Stress Testing Analysis

Pennsylvania Public School Employees' Retirement System (PSERS)
July 24, 2019

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Executive Summary

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Purpose

- In December 2018, the Public Pension Management and Asset Investment Review Commission (PPMAIRC) issued their final report and recommendations
  - The recommendations called for annual stress testing, aligning to the Society of Actuaries' Blue Ribbon Panel, and covering the following scenarios:
    - **Baseline** – assumes the pension plan earns its expected return assumption for the next 30 years
    - **Excess Return** – assumes the pension plan annually earns 2% <u>higher</u> than its expected return assumption for 20 years and then the baseline assumption for the next 10 years
    - **Low Return** – assumes the pension plan annually earns 2% <u>lower</u> than its expected return assumption for 20 years and then the baseline assumption for the next 10 years
    - **Contribution Risk** – assumes the pension plan is funded with 80% of the actuarially-determined contributions for 20 years followed by the full amounts for the next 10 years
  - The variables analyzed include the following:
    - Contributions (in dollars)
    - Contributions (as a percent of payroll)
    - Funded Ratio

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Stress Testing Conclusions

- Deterministic projections are beneficial in the absence of other stress testing because it aids a plan sponsor to understand the risks inherent in the pension plan should actual experience differ from expectations

- The PPMAIRC's deterministic scenarios are limited in that they imply a smooth pattern of results over time rather than a choppier progression of highs and lows (i.e., +/-2% of the expected return on assets for 20 years)
  - For this reason, Aon prefers the robustness of our stochastic projection analysis as it looks at 5,000 individual scenarios over a period of 30 years with each individual scenario exhibiting a non-uniform pattern of results

- The overall takeaways from the PPMAIRC stress testing analysis coincide with Aon's stochastic projection analysis
  - Contributions are expected to increase over the next 15-20 years, decreasing (or increasing) from baseline expectations depending on actual versus expected asset performance
  - The 30 year ending funded ratio in the PPMAIRC's Low Return scenario (76%) is comparable to the 75th percentile outcomes under our stochastic analysis (74%)
    - Approximately 25% of Aon's scenarios in its stochastic analysis are worse than the PPMAIRC's Low Return scenario, making for an even more conservative stress testing approach

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Analysis

- Asset-Liability Projection Results (Deterministic Results)

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Asset-Liability Projection Results (Deterministic Results)

Summary of Results

Scenario	5 Years				10 Years				30 Years			
	Cumulative Contributions		Funded Ratio		Cumulative Contributions		Funded Ratio		Cumulative Contributions		Funded Ratio	
	$	Δ (from Baseline)	%	Δ (from Baseline)	$	Δ (from Baseline)	%	Δ (from Baseline)	$	Δ (from Baseline)	%	Δ (from Baseline)
1. Baseline	$29.6	N/A	61.4%	N/A	$63.4	N/A	71.6%	N/A	$150.2	N/A	104.7%	N/A
2. Excess Return	$29.5	-$0.1	67.6%	6.2%	$62.2	-$1.2	86.7%	15.1%	$125.5	-$24.6	186.4%	81.7%
3. Low Return	$29.6	$0.1	55.6%	-5.8%	$64.6	$1.2	58.9%	-12.7%	$196.1	$46.0	76.2%	-28.5%
4. Low Contributions	$24.1	-$5.5	55.6%	-5.7%	$53.5	-$9.9	59.9%	-11.7%	$173.5	$23.3	92.8%	-11.9%

Key Takeaways:

- Greater return on plan assets will lead to lower future contributions and higher funded ratio; and vice versa
- Funding less than the full actuarially-determined amount will lead to lower funded ratios and higher contribution amounts

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Detailed Stress Test Scenario

1. Baseline Scenario

June 30th	Return	Total Contribution ($ Billions)	Total Contribution (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2018	7.25%	$5.5	40.2%	54.7%
2019	7.25%	$5.7	41.3%	55.7%
2020	7.25%	$5.9	42.1%	56.9%
2021	7.25%	$6.1	42.6%	58.3%
2022	7.25%	$6.3	43.1%	59.8%
2023	7.25%	$6.4	43.5%	61.4%
2024	7.25%	$6.6	43.9%	63.1%
2025	7.25%	$6.8	44.4%	65.0%
2026	7.25%	$7.0	44.8%	67.0%
2027	7.25%	$7.1	45.0%	69.2%
2028	7.25%	$7.3	45.4%	71.6%
2029	7.25%	$7.4	45.8%	74.1%
2030	7.25%	$7.6	46.2%	76.8%
2031	7.25%	$7.8	46.6%	79.7%
2032	7.25%	$8.0	47.1%	82.9%
2033	7.25%	$8.2	47.6%	86.4%
2034	7.25%	$8.3	48.1%	90.2%
2035	7.25%	$5.3	30.1%	94.4%
2036	7.25%	$4.3	24.2%	96.6%
2037	7.25%	$3.9	21.8%	98.2%
2038	7.25%	$3.5	19.1%	99.7%
2039	7.25%	$3.1	16.9%	101.0%
2040	7.25%	$1.7	8.8%	102.2%
2041	7.25%	$1.6	8.5%	102.4%
2042	7.25%	$1.6	8.1%	102.6%
2043	7.25%	$1.5	7.8%	102.9%
2044	7.25%	$1.5	7.5%	103.2%
2045	7.25%	$1.4	7.1%	103.5%
2046	7.25%	$1.4	6.9%	103.9%
2047	7.25%	$1.4	6.6%	104.2%
2048				104.7%

Key Takeaways:

- Contributions are expected to peak in 2034 and decrease thereafter
- Plan reaches 100% funded ratio by 2039

$150.2B
Cumulative 30 Year Contributions

104.7%
Expected Funded Ratio After 30 Years

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Detailed Stress Test Scenario

2. Excess Return Scenario (Asset Returns Increase by 2% for 20 Years)

June 30th	Return	Total Contribution ($ Billions)	Total Contribution (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2018	9.25%	$5.5	40.2%	54.7%
2019	9.25%	$5.7	41.3%	56.8%
2020	9.25%	$5.9	42.0%	59.1%
2021	9.25%	$6.1	42.4%	61.7%
2022	9.25%	$6.2	42.8%	64.6%
2023	9.25%	$6.3	42.9%	67.6%
2024	9.25%	$6.4	42.9%	70.9%
2025	9.25%	$6.6	43.0%	74.4%
2026	9.25%	$6.7	42.8%	78.2%
2027	9.25%	$6.7	42.5%	82.3%
2028	9.25%	$6.7	42.1%	86.7%
2029	9.25%	$6.8	41.6%	91.3%
2030	9.25%	$6.8	41.1%	96.3%
2031	9.25%	$6.8	40.5%	101.6%
2032	9.25%	$6.7	39.8%	107.3%
2033	9.25%	$6.7	39.1%	113.4%
2034	9.25%	$1.9	10.9%	120.1%
2035	9.25%	$1.9	10.6%	123.6%
2036	9.25%	$1.8	10.3%	127.6%
2037	9.25%	$1.8	9.9%	132.1%
2038	7.25%	$1.7	9.6%	137.0%
2039	7.25%	$1.7	9.2%	139.9%
2040	7.25%	$1.7	8.8%	143.1%
2041	7.25%	$1.6	8.5%	146.6%
2042	7.25%	$1.6	8.1%	150.6%
2043	7.25%	$1.5	7.8%	155.1%
2044	7.25%	$1.5	7.5%	160.2%
2045	7.25%	$1.4	7.1%	165.7%
2046	7.25%	$1.4	6.9%	171.9%
2047	7.25%	$1.4	6.6%	178.8%
2048				186.4%

