Stress Testing Analysis

Pennsylvania Public School Employees’ Retirement System (PSERS)
November 2020

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Executive Summary

Stress Testing Conclusions

- Stochastic projection analysis provides a wide range of potential future outcomes, preparing PSERS for the uncertainty that lies ahead
  - 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 based on specific asset portfolios being studied

- Deterministic projections are also included, as provided by the Society of Actuaries' Blue Ribbon Panel recommendations
  - 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) and do not reflect the volatility for different asset portfolios

- Overall results are similar across both stochastic and deterministic projections
  - Total contributions (employee + employer) 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 Low Return deterministic scenario (83%) falls between the 25th and 50th percentile outcomes under our stochastic analysis (65% and 101% respectively) for PSERS' Current Portfolio
    - This means more than 25% of Aon's stochastic scenarios are worse than the Low Return deterministic scenario, making for an even more conservative stress testing approach

Analysis

- Asset-Liability Projection Results (Stochastic Results)

Asset-Liability Projection Results (Stochastic Results)

Summary of Results

All Scenarios (in $ billions)	30-year Present Value of Gross Contributions (Employee + Employer)		30-year Ending Funded Ratio (MVA / AL)		30-Year Total Nominal Employer Contributions	
	Expected[1]	Downside[2]	Expected[1]	Downside[3]	Expected[1]	Downside[2]
(A) PSERS Current	$80.9	$100.8	101%	37%	$136.4	$229.8
(B) Highest Return, Liquidity, Fixed Income & Leverage	$78.9	$100.0	114%	39%	$128.6	$226.2
(C) Higher Return, Liquidity & Leverage	$79.5	$100.4	110%	38%	$130.7	$228.1
(H) Higher Return & Liquidity / Lower Leverage	$79.8	$100.6	108%	37%	$131.7	$229.4

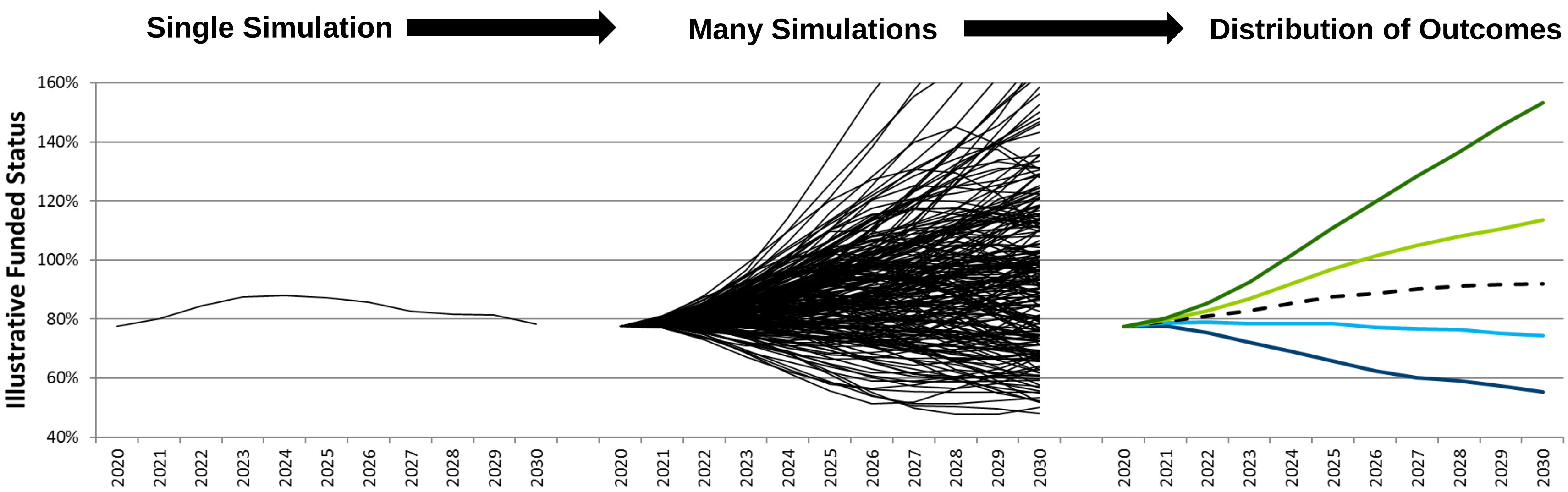
Key Findings:

- The Plan is expected to reach full funding in the central expectation (50th percentile) under Portfolios A, B, C, and H 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

