

# Texas Emergency Services Retirement System Asset Liability Modeling Report

Report to the Board

December 10, 2019

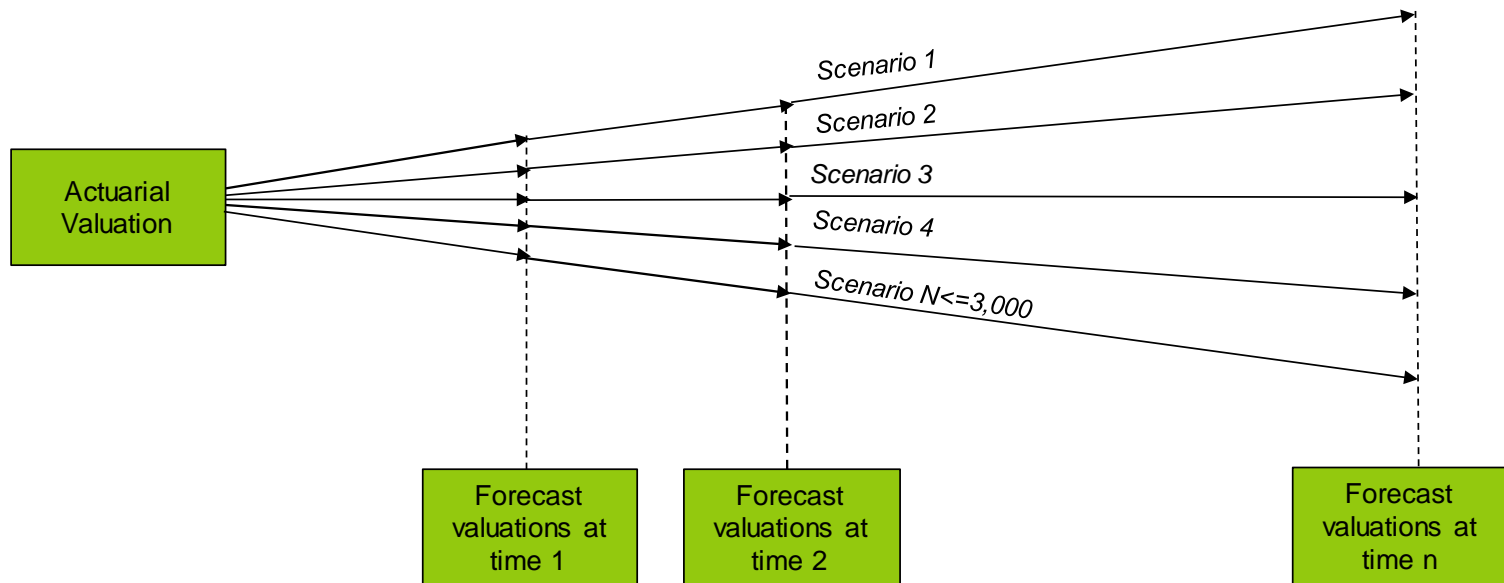


# Study Overview

- The purpose of the study is to identify and evaluate alternative portfolios providing opportunities for performance improvement vis-à-vis the current portfolio.
- The development and evaluation of alternative portfolios will reflect a current capital market outlook represented by a set of assumptions for asset class return, risk, and diversification benefits.
- For each portfolio, a forecast will be done of plan assets, liabilities, funded ratios, contributions, and benefits based on the TESRS benefit provisions, current funding policy, and actuarial assumptions.
- Forecast results will illuminate the relative rewards and risks of the alternative portfolios.

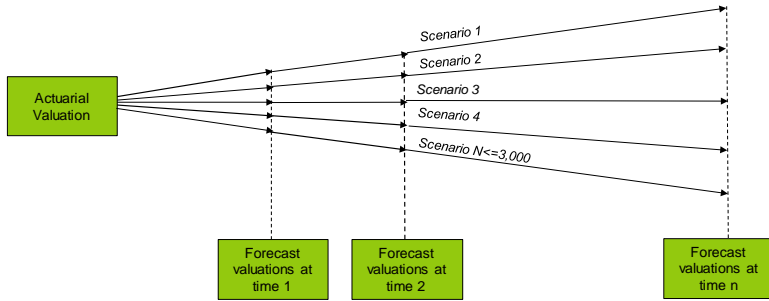
# What is Asset Liability Modeling?

- Asset liability analysis extends the “point in time” actuarial valuation measurement to encompass multiple possible future states at different times and representing various capital market scenarios and/or investment strategies. It can be used to assess the risks/rewards of the current portfolio on a standalone basis or in comparison to alternative portfolios.
- States can be defined by specific scenarios (e.g. 6% investment return, repeat of Global Financial Crisis) or by stochastic modeling of current and alternative portfolios under several thousand scenarios.