Key Takeaways:

- Contributions are expected to peak in 2029-2031 and decrease thereafter
- Plan reaches 100% funded ratio by 2031

$125.5B
Cumulative 30 Year Contributions

186.4%
Expected Funded Ratio After 30 Years

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Detailed Stress Test Scenario

3. Low Return Scenario (Asset Returns Decrease by 2% for 20 Years)

June 30th	Return	Total Contribution ($ Billions)	Total Contribution (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2018	5.25%	$5.5	40.2%	54.7%
2019	5.25%	$5.7	41.3%	54.7%
2020	5.25%	$5.9	42.1%	54.8%
2021	5.25%	$6.1	42.8%	55.0%
2022	5.25%	$6.3	43.5%	55.2%
2023	5.25%	$6.5	44.1%	55.6%
2024	5.25%	$6.7	44.8%	56.0%
2025	5.25%	$7.0	45.7%	56.6%
2026	5.25%	$7.2	46.5%	57.2%
2027	5.25%	$7.5	47.4%	58.0%
2028	5.25%	$7.7	48.3%	58.9%
2029	5.25%	$8.0	49.5%	59.9%
2030	5.25%	$8.3	50.6%	61.1%
2031	5.25%	$8.7	51.9%	62.5%
2032	5.25%	$9.0	53.2%	64.1%
2033	5.25%	$9.4	54.6%	66.0%
2034	5.25%	$9.7	56.1%	68.1%
2035	5.25%	$6.9	39.1%	70.5%
2036	5.25%	$6.1	34.3%	70.9%
2037	5.25%	$5.9	32.9%	70.6%
2038	7.25%	$5.7	31.4%	70.2%
2039	7.25%	$5.6	30.3%	71.0%
2040	7.25%	$5.5	29.5%	71.7%
2041	7.25%	$4.9	25.8%	72.4%
2042	7.25%	$4.8	25.0%	72.7%
2043	7.25%	$4.9	25.1%	72.9%
2044	7.25%	$5.0	25.3%	73.2%
2045	7.25%	$5.1	25.3%	73.7%
2046	7.25%	$5.1	24.9%	74.4%
2047	7.25%	$5.1	24.5%	75.2%
2048				76.2%

Key Takeaways:

- Contributions are expected to peak in 2034
- Plan does not reach 100% funded ratio over the projection period

$196.1B
Cumulative 30 Year Contributions

76.2%
Expected Funded Ratio After 30 Years

Detailed Stress Test Scenario

4. Low Contribution Scenario (Contribute 80% of ADC for 20 Years)

June 30th	Return	Total Contribution ($ Billions)	Total Contribution (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2018	7.25%	$4.4	32.1%	54.7%
2019	7.25%	$4.6	33.1%	54.6%
2020	7.25%	$4.8	34.1%	54.7%
2021	7.25%	$5.0	35.0%	54.9%
2022	7.25%	$5.2	36.0%	55.2%
2023	7.25%	$5.4	36.8%	55.6%
2024	7.25%	$5.7	37.6%	56.2%
2025	7.25%	$5.9	38.5%	56.9%
2026	7.25%	$6.1	39.5%	57.7%
2027	7.25%	$6.4	40.3%	58.7%
2028	7.25%	$6.6	41.2%	59.9%
2029	7.25%	$6.9	42.2%	61.2%
2030	7.25%	$7.1	43.2%	62.7%
2031	7.25%	$7.4	44.3%	64.4%
2032	7.25%	$7.7	45.4%	66.3%
2033	7.25%	$8.0	46.6%	68.5%
2034	7.25%	$8.3	47.8%	71.0%
2035	7.25%	$6.0	34.3%	73.9%
2036	7.25%	$5.4	30.5%	75.2%
2037	7.25%	$5.3	29.2%	76.2%
2038	7.25%	$6.3	34.8%	77.1%
2039	7.25%	$6.2	33.4%	78.8%
2040	7.25%	$5.9	31.7%	80.6%
2041	7.25%	$5.2	27.3%	82.4%
2042	7.25%	$5.0	25.8%	83.7%
2043	7.25%	$4.9	25.2%	85.0%
2044	7.25%	$4.8	24.0%	86.5%
2045	7.25%	$4.6	22.8%	88.0%
2046	7.25%	$4.3	21.1%	89.6%
2047	7.25%	$4.1	19.7%	91.2%
2048				92.8%

Key Takeaways:

- Contributions are expected to peak in 2034
- Plan does not reach 100% funded ratio over the projection period

$173.5B
Cumulative 30 Year Contributions

92.8%
Expected Funded Ratio After 30 Years

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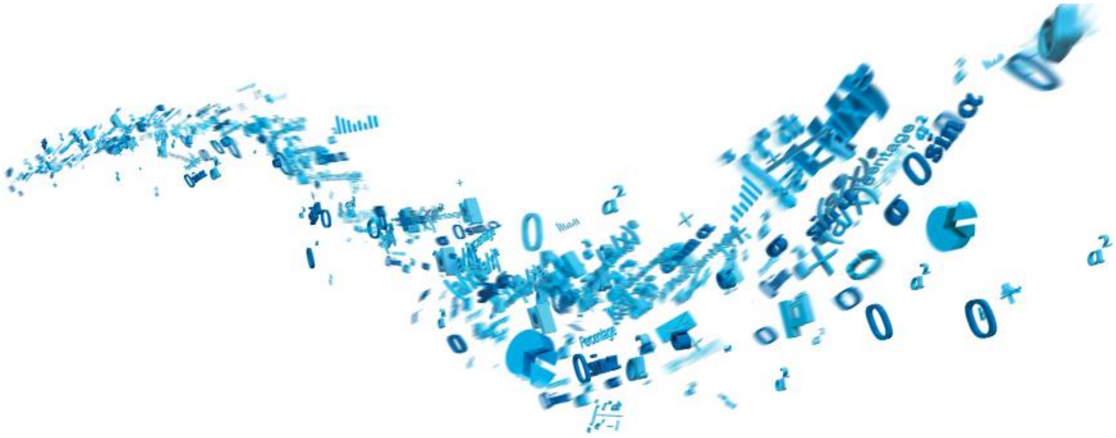

