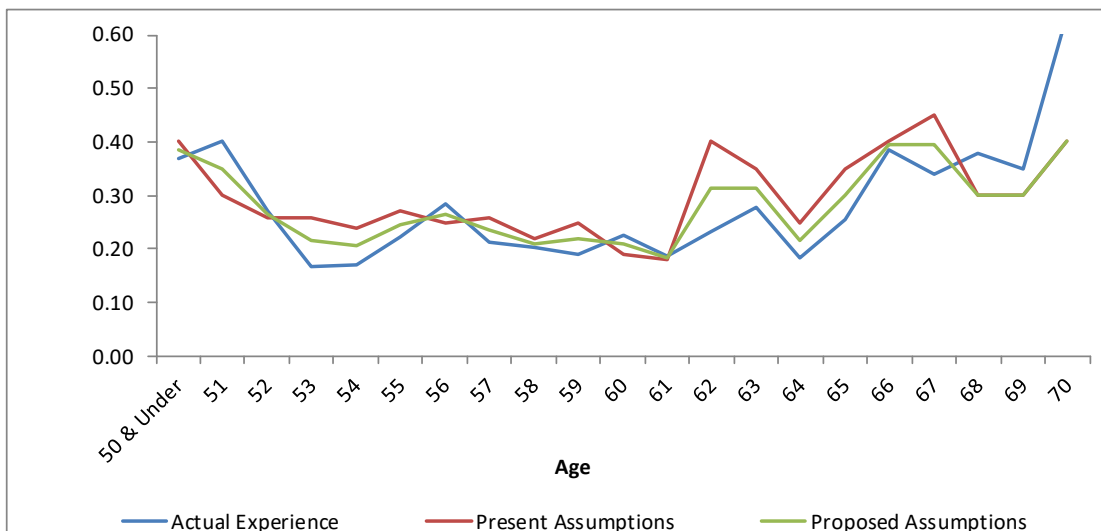
The data for 2011 Tier plan members is insufficient for retirement rate analysis purposes. The present rates appear generally reasonable and we recommend their continued use.

Age	Retirement Rates	
	Present	Proposed
55	0.3000	0.3000
56	0.3000	0.3000
57	0.3000	0.3000
58	0.3000	0.3000
59	0.3000	0.3000
60	1.0000	1.0000

# Non-Uniformed Males Closed and Year 2000 Plans Age & Service Normal Retirement Experience

There were 745 age and service unreduced retirements and 3,130 life years of exposure (exposure includes active members eligible for unreduced retirement) in the male retirement investigation.

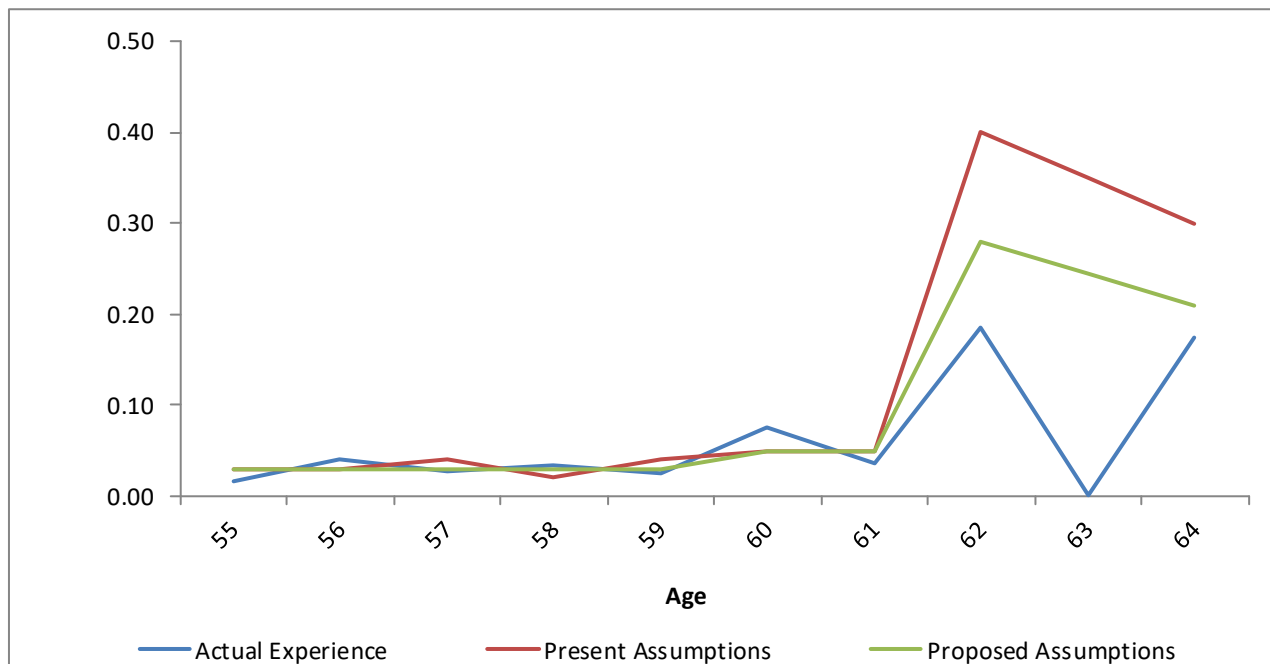
Age	Life Years Exposure	Number of Retirements			Retirement Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
50 & Under	19	7	8	7	0.3684	0.4000	0.3850
51	80	32	24	28	0.4000	0.3000	0.3500
52	147	40	38	39	0.2721	0.2600	0.2650
53	161	27	42	35	0.1677	0.2600	0.2150
54	199	34	48	41	0.1709	0.2400	0.2050
55	225	50	61	55	0.2222	0.2700	0.2450
56	222	63	56	59	0.2838	0.2500	0.2650
57	213	45	55	50	0.2113	0.2600	0.2350
58	213	43	47	45	0.2019	0.2200	0.2100
59	211	40	53	46	0.1896	0.2500	0.2200
60	233	53	44	49	0.2275	0.1900	0.2100
61	192	36	35	36	0.1875	0.1800	0.1850
62	283	66	113	89	0.2332	0.4000	0.3150
63	215	60	75	68	0.2791	0.3500	0.3150
64	153	28	38	33	0.1830	0.2500	0.2150
65	130	33	46	39	0.2538	0.3500	0.3000
66	88	34	35	35	0.3864	0.4000	0.3950
67	59	20	27	23	0.3390	0.4500	0.3950
68	29	11	9	9	0.3793	0.3000	0.3000
69	20	7	6	6	0.3500	0.3000	0.3000
70	11	7	4	4	0.6364	0.4000	0.4000
71	6	2	3	3	0.3333	0.5000	0.5000
72	6	2	3	3	0.3333	0.5000	0.5000
73	5	1	3	3	0.2000	0.5000	0.5000
74	3	1	3	3	0.3333	1.0000	1.0000
75 & Over	7	3	7	7	0.4286	1.0000	1.0000
Totals	3,130	745	883	815	0.2380	0.2821	0.2604



## Non-Uniformed Males Closed and Year 2000 Plans Age & Service Reduce Early Retirement Experience

There were 58 age and service reduced retirements and 1,439 life years of exposure (exposure includes active members eligible for reduced retirement) in the male retirement investigation.

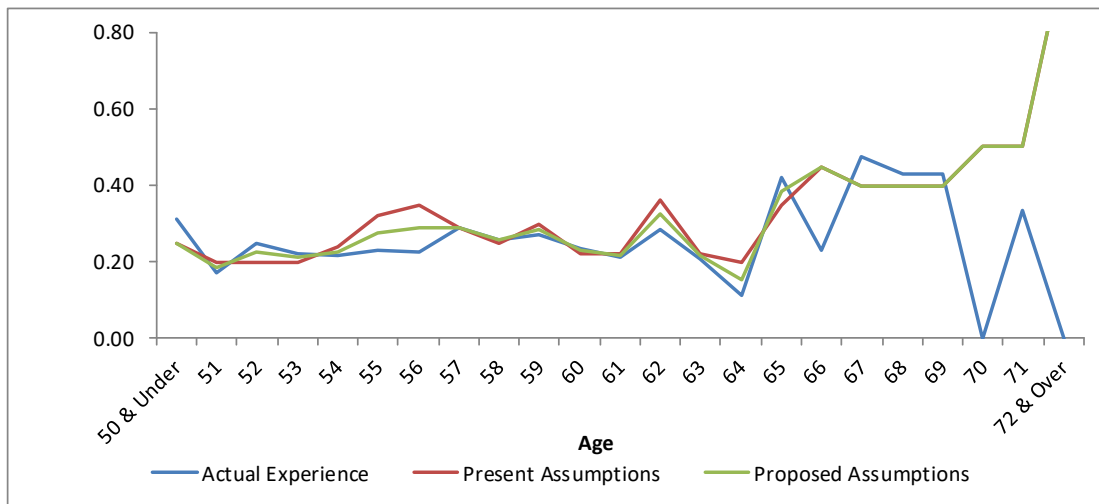
Age	Life Years Exposure	Number of Retirements			Retirement Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
55	129	2	4	4	0.0155	0.0300	0.0300
56	100	4	3	3	0.0400	0.0300	0.0300
57	291	8	12	9	0.0275	0.0400	0.0300
58	272	9	5	8	0.0331	0.0200	0.0300
59	251	6	10	8	0.0239	0.0400	0.0300
60	160	12	8	8	0.0750	0.0500	0.0500
61	138	5	7	7	0.0362	0.0500	0.0500
62	43	8	17	12	0.1860	0.4000	0.2800
63	32	-	11	8	0.0000	0.3500	0.2450
64	23	4	7	5	0.1739	0.3000	0.2100
Totals	1,439	58	84	72	0.0403	0.0584	0.0500



# Non-Uniformed Females Closed and Year 2000 Plans Age & Service Normal Retirement Experience

There were 292 age and service unreduced retirements and 1,187 life years of exposure (exposure includes active members eligible for unreduced retirement) in the female retirement investigation.