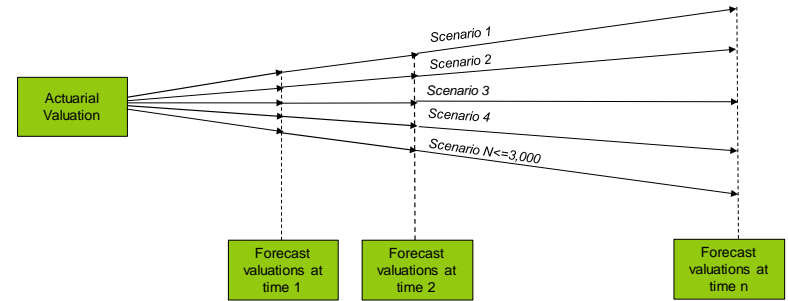


# What is Asset Liability Modelling?

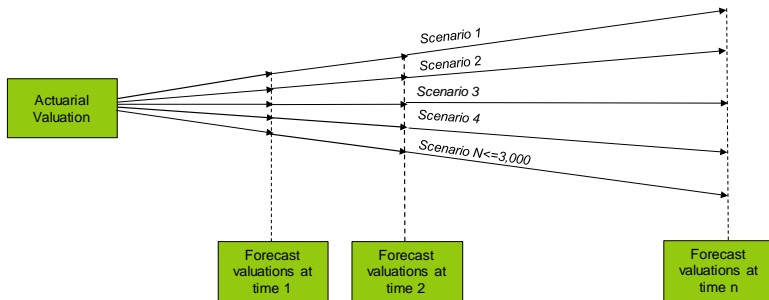
## Current



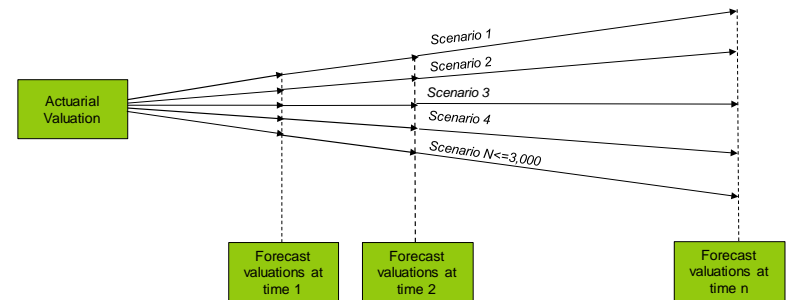
## Alternative Mix 3



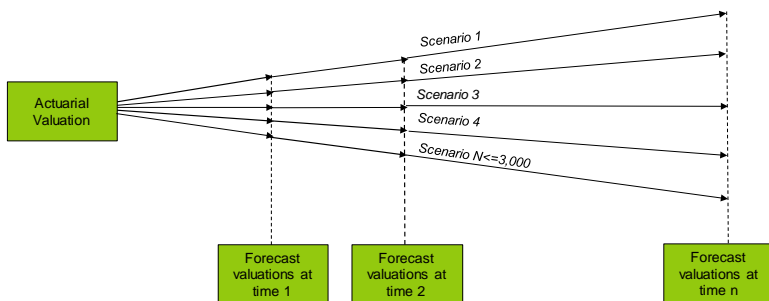
## Alternative Mix 1



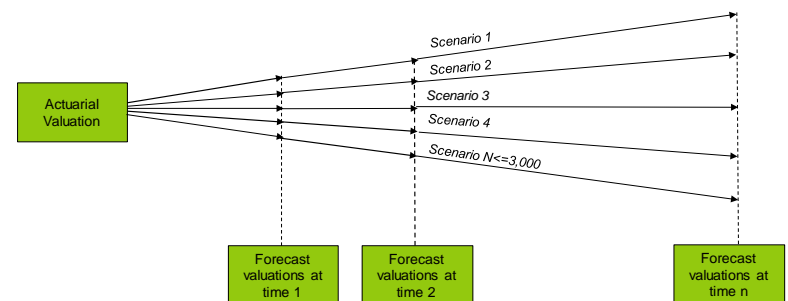
## Alternative Mix 4



## Alternative Mix 2



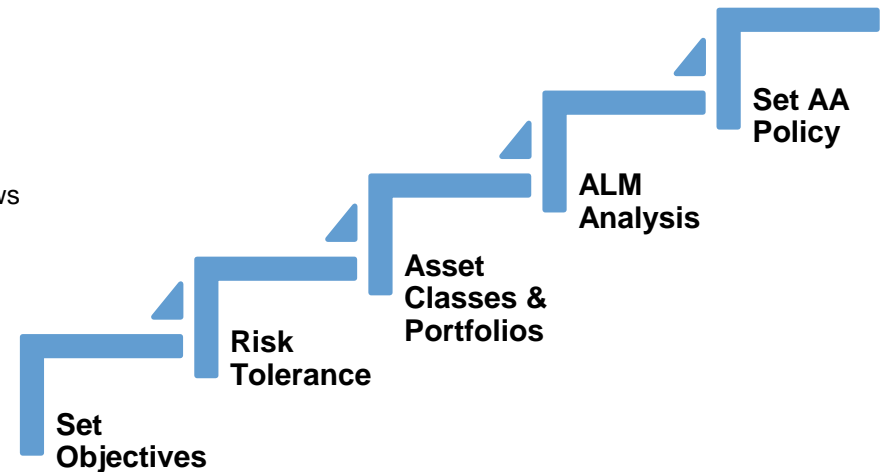
## Alternative Mix 5



# Steps In An ALM Study

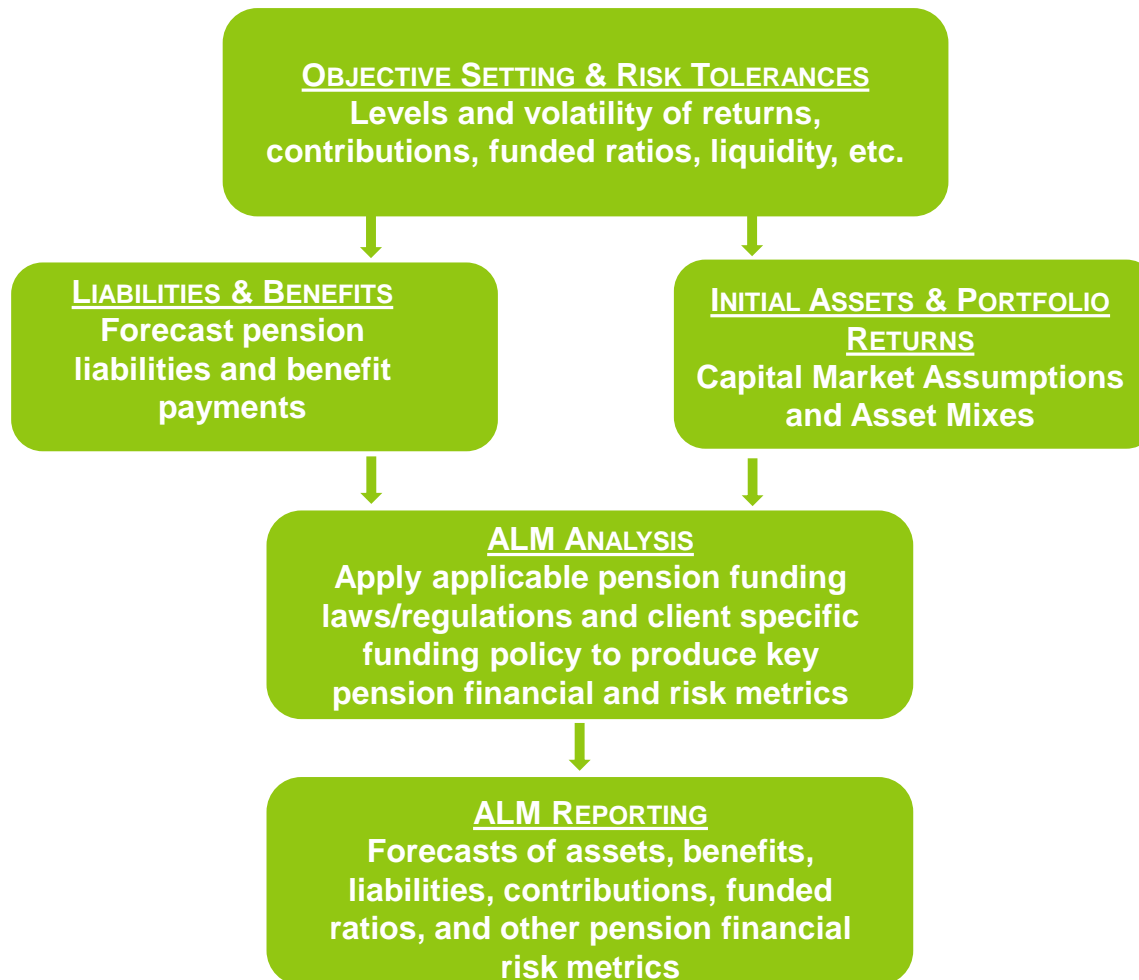
- Asset liability modeling is a tool employed to evaluate the potential financial impact and risk exposure that a retirement system is exposed to by an existing portfolio or a set of potential alternative portfolios. Risk may be defined as the standard deviation of returns, the probability of achieving a target return, or various pension financial metrics related to contributions, funded ratios, or liquidity measures. In theory there is a positive relationship between risk and returns – the greater the risk, the greater the returns. However, the capital markets do not always behave in this manner particularly over shorter time horizons. Risk tolerances and return goals vary from situation to situation and over time, so it is important to consider the unique circumstances present in any situation.
- The modeling process is imperfect, relying on forecasts for the asset classes and plan liabilities. Accurately predicting the performance of the capital markets is nearly impossible. Plan liability forecasts can vary depending on economic and demographic factors outcomes. It is important to understand the potential variability of outcomes, the potential impact on results, and the conclusions drawn from them.
- Key Steps In Conducting An Asset Liability Study:

- Identify and define the objectives.
  - Funded ratio targets
  - Contribution targets
  - Assess liquidity needs – current and future cash flows
  - Time horizon
- Assess risk tolerance
  - Portfolio risk
  - Funded ratio volatility and minimums
  - Contribution volatility and maximums
  - Liquidity – risk of forced asset sales
- Determine appropriate asset classes and portfolios
- ALM analysis of investment portfolio alternatives
  - Monte Carlo simulations and scenarios
  - Human overlay
- Select an appropriate target asset allocation policy



# ALM Modeling Process Flow

- The ALM model will first forecast liabilities, benefits, and portfolio returns. Then it will apply the funding policy and relevant pension regulations to forecast key financial and risk metrics.

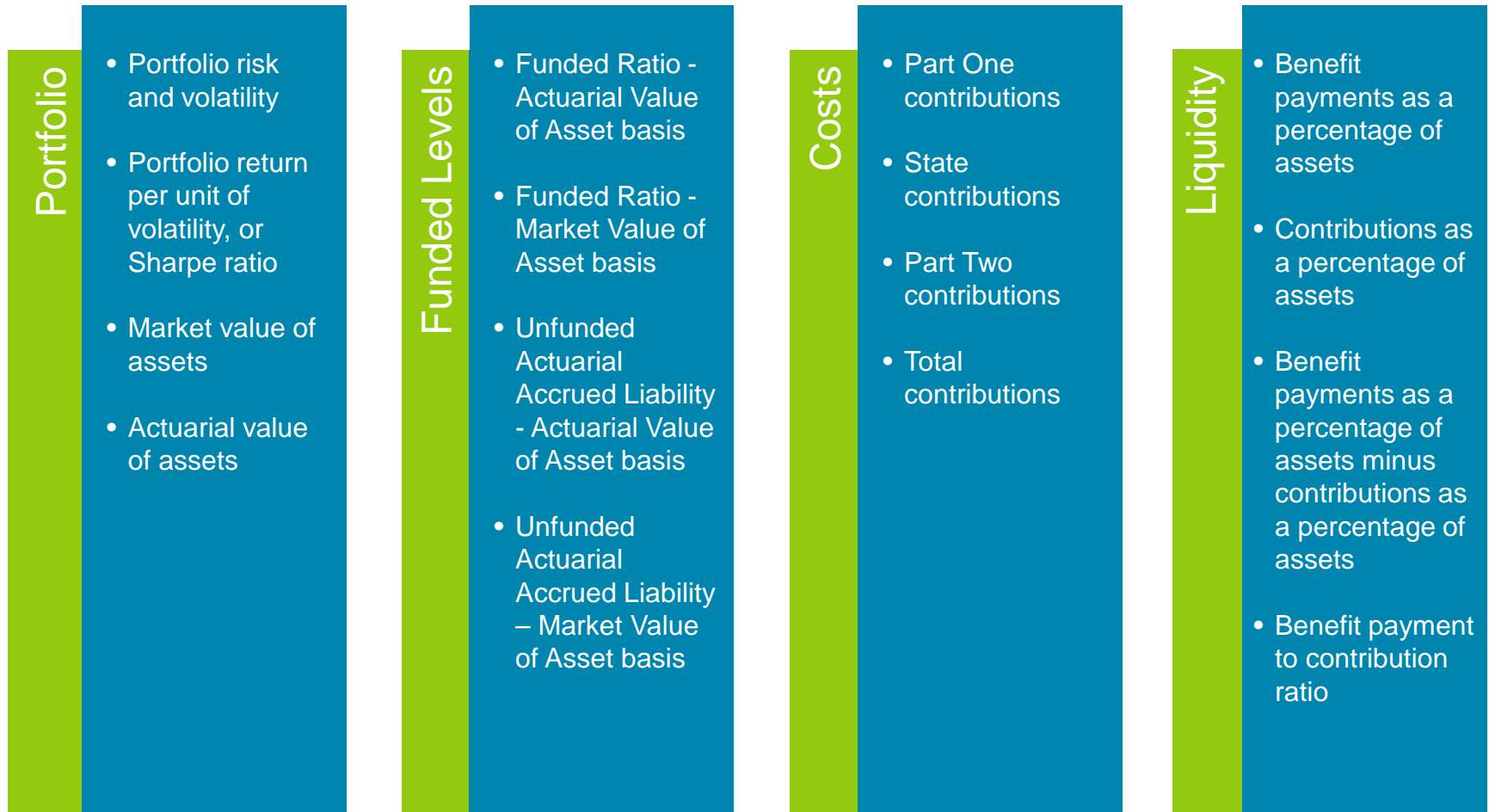


## Key Decisions/Inputs

- Metric specific objectives and risk tolerances
- Future plan population profile and growth trend
- Capital market assumption set(s)
- Asset classes to specifically include or exclude
- Confirm financial metrics
- Confirm forecast time horizons

# ALM Pension Financial Performance Metrics

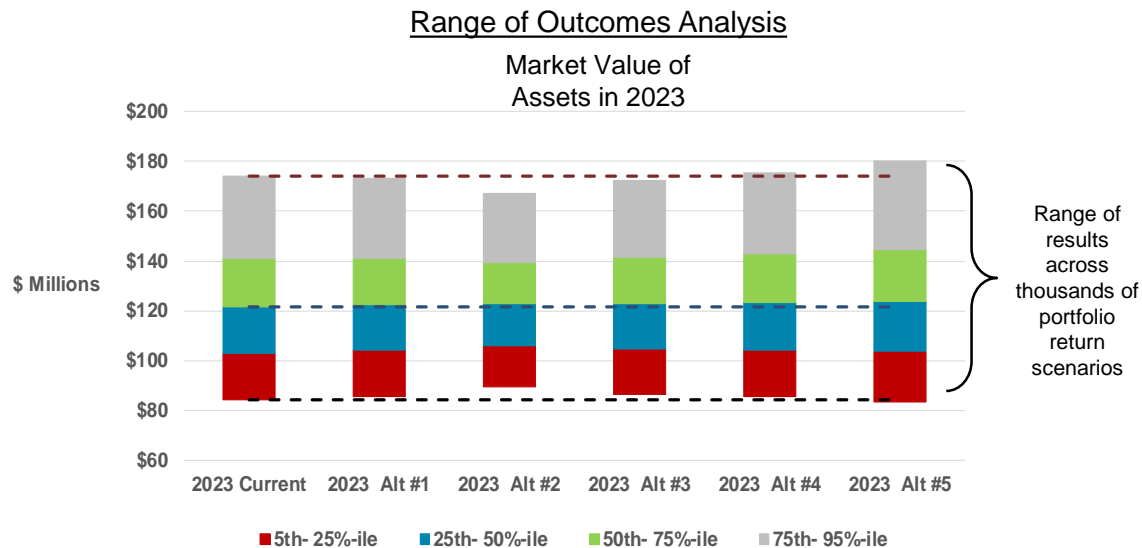
- There are various pension financial metrics that can be contemplated for a study. Those contemplated in this study, are shown below:



# Interpreting ALM Analysis – Market Value of Assets 2023

- This report contains two main types of ALM analysis exhibits, range of outcomes and trade-off analysis.
- Range of outcome analysis is described below.

- For each year of the analysis graphed, the asset mixes are grouped together.
- Results on the bar graph are shown from the highest value at the top of the bar to the lowest value at the bottom of the bar. The color coding separates the results in percentile groups, e.g. 75<sup>th</sup> to 95<sup>th</sup> percentile (see graph legend).
- To understand percentiles consider the following. In the case of 2,000 scenarios, the 95<sup>th</sup> percentile result is the 1,900<sup>th</sup> highest value out of 2,000 results computed in each year. For a metric like assets, a higher value is relatively more favorable. For a metric like contributions, a higher value is relatively less favorable.