Asset-Liability Simulation Overview

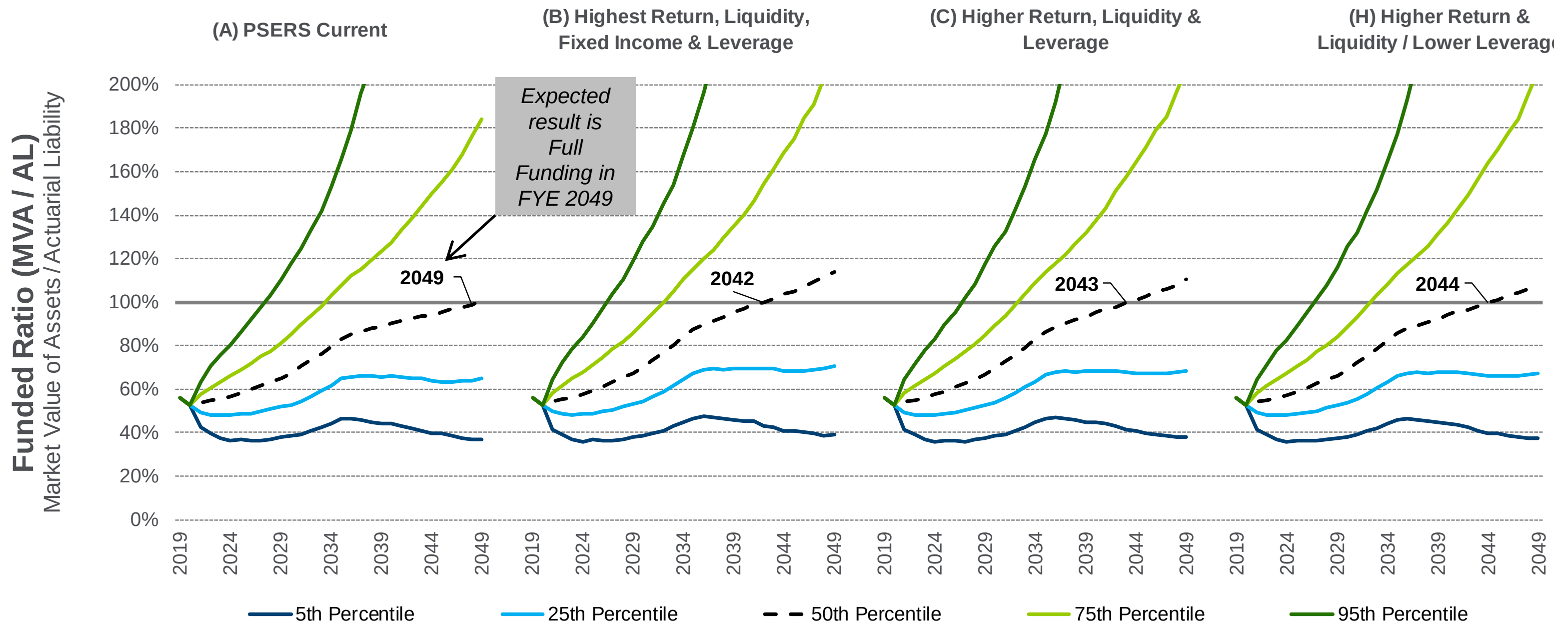
- Thousands of simulations plotted in one graph would be impossible to interpret
- Instead, we rank the simulations at each point over the future
- This produces a distribution of outcomes illustrating the degree of uncertainty of a plan's financial position over the projection period
- Different investment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

Asset-Liability Projection Results (Stochastic Results)

Market Value of Assets / Actuarial Liability Funded Ratio



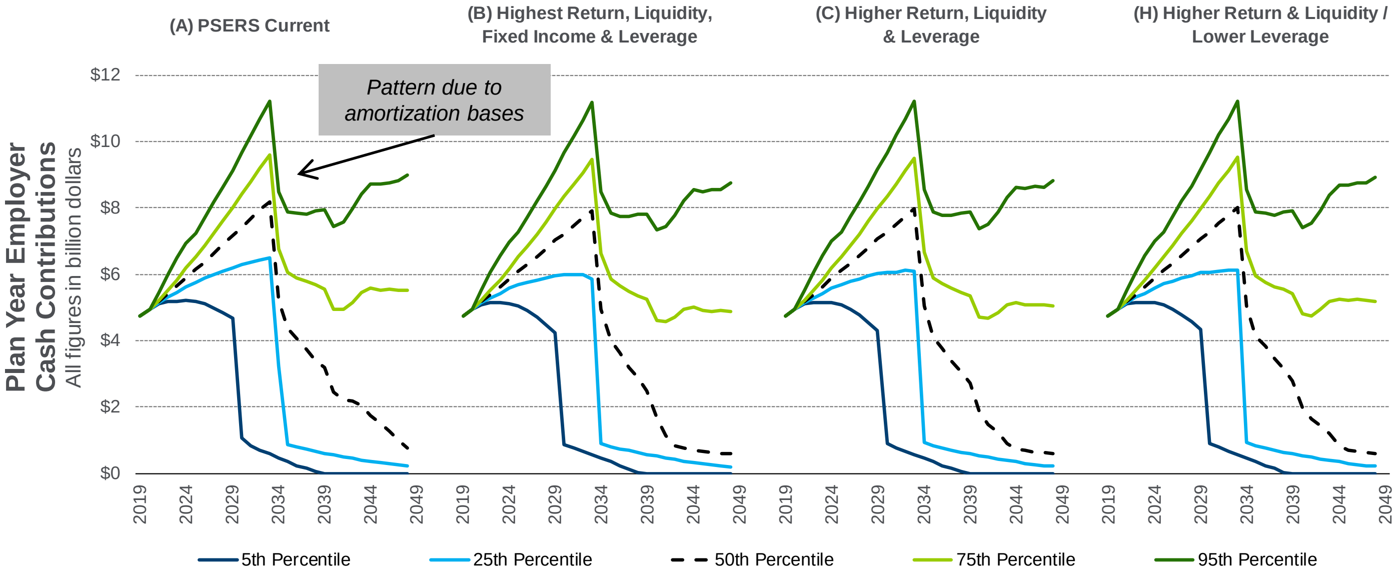
Strategy	(A) PSERS Current			(B) Highest Return, Liquidity, Fixed Income & Leverage			(C) Higher Return, Liquidity & Leverage			(H) Higher Return & Liquidity / Lower Leverage		
Year	**2029**	**2039**	**2049**	**2029**	**2039**	**2049**	**2029**	**2039**	**2049**	**2029**	**2039**	**2049**
5th Percentile	38%	44%	37%	38%	46%	39%	38%	45%	38%	38%	45%	37%
25th Percentile	52%	66%	65%	53%	69%	71%	53%	68%	69%	52%	68%	67%
50th Percentile	65%	89%	101%	67%	95%	114%	67%	93%	110%	66%	92%	108%
75th Percentile	81%	123%	184%	86%	134%	>200%	84%	132%	>200%	84%	131%	>200%
95th Percentile	110%	>200%	>200%	119%	>200%	>200%	117%	>200%	>200%	116%	>200%	>200%
Probability > 100%	12%	42%	51%	16%	47%	58%	16%	46%	56%	15%	45%	55%

