Public Employees' Retirement Association of Colorado

# Signal Light Reporting for the Hybrid Defined Benefit Plan

## Based on the Results of the December 31, 2023, Actuarial Valuation

July 18, 2024



Segal

Segal

101 North Wacker Drive
Suite 500
Chicago, IL 60606-1724
segalco.com

July 18, 2024

The Board of Trustees
Public Employees' Retirement Association of Colorado
1301 Pennsylvania Street
Denver, CO 80203-2386

Dear Trustees:

We are pleased to submit the results of the Signal Light reporting for the Hybrid Defined Benefit Plan (Plan) of the Public Employees' Retirement Association of Colorado (PERA), prepared as of December 31, 2023. The purpose of this report is to provide a sensitivity analysis of the Plan's actuarial assumptions on certain funding targets and to provide a reconciliation of the changes in the expected full funding dates, which are determined assuming all actuarial assumptions are met in the future.

As a result of annual discussion and analysis of the PERA Board of Trustees (Board), the Signal Light reporting process has been enhanced over the years:

- In 2020, when stochastic modeling was employed regarding the analysis of the long-term rate of return assumptions;
- In 2021, when a one-year short-term view was added to provide a better understanding of the conditions required as of the next Automatic Adjustment Provision (AAP) assessment to possibly trigger AAP adjustments;
- In 2022, when an additional short-term view was added to illustrate the probability of triggering AAP adjustments within the next 10-year period under alternative scenarios; and
- In 2024, when – specifically for purposes of the Signal Light report – projection results reflect the impact of expected adjustments from future AAP triggers determined in the projection model.

All calculations have been made in conformity with generally accepted actuarial principles and practices, and with the Actuarial Standards of Practice issued by the Actuarial Standards Board. In our opinion, the results presented also comply with Colorado Statutes, and, where applicable, the Internal Revenue Code, ERISA, and the Statements of the Governmental Accounting Standards Board (GASB). The undersigned are independent actuaries. All are Fellows of the Society of Actuaries, Enrolled Actuaries, and Members of the American Academy of Actuaries, and are experienced in performing valuations for large public retirement systems.

The projections included in this report are based on data provided by PERA and the baseline actuarial assumptions, as approved by the Board, and used in the December 31, 2023, actuarial valuation. As with any projection analysis, this report should not be viewed for absolute results, but rather for trends in the financial measurements. It is important to note that this report is based on plan assets as of December 31, 2023, and does not reflect any returns experienced by the fund after that date.

Future actuarial results may differ significantly from the current results presented in this report due to such factors as the following: plan experience differing from that anticipated by the economic or demographic assumptions; changes in economic or demographic assumptions; increases or decreases expected as part of the natural operation of the methodology used for these measurements (such as the end of an amortization period or additional cost or contribution requirements based on the plan's funded status); and changes in plan provisions or applicable law.

## PENSION FINANCING OBJECTIVES

PERA maintains five pre-funded, hybrid defined benefit pension plans [i.e., State Division Trust Fund, School Division Trust Fund, Local Government Division Trust Fund, Judicial Division Trust Fund, and Denver Public Schools (DPS) Division Trust Fund]. Each defined benefit pension plan is funded through PERA-affiliated employer and member contributions including adjustments resulting from the AAP and direct distribution payments from the State of Colorado. The fixed contribution rate at which each division's employers and members contribute is determined by the Colorado General Assembly and defined within the statutes governing PERA. In addition, for employees of employers of the State and Local Government Divisions, hired on or after January 1, 2019, who chose to participate in the PERAChoice Defined Contribution (DC) Plan in lieu of participating in PERA's Defined Benefit Plan, a DC Supplement is paid to the Defined Benefit Plan to help fund the unfunded actuarial accrued liability (UAAL). Determined separately for the State and Local Government Divisions and calculated as a rate of pay, the DC Supplement was first payable as of January 1, 2021, by all employers of the two divisions, updated annually with each funding actuarial valuation.