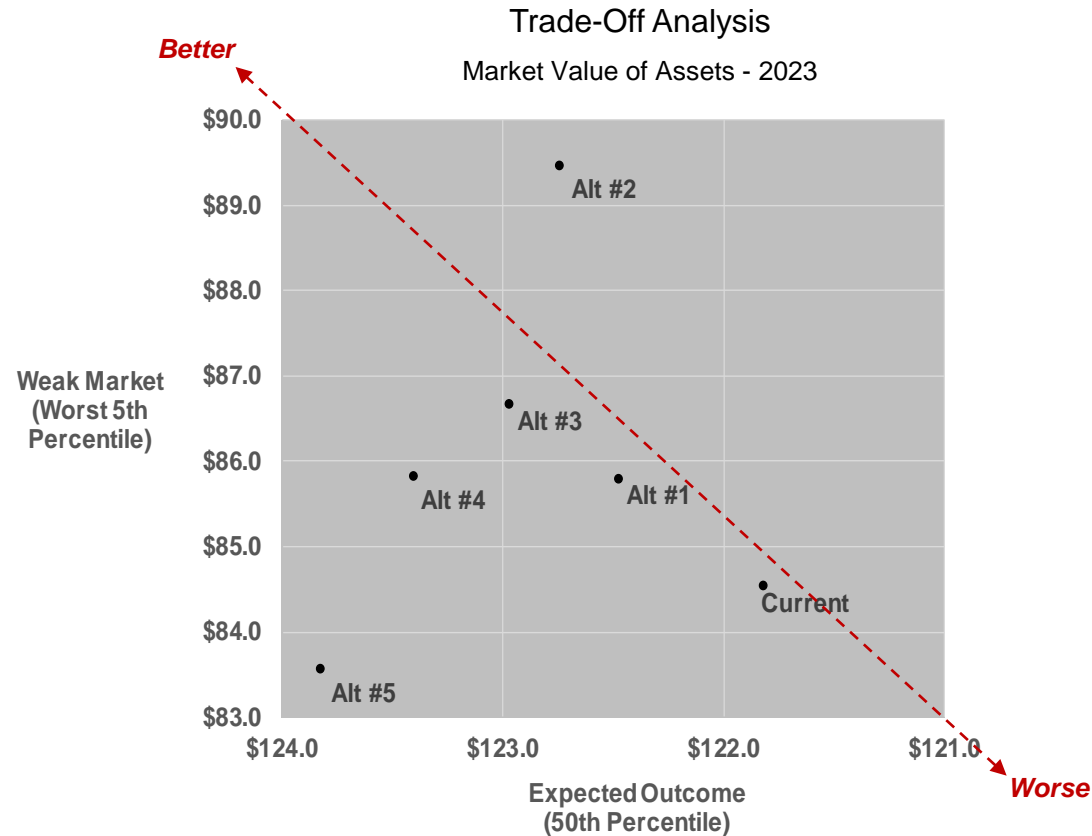
	Mix	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
High Value to Low Value	95th %-ile	\$173.9	\$173.0	\$167.2	\$172.2	\$175.4	\$180.2
	75th %-ile	\$141.3	\$141.3	\$139.4	\$141.6	\$142.6	\$144.5
	50th %-ile	\$121.8	\$122.5	\$122.7	\$123.0	\$123.4	\$123.8
	25th %-ile	\$103.1	\$104.1	\$106.1	\$104.9	\$104.4	\$103.8
	5th %-ile	\$84.5	\$85.8	\$89.5	\$86.7	\$85.8	\$83.6



# Interpreting ALM Analysis – Market Value of Assets 2023 (cont.)

- Trade-off analysis is described below.

- For a given year, e.g. 2023 the results for each asset mix for a metric are plotted on a scatter diagram.
- The horizontal axis plots the result for each mix in the expected market scenario.
- The vertical axis plots the result for each mix in a weak market scenario.
- Trade-offs will need to be evaluated when no one mix is expected to outperform best in both the expected market scenario and the weak market scenario.



Mix	Expected Outcome	Weak Market
Current	\$121.8	\$84.5
Alt #1	\$122.5	\$85.8
Alt #2	\$122.7	\$89.5
Alt #3	\$123.0	\$86.7
Alt #4	\$123.4	\$85.8
Alt #5	\$123.8	\$83.6



# Current Asset Allocation Target and Ranges

	Minimum	Target	Maximum
U.S. Equities – Large Cap	20.0%	30.0%	40.0%
U.S. Equities – Small/Mid Cap	5.0%	15.0%	25.0%
International Equities - Developed	10.0%	15.0%	20.0%
International Equities - Emerging	0.0%	5.0%	10.0%
Core Fixed Income	15.0%	20.0%	25.0%
Cash & Equivalents	0.0%	0.0%	5.0%
Master Limited Partnerships (Energy)	0.0%	5.0%	10.0%
U.S. Core Real Estate	0.0%	5.0%	10.0%
GTAA	0.0%	5.0%	10.0%

Source: Retirement Plan Investment Policy Statement as of mm/dd/ccyy.



# Asset Allocations Modeled

Asset Class	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
		+ Infrastructure - MLP	+ US High Yield + Emerging Mkt Bond + US Core RE + Global Infrastructure - US Large Cap - US Mid Cap - US Small Cap - MLP	+ US High Yield + Emerging Mkt Bond + US Core RE + Global Infrastructure + GTAA - US Large Cap - Int'l equity dev. - Core fixed income - MLP	+ US High Yield + Emerging Mkt Bond + US Core RE + Global Infrastructure - US Large Cap - Core fixed income - MLP	+ US Mid Cap + US Small Cap + Int'l Eq. dev + Int'l Eq. Emerging + US Core RE + Global Infrastructure + GTAA - US Large Cap - Core fixed income - MLP
US Large Cap	N/A	0.0%	-10.0%	-5.0%	-5.0%	-10.0%
US Mid Cap	N/A	0.0%	-2.5%	0.0%	0.0%	2.5%
US Small Cap	N/A	0.0%	-2.5%	0.0%	0.0%	2.5%
<b>Total US Equity</b>	<b>N/A</b>	<b>0.0%</b>	<b>-15.0%</b>	<b>-5.0%</b>	<b>-5.0%</b>	<b>-5.0%</b>
International Equity - Developed	N/A	0.0%	0.0%	-5.0%	0.0%	2.5%
International Equity - Emerging	N/A	0.0%	0.0%	0.0%	0.0%	2.5%
<b>Total International Equity</b>	<b>N/A</b>	<b>0.0%</b>	<b>0.0%</b>	<b>-5.0%</b>	<b>0.0%</b>	<b>5.0%</b>
Core Fixed Income	N/A	0.0%	0.0%	-10.0%	-10.0%	-10.0%
US High Yield	N/A	0.0%	5.0%	5.0%	5.0%	0.0%
Emerging Market Bond	N/A	0.0%	5.0%	5.0%	5.0%	0.0%
<b>Total Fixed Income</b>	<b>N/A</b>	<b>0.0%</b>	<b>10.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>-10.0%</b>
US Core RE	N/A	0.0%	5.0%	5.0%	5.0%	5.0%
Global Infrastructure	N/A	5.0%	5.0%	5.0%	5.0%	5.0%
GTAA	N/A	0.0%	0.0%	5.0%	0.0%	5.0%
MLP	N/A	-5.0%	-5.0%	-5.0%	-5.0%	-5.0%
<b>Other</b>	<b>N/A</b>	<b>0.0%</b>	<b>5.0%</b>	<b>10.0%</b>	<b>5.0%</b>	<b>10.0%</b>
Return (Mean)	N/A	0.05%	0.03%	0.17%	0.27%	0.45%
Standard Deviation	N/A	-0.35%	-1.45%	-0.46%	-0.06%	0.69%
No change						
Increase						
Decrease						



# Capital Market Assumptions

Annualized as of 12/31/2018

-----Historical----- Forecast-----

A/O 12/2018	5 Year	10 Year	15 Year	20 Year	LT Std. Dev.*	Return	Std. Dev.
US Cash	0.59%	0.34%	1.26%	1.82%	0.57%	2.00%	0.50%
US Aggregate	2.52%	3.48%	3.87%	4.55%	3.38%	4.06%	3.50%
US High Yield	3.83%	11.12%	7.00%	6.55%	9.04%	5.82%	8.25%
US Leveraged Loan	3.05%	8.57%	4.52%	4.62%	5.96%	5.27%	7.50%
WGB exUS	0.28%	1.27%	2.81%	3.41%	8.09%	2.96%	8.00%
Emerging Mkts Bond	4.80%	8.20%	7.05%	9.09%	8.25%	6.67%	9.50%
US Large Cap	8.21%	13.28%	7.93%	5.85%	14.66%	6.03%	13.75%
US Mid Cap	6.26%	14.03%	8.89%	8.47%	16.41%	6.79%	15.75%
US Small Cap	4.41%	11.97%	7.50%	7.40%	19.42%	7.47%	18.25%
EAFE Equity	0.53%	6.32%	4.74%	3.52%	16.32%	7.94%	16.75%
Emerging Markets Equity	1.65%	8.02%	7.90%	8.53%	21.81%	10.43%	21.25%
Private Equity**	13.67%	10.80%	14.70%	12.33%	11.62%	10.20%	21.00%
US Core RE	9.41%	6.01%	7.24%	7.55%	7.10%	6.45%	12.25%
US Val Add RE**	13.84%	3.35%	8.85%	9.50%	11.06%	9.53%	20.00%
US REITs	8.29%	12.41%	7.94%	9.58%	19.45%	7.35%	15.50%
Infrastructure	4.10%	7.58%	8.22%	—	15.46%	6.64%	11.75%
Hedge Funds – Diversified	1.47%	3.22%	2.80%	4.27%	5.23%	4.52%	7.50%
Commodities	-8.80%	-3.78%	-2.47%	1.75%	16.00%	3.50%	16.25%

\*20 years or longest period available

\*\*Due to the lag in reporting of index performance, trailing periods calculated as of 6/30/2018

Note: Forecasted assumptions are the 2019 JPMorgan Long Term Capital Market Assumptions. Not all asset classes are appropriate for every client portfolio.

# Asset Allocations Modeled

- The current target asset allocation along with five potential alternatives were identified. Their performance was evaluated by modeling their performance over several thousand different portfolio return scenarios representing a range of capital market environments and outcomes.

Asset Class	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
US Large Cap	30.00%	30.00%	20.00%	25.00%	25.00%	20.00%
US Mid Cap	7.50%	7.50%	5.00%	7.50%	7.50%	10.00%
US Small Cap	7.50%	7.50%	5.00%	7.50%	7.50%	10.00%
<b>US Equity</b>	<b>45.00%</b>	<b>45.00%</b>	<b>30.00%</b>	<b>40.00%</b>	<b>40.00%</b>	<b>40.00%</b>
International Equity - Developed	15.00%	15.00%	15.00%	10.00%	15.00%	17.50%
International Equity - Emerging	5.00%	5.00%	5.00%	5.00%	5.00%	7.50%
<b>International Equity</b>	<b>20.00%</b>	<b>20.00%</b>	<b>20.00%</b>	<b>15.00%</b>	<b>20.00%</b>	<b>25.00%</b>
Core Fixed Income	20.00%	20.00%	20.00%	10.00%	10.00%	10.00%
US High Yield	0.00%	0.00%	5.00%	5.00%	5.00%	0.00%
Emerging Market Bond	0.00%	0.00%	5.00%	5.00%	5.00%	0.00%
<b>Fixed Income</b>	<b>20.00%</b>	<b>20.00%</b>	<b>30.00%</b>	<b>20.00%</b>	<b>20.00%</b>	<b>10.00%</b>
US Core RE	5.00%	5.00%	10.00%	10.00%	10.00%	10.00%
Global Infrastructure	0.00%	5.00%	5.00%	5.00%	5.00%	5.00%
GTAA	5.00%	5.00%	5.00%	10.00%	5.00%	10.00%
MLP	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%
<b>Other</b>	<b>15.00%</b>	<b>15.00%</b>	<b>20.00%</b>	<b>25.00%</b>	<b>20.00%</b>	<b>25.00%</b>
Return (Mean)	6.32%	6.37%	6.35%	6.48%	6.59%	6.77%
<b>Real Return (2% CPI)</b>	<b>4.32%</b>	<b>4.37%</b>	<b>4.35%</b>	<b>4.48%</b>	<b>4.59%</b>	<b>4.77%</b>
Standard Deviation	11.10%	10.70%	9.60%	10.60%	11.00%	11.80%
Sharpe Ratio	0.57%	0.60%	0.66%	0.61%	0.60%	0.58%