Analysis

- Asset-Liability Projection Results (Stochastic Results)

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Asset-Liability Projection Results (Stochastic Results)

Summary of Results

All Scenarios	30-year Present Value of Gross Contributions (Employee + Employer)		30-year Ending Funded Ratio (MVA / AL)		30-Year Total Nominal Employer Contributions	
$ billions	Expected[1]	Downside[2]	Expected[1]	Downside[3]	Expected[1]	Downside[2]
(B) Proposed 1 Year Target	$75.5	$94.5	117%	33%	$121.5	$211.8
(G) Proposed Long-Term Target	$74.1	$94.5	134%	35%	$115.0	$210.2

Key Findings:

- The Plan is expected to reach full funding in the central expectation (50th percentile) under both the Proposed 1 Year and the Proposed Long-Term Target policy over the course of the projection period assuming the expected contributions are made
- Adverse market experience and/or not making required contributions will negatively impact the funded status over the projection period

[1] Expected = 50th percentile outcome or central expectation across all 5,000 simulations
[2] Downside = 95th percentile outcome across all 5,000 simulations
[3] Downside = 5th percentile outcome across all 5,000 simulations

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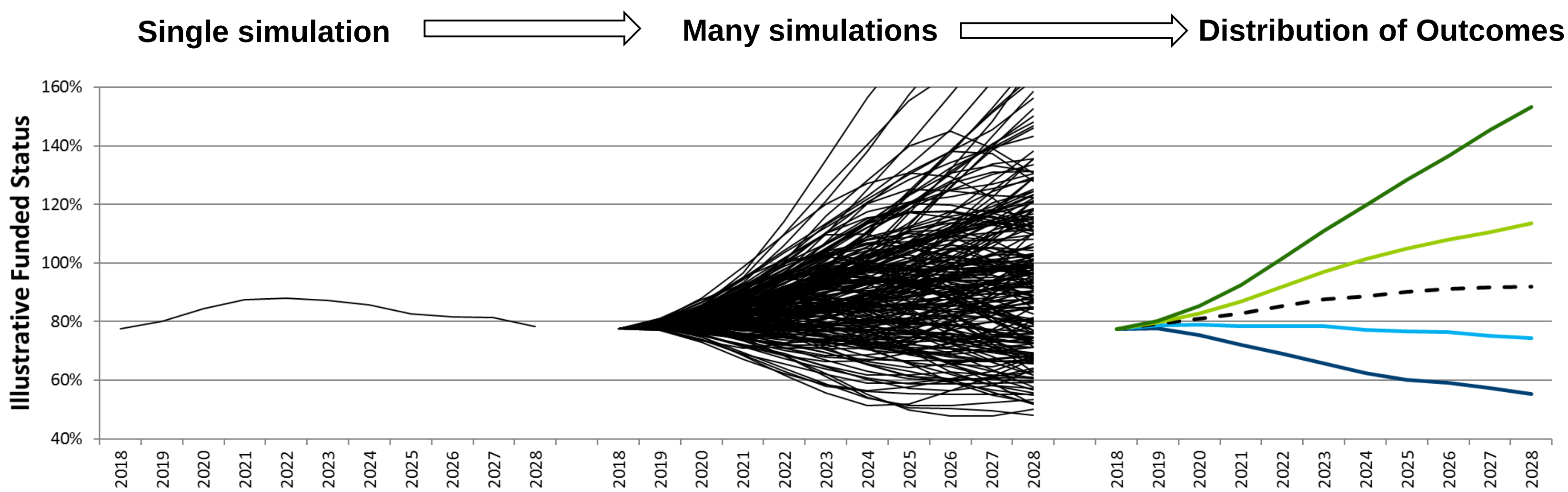
Asset-Liability Simulation Overview

- Thousands of simulations plotted in one graph would be impossible to interpret
- Instead, we rank the simulations at each point over the future
- This produces a distribution of outcomes illustrating the degree of uncertainty of a plan's financial position over the projection period
- Different investment strategies will produce different distributions of outcomes



* The path of a given scenario will follow a much less smooth pattern than the distribution suggests, as illustrated above

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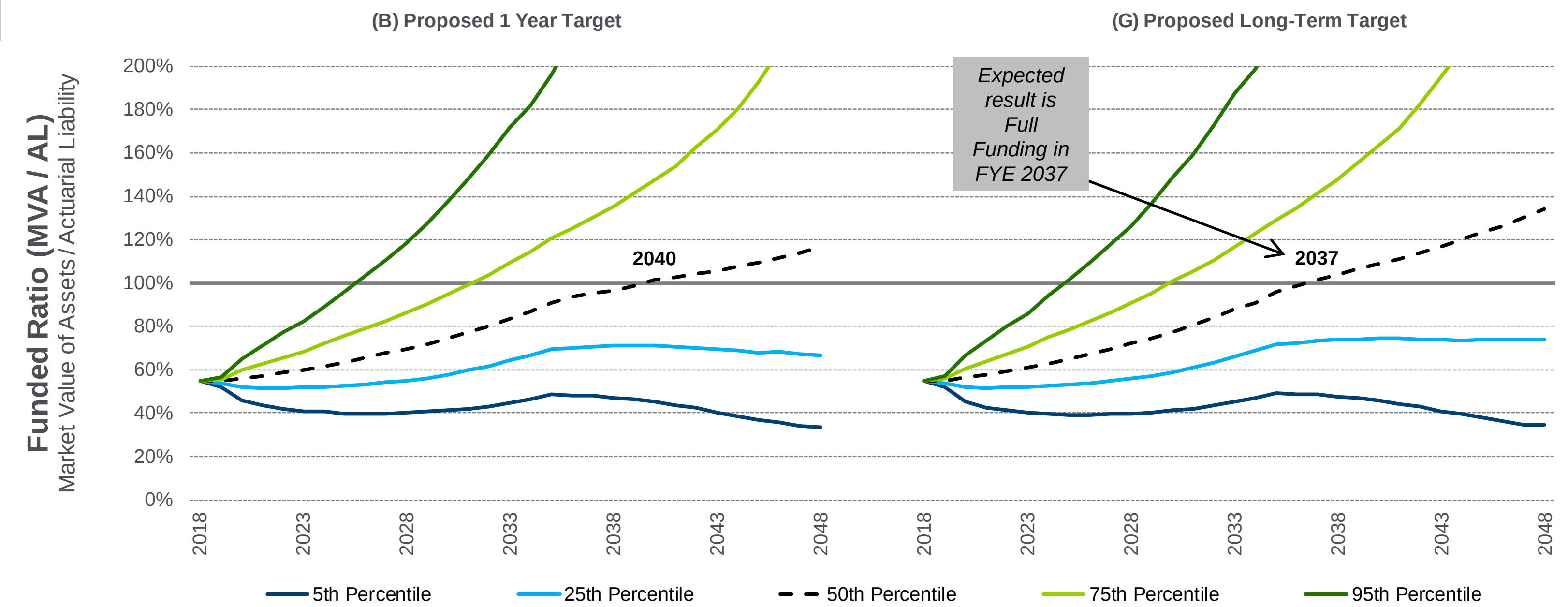
Asset-Liability Projection Results (Stochastic Results)

