

# Mid-Cycle Asset Liability Management Review

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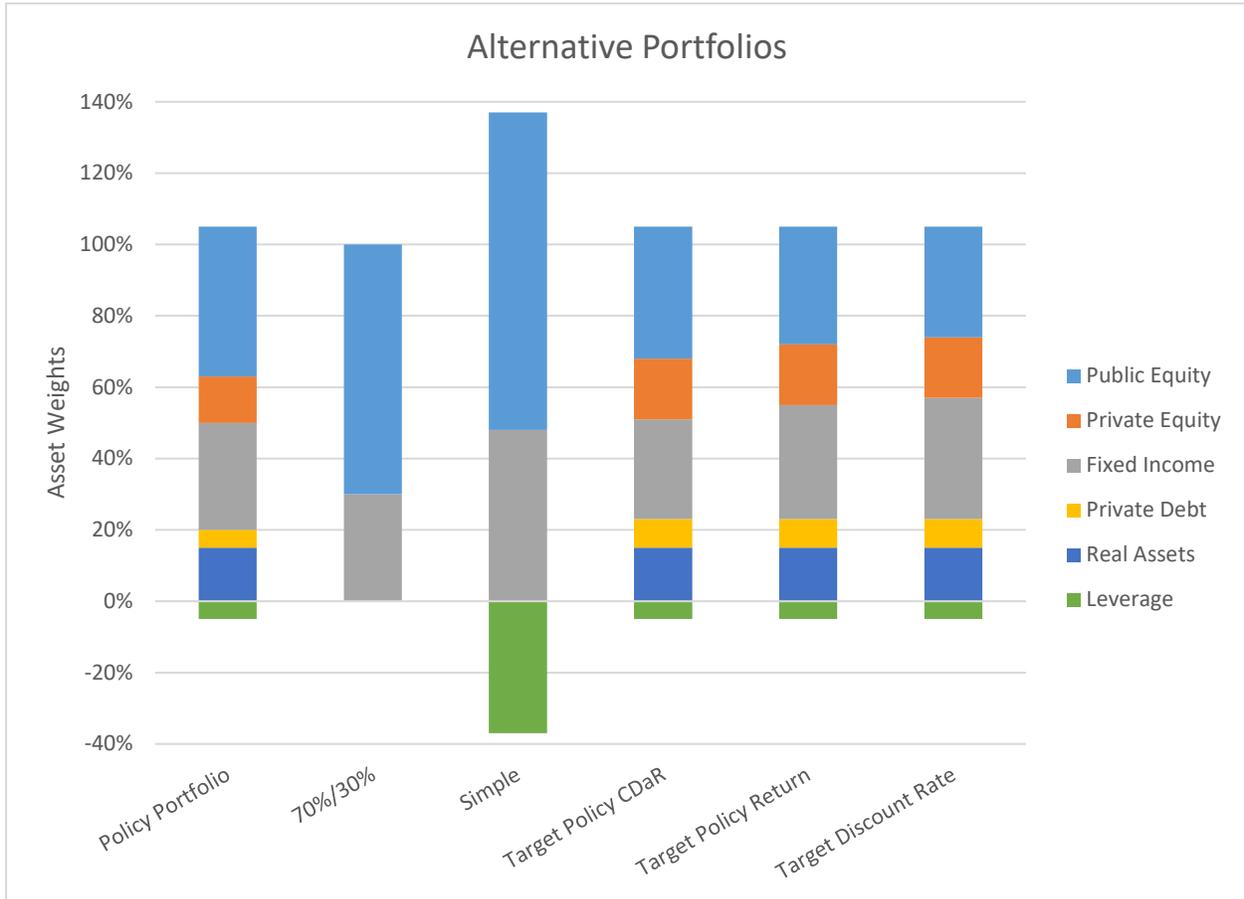
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# Purpose

Discuss to the CalPERS Board an updated Strategic Asset Allocation (SAA) for the PERF Policy Portfolio. The current and studied portfolio allocations are presented in Table 1.



6.9%	6.3%	6.9%	7.0%	6.9%	6.8%	<b>Geometric Return</b>
21.5%	26.0%	34.6%	21.4%	20.1%	19.5%	<b>CDaR</b>
11.2%	12.6%	16.4%	11.3%	10.9%	10.6%	<b>Volatility</b>

Table 1 The current and potential policy portfolio allocations

The insights and suggestions presented emerge from the ALM Mid-Cycle Review. The portfolios we have examined align with the Board's risk appetite, as expressed in the 2021 ALM, and appear to meet the Board's return expectations. The examined SAA maintains ample liquidity to fulfill our current and future obligations.

The allocation adjustments we have studied resonate with our discussions during and post the 2021 ALM, emphasizing the enhancement of diversification and returns for the total portfolio.

The subsequent sections of this document detail our rationale behind the suggested allocation adjustments.

## Introduction

### Objective

The choice of PERF Policy Portfolio is the CalPERS Board's most important investment decision (see Belief 6, Appendix A). This decision is guided by the Constitution of California (Appendix B), which requires the portfolio to be constructed to "minimize the risk of loss", "maximize the rate of return", and "assure prompt delivery of benefits", while "minimizing employer contributions". The actual choice of portfolio must strike a balance among these competing objectives.

### Background

The PERF Policy Portfolio is a benchmark asset mix designed to harvest scalable long-term risk premia while maintaining an acceptable risk of loss.

The SAA is designed with the following considerations in mind:

- a) Having a reasonable expectation of PERF returns meeting or exceeding the actuarial discount rate over the long-term. We discuss the meaning of 'long-term' below.
- b) Minimizing the risk of loss needed to support the harvesting of risk premia. We discuss 'risk of loss' below, and our interpretation of the CalPERS Board's risk appetite.
- c) Ensuring sufficient liquidity to meet our obligations now and in the future.

Our SAA review considers the need to change the PERF asset allocation in response to material changes in our liabilities, our risk appetite, our capabilities, or long-term market conditions. Based on our analysis, we have observed significant shifts in market conditions, prompting us to suggest revisions to the PERF allocations.

### Harvesting Risk Premia

The most scalable risk premia are associated with broad equity portfolios and long-term treasuries. Though scalable, these risk premia are highly volatile and reliably harvesting them requires long periods of time.

The Equity Risk Premium (ERP) is defined as the return of a broad equity portfolio less the return of long-term treasuries. As mentioned previously, we harvest this risk premia using a long-term exposure to equities. The meaning of 'long-term' depends upon risk appetite, as illustrated by estimating the ERP using a 10-year rolling window (figure 1). Over the period 1900-2023, the 10-year ERP has taken values from -10% to 20%, with an average around 5%. During this period the ERP was negative about 13% of

the time. These results suggest for an investor looking to reliably harvest the ERP, 10 years is not long-term.

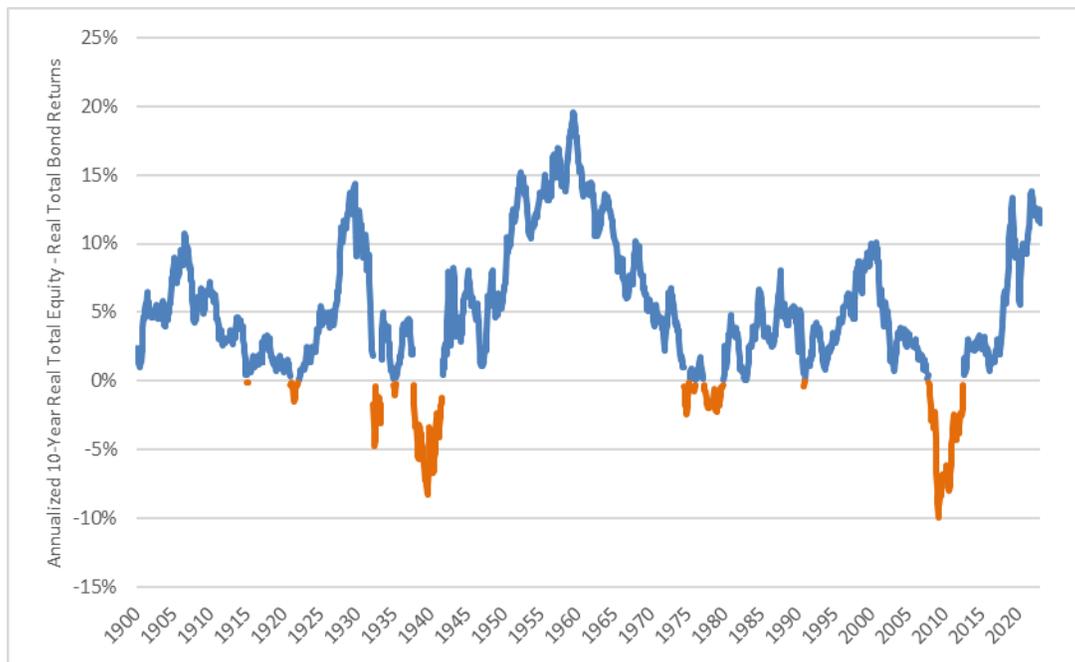


Figure 1. Outperformance of Rolling Equity Returns versus Rolling 10-year Treasury Returns. Source: Shiller, shared with permission.

The Bond Risk Premium (BRP) is associated with the return of the long treasury less cash returns. Lacking sufficient cash return data, we substitute long-term U.S. inflation as a reasonable proxy for long-term cash returns. The BRP over a 10-year rolling period can vary from -6% to 11%, with an average of 2%. And this premium is negative about 31 % of the time (figure 2).