# Results Summary

## Key Observations

Current	Alt #1	Alt #2
<ul style="list-style-type: none"> <li>Can be improved upon in one or more respects by the various alternatives, each with their own distinct risk / return profile.</li> </ul>	<ul style="list-style-type: none"> <li>Virtually indistinguishable from the Current portfolio in both composition and modeling outcomes.</li> <li>Risk associated with MLP allocation is reduced with the swap of global infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>Same expected return as the Current portfolio but with lower volatility.</li> <li>Better opportunity to manage downside risk than Current, however the tradeoff is reduced liquidity</li> <li>Diversifies risk-seeking portion of the portfolio. Increases fixed income exposure downside protection.</li> <li>Platform to use to increase risk exposure if market conditions warrant.</li> </ul>
Alt #3	Alt #4	Alt #5
<ul style="list-style-type: none"> <li>Portfolio illustrates the potential of reducing equity risk in favor of credit risk to maintain and potentially improve return expectations while also reducing volatility</li> </ul>	<ul style="list-style-type: none"> <li>Portfolio reduces equity risk in favor of credit risk while also increasing illiquid exposures</li> <li>Result is a gain of .3% in return while maintaining the same level of volatility as the current allocation</li> </ul>	<ul style="list-style-type: none"> <li>Offers the highest potential return but does so by maintaining high equity allocations while also increasing illiquidity</li> <li>Lowering the fixed income exposure to 10% is a considerable reduction in risk managing assets.</li> </ul>



# Results Summary

## Financial Metric Forecasted Results Through 2023

Asset Class	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
Highest return per unit of risk	0.57%	0.60%	0.66%	0.61%	0.60%	0.57%
Highest funded ratio in "normal" markets	75.3%	75.4%	75.6%	75.6%	75.8%	75.9%
Highest funded ratio in market downturns	59.1%	60.0%	61.9%	60.3%	59.8%	58.7%
Highest funded ratio in market upturns	93.9%	93.4%	91.7%	93.7%	94.5%	95.8%
Lowest accumulated contributions <sup>1</sup>	\$31.2m - \$32.7m	\$31.2m - \$32.7m	\$31.2m - \$32.7m	\$31.2m - \$32.7m	\$31.2m - \$32.7m	\$30.9m - \$32.7m
Adequate liquidity (percent of assets needed to cover annual benefits not funded by contributions)	2.10%-3.82%	2.10%-3.76%	2.15%-3.6%	2.12%-3.72%	2.1%-3.76%	2.08%-3.86%

1. Estimated based on current tier one, State, and tier two contributions specifications..

# Results Summary

## Discount Rate and Funding Policy

- Effect of lowering the rate of return assumption.
  - Lowering the discount rate does not change the conclusion about the asset allocation over the short term.
  - The table below shows the impact of lowering the discount rate on the funded ratio.

	7.75%	7.50%	7.25%
Funded Ratio – Market Value of Assets Basis	77.0%	75.1%	72.7%
Funded Ratio – Actuarial Value of Assets Basis	80.8%	78.2%	75.7%

- Part Two contributions will also increase when the discount rate is lowered. For the change to 7.50%, the first year Part Two contribution increases from 0% of the Part One contribution to approximately 10%, or about \$300,000. For the change to 7.25%, the first year Part Two contribution increases from 0% of the Part One contribution to the maximum of 15%, or about \$450,000.
- Funding policy observations
  - Due to the relatively fixed dollar nature of the current funding, contributions from all sources can become insufficient to meet the goals of sound actuarial funding, which is defined as a contribution that is sufficient to fund the normal cost and amortize the unfunded actuarial accrued liability over a maximum of 30 years. If the current contribution levels are maintained indefinitely, the fund could be fully depleted by the mid 2030's if there are persistent weak markets. Even in more expected markets the fund could be depleted by mid 2040's.

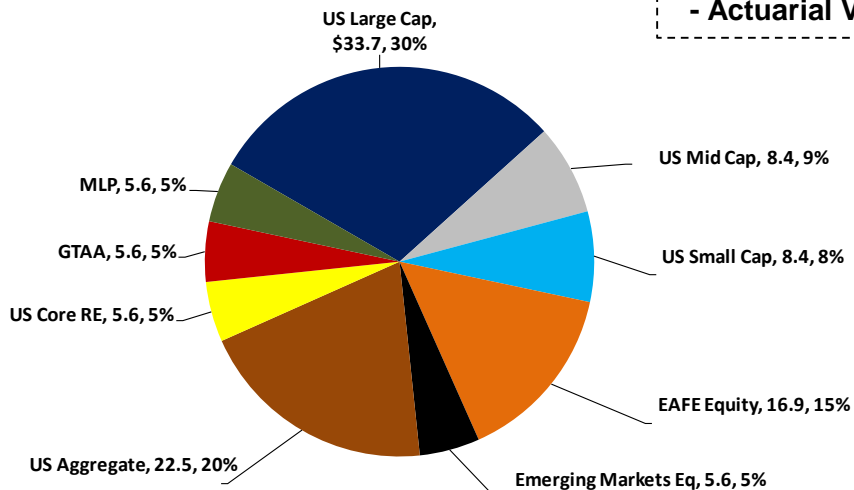




Appendix: TESRS ALM Analysis: Discount Rate = 7.75%

# Current Plan Financial Status

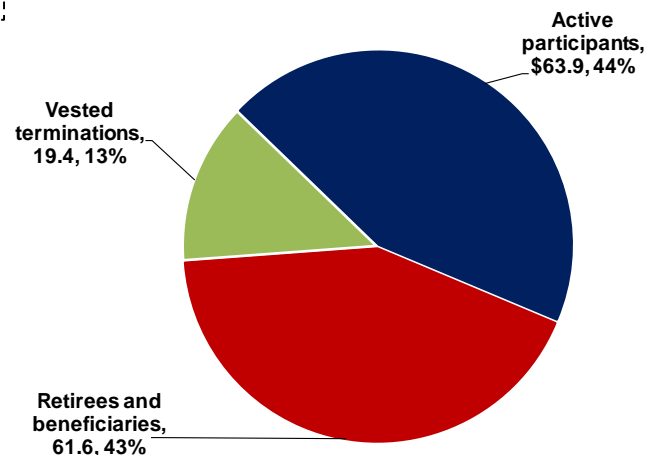
## Market Value of Assets, 8/31/2019 <sup>(1)</sup>



**Funded Ratio (est.)**  
 - Market Value = 77.0%  
 - Actuarial Value = 80.8%

Asset Class	Dollars (millions)	Target Percent of Assets
US Large Cap	\$33.7	30.0%
US Mid Cap	8.4	7.5%
US Small Cap	8.4	7.5%
International Equities - Developed	16.9	15.0%
International Equities - Emerging	5.6	5.0%
Core Fixed Income	22.5	20.0%
US Core RE	5.6	5.0%
GTAA	5.6	5.0%
MLP	5.6	5.0%
<b>Market Value of Assets</b>	<b>\$112.4</b>	<b>100.0%</b>
Unrecognized (gains)/losses	<b>\$4.6</b>	
<b>Actuarial Value of Assets</b>	<b>\$117.0</b>	

## Actuarial Liability @ 7.75%, 8/31/2019 (est.) <sup>(2)</sup>

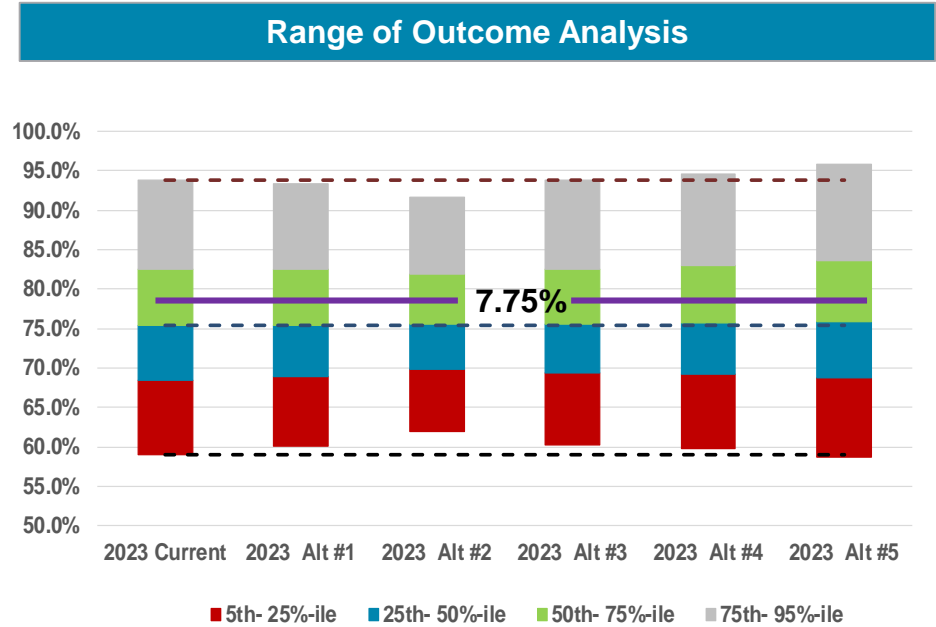
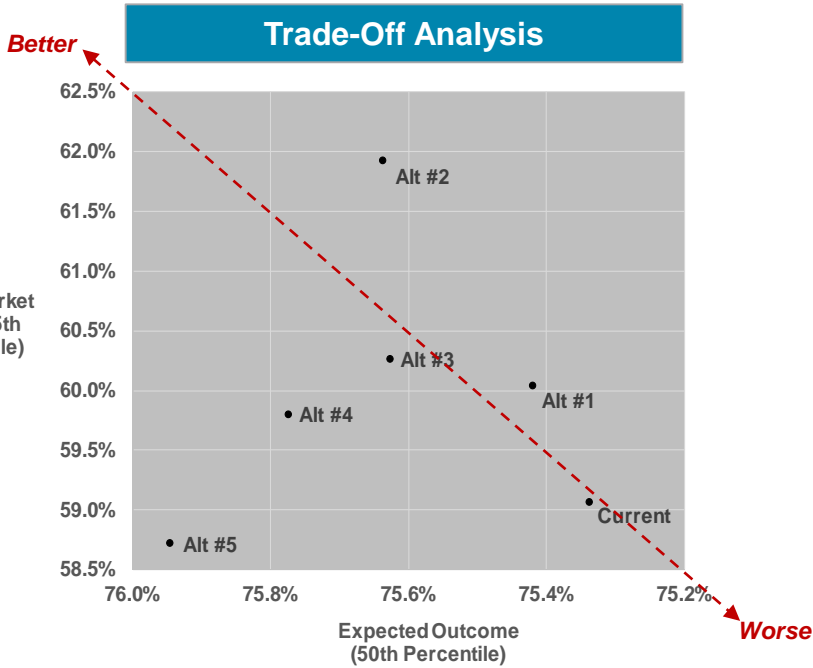


Liability Source	Dollars (millions)	Percent of Liabilities (est.)
Active participants	\$63.9	44.1%
Retirees and beneficiaries	61.6	42.5%
Vested terminations	<u>19.4</u>	<u>13.4%</u>
<b>Total</b>	<b>\$144.9</b>	<b>100.0%</b>

(1) Source: AndCo Consulting 8/31/2019 flash report.

(2) Source: Liability forecast provided by actuarial firm of Rudd & Wisdom.

