



Cavanaugh Macdonald

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January 14, 2021

Mr. Jay Stoffel
Executive Director
Teacher Retirement Association of Minnesota
60 Empire Drive, Suite 400
St. Paul, MN 55103

Re: Projection of Future Actuarial Results

Dear Jay:

The Standards for Actuarial Work, as specified by the Legislative Commission on Pension and Retirement, require that a sensitivity analysis for the Teacher Retirement Association (TRA) be performed every two years. This involves modeling projections of future valuation results assuming future investment returns that are 1.5% higher and lower than the actuarial assumed rate of return in all years. Given that the assumed rate of return is currently 7.5%, the resulting investment return scenarios that are modeled are:

- (1) 6.0% for all years,
- (2) 7.5% for all years, and
- (3) 9.0% for all years.

Attached to this letter are both graphs and tables of numerical results that provide the estimated funded status, required and statutory contribution rates, contributions and benefit payment amounts, and the unfunded actuarial accrued liability (UAAL) under the three required investment return scenarios. These projections are based on the valuation assumptions and statutory benefit provisions used in the July 1, 2020 valuation.

While the actual investment returns earned in future years change under the three different scenarios, the investment return assumption of 7.5%, used in the valuation, is not changed, as specified by the LCPR Standards. As a result, the actuarial accrued liability and normal cost are the same for all three scenarios. It should be noted that these projections are strictly for the purpose of sensitivity analysis, as required by the LCPR. The scenarios that reflect a rate of return of 6.0% or 9.0% do not represent reasonable outcomes, because neither changes to the contribution rates nor changes to the benefit structure are assumed to be implemented despite the trends disclosed in future valuation results. In reality, if the funding results in either of those scenarios were to actually occur, changes to the contributions and/or benefit provisions would most likely be made, as past experience has demonstrated.



The projections are developed by first creating a demographic profile of recent new entrants. Next, the membership population from the July 1, 2020 valuation is projected forward one year assuming all demographic assumptions are met. Members who are assumed to leave active employment are replaced with an equal number of new members from the new entrant demographic profile mentioned earlier so the number of actives members remains constant. Then, a valuation is performed as of July 1, 2021 to determine the various actuarial accrued liability and cost measurements. The last two steps are repeated in each future year until projections have been performed through the July 1, 2050 valuation. In preparing these exhibits, we have followed the LCPR Standards for Actuarial Work, with the following exceptions which are permitted. Because of the expected changes in the active membership demographics over time as members of the pre-July 1, 1989 tier leave covered employment and are replaced by new employees with different retirement eligibility provisions as well as different demographic patterns, we have modeled future populations and valued them directly by using an open group projection. We believe that this approach provides a better reflection of future valuation results than would be produced by using a simplified methodology and assumptions of a constant normal cost rate and fixed growth in covered payroll. In addition, please note that the new assumptions adopted by the Board of Trustees in 2019, as a result of the experience study, are first reflected in the July 1, 2020 valuation and these projections.

Disclaimers, Caveats, and Limitations

In order to prepare these results, we have utilized appropriate actuarial models that were developed for this purpose. These models use assumptions about future contingent events along with recognized actuarial approaches to develop the results. The projection results are based upon the July 1, 2020 actuarial valuation results and the projection model prepared by TRA's actuary, Cavanaugh Macdonald Consulting. Significant items are noted below:

- The investment returns in all future years, as described earlier in this letter, are assumed to apply to the market value of assets.
- All actuarial assumptions other than the investment return, which include mortality, disability, retirement, salary increases, and termination of employment, are assumed to be met exactly in each year in the future. Please note that the actuarial assumption assumes that mortality will improve in the future (i.e. people will live longer).
- It is possible that changes to other programs may have an effect on future retirement patterns. For example, if changes in Social Security and/or Medicare are implemented to reduce benefits or delay eligibility for those programs, retirements from TRA are likely to also be delayed, thereby lowering the cost of the plan and vice versa. However, because such changes cannot be reasonably anticipated, they are not reflected in this analysis.
- The number of active members covered by TRA in the future is assumed to remain level (neither growth nor decline in the active membership count). As active members leave employment, they are assumed to be replaced by new employees who have a similar demographic profile as recent new hires. With the departure of current active members who were hired before July 1, 1989, whose benefit structure has different retirement eligibility provisions from those of members hired since then, the demographic composition of the membership may gradually change over time.
- Plan provision changes being phased in (such as early retirement reductions) and scheduled contribution rate increases are assumed to occur as provided in the 2018 pension reform legislation and other relevant laws.
- The funding methods, including the entry age normal cost method, the asset smoothing method, and the amortization method and period, are as set out in statute.



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- The current supplementary contributions made by the state are assumed to continue to be paid at approximately the same dollar amount as currently paid for the entire 30-year projection period but are eliminated if the plan reaches 100% funded.
- The actuaries relied upon the membership data provided by TRA for the actuarial valuation. The numerical results depend on the integrity of this information. If there are material inaccuracies in this data, the results presented herein may be different and the projections may need to be revised.

Models are designed to identify anticipated trends and to compare various scenarios rather than predicting some future state of events. These projections are based on TRA's estimated financial status on July 1, 2020, and project future events using several sets of assumptions out of a range of many possibilities. The projections do not predict TRA's financial condition or its ability to pay benefits in the future and do not provide any guarantee of future financial soundness of the System. Over time, a defined benefit plan's total cost will depend on a number of factors, including the amount of benefits paid, the number of people paid benefits, the duration of the benefit payments, plan expenses, and the amount of earnings on assets invested to pay benefits. These amounts and other variables are uncertain and unknowable at the time the projections were made. Not all of the actuarial assumptions will unfold exactly as expected so actual valuation results in the future will differ from those in the projections. To the extent that actual experience deviates significantly from the assumptions, results could be significantly better or significantly worse than indicated in this letter. Decisions about making changes to the benefit structure, funding the plan, or investment policy should not be made based on these projections as the purpose of this information is only to provide a sensitivity analysis of the actual versus expected investment return.

We, Patrice A. Beckham and Brent A. Banister, are members of the American Academy of Actuaries and meet the Qualification Standards of the American Academy of Actuaries to render the actuarial opinion contained herein. We are available to answer any questions on the material in this letter or to provide explanations or further details as appropriate. We also meet the requirements of "approved actuary" under Minnesota Statutes, Section 356.215, Subdivision 1, Paragraph (c).

Sincerely,

A handwritten signature in cursive script that reads "Patrice Beckham".