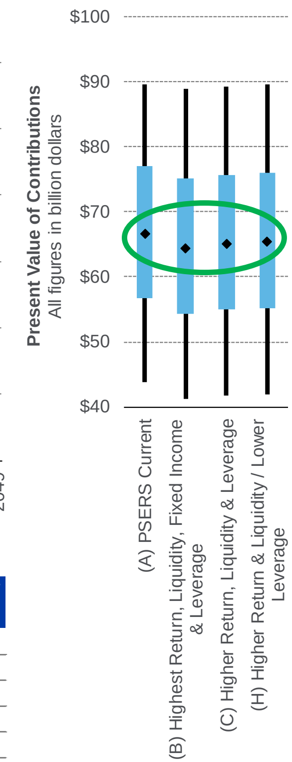
Key Takeaways:

- 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

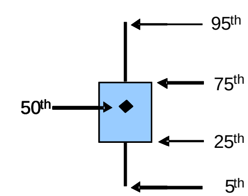
Asset-Liability Projection Results (Stochastic Results)
Employer Contribution Amount





Strategy	(A) PSERS Current			(B) Highest Return, Liquidity, Fixed Income & Leverage			(C) Higher Return, Liquidity & Leverage			(H) Higher Return & Liquidity / Lower Leverage		
Year	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**
5th Percentile	$4.83	$0.04	$0.00	$4.49	$0.03	$0.00	$4.55	$0.04	$0.00	$4.57	$0.03	$0.00
25th Percentile	$6.09	$0.67	$0.22	$5.89	$0.63	$0.20	$5.94	$0.64	$0.21	$5.96	$0.64	$0.21
50th Percentile	$6.88	$3.41	$0.75	$6.77	$2.87	$0.58	$6.81	$3.05	$0.60	$6.82	$3.14	$0.60
75th Percentile	$7.62	$5.67	$5.53	$7.58	$5.36	$4.89	$7.60	$5.46	$5.05	$7.60	$5.54	$5.19
95th Percentile	$8.64	$7.90	$9.00	$8.66	$7.80	$8.77	$8.67	$7.85	$8.84	$8.66	$7.88	$8.93

Percentile



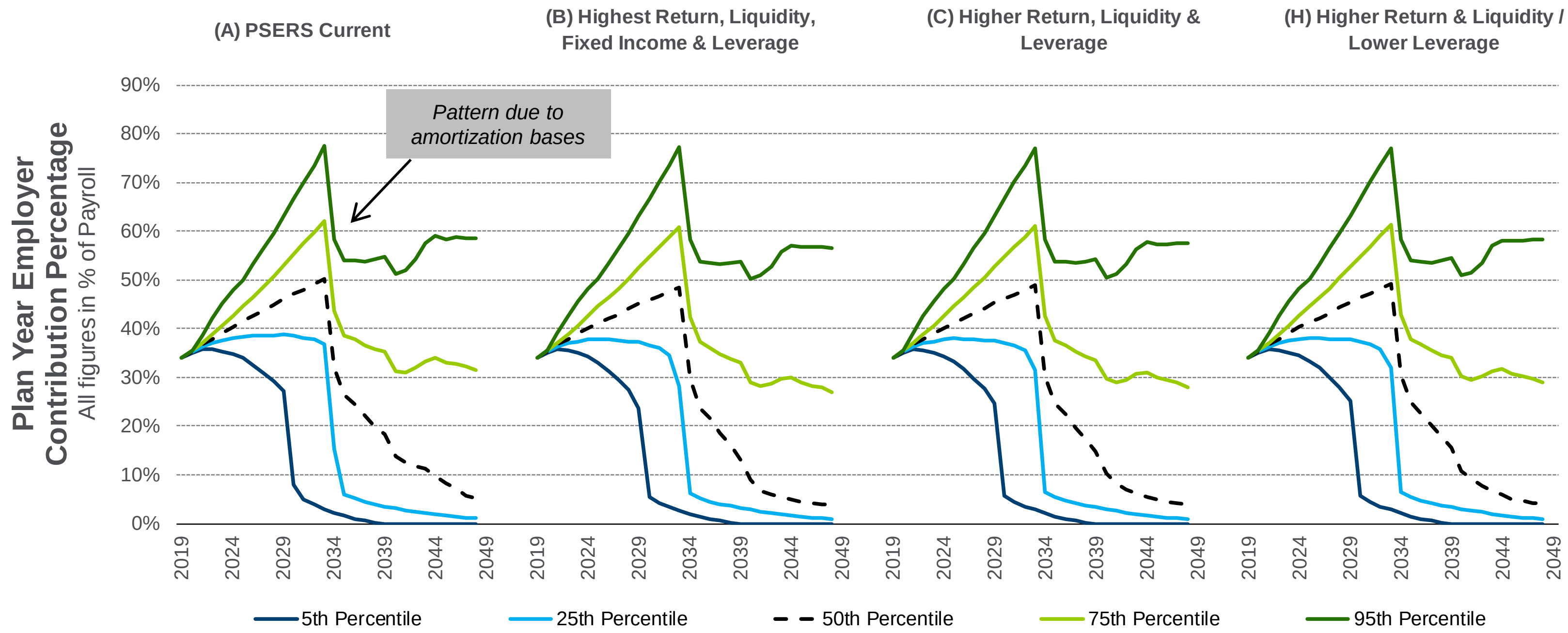
Key Takeaway:

- 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	(A) PSERS Current			(B) Highest Return, Liquidity, Fixed Income & Leverage			(C) Higher Return, Liquidity & Leverage			(H) Higher Return & Liquidity / Lower Leverage		
Year	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**
5th Percentile	29%	0%	0%	27%	0%	0%	28%	0%	0%	28%	0%	0%
25th Percentile	39%	4%	1%	37%	4%	1%	38%	4%	1%	38%	4%	1%
50th Percentile	45%	20%	5%	44%	16%	4%	44%	17%	4%	44%	18%	4%
75th Percentile	51%	36%	31%	50%	34%	27%	50%	34%	28%	51%	34%	29%
95th Percentile	59%	54%	59%	60%	54%	56%	60%	54%	58%	60%	54%	58%

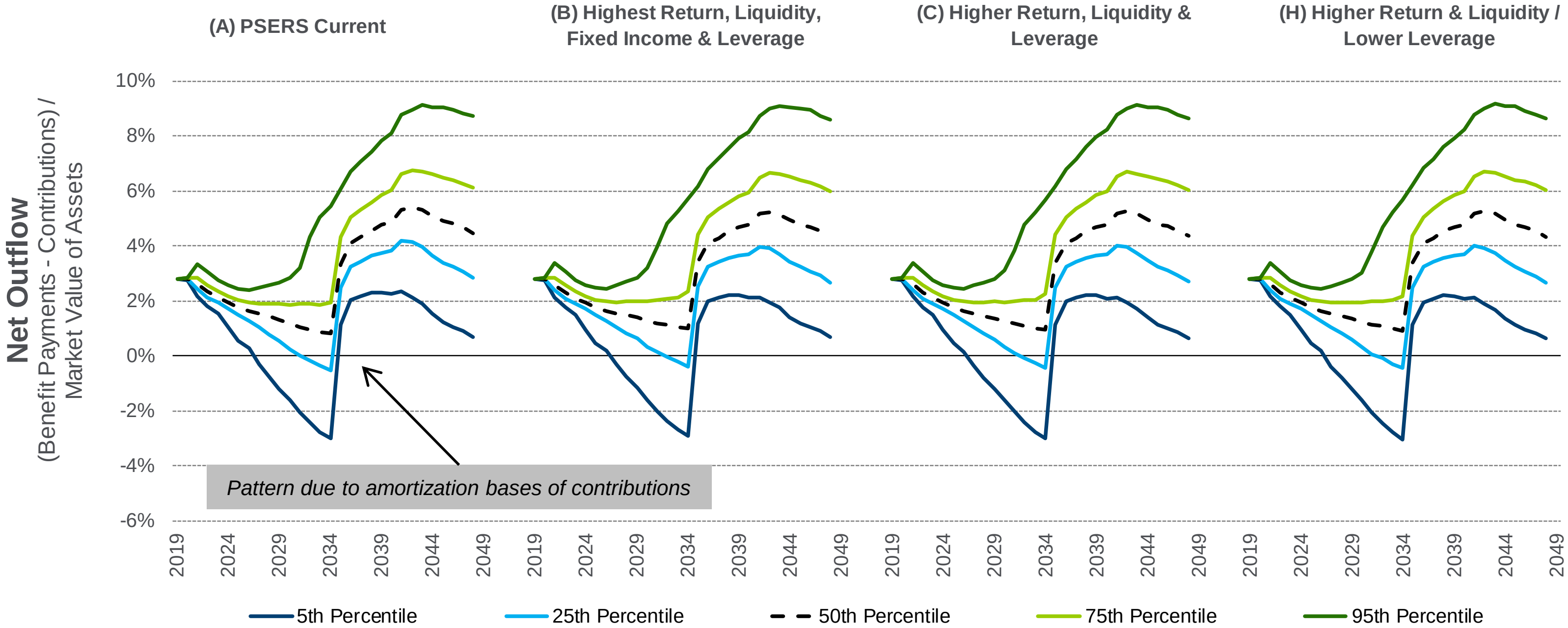
Key Takeaway:

- 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	(A) PSERS Current			(B) Highest Return, Liquidity, Fixed Income & Leverage			(C) Higher Return, Liquidity & Leverage			(H) Higher Return & Liquidity / Lower Leverage		
Year	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**	**2028**	**2038**	**2048**
5th Percentile	-1%	2%	1%	-1%	2%	1%	-1%	2%	1%	-1%	2%	1%
25th Percentile	1%	4%	3%	1%	4%	3%	1%	4%	3%	1%	4%	3%
50th Percentile	1%	5%	4%	1%	5%	4%	1%	5%	4%	1%	5%	4%
75th Percentile	2%	6%	6%	2%	6%	6%	2%	6%	6%	2%	6%	6%
95th Percentile	3%	7%	9%	3%	8%	9%	3%	8%	9%	3%	8%	9%
Probability > 10%	<1%	<1%	2%	<1%	<1%	1%	<1%	<1%	2%	<1%	<1%	2%

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

Analysis

- Asset-Liability Projection Results (Deterministic Results)

Deterministic Projections

- Deterministic projections were conducted in accordance with the Society of Actuaries' Blue Ribbon Panel recommendations, 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% higher 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% lower 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 in these projections include the following:
  - Contributions (in dollars)
  - Contributions (as a percent of payroll)
  - Funded Ratio