The following legislation, enacted in 2022, 2023, and 2024 was reflected in this actuarial analysis, to the extent possible:

- HB 22-1029, effective upon enactment in 2022, required the State Treasurer to (in addition to the regularly scheduled $225 million direct distribution) issue a warrant to PERA in the amount of $380 million, upon enactment, with potential reductions to future direct distributions scheduled to occur July 1, 2023, and July 1, 2024, based upon the actual investment returns reported by PERA for 2021 and 2022, respectively. The payment scheduled for July 1, 2023, was reduced by $190 million, from $225 million to $35 million, based on the total fund investment return in 2021 of 16.1%. No reduction is required for the payment scheduled to occur July 1, 2024, due to a negative investment return in 2022.

- SB 23-056, enacted and effective June 2, 2023, intended to recompense PERA for the remaining portion of the $225 million direct distribution originally scheduled for receipt July 1, 2020, suspended due to the enactment of HB 20-1379, but not fully repaid through the provisions within HB 22-1029. Pursuant to SB 23-056, the State Treasurer issued a warrant to PERA consisting of the balance of the PERA Payment Cash Fund, created in §24-51-416, plus $10 million from the General Fund, totaling $14.56 million.

- SB 23-163, enacted and effective June 6, 2023, states that beginning July 1, 2023, a wildlife officer and a parks and recreation officer (officer), employed by the Division of Parks and Wildlife in the Department of Natural Resources, is classified as a "state trooper" for the purpose of determining the officer's service retirement eligibility and benefit under PERA.

- SB 24-099, enacted April 11, 2024, and effective 90 days following adjournment, adds superintendents and principals to the list of service retirees (along with teachers, school bus drivers, food services cooks, school nurses and paraprofessionals) that may be hired by a rural school district and employed without a reduction in retirement benefits. This legislation clarifies that the exemption for a rural school district also includes a small rural school district which has a funded pupil count for the prior budget year of less than 1,000 pupils. The bill extends the BOCES critical shortage provisions through June 30, 2030, and also clarifies that the two-year moratorium for those who have not met full-service retirement applies to all critical shortage positions and aligns the designation date for reporting critical shortage positions to September 1st of each year.

- HB 24-1044, enacted April 19, 2024, and effective July 1, 2024, increases the number of retirees that can be designated under the 140-day provision. This legislation increases the current retiree limit of 10 "140-day provision" designees, for certain districts. For districts with over 10,000 students, an additional retiree may be designated under the "140-day provision" for each thousand students in excess of 10,000. In addition, this bill modifies the requirement that positions be filled based on a "critical shortage of qualified candidates" test to filling positions based on "need". The bill places a 6-year cap on the total years a retiree may be designated under the "140-day provision" and aligns the designation date for all "140-day" designees to September 1st of each year.

- SB 24-169, enacted May 24, 2024, and effective July 1, 2025, modifies the definition of "state trooper" to include a duly sworn employee of the division of fire prevention and control in the department of public safety. The bill applies the "state trooper" member and employer contribution rates and benefit structure to eligible employees whose duties include structural or wildfire management, wildfire response, live-fire training, or wildfire leadership, as determined by the executive director of the department of public safety.

- SB 24-186, enacted June 5, 2024, and effective January 1, 2025, modifies the definition of "state trooper" to include employees of a local government division employer classified as a coroner or deputy coroner who were elected, reelected, or appointed on or after January 1, 2021, which includes the Boulder County Coroner. The bill applies

the “state trooper” member and employer contribution rates and benefit structure to eligible employees meeting these criteria.

Note that 2022, 2023, and 2024 PERA-related legislation listed above had minimal impact on the results of the funding actuarial valuation as of December 31, 2023, however, HB 22-1029 and SB 23-056 directly impact the market and actuarial value of assets as of the December 31, 2023, valuation date for all divisions except the Local Government Division.

PERA’s defined benefit pension plan funding policy, as developed and maintained by the Board, is used to gauge the adequacy of the statutory contributions. The purposes of this funding policy are to state the overall funding goals and annual actuarial metrics and to guide the Board when considering whether to pursue or support proposed contribution and benefit legislation related to the Division Trust Funds. The policy also includes a brief list of governance responsibilities regarding the commissioning, collection, and review of actuarial information, as described in the Board's Governance Manual.