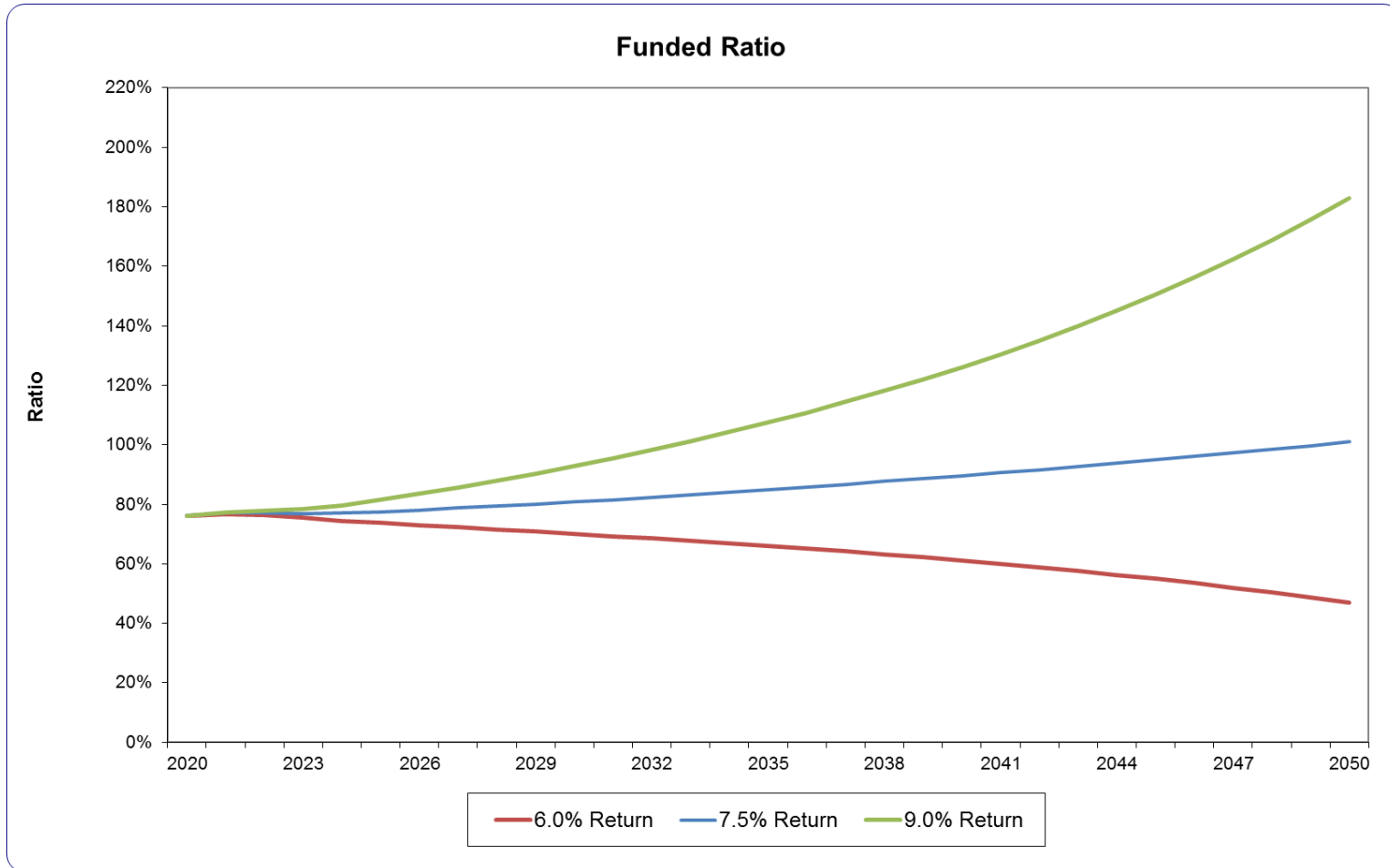
Patrice A. Beckham, FSA, EA, FCA, MAAA
Principal and Consulting Actuary

A handwritten signature in cursive script that reads "Brent A. Banister".

Brent A. Banister, PhD, FSA, EA, FCA, MAAA
Chief Actuary



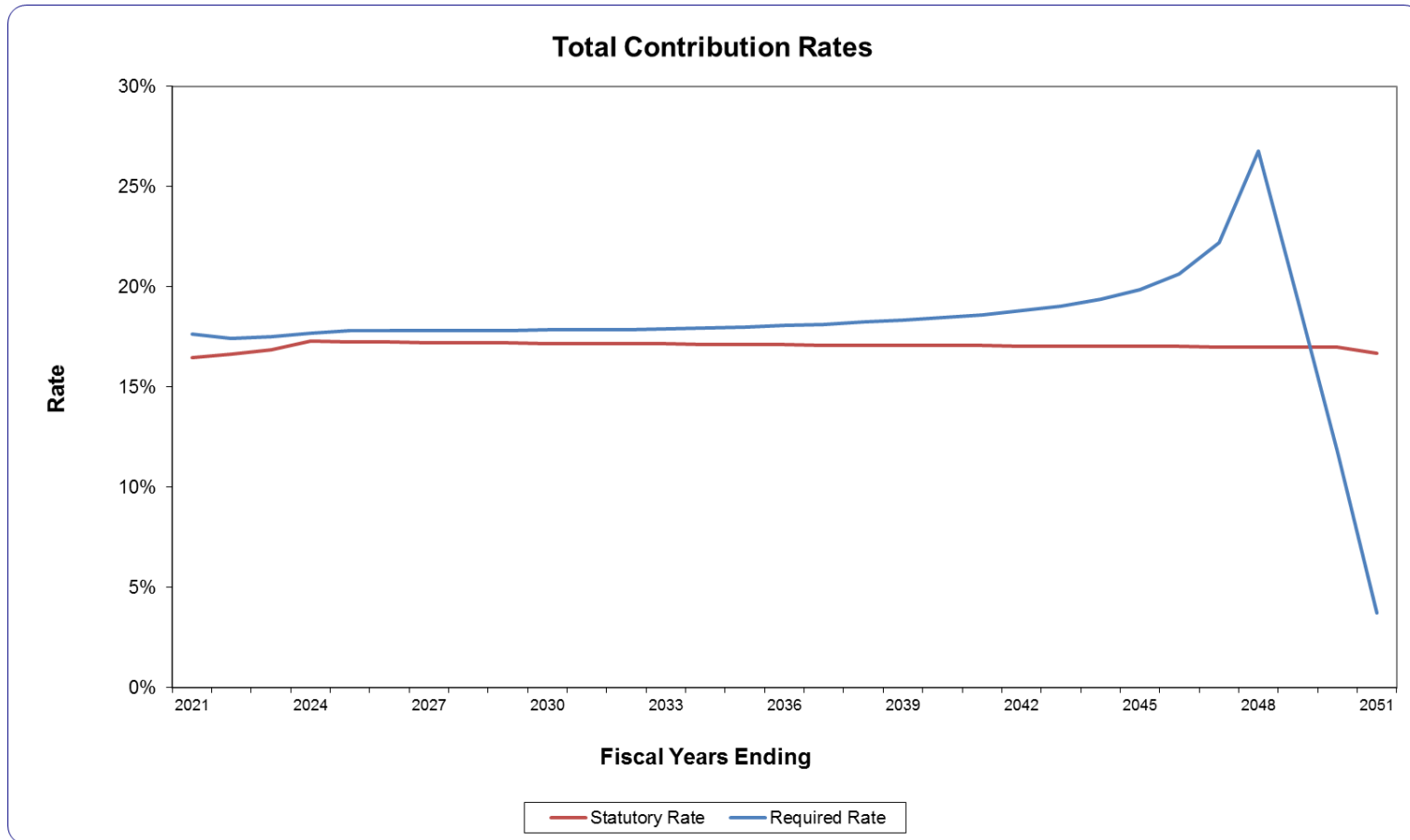
Exhibit A
All Investment Return Scenarios



Results are modeled based on specified investment returns and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



