Verus

APRIL 1, 2021

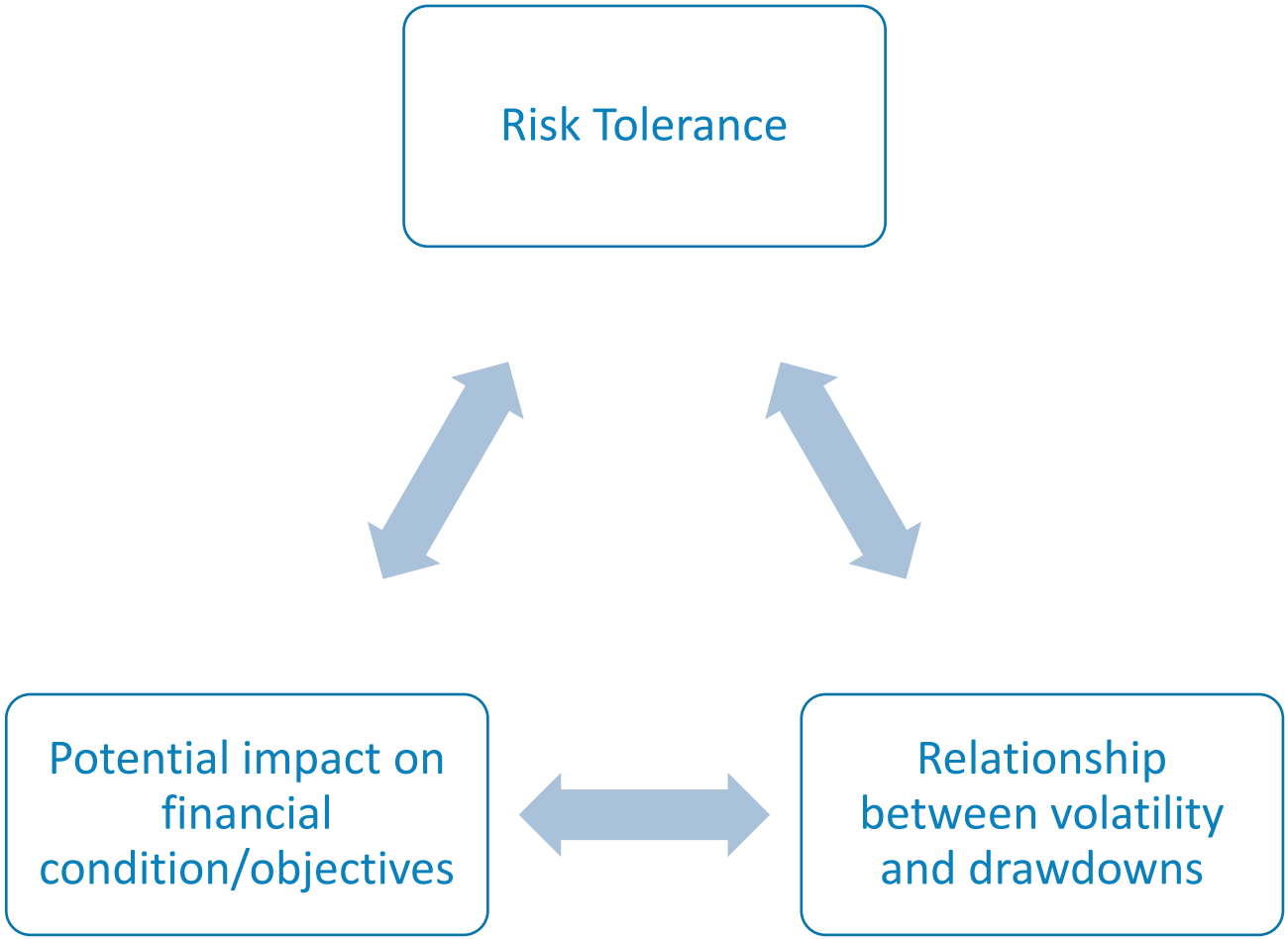
Risk Allocation Study

City of San Jose Police and Fire Employees' Retirement System

Summary

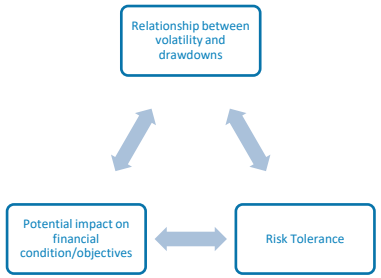
- Risk limits were established by the board by analyzing the relationship between:
  - Risk tolerance
  - Volatility and drawdowns
  - Potential impact on financial conditions and plan objectives
- Versus the current strategic asset allocation, the set of asset allocation mixes being considered today:
  - Fall both within and outside the limit for Board risk as defined in IPS for portfolios with higher growth allocations
  - Increases in volatility come from taking more equity risk. Higher growth from assets other than equities increases volatility modestly, but reduces equity beta
  - Duration risk is not significant risk among mixes considered as it is relatively short across all mixes
  - None of the mixes provide very different outcomes in stress scenarios or shocks with one exception

Risk limit framework



The board has used the following framework to determine the appropriate level of portfolio volatility

Volatility, drawdowns and risk tolerance



Risk Tolerance

Aggressive

Conservative

Risk Tolerance

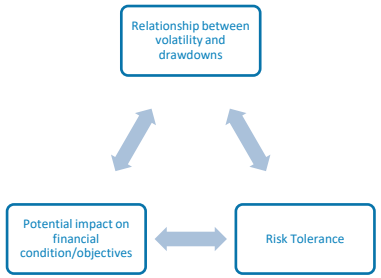
Conservative

Aggressive

Portfolio Volatility	95% VaR	95% CVaR	99% VaR	99% CVaR	Average 3 worst scenarios
8% Risk	-14%	-17%	-18%	-20%	-19%
9% Risk	-15%	-18%	-19%	-22%	-21%
10% Risk	-16%	-19%	-21%	-24%	-23%
11% Risk	-18%	-22%	-24%	-27%	-28%
12% Risk	-20%	-25%	-27%	-31%	-32%
13% Risk	-22%	-28%	-30%	-34%	-36%
14% Risk	-24%	-29%	-31%	-36%	-39%
15% Risk	-25%	-31%	-33%	-38%	-40%

The board's risk tolerance determines the appropriate level of risk and how expected drawdowns will be estimated

Actuarial projections



Potential impact on financial condition/objectives

Based on discussions with Verus and Cheiron the board determined there were three actuarial metrics to include in the formulation of their risk limits: Funded Ratio, City Contributions, and Interest cost. Applying drawdowns in 5% increments ranging from 20% to 40%, we can determine the impact on the three metrics.