PERA also maintains two pre-funded defined benefit retiree health care subsidy plans (i.e., Health Care Trust Fund and DPS Health Care Trust Fund), classified as other postemployment benefit (OPEB) plans. The Board maintains a separate OPEB plan funding policy with regard to these plans. Analysis regarding specific OPEB-related plans and assumptions are not included in this report.

A summary of PERA’s pension funding policy is provided in PERA’s Actuarial Valuation and Review as of December 31, 2023.

## BENEFIT PROVISIONS

Plan benefits are specified in Title 24, Article 51 of the Colorado Revised Statutes (C.R.S.), administrative rules set forth at 8 C.C.R. 1502-1, and applicable provisions of the federal Internal Revenue Code. The Colorado General Assembly may amend Colorado State law provisions from time to time. A summary of plan provisions is provided in PERA’s Actuarial Valuation and Review as of December 31, 2023.

## ASSUMPTIONS AND METHODS

The information and analysis used in selecting each assumption that has a significant effect on this actuarial valuation resulted from the 2020 Experience Analysis report, titled, **Public Employees’ Retirement Association of Colorado Analysis of Actuarial Experience during the Period January 1, 2016 through December 31, 2019**. All recommended changes to the demographic and economic actuarial assumptions resulting from this study were reviewed and adopted by the Board at their November 20, 2020, meeting, to be effective beginning with the December 31, 2020, actuarial valuation.

Particularly relevant to this Signal Light report, the assumption related to annual increases in active headcount used for purposes of the open group projections are as follows:

| Division Trust Fund | Current Assumption |
|---|---|
| State | 0.25% |
| School | 1.00% |
| Local Government | 1.00% |
| Judicial | 0.25% |
| Denver Public Schools | 1.00% |

As a result of the 2019 Asset Liability Study, concluded at the November 15, 2019, Board meeting, the Board reaffirmed the 7.25% assumed long-term rate of investment return effective as of January 1, 2020. This Board decision also was in alignment with the analysis provided in the 2020 Analysis of Actuarial Experience report.

## DATA

Member data for retired, active, and inactive participants was supplied as of December 31, 2023, by PERA. We have not subjected this data to any auditing procedures but have examined the data for reasonableness and consistency with the prior year's data. Asset information was also supplied by PERA. That assistance is gratefully acknowledged.

Regards,

Segal

Matthew Strom, FSA, MAAA, EA
Senior Vice President and Actuary

Brad Ramirez, FSA, MAAA, EA
Vice President and Actuary

Tatsiana Dybal, FSA, MAAA, EA
Vice President and Actuary

# Contents

# Executive Summary

## Introduction

### Background & Purpose

In accordance with C.R.S. § 24-51-204(7.5), each year the Public Employees' Retirement Association (PERA) of Colorado, Board of Trustees (Board) requests their actuarial service provider to "**perform a sensitivity analysis to determine when, from an actuarial perspective, model assumptions are meeting targets and achieving sustainability**". This sensitivity analysis, known as Signal Light reporting, has been produced for or on behalf of the Board since 2015. The current report was produced by Segal using the December 31, 2023, actuarial valuation as a basis in conjunction with a projection modeling tool.

The intent of this report is to provide a format for conveying certain actionable information to both PERA and the General Assembly for making decisions with respect to the Plan. The Signal Light process should be viewed as an enhancement to the actuarial valuation control cycle by providing additional evaluation metrics to assess the need for further, in-depth analysis of the actuarial assumptions and/or other major risks to the Plan's sustainability.

Detail regarding the background, as well as all actuarial methods and assumptions employed within this analysis, are provided in Section 1 and Section 8, respectively, of the report.