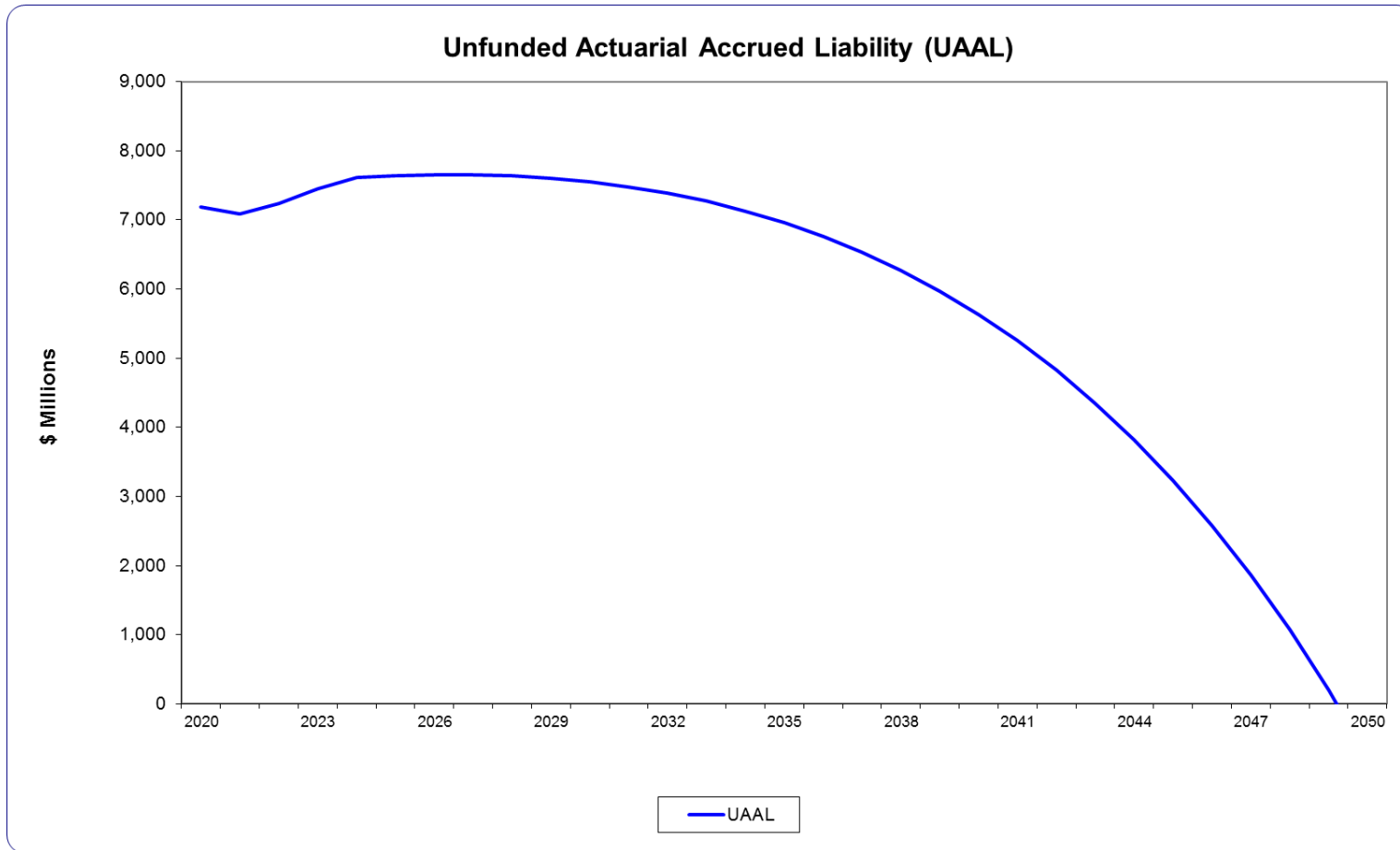
Exhibit B-1
7.5% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



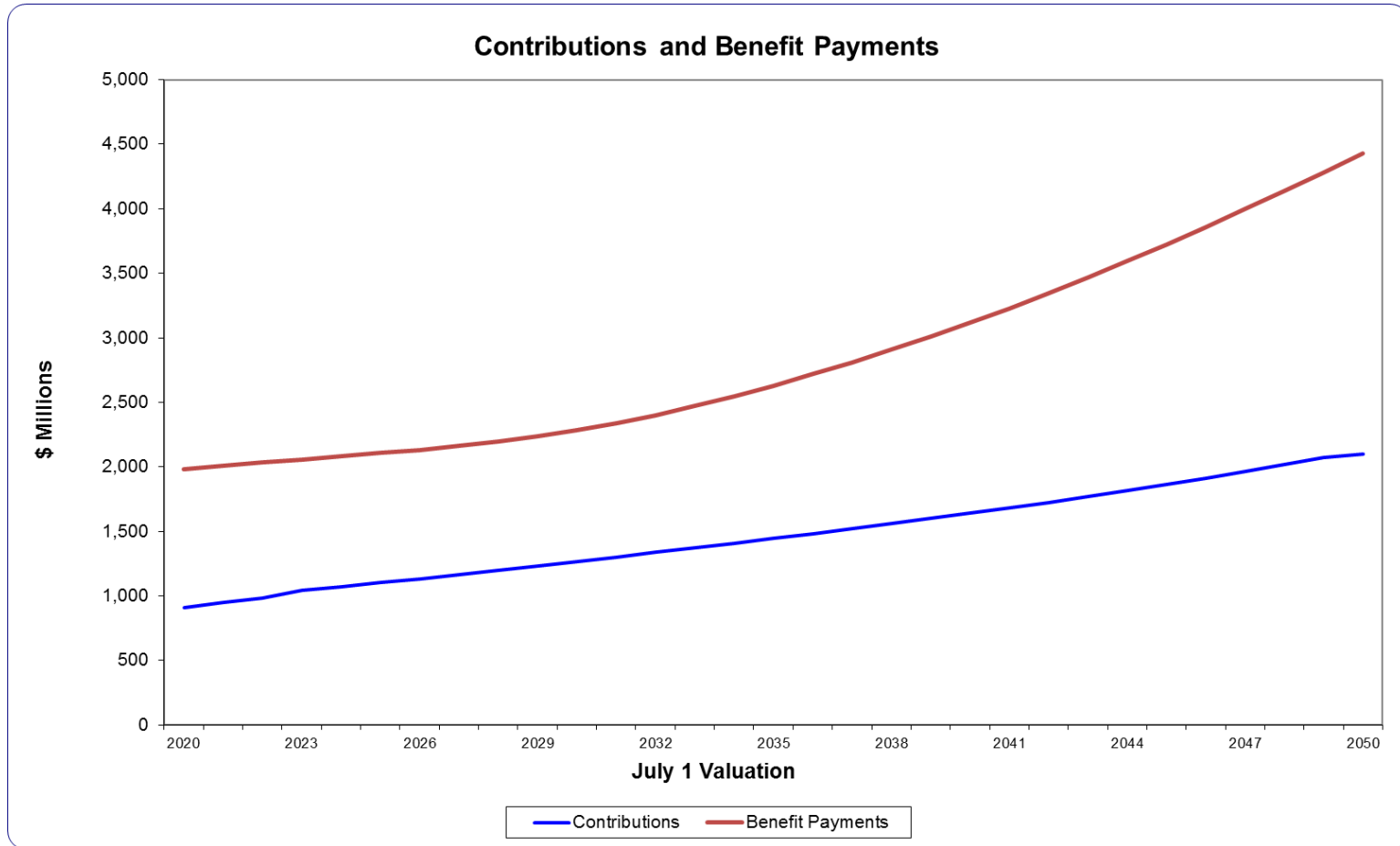
Exhibit B-2
7.5% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