Age	Life Years Exposure	Number of Retirements			Retirement Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
50 & Under	16	5	4	4	0.3125	0.2500	0.2500
51	41	7	8	8	0.1707	0.2000	0.1850
52	60	15	12	14	0.2500	0.2000	0.2250
53	82	18	16	17	0.2195	0.2000	0.2100
54	84	18	20	19	0.2143	0.2400	0.2250
55	91	21	29	25	0.2308	0.3200	0.2750
56	84	19	29	24	0.2262	0.3500	0.2900
57	80	23	23	23	0.2875	0.2900	0.2900
58	74	19	19	19	0.2568	0.2500	0.2550
59	77	21	23	22	0.2727	0.3000	0.2850
60	72	17	16	17	0.2361	0.2200	0.2300
61	71	15	16	15	0.2113	0.2200	0.2150
62	98	28	35	32	0.2857	0.3600	0.3250
63	67	14	15	14	0.2090	0.2200	0.2150
64	53	6	11	8	0.1132	0.2000	0.1550
65	50	21	18	19	0.4200	0.3500	0.3850
66	26	6	12	12	0.2308	0.4500	0.4500
67	19	9	8	8	0.4737	0.4000	0.4000
68	14	6	6	6	0.4286	0.4000	0.4000
69	7	3	3	3	0.4286	0.4000	0.4000
70	4	-	2	2	0.0000	0.5000	0.5000
71	3	1	2	2	0.3333	0.5000	0.5000
72 & Over	14	-	14	14	0.0000	1.0000	1.0000
Totals	1,187	292	341	327	0.2460	0.2873	0.2755

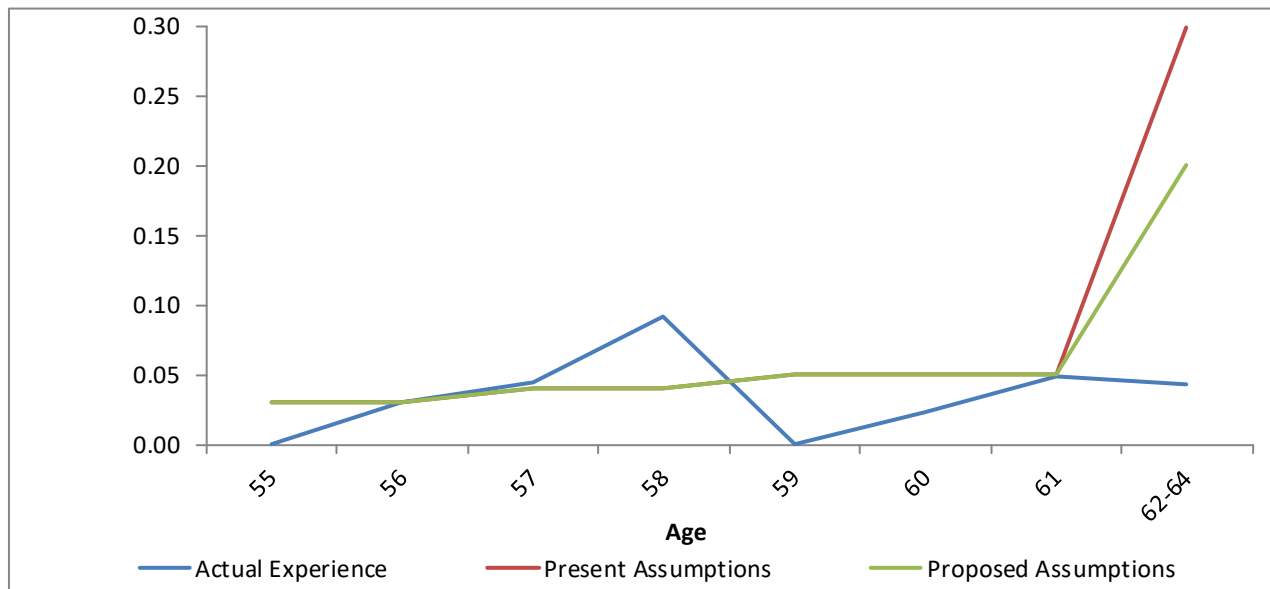




# Non-Uniformed Females Closed and Year 2000 Plans Age & Service Reduced Early Retirement Experience

There were 16 age and service reduced retirements and 397 life years of exposure (exposure includes active members eligible for reduced retirement) in the female retirement investigation.

Age	Life Years Exposure	Number of Retirements			Retirement Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
55	42	-	1	1	0.0000	0.0300	0.0300
56	33	1	1	1	0.0303	0.0300	0.0300
57	89	4	4	4	0.0449	0.0400	0.0400
58	76	7	3	3	0.0921	0.0400	0.0400
59	49	-	2	2	0.0000	0.0500	0.0500
60	44	1	2	2	0.0227	0.0500	0.0500
61	41	2	2	2	0.0488	0.0500	0.0500
62-64	23	1	7	4	0.0435	0.3000	0.2000
Totals	397	16	22	19	0.0403	0.0554	0.0479



# Non-Uniformed Members 2011 Tier Plan Age & Service Normal Retirement Experience

The data for 2011 Tier plan members is insufficient for retirement purposes. The present rates appear generally reasonable and we recommend their continued use.

Age	Present		Proposed	
	Age & Service	Rule of 90	Age & Service	Rule of 90
55		0.3000		0.3000
56		0.3000		0.3000
57		0.3000		0.3000
58		0.3000		0.3000
59		0.3000		0.3000
60		0.3000		0.3000
61		0.3000		0.3000
62		0.3000		0.3000
63		0.3000		0.3000
64		0.3000		0.3000
65		0.3000		0.3000
66		0.3000		0.3000
67	0.5000	0.3000	0.5000	0.3000
68	0.5000	0.3000	0.5000	0.3000
69	0.5000	0.3000	0.5000	0.3000
70	1.0000	1.0000	1.0000	1.0000



# Non-Uniformed Members 2011 Tier Plan Age & Service Reduced Early Retirement Experience

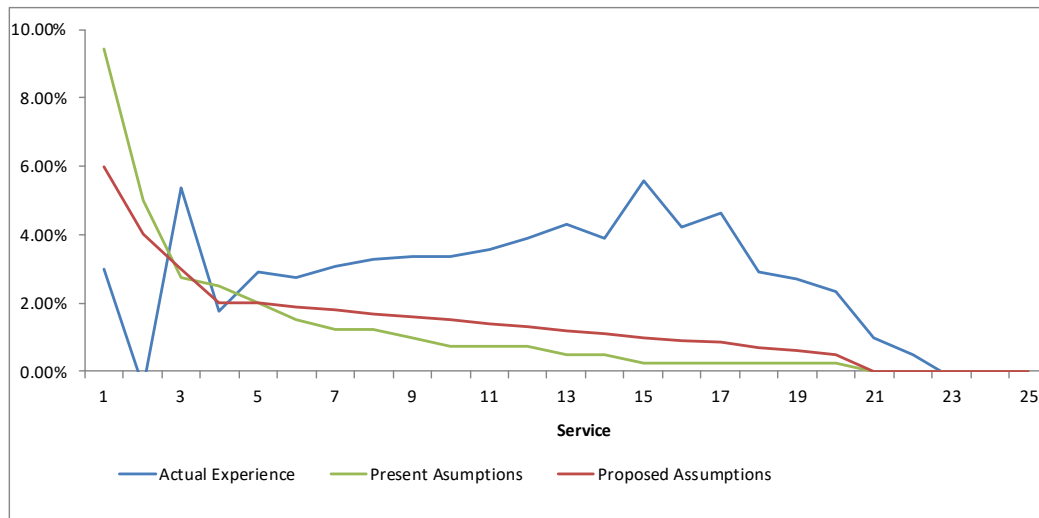
The data for 2011 Tier plan members is insufficient for early retirement purposes. The present rates appear generally reasonable and we recommend their continued use.

Age	Retirement Rates	
	Present	Proposed
62	0.1000	0.1000
63	0.1000	0.1000
64	0.1000	0.1000
65	0.1000	0.1000
66	0.1000	0.1000

# Uniformed Members Pay Increase Assumptions

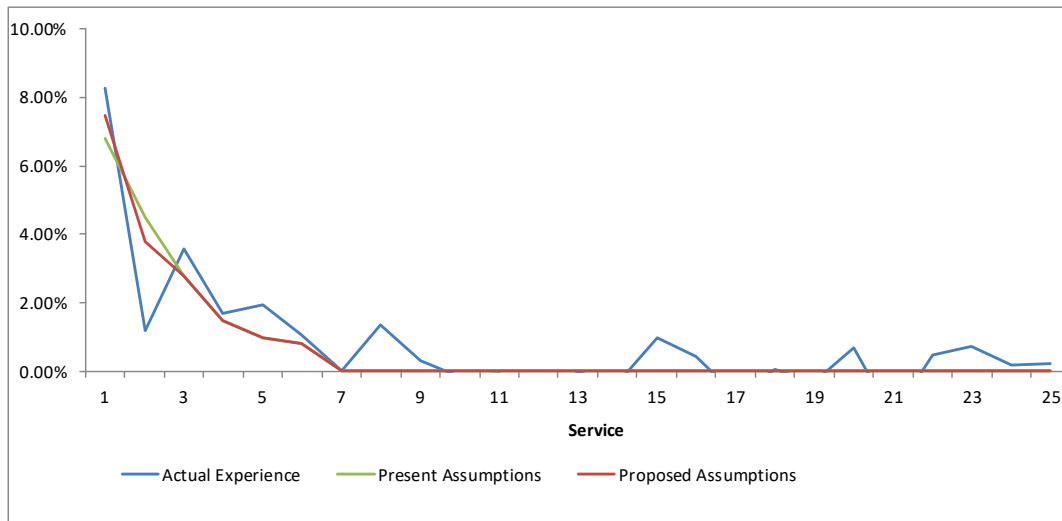
We began our study by analyzing the gross rates of salary increases from 2017 to 2022 but determined more data was needed to complete our analysis. Accordingly, we extended our study from 2013 to 2022. These results are shown below:

Service Index	Number	Merit & Seniority		
		Actual	Present	Proposed
1	160	3.01 %	9.45 %	6.00 %
2	444	(0.45)%	5.00 %	4.00 %
3	458	5.38 %	2.75 %	3.00 %
4	441	1.77 %	2.50 %	2.00 %
5	422	2.90 %	2.00 %	2.00 %
6	427	2.75 %	1.50 %	1.90 %
7	390	3.08 %	1.25 %	1.80 %
8	380	3.26 %	1.25 %	1.70 %
9	365	3.35 %	1.00 %	1.60 %
10	358	3.38 %	0.75 %	1.50 %
11	370	3.59 %	0.75 %	1.40 %
12	354	3.91 %	0.75 %	1.30 %
13	363	4.29 %	0.50 %	1.20 %
14	347	3.92 %	0.50 %	1.10 %
15	340	5.59 %	0.25 %	1.00 %
16	365	4.21 %	0.25 %	0.90 %
17	382	4.64 %	0.25 %	0.85 %
18	443	2.90 %	0.25 %	0.70 %
19	463	2.69 %	0.25 %	0.60 %
20	470	2.33 %	0.25 %	0.50 %
21	449	1.00 %	0.00 %	0.00 %
22	439	0.49 %	0.00 %	0.00 %
23	442	(0.17)%	0.00 %	0.00 %
24	457	(0.48)%	0.00 %	0.00 %
25	436	0.00 %	0.00 %	0.00 %



## Non-Uniformed Members Pay Increase Assumptions

Service Index	Number	Merit & Seniority		
		Actual	Present	Proposed
1	825	8.30 %	6.80 %	7.50 %
2	1,987	1.20 %	4.50 %	3.80 %
3	1,741	3.57 %	2.80 %	2.80 %
4	1,604	1.68 %	1.50 %	1.50 %
5	1,439	1.93 %	1.00 %	1.00 %
6	1,197	1.08 %	0.80 %	0.80 %
7	920	0.02 %	0.00 %	0.00 %
8	736	1.35 %	0.00 %	0.00 %
9	626	0.32 %	0.00 %	0.00 %
10	605	(0.16)%	0.00 %	0.00 %
11	675	(0.08)%	0.00 %	0.00 %
12	779	(0.74)%	0.00 %	0.00 %
13	827	(0.02)%	0.00 %	0.00 %
14	884	(0.34)%	0.00 %	0.00 %
15	882	0.98 %	0.00 %	0.00 %
16	844	0.44 %	0.00 %	0.00 %
17	838	(0.71)%	0.00 %	0.00 %
18	916	0.04 %	0.00 %	0.00 %
19	938	(0.31)%	0.00 %	0.00 %
20	884	0.69 %	0.00 %	0.00 %
21	857	(1.32)%	0.00 %	0.00 %
22	832	0.48 %	0.00 %	0.00 %
23	736	0.74 %	0.00 %	0.00 %
24	711	0.18 %	0.00 %	0.00 %
25	654	0.24 %	0.00 %	0.00 %



## SECTION E

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### MORTALITY

# Mortality Experience

Post-retirement mortality is an important component in cost calculations and should be updated from time to time to reflect current and expected future longevity improvements. Pre-retirement mortality is a relatively minor component in cost calculations. The frequency of pre-retirement deaths is so low that mortality assumptions based solely on actual experience cannot be produced even for very large retirement systems.

## Actuarial Standards of Practice

Actuarial Standards of Practice (ASOP) No. 35 Disclosure Section 4.1.1 states, “The disclosure of the mortality assumption should contain sufficient detail to permit another qualified actuary to understand any adjustment to reflect mortality improvement from the effective date of the table to the measurement date and the provision made for future mortality improvement. If the actuary assumes zero mortality improvement after the measurement date, the actuary should state that no provision was made for future mortality improvement.” The current mortality rates used in the valuation include a provision for future mortality improvement up to calendar year 2022.

## The New Mortality Tables and Projection Scale

The Society of Actuaries (SOA) published new tables called the Pub-2010 tables in early 2019. As opposed to the RP-2014 mortality tables which are based upon private sector pension plan mortality experience, the Pub-2010 mortality tables are based upon public sector pension plan mortality experience. Therefore, our new proposed assumptions are based upon the Pub-2010 mortality tables. The Pub-2010 mortality tables are based upon different employment categories: Teachers, General and Public Safety. We propose updating the Non-Uniformed mortality tables to the Pub-2010 General Healthy Below Median Income tables. We propose updating the Uniformed mortality tables to the Pub-2010 Amount-Weighted Safety Healthy Retiree tables.

The proposed rates assume that future mortality rates will continue to decline with each generation. For this “generational” approach, this means that next year’s 65-year-old will generally have a slightly longer life expectancy than this year’s, etc. The SOA publishes annual mortality improvement scales referred to as MP improvement scales. The mortality improvement scale is applied to the rates of the base mortality table to project future mortality improvement. We propose updating the mortality improvement scale from the currently used MP-2017 projection scale to the most recent scale available at the time of the study, the MP-2021 mortality improvement scale. We modified the scale by reducing the improvement by 10% for years after 2019.

## Partial Credibility

We apply a more formal credibility procedure in accordance with ASOP No. 25, Credibility Procedures. MPERS has a large enough aggregate population to be considered partially credible for determining an appropriate set of base tables for post-retirement. We use a partial credibility procedure based on the limited fluctuation method to determine appropriate adjustments to the base table to be applied to each gender within each member classification. For Uniformed Healthy Male Retirees, using the simplistic credibility procedure would have moved the tables in the wrong direction from the experience therefore we used a scale factor of 105%.

	Benefits- Weighted Deaths Needed for Full	Observed Deaths	Z-Factor	Best Fit	Final Scale Factor
Non-Uniform Healthy Male Retirees	1,430	1,666	100.0%	96%	<b>96%</b>
Non-Uniform Healthy Female Retirees	1,545	181	34.2%	101%	<b>100%</b>
Uniform Healthy Male Retirees	1,166	188	40.2%	106%	<b>105%</b>
Uniform Healthy Female Retirees	1,179	0	0.0%	0%	<b>100%</b>



# Mortality Experience

## Findings

### Healthy Retirees

We reviewed the mortality experience of healthy retirees during the 10-year period on a benefits-weighted basis. We recommend updating the Non-Uniformed post-retirement mortality tables to the Pub-2010 Amount-Weighted, General, Below-Median Income Healthy Retiree tables. We recommend updating the Uniformed post-retirement mortality tables to the Pub-2010 Amount-Weighted, Safety Healthy Retiree tables.

The proposed assumptions are adjusted for mortality improvement back to the observation period base year of 2010 and then projected generationally from 2010 to 2020 using scale MP-2021 and 90% of scale MP-2021 for years following 2020. The assumptions include a margin for future mortality improvements and will result in higher computed liabilities and contributions.

### Disabled Retirees

Disabled member mortality experience during the study period was not sufficient to be credible. We recommend updating the Non-Uniformed disabled retiree mortality tables to the Pub-2010 Amount-Weighted, General Disabled Retiree tables. We recommend updating the Uniformed disabled retiree mortality tables to the Pub-2010 Amount-Weighted, Safety Disabled Retiree tables.

The proposed assumptions are adjusted for mortality improvement back to the observation period base year of 2010 and then projected generationally from 2010 to 2020 using scale MP-2021 and 90% of scale MP-2021 for years following 2020. The assumptions include a margin for future mortality improvements and will result in higher computed liabilities and contributions.

### Active Members

Active member mortality experience during the study period was not sufficient to be credible. We recommend updating the Non-Uniformed pre-retirement mortality tables to the Pub-2010 Amount-Weighted, General, Below-Median Employee tables. We recommend updating the Uniformed pre-retirement mortality tables to the Pub-2010 Amount-Weighted, Safety Employee tables.

The proposed assumptions are adjusted for mortality improvement back to the observation period base year of 2010 and then projected generationally from 2010 to 2020 using scale MP-2021 and 90% of scale MP-2021 for years following 2020. The assumptions include a margin for future mortality improvements and will result in higher computed liabilities and contributions.



## Mortality Experience

The future life expectancies under the current and proposed tables is shown below for both Uniformed and Non-Uniformed Plan members.

Non-Uniformed								
Sample Attained Ages	Future Life Expectancy (years)							
	Present		Proposed 2022*		Proposed 2032*		Proposed 2042*	
	Men	Women	Men	Women	Men	Women	Men	Women
45	39.58	42.25	37.42	42.00	38.39	42.79	39.40	43.58
50	34.68	37.25	32.53	36.94	33.45	37.72	34.43	38.49
55	29.93	32.31	28.19	32.28	29.06	33.02	29.96	33.75
60	25.36	27.53	23.99	27.68	24.79	28.37	25.61	29.04
65	21.01	22.97	19.91	23.13	20.61	23.75	21.34	24.37
70	16.92	18.65	15.96	18.70	16.54	19.24	17.17	19.80
75	13.14	14.60	12.33	14.56	12.79	15.02	13.32	15.50
80	9.76	10.95	9.14	10.86	9.50	11.23	9.91	11.62

\* Life expectancy in future years are determined by 90% of the MP-2021 projection scales.