		Funded Ratio	City Contributions	Funded Ratio change	City Contributions change
Single Year	Baseline	74%	$ 241	0%	$ -
	-20%	63%	$ 356	-11%	$ 115
	-25%	60%	$ 376	-14%	$ 136
	-30%	57%	$ 397	-17%	$ 156
	-35%	53%	$ 417	-21%	$ 176
	-40%	49%	$ 437	-25%	$ 196

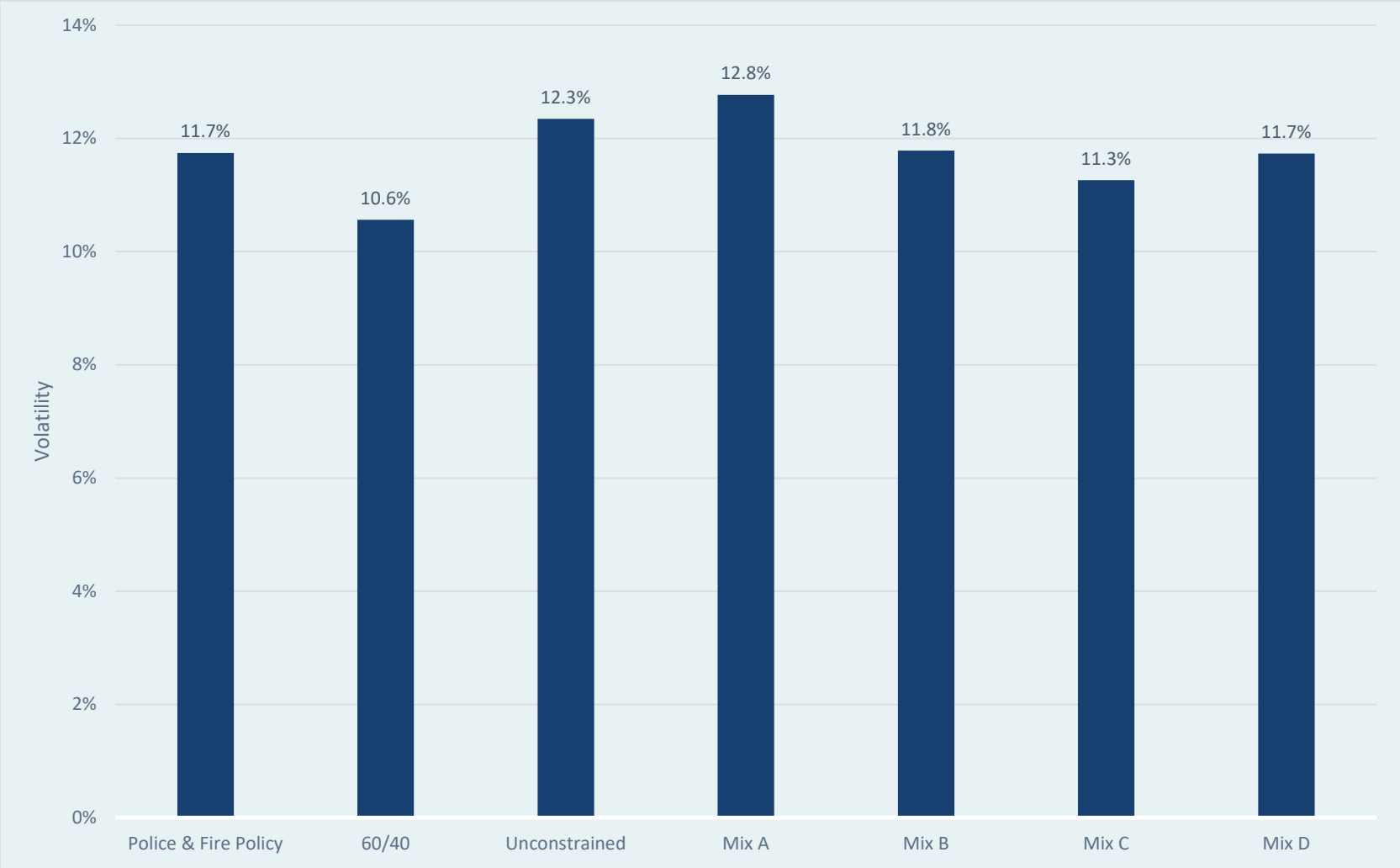
The Single Year table identifies the maximum or minimum for each category.

		Funded Ratio	City Contributions	Funded Ratio change	City Contributions change
10-year (cumulative)	Baseline	89%	$ 2,282	0%	$ -
	-20%	75%	$ 2,987	-14%	$ 705
	-25%	73%	$ 3,138	-16%	$ 856
	-30%	71%	$ 3,288	-18%	$ 1,006
	-35%	69%	$ 3,445	-20%	$ 1,163
	-40%	67%	$ 3,604	-22%	$ 1,322

The 10-year Cumulative table identifies the end of period financial situation and total dollar amount for each category