### Enhancements

As a result of annual discussion and analysis of the Board, the Signal Light reporting process has been enhanced over the last few years, as follows:

| Signal Light Report | Description of Enhancement |
|---|---|
| **2020** | Began employing stochastic modeling in lieu of deterministic modeling regarding the analysis of the likelihood of achieving the long-term rate of return assumption. The stochastic approach enhances the analysis by considering PERA's investment portfolio and asset allocation in conjunction with the impact of actual market activity including the effect of the timing and order of investment returns. |
| **2021** | A section providing a **Short-Term View** was added to the reporting process to provide a better understanding of the conditions that would need to exist as of the next AAP assessment that would trigger additional AAP adjustments. |
| **2022** | Expanded the **Short-Term View** section to include 10-year projection graphs under various scenarios that show the likelihood (in any one year) of triggering the AAP adjustments in either direction, regarding the 98% and 120% thresholds. Included an Executive Summary at the front of this report. |
| **2024** | Specifically for purposes of the Signal Light report, all projection results (unless otherwise noted), including the 10-year short-term view, reflect the impact of expected adjustments from future AAP triggers determined in the model as well as projected changes to employer Amortization Equalization Disbursement and Supplemental Amortization Equalization Disbursement (AED/SAED) contribution rates. |

The Board intends to continue to evolve the Signal Light reporting process, as additional, useful modeling tools and methods present themselves or are brought to the Board's attention.

## 2024 Enhancement – "Signal Light 3.0"

Initially, Signal Light reporting was done entirely with deterministic modeling. The analysis for each Division was determined based on the single portfolio return that – if achieved every year in the future – resulted in attaining a 100% funded ratio by certain years according to the signal light status definitions (outlined in the table on page 12). For example, if a certain division were to achieve an investment return of 10% per year each year in the future, it would be projected to achieve 100% funded by 2041 (i.e., **Dark Green** status). If that division were to earn 9% per year each year in the future, it would be projected to achieve 100% funded by 2048 (i.e., **Green** status), etc. Then using the portfolio's mean expected return and standard deviation, and assuming that returns followed a normal distribution, the probability of meeting each signal light status could be estimated for each division. A similar approach was used for determining the sensitivity impact of other non-investment assumptions.

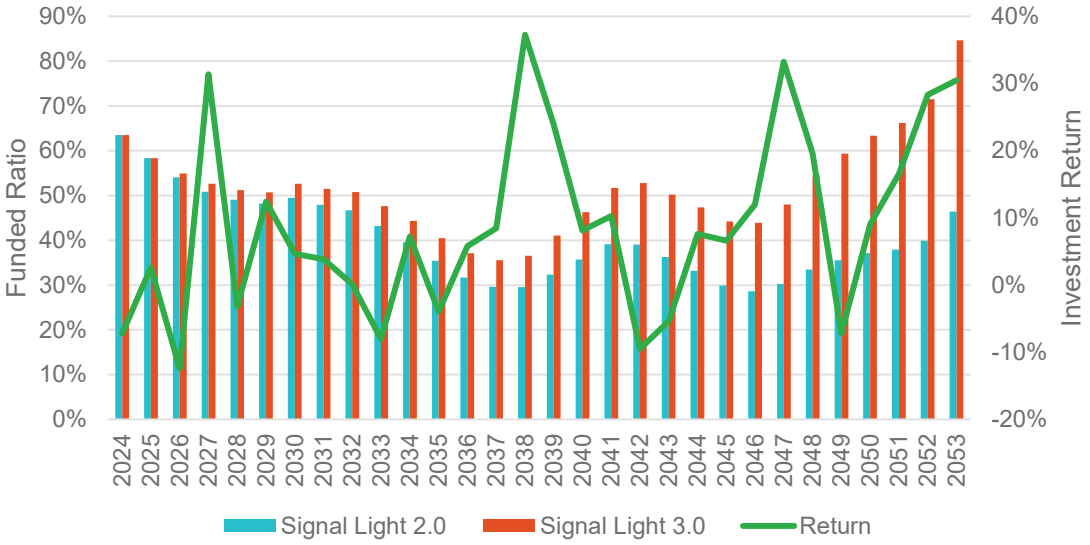
While a useful exercise in many respects, we know that portfolio returns rarely occur in a deterministic, "X% return every year in the future" manner. Further, we know that even when average portfolio returns are consistent over a period, the order of those returns through the time horizon can have a significant impact on projected results. This is discussed and demonstrated in further detail in Section 3. Due to this, "Signal Light 2.0" was developed beginning with the 2020 Signal Light reporting, which utilized stochastic modeling in place of deterministic modeling to more thoroughly analyze the risks associated with investment returns different than expected under various investment return scenarios. As outlined in the prior table, subsequent reports have included additional content, which has enhanced the information provided in the Signal Light reporting.