Uniformed								
Sample Attained Ages	Future Life Expectancy (years)							
	Present		Proposed 2022*		Proposed 2032*		Proposed 2042*	
	Men	Women	Men	Women	Men	Women	Men	Women
45	36.81	39.42	39.93	42.48	40.72	43.23	41.51	43.98
50	32.36	34.85	34.84	37.31	35.61	38.06	36.39	38.79
55	28.05	30.34	29.84	32.24	30.59	32.98	31.35	33.70
60	23.89	25.97	25.01	27.37	25.73	28.08	26.45	28.77
65	19.90	21.76	20.47	22.76	21.12	23.40	21.79	24.04
70	16.11	17.74	16.26	18.40	16.81	18.95	17.40	19.54
75	12.58	13.97	12.41	14.36	12.86	14.83	13.36	15.33
80	9.41	10.56	9.05	10.78	9.40	11.16	9.79	11.56

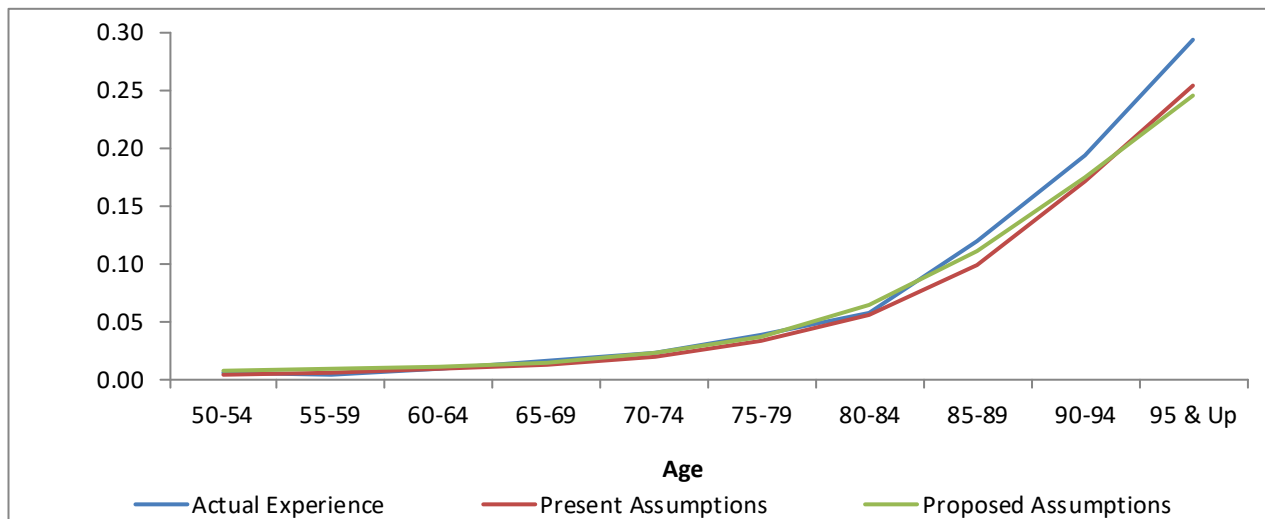
\* Life expectancy in future years are determined by 90% of the MP-2021 projection scales.



# Post-Retirement Mortality Experience Non-Uniformed Healthy Males Benefits-Weighted Analysis (Normal & Early Retirement, Original Annuitants Only)

Actual and expected deaths and exposures are **benefits-weighted** with a scaling factor of 100,000. The analysis is based on the past 10 years of experience.

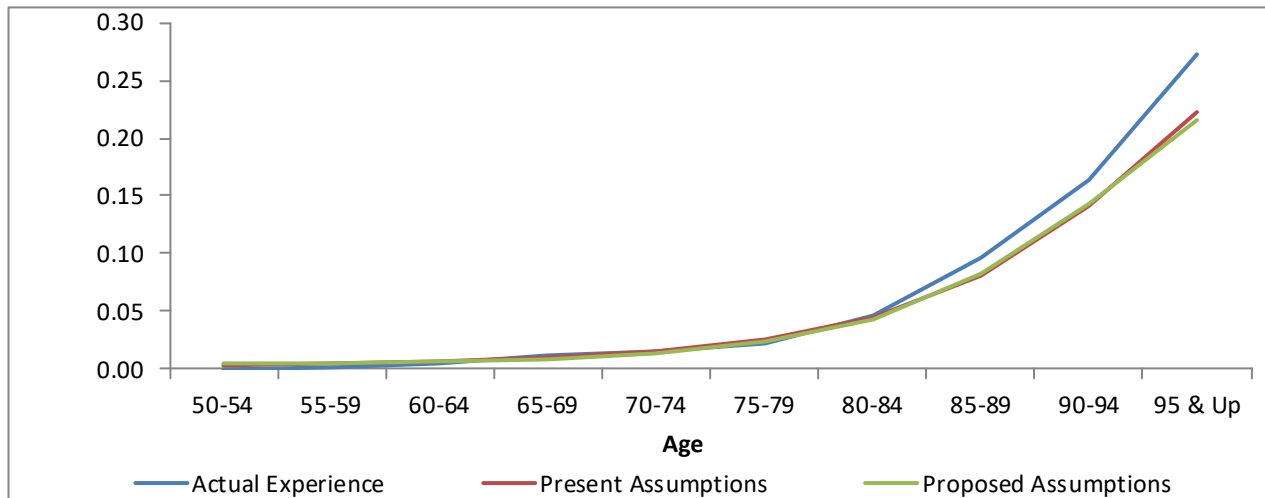
Age	Life Years Exposure	Post-Retirement Death			Post-Retirement Death Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
50-54	397	2	2	3	0.0056	0.00456	0.00714
55-59	1,605	6	11	15	0.0039	0.00640	0.00938
60-64	1,969	17	18	23	0.0088	0.00921	0.01161
65-69	1,974	32	27	29	0.0164	0.01339	0.01461
70-74	1,956	44	40	44	0.0225	0.02026	0.02240
75-79	1,864	71	62	70	0.0379	0.03277	0.03731
80-84	1,564	91	88	101	0.0584	0.05616	0.06481
85-89	878	105	85	95	0.1191	0.09942	0.11090
90-94	278	54	45	46	0.1936	0.17086	0.17422
95 & Up	38	11	9	9	0.2936	0.25444	0.24569
Totals	12,522	433	385	435	0.0346	0.00000	0.03477



# Post-Retirement Mortality Experience Non-Uniformed Healthy Females Benefits-Weighted Analysis (Normal & Early Retirement, Original Annuitants Only)

Actual and expected deaths and exposures are **benefits-weighted** with a scaling factor of 100,000. The analysis is based on the past 10 years of experience.

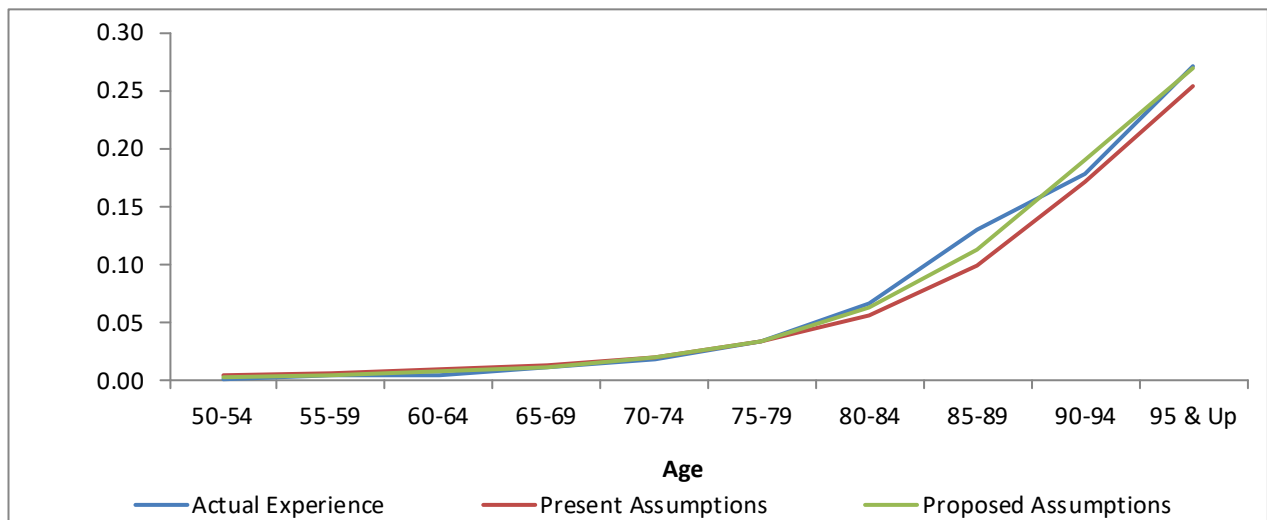
Age	Life Years Exposure	Post-Retirement Death			Post-Retirement Death Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
50-54	104	-	0	0	0.0000	0.00299	0.00422
55-59	436	1	2	2	0.0015	0.00441	0.00511
60-64	510	2	3	3	0.0043	0.00666	0.00596
65-69	369	4	4	3	0.0115	0.00985	0.00789
70-74	234	4	4	3	0.0155	0.01539	0.01322
75-79	127	3	3	3	0.0219	0.02554	0.02378
80-84	79	4	4	3	0.0460	0.04478	0.04369
85-89	40	4	3	3	0.0966	0.08105	0.08179
90-94	16	3	2	2	0.1638	0.14186	0.14345
95 & Up	4	1	1	1	0.2727	0.22234	0.21560
Totals	1,921	25	26	24	0.0128	0.00000	0.01270



# Post-Retirement Mortality Experience Uniformed Healthy Males Benefits-Weighted Analysis (Normal & Early Retirement, Original Annuitants Only)

Actual and expected deaths and exposures are **benefits-weighted** with a scaling factor of 100,000. The analysis is based on the past 10 years of experience.