Exhibit B-3
7.5% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



Teachers Retirement Association of Minnesota

Exhibit C

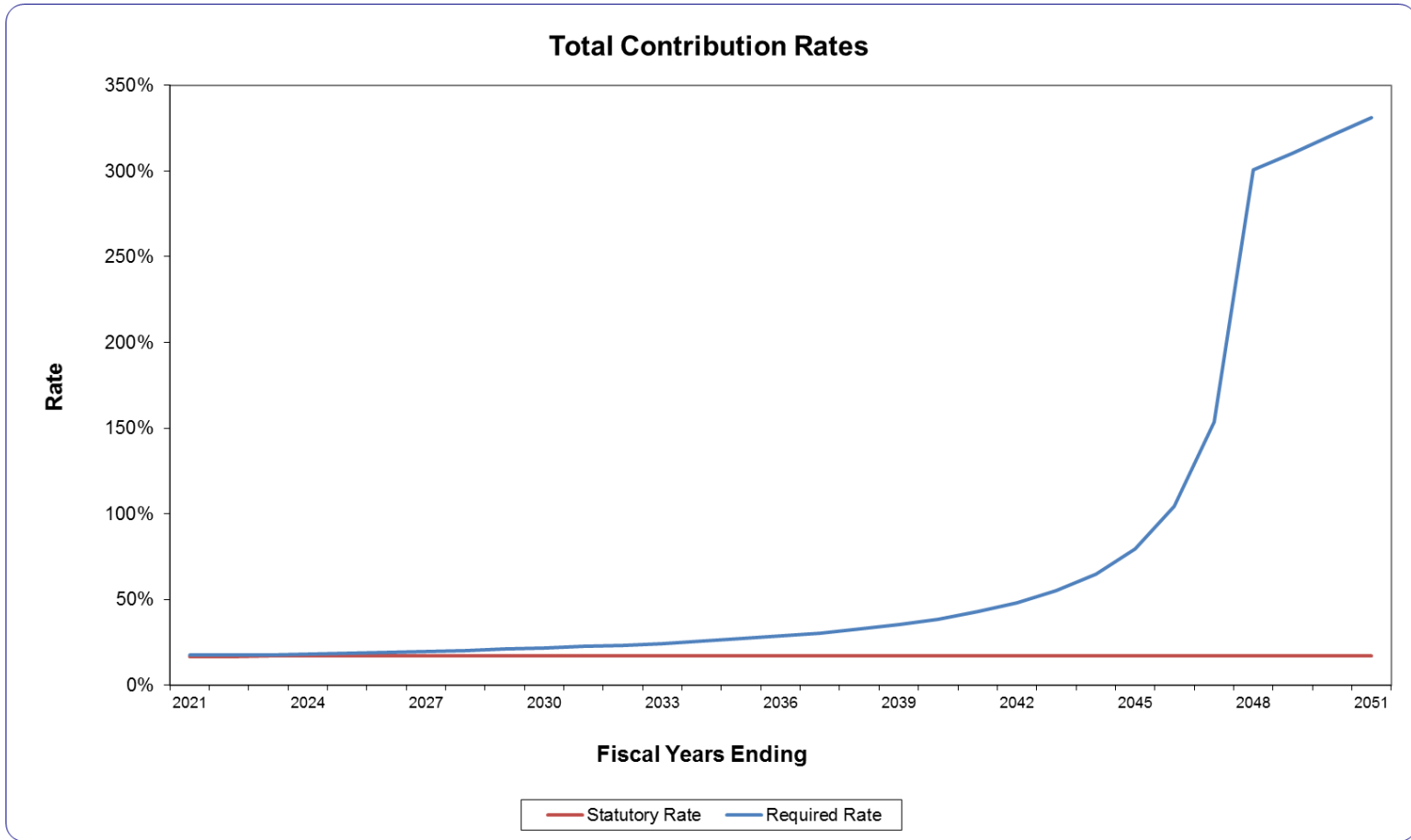
7.5% Actual Investment Return in Future Years

July 1	Asset Values		Actuarial Accrued Liability	Unfunded Actuarial Accrued Liability	Funded Ratio	Contribution Rates			Total Contributions	Benefit Payments
	Actuarial	Market				Statutory	Required	Sufficiency/ (Deficiency)		
2020	\$22,936.91	\$22,741.05	\$30,129.18	\$7,192.27	76%	16.46%	17.65%	-1.19%	\$908.83	\$1,983.16
2021	23,717.85	23,332.74	30,808.93	7,091.08	77%	16.65%	17.43%	-0.78%	948.48	2,006.38
2022	24,291.77	23,985.83	31,530.35	7,238.58	77%	16.84%	17.53%	-0.69%	986.60	2,032.41
2023	24,847.61	24,700.45	32,299.99	7,452.38	77%	17.28%	17.70%	-0.42%	1,041.72	2,056.93
2024	25,500.39	25,500.39	33,113.99	7,613.60	77%	17.26%	17.82%	-0.56%	1,071.93	2,081.25
2025	26,366.44	26,366.44	34,007.24	7,640.80	78%	17.24%	17.82%	-0.58%	1,102.68	2,106.30
2026	27,303.34	27,303.34	34,958.23	7,654.89	78%	17.23%	17.81%	-0.58%	1,134.16	2,132.54
2027	28,315.95	28,315.95	35,970.46	7,654.52	79%	17.21%	17.82%	-0.61%	1,166.05	2,161.64
2028	29,407.40	29,407.40	37,045.65	7,638.26	79%	17.20%	17.82%	-0.62%	1,198.11	2,196.92
2029	30,577.36	30,577.36	38,182.29	7,604.93	80%	17.18%	17.84%	-0.66%	1,230.03	2,236.56
2030	31,827.08	31,827.08	39,380.72	7,553.64	81%	17.17%	17.85%	-0.68%	1,266.29	2,284.30
2031	33,158.61	33,158.61	40,639.70	7,481.09	82%	17.16%	17.87%	-0.71%	1,302.25	2,339.02
2032	34,570.56	34,570.56	41,956.83	7,386.27	82%	17.14%	17.90%	-0.76%	1,337.98	2,401.65
2033	36,060.52	36,060.52	43,328.55	7,268.03	83%	17.13%	17.94%	-0.81%	1,373.62	2,471.03
2034	37,627.24	37,627.24	44,752.46	7,125.22	84%	17.12%	18.00%	-0.88%	1,409.69	2,547.43
2035	39,269.65	39,269.65	46,225.53	6,955.88	85%	17.11%	18.07%	-0.96%	1,446.26	2,629.82
2036	40,987.73	40,987.73	47,745.61	6,757.88	86%	17.10%	18.14%	-1.04%	1,483.27	2,718.53
2037	42,781.06	42,781.06	49,310.15	6,529.08	87%	17.09%	18.23%	-1.14%	1,521.00	2,811.24
2038	44,651.90	44,651.90	50,918.95	6,267.05	88%	17.08%	18.33%	-1.25%	1,559.75	2,907.12
2039	46,603.81	46,603.81	52,572.60	5,968.78	89%	17.07%	18.46%	-1.39%	1,599.48	3,008.27
2040	48,638.44	48,638.44	54,269.71	5,631.28	90%	17.06%	18.61%	-1.55%	1,640.03	3,115.58
2041	50,756.44	50,756.44	56,007.85	5,251.41	91%	17.05%	18.80%	-1.75%	1,681.55	3,228.38
2042	52,959.39	52,959.39	57,785.05	4,825.66	92%	17.04%	19.04%	-2.00%	1,724.28	3,345.56
2043	55,250.37	55,250.37	59,600.78	4,350.41	93%	17.03%	19.37%	-2.34%	1,768.54	3,466.66
2044	57,633.49	57,633.49	61,455.19	3,821.70	94%	17.02%	19.85%	-2.83%	1,814.63	3,592.11
2045	60,113.07	60,113.07	63,347.58	3,234.50	95%	17.01%	20.64%	-3.63%	1,862.43	3,723.28
2046	62,692.19	62,692.19	65,275.81	2,583.62	96%	17.00%	22.19%	-5.19%	1,911.91	3,858.95
2047	65,375.36	65,375.36	67,239.37	1,864.01	97%	17.00%	26.79%	-9.79%	1,963.62	3,997.34
2048	68,169.91	68,169.91	69,239.53	1,069.62	98%	16.99%	19.40%	-2.41%	2,017.98	4,137.69
2049	71,084.89	71,084.89	71,278.62	193.73	100%	16.98%	11.72%	5.26%	2,075.13	4,280.26
2050	74,129.93	74,129.93	73,358.73	(771.20)	101%	16.69%	3.72%	12.97%	2,099.44	4,427.54

Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



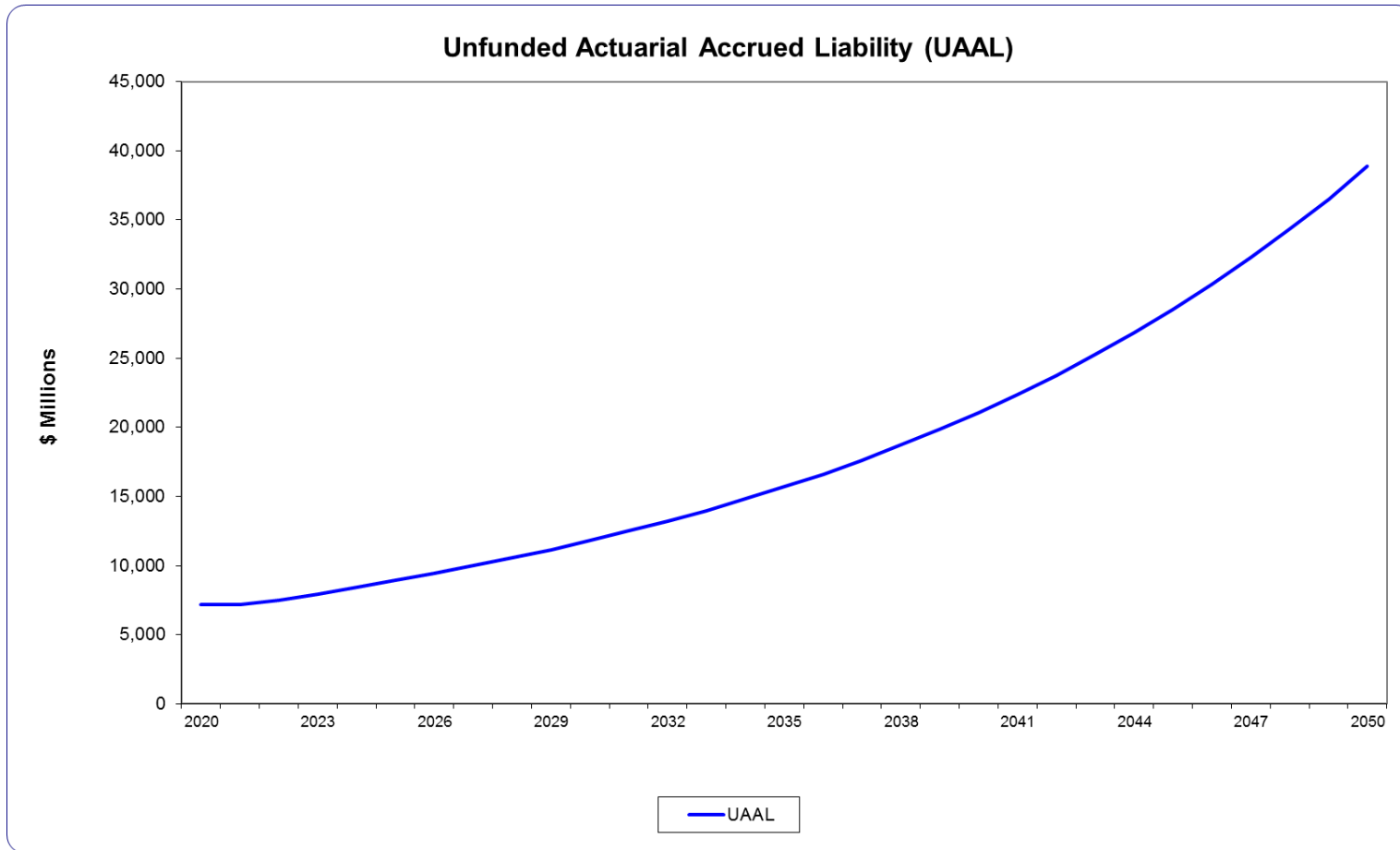
Exhibit D-1
6.0% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



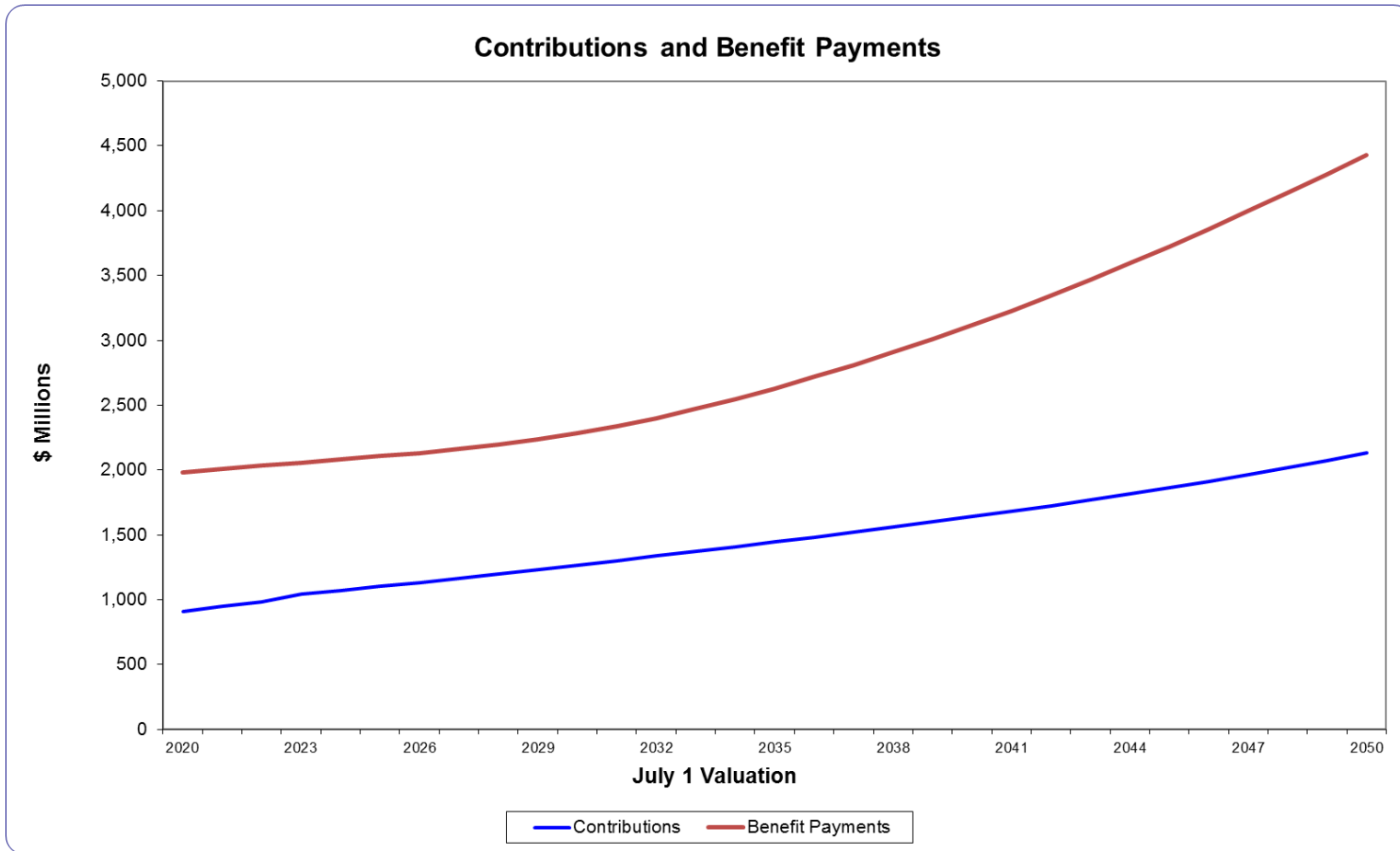
Exhibit D-2
6.0% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