# Funded Ratio: Actuarial Value of Assets Basis - 2023

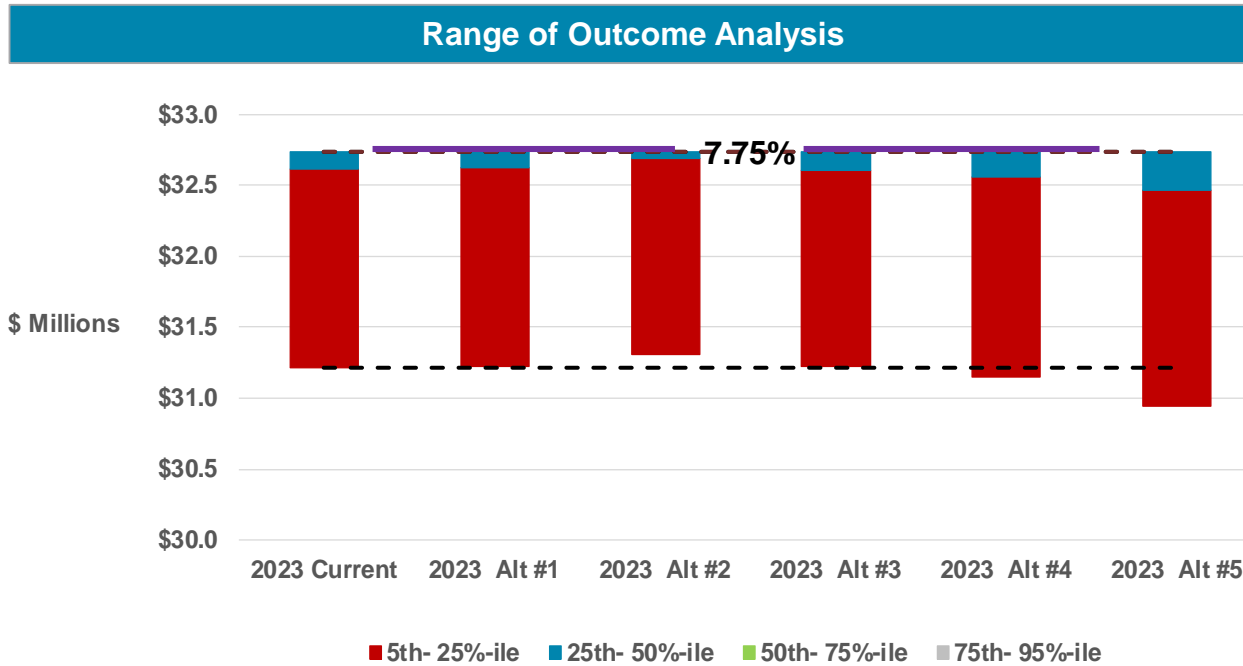


	Mix	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
High Value to Low Value	95th %-ile	93.9%	93.4%	91.7%	93.7%	94.5%	95.8%
	75th %-ile	82.6%	82.5%	81.8%	82.5%	82.9%	83.6%
	50th %-ile	75.3%	75.4%	75.6%	75.6%	75.8%	75.9%
	25th %-ile	68.5%	68.9%	69.8%	69.3%	69.2%	68.8%
	5th %-ile	59.1%	60.0%	61.9%	60.3%	59.8%	58.7%
	7.75% return	78.8%	78.8%	78.8%	78.8%	78.8%	78.8%

- The observations with respect to the impact of each portfolio on asset values flows through to the impact on funded ratios.



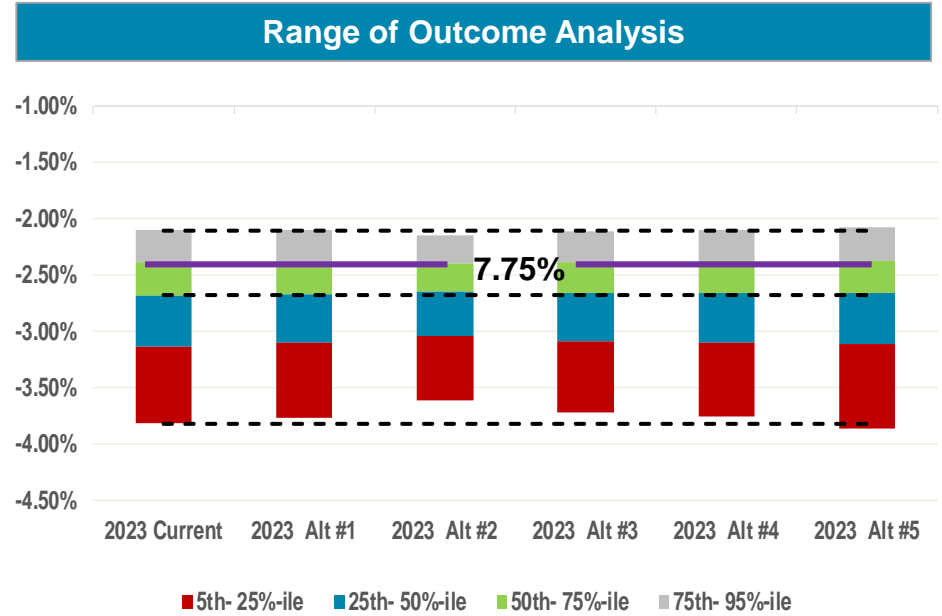
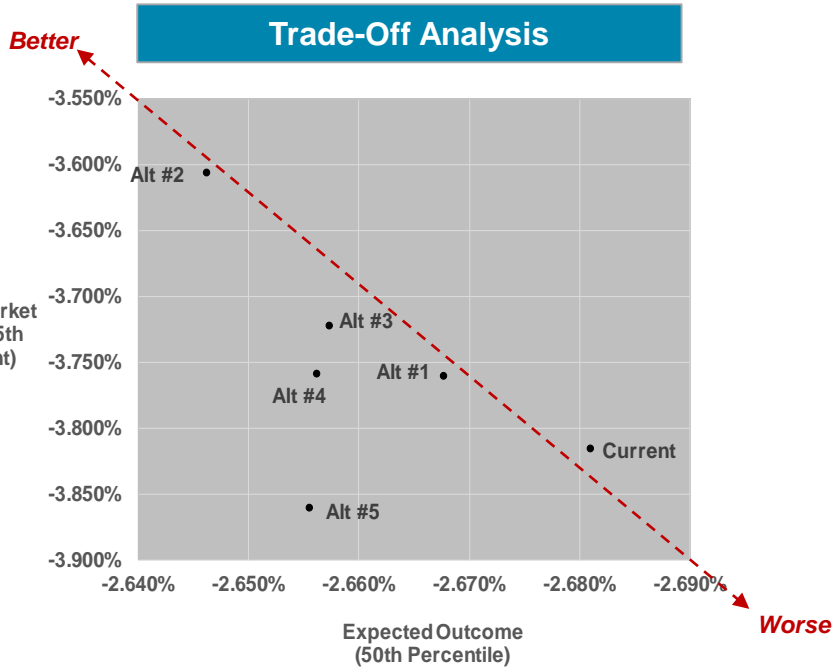
# Accumulated Total Contributions - 2023



	Mix	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
High Value to Low Value	95th %-ile	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7
	75th %-ile	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7
	50th %-ile	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7
	25th %-ile	\$32.6	\$32.6	\$32.7	\$32.6	\$32.6	\$32.5
	5th %-ile	\$31.2	\$31.2	\$31.3	\$31.2	\$31.2	\$30.9
	7.75% return	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7	\$32.7

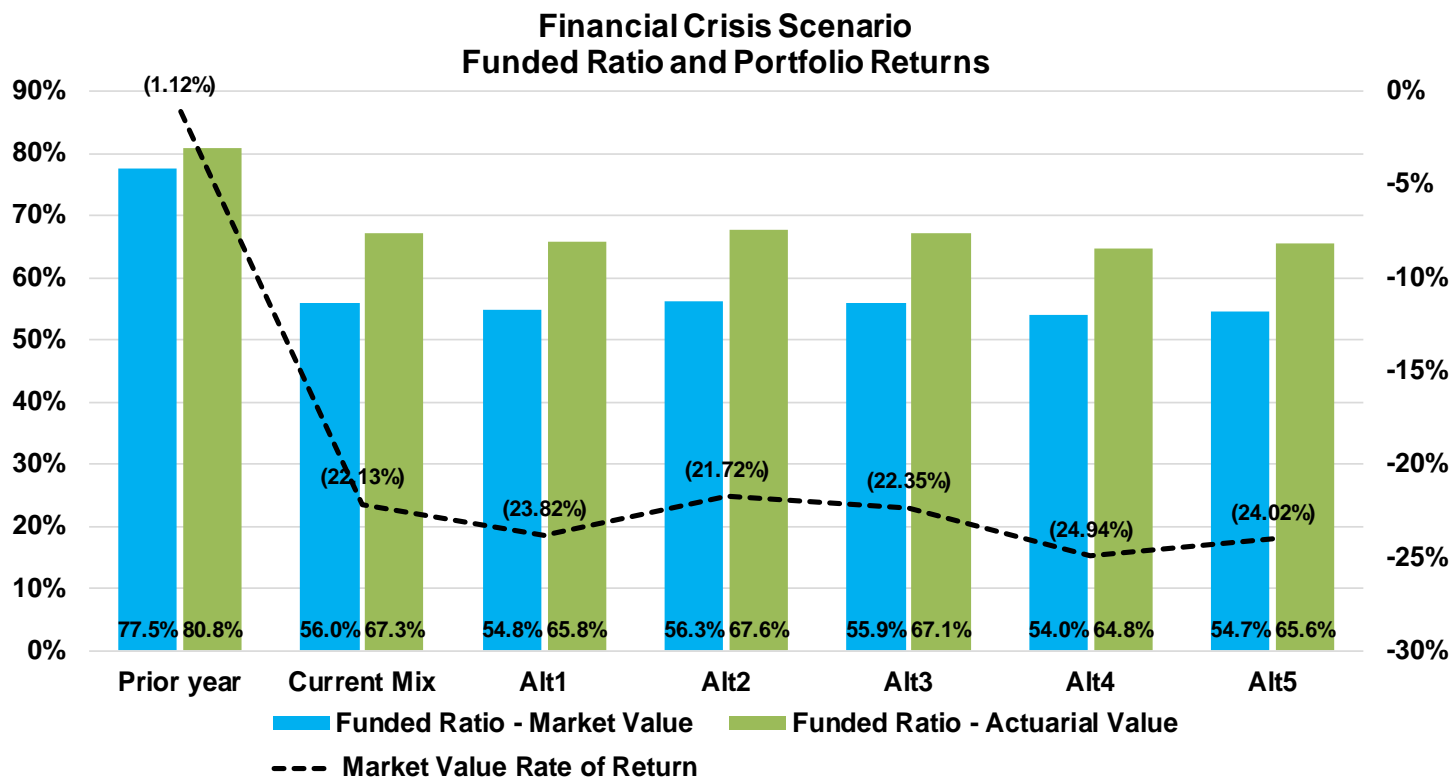
- Due to the relatively fixed characteristic of the funding policy, contribution volatility is very low and the difference between the various mixes is driven by the incidence of Part Two contributions being below their cap of 15% of Part One contributions. The asset mix with the highest returns and thus the greatest incidence of Part Two contributions being below the 15% cap is Alt #5.
- In market downturns, the asset mixes are virtually indistinguishable over this time horizon with respect to total contributions due to the fixed and capped nature of the current funding policy.

# Liquidity Analysis: Contributions Less Benefits as a Percentage of Assets - 2023



	Mix	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
High Value to Low Value	95th %-ile	-2.101%	-2.105%	-2.148%	-2.117%	-2.098%	-2.082%
	75th %-ile	-2.388%	-2.385%	-2.393%	-2.381%	-2.377%	-2.372%
	50th %-ile	-2.681%	-2.668%	-2.646%	-2.657%	-2.656%	-2.655%
	25th %-ile	-3.132%	-3.103%	-3.044%	-3.083%	-3.094%	-3.113%
	5th %-ile	-3.816%	-3.760%	-3.606%	-3.722%	-3.759%	-3.860%
	7.75% return	-2.444%	-2.444%	-2.444%	-2.444%	-2.444%	-2.444%

# Financial Crisis Scenario One Year Funded Ratio Impact



	2020						
	Est. 2019	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
Funded Ratio - Market Value <sup>(1)</sup>	77.5%	56.0%	54.8%	56.3%	55.9%	54.0%	54.7%
Funded Ratio - Actuarial Value <sup>(1)</sup>	80.8%	67.3%	65.8%	67.6%	67.1%	64.8%	65.6%
Rate of Return	(1.12%) est.	(22.1%)	(23.8%)	(21.7%)	(22.3%)	(24.9%)	(24.0%)

- Alt# 2 is expected to be the best performer in a financial crisis scenario such as the one experienced in 2008 due to its lower volatility.