Market Value of Assets / Actuarial Liability Funded Ratio



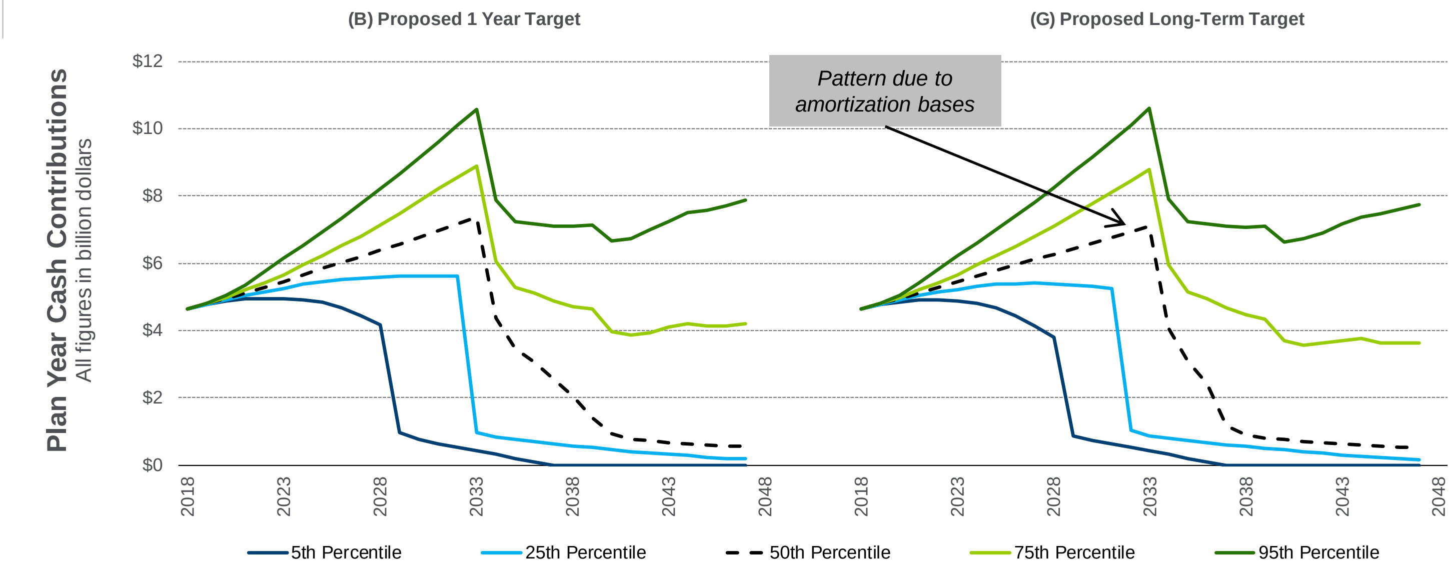
Strategy	(B) Proposed 1 Year Target			(G) Proposed Long-Term Target		
Year	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**
5th Percentile	40%	47%	33%	40%	47%	35%
25th Percentile	55%	71%	66%	56%	74%	74%
50th Percentile	70%	97%	117%	72%	104%	134%
75th Percentile	87%	136%	>200%	91%	148%	>200%
95th Percentile	118%	>200%	>200%	126%	>200%	>200%
Probability > 100%	17%	48%	58%	20%	53%	64%

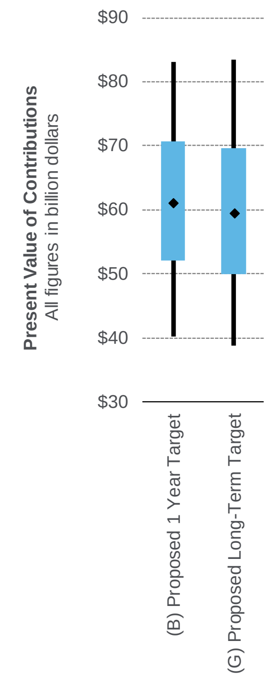
Key Takeaways:

- The funded ratio is projected to trend toward full funding over the course of the projection period
- Adverse market experience could significantly impact the funded status of the Plan

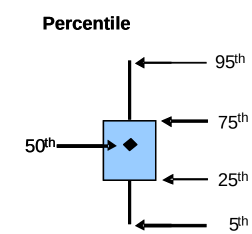
* Liability projections assume discount rates of 7.25% for all investment policies studied

Asset-Liability Projection Results (Stochastic Results)
Employer Contribution Amount





Strategy	(B) Proposed 1 Year Target			(G) Proposed Long-Term Target		
Year	**2027**	**2037**	**2047**	**2027**	**2037**	**2047**
5th Percentile	$4.44	$0.00	$0.00	$4.14	$0.00	$0.00
25th Percentile	$5.55	$0.63	$0.17	$5.40	$0.61	$0.16
50th Percentile	$6.20	$2.55	$0.56	$6.11	$1.17	$0.51
75th Percentile	$6.82	$4.88	$4.20	$6.79	$4.67	$3.62
95th Percentile	$7.76	$7.10	$7.87	$7.81	$7.10	$7.75
Probability > $7B	21%	6%	10%	21%	6%	9%