Exhibit D-3
6.0% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



Teachers Retirement Association of Minnesota

Exhibit E

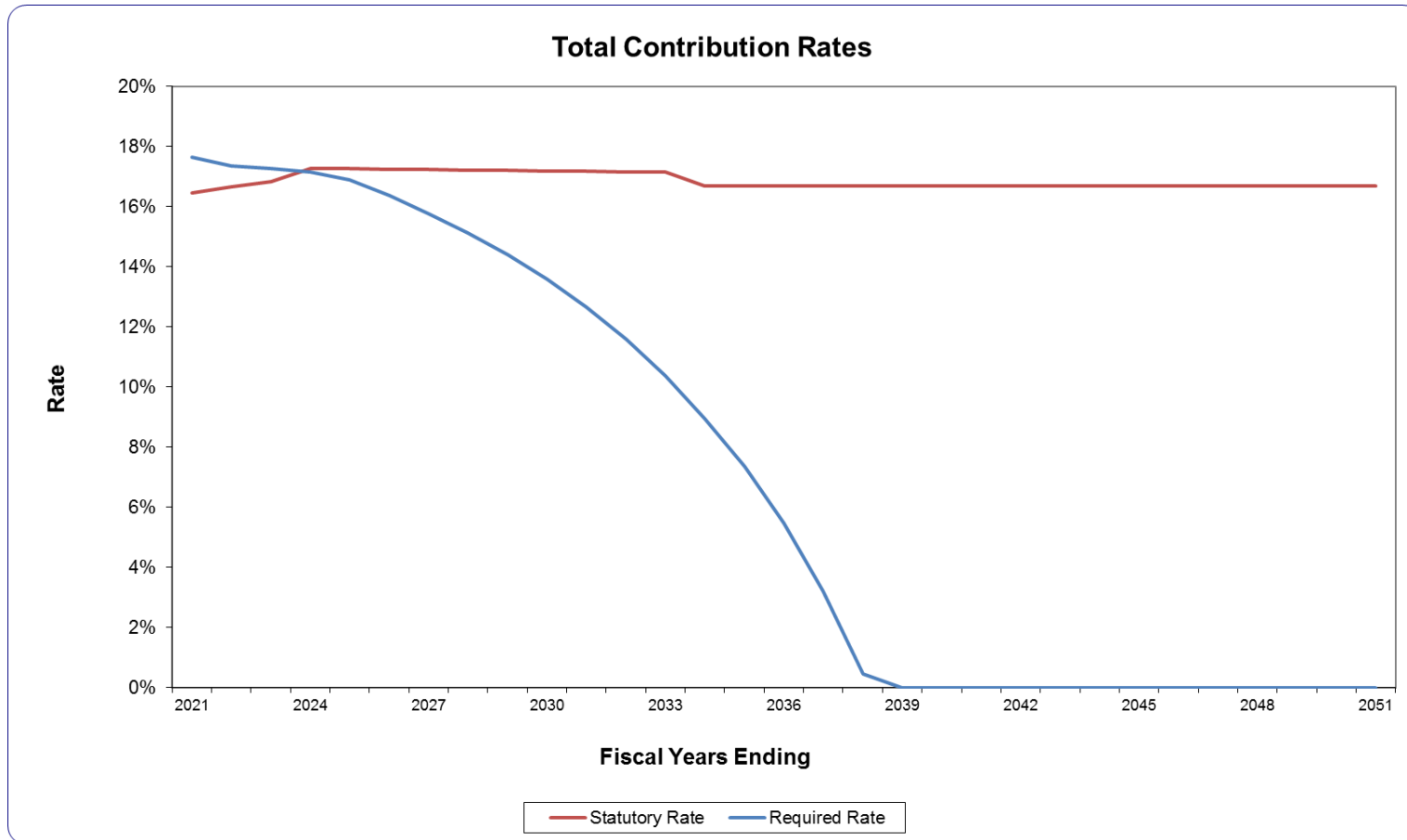
6.0% Actual Investment Return in Future Years

July 1	Asset Values		Actuarial Accrued Liability	Unfunded Actuarial Accrued Liability	Funded Ratio	Contribution Rates			Total Contributions	Benefit Payments
	Actuarial	Market				Statutory	Required	Sufficiency/ (Deficiency)		
2020	\$22,936.91	\$22,741.05	\$30,129.18	\$7,192.27	76%	16.46%	17.65%	-1.19%	\$908.83	\$1,983.16
2021	23,651.19	22,999.42	30,808.93	7,157.74	77%	16.65%	17.50%	-0.85%	948.48	2,006.38
2022	24,065.99	23,290.20	31,530.35	7,464.37	76%	16.84%	17.78%	-0.94%	986.60	2,032.41
2023	24,367.17	23,610.89	32,299.99	7,932.82	75%	17.28%	18.23%	-0.95%	1,041.72	2,056.93
2024	24,666.40	23,982.32	33,113.99	8,447.59	74%	17.26%	18.73%	-1.47%	1,071.93	2,081.25
2025	25,076.27	24,382.10	34,007.24	8,930.96	74%	17.24%	19.22%	-1.98%	1,102.68	2,106.30
2026	25,517.00	24,811.73	34,958.23	9,441.23	73%	17.23%	19.75%	-2.52%	1,134.16	2,132.54
2027	25,989.87	25,272.54	35,970.46	9,980.59	72%	17.21%	20.34%	-3.13%	1,166.05	2,161.64
2028	26,494.18	25,763.87	37,045.65	10,551.47	72%	17.20%	20.99%	-3.79%	1,198.11	2,196.92
2029	27,025.51	26,281.37	38,182.29	11,156.78	71%	17.18%	21.72%	-4.54%	1,230.03	2,236.56
2030	27,580.75	26,821.97	39,380.72	11,799.97	70%	17.17%	22.52%	-5.35%	1,266.29	2,284.30
2031	28,157.33	27,383.18	40,639.70	12,482.37	69%	17.16%	23.42%	-6.26%	1,302.25	2,339.02
2032	28,748.90	27,958.75	41,956.83	13,207.93	69%	17.14%	24.45%	-7.31%	1,337.98	2,401.65
2033	29,347.78	28,541.16	43,328.55	13,980.76	68%	17.13%	25.63%	-8.50%	1,373.62	2,471.03
2034	29,947.17	29,123.78	44,752.46	14,805.28	67%	17.12%	27.01%	-9.89%	1,409.69	2,547.43
2035	30,540.11	29,699.84	46,225.53	15,685.42	66%	17.11%	28.60%	-11.49%	1,446.26	2,629.82
2036	31,120.35	30,263.27	47,745.61	16,625.27	65%	17.10%	30.47%	-13.37%	1,483.27	2,718.53
2037	31,680.89	30,807.29	49,310.15	17,629.26	64%	17.09%	32.69%	-15.60%	1,521.00	2,811.24
2038	32,217.01	31,327.35	50,918.95	18,701.94	63%	17.08%	35.36%	-18.28%	1,559.75	2,907.12
2039	32,724.92	31,819.79	52,572.60	19,847.68	62%	17.07%	38.63%	-21.56%	1,599.48	3,008.27
2040	33,198.37	32,278.54	54,269.71	21,071.35	61%	17.06%	42.73%	-25.67%	1,640.03	3,115.58
2041	33,629.70	32,696.09	56,007.85	22,378.15	60%	17.05%	48.00%	-30.95%	1,681.55	3,228.38
2042	34,011.60	33,065.30	57,785.05	23,773.45	59%	17.04%	55.04%	-38.00%	1,724.28	3,345.56
2043	34,337.70	33,380.01	59,600.78	25,263.08	58%	17.03%	64.89%	-47.86%	1,768.54	3,466.66
2044	34,602.08	33,634.48	61,455.19	26,853.11	56%	17.02%	79.65%	-62.63%	1,814.63	3,592.11
2045	34,798.37	33,822.52	63,347.58	28,549.21	55%	17.01%	104.21%	-87.20%	1,862.43	3,723.28
2046	34,918.24	33,936.02	65,275.81	30,357.57	53%	17.00%	153.32%	-136.32%	1,911.91	3,858.95
2047	34,954.12	33,967.57	67,239.37	32,285.26	52%	17.00%	300.50%	-283.50%	1,963.62	3,997.34
2048	34,900.38	33,911.78	69,239.53	34,339.15	50%	16.99%	310.53%	-293.54%	2,017.98	4,137.69
2049	34,752.32	33,764.11	71,278.62	36,526.30	49%	16.98%	320.74%	-303.76%	2,075.13	4,280.26
2050	34,504.86	33,519.64	73,358.73	38,853.87	47%	16.97%	331.17%	-314.20%	2,134.77	4,427.54

Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



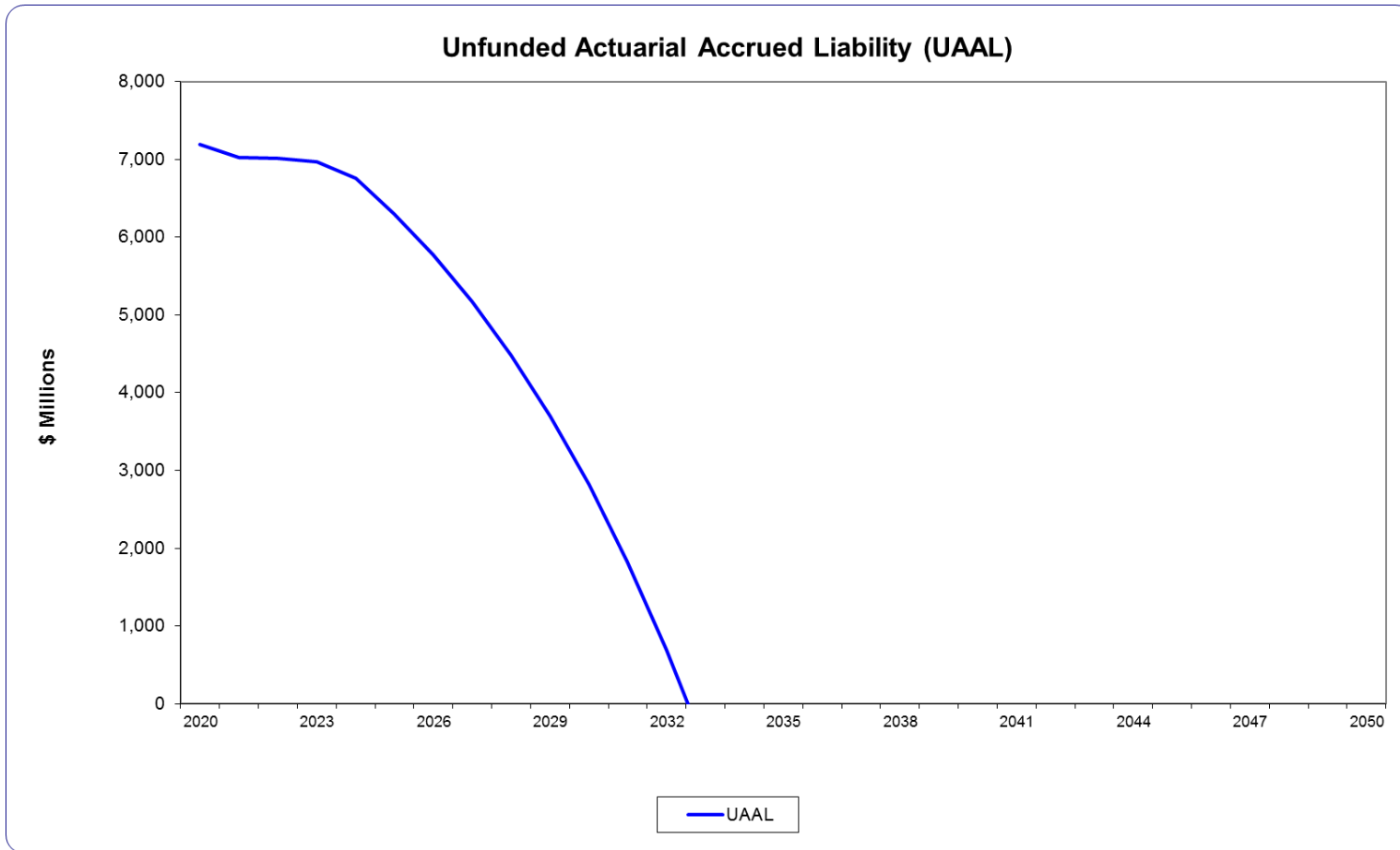
Exhibit F-1
9.0% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