Source: Actuarial metrics provided by Cheiron. Dollar amounts in millions

Board risk limits

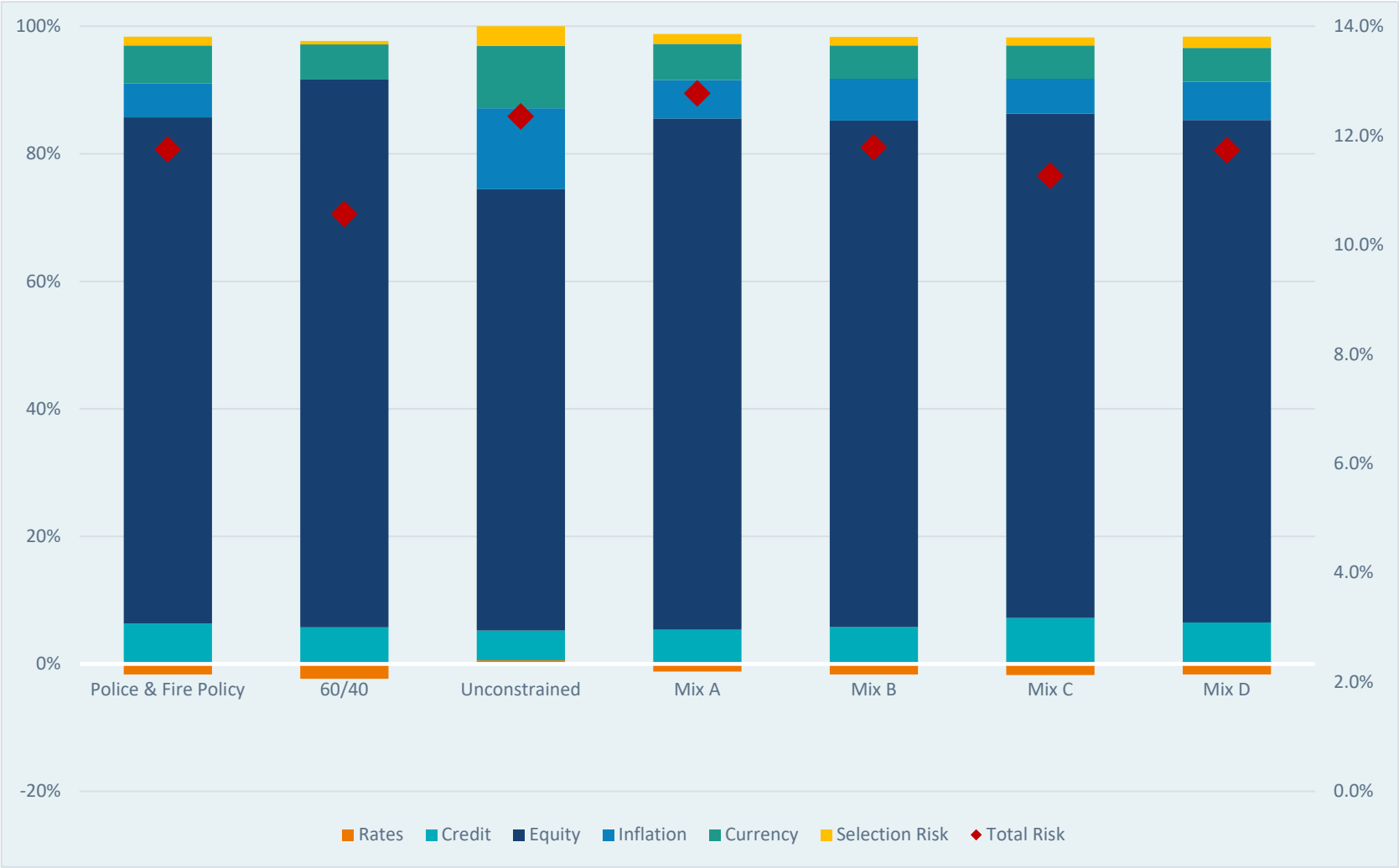


From IPS, Board risk operating zone limit is when portfolio forecast risk is >12%.

The current policy falls within this limit.

Data from MSCI BarraOne, 303XL model.

Risk decomposition



Equity factor risk remains the largest contributor to volatility across all the mixes considered. We see marginal differences in credit, inflation, and currency factors.

Data from MSCI BarraOne, 303XL model.