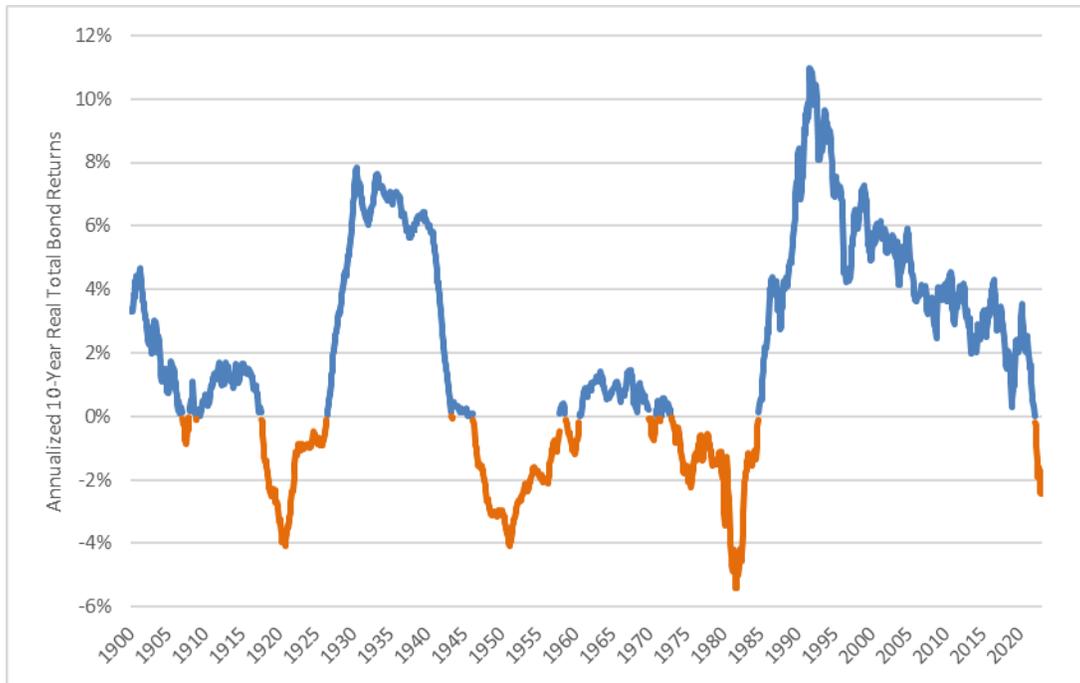


Figure 2. Rolling 10-year Treasury Risk Premia (relative to CPI). Source: Shiller, shared with permission.

Given the two most scalable risk premia can vary significantly in value even when measured over ten-year periods, it is not surprising that our survey of expert twenty-year Capital Market Assumptions has a diverse range of outcomes.

## Differentiating Risk and Uncertainty

Risk and uncertainty are differentiated by what we know, and don't know, about outcomes. We can measure risk when we know all the possible outcomes, and the probability of each of those outcomes. When we roll a fair set of dice, for example, all the possible outcomes and associated probabilities are known, and a player can calculate the risks associated with playing.

Uncertainty arises when not all outcomes are known or, even if all outcomes are known, the probabilities of the outcomes are not known. In either case we cannot formally calculate risk. Calculation of risk or return relies on a specific set of Capital Market Assumptions (CMAs) and, since these assumptions are uncertain, so are our risk and return estimates. We use multiple CMAs including scenarios, sensitivity analysis, and stress tests, to better understand the range of portfolio risk and return. By doing so we can select portfolios whose outcomes are most acceptable.

## Risk Appetite

The Board approved the current policy portfolio in November 2021, setting a strategic asset mix, a projected return, and a projected risk. To facilitate this mid-cycle review, we use the 2021 Policy Portfolio asset mix to represent the Board risk appetite.

## The Drawdown Risk Measure

The Constitution of California requires CalPERS to minimize the risk of loss, without specifying how to measure 'risk of loss'. In 2021 CalPERS adopted Conditional Drawdown (CDaR) as our measure of risk of loss (Appendix C). This risk measure is well aligned with the concept of 'loss'. Volatility, on the other hand is a measure of variation around the mean and relies on both gains and losses. Hence, we prefer CDaR as a measure of risk of loss.

Conditional Drawdown is the average of possible 'large' losses that could occur during a three-year period. We start with 18,000 3-year simulations to estimate the distribution of losses (the total of red and yellow areas in figure 3). We define 'large losses' to be the average of the worst ten percent of all losses (the average of the losses in the red area).

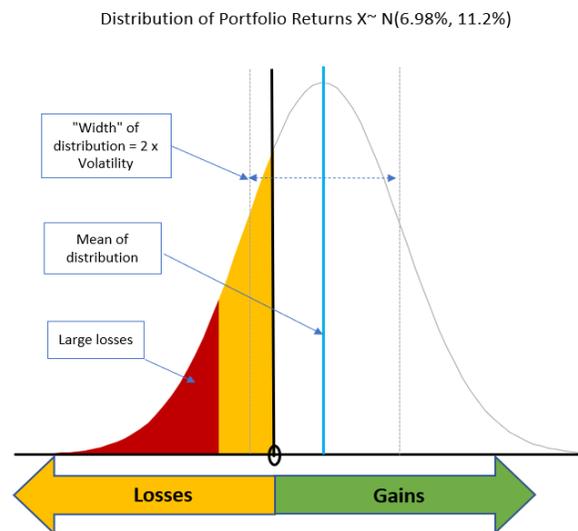


Figure 3 Drawdown as a risk measure

## Asset Classes – Purpose

Each asset class has a purpose within our strategic asset allocation. Implementation choices, including whether to manage the assets internally or externally, can and do affect asset class returns. Each asset class has two objectives. First, to implement the long-term risk premia harvesting strategy benchmarked by the PERF Policy Portfolio. Second, to add value relative to the benchmark. Each asset class has incorporated Sustainable Investing practices into their processes.

In the public markets these strategies can be implemented somewhat independently. Global Public Equities, for example, implements the internal market capital weighted strategy to harvest the long-term equity risk premia. Separately, Global Public Equities engages in internal and external active strategies to add value over and above the market capital weighted strategy.

Private assets usually combine the harvesting and skill-based active returns in one strategy.

The purpose and implementation choices for the asset classes are summarized in Table 2. A detailed discussion can be found in Appendix D.

Asset Class	Purpose	Implementation
Public Equity	<ul style="list-style-type: none"> <li>• Efficiently capture the equity risk premia</li> <li>• Total return oriented, comprised of price appreciation and cash yields</li> <li>• Reliable source of liquidity</li> <li>• Consists of a market-cap weighted and non-cap-weighted segment</li> <li>• Non-cap-weighted is intended to reduce overall volatility and provide some diversification</li> </ul>	94% internally managed
Fixed Income	<ul style="list-style-type: none"> <li>• long-term economic diversifier to equity risk and reliable source of income and liquidity</li> <li>• Consists of multiple segments: Long Treasuries, Agency Mortgage-Backed Securities, Investment Grade Corporates, High Yield, and Emerging Market Sovereign Bonds</li> <li>• Segments have different risk and return characteristics and vary on liquidity, income, and diversification</li> </ul>	78% internally managed
Private Equity	<ul style="list-style-type: none"> <li>• Active equity exposure to private companies to generate returns greater than public equity</li> <li>• Major driver of returns is appreciation, aided by leverage, with negligible cash yield</li> <li>• Diversified across investment type, industry segment, investment strategy, geography, vintage year, and underlying portfolio companies</li> </ul>	<p>100% externally managed</p> <p>Focusing on increasing exposures to co-investment</p>
Real Assets	<ul style="list-style-type: none"> <li>• Provide stable and predictable cash yield, diversification of equity risk, and some inflation protection</li> <li>• Returns predominately derived from stable income under long-term leases with good credit tenants</li> <li>• Real Estate targets Core, well-located assets with strong competitive positions and defensive characteristic.</li> <li>• Infrastructure targets essential, durable/long-lived assets and interests in portfolio companies</li> </ul>	<p>100% externally managed</p> <p>Majority in separate accounts</p>
Private Debt	<ul style="list-style-type: none"> <li>• Invests in privately negotiated, non-traded debt or debt-like instruments typically issued to companies</li> <li>• Attractive risk-adjusted return through premia driven by illiquidity and complexity of private loans</li> <li>• Complements Private Equity</li> </ul>	<p>Externally managed</p> <p>Mix of commingled fund, separate account, and co-investment</p>

Table 2 Asset classes

## Capital Market Assumptions

Capital Market Assumptions (CMAs) refer to the projected returns and risk related parameters (e.g., standard deviations, correlation coefficients) for various asset classes over a specified timeframe, typically the long-term. The CMA assumptions are critical inputs in strategic asset allocation processes, helping to guide investment decisions and portfolio construction.

Our CMAs are based on our quarterly survey of 15 CMA providers (See Appendix E), including institutional consultants and asset managers. We also have an internal CMA model we use to gain deeper insights into the survey results.

Our most recent survey of 20-year projected returns is presented in figure 4. The light blue box represents the range of responses for asset class returns, and the blue dot represents the median value of the responses for the asset class. The orange dot represents the median values used in the 2021 ALM analysis. The size of the blue boxes represents the diversity of surveyed expert opinion and are indicative of the uncertainty associated with return projections.

Projections for fixed income and private debt returns have increased, while projected private equity returns have decreased. These changes are attributed to the general increase in both short- and long-term rates, leading to increased bond returns. These same rate increases can lead to increased financing costs for private equity, reducing private equity returns.