Age	Life Years Exposure	Post-Retirement Death			Post-Retirement Death Rates		
		Actual Experience	Expected		Actual	Expected	
			Present	Proposed		Present	Proposed
50-54	74	-	0	0	0.0000	0.00456	0.00228
55-59	533	2	4	2	0.0035	0.00640	0.00392
60-64	853	4	8	6	0.0050	0.00921	0.00690
65-69	879	10	12	10	0.0111	0.01339	0.01135
70-74	810	14	17	16	0.0172	0.02026	0.01904
75-79	650	21	21	22	0.0328	0.03277	0.03404
80-84	413	28	23	25	0.0669	0.05616	0.06247
85-89	176	23	17	19	0.1292	0.09942	0.11269
90-94	67	12	11	12	0.1781	0.17086	0.19088
95 & Up	12	3	3	3	0.2707	0.25444	0.27001
Totals	4,467	117	115	116	0.0262	0.00000	0.02592



## **SECTION F**

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### **ACTUARIAL METHODS AND MISCELLANEOUS AND TECHNICAL ASSUMPTIONS**

## Actuarial Methods

**Actuarial Cost Method:** The actuarial cost method is called the Entry Age Actuarial Cost Method. This method is consistent with the Board's level percent-of-payroll funding objective. With this method, the level percent-of-payroll is determined that will fund a member's retirement benefit over the member's entire working lifetime, from date of hire (Entry Age) to date of exit from the active member population. Differences in the past between assumed and actual experience become part of unfunded actuarial accrued liabilities and are amortized with level percent-of-payroll contributions. **We recommend continued use of the entry age actuarial cost method.** Note, this method is required in the Missouri Statutes.

**Asset Valuation Method:** The asset valuation method is a three-year smoothed market value method in which assumed investment return is recognized immediately each year and differences between actual and assumed investment return are phased-in over a closed three-year period. This asset valuation method is intended to give recognition to the long-term accuracy of market values while filtering out and dampening short term market swings. **We recommend continued use of the current asset valuation method.** While we recommend the Board **consider** resetting the actuarial value of assets to the market value, given the recent market volatility, we are not making a hard recommendation to make this change.

### **Amortization Policy:**

*Permanent Policy:* The total contribution will be based on normal cost plus a 13-year amortization of unfunded actuarial accrued liabilities. The amortization period is a closed 13-year period starting July 1, 2023.

*Temporary Accelerated Policy:* The total contribution is based on normal cost plus a 2-year amortization period for unfunded retiree liabilities and a 17-year amortization period for other unfunded liabilities. Both amortization periods are closed periods starting July 1, 2023.

This temporary accelerated policy was adopted by the Retirement Board on September 17, 2009 and will remain in effect until such time as the retiree liability becomes 100% funded or the permanent policy produces a higher contribution rate.

In September 2014, the Board adopted a contribution stabilization reserve fund from experience gains in an effort to keep the employer contribution rate at or near 58%, in the near term. In February 2015, the Board established a maximum of \$250 million in the contribution stabilization reserve fund. The contribution stabilization reserve fund is expected to result in the fund becoming more than 100% funded by the end of the amortization period, if experience is exactly as assumed.



## Actuarial Methods

Given that the temporary policy is set to expire, we feel that it is time to consider whether or not a change in the amortization policy is needed. Some alternative policies for consideration include:

- 1) The current unfunded liability will be amortized over the remaining permanent policy period of 13 years (12 years in the 2023 valuation). Any new gains and losses will be amortized over a closed 20-year period. We refer to this as layered amortization.
- 2) Adopting a layered amortization approach for future gains and losses. The current unfunded liability will be amortized over the remaining permanent policy period of 20 years (20 years in the 2023 valuation). Any new gains and losses will be amortized over a closed 20-year period.
- 3) Reset the amortization period to a closed 20-year period beginning in the 2023 valuation. Discussions will continue prior to the next experience study where we will again recommend adopting a layered amortization approach. Please note, resetting the amortization period frequently is not recommended. The goal of the System is to fund its unfunded actuarial accrued liabilities at 100%. Use of an open or frequent resetting of the amortization period is not conducive to this goal.

## Miscellaneous and Technical Assumptions

<b>Administrative Expenses:</b>	1.38% of payroll, based upon actual results from previous year.
<b>Disability Expenses:</b>	0.475% of payroll included in contribution. Retirement system pays premium directly to an outside insurance company or TPA.
<b>Marriage Assumption:</b>	90% of participants are assumed to be married for purposes of death-in-service benefits. Applies to disabled members entitled to future retirement benefits also. Male spouses are assumed to be 3 years older than females if beneficiary information is not available. For purposes of valuing the 50% death after retirement benefit, 100% of closed active members are assumed to be married.
<b>Pay Increase Timing:</b>	Beginning of (Fiscal) year. This is equivalent to assuming that reported pays represent amounts paid to members during the year ended on the valuation date.
<b>Decrement Timing:</b>	Decrements of all types are assumed to occur mid-year.
<b>Eligibility Testing:</b>	Eligibility for benefits is determined based upon the age nearest birthday and service nearest whole year on the date the decrement is assumed to occur.
<b>Benefit Service:</b>	Exact fractional service is used to determine the amount of benefit payable.
<b>Decrement Relativity:</b>	Decrement rates are used directly from the experience study, without adjustment for multiple decrement table effects.
<b>Normal Form of Benefit:</b>	The assumed normal form of benefit is a 50% joint & survivor benefit for married members in the Closed Plan and a straight life benefit for all other members.
<b>Optional Benefit Factors:</b>	Optional Benefit Factors are in accordance with tables adopted by the Board. We believe these factors are reasonably close to actuarial equivalence based on valuation assumptions. The reduction for the Y2K and 2011 Tier benefits was calculated in accordance with 104.1027 RSMo.
<b>Deferred Plan Choice:</b>	It was assumed that deferred members eligible for the Closed plan would choose the Closed plan benefits at retirement.
<b>Other:</b>	Turnover decrements do not operate during retirement eligibility.
<b>Miscellaneous Adjustments:</b>	The calculated normal and early retirement benefits for the Closed and Year 2000 plans were increased by 3.75% for Uniformed and 2.3% for Non-Uniformed to account for the inclusion of unused sick leave in the calculation of Average Pay. The calculated normal and early retirement benefits for the 2011 Tier plan were increased by 3.75% for Uniformed and 2.3% for Non-Uniformed to account for the inclusion of unused sick leave in the calculation of Average Pay. Post disability benefit liabilities were increased by 25% for all future disabilities to account for potential survivor benefits payable by the retirement system during the period of disability. Current self-insured disability retirant liabilities are increased by 12% to account for future survivor benefits. Liabilities for future deferred members were increased by 3% to account for potential survivor benefits payable if the member dies during the deferred period. The rationale for this load is based on the associated liabilities for the current deferred members.





## Miscellaneous and Technical Assumptions

<b>Contribution Stabilization Reserve Fund:</b>	The contribution stabilization reserve fund affects the total amount of UAAL financed and is assumed to grow at the investment return rate.
<b>Death Prior to Retirement:</b>	100% of deaths in service are assumed to be non-duty.
<b>Gainful Employment Offset:</b>	30% of the \$90 per month special benefit is assumed to be offset by gainful employment.
<b>Minimum Benefit Eligibility:</b>	Deferred benefits and death prior to retirement benefits are assumed to be eligible for the minimum base benefit along with normal and early retirement benefits.
<b>Active Plan Choice:</b>	It was assumed that active members eligible for the Closed plan would choose the Closed plan benefits at retirement.
<b>Member Contribution Interest:</b>	Member contributions are assumed to be credited with 3.0% interest.

## **SECTION G**

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### **COMPREHENSIVE LISTING OF DEMOGRAPHIC ASSUMPTIONS**

# Actuarial Assumptions Based on 2017-2022 Experience Study

## Withdrawal Rates

Age	Service	% of Active Participants Withdrawing			
		Uniformed Members		Non-Uniformed Members	
		Male	Female	Male	Female
	0-1	10.00%	10.00%	28.00%	22.00%
	1-2	6.00%	6.00%	18.50%	15.00%
	2-3	3.25%	3.25%	12.50%	14.00%
	3-4	3.00%	3.00%	9.00%	12.00%
	4-5	2.75%	2.75%	8.00%	7.00%
25	5 & Up	3.51%	3.51%	9.04%	10.40%
26		3.51%	3.51%	9.04%	10.40%
27		3.51%	3.51%	9.04%	10.40%
28		3.51%	3.51%	8.71%	10.08%
29		3.51%	3.51%	8.38%	9.75%
30		3.51%	3.51%	8.05%	9.43%
31		3.51%	3.51%	7.73%	9.10%
32		3.39%	3.39%	7.41%	8.78%
33		3.07%	3.07%	7.10%	8.35%
34		2.77%	2.77%	6.79%	7.92%
35		2.49%	2.49%	6.48%	7.49%
36		2.22%	2.22%	6.18%	7.06%
37		1.97%	1.97%	5.89%	6.63%
38		1.76%	1.76%	5.60%	6.33%
39		1.59%	1.59%	5.31%	6.03%
40		1.47%	1.47%	5.04%	5.73%
41		1.37%	1.37%	4.77%	5.43%
42		1.28%	1.28%	4.51%	5.14%
43		1.19%	1.19%	4.26%	4.97%
44		1.11%	1.11%	4.02%	4.80%
45		1.02%	1.02%	3.78%	4.63%
46		0.94%	0.94%	3.55%	4.46%
47		0.85%	0.85%	3.34%	4.29%
48		0.76%	0.76%	3.14%	4.17%
49		0.67%	0.67%	2.95%	4.06%
50		0.59%	0.59%	2.76%	3.94%
51		0.50%	0.50%	2.60%	3.82%
52		0.43%	0.43%	2.43%	3.71%
53		0.38%	0.38%	2.29%	3.71%
54		0.36%	0.36%	2.15%	3.71%
55		0.30%	0.30%	2.02%	3.71%
56		0.32%	0.32%	1.93%	3.71%
57		0.24%	0.24%	1.83%	3.71%
58		0.24%	0.24%	1.75%	3.71%
59		0.23%	0.23%	1.68%	3.71%
60		0.22%	0.22%	1.64%	3.71%
Ref		1426	1426	1427	1428
		1272	1272	63	1429
		130%	130%	110%	130%