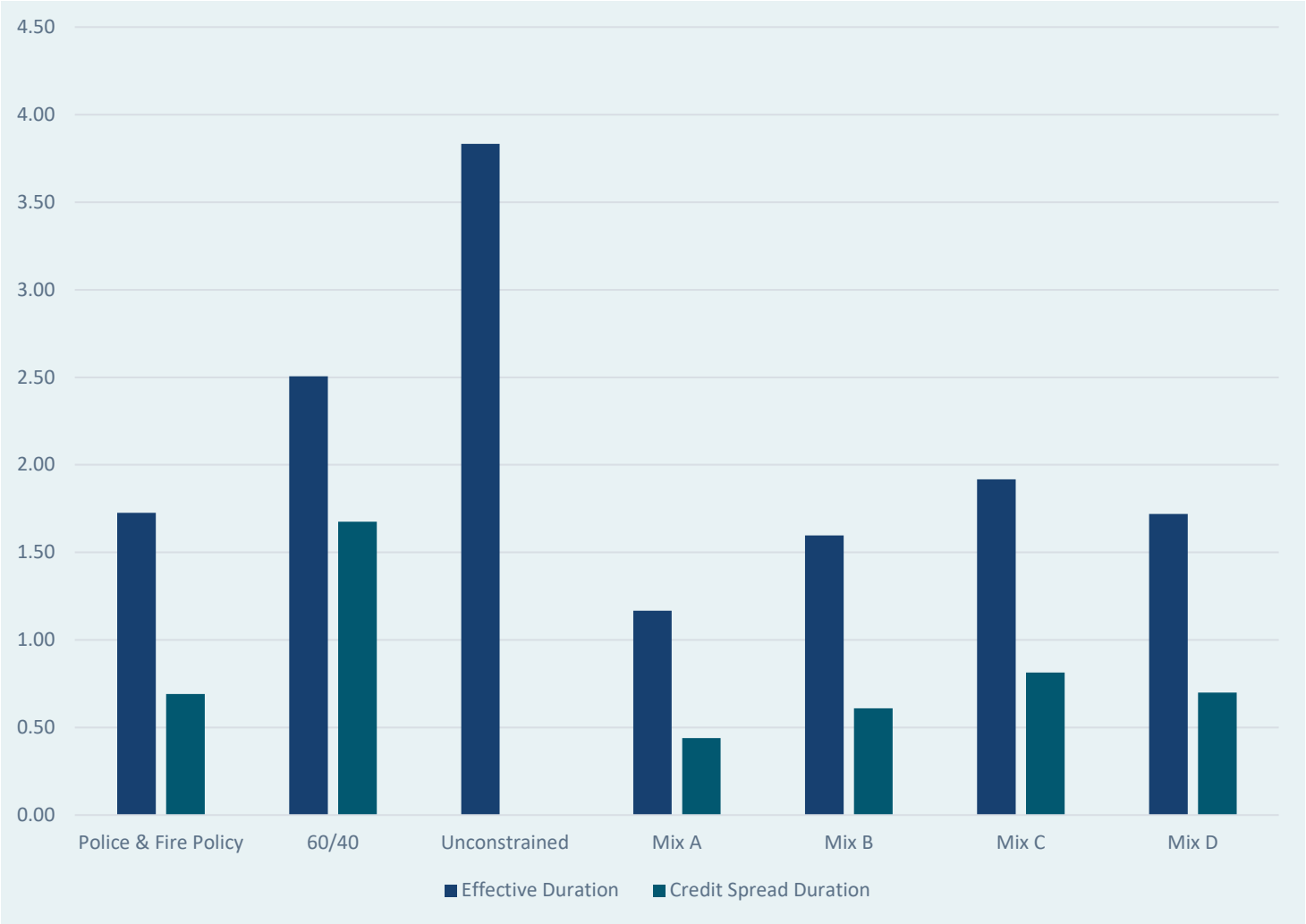
Equity Beta

Mix A is the highest volatility mix and the increase in risk is mainly through more equity beta.

The current policy and Mix B have similar levels of equity beta.

Source: MSCI BarraOne. Equity beta is measured relative to the MSCI ACWI IMI index.

Duration

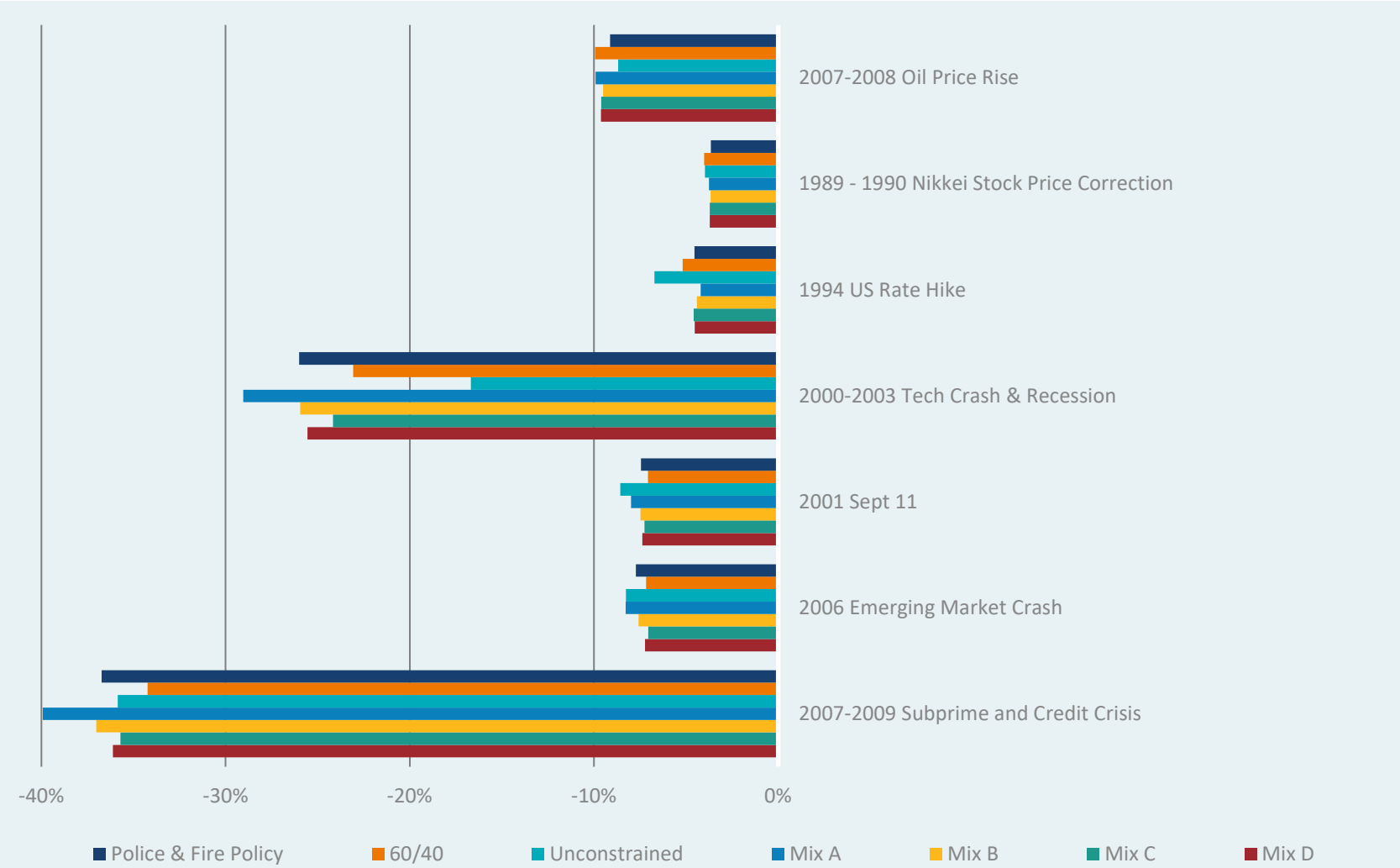


The unconstrained mix has a large allocation to long term government bonds which shows the highest effective duration and the lowest credit spread duration as all fixed income exposure is obtained through government bonds.

Mixes A, B, and C do not cause a material change in duration relative to the current P&F Policy.