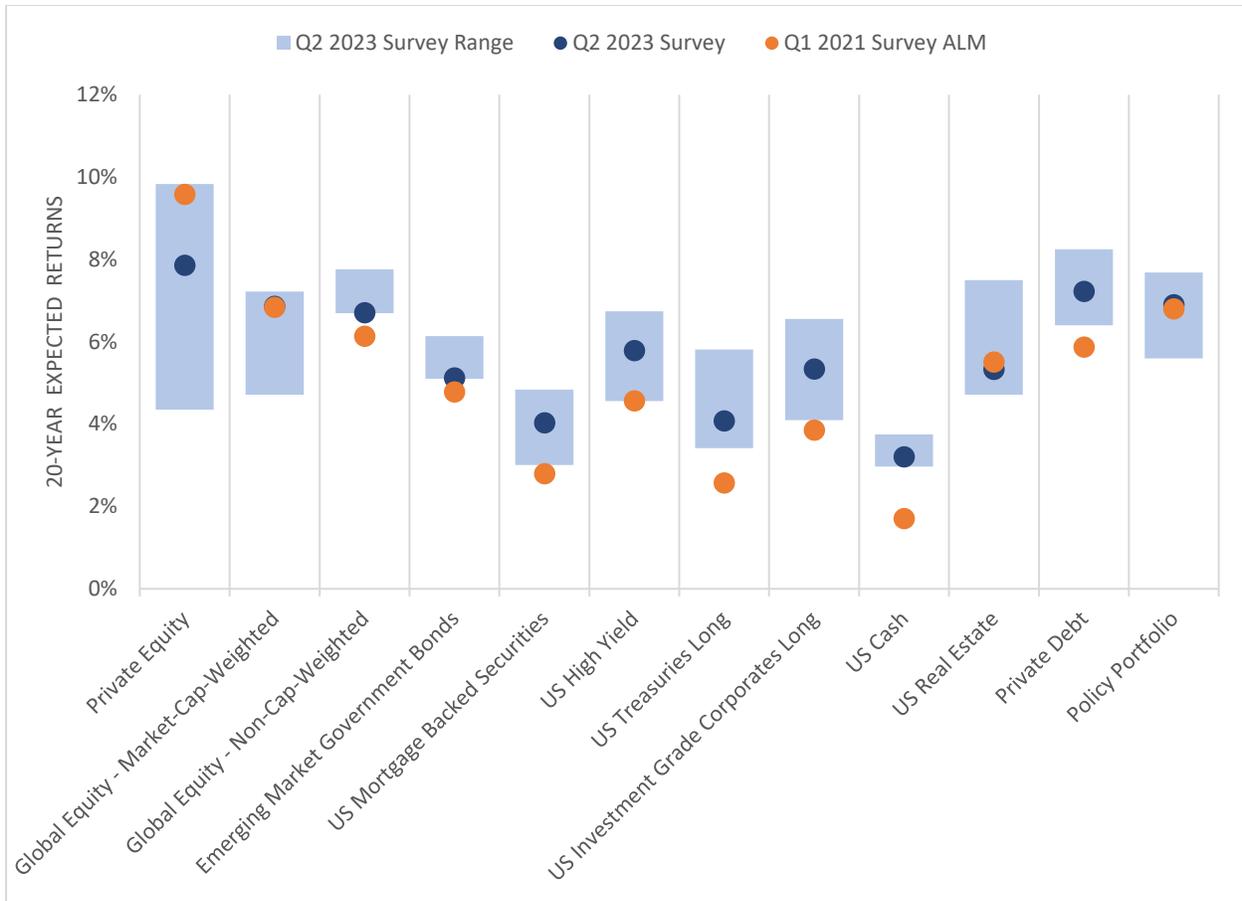


Figure 4. Expected Returns: 20-Year CMA Survey Estimates

## Portfolio Construction

Our construction of a good portfolio depends on the following:

- a) **Objective.** Having reasonable expectations of achieving the actuarial discount rate over the long-term. The portfolio will use risk efficiently and maintain an appropriate amount of liquidity.
- b) **Capital Market Assumptions.** Using the median returns of our CMA survey. We feel this choice is justified as we survey experts, and there is no reason to believe one expert is reliably better than the others. The median represents a typical value of expert opinion. We use additional capital market assumptions – forward looking and historic scenarios, stress tests, sensitivity analysis – to better understand the range of possible outcomes.
- c) **Constraints.** Imposing constraints on allocations to reflect capacity constraints (e.g., maintain a minimum level of liquidity), our finite capabilities to originate and manage assets, and the need to ease incrementally into new allocations (e.g. limit on strategic leverage).
- d) **Good judgment.** Good judgment is needed to ensure portfolios are practical. Optimal portfolios are a mathematical concept, and miniscule differences in assumptions can lead to large changes in asset allocations without materially changing total portfolio risk and return. Good judgment

can find 'good' portfolios that deliver the desired risk and return while avoiding unimpactful but significant allocation changes.

The studied SAA aligns with all these criteria.

## Portfolio Constraints

There are several reasons for imposing constraints on asset allocations (see also Appendix F).

First, CMAs change quarter to quarter and some of these changes, however small, can lead optimizers to generate significant changes in allocations without materially changing projected total portfolio risk and return. We temper these overreactions by first understanding the sensitivity of allocations to small changes, and then limiting these changes by imposing minimum and maximum constraints on asset allocations.

Second, market capacity for some assets is limited. In addition, private asset programs pace their commitments to avoid excessive concentrations in vintage years. In this case, we use constraints to ensure our allocation can be implemented in a reasonable period and remain consistent with our pacing.

And third, the Investment Office has finite capacity to originate and manage assets. We will align our allocations to available capabilities.

## Diversification

Portfolio diversification is an integral part of asset management and is a critical component of managing the overall risk of a portfolio. Diversification is a strategy designed to reduce risk by allocating investments across various financial instruments, industries, and geographic locations. By doing so investors can reduce the impact of any single investment's poor performance on the overall portfolio. Adding leverage can improve diversification (see leverage discussion).

Due to their low correlation to Global Equities and Treasury, other secondary asset classes (Credit and Private Market Assets) can provide additional diversification to the broad asset classes of Market Cap Weighted Equity and Treasury. Mortgages provide additional compensation for prepayment uncertainty.

Segment 2, while still an equity investment and moving closely with market-cap weighted equity, is constructed to have lower overall volatility and provides reduced drawdown risk in an equity market downturn. All these assets, although much of their value is derived from corporate risk and rate exposure, can provide diversification when included as assets in the overall portfolio.

Private assets offer additional economic diversification within their asset class. The valuation process for private assets introduces elements of smoothing and lagging, which means changes in their market values tend to be less abrupt compared to publicly traded assets. While these characteristics don't alter the fundamental economic properties or long-term return prospects of the assets, they do play a role in moderating short-term value fluctuations. As a result, portfolios that incorporate private assets can experience reduced volatility, providing a cushion against short-term market volatility and offering a more stable performance over time. This reduced asset volatility reduces contribution volatility.

The benefits of diversification can be studied by progressively adding new asset classes and leverage. In the following example, we start with a simple portfolio, then progressively add leverage and additional asset classes (Appendix G).

- A. Construct an optimal portfolio with three public asset classes: public equities, long treasuries, and cash.
- B. Making leverage available, along with the public equities, long treasuries and cash used to construct portfolio A.
- C. Making investment grade bonds available, along with the leverage, public equities, long treasuries, and cash used to construct portfolio B.
- D. Making private assets available, along with the investment grade bonds, leverage, public equities, long treasuries, and cash used to construct portfolio C and D.

To illustrate the benefits of diversification, each portfolio targets a return of 6.8% (the projected return of the current portfolio). CDaR declines as we add leverage, and then additional diversifying assets (figure 5). Note the portfolio consisting solely of equities and treasuries could not meet the target (Table 4). Such a simple portfolio, despite the return shortfall, has the highest CDaR – about 37%. The final result is a portfolio with substantially lower CDaR – around 16%.

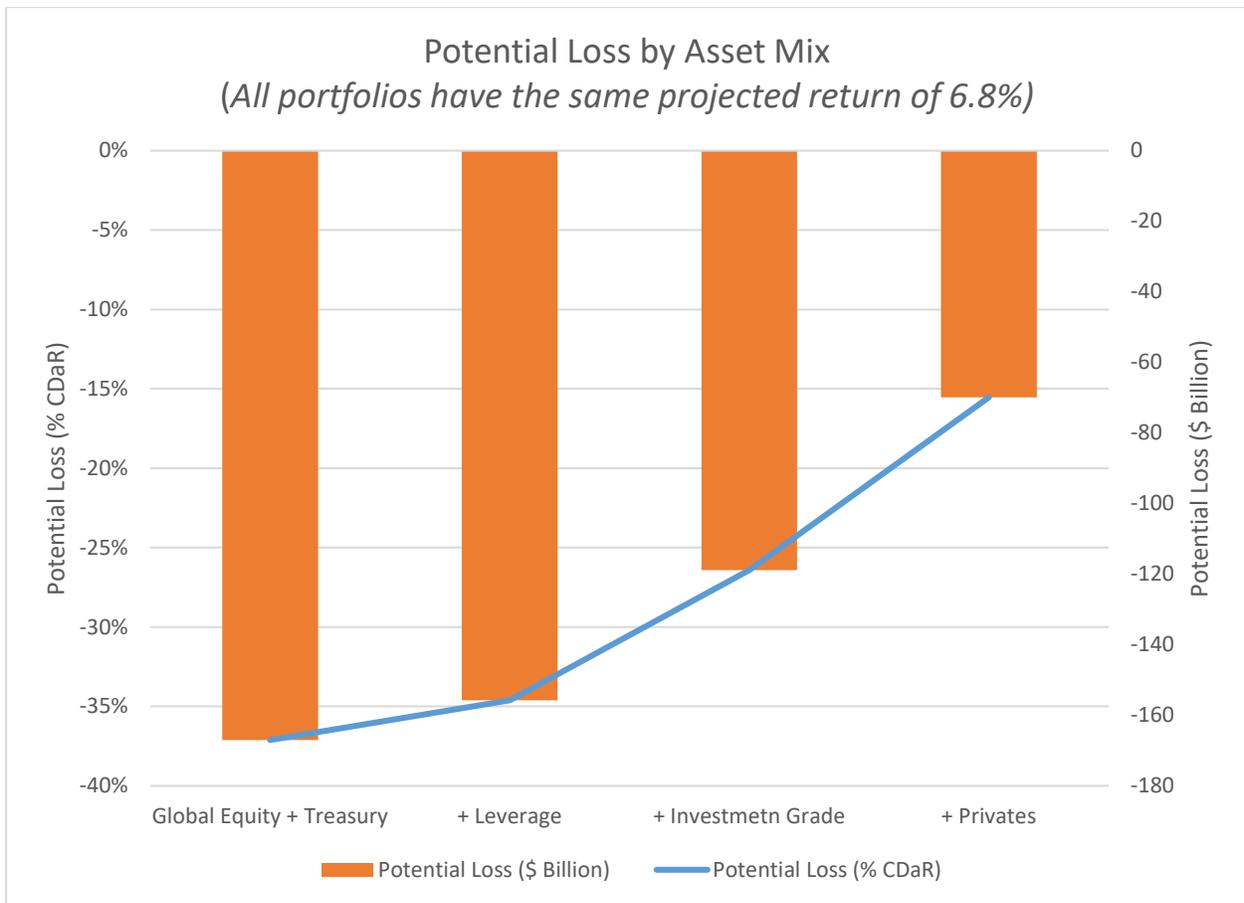


Figure 5. Incorporating additional assets beyond just the typical Equity and Treasury mix help create a well-diversified portfolio. As additional assets are included in the optimization, the required risk for given return targets decreases.