"Signal Light 3.0" introduced with this 2024 report is the next significant iteration of Signal Light reporting. With Signal Light 3.0, the projection model has been modified to accommodate certain changes to liabilities and contributions that may result in the future. The most significant source of potential change is from AAP triggers expected to happen over time based on projections for each division. In addition to modeling potential future AAP changes, the Signal Light basis also contemplates any projected changes to employer Amortization Equalization Disbursement and Supplemental Amortization Equalization Disbursement (AED/SAED) rates, which can occur when a division's projected funded ratio exceeds 103% or drops below 90%.

Whereas prior iterations of Signal Light reporting relied on projections that were intended to identically match the valuation baseline under the same set of projection assumptions, Signal Light 3.0 represents a shift towards modeling potential outcomes that utilize the various statutory tools available to improve PERA's funded status under unfavorable economic scenarios and demographic conditions as well as those that improve benefits and reduce contribution rates for members and employers under favorable economic scenarios and demographic conditions.

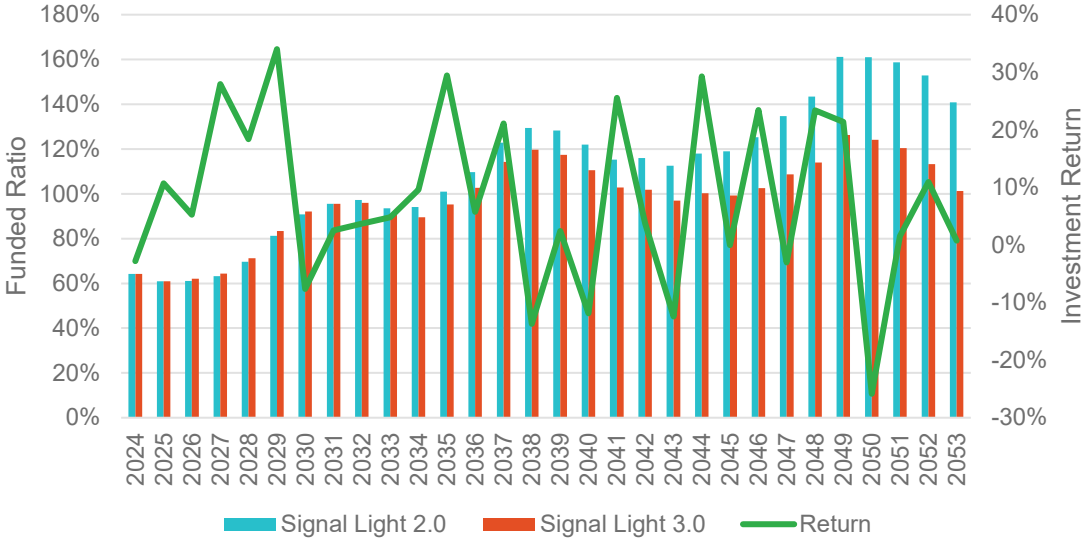
To illustrate the advantages that Signal Light 3.0 provides to the modeling results, consider the following two examples provided for the State Division based on a "pessimistic" investment return scenario and an "optimistic" investment return scenario.

### Pessimistic Scenario – State Division Illustration




In the pessimistic return scenario above, investment returns average 2.4% over the first ten years through the year 2033. Under Signal Light 2.0, this unfavorable investment experience would cause the projected funded ratio to decline to 30% and subsequent returns are not significant enough to elicit any meaningful recovery. Under the same investment return scenario, the Signal Light 3.0 model would cause two consecutive less-than-98% AAP ratio triggers in the 2025 and 2026 valuation years. Higher contribution rates and a lower AI cap ultimately result in a nearly 40-percentage point improvement in projected funded ratio over 30 years.