Source: MSCI BarraOne

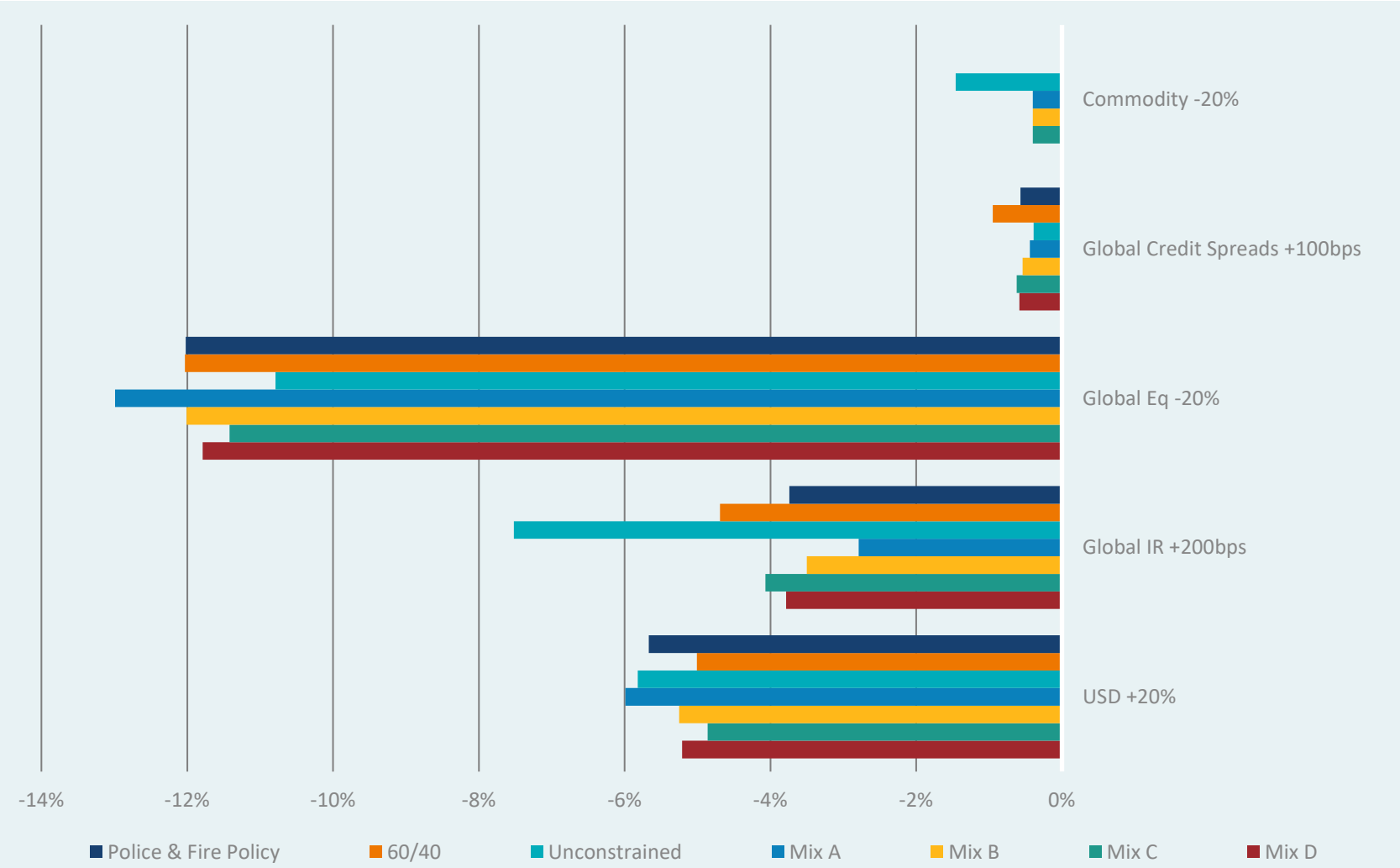
Scenario analysis



We see the largest differences in tail risk in the tech crash and subprime crisis.

Data from MSCI BarraOne.

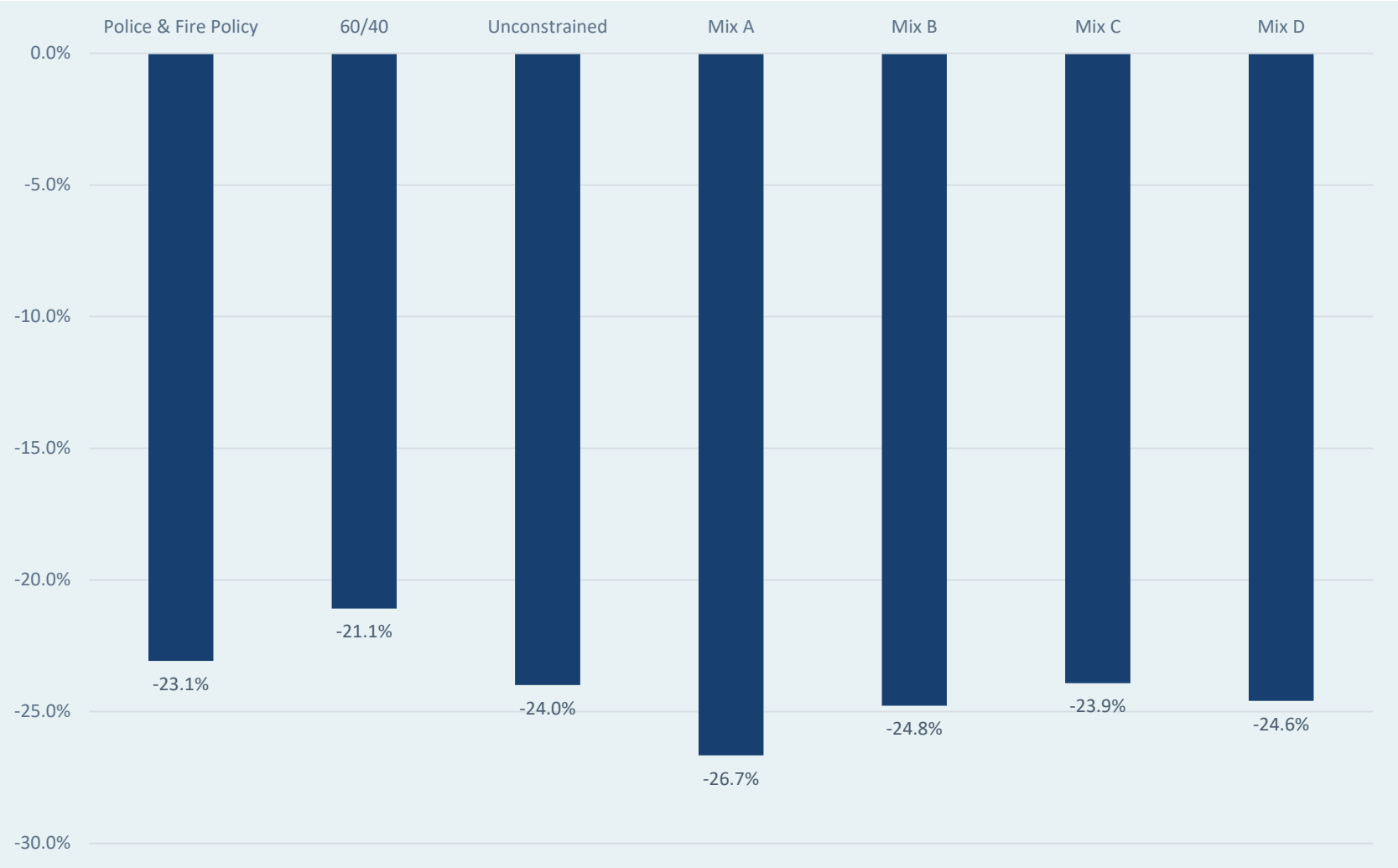
Stress tests



Of the stress tests considered, global equities falling 20% is the most severe, followed by the U.S. Dollar appreciating 20%.