# Discussion

## Treasuries

In 2017, the low interest rates set by central banks limited the role of Treasuries as a diversifier to Equities. To address this issue, the Factor-weighted segment was incorporated. In 2021, the low-rate environment led us to reduce the Treasury allocation from 10% to 5%. At that time, we indicated the policy portfolio allocation would be reviewed when the rate environment changed. At that time Federal Reserve signaled a forthcoming rise in rates, suggesting that Treasuries would regain their diversification appeal. Consistent with these observations, rates have since increased, suggesting a potential adjustment in Treasury allocation for consideration. Our return survey reflected increased expected returns for all fixed income assets. Treasuries now provide a source of yield, while also providing liquidity and potential risk mitigation during a downturn.

## Non-Cap-Weighted Segment

The Non-Cap-Weighted segment was introduced into the Strategic Asset Allocation in 2017, against a backdrop where traditional diversifiers, such as US Treasuries, offered limited appeal due to low yields (below 2%). Simulated historical data showed that this segment offered lower drawdown risk compared to market-cap equities, while potentially yielding a premium above the beta-equivalent equity exposure.

In theory, the Non-Cap-Weighted Segment should have better risk-adjusted returns than the market cap segment. The segment has an average beta of around 0.7 and, because of its lower risk, could underperform the cap-weighted index over extended periods. The historic beta adjusted excess returns of the Non-Cap-Weighted segment have an Information Ratio (IR) of a 0.07. The realized outcomes, however, have a negative IR. Despite these realized outcomes, the potential for risk adjusted outperformance remains.

This segment aligns positively with the Quality factor, while having negative stances on Beta, Residual Volatility, and Growth. On a sectoral front, the segment favors Utilities, Health Care, and Consumer Staples, while leaning against IT, Financials, Energy, and Consumer Discretionary. Its current valuation metrics indicate a high likelihood of outperformance should a bear market materialize in the near term.

As mentioned, though the Non-Cap-Weighted segment offers potential drawdown protection in some scenarios, its performance has shown degradation when moving from in-sample testing to actual live records. Staff continue to develop means of improving total portfolio diversification. With the improved rate environment, there's a potential consideration for adjusting the allocation towards Treasuries and revisiting the allocation to the Non-Cap-Weighted segment. The overarching strategy should aim for balanced diversification, drawing on the strengths of different asset classes to enhance the portfolio's resilience and performance.

## Private Assets

Private markets offer a large investment opportunity set with the potential for value creation over a long-term horizon. Private assets also improve diversification relative to their public equivalents, reducing portfolio drawdown and volatility.

Our private asset target allocation can be increased without compromising on the portfolio's liquidity requirements. The private asset valuation processes, which involves smoothing and lagging, helps moderate short-term value fluctuations, leading to more stable portfolio performance over time.

Based on these observations, there's an inclination to consider a shift in asset allocation towards private assets.

## Leverage

Leverage, used judiciously, can further enhance the risk-return characteristics of a portfolio through exposure to a larger notional value of less risky assets, marginally reducing exposures to more risky assets. Employing leverage to reduce risk requires a comprehensive understanding of tail correlations and specific asset class nuances in adverse market scenarios.

## Liquidity

We approach liquidity management on two levels. First, Operational Liquidity, which generally covers time horizons of less than a year, is concerned with ensuring the PERF maintains enough cash on hand to meet its day-to-day obligations. These obligations include paying pensions, funding capital calls and other private asset deployments, meeting margin requirements on derivatives contracts, and managing public market trading activity. Effective operational liquidity management relies first and foremost on maintaining adequate short term cash balances to support obligations and provide a buffer for market stress events. It also requires an effective management and monitoring framework. CalPERS can finance excess cash balances as part of its overall funding activities, which means that for SAA purposes, an explicit allocation to cash is not required to support liquidity needs.

The second aspect of liquidity management entails longer horizon planning, spanning anywhere from one to 20+ years. For this process, the key concern is maintaining flexibility in the form of liquid public asset classes to support the future evolution of net pension flows, rebalancing to SAA targets, acquisition of private assets, and as collateral for shorter-term financing activities (including, e.g., maintaining adequate short term cash balances). Under the current allocations being contemplated, PERF is expected to still retain significant allocations to liquid, highly saleable public assets.

## Scenario Analysis

We use scenarios, stress tests, and sensitivity analyses to provide insights into the range of portfolio performance outcomes. Scenarios range from historical events to forward-looking speculation, including climate-based scenarios. Scenarios are a form of 'what-if' analysis. As such, they express our understanding of key relationships between a wide range of variables, including economic, climate,

geopolitical, and financial variables. Scenarios are used to prepare for possible outcomes and are not predictions.

The climate-based scenarios are perhaps the most speculative, with expert opinion on climate influence on our financial outcomes highly uncertain. The diverse range of expert opinions reflects this uncertainty, with estimates on financial outcomes ranging from marginal to transformational. With such a diverse range of opinions, quantifying the impact of climate change on a portfolio is challenging. CalPERS is working to keep abreast of this research. For the moment, we share results based on a commonly used model.

We use several scenarios (see Appendix I) to assess the sensitivity of long-term portfolio returns to changes in economic, geopolitical, and climate policy assumptions. The results presented correspond to the portfolio targeting the policy portfolio's CDaR. Also, we highlight the 20-year period returns of the portfolio targeting the policy portfolio's CDaR using red marks within the range of expert opinion survey returns.

- a) Stress tests provide estimates of extreme return outcomes, without necessarily being specific regarding causes.

Type	Scenario	Period Return
Historical	Oil Crisis (1974)	-26.1%
Historical	Equity Crash (Sep-Nov 2008)	-24.0%
Historical	GFC (Dec 07-Mar-09)	-42.8%
Forward	2 <sup>nd</sup> Decile of Base Case Scenario Generated 5-year returns	2.3%

- b) Economic scenarios, developed through Oxford Economics, evaluate the impact of long-term economic assumptions on the potential long-term returns of the portfolio.

Scenario	Inflation	GDP Growth	Expert Opinions Survey Return Range
Base Case	2.2%	1.8%	
Downside	2.0%	1.5%	
Upside	2.2%	1.9%	

- c) The Network for Greening the Financial System (NGFS) provides six climate scenarios to assess the forecasts of long-term global inflation and GDP growth.

Scenario	Inflation	GDP Growth	Expert Opinions Survey Return Range
Net Zero 2050	2.4%	1.7%	
Below 2°C	2.4%	1.7%	
Divergent Net Zero	2.7%	1.6%	
Delayed Transition	2.8%	1.4%	
NDCs	2.5%	1.6%	
Current Policy	2.4%	1.6%	

NGFS climate scenarios data sourced from the Network for Greening the Financial System (NGFS) Scenario Explorer, hosted by IIASA, scenario vintage 3.4 dated October 14, 2022. Modifications: No modifications made. For comprehensive data and updates, visit the NGFS Scenario Explorer: <https://data.ene.iiasa.ac.at/ngfs>. This work is under the NGFS Public License. More details on the license can be found at: <https://data.ene.iiasa.ac.at/ngfs/#/license>

## Implementation

We explored the implications for a potential transition path from the current portfolio to the suggested allocation.

# Appendix A. CalPERS Investment Beliefs

1. Liabilities must influence the asset structure
  - Ensuring the ability to pay promised benefits by maintaining an adequate funding status is the primary measure of success for CalPERS
  - CalPERS has a large and growing cash requirement and inflation-sensitive liabilities; assets that generate cash and hedge inflation should be an important part of the CalPERS investment strategy
  - CalPERS cares about both the income and appreciation components of total return
  - Concentrations of illiquid assets must be managed to ensure sufficient availability of cash to meet obligations to beneficiaries
2. A long time investment horizon is a responsibility and an advantage
  - Long-time horizon requires that CalPERS:
    - Consider the impact of its actions on future generations of members and taxpayers
    - Encourage investee companies and external managers to consider the long-term impact of their actions
    - Favor investment strategies that create long-term, sustainable value and recognize the critical importance of a strong and durable economy in the attainment of funding objectives
    - Advocate for public policies that promote fair, orderly and effectively regulated capital markets.
  - Long-time horizon enables CalPERS to:
    - Invest in illiquid assets, provided an appropriate premium is earned for illiquidity risk
    - Invest in opportunistic strategies, providing liquidity when the market is short of it
    - Take advantage of factors that materialize slowly such as demographic trends
    - Tolerate some volatility in asset values and returns, as long as sufficient liquidity is available
3. CalPERS investment decisions may reflect wider stakeholder views, provided they are consistent with its fiduciary duty to members and beneficiaries
  - As a public agency, CalPERS has many stakeholders who express opinions on investment strategy or ask CalPERS to engage on an issue. CalPERS preferred means of responding to issues raised by stakeholders is engagement
  - CalPERS primary stakeholders are members/beneficiaries, employers, and California taxpayers as these stakeholders bear the economic consequences of CalPERS investment decisions
  - In considering whether to engage on issues raised by stakeholders, CalPERS will use the following prioritization framework:
    - Principles and Policy - to what extent is the issue supported by CalPERS Investment Beliefs, Principles of Accountable Corporate Governance or other Investment Policy?
    - Materiality - does the issue have the potential for an impact on portfolio risk or return?