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Asset-Liability Projection Results (Deterministic Results)

Summary of Results

Scenario	5 Years				10 Years				30 Years			
	Cumulative Contributions (Employee + Employer)		Funded Ratio		Cumulative Contributions (Employee + Employer)		Funded Ratio		Cumulative Contributions (Employee + Employer)		Funded Ratio	
	$	Δ (from Baseline)	%	Δ (from Baseline)	$	Δ (from Baseline)	%	Δ (from Baseline)	$	Δ (from Baseline)	%	Δ (from Baseline)
1. Baseline	$30.2	N/A	63.2%	N/A	$64.9	N/A	74.3%	N/A	$145.6	N/A	104.1%	N/A
2. Excess Return	$30.1	($0.1)	69.6%	6.4%	$63.2	($1.6)	89.6%	15.2%	$121.3	($24.4)	174.5%	70.4%
3. Low Return	$30.3	$0.1	57.3%	(5.9%)	$66.4	$1.5	61.6%	(12.7%)	$196.4	$50.7	83.0%	(21.1%)
4. Low Contributions	$25.6	($4.6)	58.5%	(4.7%)	$56.4	($8.4)	64.6%	(9.7%)	$165.3	$19.6	96.5%	(7.6%)

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

Note: Figures displayed may not add/subtract as shown due to using unrounded underlying values

Detailed Stress Test Scenario

1. Baseline Scenario

June 30th	Return	Total Contribution (Employee + Employer) ($ Billions)	Total Contribution (Employee + Employer) (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2019	7.25%	$5.7	41.0%	55.8%
2020	7.25%	$5.9	41.8%	57.1%
2021	7.25%	$6.0	42.3%	58.4%
2022	7.25%	$6.2	42.9%	59.9%
2023	7.25%	$6.4	43.3%	61.5%
2024	7.25%	$6.6	43.7%	63.2%
2025	7.25%	$6.8	44.3%	65.1%
2026	7.25%	$6.9	44.7%	67.2%
2027	7.25%	$7.1	45.0%	69.4%
2028	7.25%	$7.3	45.3%	71.8%
2029	7.25%	$7.4	45.7%	74.3%
2030	7.25%	$7.6	46.1%	77.2%
2031	7.25%	$7.8	46.4%	80.1%
2032	7.25%	$7.9	46.9%	83.3%
2033	7.25%	$8.1	47.4%	86.8%
2034	7.25%	$8.3	47.9%	90.6%
2035	7.25%	$5.3	29.9%	94.6%
2036	7.25%	$4.3	24.0%	96.8%
2037	7.25%	$3.9	21.6%	98.3%
2038	7.25%	$3.5	18.9%	99.7%
2039	7.25%	$3.1	16.7%	100.9%
2040	7.25%	$1.7	8.9%	102.0%
2041	7.25%	$1.6	8.5%	102.2%
2042	7.25%	$1.6	8.1%	102.3%
2043	7.25%	$1.5	7.8%	102.6%
2044	7.25%	$1.5	7.5%	102.8%
2045	7.25%	$1.5	7.2%	103.0%
2046	7.25%	$1.4	6.9%	103.3%
2047	7.25%	$1.4	6.7%	103.5%
2048	7.25%	$1.4	6.4%	103.8%
2049				104.1%

Key Takeaways:

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

$145.6B
Cumulative 30 Year Contributions

104.1%
Expected Funded Ratio After 30 Years

Detailed Stress Test Scenario

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

June 30th	Return	Total Contribution (Employee + Employer) ($ Billions)	Total Contribution (Employee + Employer) (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2019	9.25%	$5.7	41.0%	55.8%
2020	9.25%	$5.9	41.8%	58.2%
2021	9.25%	$6.0	42.2%	60.7%
2022	9.25%	$6.2	42.7%	63.4%
2023	9.25%	$6.3	42.9%	66.4%
2024	9.25%	$6.4	42.9%	69.6%
2025	9.25%	$6.6	43.0%	73.1%
2026	9.25%	$6.7	42.9%	76.8%
2027	9.25%	$6.7	42.5%	80.8%
2028	9.25%	$6.7	42.1%	85.0%
2029	9.25%	$6.8	41.6%	89.6%
2030	9.25%	$6.8	41.0%	94.4%
2031	9.25%	$6.7	40.3%	99.6%
2032	9.25%	$6.7	39.6%	105.0%
2033	9.25%	$6.7	38.8%	110.9%
2034	9.25%	$1.9	10.9%	117.1%
2035	9.25%	$1.9	10.6%	120.3%
2036	9.25%	$1.8	10.2%	123.9%
2037	9.25%	$1.8	9.9%	127.8%
2038	9.25%	$1.7	9.6%	132.0%
2039	7.25%	$1.7	9.2%	136.8%
2040	7.25%	$1.7	8.9%	139.3%
2041	7.25%	$1.6	8.5%	142.1%
2042	7.25%	$1.6	8.1%	145.1%
2043	7.25%	$1.5	7.8%	148.5%
2044	7.25%	$1.5	7.5%	152.1%
2045	7.25%	$1.5	7.2%	156.0%
2046	7.25%	$1.4	6.9%	160.2%
2047	7.25%	$1.4	6.7%	164.7%
2048	7.25%	$1.4	6.4%	169.4%
2049				174.5%

Key Takeaways:

- Contributions are expected to peak in 2029-2030 and decrease thereafter
- Plan reaches 100% funded ratio by 2032