(1) 2019 results estimated based on liability forecast provided by System's actuary and AndCo Consulting 8/31/2019 flash report.

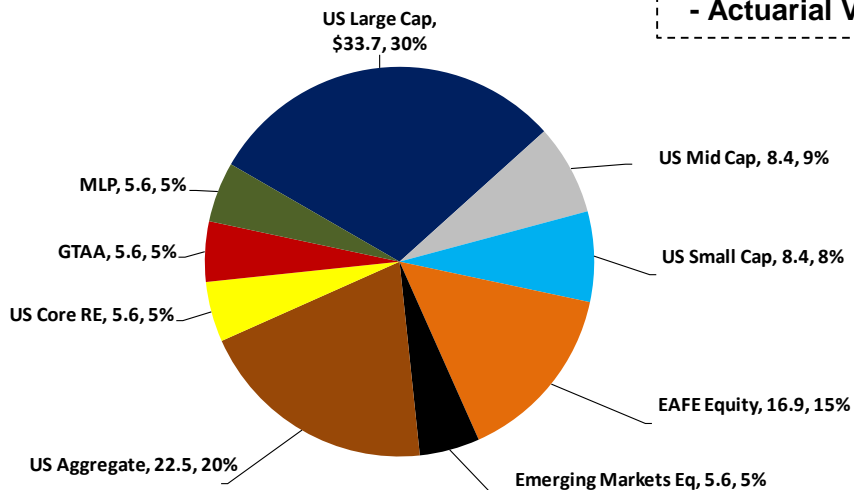
For illustrative purposes only. The above demonstrates hypothetical scenarios whereby the actual results could differ materially from those indicated.



Appendix: TESRS ALM Analysis - Discount Rate = 7.50%

# Current Plan Financial Status

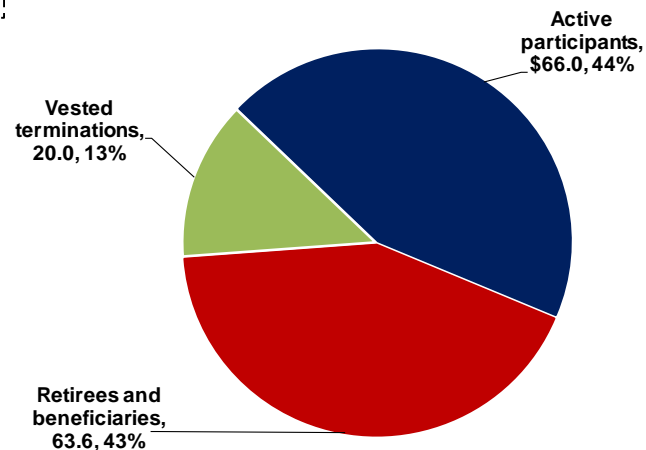
Market Value of Assets, 8/31/2019 <sup>(1)</sup>



**Funded Ratio (est.)**  
 - Market Value = 75.1%  
 - Actuarial Value = 78.2%

Asset Class	Dollars (millions)	Target Percent of Assets
US Large Cap	\$33.7	30.0%
US Mid Cap	8.4	7.5%
US Small Cap	8.4	7.5%
International Equities - Developed	16.9	15.0%
International Equities - Emerging	5.6	5.0%
Core Fixed Income	22.5	20.0%
US Core RE	5.6	5.0%
GTAA	5.6	5.0%
MLP	5.6	5.0%
<b>Market Value of Assets</b>	<b>\$112.4</b>	<b>100.0%</b>
Unrecognized (gains)/losses	<u>\$4.6</u>	
<b>Actuarial Value of Assets</b>	<b>\$117.0</b>	

Actuarial Liability @ 7.50%, 8/31/2019 (est.) <sup>(2)</sup>



Liability Source	Dollars (millions)	Percent of Liabilities (est.)
Active participants	\$66.0	44.1%
Retirees and beneficiaries	63.6	42.5%
Vested terminations	<u>20.0</u>	<u>13.4%</u>
<b>Total</b>	<b>\$149.6</b>	<b>100.0%</b>

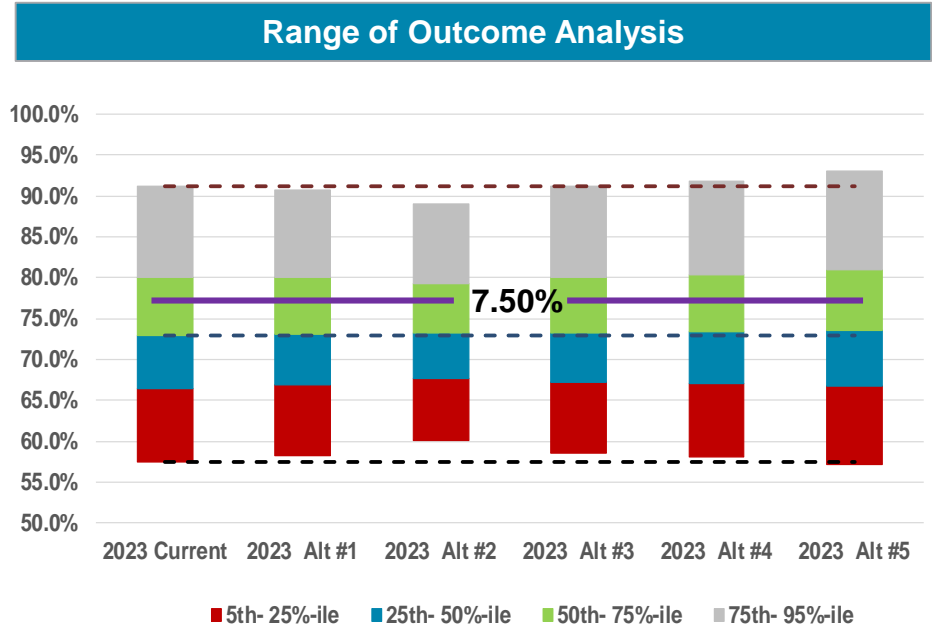
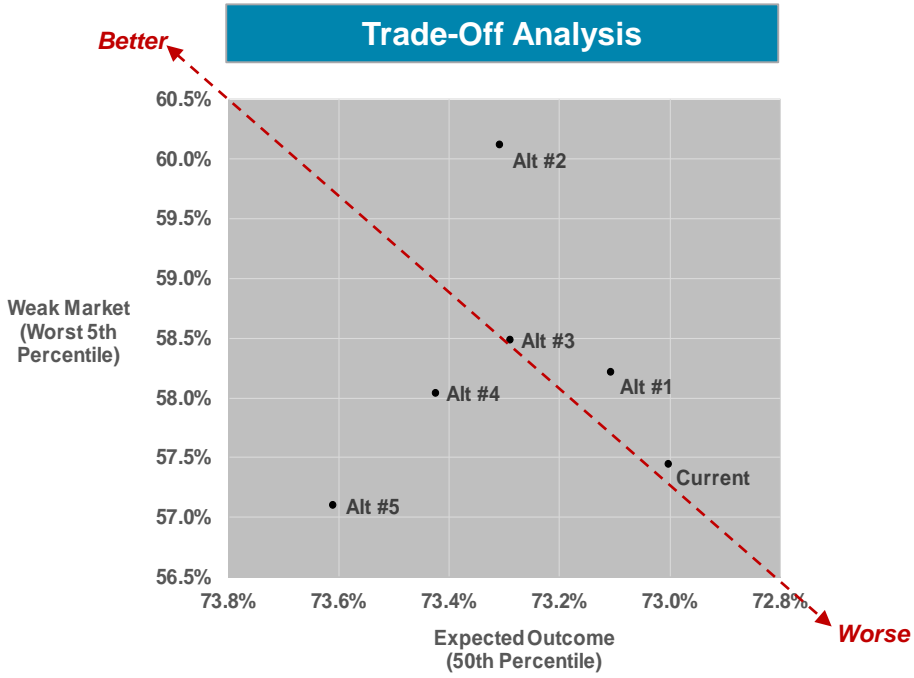
(1) Source: AndCo Consulting 8/31/2019 flash report.

(2) Source: Liability forecast provided by actuarial firm of Rudd & Wisdom.





# Funded Ratio: Actuarial Value of Assets Basis - 2023



	Mix	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
High Value to Low Value	95th %-ile	91.2%	90.7%	89.1%	91.1%	91.9%	93.1%
	75th %-ile	80.0%	80.0%	79.3%	80.1%	80.4%	81.0%
	50th %-ile	73.0%	73.1%	73.3%	73.3%	73.4%	73.6%
	25th %-ile	66.5%	66.9%	67.7%	67.2%	67.0%	66.7%
	5th %-ile	57.5%	58.2%	60.1%	58.5%	58.0%	57.1%
	7.50% return	76.3%	76.3%	76.3%	76.3%	76.3%	76.3%

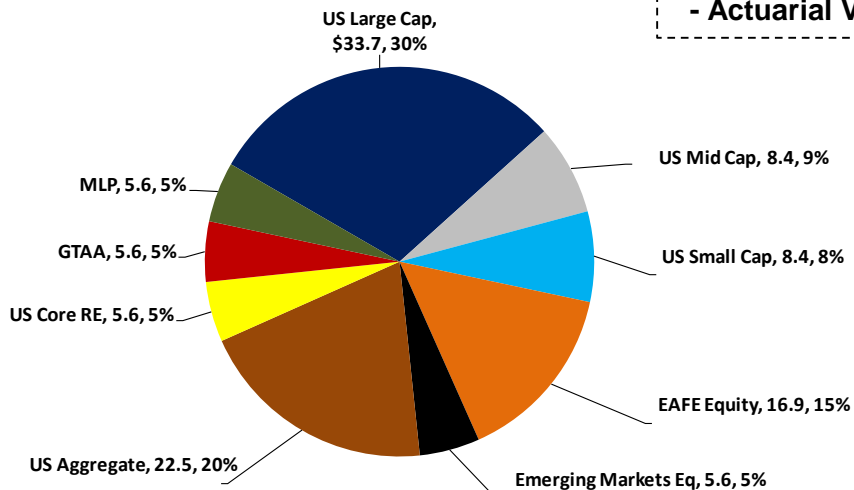




Appendix: TESRS ALM Analysis - Discount Rate = 7.25%

# Current Plan Financial Status

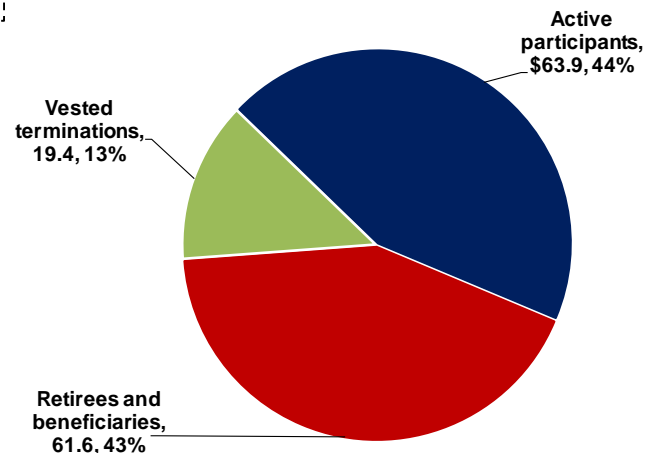
Market Value of Assets, 8/31/2019 <sup>(1)</sup>