- Definition and Likelihood of Success - is success likely, in that CalPERS action will influence an outcome which can be measured? Can we partner with others to achieve success or would someone else be more suited to carry the issue?
  - Capacity - does CalPERS have the expertise, resources, and standing to influence an outcome?
- 4. Long-term value creation requires effective management of three forms of capital: financial, physical, and human
  - Governance is the primary tool to align interests between CalPERS and managers of its capital, including investee companies and external managers
  - Strong governance, along with effective management of environmental and human capital factors, increases in the likelihood that companies will perform over the long-term and manage risk effectively
  - CalPERS may engage investee companies and external managers on their governance and sustainability issues, including:
    - Governance practices, including but not limited to alignment of interests
    - Risk management practices
    - Human capital practices, including but not limited to fair labor practices, health and safety, responsible contracting and diversity
    - Environmental practices, including but not limited to climate change and natural resource availability
- 5. CalPERS must articulate its investment goals and performance measures and ensure clear accountability for their execution
  - A key success measure for the CalPERS investment program is delivery of the long-term target return for the fund
  - The long-term horizon of the fund poses challenges in aligning interests of the fund with staff and external managers
  - Staff can be measured on returns relative to an appropriate benchmark, but staff performance plans should include additional objectives or key performance indicators to align staff with the fund's long-term goals
  - Each asset class should have explicit alignment of interest principles for its external managers
- 6. Strategic asset allocation is the dominant determinant of portfolio risk and return
  - CalPERS strategic asset allocation process transforms the fund's required rate of return to the market exposures that staff will manage
  - CalPERS will aim to diversify its overall portfolio across distinct risk factors return drivers
  - CalPERS will seek to add value with disciplined, dynamic asset allocation processes, such as mean reversion. The processes must reflect CalPERS characteristics such as time horizon and size of assets
  - CalPERS will consider investment strategies if they have the potential to have a material impact on portfolio risk and return
- 7. CalPERS will take risk only where we have a strong belief we will be rewarded for it
  - An expectation of a return premium is required to take risk; CalPERS aims to maximize return for the risk taken
  - Markets are not perfectly efficient, but inefficiencies are difficult to exploit after costs
  - CalPERS will use index tracking strategies where we lack conviction or demonstrable evidence that we can add value through active management

- CalPERS should measure its investment performance relative to reference portfolio of public, passively managed assets to ensure that active risk is being compensated at the Total Fund level over the long-term
- 8. Costs matter and need to be effectively managed
  - CalPERS will balance risk, return and cost when choosing and evaluating investment managers and investment strategies
  - Transparency of the total costs to manage the CalPERS portfolio is required of CalPERS business partners and itself
  - Performance fee arrangements and incentive compensation plans should align the interests of the fund, staff, and external managers
  - CalPERS will seek to capture a larger share of economic returns by using our size to maximize our negotiating leverage. We will also seek to reduce cost, risk, and complexity related to manager selection and oversight
  - When deciding how to implement an investment strategy, CalPERS will implement in the most cost-effective manner
- 9. Risk to CalPERS is multi-faceted and not fully captured through measures such as volatility or tracking error
  - CalPERS shall develop a broad set of investment and actuarial risk measures and clear processes for managing risk
  - The path of returns matters, because highly volatile returns can have unexpected impacts on contribution rates and funding status
  - As a long-term investor, CalPERS must consider risk factors, for example climate change and natural resource availability, that emerge slowly over long time periods, but could have a material impact on company or portfolio returns.
- 10. Strong processes and teamwork and deep resources are needed to achieve CalPERS goals and objectives
  - Diversity of talent (including a broad range of education, experience, perspectives, and skills) at all levels (board, staff, external managers, corporate boards) is important
  - CalPERS must consider the government agency constraints under which it operates (e.g., compensation, civil service rules, contracting, transparency) when choosing its strategic asset allocation and investment strategies
  - CalPERS will be best positioned for success if it:
    - Has strong governance
    - Operates with effective, clear processes
    - Focuses resources on highest value activities
    - Aligns interests through well designed compensation structures
    - Employs professionals who have intellectual rigor, deep domain knowledge, a broad range of experience, and a commitment to implement CalPERS Investment Belief

# Appendix B. Constitution of California, Article XVI, Section 17

The State shall not in any manner loan its credit, nor shall it subscribe to, or be interested in the stock of any company, association, or corporation, except that the State and each political subdivision, district, municipality, and public agency thereof is hereby authorized to acquire and hold shares of the capital stock of any mutual water company or corporation when the stock is so acquired or held for the purpose of furnishing a supply of water for public, municipal or governmental purposes; and the holding of the stock shall entitle the holder thereof to all of the rights, powers and privileges, and shall subject the holder to the obligations and liabilities conferred or imposed by law upon other holders of stock in the mutual water company or corporation in which the stock is so held.

Notwithstanding any other provisions of law or this Constitution to the contrary, the retirement board of a public pension or retirement system shall have plenary authority and fiduciary responsibility for investment of moneys and administration of the system, subject to all of the following:

(a)The retirement board of a public pension or retirement system shall have the sole and exclusive fiduciary responsibility over the assets of the public pension or retirement system. The retirement board shall also have sole and exclusive responsibility to administer the system in a manner that will assure prompt delivery of benefits and related services to the participants and their beneficiaries. The assets of a public pension or retirement system are trust funds and shall be held for the exclusive purposes of providing benefits to participants in the pension or retirement system and their beneficiaries and defraying reasonable expenses of administering the system.

(b)The members of the retirement board of a public pension or retirement system shall discharge their duties with respect to the system solely in the interest of, and for the exclusive purposes of providing benefits to, participants and their beneficiaries, minimizing employer contributions thereto, and defraying reasonable expenses of administering the system. A retirement board's duty to its participants and their beneficiaries shall take precedence over any other duty.

(c)The members of the retirement board of a public pension or retirement system shall discharge their duties with respect to the system with the care, skill, prudence, and diligence under the circumstances then prevailing that a prudent person acting in alike capacity and familiar with these matters would use in the conduct of an enterprise of a like character and with like aims.

(d)The members of the retirement board of a public pension or retirement system shall diversify the investments of the system so as to minimize the risk of loss and to maximize the rate of return, unless under the circumstances it is clearly not prudent to do so.

(e)The retirement board of a public pension or retirement system, consistent with the exclusive fiduciary responsibilities vested in it, shall have the sole and exclusive power to provide for actuarial services in order to assure the competency of the assets of the public pension or retirement system.

(f)With regard to the retirement board of a public pension or retirement system which includes in its composition elected employee members, the number, terms, and method of selection or removal of members of the retirement board which were required by law or otherwise in effect on July 1, 1991, shall not be changed, amended, or modified by the Legislature unless the change, amendment, or modification enacted by the Legislature is ratified by a majority vote of the electors of the jurisdiction in which the participants of the system are or were, prior to retirement, employed.

(g)The Legislature may by statute continue to prohibit certain investments by a retirement board where it is in the public interest to do so, and provided that the prohibition satisfies the standards of fiduciary care and loyalty required of a retirement board pursuant to this section.

(h)As used in this section, the term "retirement board" shall mean the board of administration, board of trustees, board of directors, or other governing body or board of a public employees' pension or retirement system; provided, however, that the term "retirement board" shall not be interpreted to mean or include a governing body or board created after July 1, 1991 which does not administer pension or retirement benefits, or the elected legislative body of a jurisdiction which employs participants in a public employees' pension or retirement system.

(Sec. 17 amended Nov. 3, 1992, by Prop. 162. Initiative measure.)

# Appendix C. Conditional Drawdown Risk Measure

Conditional Drawdown is the average of possible 'large' losses that could occur during a three-year period (the total of the red and yellow areas in the figure). We define 'large losses' to be the average of the worst ten percent of all losses (the average of the losses in the red area).

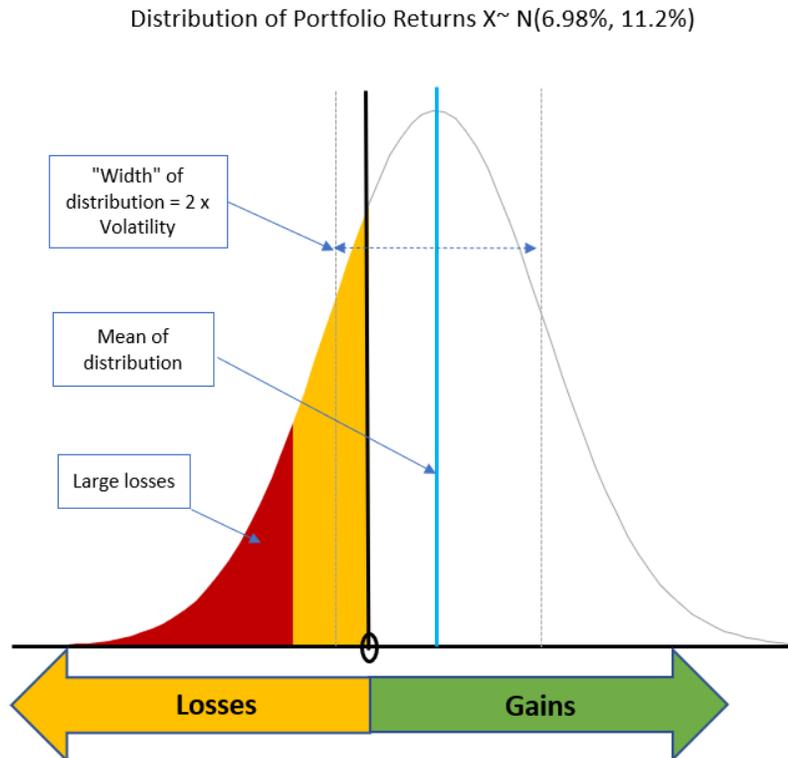


Figure 6. Drawdown as a risk measure

Risk of loss is measured as a tail outcome. In the 2021 ALM, we adopted CDaR as our measure of risk of loss.

Drawdown is defined as maximum loss that could occur during a three-year period. CDaR is calculated using simulations of asset and portfolio returns. We use 5,000 paths of annual returns for 20 years. Each path has 18 possible three-year periods, giving us a total of 90,000 estimates of returns over three years. These results are used to estimate the distribution of all 3-year-max drawdowns. We use this distribution of losses to estimate our average of the worst 10 percent (bottom decile) of all losses.

# Appendix D. Asset Classes

## Public Equity

The role of Public Equity is to efficiently capture the equity risk premia. Total expected return comprises of both price appreciation and cash yield. Underlying investments are publicly listed and traded, thus provide a reliable source of liquidity. The two segments within Public Equity are the broad-based market-cap-weighted segment and factor-weighted segment. Introduced in 2017 during a low-rate environment when Treasuries was expected to have limited ability to diversify downturn risk, factor-weighted is intended to reduce overall volatility and provide some diversification.