# Actuarial Assumptions Based on 2017-2022 Experience Study

## Disability Rates

Age	% of Active Participants Becoming Disabled			
	Uniformed Members		Non-Uniformed Members	
	Male	Female	Male	Female
20	0.10%	0.10%	0.06%	0.06%
21	0.10%	0.10%	0.06%	0.06%
22	0.10%	0.10%	0.07%	0.07%
23	0.10%	0.10%	0.07%	0.07%
24	0.10%	0.10%	0.07%	0.07%
25	0.10%	0.10%	0.08%	0.08%
26	0.10%	0.10%	0.08%	0.08%
27	0.10%	0.10%	0.09%	0.09%
28	0.10%	0.10%	0.09%	0.09%
29	0.10%	0.10%	0.09%	0.09%
30	0.10%	0.10%	0.09%	0.09%
31	0.10%	0.10%	0.09%	0.09%
32	0.10%	0.10%	0.10%	0.10%
33	0.10%	0.10%	0.10%	0.10%
34	0.10%	0.10%	0.11%	0.11%
35	0.10%	0.10%	0.12%	0.12%
36	0.10%	0.10%	0.12%	0.12%
37	0.10%	0.10%	0.13%	0.13%
38	0.10%	0.10%	0.14%	0.14%
39	0.10%	0.10%	0.14%	0.14%
40	0.10%	0.10%	0.16%	0.16%
41	0.10%	0.10%	0.18%	0.18%
42	0.10%	0.10%	0.20%	0.20%
43	0.10%	0.10%	0.21%	0.21%
44	0.10%	0.10%	0.23%	0.23%
45	0.10%	0.10%	0.26%	0.26%
46	0.10%	0.10%	0.28%	0.28%
47	0.10%	0.10%	0.31%	0.31%
48	0.10%	0.10%	0.34%	0.34%
49	0.10%	0.10%	0.38%	0.38%
50	0.10%	0.10%	0.43%	0.43%
51	0.10%	0.10%	0.49%	0.49%
52	0.10%	0.10%	0.56%	0.56%
53	0.10%	0.10%	0.64%	0.64%
54	0.10%	0.10%	0.72%	0.72%
55	0.10%	0.10%	0.82%	0.82%
56	0.10%	0.10%	0.92%	0.92%
57	0.10%	0.10%	1.03%	1.03%
58	0.10%	0.10%	1.15%	1.15%
59	0.10%	0.10%	1.28%	1.28%
60	0.10%	0.10%	1.41%	1.41%
61	0.10%	0.10%	1.55%	1.55%
62	0.10%	0.10%	1.70%	1.70%
63	0.10%	0.10%	1.86%	1.86%
64	0.10%	0.10%	2.03%	2.03%
65	0.10%	0.10%	0.00%	0.00%
66	0.10%	0.10%	0.00%	0.00%
67	0.10%	0.10%	0.00%	0.00%
68	0.10%	0.10%	0.00%	0.00%
69	0.10%	0.10%	0.00%	0.00%
70	0.10%	0.10%	0.00%	0.00%
71	0.10%	0.10%	0.00%	0.00%
72	0.10%	0.10%	0.00%	0.00%
Ref	60	60	189	189
Multiplier	20%	20%	85%	85%



# Actuarial Assumptions Based on 2017-2022 Experience Study

## Salary Scale – Service Based Rates

% Merit Increases in Salaries Next Year		
Service Index	Uniformed Members	Non-Uniformed Members
1	6.00%	7.50%
2	4.00%	3.80%
3	3.00%	2.80%
4	2.00%	1.50%
5	2.00%	1.00%
6	1.90%	0.80%
7	1.80%	0.00%
8	1.70%	0.00%
9	1.60%	0.00%
10	1.50%	0.00%
11	1.40%	0.00%
12	1.30%	0.00%
13	1.20%	0.00%
14	1.10%	0.00%
15	1.00%	0.00%
16	0.90%	0.00%
17	0.85%	0.00%
18	0.70%	0.00%
19	0.60%	0.00%
20	0.50%	0.00%
21	0.00%	0.00%
22	0.00%	0.00%
23	0.00%	0.00%
24	0.00%	0.00%
25	0.00%	0.00%
Ref		968

# Actuarial Assumptions Based on 2017-2022 Experience Study

## Normal and Early Retirement Pattern

Age	% of Active Participants Retiring								
	Closed and Year 2000 Plans					2011 Tier			
	Non-Uniformed Members				Uniformed	Non-Uniformed			Uniformed
	Male		Female			Normal		Early	
	Normal	Early	Normal	Early	Normal	Age & Service	Rule of 90		Early
50	39%		25%		45%				
51	35%		19%		15%				
52	27%		23%		18%				
53	22%		21%		16%				
54	21%		23%		19%				
55	25%	3%	28%	3%	26%		30%		30%
56	27%	3%	29%	3%	30%		30%		30%
57	24%	3%	29%	4%	28%		30%		30%
58	21%	3%	26%	4%	30%		30%		30%
59	22%	3%	29%	5%	40%		30%		30%
60	21%	5%	23%	5%	100%		30%		100%
61	19%	5%	22%	5%	100%		30%		100%
62	32%	28%	33%	20%	100%		30%	10%	100%
63	32%	25%	22%	20%	100%		30%	10%	100%
64	22%	21%	16%	20%	100%		30%	10%	100%
65	30%		39%		100%		30%	10%	100%
66	40%		45%		100%		30%	10%	100%
67	40%		40%		100%	50%	30%		100%
68	30%		40%		100%	50%	30%		100%
69	30%		40%		100%	50%	30%		100%
70	40%		50%		100%	100%	100%		100%
71	50%		50%		100%	100%	100%		100%
72	50%		100%		100%	100%	100%		100%
73	50%		100%		100%	100%	100%		100%
74	100%		100%		100%	100%	100%		100%
Ref	3363	3365	3364	3366	3362	1873	1875	1262	1875
	50	55	50	55	50	67	55	62	45



# Actuarial Assumptions Based on 2017-2022 Experience Study

## Non-Uniform Retired Lives Mortality Rates

Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year	
	Male	Female		Male	Female		Male	Female
20	0.0405%	0.0141%	60	1.0724%	0.5555%	100	29.8020%	27.0922%
21	0.0422%	0.0144%	61	1.1162%	0.5742%	101	31.7544%	29.1890%
22	0.0421%	0.0136%	62	1.1564%	0.5944%	102	33.6940%	31.3076%
23	0.0433%	0.0139%	63	1.1945%	0.6162%	103	35.6193%	33.4353%
24	0.0435%	0.0131%	64	1.2301%	0.6389%	104	37.5007%	35.5454%
25	0.0462%	0.0146%	65	1.2670%	0.6637%	105	39.3236%	37.6348%
26	0.0502%	0.0163%	66	1.3562%	0.7199%	106	41.0920%	39.6617%
27	0.0544%	0.0180%	67	1.4589%	0.7841%	107	42.7965%	41.6329%
28	0.0589%	0.0210%	68	1.5743%	0.8591%	108	44.4065%	43.5324%
29	0.0648%	0.0228%	69	1.7070%	0.9456%	109	45.9462%	45.3425%
30	0.0694%	0.0260%	70	1.8570%	1.0466%	110	47.1913%	47.0553%
31	0.0752%	0.0291%	71	2.0272%	1.1641%	111	47.3399%	48.6742%
32	0.0808%	0.0308%	72	2.2197%	1.2992%	112	47.4884%	49.5821%
33	0.0862%	0.0351%	73	2.4398%	1.4556%	113	47.6417%	49.7133%
34	0.0925%	0.0377%	74	2.6913%	1.6348%	114	47.8012%	49.8357%
35	0.0969%	0.0414%	75	2.9776%	1.8394%	115	47.9510%	49.9630%
36	0.1032%	0.0432%	76	3.3042%	2.0714%	116	47.9736%	49.9815%
37	0.1071%	0.0473%	77	3.6740%	2.3343%	117	47.9870%	49.9910%
38	0.1128%	0.0496%	78	4.0933%	2.6346%	118	48.0000%	50.0000%
39	0.1173%	0.0526%	79	4.5683%	2.9742%	119	48.0000%	50.0000%
40	0.1219%	0.0552%	80	5.1039%	3.3620%	120	100.0000%	100.0000%
41	0.1256%	0.0573%	81	5.7109%	3.8059%	Ref	2753 x 96%	2754 x 100%
42	0.1307%	0.0593%	82	6.3919%	4.3117%	Set Back	0	0
43	0.1350%	0.0621%	83	7.1494%	4.8892%	Proj. Scale	983	984
44	0.1409%	0.0659%	84	7.9882%	5.5477%	Base Year	2010	2010
45	0.1793%	0.0872%	85	8.9082%	6.2983%	Proj. Year	2022	2022
46	0.2292%	0.1163%	86	9.9071%	7.1519%			
47	0.2947%	0.1550%	87	10.9801%	8.1147%			
48	0.3814%	0.2085%	88	12.1310%	9.1896%			
49	0.4967%	0.2829%	89	13.3588%	10.3682%			
50	0.6510%	0.3857%	90	14.6499%	11.6366%			
51	0.6774%	0.3987%	91	15.9729%	12.9500%			
52	0.7092%	0.4138%	92	17.2999%	14.2752%			
53	0.7461%	0.4311%	93	18.6276%	15.6091%			
54	0.7861%	0.4496%	94	19.9658%	16.9487%			
55	0.8305%	0.4687%	95	21.3154%	18.3253%			
56	0.8780%	0.4865%	96	22.8201%	19.8403%			
57	0.9269%	0.5040%	97	24.4075%	21.4606%			
58	0.9767%	0.5204%	98	26.0989%	23.2072%			
59	1.0252%	0.5381%	99	27.9047%	25.0840%			