**Funded Ratio (est.)**  
 - Market Value = 72.7%  
 - Actuarial Value = 75.7%

Asset Class	Dollars (millions)	Target Percent of Assets
US Large Cap	\$33.7	30.0%
US Mid Cap	8.4	7.5%
US Small Cap	8.4	7.5%
International Equities - Developed	16.9	15.0%
International Equities - Emerging	5.6	5.0%
Core Fixed Income	22.5	20.0%
US Core RE	5.6	5.0%
GTAA	5.6	5.0%
MLP	5.6	5.0%
<b>Market Value of Assets</b>	<b>\$112.4</b>	<b>100.0%</b>
Unrecognized (gains)/losses	<u>\$4.6</u>	
<b>Actuarial Value of Assets</b>	<b>\$117.0</b>	

Actuarial Liability @ 7.25%, 8/31/2019 (est.) <sup>(2)</sup>



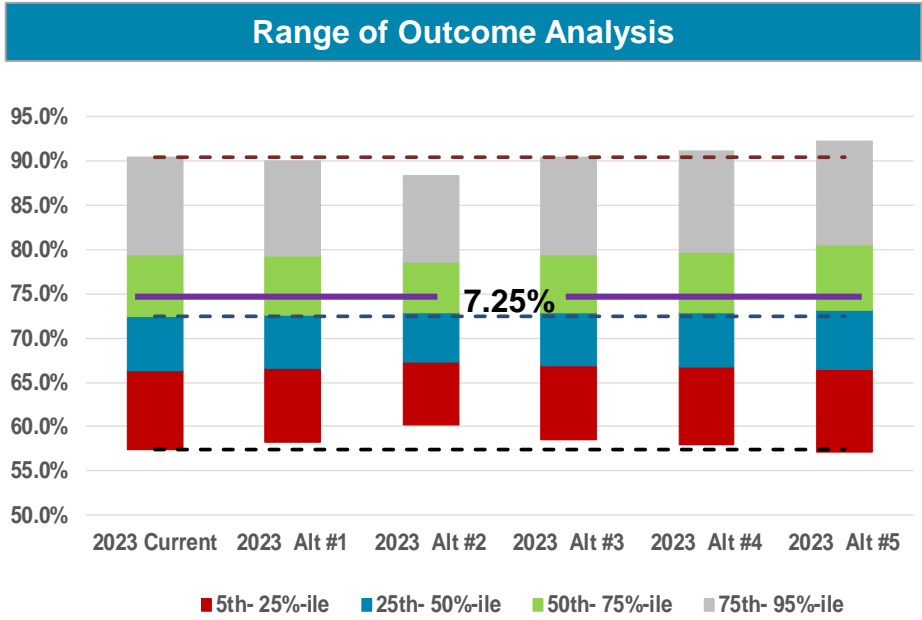
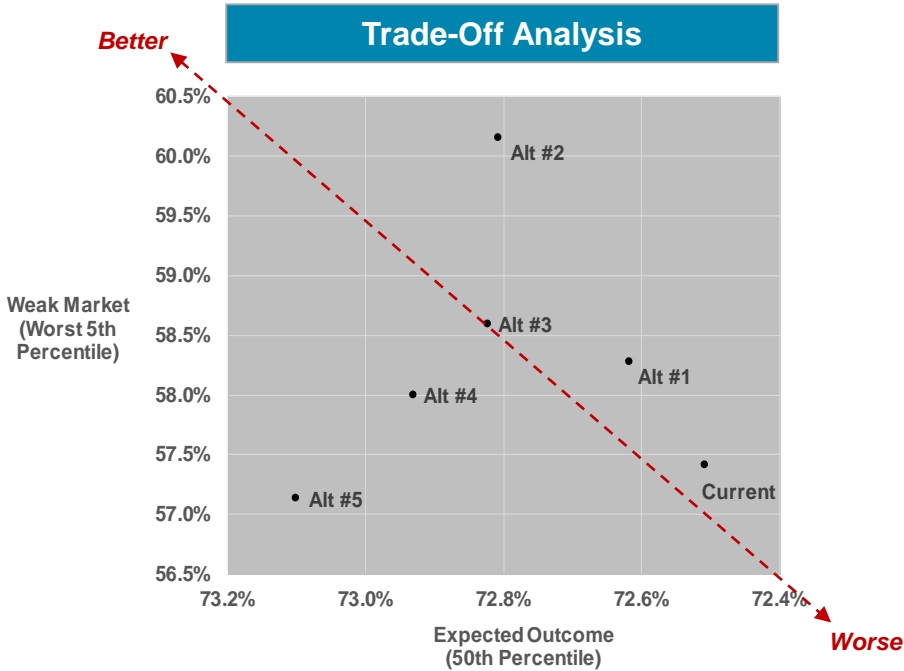
Liability Source	Dollars (millions)	Percent of Liabilities (est.)
Active participants	\$68.1	44.1%
Retirees and beneficiaries	65.7	42.5%
Vested terminations	<u>20.7</u>	<u>13.4%</u>
<b>Total</b>	<b>\$154.5</b>	<b>100.0%</b>

(1) Source: AndCo Consulting 8/31/2019 flash report.

(2) Source: Liability forecast provided by actuarial firm of Rudd & Wisdom.



# Funded Ratio: Actuarial Value of Assets Basis - 2023



	Mix	Current	Alt #1	Alt #2	Alt #3	Alt #4	Alt #5
High Value to Low Value	95th %-ile	90.4%	90.0%	88.3%	90.3%	91.1%	92.2%
	75th %-ile	79.3%	79.3%	78.6%	79.4%	79.7%	80.5%
	50th %-ile	72.5%	72.6%	72.8%	72.8%	72.9%	73.1%
	25th %-ile	66.3%	66.6%	67.3%	66.9%	66.7%	66.4%
	5th %-ile	57.4%	58.3%	60.2%	58.6%	58.0%	57.1%
	7.25% return	74.9%	74.9%	74.9%	74.9%	74.9%	74.9%