CalPERS currently manages about 94% of PERF public equity internally. We expect this number will decline as we increase our allocation to external value adding active strategies. The increased costs associated with external managers are expected to be more than offset by the external managers' value adding strategies.

## Fixed Income

The role of Fixed Income is to serve as a long-term economic diversifier to equity risk and reliable source of income and liquidity. This asset class is consisted of multiple segments: Long Treasuries, MBS, Investment Grade Corporates, High Yield, and Emerging Market Debt. Each segment has different risk and return characteristics and varies on liquidity, income, and diversification benefits. Fixed Income is predominately invested in cost-efficient and internally managed strategies.

CalPERS currently manages about 78% of PERF fixed income internally, consisting mostly of treasuries, investment grade, and agency mortgage-backed securities. High yield and significant parts of the emerging market sovereign are managed externally. Again, the increased costs associated with external managers are expected to be more than offset by the external managers' value adding strategies.

## Private Equity

The role of Private Equity is to enhance equity returns through an active, value-added approach. It seeks active equity exposure to private companies to generate returns greater than public equity. The major driver of returns is appreciation, aided by leverage, with negligible cash yield. The underlying investments are diversified across investment type, industry segment, investment strategy, geography, vintage year, and underlying portfolio companies.

There are three generic implementation strategies for private equity: fund of funds, funds, and internal. In a paper published in 2020 in the Journal of Investing, CEM, a third party specializing in benchmarking pension funds, found internal implementations (which includes co-investments) historically outperformed funds by 2.13%, and outperformed fund of funds by 3.71% for the periods from 1996 to 2018. These return differences are driven by differences in fee structures. CalPERS private equity strategy is focused on increasing value-add through increased exposures to co-investments.

## Real Assets

The role of Real Assets is to provide stable and predictable cash yield, diversification of equity risk, and inflation protection. Investment returns are predominately derived from stable income under long-term leases with good credit tenants. Real Assets invest in real estate and infrastructure assets. Real Estate targets Core, well-located assets with strong competitive positions and defensive characteristics. Infrastructure targets essential, durable/long-lived assets and interests in portfolio companies.

A separate account is a unique arrangement where a single investor contributes the majority of the necessary equity capital to achieve a specific investment objective. This differs from joint ventures or partnerships, which involve multiple equity stakeholders. The benefits of separate accounts include a better alignment of investors' and managers' interests, enhanced control for investors over their investments, and reduced costs.

A commingled fund, on the other hand, is an investment vehicle that amalgamates capital from multiple investors, typically institutional ones. These funds are often utilized by institutional investors to gain exposure to a diversified portfolio of real assets managed by investment managers. Investors have very limited control over these investments. Direct investment in real assets refers to an investment made directly into a specific asset or business by an entity. Co-investment occurs when several investors pool their resources to jointly invest in a specific opportunity that is generally an offshoot from an existing commingled fund.

At present, most Real Assets investments are held in separate accounts. This is followed by commingled funds, direct investments, and co-investments.

## Private Debt

The role of Private Debt is to provide diversification to the Total Fund while seeking to add value over equivalent public debt markets through exposure to risks including illiquidity and leverage as well as terms and characteristics available through private transactions. It invests in privately negotiated, non-traded debt or debt-like instruments typically issued to companies. Private Debt complements Private Equity and offers attractive risk-adjusted return through premia driven by illiquidity and complexity of private loans.

Private Debt exposures are implemented using external managers and obtained held in a mix of investment structures including commingled fund, separate account, and co-investment.

## Appendix E. Quarterly CMA Survey

Assets	Q2 2023 Survey		# of Providers	
	5-Year Geometric Return	20-Year Geometric Return	5-Year Geometric Return	20-Year Geometric Return
Private Equity	7.71%	7.86%	7	7
Public Equity Market-Cap-Weighted	6.32%	6.86%	9	7
Public Equity Non-Cap-Weighted	6.50%	6.71%	5	4
Emerging Market Sovereign Bonds	7.00%	5.12%	5	3
US Mortgage-backed Securities	4.41%	4.03%	5	6
US High Yield	5.50%	5.79%	9	8
Treasuries Long	3.72%	4.08%	6	6
US Investment Grade Corporates Long	5.41%	5.34%	6	6
U.S. Cash	3.95%	3.21%	8	6
Real Assets	6.83%	5.33%	6	6
Private Debt	8.40%	7.23%	5	5

## Appendix F. Constraints

Constraints are the “Inconvenient truth in Strategic Asset Allocation”. Building and choosing a policy portfolio is not a straight-forward mathematical optimization problem that leads to a precise solution. The issue was recognized by British statistician George Box proclaiming in 1976: “All models are wrong, some are useful.” Staff aims to make these models more “useful”.

The model is unable to identify the whole spectra of inter-connected issues associated with portfolio construction, such as market capacity. The challenges associated with forecasting twenty year expected returns mandates a process that is both “art” and “science”. Asset class constraints ensure a sensible portfolio construction.

Maximum weight constraints are determined by market capacity, internal resources, and risk considerations while minimums are a function of current holdings that are deemed to be illiquid assets (E.g., private equity, real estate) or are identified as desirable to maintain current internal expertise and/or valuable external relationships.

Additional considerations regarding a lower bound for asset class weight include:

1. Potential and aspiration to develop asset class expertise
2. Create Total Fund liquidity (E.g., Treasuries, Mortgage-Backed Securities)
3. Ensure operational efficiency

## Appendix G. Diversification

The effect of diversification is studied by adding asset classes and leverage in a progressive way. The constraints used in the portfolio optimization for asset classes are listed in the table below. We set all constraints to be between 0% and 100% so that constraints won't be driving forces of optimal portfolios. However, there is one exception: we set 40% upper limits for total private assets to maintain a reasonable liquidity profile for the Total Fund. Because the optimizer requires finite leverage, we set the upper limit of leverage to be 100% even though we use the term of "unlimited" leverage.

<b>Asset Class</b>	<b>Min</b>	<b>max</b>
Public Equity Market-Cap-Weighted	0.0%	100.0%
Private Equity	0.0%	100.0%
Treasuries Long	0.0%	100.0%
US Investment Grade Corporates Long	0.0%	100.0%
Real Asset / Real Estate	0.0%	100.0%
Private Debt	0.0%	100.0%
Leverage	0.0%	100.0%
Infrastructure	0.0%	100.0%
Private Assets	0.0%	40.0%

*Table 3 Asset Constraints Used in the Analysis of Diversification*

We minimize the CDaR, while setting a target for expected returns at 6.86%, which aligns with the returns of the Policy Portfolio, based on recent capital market assumptions. The resulted optimal portfolios are as follows:

Asset	Policy	A: CapWt + Tsy	B: CapWt + Tsy + Unlimited Leverage	C: CapWt + Tsy + IG + Unlimited Leverage	D: CapWt + Tsy + IG + Unlimited Leverage + Private Assets (≤40%)
Public Equity Market-Cap-Weighted	30.0%	100.0%	89.0%	50.0%	18.0%
Public Equity Non-Cap-Weighted	12.0%				
Private Equity	13.0%	0.0%	0.0%	0.0%	5.0%
Treasuries Long	5.0%		48.0%		
US Mortgage-backed Securities	5.0%	0.0%	0.0%	0.0%	0.0%
US Investment Grade Corporates Long	10.0%			87.0%	49.0%
US High Yield	5.0%	0.0%	0.0%	0.0%	0.0%
Emerging Market Sovereign Bonds	5.0%				
Private Debt	5.0%	0.0%	0.0%	0.0%	25.0%
Real Assets / Real Estate	15.0%				
Infrastructure	0.0%	0.0%	0.0%	0.0%	10.0%
Leverage	5.0%		37.0%	37.0%	7.0%
Geometric Return	6.86%	6.76%	6.85%	6.85%	6.88%
CDaR	21.46%	37.11%	34.61%	26.42%	15.53%
Volatility	11.15%	16.76%	16.38%	13.39%	9.23%
Duration	2.59	0.00	6.25	9.56	5.42

Table 4 Optimal portfolios targeting 6.86% expected return

From the table above, we can observe that Portfolio B, which incorporates leverage into Portfolio A, effectively reduces risk. Thus, the introduction of leverage serves to diversify Portfolio A. Private assets play a significant role in risk reduction, specifically in terms of CDaR and volatility, while maintaining the same level of expected returns, as demonstrated by Portfolio D.

This analysis further highlights that the benefits of diversification are contingent upon the risk and return profiles of the new asset classes under consideration for inclusion in the existing portfolio. This principle extends to leverage as well, given that leveraging essentially involves short-selling risk-free assets. However, it's noteworthy that private assets consistently offer diversification benefits to the existing portfolio, as evidenced by our analysis.

## Appendix H. Additional Studied Portfolios

The team has studied two distinct alternative portfolios. The first portfolio is constructed by minimizing CDaR while targeting an expected return of 6.8% that is the current discount rate. The total allocation to private assets is capped at 40%. As illustrated in the table below, this portfolio has a lower allocation to

public equity and a higher allocation to bonds and private assets compared to the Policy portfolio. Both CDaR and volatility risks are reduced in this portfolio.

The second portfolio is constructed by maximizing returns while maintaining the same expected CDaR as the Policy portfolio. The allocation to private assets remains unchanged from the Policy portfolio due to the typically lengthy transaction times associated with these assets. This portfolio generates a similar expected return. When compared to the Policy portfolio, the asset class weights are also similar.

Asset Class	Policy Portfolio	Total Privates <= 40%		Unchanged Private Asset Weight	
		Target Return: 6.80%		Target CDaR: 21.46%	
		Portfolio	v.s. Policy	Portfolio	v.s. Policy
Public Equity	42.0%	31.0%	-11.0%	42.0%	0.0%
Private Equity	13.0%	10.0%	-3.0%	13.0%	0.0%
Fixed Income	30.0%	34.0%	4.0%	30.0%	0.0%
Private Debt	5.0%	8.0%	3.0%	5.0%	0.0%
Real Assets	15.0%	15.0%	0.0%	15.0%	0.0%
Leverage	-5.0%	-5.0%	0.0%	-5.0%	0.0%
Geo Return	6.9%	6.8%	0.0%	6.8%	0.0%
CDaR	21.5%	19.5%	-2.0%	21.4%	-0.1%
Volatility	11.2%	10.6%	-0.6%	11.2%	0.0%

Table 5 Additional Studied Portfolios

## Appendix I. Scenario Analysis

### Historical Scenarios

Historical market events provide opportunities to stress test the SAA and run a sensitivity analysis at the asset class level. To accomplish this, we utilize Blackrock Aladdin’s Broad Factor Multi-Asset Class risk model and current portfolio holdings to ascertain what *would have been* the performance, giving us insights into what *may* happen during a future event.