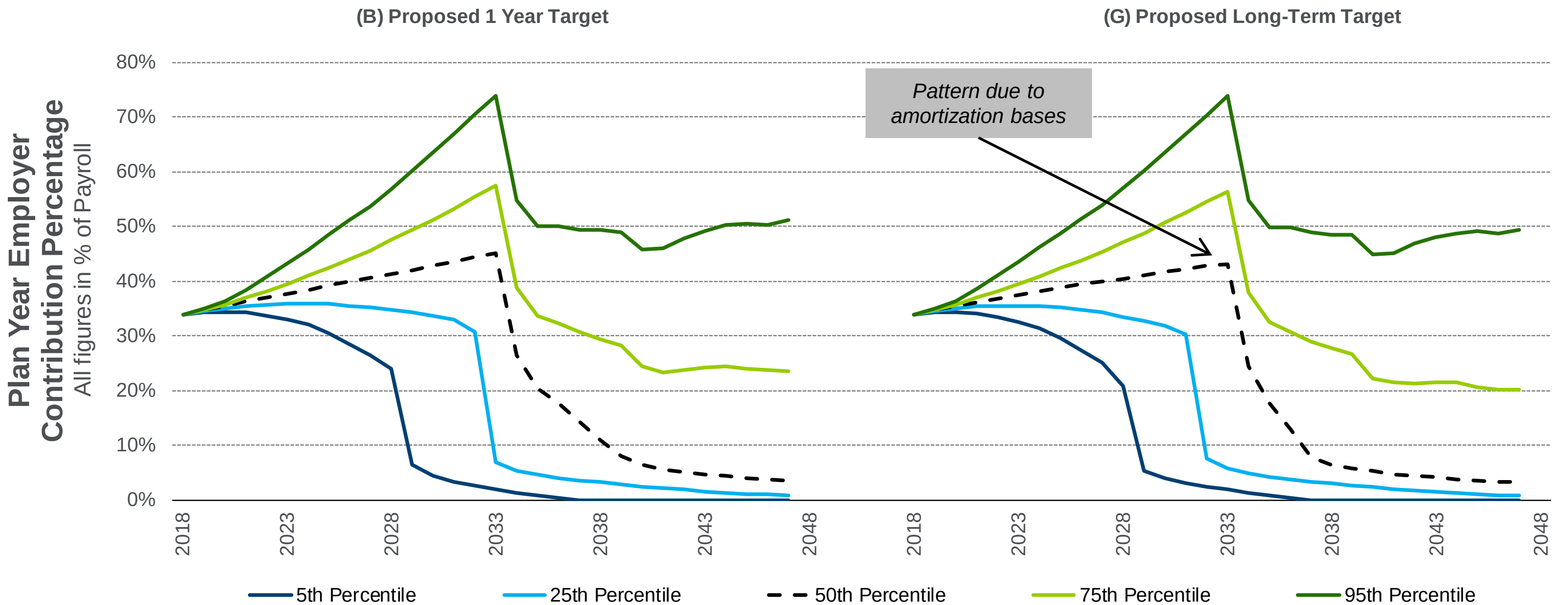


Key Takeaway:

- Contributions in the central expectation (50th percentile outcomes) are projected to increase from their current levels until the expiration of individual amortization bases or when the plan reaches a funded status of at least 100% on an actuarial value of assets basis

* Liability projections assume discount rates of 7.25% for all investment policies studied

Asset-Liability Projection Results (Stochastic Results)
Employer Contribution Percentage of Payroll



Strategy	(B) Proposed 1 Year Target			(G) Proposed Long-Term Target		
Year	2027	2037	2047	2027	2037	2047
5th Percentile	27%	0%	0%	25%	0%	0%
25th Percentile	35%	4%	1%	34%	3%	1%
50th Percentile	41%	14%	4%	40%	8%	3%
75th Percentile	46%	31%	23%	45%	29%	20%
95th Percentile	54%	49%	51%	54%	49%	49%
Probability > 45%	28%	10%	9%	27%	9%	8%

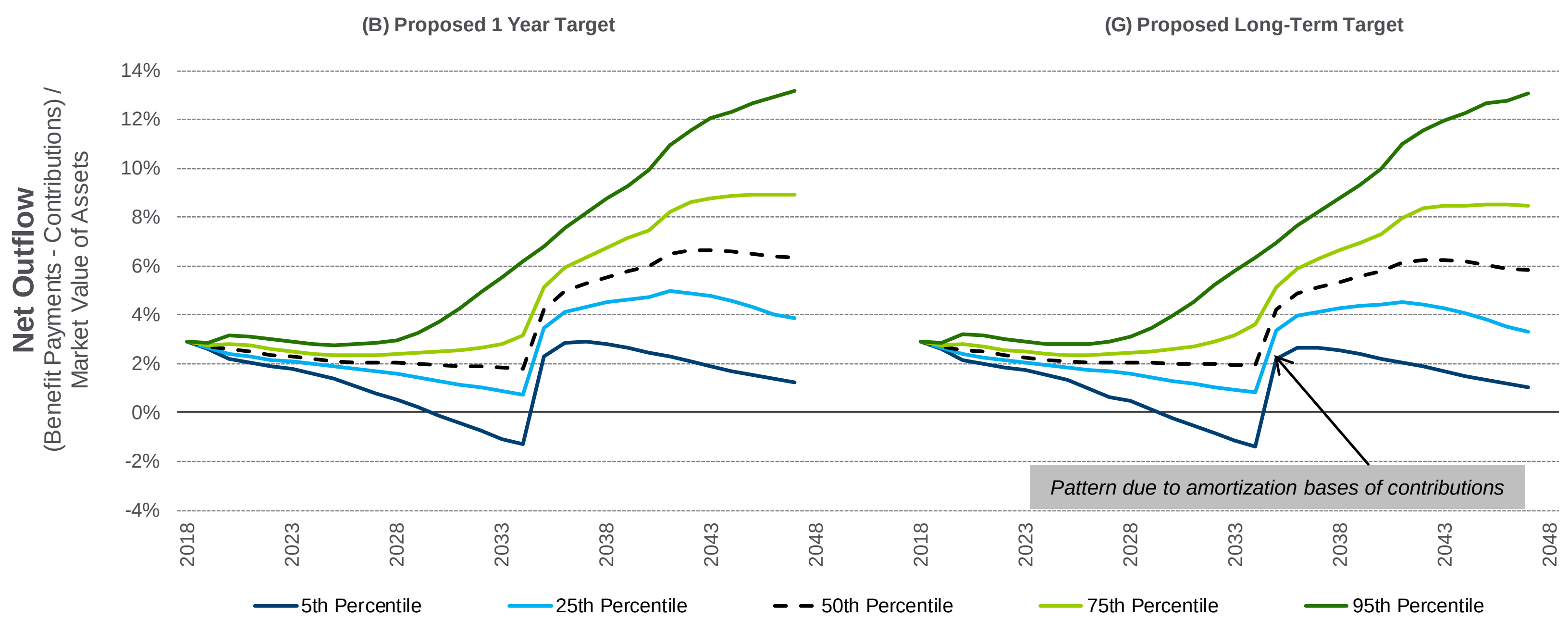
Key Takeaway:

- The trajectories of the central expectations (50th percentile outcomes) are projected to increase until the expiration of individual amortization bases or when the plan reaches a funded status of at least 100% on an actuarial value of assets basis

* Liability projections assume discount rates of 7.25% for all investment policies studied

Asset-Liability Projection Results (Stochastic Results)

Net Outflow Analysis: (Benefit Payments less Contributions) / Market Value of Assets