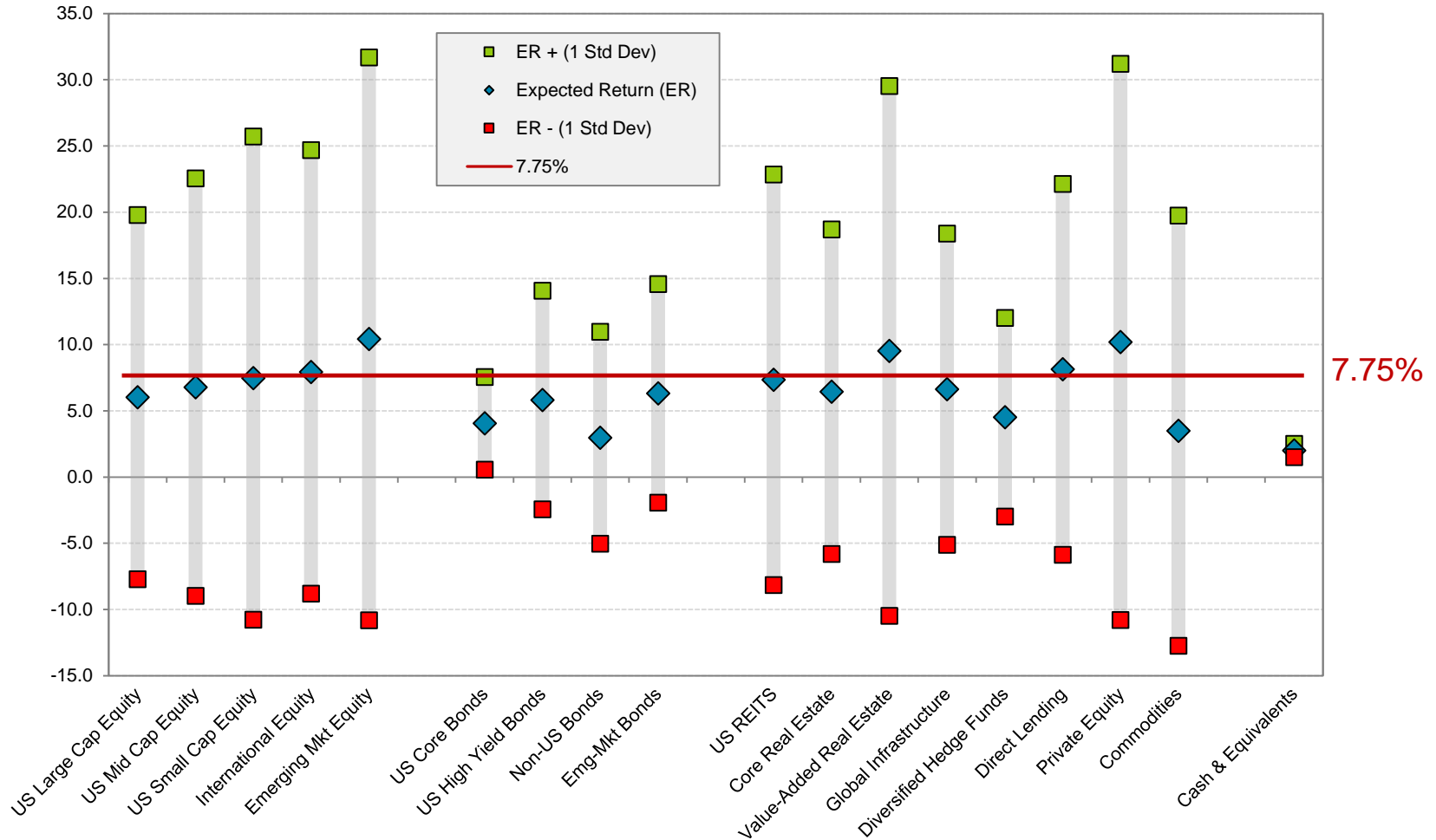




## Appendix - Supplemental Capital Market Materials

# Blending the Return & Risk in a Single View

## Expected Returns & Risk (Std Dev) Relative to a 7.75% Return Assumption

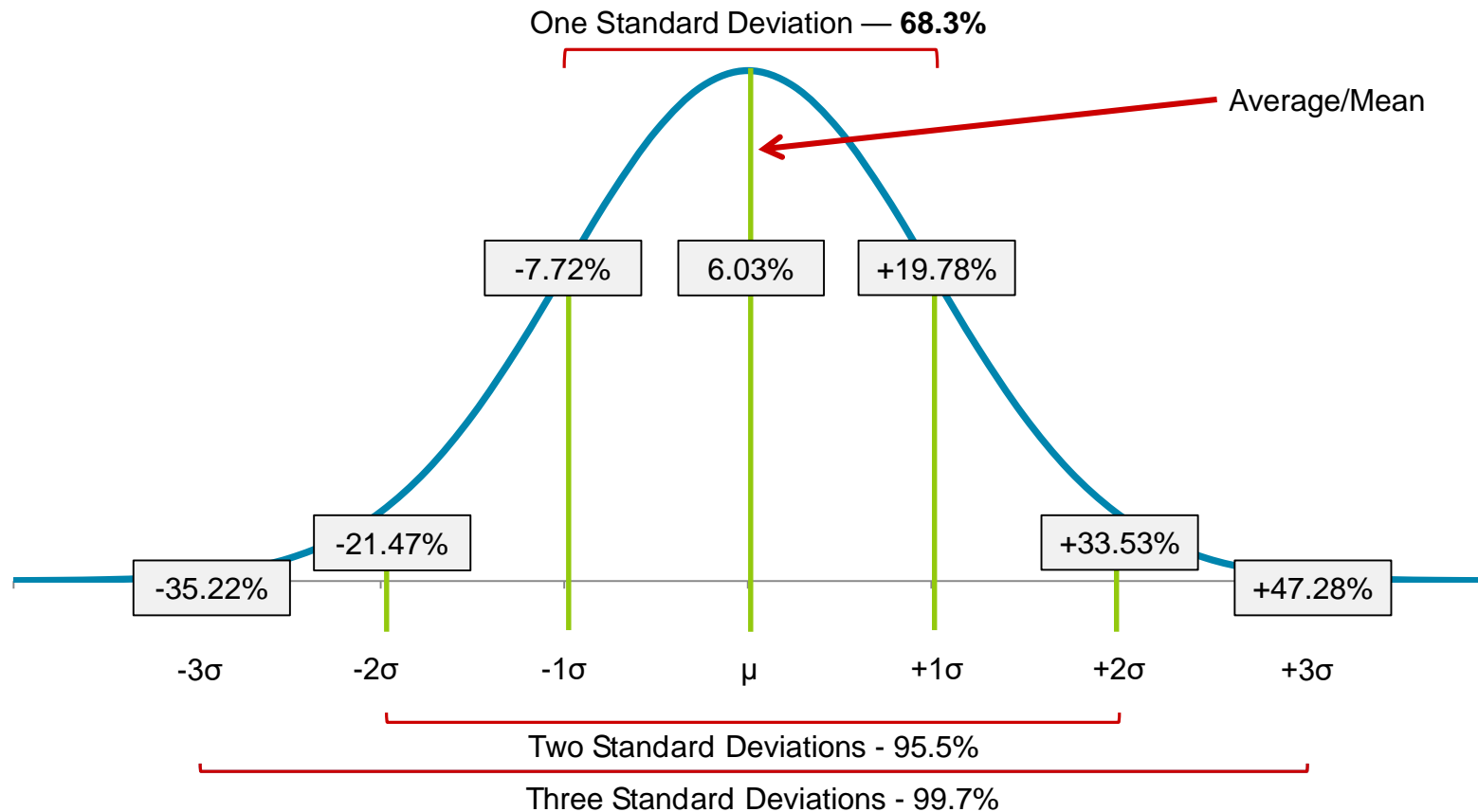


# A Closer Look at Investment Risk as Defined by Math

**Risk = Variability Around Mean = Standard Deviation**

Variability of return around its arithmetic average

Large Cap Equity Average Expected Return of 6.03% with a Standard Deviation of 13.75%

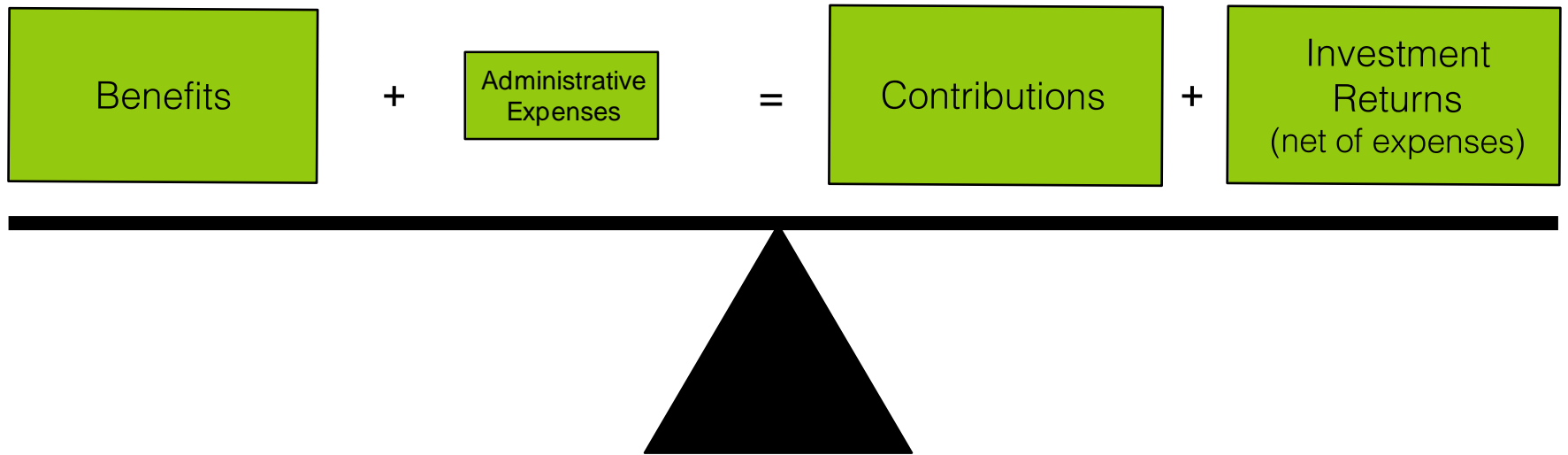




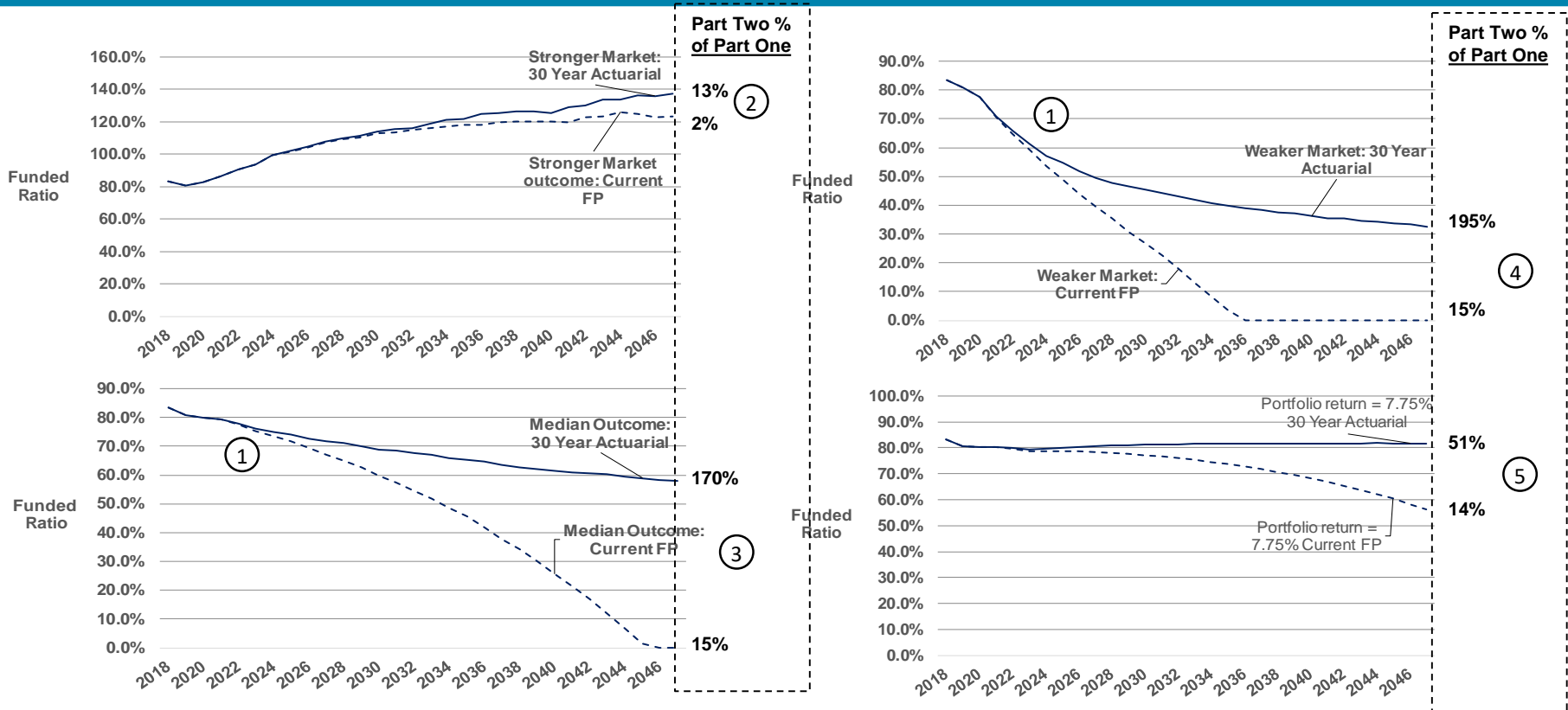
## Appendix: Funding Policy Analysis - Current vs. 30-year



## *The Balance Equation*



# Current Funding Rate vs. 30-Year Actuarial Funding



The analysis above compares the forecasted funded ratio and Part Two percent of Part One contributions under the current funding policy (Current FP) with a policy in which the unfunded actuarial liability (UAL) is amortized over 30 years (30 year actuarial).

- ① The fixed dollar funding policy or a policy with caps can be unresponsive to changes in asset values. This can be seen after about five or six years when the funded ratios between the two funding policies start to diverge in the expected median outcome and weaker market scenarios. The fixed funding policy does not keep up with the actuarial determined funding and in the expected and weak market cases the fund is depleted in less than 30 years.
- ② In an illustrative strong market scenario, the average Part Two contribution could increase 2% to 13% of Part One.
- ③ In an illustrative scenario that produces the median funded ratio outcome, the average Part Two contribution could increase from 15% to 170% of Part One.
- ④ In an illustrative weaker market scenario, the average Part Two contribution could increase from 15% to 195% of Part One.
- ⑤ If the portfolio were to earn its 7.75% assumed rate or return each year the average Part Two contribution could increase from 14% to 51% of 3Part One.. For illustrative purposes only. The above demonstrates hypothetical scenarios whereby the actual results could differ materially from those indicated.





## Appendix - Methods and Assumptions

# Methods and Assumptions

Liability measurement	Initial liabilities as of 8/31/2018, and 30-year forecasts of plan population, benefit payments and liabilities were provided by the retirement system's actuary. Liabilities were provided at the current investment return assumption of 7.75%, as well as 7.50% and 7.25%.
Plan assets	Market and actuarial value of assets were taken from the 08/31/2018 actuarial valuation and were updated on an estimated basis to 8/31/2019 using AndCo Consulting's flash report. Forecasted market value of plan assets were estimated by AndCo based on model investment returns, and estimated funding policy contributions, benefit payments, and administrative expenses. Forecasted actuarial value of assets were estimated by AndCo based on the method used in the 08/31/2018 actuarial valuation.
Funding policy	Forecasted funding policy based on policy in effect for the 8/31/2018 actuarial valuation. <ul style="list-style-type: none"> <li>– Part One Contribution assumed to be \$2.9 million for all forecast years.</li> <li>– State contribution to administrative expenses assumed to be \$725,000 per year.</li> <li>– State contribution limited to one-third of expected contributions as illustrated in the 8/31/2018 actuarial valuation.</li> <li>– Part Two contribution is limited to 15% of Part One contribution.</li> </ul>
Forecast assumptions - Plan population  - Demographic and economic assumptions	Plan active membership is assumed to remain level into the future with the number of new entrants equaling the number exiting active membership. Demographic methods and economic assumptions set by the TESRS actuary.
Forecasting system	Forecasting was done using an Excel-based model developed by AndCo that: 1) accepts the liability and benefit payment forecasts from the actuary, and 2) uses the mm/dd/ccyy actuarial valuation calculation provided by the actuary as the "time 0" forecast result. AndCo then replicates the "time 0" calculation methodology in each subsequent year's forecast over a set of stochastic investment return scenarios.
Other	Consistent with funding levels, administrative expenses assumed to remain level on a dollar basis at the level shown in the August 31, 2018 actuarial valuation.

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Additionally, this document uses assumptions from the 2019 JPMorgan Long Term Capital Market Assumptions (the “2019 JPMorgan Assumptions”). The reader should be aware that the outputs presented in this model are slightly different than those presented in the original 2019 JPMorgan Assumptions. Due to changes in the underlying forecasted correlations from the 2018 JPMorgan Long Term Capital Assumptions, and thereby changes to the methodology used by JPMorgan to create correlation estimates, a malfunction occurs when the 2019 JPMorgan Assumptions interface with Morningstar (i.e., one of the means by which AndCo creates this model). Accordingly, the utilization of a secondary resource created by Morningstar is utilized to remediate this issue; however, this remedy causes some deviation in figures from the original 2019 JPMorgan Assumptions. We consider these deviations to be generally immaterial.

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