Using three historical scenarios: Oil Crisis in 1974, Equity market crash in the fall of 2008, and the Great Financial Crisis, Blackrock’s factor model calculates portfolio returns. Below is the asset class performance attribution.

Market	Policy Portfolio			Targeting Policy CDaR Portfolio		
	Oil Crisis 1974	Equity Crash Sep - Nov 08	Great Recession Dec 07 - Mar 09	Oil Crisis 1974	Equity Crash Sep - Nov 08	Great Recession Dec 07 - Mar 09
Public Equity Market-Cap-Weighted	-9.9%	-7.9%	-18.0%	-8.9%	-7.1%	-16.2%
Public Equity Non- Cap-Weighted	-2.7%	-2.1%	-4.6%	-2.2%	-1.8%	-3.9%
Private Equity	-5.7%	-5.7%	-10.5%	-7.5%	-7.4%	-13.7%
Treasuries Long	-0.3%	-0.1%	0.4%	-0.4%	-0.2%	0.6%
US Mortgage-backed Securities	-0.2%	-0.3%	0.1%	-0.2%	-0.3%	0.1%
US Investment Grade Corporates Long	-2.3%	-2.7%	-2.8%	-1.4%	-1.6%	-1.7%
US High Yield	-0.7%	-1.0%	-1.7%	-0.7%	-1.0%	-1.7%
Emerging Market Sovereign Bonds	-0.4%	-1.3%	-0.6%	-0.4%	-1.3%	-0.6%
Private Debt	-0.4%	-1.0%	-1.7%	-0.7%	-1.7%	-2.8%
Real Assets	-3.5%	-1.9%	-3.3%	-3.5%	-1.9%	-3.3%
Leverage	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Portfolio</b>	<b>-26.1%</b>	<b>-24.0%</b>	<b>-42.8%</b>	<b>-25.9%</b>	<b>-24.2%</b>	<b>-43.2%</b>

Table 6 Blackrock Aladdin Portfolio Factor Risk Model

## Tail Results of Base Case

Looking forward we can model potential portfolio returns with Moody’s Scenario Generator (SG). SG generates 5000 pathways of twenty-year returns using asset class weights and current Capital Market Assumptions (expected return, volatility, and correlation).

Focusing on the 80<sup>th</sup> to 90<sup>th</sup> and 10<sup>th</sup> to 20<sup>th</sup> percentile model generated scenarios, we can gain an understanding of potential portfolio returns in upside and downside market environments. Below we show the portfolio’s simulated 5-year compounded annual growth rate, and asset class attribution for both scenarios compared with the expected performance. The results presented relate to the portfolio targeting the policy portfolio's CDaR.

<b>Asset Class</b>	<b>Expected</b>	<b>Upside</b>	<b>Downside</b>
Public Equity Market-Cap-Weighted	6.3%	12.9%	-0.5%
Public Equity Non- Cap-Weighted	6.5%	11.5%	1.3%
Private Equity	7.7%	16.7%	-0.8%
Treasuries Long	3.7%	4.4%	2.9%
US Mortgage-backed Securities	4.4%	4.6%	4.2%
US Investment Grade Corporates Long	5.4%	6.3%	4.3%
US High Yield	5.5%	6.5%	4.2%
Emerging Market Sovereign Bonds	7.0%	7.8%	5.7%
Private Debt	8.4%	10.7%	6.0%
Real Assets	6.8%	10.8%	3.3%
Liquidity	4.0%	4.0%	3.9%
<b>Targeting Policy CDaR Portfolio</b>	<b>7.0%</b>	<b>11.7%</b>	<b>2.3%</b>
<b>Policy Portfolio</b>	<b>6.9%</b>	<b>11.5%</b>	<b>2.2%</b>

*Table 7 Moody's Economic Scenario Generator 5 Year Geometric Returns*

## Economic Scenarios

### Base Case

US and global real economic activity is projected to suffer a small deterioration. Real economic activity in the US falls for three consecutive quarters (qoq saar) but the size of these declines is small. Consequently, annual GDP dips into negative territory in Q2 2024. The March 2023 banking crisis, supported by the liquidity provided by the FDIC/Treasury/Fed eliminates bank failures at GSIBs, but latent credit tightening and higher interest rates weigh on growth. In the base case we leave the Fed's reaction function to run unhindered (there are no set assumptions on the Fed's rate path). The mechanical model output suggests, from June 2023, the Fed needs to raise rates an additional 50bps to keep inflation contained.

### Downside

A more notable recession in the US in 2024, driven by weaker household finances as inflation only slowly reverts to its 2% target, while tighter credit conditions and a higher cost of capital restrains borrowing. Growth assets and credit perform poorly, with the expectations adjustment resulting in a particularly weak equity return over the five-year horizon (-27% price return peak to trough). In this scenario, bonds and duration outperforms, as the Fed eases monetary policy rapidly in 2024 and into 2025.

### Upside

The major economies (US, Japan, Eurozone, and the United Kingdom) avoid a recession. Global growth is projected to trough at 1.8% yoy (1ppt below 1980-2019 average) before rising again as central banks reduce interest rates. Households are deemed the driver of both the economic slowdown (the pandemic fiscal boost to incomes has passed and real incomes are lower) and

the recovery (householders' burdens lift as interest rates fall). A gradual rebalancing of the labor market is assumed to keep unemployment low – a key contributor to real private consumption strength. The Federal Reserve keeps rates unchanged, compared to the base case scenario.

In this scenario, the equity market retracement is shallow (-7%) and short-lived. Credit spreads widen modestly.

## Climate Scenarios

The objective of climate scenarios analysis is to assess the Capital Market Assumptions (CMAs) across asset classes and portfolio implications under forward-looking climate scenarios.

The Network for Greening the Financial System (NGFS) climate scenarios provide a common reference framework for examining the effects of climate change and policy.

The NGFS has defined six climate scenarios, including Orderly, Disorderly, and Hot House World scenarios. The Orderly scenarios involve early, increasing climate policies with minimal risks, while the Disorderly scenarios have delayed, inconsistent policies, and higher carbon prices. The Hot house world scenarios see limited policies and irreversible warming effects, resulting in severe physical risk, such as sea-level rise.

The level of physical and transition risk in each climate scenario is determined by five key features that play a crucial role in assessing the Capital Market Assumptions (CMAs) and portfolio implications.

- The overall level of policy ambition determines the climate outcome, which sets the direction of climate policies.
- The timing of policy action is essential because delayed policy action will require stronger and more abrupt measures to achieve the same policy ambition.
- The pace of technological change is a significant determinant of the level of physical and transition risk. The faster the technological change, the quicker and more cost-effective the transition will be.
- The deployment of carbon dioxide removal technologies can reduce the net cost of emissions. However, its practical feasibility is far from clear, and therefore the scenarios have kept it lower, with slightly more leeway in the Orderly scenarios.
- The extent of policy coordination is crucial because a globally coordinated response will be economically more efficient than a fragmented one.

A scenario that needs to be considered is one where the world fails to make a meaningful reduction in emissions of greenhouse gasses into the atmosphere. In that case, the prospects of geoengineering or even just adaptation become more likely. Geoengineering solutions such as the injection of sulfate aerosols into the upper atmosphere or even buffering the ocean become more likely if plans to decarbonize the energy grid do not come to fruition. An example of adaptation would be the relocation of crop-growing regions to more northern latitudes. Finally, we need to consider the prospect of new technologies to produce energy that are competitive with current energy production technologies and their impact on the CMAs.

We gain insights into climate scenario analysis using our internal CMA models. Based on the findings, it seems that adopting more aggressive de-carbonization strategies such as Divergent Net Zero and Net Zero 2050 can lead to higher mid-term and long-term Public Equity and Real Asset CMAs, mainly due to anticipated higher inflation rates. Additionally, the analysis reveals that long-term fixed-income and private debt CMAs are generally higher than baseline CMAs under most climate scenarios. However, mid-term fixed-income CMAs are either similar to or lower than baseline CMAs. These findings emphasize the significance of considering climate scenarios in the CMA modeling to make informed investment decisions that align with sustainability goals.

Below we further elaborate on the details of the internal climate scenario CMAs vs. Baseline as of Q2 2023.

Mid-term CMA Climate vs Baseline	CE Baseline	Net Zero 2050		Below 2°C		Divergent Net Zero		Delayed Transition		NDCs		Current Policy	
	Mid-term Return	Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta
U.S. Cash	4.0%	4.4%	<b>0.4%</b>	4.2%	<b>0.2%</b>	5.3%	<b>1.3%</b>	4.0%	0.0%	4.1%	<b>0.1%</b>	4.0%	0.0%
Treasuries Long	4.9%	3.5%	<b>-1.4%</b>	4.1%	<b>-0.9%</b>	-0.6%	<b>-5.5%</b>	4.9%	0.0%	4.3%	<b>-0.6%</b>	4.9%	0.0%
Emerging Market Sovereign Bonds	7.2%	6.5%	<b>-0.7%</b>	6.8%	<b>-0.4%</b>	4.7%	<b>-2.5%</b>	7.2%	0.0%	6.9%	<b>-0.3%</b>	7.2%	0.0%
US Mortgage-backed Securities	4.2%	4.5%	<b>0.3%</b>	4.4%	<b>0.2%</b>	3.9%	<b>-0.3%</b>	4.2%	0.0%	4.4%	<b>0.2%</b>	4.2%	0.0%
US High Yield	6.5%	6.2%	<b>-0.3%</b>	6.4%	<b>-0.1%</b>	5.8%	<b>-0.7%</b>	6.5%	0.0%	6.4%	<b>-0.1%</b>	6.5%	0.0%
US Investment Grade Corporates Long	6.2%	5.0%	<b>-1.2%</b>	5.5%	<b>-0.7%</b>	1.8%	<b>-4.4%</b>	6.2%	0.0%	5.7%	<b>-0.5%</b>	6.2%	0.0%
Private Debt	8.9%	8.6%	<b>-0.3%</b>	8.8%	0.0%	8.9%	0.0%	8.9%	0.0%	8.9%	0.0%	8.8%	0.0%