$121.3B
Cumulative 30 Year Contributions

174.5%
Expected Funded Ratio After 30 Years

Detailed Stress Test Scenario

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

June 30th	Return	Total Contribution (Employee + Employer) ($ Billions)	Total Contribution (Employee + Employer) (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2019	5.25%	$5.7	41.0%	55.8%
2020	5.25%	$5.9	41.8%	56.0%
2021	5.25%	$6.0	42.3%	56.2%
2022	5.25%	$6.3	43.1%	56.5%
2023	5.25%	$6.5	43.8%	56.9%
2024	5.25%	$6.7	44.5%	57.3%
2025	5.25%	$7.0	45.5%	57.9%
2026	5.25%	$7.2	46.4%	58.6%
2027	5.25%	$7.5	47.2%	59.5%
2028	5.25%	$7.7	48.3%	60.5%
2029	5.25%	$8.0	49.4%	61.6%
2030	5.25%	$8.4	50.6%	63.0%
2031	5.25%	$8.7	51.8%	64.5%
2032	5.25%	$9.0	53.1%	66.2%
2033	5.25%	$9.4	54.5%	68.2%
2034	5.25%	$9.7	56.0%	70.4%
2035	5.25%	$6.9	39.0%	72.9%
2036	5.25%	$6.1	34.2%	73.5%
2037	5.25%	$5.9	32.8%	73.4%
2038	5.25%	$5.7	31.3%	73.3%
2039	7.25%	$5.6	30.3%	72.9%
2040	7.25%	$5.5	29.5%	73.9%
2041	7.25%	$4.9	25.9%	74.8%
2042	7.25%	$4.9	25.2%	75.4%
2043	7.25%	$5.0	25.4%	76.0%
2044	7.25%	$5.2	26.0%	76.8%
2045	7.25%	$5.3	26.2%	77.7%
2046	7.25%	$5.3	25.5%	78.9%
2047	7.25%	$5.3	24.9%	80.2%
2048	7.25%	$5.2	24.1%	81.5%
2049				83.0%

Key Takeaways:

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

$196.4B
Cumulative 30 Year Contributions

83.0%
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 (Employee + Employer) ($ Billions)	Total Contribution (Employee + Employer) (% of Payroll)	Funded Ratio (Market Value of Assets / Accrued Liability)
2019	7.25%	$4.8	34.3%	55.8%
2020	7.25%	$4.9	34.9%	56.2%
2021	7.25%	$5.1	35.7%	56.6%
2022	7.25%	$5.3	36.6%	57.1%
2023	7.25%	$5.5	37.3%	57.7%
2024	7.25%	$5.7	38.1%	58.5%
2025	7.25%	$6.0	38.9%	59.4%
2026	7.25%	$6.2	39.7%	60.5%
2027	7.25%	$6.4	40.4%	61.7%
2028	7.25%	$6.6	41.2%	63.1%
2029	7.25%	$6.8	42.0%	64.6%
2030	7.25%	$7.1	42.9%	66.4%
2031	7.25%	$7.3	43.7%	68.4%
2032	7.25%	$7.6	44.7%	70.5%
2033	7.25%	$7.9	45.7%	73.0%
2034	7.25%	$8.1	46.8%	75.7%
2035	7.25%	$5.8	33.1%	78.7%
2036	7.25%	$5.2	29.1%	80.3%
2037	7.25%	$5.0	27.7%	81.5%
2038	7.25%	$4.8	26.1%	82.5%
2039	7.25%	$5.5	29.5%	83.5%
2040	7.25%	$5.3	28.1%	85.1%
2041	7.25%	$4.5	23.6%	86.7%
2042	7.25%	$4.2	22.0%	87.8%
2043	7.25%	$4.2	21.6%	88.9%
2044	7.25%	$4.3	21.6%	90.1%
2045	7.25%	$4.2	20.5%	91.4%
2046	7.25%	$3.9	18.9%	92.7%
2047	7.25%	$3.7	17.5%	94.0%
2048	7.25%	$3.5	16.2%	95.3%
2049				96.5%

Key Takeaways:

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

$165.3B
Cumulative 30 Year Contributions

96.5%
Expected Funded Ratio After 30 Years

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Appendix

Sensitivity of the Net Pension Liability to Changes in the Discount Rate

- As provided by the plan actuary in their FYE 2019 GASB 67 actuarial valuation report, the following presents the net pension liability calculated at PSERS' 7.25% actuarial assumed rate of return as well as what it would be using a discount rate +/-1% from the current rate.

	1% Decrease (6.25%)	Current Discount Rate (7.25%)	1% Increase (8.25%)
Net Pension Liability (in $ billions)	$58.3	$46.8	$37.1