# Actuarial Assumptions Based on 2017-2022 Experience Study

## Non-Uniform Death-in-Service Rates\*

Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year	
	Male	Female		Male	Female		Male	Female
20	0.0422%	0.0141%	60	0.4807%	0.2481%	100	31.0437%	27.0922%
21	0.0440%	0.0144%	61	0.5207%	0.2685%	101	33.0775%	29.1890%
22	0.0439%	0.0136%	62	0.5624%	0.2901%	102	35.0979%	31.3076%
23	0.0451%	0.0139%	63	0.6041%	0.3126%	103	37.1034%	33.4353%
24	0.0453%	0.0131%	64	0.6453%	0.3361%	104	39.0632%	35.5454%
25	0.0481%	0.0146%	65	0.6882%	0.3629%	105	40.9621%	37.6348%
26	0.0523%	0.0163%	66	0.7317%	0.3912%	106	42.8042%	39.6617%
27	0.0567%	0.0180%	67	0.7794%	0.4236%	107	44.5797%	41.6329%
28	0.0614%	0.0210%	68	0.8296%	0.4606%	108	46.2568%	43.5324%
29	0.0675%	0.0228%	69	0.8872%	0.5034%	109	47.8606%	45.3425%
30	0.0723%	0.0260%	70	0.9505%	0.5519%	110	49.1576%	47.0553%
31	0.0783%	0.0291%	71	1.0234%	0.6070%	111	49.3124%	48.6742%
32	0.0842%	0.0308%	72	1.1058%	0.6710%	112	49.4671%	49.5821%
33	0.0898%	0.0351%	73	1.1998%	0.7431%	113	49.6268%	49.7133%
34	0.0964%	0.0377%	74	1.3065%	0.8244%	114	49.7929%	49.8357%
35	0.1009%	0.0414%	75	1.4260%	0.9171%	115	49.9490%	49.9630%
36	0.1075%	0.0432%	76	1.5605%	1.0205%	116	49.9725%	49.9815%
37	0.1116%	0.0473%	77	1.7110%	1.1361%	117	49.9865%	49.9910%
38	0.1175%	0.0496%	78	1.8785%	1.2648%	118	50.0000%	50.0000%
39	0.1222%	0.0526%	79	2.0645%	1.4077%	119	50.0000%	50.0000%
40	0.1270%	0.0552%	80	2.2708%	1.5670%	120	100.0000%	100.0000%
41	0.1308%	0.0573%	81	2.9216%	2.0214%	Ref	2771 x 100%	2772 x 100%
42	0.1361%	0.0593%	82	3.7601%	2.6062%	Set Back	0	0
43	0.1406%	0.0621%	83	4.8381%	3.3578%	Proj. Scale	983	984
44	0.1468%	0.0659%	84	6.2272%	4.3232%	Base Year	2010	2010
45	0.1526%	0.0698%	85	8.0164%	5.5619%	Proj. Year	2022	2022
46	0.1605%	0.0737%	86	10.3199%	7.1519%			
47	0.1695%	0.0780%	87	11.4376%	8.1147%			
48	0.1797%	0.0836%	88	12.6365%	9.1896%			
49	0.1915%	0.0906%	89	13.9154%	10.3682%			
50	0.2050%	0.0983%	90	15.2603%	11.6366%			
51	0.2206%	0.1066%	91	16.6384%	12.9500%			
52	0.2382%	0.1166%	92	18.0207%	14.2752%			
53	0.2581%	0.1284%	93	19.4037%	15.6091%			
54	0.2815%	0.1417%	94	20.7977%	16.9487%			
55	0.3072%	0.1566%	95	22.2035%	18.3253%			
56	0.3364%	0.1727%	96	23.7709%	19.8403%			
57	0.3678%	0.1907%	97	25.4245%	21.4606%			
58	0.4029%	0.2082%	98	27.1864%	23.2072%			
59	0.4411%	0.2278%	99	29.0674%	25.0840%			

\* Rates and life expectancies in future years are determined by the MP-2021 projection scale.





# Actuarial Assumptions Based on 2017-2022 Experience Study

## Non-Uniform Disabled Retired Lives Mortality Rates\*

Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year	
	Male	Female		Male	Female		Male	Female
20	0.4240%	0.2523%	60	2.5818%	2.0386%	100	31.0437%	27.0922%
21	0.4040%	0.2377%	61	2.6802%	2.0656%	101	33.0775%	29.1890%
22	0.3765%	0.2194%	62	2.7776%	2.0875%	102	35.0979%	31.3076%
23	0.3472%	0.2039%	63	2.8758%	2.1074%	103	37.1034%	33.4353%
24	0.3276%	0.1948%	64	2.9740%	2.1278%	104	39.0632%	35.5454%
25	0.3261%	0.1999%	65	3.0715%	2.1544%	105	40.9621%	37.6348%
26	0.3551%	0.2238%	66	3.1698%	2.1905%	106	42.8042%	39.6617%
27	0.3859%	0.2513%	67	3.2706%	2.2417%	107	44.5797%	41.6329%
28	0.4193%	0.2825%	68	3.3757%	2.3111%	108	46.2568%	43.5324%
29	0.4549%	0.3156%	69	3.4903%	2.4026%	109	47.8606%	45.3425%
30	0.4919%	0.3517%	70	3.6176%	2.5192%	110	49.1576%	47.0553%
31	0.5298%	0.3901%	71	3.7648%	2.6620%	111	49.3124%	48.6742%
32	0.5679%	0.4298%	72	3.9343%	2.8337%	112	49.4671%	49.5821%
33	0.6053%	0.4715%	73	4.1331%	3.0356%	113	49.6268%	49.7133%
34	0.6438%	0.5123%	74	4.3638%	3.2713%	114	49.7929%	49.8357%
35	0.6794%	0.5528%	75	4.6302%	3.5434%	115	49.9490%	49.9630%
36	0.7154%	0.5915%	76	4.9346%	3.8522%	116	49.9725%	49.9815%
37	0.7505%	0.6295%	77	5.2821%	4.2015%	117	49.9865%	49.9910%
38	0.7855%	0.6659%	78	5.6747%	4.5947%	118	50.0000%	50.0000%
39	0.8194%	0.7023%	79	6.1182%	5.0333%	119	50.0000%	50.0000%
40	0.8533%	0.7383%	80	6.6135%	5.5209%	120	100.0000%	100.0000%
41	0.8887%	0.7748%	81	7.1674%	6.0625%	Ref	2711 x 100%	2712 x 100%
42	0.9271%	0.8130%	82	7.7789%	6.6598%	Set Back	0	0
43	0.9691%	0.8545%	83	8.4472%	7.3159%	Proj. Scale	983	984
44	1.0187%	0.9012%	84	9.1763%	8.0345%	Base Year	2010	2010
45	1.0748%	0.9543%	85	9.9630%	8.8202%	Proj. Year	2022	2022
46	1.1412%	1.0143%	86	10.8086%	9.6399%			
47	1.2171%	1.0834%	87	11.7145%	10.4790%			
48	1.3036%	1.1639%	88	12.6915%	11.3312%			
49	1.4006%	1.2570%	89	13.9154%	12.1927%			
50	1.5094%	1.3621%	90	15.2603%	13.0725%			
51	1.5999%	1.4232%	91	16.6384%	13.9935%			
52	1.6981%	1.4926%	92	18.0207%	14.9673%			
53	1.8032%	1.5709%	93	19.4037%	16.0167%			
54	1.9145%	1.6536%	94	20.7977%	17.1503%			
55	2.0297%	1.7373%	95	22.2035%	18.3949%			
56	2.1462%	1.8171%	96	23.7709%	19.8412%			
57	2.2601%	1.8893%	97	25.4245%	21.4606%			
58	2.3722%	1.9506%	98	27.1864%	23.2072%			
59	2.4789%	1.9999%	99	29.0674%	25.0840%			

\* Rates and life expectancies in future years are determined by the MP-2021 projection scale.