Data from MSCI BarraOne.

COVID 19 Shock



COVID 19 shock represents the peak to trough return from 2/19/2020 to 3/23/2020.

Appendix – Asset mixes

	Police & Fire Policy	60/40	Unconstrained	Mix A	Mix B	Mix C	Mix D	Verus 2021 CMA's (10 Yr) Return (g)	Return (a)	Standard Deviation	Sharpe Ratio (a)
Growth	***70***	***60***	***72***	***75***	***69***	***67***	***70***				
Public Equity	46.0	60.0	0.0	49.0	46.0	44.0	42.0	*5.2*	*6.6*	*17.3*	*0.37*
Private Equity	10.0	0.0	14.1	12.0	10.0	9.0	12.0	*9.3*	*12.1*	*28.1*	*0.46*
Private Debt	3.0	0.0	6.9	3.0	3.0	3.0	3.0	*4.6*	*5.2*	*11.2*	*0.45*
Growth Real Estate	3.0	0.0	12.5	3.0	3.0	2.0	4.0	*7.8*	*9.1*	*17.1*	*0.52*
Private Real Assets	3.0	0.0	38.3	3.0	3.0	3.0	4.0	*7.8*	*9.4*	*18.8*	*0.49*
Emerging Market Bonds (Hard)	1.5	0.0	0.0	1.5	1.0	2.0	1.5	*5.2*	*6.0*	*12.7*	*0.45*
Emerging Market Bonds (Local)	1.5	0.0	0.0	1.5	1.0	2.0	1.5	*4.3*	*5.0*	*12.2*	*0.39*
High Yield Bonds	2.0	0.0	0.0	2.0	2.0	2.0	2.0	*3.4*	*4.0*	*11.3*	*0.34*
Low Beta	***8***	***0***	***0***	***8***	***8***	***8***	***8***				
Market Neutral Strategies	3.0	0.0	0.0	3.0	3.0	3.0	3.0	*3.8*	*4.1*	*7.8*	*0.49*
Immunized Cash Flows	5.0	0.0	0.0	5.0	5.0	5.0	5.0	*0.2*	*0.2*	*1.2*	*-*
Other	***22***	***40***	***28***	***17***	***23***	***25***	***22***				
US TIPS	2.0	0.0	0.0	2.0	2.0	2.0	2.0	*1.1*	*1.2*	*5.3*	*0.18*
Core Real Estate	5.0	0.0	0.0	5.0	5.0	4.0	5.0	*5.8*	*6.5*	*12.6*	*0.50*
Core Bonds	12.0	40.0	0.0	6.0	11.0	14.0	12.0	*1.1*	*1.3*	*6.1*	*0.17*
Commodities	0.0	0.0	7.3	2.0	2.0	2.0	0.0	*2.2*	*3.4*	*15.9*	*0.20*
Long-Term Government Bonds	3.0	0.0	21.0	2.0	3.0	3.0	3.0	*0.7*	*0.9*	*6.7*	*0.10*
Total Allocation	**100**	**100**	**100**	**100**	**100**	**100**	**100**				

	Police & Fire Policy	60/40	Unconstrained	Mix A	Mix B	Mix C	Mix D
Mean Variance Analysis							
Forecast 10 Year Return	***5.4***	***4.1***	***6.9***	***5.7***	***5.4***	***5.2***	***5.6***
Standard Deviation	12.1	10.4	12.2	13.1	12.0	11.3	11.8
Return/Std. Deviation	*0.5*	*0.4*	*0.6*	*0.4*	*0.5*	*0.5*	*0.5*
1st percentile ret. 1 year	*-19.0*	*-17.5*	*-17.9*	*-20.5*	*-18.9*	*-17.8*	*-18.5*
Sharpe Ratio	0.48	0.41	0.59	0.47	0.47	0.48	0.49

Source: Verus and MPI

Appendix - Downside measures

We have discussed three methods of determining downside risk (or tail risk) for the investment portfolio.

Value at risk (VaR): VaR calculates the maximum loss expected over a 1-year period given a specified degree of confidence

Conditional Value at Risk (CVaR): CVaR measures the expected loss if VaR is exceeded. It takes the average of the tail observations

Average of three worst historical scenarios: We simulate the portfolio through historic scenarios to determine the three worst periods and take the average of those scenarios.

Risk Metric	Description
95% VaR	(95% Confidence) We don't expect the worst annual loss to exceed
99% VaR	(99% Confidence) we don't expect the worst annual loss to exceed
95% CVaR	(95% Confidence) If VaR is exceeded, the average expected loss
99% CVaR	(99% Confidence) If VaR is exceeded, the average expected loss
Avg. Scenario Drawdown	The average of the three worst historic scenarios measured in BarraOne

There are three methods to calculate VaR: Historic, Parametric, and Monte Carlo. VaR calculations are conducted in BarraOne using Monte Carlo VaR.