Strategy	(B) Proposed 1 Year Target			(G) Proposed Long-Term Target		
Year	**2027**	**2037**	**2047**	**2027**	**2037**	**2047**
5th Percentile	1%	3%	1%	1%	3%	1%
25th Percentile	2%	4%	4%	2%	4%	3%
50th Percentile	2%	5%	6%	2%	5%	6%
75th Percentile	2%	6%	9%	2%	6%	8%
95th Percentile	3%	8%	13%	3%	8%	13%
Probability > 10%	<1%	<1%	20%	<1%	<1%	18%

Key Takeaway:

- Net outflow is consistent across the portfolios modeled, sharply increasing once amortization bases fall out of the contribution calculations

* Liability projections assume discount rates of 7.25% for all investment policies studied

Appendix

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Portfolio Analysis
Portfolios Evaluated

	B	G
	Proposed 1 Year Target	Proposed Long-Term Target
US Equity	4.8%	7.8%
Global Equity	0.0%	0.0%
Non-US Dev, Unhedged	1.6%	2.0%
Non-US Dev, USD Hedged	4.9%	6.0%
Emerging Markets	3.7%	4.2%
Private Equity, Unhedged[1]	15.0%	15.0%
Total Equity	**30.0%**	**35.0%**
US Core Fixed Income	4.0%	5.0%
Non-US Dev, USD Hedged	0.0%	1.0%
US Long-Term Treasury	6.0%	6.0%
Emerging Markets Debt[2]	1.0%	2.0%
High Yield	0.0%	0.0%
Private Credit	10.0%	10.0%
US TIPS	7.5%	7.5%
Non-US Inflation-Linked	7.5%	7.5%
Total Fixed Income	**36.0%**	**39.0%**
Infrastructure: Energy MLPS	3.0%	0.0%
Infrastructure: Private, USD Hedged	1.0%	4.0%
Infrastructure: Public, USD Hedged	2.0%	4.0%
Commodities: Diversified	5.0%	5.0%
Commodities: Gold	3.0%	3.0%
Private Real Estate, Unhedged	8.0%	8.0%
Global REITs, USD Hedged	2.0%	2.0%
Total Real Assets	**24.0%**	**26.0%**
Risk Parity[4]	**8.0%**	**8.0%**
Hedge Funds[5]	**10.0%**	**10.0%**
Cash	**6.0%**	**3.0%**
LIBOR (Leverage)	**-14.0%**	**-21.0%**
Total Plan	**100.0%**	**100.0%**
30-Year Exp. Nom. Return	**7.28%**	**7.66%**
30-Year Exp. Real Return	**4.96%**	**5.34%**
30-Year Expected Risk	**10.62%**	**11.56%**
Sharpe Ratio	**0.448**	**0.445**

[1] Private Equity assumptions developed as follows: 72% Buyouts, 13% Venture Capital, 15% Distressed Debt

[2] The Emerging Markets Debt allocation is comprised as follows: Proposed 1 Year Target:1% Local EMD; Proposed Long-Term: 1% Local EMD, 1% Hard EMD

[3] Risk Parity assumptions developed as follows: 50% Global Equity, -100% LIBOR, 55% TIPS, 75% Intermediate Gov't. Bonds, 20% Commodities

[4] Hedge Fund assumptions developed as follows: 14% Event Driven, 38% Global Macro, 20% Distressed Debt, 16% Fixed Income Arbitrage, 12% Cat. Bonds; Hedge funds have elements of both return-seeking and risk-reducing assets. Hedge funds have been categorized as risk-reducing based on the composition of the hedge funds within the PSERS portfolio.

Percentages in table may not sum to 100% due to rounding

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AHIC Capital Market Assumptions
As of March 31, 2019 (30 Years)

		Expected Real Return[1]	Expected Nominal Return[1]	Expected Nominal Volatility
	Equity			
1	Large Cap U.S. Equity	4.5%	6.8%	17.3%
2	Small Cap U.S. Equity	5.0%	7.3%	23.6%
3	Global Equity IMI	5.4%	7.8%	18.8%
4	International Equity (Developed) - Hedged	5.9%	8.2%	18.0%
5	International Equity (Developed)	5.3%	7.6%	20.0%
6	Emerging Markets Equity	6.3%	8.6%	27.6%
	Fixed Income			
7	Cash (Gov't)	0.3%	2.5%	1.7%
8	Cash (LIBOR)	0.7%	2.9%	1.8%
9	Non-US Inflation-Linked	0.3%	2.5%	3.6%
10	Core Fixed Income	1.1%	3.4%	4.9%
11	TIPS	1.0%	3.2%	4.5%
12	Long Duration Bonds – Gov't	0.8%	3.0%	10.6%
13	High Yield Bonds	2.9%	5.1%	12.2%
14	Non-US Developed Bond (100% Hedged)	0.5%	2.8%	4.1%
15	Emerging Market Bonds	2.7%	5.0%	13.7%
16	Emerging Market Bonds (Sov. Local)	3.1%	5.4%	14.4%
	Alternatives			
17	Hedge Funds[2]	3.4%	5.6%	8.8%
18	Non Core Real Estate	3.9%	6.2%	19.8%
19	Real Estate[3]	3.9%	6.2%	17.3%
20	US REITs	3.9%	6.2%	18.9%
21	Commodities	2.8%	5.1%	16.8%
22	Private Equity[4]	7.4%	9.7%	26.6%
23	Private Infrastructure	5.5%	7.8%	14.8%
24	Public Infrastructure	5.0%	7.3%	17.4%
25	Risk Parity[5]	4.1%	6.4%	10.9%
26	Master Limited Partnerships	5.2%	7.5%	16.4%
27	Gold	1.0%	3.2%	19.5%
28	Private Debt	5.0%	7.4%	16.8%
	Inflation			
	Inflation	0.0%	2.2%	1.6%

[1] All expected returns are geometric (long-term compounded; rounded to the nearest decimal) and net of investment fees.
[2] Hedge Fund assumptions developed as follows: 14% Event Driven, 38% Global Macro, 20% Distressed Debt, 16% Fixed Income Arbitrage, 12% Cat. Bonds
[3] Real Estate assumption developed as follows: 80% Non-Core Rel Estate, 20% Core Real Estate
[4] Private Equity assumptions developed as follows: 72% Buyouts, 13% Venture Capital, 15% Distressed Debt
[5] Risk Parity assumptions developed as follows: 50% Global Equity, -100% LIBOR, 55% TIPS, 75% Intermediate Gov't. Bonds, 20% Commodities

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AHIC Capital Market Assumptions

As of March 31, 2019 (30 Years)