### Optimistic Scenario – State Division Illustration




In the optimistic return scenario above, despite a first-year return of nearly −3%, investment returns average in excess of 9% over the first 25 years of the projection. Under Signal Light 2.0, this favorable investment experience would cause the projected funded ratio to exceed 100% by

2035 and eclipse 160% by 2049. Under the same investment return scenario, the Signal Light 3.0 model initially causes a single less-than-98% AAP ratio trigger in the 2025 valuation year due to a low first-year investment return. However, with favorable double-digit investment performance in four of the subsequent five years, the model results in five consecutive more-than-120% AAP ratio triggers beginning with the 2029 valuation year. This results in lower member and employer contribution rates and a higher AI cap, all while keeping the State Division on track to meet PERA's funding goals.

This dynamic aspect of adjusting contribution rates and the AI cap based on inter-scenario factors results in a more realistic view of modeled outcomes.

An additional change implemented with Signal Light 3.0 is the method used to model the sensitivity of non-investment assumptions. Historically, the non-investment assumptions reflected in the Signal Light reporting included active membership growth, individual pay increases for active members, and demographic experience. As previously mentioned, the impact of these assumptions was measured on a deterministic basis assuming a certain level of gain or loss relative to the assumption persisted each year in the future. In the case of assessing the impact of all assumptions in combination, the underlying premise was that each assumption was perfectly correlated with one another. For example, if a scenario included an investment return that was exactly one standard deviation to the right of the mean, each other non-investment assumption modeled also occurred at one standard deviation to the right of the mean.

While there may be some correlation among portfolio returns, active membership growth, individual pay increases, and other demographic experience, there certainly is not perfect correlation among them. Under Signal Light 3.0, sensitivity of active membership growth and pay increase variables (when viewed in combination represent growth in total payroll), as well as other demographic gain and loss also are modeled stochastically. Historical data is used to develop the mean and standard deviations of total payroll and demographic gain and loss. These means and standard deviations are then used to simulate year-by-year deviations from the assumptions for each of the 5,000 trials in the simulation. In this way experience for all variables can be modeled in a more random, stochastic fashion.

**The Board intends to continue to evolve the Signal Light reporting process, as additional, useful modeling tools and methods present themselves or are brought to the Board's attention.**

## Long-Term View

Under the **Long-Term View**, the analysis within this report determines the **likelihood of achieving the expected long-term rate of investment return and certain demographic assumptions**. This is done through stochastic projections, modeling 5,000 deterministic trials for each testing scenario based upon:

- The 30-year capital market assumptions, provided by the Board's investment consultants, at the time the Board last reviewed the current expected long-term rate of investment return of 7.25%;
- The resulting likelihoods of achieving certain returns based upon 50-year probability outlooks reviewed and adjusted annually; and

- The provisions of SB 18-200, reflecting the AAP.

The Signal Light reporting compares the projection of each division's funded ratio over certain time periods and assigns a color to indicate the relative strength of the result. The colors and corresponding criteria are defined in the following table.

**Status Definitions – Long-Term View**

| Status | Definition |
|---|---|
| **Dark Green** | 100% funded by 2041 (30 years from 2011 [December 31, 2010]) |
| **Green** | 100% funded by 2048 (30 years from 2018 [December 31, 2017]) |
| **Light Yellow** | 100% funded by 2058 (40 years from 2018 [December 31, 2017]) |
| **Yellow** | 100% funded by 2068 (50 years from 2018 [December 31, 2017]) |
| **Orange** | Solvent but more than 50 years to reach 100% funded |
| **Red** | Insolvent after 2043 (after 20 years from December 31, 2023) |
| **Dark Red** | Insolvent by 2043 (within 20 years of December 31, 2023) |

The **Dark Green** through **Yellow** status definitions provide the benchmark year by which the Division would be expected to be 100% funded. The **Orange** through **Dark Red** status definitions provide the number of years that the solvency of the Division is measured. A summary of the change in the Signal Light reporting from last year to this year is summarized in the following table.