Appendix: Actuarial Tables

San Jose P&F - Baseline Projections

June 30th	Actuarial Liability	Assets Market	Assets Actuarial	Funded Ratio Market	Funded Ratio Actuarial	FYE	Investment Return	Contribution Amounts Member	Contribution Amounts City	Contribution Rates Member	Contribution Rates City	NC + Admin	Interest Cost	ICaR
2020	5,235.3	3,702.0	3,851.9	70.7%	73.6%	2021	6.625%	29.4	206.5	12.3%	84.6%	39.5%	40.9%	25.1%
2021	5,417.3	3,927.8	4,046.2	72.5%	74.7%	2022	6.625%	31.2	216.9	12.6%	87.4%	38.8%	38.6%	25.8%
2022	5,599.4	4,168.0	4,238.8	74.4%	75.7%	2023	6.625%	32.6	223.5	12.8%	87.5%	37.9%	36.0%	26.6%
2023	5,777.6	4,415.8	4,438.5	76.4%	76.8%	2024	6.625%	34.2	224.8	13.0%	85.4%	37.2%	33.2%	27.3%
2024	5,951.6	4,665.9	4,665.9	78.4%	78.4%	2025	6.625%	35.8	228.1	13.2%	84.1%	36.6%	30.4%	28.1%
2025	6,122.0	4,921.2	4,921.2	80.4%	80.4%	2026	6.625%	37.4	233.9	13.4%	83.8%	36.0%	27.6%	28.7%
2026	6,289.0	5,185.1	5,185.1	82.4%	82.4%	2027	6.625%	39.1	237.6	13.6%	82.6%	35.5%	24.6%	29.4%
2027	6,451.4	5,454.6	5,454.6	84.5%	84.5%	2028	6.625%	40.7	239.4	13.8%	80.8%	35.0%	21.6%	30.0%
2028	6,609.9	5,729.3	5,729.3	86.7%	86.7%	2029	6.625%	42.4	240.6	13.9%	78.9%	34.6%	18.5%	30.6%
2029	6,766.2	6,010.6	6,010.6	88.8%	88.8%	2030	6.625%	44.0	230.8	14.0%	73.5%	34.2%	15.4%	31.2%

San Jose P&F - Minus 20% Projections

June 30th	Actuarial Liability	Assets Market	Assets Actuarial	Funded Ratio Market	Funded Ratio Actuarial	FYE	Investment Return	Contribution Amounts Member	Contribution Amounts City	Contribution Rates Member	Contribution Rates City	NC + Admin	Interest Cost	ICaR
2020	5,235.3	3,702.0	3,851.9	70.7%	73.6%	2021	-20.000%	29.4	206.5	12.3%	84.6%	39.5%	40.9%	25.1%
2021	5,417.3	2,944.7	3,533.7	54.4%	65.2%	2022	6.625%	31.2	216.9	12.6%	87.4%	38.8%	64.0%	19.3%
2022	5,599.4	3,119.8	3,736.8	55.7%	66.7%	2023	6.625%	32.9	272.8	12.9%	106.8%	37.9%	62.3%	19.9%
2023	5,777.6	3,349.4	3,765.3	58.0%	65.2%	2024	6.625%	34.6	271.0	13.1%	103.0%	37.2%	59.2%	20.7%
2024	5,951.6	3,576.9	3,773.5	60.1%	63.4%	2025	6.625%	36.4	293.4	13.4%	108.2%	36.6%	56.2%	21.5%
2025	6,122.0	3,828.1	3,828.1	62.5%	62.5%	2026	6.625%	38.2	322.1	13.7%	115.4%	36.0%	52.7%	22.3%
2026	6,289.0	4,111.3	4,111.3	65.4%	65.4%	2027	6.625%	40.0	347.9	13.9%	121.0%	35.5%	48.6%	23.3%
2027	6,451.4	4,424.6	4,424.6	68.6%	68.6%	2028	6.625%	41.7	352.2	14.1%	118.9%	35.0%	43.9%	24.3%
2028	6,609.9	4,748.5	4,748.5	71.8%	71.8%	2029	6.625%	43.4	355.9	14.2%	116.7%	34.6%	39.1%	25.4%
2029	6,766.2	5,084.9	5,084.9	75.2%	75.2%	2030	6.625%	45.0	348.8	14.3%	111.0%	34.2%	34.3%	26.4%

Appendix: Actuarial Tables

San Jose P&F - Minus 25% Projections

June 30th	Actuarial Liability	Assets Market	Assets Actuarial	Funded Ratio Market	Funded Ratio Actuarial	FYE	Investment Return	Contribution Amounts Member	Contribution Amounts City	Contribution Rates Member	Contribution Rates City	NC + Admin	Interest Cost	ICaR
2020	5,235.3	3,702.0	3,851.9	70.7%	73.6%	2021	-25.000%	29.4	206.5	12.3%	84.6%	39.5%	40.9%	25.1%
2021	5,417.3	2,760.2	3,312.2	51.0%	61.1%	2022	6.625%	31.2	216.9	12.6%	87.4%	38.8%	68.8%	18.1%
2022	5,599.4	2,923.0	3,503.1	52.2%	62.6%	2023	6.625%	32.9	294.2	12.9%	115.2%	37.9%	67.2%	18.6%
2023	5,777.6	3,161.7	3,651.4	54.7%	63.2%	2024	6.625%	34.6	292.6	13.2%	111.2%	37.2%	63.8%	19.6%
2024	5,951.6	3,399.2	3,632.7	57.1%	61.0%	2025	6.625%	36.5	304.5	13.5%	112.4%	36.6%	60.4%	20.4%
2025	6,122.0	3,650.2	3,650.2	59.6%	59.6%	2026	6.625%	38.3	337.5	13.7%	120.9%	36.0%	56.8%	21.3%
2026	6,289.0	3,937.7	3,937.7	62.6%	62.6%	2027	6.625%	40.2	367.4	14.0%	127.8%	35.5%	52.5%	22.3%
2027	6,451.4	4,259.8	4,259.8	66.0%	66.0%	2028	6.625%	41.9	372.1	14.1%	125.7%	35.0%	47.5%	23.4%
2028	6,609.9	4,593.7	4,593.7	69.5%	69.5%	2029	6.625%	43.6	376.3	14.3%	123.4%	34.6%	42.4%	24.5%
2029	6,766.2	4,941.1	4,941.1	73.0%	73.0%	2030	6.625%	45.2	369.6	14.4%	117.7%	34.2%	37.3%	25.6%