	Nominal Correlations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Large Cap U.S. Equity	**1.00**	0.92	0.96	0.89	0.78	0.72	0.08	0.08	-0.06	0.04	-0.06	-0.13	0.60	0.01	0.42	0.47	0.56	0.24	0.27	0.66	0.32	0.92	0.38	0.88	0.86	0.94	0.01	0.34
2	Small Cap U.S. Equity	0.92	**1.00**	0.90	0.82	0.72	0.67	0.07	0.07	-0.06	0.03	-0.06	-0.12	0.56	0.00	0.39	0.42	0.51	0.22	0.25	0.61	0.27	0.87	0.36	0.82	0.80	0.88	0.00	0.32
3	Global Equity IMI	0.96	0.90	**1.00**	0.92	0.91	0.84	0.07	0.07	-0.07	0.04	-0.06	-0.13	0.66	0.00	0.47	0.56	0.55	0.24	0.27	0.64	0.38	0.89	0.38	0.92	0.89	0.98	0.01	0.36
4	International Equity (Developed) - Hedged	0.89	0.82	0.92	**1.00**	0.88	0.73	0.10	0.10	-0.06	0.05	-0.04	-0.11	0.57	0.01	0.40	0.41	0.51	0.25	0.28	0.61	0.27	0.82	0.35	0.84	0.82	0.89	0.01	0.33
5	International Equity (Developed)	0.78	0.72	0.91	0.88	**1.00**	0.75	0.04	0.04	-0.08	0.03	-0.04	-0.11	0.58	-0.02	0.43	0.60	0.50	0.22	0.25	0.53	0.44	0.73	0.32	0.84	0.79	0.90	0.01	0.32
6	Emerging Markets Equity	0.72	0.67	0.84	0.73	0.75	**1.00**	0.06	0.06	-0.06	0.04	-0.05	-0.11	0.66	0.01	0.48	0.53	0.41	0.20	0.22	0.49	0.31	0.68	0.30	0.77	0.74	0.82	0.01	0.32
7	Cash (Gov't)	0.08	0.07	0.07	0.10	0.04	0.06	**1.00**	0.99	0.54	0.46	0.44	0.23	0.15	0.59	0.17	0.00	0.07	0.09	0.11	0.08	0.22	0.04	0.11	0.10	0.21	0.11	0.06	0.02
8	Cash (LIBOR)	0.08	0.07	0.07	0.10	0.04	0.06	0.99	**1.00**	0.53	0.46	0.44	0.23	0.15	0.58	0.18	0.01	0.07	0.09	0.10	0.08	0.22	0.04	0.11	0.10	0.20	0.11	0.06	0.03
9	Non-US Inflation-Linked	-0.06	-0.06	-0.07	-0.06	-0.08	-0.06	0.54	0.53	**1.00**	0.21	0.45	0.07	0.03	0.40	0.04	-0.04	0.03	0.02	0.02	-0.03	0.20	-0.07	0.02	-0.03	0.09	-0.03	0.04	0.01
10	Core Fixed Income	0.04	0.03	0.04	0.05	0.03	0.04	0.46	0.46	0.21	**1.00**	0.49	0.76	0.34	0.61	0.50	0.14	0.16	0.04	0.04	0.04	0.08	0.03	0.05	0.05	0.31	0.05	0.02	0.06
11	TIPS	-0.06	-0.06	-0.06	-0.04	-0.04	-0.05	0.44	0.44	0.45	0.49	**1.00**	0.31	0.11	0.20	0.15	-0.02	-0.02	0.01	0.02	-0.03	0.18	-0.06	0.00	-0.02	0.30	-0.02	0.05	-0.08
12	Long Duration Bonds – Gov't	-0.13	-0.12	-0.13	-0.11	-0.11	-0.11	0.23	0.23	0.07	0.76	0.31	**1.00**	-0.10	0.51	0.18	-0.04	-0.11	-0.02	-0.03	-0.08	-0.03	-0.12	-0.04	-0.11	0.10	-0.12	-0.01	-0.33
13	High Yield Bonds	0.60	0.56	0.66	0.57	0.58	0.66	0.15	0.15	0.03	0.34	0.11	-0.10	**1.00**	0.14	0.73	0.58	0.59	0.16	0.18	0.41	0.38	0.58	0.27	0.62	0.66	0.66	0.02	0.64
14	Non-US Developed Bond (100% Hedged)	0.01	0.00	0.00	0.01	-0.02	0.01	0.59	0.58	0.40	0.61	0.20	0.51	0.14	**1.00**	0.28	0.08	0.09	0.04	0.05	0.01	0.09	-0.01	0.05	0.01	0.12	0.02	0.02	0.01
15	Emerging Market Bonds	0.42	0.39	0.47	0.40	0.43	0.48	0.17	0.18	0.04	0.50	0.15	0.18	0.73	0.28	**1.00**	0.63	0.53	0.11	0.13	0.28	0.24	0.40	0.18	0.44	0.51	0.47	0.02	0.37
16	Emerging Market Bonds (Sov. Local)	0.47	0.42	0.56	0.41	0.60	0.53	0.00	0.01	-0.04	0.14	-0.02	-0.04	0.58	0.08	0.63	**1.00**	0.47	0.06	0.07	0.29	0.44	0.45	0.13	0.54	0.50	0.58	0.00	0.37
17	Hedge Funds[1]	0.56	0.51	0.55	0.51	0.50	0.41	0.07	0.07	0.03	0.16	-0.02	-0.11	0.59	0.09	0.53	0.47	**1.00**	0.13	0.15	0.37	0.36	0.52	0.22	0.54	0.52	0.57	0.01	0.53
18	Non Core Real Estate	0.24	0.22	0.24	0.25	0.22	0.20	0.09	0.09	0.02	0.04	0.01	-0.02	0.16	0.04	0.11	0.06	0.13	**1.00**	0.99	0.29	0.05	0.21	0.12	0.24	0.22	0.25	0.01	0.09
19	Real Estate[2]	0.27	0.25	0.27	0.28	0.25	0.22	0.11	0.10	0.02	0.04	0.02	-0.03	0.18	0.05	0.13	0.07	0.15	0.99	**1.00**	0.33	0.06	0.24	0.14	0.27	0.25	0.29	0.01	0.10
20	US REITs	0.66	0.61	0.64	0.61	0.53	0.49	0.08	0.08	-0.03	0.04	-0.03	-0.08	0.41	0.01	0.28	0.29	0.37	0.29	0.33	**1.00**	0.20	0.61	0.26	0.68	0.57	0.72	0.00	0.22
21	Commodities	0.32	0.27	0.38	0.27	0.44	0.31	0.22	0.22	0.20	0.08	0.18	-0.03	0.38	0.09	0.24	0.44	0.36	0.05	0.06	0.20	**1.00**	0.29	0.08	0.48	0.59	0.51	0.04	0.13
22	Private Equity[3]	0.92	0.87	0.89	0.82	0.73	0.68	0.04	0.04	-0.07	0.03	-0.06	-0.12	0.58	-0.01	0.40	0.45	0.52	0.21	0.24	0.61	0.29	**1.00**	0.35	0.82	0.79	0.87	0.01	0.33
23	Private Infrastructure	0.38	0.36	0.38	0.35	0.32	0.30	0.11	0.11	0.02	0.05	0.00	-0.04	0.27	0.05	0.18	0.13	0.22	0.12	0.14	0.26	0.08	0.35	**1.00**	0.34	0.33	0.36	0.01	0.15
24	Public Infrastructure	0.88	0.82	0.92	0.84	0.84	0.77	0.10	0.10	-0.03	0.05	-0.02	-0.11	0.62	0.01	0.44	0.54	0.54	0.24	0.27	0.68	0.48	0.82	0.34	**1.00**	0.86	0.94	0.01	0.33
25	Risk Parity[4]	0.86	0.80	0.89	0.82	0.79	0.74	0.21	0.20	0.09	0.31	0.30	0.10	0.66	0.12	0.51	0.50	0.52	0.22	0.25	0.57	0.59	0.79	0.33	0.86	**1.00**	0.91	0.03	0.24
26	Master Limited Partnerships	0.94	0.88	0.98	0.89	0.90	0.82	0.11	0.11	-0.03	0.05	-0.02	-0.12	0.66	0.02	0.47	0.58	0.57	0.25	0.29	0.72	0.51	0.87	0.36	0.94	0.91	**1.00**	0.02	0.35
27	Gold	0.01	0.00	0.01	0.01	0.01	0.01	0.06	0.06	0.04	0.02	0.05	-0.01	0.02	0.02	0.02	0.00	0.01	0.01	0.01	0.00	0.04	0.01	0.01	0.01	0.03	0.02	**1.00**	0.01
28	Private Debt	0.34	0.32	0.36	0.33	0.32	0.32	0.02	0.03	0.01	0.06	-0.08	-0.33	0.64	0.01	0.37	0.37	0.53	0.09	0.10	0.22	0.13	0.33	0.15	0.33	0.24	0.35	0.01	**1.00**