**Signal Light Status – Long-Term View**

| Division | Probability of 100% Funded by 2048 | December 31, 2023 | December 31, 2022 |
|---|---|---|---|
| State | 42% | **Light Yellow** | **Yellow** |
| School | 36% | **Yellow** | **Yellow** |
| Local Government | 58% | **Green** | **Light Yellow** |
| Judicial | 65% | **Dark Green** | **Dark Green** |
| DPS | 67% | **Dark Green** | **Dark Green** |

Detail regarding the analysis and results related to the **Long-Term View** is provided in Sections 2-5 of the report. Results summarized directly above are discussed in Section 5 reflecting sensitivity on all assumptions.

# Short-Term View

## One-Year Analysis

The one-year projection of the AAP ratio can be modeled with three key variables for experience during the year:

- Market value investment return for the year – baseline assumption is 7.25%
- Increase in total payroll for the year – baseline assumption is 3.00%
- Level of demographic gain/loss for the year[1] – baseline assumption is 0.00%

In order for the projected AAP ratio as of December 31, 2024, to be lower than 98% or greater than 120% (and therefore trigger AAP adjustments), experience for 2024 of any single variable above (assuming the other two variables meet their respective assumptions for the year) would need to be:

| Variable | AAP Ratio of 98% or Less | AAP Ratio of 120% or More |
|---|---|---|
| Market value investment return | Worse than −23.5% | Better than 70.2% |
| Year-over-year change in total payroll | Lower than 8.1% decrease | Higher than 35.0% increase |
| Demographic experience | More than 4.7% loss | More than 9.5% gain |

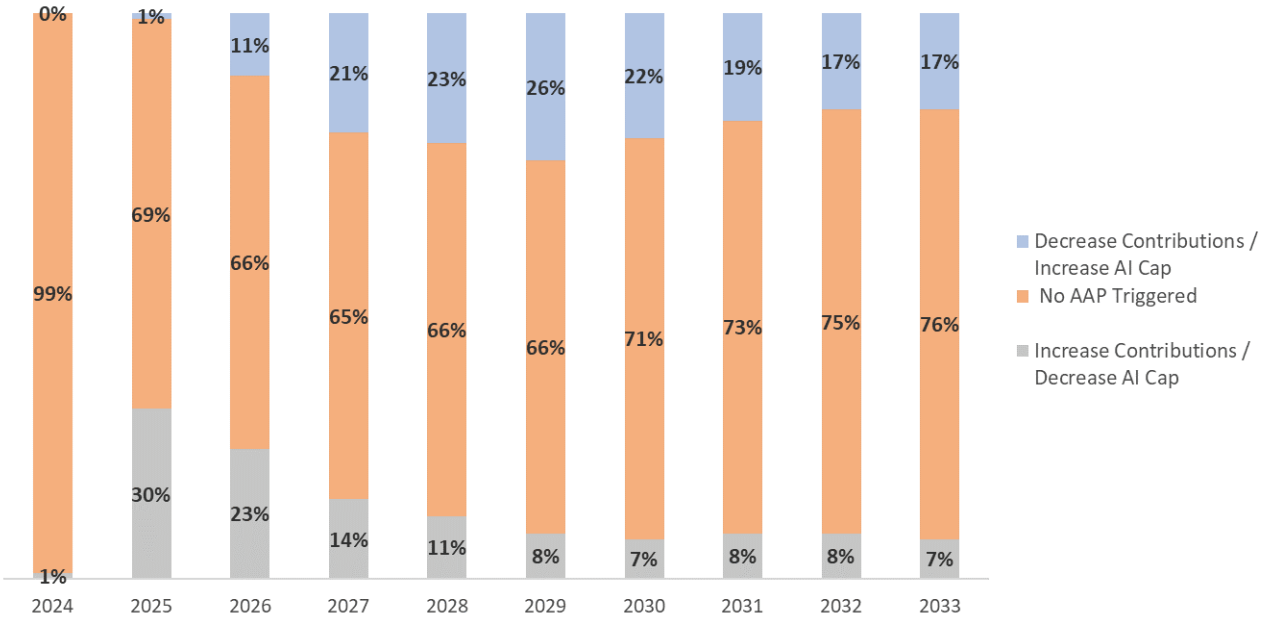
For context, there is only one occurrence of one of the variables falling outside of the thresholds outlined above in the last 30 years: a −26.0% market value investment return in 2008. The lowest year-over-year change in total payroll was a 2.5% decrease, which occurred in 2012. The largest demographic loss (as a percentage of actuarial accrued liability) was 2.2% in 2002.