# Actuarial Assumptions Based on 2017-2022 Experience Study

## Uniform Retired Lives Mortality Rates\*

Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year	
	Male	Female		Male	Female		Male	Female
20	0.0443%	0.0173%	60	0.5502%	0.4648%	100	32.5959%	27.0922%
21	0.0450%	0.0188%	61	0.6165%	0.5133%	101	34.7314%	29.1890%
22	0.0449%	0.0192%	62	0.6874%	0.5638%	102	36.8528%	31.3076%
23	0.0450%	0.0209%	63	0.7632%	0.6172%	103	38.9586%	33.4353%
24	0.0453%	0.0226%	64	0.8451%	0.6741%	104	41.0164%	35.5454%
25	0.0456%	0.0244%	65	0.9334%	0.7353%	105	43.0102%	37.6348%
26	0.0485%	0.0263%	66	1.0288%	0.8011%	106	44.9444%	39.6617%
27	0.0517%	0.0282%	67	1.1338%	0.8756%	107	46.8087%	41.6329%
28	0.0548%	0.0315%	68	1.2492%	0.9608%	108	48.5696%	43.5324%
29	0.0581%	0.0336%	69	1.3795%	1.0575%	109	50.2536%	45.3425%
30	0.0598%	0.0369%	70	1.5268%	1.1698%	110	51.6155%	47.0553%
31	0.0628%	0.0389%	71	1.6954%	1.2981%	111	51.7780%	48.6742%
32	0.0656%	0.0420%	72	1.8867%	1.4461%	112	51.9405%	49.5821%
33	0.0680%	0.0449%	73	2.1062%	1.6160%	113	52.1081%	49.7133%
34	0.0701%	0.0475%	74	2.3586%	1.8099%	114	52.2825%	49.8357%
35	0.0732%	0.0496%	75	2.6462%	2.0315%	115	52.4464%	49.9630%
36	0.0757%	0.0513%	76	2.9758%	2.2817%	116	52.4711%	49.9815%
37	0.0760%	0.0539%	77	3.3515%	2.5642%	117	52.4858%	49.9910%
38	0.0788%	0.0546%	78	3.7805%	2.8836%	118	52.5000%	50.0000%
39	0.0807%	0.0563%	79	4.2687%	3.2406%	119	52.5000%	50.0000%
40	0.0889%	0.0599%	80	4.8225%	3.6414%	120	100.0000%	100.0000%
41	0.0973%	0.0641%	81	5.4510%	4.0910%	Ref	2703 x 105%	2704 x 100%
42	0.1059%	0.0679%	82	6.1605%	4.5920%	Set Back	0	0
43	0.1159%	0.0725%	83	6.9537%	5.1505%	Proj. Scale	983	984
44	0.1261%	0.0779%	84	7.8438%	5.7736%	Base Year	2010	2010
45	0.1367%	0.0843%	85	8.8361%	6.4675%	Proj. Year	2022	2022
46	0.1437%	0.0917%	86	9.9389%	7.2392%			
47	0.1528%	0.1003%	87	11.1576%	8.0995%			
48	0.1632%	0.1102%	88	12.5071%	9.0589%			
49	0.1761%	0.1227%	89	13.9986%	10.1235%			
50	0.1896%	0.1368%	90	15.6359%	11.3027%			
51	0.2071%	0.1548%	91	17.3122%	12.5632%			
52	0.2266%	0.1749%	92	18.9544%	13.8751%			
53	0.2494%	0.1983%	93	20.5362%	15.2311%			
54	0.2767%	0.2258%	94	22.0630%	16.6230%			
55	0.3085%	0.2573%	95	23.5416%	18.0698%			
56	0.3450%	0.2925%	96	25.1483%	19.6608%			
57	0.3871%	0.3309%	97	26.8237%	21.3526%			
58	0.4358%	0.3726%	98	28.6133%	23.1555%			
59	0.4899%	0.4169%	99	30.5417%	25.0696%			

\* Rates and life expectancies in future years are determined by the MP-2021 projection scale.



# Actuarial Assumptions Based on 2017-2022 Experience Study

## Uniform Death-in-Service Rates\*

Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year	
	Male	Female		Male	Female		Male	Female
20	0.0422%	0.0173%	60	0.2723%	0.1751%	100	31.0437%	27.0922%
21	0.0429%	0.0188%	61	0.2987%	0.1838%	101	33.0775%	29.1890%
22	0.0428%	0.0192%	62	0.3268%	0.1934%	102	35.0979%	31.3076%
23	0.0429%	0.0209%	63	0.3552%	0.2018%	103	37.1034%	33.4353%
24	0.0431%	0.0226%	64	0.3835%	0.2100%	104	39.0632%	35.5454%
25	0.0434%	0.0244%	65	0.4137%	0.2177%	105	40.9621%	37.6348%
26	0.0462%	0.0263%	66	0.4616%	0.2446%	106	42.8042%	39.6617%
27	0.0492%	0.0282%	67	0.5131%	0.2745%	107	44.5797%	41.6329%
28	0.0522%	0.0315%	68	0.5719%	0.3104%	108	46.2568%	43.5324%
29	0.0553%	0.0336%	69	0.6366%	0.3516%	109	47.8606%	45.3425%
30	0.0570%	0.0369%	70	0.7103%	0.3996%	110	49.1576%	47.0553%
31	0.0598%	0.0389%	71	0.7945%	0.4564%	111	49.3124%	48.6742%
32	0.0625%	0.0420%	72	0.8912%	0.5232%	112	49.4671%	49.5821%
33	0.0648%	0.0449%	73	1.0020%	0.6012%	113	49.6268%	49.7133%
34	0.0668%	0.0475%	74	1.1294%	0.6924%	114	49.7929%	49.8357%
35	0.0697%	0.0496%	75	1.2771%	0.7993%	115	49.9490%	49.9630%
36	0.0721%	0.0513%	76	1.4455%	0.9234%	116	49.9725%	49.9815%
37	0.0724%	0.0539%	77	1.6397%	1.0679%	117	49.9865%	49.9910%
38	0.0750%	0.0546%	78	1.8624%	1.2358%	118	50.0000%	50.0000%
39	0.0769%	0.0563%	79	2.1174%	1.4287%	119	50.0000%	50.0000%
40	0.0781%	0.0575%	80	2.4076%	1.6516%	120	100.0000%	100.0000%
41	0.0787%	0.0585%	81	3.0237%	2.1168%	Ref	2721 x 100%	2722 x 100%
42	0.0814%	0.0604%	82	3.7991%	2.7105%	Set Back	0	0
43	0.0825%	0.0611%	83	4.7724%	3.4683%	Proj. Scale	983	984
44	0.0845%	0.0629%	84	5.9962%	4.4352%	Base Year	2010	2010
45	0.0875%	0.0649%	85	7.5346%	5.6678%	Proj. Year	2022	2022
46	0.0906%	0.0671%	86	9.4656%	7.2392%			
47	0.0947%	0.0706%	87	10.6263%	8.0995%			
48	0.0991%	0.0735%	88	11.9115%	9.0589%			
49	0.1058%	0.0778%	89	13.3320%	10.1235%			
50	0.1129%	0.0836%	90	14.8913%	11.3027%			
51	0.1206%	0.0899%	91	16.4878%	12.5632%			
52	0.1308%	0.0969%	92	18.0518%	13.8751%			
53	0.1417%	0.1044%	93	19.5583%	15.2311%			
54	0.1535%	0.1134%	94	21.0124%	16.6230%			
55	0.1680%	0.1227%	95	22.4206%	18.0698%			
56	0.1853%	0.1331%	96	23.9508%	19.6608%			
57	0.2032%	0.1443%	97	25.5464%	21.3526%			
58	0.2246%	0.1540%	98	27.2508%	23.1555%			
59	0.2481%	0.1651%	99	29.0873%	25.0696%			

\* Rates and life expectancies in future years are determined by the MP-2021 projection scale.



# Actuarial Assumptions Based on 2017-2022 Experience Study

## Uniform Disabled Retired Lives Mortality Rates\*

Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year		Age in 2022	% Dying Next Year	
	Male	Female		Male	Female		Male	Female
20	0.1245%	0.0574%	60	0.7581%	0.7285%	100	31.0437%	27.0922%
21	0.1266%	0.0619%	61	0.8391%	0.7849%	101	33.0775%	29.1890%
22	0.1262%	0.0656%	62	0.9234%	0.8407%	102	35.0979%	31.3076%
23	0.1253%	0.0695%	63	1.0119%	0.8969%	103	37.1034%	33.4353%
24	0.1258%	0.0736%	64	1.1025%	0.9535%	104	39.0632%	35.5454%
25	0.1290%	0.0792%	65	1.1967%	1.0132%	105	40.9621%	37.6348%
26	0.1374%	0.0875%	66	1.2945%	1.0766%	106	42.8042%	39.6617%
27	0.1450%	0.0949%	67	1.3988%	1.1474%	107	44.5797%	41.6329%
28	0.1528%	0.1038%	68	1.5097%	1.2262%	108	46.2568%	43.5324%
29	0.1620%	0.1128%	69	1.6312%	1.3149%	109	47.8606%	45.3425%
30	0.1695%	0.1218%	70	1.7685%	1.4172%	110	49.1576%	47.0553%
31	0.1780%	0.1319%	71	1.9250%	1.5329%	111	49.3124%	48.6742%
32	0.1859%	0.1414%	72	2.1093%	1.6640%	112	49.4671%	49.5821%
33	0.1929%	0.1502%	73	2.3276%	1.8122%	113	49.6268%	49.7133%
34	0.1988%	0.1591%	74	2.5870%	1.9779%	114	49.7929%	49.8357%
35	0.2047%	0.1668%	75	2.8903%	2.1625%	115	49.9490%	49.9630%
36	0.2105%	0.1742%	76	3.2387%	2.3691%	116	49.9725%	49.9815%
37	0.2159%	0.1800%	77	3.6326%	2.6010%	117	49.9865%	49.9910%
38	0.2208%	0.1843%	78	4.0663%	2.8836%	118	50.0000%	50.0000%
39	0.2251%	0.1896%	79	4.5353%	3.2406%	119	50.0000%	50.0000%
40	0.2302%	0.1925%	80	5.0385%	3.6414%	120	100.0000%	100.0000%
41	0.2336%	0.1968%	81	5.5855%	4.0910%	Ref	2709 x 100%	2710 x 100%
42	0.2394%	0.2005%	82	6.1877%	4.5920%	Set Back	0	0
43	0.2440%	0.2051%	83	6.8570%	5.1505%	Proj. Scale	983	984
44	0.2502%	0.2098%	84	7.6160%	5.7736%	Base Year	2010	2010
45	0.2583%	0.2161%	85	8.4872%	6.4675%	Proj. Year	2022	2022
46	0.2676%	0.2250%	86	9.4656%	7.2392%			
47	0.2791%	0.2349%	87	10.6263%	8.0995%			
48	0.2933%	0.2471%	88	11.9115%	9.0589%			
49	0.3116%	0.2618%	89	13.3320%	10.1235%			
50	0.3320%	0.2792%	90	14.8913%	11.3027%			
51	0.3486%	0.3060%	91	16.4878%	12.5632%			
52	0.3689%	0.3376%	92	18.0518%	13.8751%			
53	0.3942%	0.3736%	93	19.5583%	15.2311%			
54	0.4246%	0.4144%	94	21.0124%	16.6230%			
55	0.4608%	0.4598%	95	22.4206%	18.0698%			
56	0.5041%	0.5089%	96	23.9508%	19.6608%			
57	0.5561%	0.5607%	97	25.5464%	21.3526%			
58	0.6165%	0.6162%	98	27.2508%	23.1555%			
59	0.6840%	0.6719%	99	29.0873%	25.0696%			

\* Rates and life expectancies in future years are determined by the MP-2021 projection scale.