San Jose P&F - Minus 30% Projections

June 30th	Actuarial Liability	Assets Market	Assets Actuarial	Funded Ratio Market	Funded Ratio Actuarial	FYE	Investment Return	Contribution Amounts Member	Contribution Amounts City	Contribution Rates Member	Contribution Rates City	NC + Admin	Interest Cost	ICaR
2020	5,235.3	3,702.0	3,851.9	70.7%	73.6%	2021	-30.000%	29.4	206.5	12.3%	84.6%	39.5%	40.9%	25.1%
2021	5,417.3	2,575.6	3,090.7	47.5%	57.1%	2022	6.625%	31.2	216.9	12.6%	87.4%	38.8%	73.6%	16.9%
2022	5,599.4	2,726.3	3,269.3	48.7%	58.4%	2023	6.625%	32.9	315.7	12.9%	123.6%	37.9%	72.2%	17.4%
2023	5,777.6	2,974.0	3,537.6	51.5%	61.2%	2024	6.625%	34.7	314.3	13.2%	119.4%	37.2%	68.4%	18.4%
2024	5,951.6	3,221.6	3,492.0	54.1%	58.7%	2025	6.625%	36.6	315.6	13.5%	116.5%	36.6%	64.6%	19.4%
2025	6,122.0	3,472.4	3,472.4	56.7%	56.7%	2026	6.625%	38.5	352.9	13.8%	126.4%	36.0%	60.9%	20.3%
2026	6,289.0	3,764.1	3,764.1	59.9%	59.9%	2027	6.625%	40.4	386.9	14.0%	134.6%	35.5%	56.3%	21.3%
2027	6,451.4	4,095.1	4,095.1	63.5%	63.5%	2028	6.625%	42.1	392.1	14.2%	132.4%	35.0%	51.0%	22.5%
2028	6,609.9	4,438.8	4,438.8	67.2%	67.2%	2029	6.625%	43.8	396.7	14.3%	130.1%	34.6%	45.7%	23.7%
2029	6,766.2	4,797.3	4,797.3	70.9%	70.9%	2030	6.625%	45.4	390.5	14.5%	124.3%	34.2%	40.2%	24.9%

Appendix: Actuarial Tables

San Jose P&F - Minus 35% Projections

June 30th	Actuarial Liability	Assets Market	Assets Actuarial	Funded Ratio Market	Funded Ratio Actuarial	FYE	Investment Return	Contribution Amounts Member	Contribution Amounts City	Contribution Rates Member	Contribution Rates City	NC + Admin	Interest Cost	ICaR
2020	5,235.3	3,702.0	3,851.9	70.7%	73.6%	2021	-35.000%	29.4	206.5	12.3%	84.6%	39.5%	40.9%	25.1%
2021	5,417.3	2,391.1	2,869.3	44.1%	53.0%	2022	6.625%	31.2	216.9	12.6%	87.4%	38.8%	78.3%	15.7%
2022	5,599.4	2,529.5	3,035.3	45.2%	54.2%	2023	6.625%	32.9	337.1	12.9%	132.0%	37.9%	77.1%	16.1%
2023	5,777.6	2,786.4	3,331.1	48.2%	57.7%	2024	6.625%	34.8	335.9	13.2%	127.7%	37.2%	73.0%	17.3%
2024	5,951.6	3,043.9	3,351.3	51.1%	56.3%	2025	6.625%	36.7	335.7	13.5%	123.9%	36.6%	68.8%	18.3%
2025	6,122.0	3,303.8	3,303.8	54.0%	54.0%	2026	6.625%	38.6	367.9	13.8%	131.8%	36.0%	64.8%	19.3%
2026	6,289.0	3,600.0	3,600.0	57.2%	57.2%	2027	6.625%	40.5	406.1	14.1%	141.2%	35.5%	60.0%	20.4%
2027	6,451.4	3,940.1	3,940.1	61.1%	61.1%	2028	6.625%	42.2	411.7	14.3%	139.0%	35.0%	54.4%	21.7%
2028	6,609.9	4,293.9	4,293.9	65.0%	65.0%	2029	6.625%	43.9	416.7	14.4%	136.6%	34.6%	48.7%	22.9%
2029	6,766.2	4,663.6	4,663.6	68.9%	68.9%	2030	6.625%	45.6	411.0	14.5%	130.8%	34.2%	42.9%	24.2%

San Jose P&F - Minus 40% Projections

June 30th	Actuarial Liability	Assets Market	Assets Actuarial	Funded Ratio Market	Funded Ratio Actuarial	FYE	Investment Return	Contribution Amounts Member	Contribution Amounts City	Contribution Rates Member	Contribution Rates City	NC + Admin	Interest Cost	ICaR
2020	5,235.3	3,702.0	3,851.9	70.7%	73.6%	2021	-40.000%	29.4	206.5	12.3%	84.6%	39.5%	40.9%	25.1%
2021	5,417.3	2,206.6	2,647.9	40.7%	48.9%	2022	6.625%	31.2	216.9	12.6%	87.4%	38.8%	83.1%	14.5%
2022	5,599.4	2,332.8	2,799.3	41.7%	50.0%	2023	6.625%	32.9	358.5	12.9%	140.3%	37.9%	82.1%	14.9%
2023	5,777.6	2,598.7	3,107.7	45.0%	53.8%	2024	6.625%	34.9	357.7	13.3%	135.9%	37.2%	77.5%	16.1%
2024	5,951.6	2,866.5	3,210.8	48.2%	53.9%	2025	6.625%	36.8	357.5	13.6%	131.9%	36.6%	73.0%	17.2%
2025	6,122.0	3,137.3	3,137.3	51.2%	51.2%	2026	6.625%	38.7	382.8	13.9%	137.1%	36.0%	68.6%	18.3%
2026	6,289.0	3,438.0	3,438.0	54.7%	54.7%	2027	6.625%	40.7	425.1	14.2%	147.8%	35.5%	63.6%	19.5%
2027	6,451.4	3,787.1	3,787.1	58.7%	58.7%	2028	6.625%	42.4	431.1	14.3%	145.6%	35.0%	57.7%	20.8%
2028	6,609.9	4,151.1	4,151.1	62.8%	62.8%	2029	6.625%	44.1	436.6	14.5%	143.1%	34.6%	51.7%	22.2%
2029	6,766.2	4,532.1	4,532.1	67.0%	67.0%	2030	6.625%	45.8	431.3	14.6%	137.3%	34.2%	45.6%	23.5%