[1] Hedge Fund assumptions developed as follows: 14% Event Driven, 38% Global Macro, 20% Distressed Debt, 16% Fixed Income Arbitrage, 12% Cat. Bonds
[2] Real Estate assumption developed as follows: 80% Non-Core Rel Estate, 20% Core Real Estate
[3] Private Equity assumptions developed as follows: 72% Buyouts, 13% Venture Capital, 15% Distressed Debt
[4] Risk Parity assumptions developed as follows: 50% Global Equity, -100% LIBOR, 55% TIPS, 75% Intermediate Gov't. Bonds, 20% Commodities

Actuarial Assumptions and Methods

- Actuarial projections were provided by the plan actuary as of the most recent valuation date (June 30, 2018)
- Actuarial assumptions:
  - Valuation Rate of Interest = 7.25% for all future years
  - Inflation = 2.75%
  - Salary Scale = effective average of 5.00% per year
  - Payroll Growth = 3.50% per year
  - Actuarial Value of Assets: smooth gains/losses relative to expected valuation rate of interest over 10 years and shall be no less than 70% and no greater than 130% of the market value of assets
  - Projection assumptions
    - The active workforce size is assumed to remain constant over the projection period;
    - Future new employees have similar characteristics (age/gender/salary) to new employees for the period July 1, 2015 through June 30, 2018 and:
      - New school employees hired on or after July 1, 2017 through June 30, 2019 are assumed to be Class T-E members
      - Among new school employees hired on or after July 1, 2019, 65% will become Class T-G members, 30% will elect Class T-H membership, and 5% will elect Class DC participation.
    - Class T-G and T-H members who terminate employment with less than 25 years of service and who commence their benefits prior to age 62 will have their benefits reduced from age 67 to age 62 based on the System's current actuarial-equivalent early retirement factors, which are based on the statutory interest rate of 4%. The benefit will be further reduced from age 62 to the member's age at benefit commencement based on new actuarial-equivalent early retirement factors based on an interest rate of 7.25%.
  - All other assumptions as documented in the Actuarial Valuation Report as of June 30, 2018

Actuarial Assumptions and Methods (continued)

- Actuarially-Determined Contribution Calculation = Normal Cost plus a level percent amortization of the unfunded liability with layered 24 year, closed periods, and a 3.50% salary scale
  - Amortization bases developed are projected to continue until either their individual expiry or the plan reaches 100% funded on an actuarial value of assets basis at which point any remaining balance is fully recognized
- Employee contributions are limited to the actuarially-determined contribution
- The health care premium assistance assets and liabilities have been excluded from this analysis
- The rate collar provision of Act 120 was not considered in this analysis as it has been deemed to no longer be effective
- “Shared Risk” provisions of Act 120 have not been considered in this analysis

About This Material

This material includes a summary of calculations and consulting related to the finances of Pennsylvania Public School Employees' Retirement System (PSERS). The following variables have been addressed:

- Contributions
- Funded Ratio
- Net Outflow

This analysis is intended to assist the Investment Committee with a review of the associated issues and options, and its use may not be appropriate for other purposes. This analysis has been prepared solely for the benefit of the Investment Committee. Any further dissemination of this report is not allowed without the written consent of Aon Hewitt Investment Consulting, Inc.

Our calculations were generally based on the methodologies identified in the actuary's valuation report for PSERS. We believe the methodology used in these calculations conforms to the applicable standards identified in the report.

Experience different than anticipated could have a material impact on the ultimate costs of the benefits. In addition, changes in plan provisions or applicable laws could have a significant impact on cost. Actual experience may differ from our modeling assumptions.

Our calculations were based on data provided by the plan actuary. The actuarial assumptions and methods and plan provisions reflected in these projections are the same as those used for the 2018 actuarial valuation for PSERS as noted in the actuarial reports, except where noted in this report. Unless specifically noted, our calculations do not reflect any other changes or events after June 30, 2018.

In conducting these projections, we have relied on plan design, demographic and financial information provided by other parties, including the plan's actuary and plan sponsor. While we cannot verify the accuracy of all of the information, the supplied information was reviewed for consistency and reasonableness. As a result of this review, we have no reason to doubt the substantial accuracy or completeness of the information and believe that it has produced appropriate results.

These projections have been conducted in accordance with generally accepted actuarial principles and practices, including applicable Actuarial Standards of Practice as issued by the Actuarial Standards Board. The undersigned actuary is familiar with the near-term and long-term aspects of pension valuations and meet the Qualification Standards of the American Academy of Actuaries necessary to render the actuarial opinions contained herein. All sections of this report are considered an integral part of the actuarial opinions.

To our knowledge, no colleague of Aon Hewitt Investment Consulting, Inc. providing services to PSERS has any direct financial interest or indirect material interest in PSERS. Thus, we believe there is no relationship existing that might affect our capacity to prepare and certify this report for PSERS.

Aon Hewitt Investment Consulting, Inc.

Phil Kivarkis FSA, CFA

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