Portfolio Analysis

Portfolios Evaluated

	A	B	C	(H)
	PSERS Current	**Highest Return, Liquidity, Fixed Income & Leverage**	**Higher Return, Liquidity & Leverage**	**Higher Return & Liquidity / Lower Leverage**
US Equity	7.1%	11.0%	11.0%	11.0%
Non-US Dev, Unhedged	1.9%	7.0%	7.0%	7.0%
Non-US Dev, USD Hedged	5.6%	2.0%	2.0%	2.0%
Emerging Markets	4.4%	7.0%	7.0%	7.0%
Private Equity, Unhedged[1]	15.0%	12.0%	12.0%	12.0%
Total Equity	**34.0%**	**39.0%**	**39.0%**	**39.0%**
US Core Fixed Income	4.0%	1.0%	1.0%	1.0%
US Long-Term Treasury	8.0%	7.0%	7.0%	7.0%
Emerging Market Debt, Local	0.0%	0.0%	1.0%	0.0%
Emerging Markets Debt, Hard	1.0%	1.0%	1.0%	2.0%
High Yield	0.0%	2.0%	2.0%	2.0%
Private Credit	10.0%	8.0%	8.0%	8.0%
US TIPS	9.5%	20.0%	18.0%	12.0%
Non-US Inflation-Linked[2]	9.5%	9.0%	5.0%	3.0%
Total Fixed Income	**42.0%**	**48.0%**	**43.0%**	**35.0%**
Infrastructure: Energy MLPS	1.0%	0.0%	0.0%	0.0%
Infrastructure: Private, USD Hedged	1.0%	3.0%	3.0%	4.0%
Infrastructure: Public, USD Hedged	4.0%	5.0%	5.0%	4.0%
Commodities: Diversified	6.0%	5.0%	3.0%	3.0%
Commodities: Gold	4.0%	8.0%	7.0%	7.0%
Private Real Estate, Unhedged	8.0%	7.0%	7.0%	7.0%
Global REITs, USD Hedged	2.0%	3.0%	3.0%	3.0%
Total Real Assets	**26.0%**	**31.0%**	**28.0%**	**28.0%**
Hedge Funds[3]	**10.0%**	**8.0%**	**8.0%**	**8.0%**
Net Cash / Financing	**-12.0%**	**-26.0%**	**-18.0%**	**-10.0%**
Total Plan	**100.0%**	**100.0%**	**100.0%**	**100.0%**
30-Year Exp. Nom. Return	**6.73%**	**7.20%**	**7.09%**	**7.04%**
30-Year Expected Risk	**11.15%**	**11.93%**	**11.85%**	**11.76%**
Sharpe Ratio	**0.508**	**0.514**	**0.509**	**0.508**

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

[2] Non-US Inflation-Linked assumptions developed as follows: 3% Canada, 52% UK, 45% Europe. Hedged to USD.

[3] 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

Aon Investments' Capital Market Assumptions

As of June 30, 2020 (30 Years)

		Expected Real Return[1]	Expected Nominal Return[1]	Expected Nominal Volatility
	Equity			
1	Large Cap U.S. Equity	4.3%	6.5%	17.0%
2	Small Cap U.S. Equity	4.8%	7.0%	23.2%
3	International Equity (Developed) - Hedged	4.8%	7.0%	18.0%
4	International Equity (Developed) - Unhedged	5.3%	7.5%	20.0%
5	Emerging Markets Equity	5.9%	8.1%	27.0%
	Fixed Income			
6	Cash (Gov't)	-1.0%	1.1%	1.8%
7	TIPS	0.0%	2.0%	4.6%
8	Non-US Inflation Linked	-0.6%	1.5%	3.9%
9	Core Fixed Income	-0.1%	2.0%	5.1%
10	Long Duration Bonds – Gov't	-0.4%	1.6%	10.7%
11	High Yield Bonds	2.0%	4.1%	12.2%
12	Emerging Market Bonds	1.9%	4.0%	13.9%
13	Emerging Market Bonds (Sov. Local)	1.6%	3.7%	14.4%
	Alternatives			
14	Hedge Funds[2]	2.5%	4.6%	8.7%
15	Non Core Real Estate	5.5%	7.7%	25.3%
16	US REITs	4.1%	6.2%	18.7%
17	Commodities	1.4%	3.5%	16.9%
18	Private Equity[3]	7.2%	9.4%	26.2%
19	Infrastructure - Private	6.1%	8.3%	14.4%
20	Infrastructure - Public	4.7%	6.9%	17.3%
21	Energy MLPs	4.7%	6.9%	17.3%
22	Gold	1.0%	3.1%	19.4%
23	Private Debt	3.7%	5.9%	16.9%
	Inflation			
24	Inflation	0.0%	2.1%	1.5%