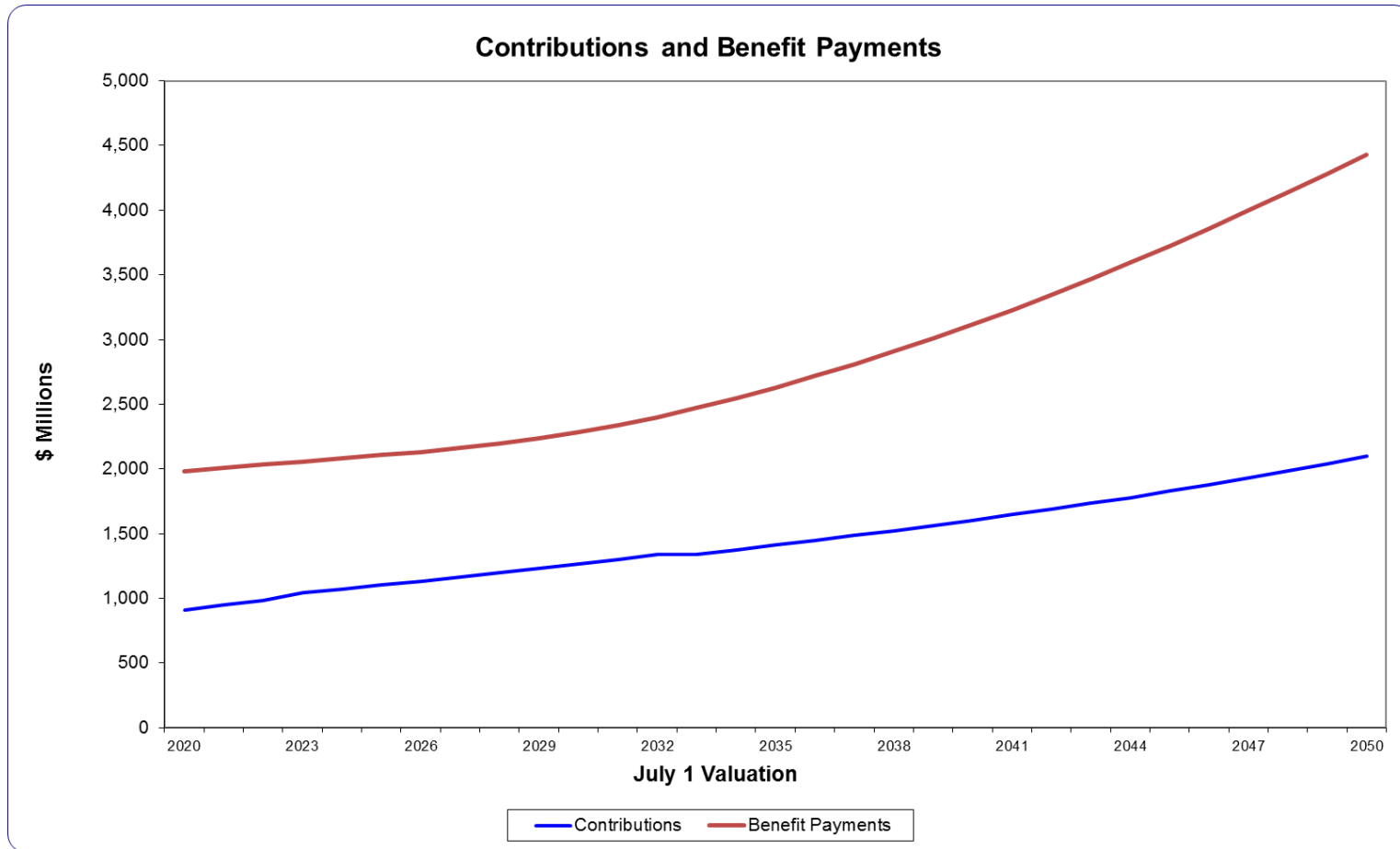
Exhibit F-2
9.0% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



Exhibit F-3
9.0% Actual Investment Return in Future Years



Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.



Teachers Retirement Association of Minnesota

Exhibit G

9.0% Actual Investment Return in Future Years

July 1	Asset Values		Actuarial	Unfunded	Funded	Contribution Rates			Total	Benefit
	Actuarial	Market	Accrued Liability	Actuarial Liability		Ratio	Statutory	Required		
2020	\$22,936.91	\$22,741.05	\$30,129.18	\$7,192.27	76%	16.46%	17.65%	-1.19%	\$908.83	\$1,983.16
2021	23,784.53	23,666.11	30,808.93	7,024.40	77%	16.65%	17.36%	-0.71%	948.48	2,006.38
2022	24,519.60	24,691.57	31,530.35	7,010.76	78%	16.84%	17.28%	-0.44%	986.60	2,032.41
2023	25,337.08	25,821.96	32,299.99	6,962.91	78%	17.28%	17.16%	0.12%	1,041.72	2,056.93
2024	26,358.69	27,086.02	33,113.99	6,755.30	80%	17.26%	16.89%	0.37%	1,071.93	2,081.25
2025	27,708.18	28,470.00	34,007.24	6,299.06	81%	17.24%	16.36%	0.88%	1,102.68	2,106.30
2026	29,184.66	29,984.49	34,958.23	5,773.57	83%	17.23%	15.77%	1.46%	1,134.16	2,132.54
2027	30,799.20	31,640.75	35,970.46	5,171.26	86%	17.21%	15.12%	2.09%	1,166.05	2,161.64
2028	32,561.78	33,449.00	37,045.65	4,483.87	88%	17.20%	14.39%	2.81%	1,198.11	2,196.92
2029	34,479.54	35,416.62	38,182.29	3,702.76	90%	17.18%	13.58%	3.60%	1,230.03	2,236.56
2030	36,561.86	37,553.27	39,380.72	2,818.86	93%	17.17%	12.65%	4.52%	1,266.29	2,284.30
2031	38,819.76	39,870.22	40,639.70	1,819.94	96%	17.16%	11.59%	5.57%	1,302.25	2,339.02
2032	41,261.58	42,376.13	41,956.83	695.24	98%	17.14%	10.37%	6.77%	1,337.98	2,401.65
2033	43,895.57	45,079.48	43,328.55	(567.02)	101%	16.69%	8.96%	7.73%	1,338.28	2,471.03
2034	46,695.38	47,954.01	44,752.46	(1,942.92)	104%	16.69%	7.36%	9.33%	1,374.35	2,547.43
2035	49,706.34	51,045.15	46,225.53	(3,480.81)	108%	16.69%	5.47%	11.22%	1,410.92	2,629.82
2036	52,941.81	54,366.64	47,745.61	(5,196.19)	111%	16.69%	3.21%	13.48%	1,447.93	2,718.53
2037	56,415.94	57,933.09	49,310.15	(7,105.79)	114%	16.69%	0.46%	16.23%	1,485.67	2,811.24
2038	60,146.85	61,763.13	50,918.95	(9,227.90)	118%	16.69%	0.00%	16.69%	1,524.42	2,907.12
2039	64,155.47	65,878.23	52,572.60	(11,582.87)	122%	16.69%	0.00%	16.69%	1,564.14	3,008.27
2040	68,462.41	70,299.56	54,269.71	(14,192.70)	126%	16.69%	0.00%	16.69%	1,604.69	3,115.58
2041	73,089.09	75,049.11	56,007.85	(17,081.24)	131%	16.69%	0.00%	16.69%	1,646.22	3,228.38
2042	78,059.68	80,151.70	57,785.05	(20,274.62)	135%	16.69%	0.00%	16.69%	1,688.94	3,345.56
2043	83,401.94	85,635.80	59,600.78	(23,801.16)	140%	16.69%	0.00%	16.69%	1,733.20	3,466.66
2044	89,146.95	91,533.23	61,455.19	(27,691.75)	145%	16.69%	0.00%	16.69%	1,779.29	3,592.11
2045	95,328.42	97,878.59	63,347.58	(31,980.84)	150%	16.69%	0.00%	16.69%	1,827.09	3,723.28
2046	101,981.54	104,707.99	65,275.81	(36,705.73)	156%	16.69%	0.00%	16.69%	1,876.57	3,858.95
2047	109,145.89	112,062.04	67,239.37	(41,906.52)	162%	16.69%	0.00%	16.69%	1,928.28	3,997.34
2048	116,867.06	119,987.47	69,239.53	(47,627.53)	169%	16.69%	0.00%	16.69%	1,982.64	4,137.69
2049	125,195.93	128,536.40	71,278.62	(53,917.31)	176%	16.69%	0.00%	16.69%	2,039.80	4,280.26
2050	134,187.81	137,765.56	73,358.73	(60,829.07)	183%	16.69%	0.00%	16.69%	2,099.44	4,427.54

Results are modeled based on a specified investment return and assuming all other actuarial assumptions being met each year in the future. Please refer to the accompanying letter from Cavanaugh Macdonald dated January 14, 2021 for important details regarding assumptions and methodology.