Table 8. 5-Year Internal Fixed Income climate scenario CMAs vs. Baseline

Long-term CMA Climate vs Baseline	CE Baseline	Net Zero 2050		Below 2°C		Divergent Net Zero		Delayed Transition		NDCs		Current Policy	
	Long-term Return	Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta
U.S. Cash	3.0%	3.7%	<b>0.7%</b>	3.3%	<b>0.3%</b>	5.2%	<b>2.2%</b>	3.1%	<b>0.1%</b>	3.2%	<b>0.2%</b>	3.0%	0.0%
Treasuries Long	4.0%	4.2%	<b>0.2%</b>	4.1%	<b>0.1%</b>	4.4%	<b>0.4%</b>	3.6%	<b>-0.3%</b>	4.1%	<b>0.1%</b>	4.0%	0.0%
Emerging Market Sovereign Bonds	6.1%	6.5%	<b>0.4%</b>	6.4%	<b>0.3%</b>	7.3%	<b>1.1%</b>	6.4%	<b>0.3%</b>	6.3%	<b>0.2%</b>	6.2%	0.0%
US Mortgage-backed Securities	3.8%	4.3%	<b>0.5%</b>	4.2%	<b>0.4%</b>	5.4%	<b>1.6%</b>	4.5%	<b>0.7%</b>	4.0%	<b>0.2%</b>	3.8%	0.0%
US High Yield	5.5%	5.9%	<b>0.4%</b>	5.7%	<b>0.3%</b>	7.0%	<b>1.5%</b>	5.8%	<b>0.4%</b>	5.6%	<b>0.1%</b>	5.4%	0.0%
US Investment Grade Corporates Long	5.4%	5.6%	<b>0.2%</b>	5.5%	<b>0.1%</b>	6.0%	<b>0.6%</b>	5.3%	<b>-0.1%</b>	5.5%	<b>0.1%</b>	5.4%	0.0%
Private Debt	7.3%	7.9%	<b>0.5%</b>	7.6%	<b>0.2%</b>	9.2%	<b>1.9%</b>	7.5%	<b>0.2%</b>	7.5%	<b>0.2%</b>	7.3%	0.0%

Table 9. 20-Year Internal Fixed Income climate scenario CMAs vs. Baseline

Mid-term CMA Climate vs Baseline	CE Baseline	Net Zero 2050		Below 2°C		Divergent Net Zero		Delayed Transition		NDCs		Current Policy	
		Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta	Mid-term Return	Delta
Real Assets	5.6%	6.6%	<b>1.0%</b>	6.1%	<b>0.4%</b>	8.0%	<b>2.4%</b>	5.7%	<b>0.1%</b>	6.0%	<b>0.4%</b>	5.7%	<b>0.1%</b>
Public Equity Market-Cap-Weighted	7.4%	7.6%	<b>0.2%</b>	7.5%	<b>0.1%</b>	8.3%	<b>1.0%</b>	7.3%	<b>-0.1%</b>	7.4%	0.0%	7.3%	<b>-0.1%</b>
Public Equity Non-Cap-Weighted	7.2%	7.5%	<b>0.3%</b>	7.3%	<b>0.1%</b>	8.3%	<b>1.1%</b>	7.1%	0.0%	7.2%	0.0%	7.1%	<b>-0.1%</b>
Private Equity	8.2%	8.4%	<b>0.2%</b>	8.3%	<b>0.1%</b>	8.7%	<b>0.5%</b>	8.2%	<b>-0.1%</b>	8.2%	0.0%	8.2%	<b>-0.1%</b>

Table 10. 5-Year Internal Non-Fixed Income climate scenario CMAs vs. Baseline

Long-term CMA Climate vs Baseline	CE Baseline	Net Zero 2050		Below 2°C		Divergent Net Zero		Delayed Transition		NDCs		Current Policy	
		Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta	Long-term Return	Delta
Real Assets	5.3%	5.4%	<b>0.1%</b>	5.4%	<b>0.1%</b>	5.9%	<b>0.7%</b>	6.1%	<b>0.9%</b>	5.5%	<b>0.3%</b>	5.4%	<b>0.1%</b>
Public Equity Market-Cap-Weighted	7.1%	7.1%	0.0%	7.1%	0.0%	7.3%	<b>0.2%</b>	7.3%	<b>0.2%</b>	7.1%	0.0%	7.0%	<b>-0.1%</b>
Public Equity Non-Cap-Weighted	6.6%	6.9%	<b>0.3%</b>	6.8%	<b>0.2%</b>	7.5%	<b>0.9%</b>	6.8%	<b>0.2%</b>	6.7%	<b>0.1%</b>	6.6%	0.0%
Private Equity	8.1%	8.1%	0.0%	8.1%	0.0%	8.2%	<b>0.1%</b>	8.2%	<b>0.1%</b>	8.1%	<b>-0.1%</b>	8.1%	<b>-0.1%</b>

Table 11. 20-Year Internal Non-Fixed Income climate scenario CMAs vs. Baseline

Note: Baseline is based on macro inputs from the Consensus Economics (CE). Source: CalPERS internal CMAs as of Q2 2023

NGFS climate scenarios data sourced from the Network for Greening the Financial System (NGFS) Scenario Explorer, hosted by IIASA, scenario vintage 3.4 dated October 14, 2022. Modifications: No modifications made. For comprehensive data and updates, visit the NGFS Scenario Explorer: <https://data.ene.iiasa.ac.at/ngfs>. This work is under the NGFS Public License. More details on the license can be found at: <https://data.ene.iiasa.ac.at/ngfs/#/license>

Goldman Sachs Asset Management Climate Aware 10-yr CMAs (arithmetic excess returns except for US Cash is the total returns) provide insights to the climate risk and opportunity on individual asset classes. Source: GSAM as of Q2 2023 (use with permission from Goldman Sachs Asset Management)

Asset Classes	Original CMA	Hot House		Disorderly		Orderly	
		NDCs	Current Policies	Divergent NZ	Delay Transition	Below 2 Degree	Net Zero 2050
US T-Bills 1-3M (ICE BoA)	3.15%	3.31%	2.51%	4.02%	2.53%	2.92%	3.58%
US LC	4.50%	4.50%	4.35%	4.78%	4.11%	4.51%	4.75%
EAFE	3.91%	3.80%	4.49%	3.20%	4.41%	4.04%	3.53%
Em Eq	4.76%	4.54%	4.38%	5.14%	4.37%	5.00%	5.12%
US TIPS (LB)	1.58%	1.64%	1.32%	1.96%	1.28%	1.47%	1.82%
Glb Inf Linked exUS	1.51%	1.47%	1.01%	2.32%	0.97%	1.36%	1.97%
US Corp 7-10Y	2.15%	2.10%	2.36%	1.87%	2.24%	2.26%	2.07%
Global Corp 5-7Y	1.65%	1.46%	1.74%	1.49%	1.68%	1.88%	1.66%
Em Debt Div	2.74%	1.98%	1.69%	3.86%	1.73%	3.46%	3.72%
US Treas 7-10Y	1.11%	1.10%	1.73%	0.29%	1.74%	1.11%	0.69%
Can Gov 7-10Y	0.97%	0.95%	1.58%	0.16%	1.59%	0.97%	0.55%
UK Gov 7-10Y (JPM)	1.16%	1.21%	1.44%	0.81%	1.28%	1.18%	1.04%
Ger Govt 7_10 Y Citi	0.94%	0.93%	1.29%	0.48%	1.16%	1.04%	0.73%
Fra Govt 7_10 Y Citi	1.08%	1.10%	1.32%	0.77%	1.19%	1.17%	0.94%
Itl Govt 7-10Y (JPM)	1.38%	1.47%	1.92%	0.58%	1.84%	1.51%	0.95%
JP Gov 7-10Y (JPM)	0.29%	0.36%	0.84%	-0.49%	0.68%	0.43%	-0.09%
Ind FI	0.15%	0.32%	0.29%	-0.21%	0.27%	0.24%	-0.01%
China Govt ABF Hgd	0.02%	0.23%	0.27%	-0.25%	0.17%	-0.11%	-0.17%
GSCI Agricultural	1.42%	0.98%	0.67%	2.95%	0.85%	1.26%	1.83%
GSCI Energy	3.44%	3.87%	3.82%	2.76%	3.74%	3.32%	3.16%
GSCI Industrial	2.98%	2.99%	2.70%	3.38%	2.73%	2.85%	3.19%
Commod	2.75%	2.89%	2.78%	2.75%	2.78%	2.63%	2.68%

Table 12. GSAM 10-Year climate scenario CMAs (arithmetic excess returns except for US Cash is the total returns)

# Appendix J. Glossary

Term	Definition	CalPERS Implementation
Conditional Drawdown at Risk	An estimate of potential for losses (compare with Volatility)	<p>During the 2021 Asset Liability Management process, team members conducted modelling and estimated the potential magnitude of significant losses over any given three-year period. This estimation is referred to as the ‘Conditional Drawdown at Risk’. It represents the average of potential ‘significant’ losses that could transpire within a three-year timeframe. For our purposes, ‘significant losses’ are defined as the most severe 10% of all losses.</p> <p>CalPERS has a constitutional objective to ‘minimize the risk of loss.’</p>
Leverage	Borrowing to acquire additional assets	<p>CalPERS has 5% leverage in its policy benchmarks. Staff have leeway to implement an additional 15% leverage incremental to the Strategic Leverage target (“Active Leverage”).</p> <p>A leverage allocation in the strategic asset allocation would improve diversification.</p>
Volatility	An estimate of the width of a return distribution (compare with Downside Risk)	<p>CalPERS 2021 Asset Liability Management uses volatility when estimating the range of return outcomes.</p> <p>As an example, the width of a Bell curve is measured using both the upside and the downside. Risk is related to loss, which involves only downside, which is why we use conditional drawdown to measure downside risk.</p>