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

Aon Investments' Capital Market Assumptions

As of June 30, 2020 (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
1	Large Cap U.S. Equity	**1.00**	0.92	0.89	0.78	0.72	0.09	-0.05	0.00	0.04	-0.13	0.59	0.42	0.47	0.55	0.47	0.67	0.34	0.92	0.38	0.89	0.89	0.00	0.37	0.06
2	Small Cap U.S. Equity	0.92	**1.00**	0.81	0.72	0.67	0.07	-0.05	0.00	0.03	-0.12	0.55	0.39	0.42	0.50	0.44	0.61	0.29	0.87	0.35	0.83	0.83	0.00	0.35	0.05
3	International Equity (Developed) - Hedged	0.89	0.81	**1.00**	0.88	0.73	0.10	-0.04	0.00	0.06	-0.12	0.57	0.41	0.42	0.50	0.48	0.61	0.29	0.82	0.35	0.84	0.84	0.01	0.36	0.06
4	International Equity (Developed) - Unhedged	0.78	0.72	0.88	**1.00**	0.75	0.04	-0.04	0.00	0.04	-0.11	0.58	0.44	0.59	0.49	0.44	0.54	0.45	0.73	0.31	0.84	0.84	0.00	0.33	0.07
5	Emerging Markets Equity	0.72	0.67	0.73	0.75	**1.00**	0.07	-0.04	0.00	0.05	-0.12	0.65	0.49	0.54	0.40	0.40	0.49	0.33	0.68	0.29	0.77	0.77	0.00	0.31	0.07
6	Cash (Gov't)	0.09	0.07	0.10	0.04	0.07	**1.00**	0.45	0.02	0.45	0.21	0.14	0.17	0.03	0.06	0.13	0.08	0.22	0.05	0.11	0.11	0.11	0.06	0.04	0.57
7	TIPS	-0.05	-0.05	-0.04	-0.04	-0.04	0.45	**1.00**	0.01	0.48	0.32	0.09	0.13	-0.02	-0.03	0.01	-0.03	0.17	-0.06	0.01	-0.01	-0.01	0.04	-0.10	0.40
8	Non-US Inflation Linked	0.00	0.00	0.00	0.00	0.00	0.02	0.01	**1.00**	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Core Fixed Income	0.04	0.03	0.06	0.04	0.05	0.45	0.48	0.01	**1.00**	0.73	0.34	0.52	0.16	0.17	0.06	0.04	0.07	0.03	0.06	0.05	0.05	0.01	0.07	0.15
10	Long Duration Bonds – Gov't	-0.13	-0.12	-0.12	-0.11	-0.12	0.21	0.32	0.01	0.73	**1.00**	-0.12	0.16	-0.05	-0.13	-0.05	-0.09	-0.04	-0.13	-0.04	-0.12	-0.12	-0.02	-0.34	-0.11
11	High Yield Bonds	0.59	0.55	0.57	0.58	0.65	0.14	0.09	0.00	0.34	-0.12	**1.00**	0.75	0.60	0.60	0.32	0.40	0.38	0.57	0.25	0.61	0.61	0.02	0.61	0.18
12	Emerging Market Bonds	0.42	0.39	0.41	0.44	0.49	0.17	0.13	0.00	0.52	0.16	0.75	**1.00**	0.65	0.56	0.23	0.28	0.24	0.40	0.18	0.44	0.44	0.01	0.40	0.09
13	Emerging Market Bonds (Sov. Local)	0.47	0.42	0.42	0.59	0.54	0.03	-0.02	0.00	0.16	-0.05	0.60	0.65	**1.00**	0.48	0.19	0.30	0.45	0.44	0.13	0.54	0.54	0.00	0.36	0.02
14	Hedge Funds	0.55	0.50	0.50	0.49	0.40	0.06	-0.03	0.00	0.17	-0.13	0.60	0.56	0.48	**1.00**	0.26	0.36	0.36	0.52	0.21	0.52	0.52	0.01	0.57	0.10
15	Non Core Real Estate	0.47	0.44	0.48	0.44	0.40	0.13	0.01	0.00	0.06	-0.05	0.32	0.23	0.19	0.26	**1.00**	0.49	0.15	0.43	0.21	0.47	0.47	0.00	0.19	0.09
16	US REITs	0.67	0.61	0.61	0.54	0.49	0.08	-0.03	0.00	0.04	-0.09	0.40	0.28	0.30	0.36	0.49	**1.00**	0.21	0.61	0.26	0.68	0.68	0.00	0.25	0.05
17	Commodities	0.34	0.29	0.29	0.45	0.33	0.22	0.17	-0.01	0.07	-0.04	0.38	0.24	0.45	0.36	0.15	0.21	**1.00**	0.31	0.08	0.49	0.49	0.04	0.11	0.39
18	Private Equity	0.92	0.87	0.82	0.73	0.68	0.05	-0.06	0.00	0.03	-0.13	0.57	0.40	0.44	0.52	0.43	0.61	0.31	**1.00**	0.35	0.82	0.82	0.00	0.36	0.05
19	Infrastructure - Private	0.38	0.35	0.35	0.31	0.29	0.11	0.01	0.00	0.06	-0.04	0.25	0.18	0.13	0.21	0.21	0.26	0.08	0.35	**1.00**	0.33	0.33	0.01	0.16	0.07
20	Infrastructure - Public	0.89	0.83	0.84	0.84	0.77	0.11	-0.01	0.00	0.05	-0.12	0.61	0.44	0.54	0.52	0.47	0.68	0.49	0.82	0.33	**1.00**	1.00	0.01	0.34	0.13
21	Energy MLPs	0.89	0.83	0.84	0.84	0.77	0.11	-0.01	0.00	0.05	-0.12	0.61	0.44	0.54	0.52	0.47	0.68	0.49	0.82	0.33	1.00	**1.00**	0.01	0.34	0.13
22	Gold	0.00	0.00	0.01	0.00	0.00	0.06	0.04	0.00	0.01	-0.02	0.02	0.01	0.00	0.01	0.00	0.00	0.04	0.00	0.01	0.01	0.01	**1.00**	0.01	0.10
23	Private Debt	0.37	0.35	0.36	0.33	0.31	0.04	-0.10	0.00	0.07	-0.34	0.61	0.40	0.36	0.57	0.19	0.25	0.11	0.36	0.16	0.34	0.34	0.01	**1.00**	0.08
24	Inflation	0.06	0.05	0.06	0.07	0.07	0.57	0.40	0.00	0.15	-0.11	0.18	0.09	0.02	0.10	0.09	0.05	0.39	0.05	0.07	0.13	0.13	0.10	0.08	**1.00**

Actuarial Assumptions and Methods

- Actuarial projections were provided by the plan actuary as of the most recent valuation date (June 30, 2019)
- 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, 2016 through June 30, 2019
      - 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, 2019

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
- Asset figures reflect preliminary performance for the period July 1, 2019 – June 30, 2020 resulting in a market asset value of $56.646 billion as of June 30, 2020
- 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 Investments USA 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.

Models are used to develop alternative scenarios based on the underlying valuation model and project financial results under those scenarios. The models were developed by experts outside and within Aon. Where outside models were used, the models were reviewed by experts within Aon. The models were selected as appropriate for these projections by the undersigned.

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 2019 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, 2019. Reflecting events after June 30, 2019 would impact the results of the projection.

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 Investments USA 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 Investments USA Inc.

Phil Kivarkis FSA, CFA

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Aon Investments USA Inc.
200 E. Randolph Street
Suite 700
Chicago, IL 60601
ATTN: Aon Investments Compliance Officer