[1] Note, to prevent double-counting, the level of demographic gain/loss would not include any gain or loss from salary experience that contributed to the total increase in payroll.

## Ten-Year Analysis

Using the 5,000 stochastically modeled investment return simulations and the baseline open group liability projection results, Segal has estimated the PERA AAP ratio for the upcoming ten valuation years. Based on these results, the probability in each year of the AAP test triggering contribution increases and a reduction in the AI cap (from an AAP ratio below 98%) or triggering contribution decreases and an increase in the AI cap (from an AAP ratio exceeding 120%) are determined and illustrated in the following graphic:

**Likelihood of Triggering the AAP in the Next Year**
**Baseline Liability Forecast**




In the exhibit above, each year's results are determined based on results from prior years. The probabilities shown in any one year consider the impact of any potential AAP changes that may have triggered in any prior year. For example, the 23% probability of triggering the 98% (lower) boundary of the AAP assessment in the 2026 valuation year considers that 30% of trials triggered an AAP adjustment increasing contributions and lowering the AI cap in the prior valuation year. As of this 2024 Signal Light report, there are only two additional triggers of the 98% (lower) boundary of the AAP assessment available in the near-term. Additional scenarios are provided on pages 44-47.

Detail regarding the ten-year analysis and results related to the **Short-Term View** is provided in Section 6 of the report.

# Take-Aways – Reflecting the December 31, 2023, Actuarial Valuation Results

## Long-Term View

- The likelihood of PERA achieving full funding status by or before 2048, has a 36%, or better, probability of success.
- The State Division Trust Fund is categorized as **Light Yellow**, the School Division Trust Fund as **Yellow**, the Local Government Trust Fund as **Green**, and the Judicial and DPS Division Trust Funds as **Dark Green**, regarding the likelihood of achieving full funding status by or before 2048.
- Better-than-expected investment performance in 2023 served to partially offset the impact of unfavorable 2022 investment performance. However, recognition of residual 2022 investment losses continue to impact PERA's overall position regarding the likelihood of being 100% funded by or before 2048. See the table titled, "Increase/(Decrease) in Projected Full Funding Year", provided at the bottom of page 21.
- Although annual demographic plan experience is important to gauge, investment performance has the single most impactful influence on the success or failure of achieving the Board's funding targets within the stated 30-year timeframe.

## Short-Term View

- To trigger the 98% (lower) boundary of the AAP assessment for 2024, would take worse than a −23.5% investment return for 2024, assuming all other assumptions were exactly met. To trigger the 120% (upper) boundary of the AAP assessment for 2024, would take better than a 70.2% investment return for 2024, assuming all other assumptions were exactly met.
- Over the next two years, as the remaining 2022 investment loss is reflected in the actuarial smoothing process, the likelihood of the AAP ratio falling below the 98% (lower) boundary diminishes while the likelihood of the AAP ratio assessment triggering the 120% (upper) boundary begins to increase.
- Under a baseline forecast, but assuming a −5.75%[2] investment return for 2024, there is a 91% likelihood that the AAP ratio will fall below the 98% (lower) boundary in 2025.

Section 6 – Ten-Year Analysis, contains additional scenarios of possible economic observations to compare with the ten-year baseline forecast. A complete summary of all significant Signal Light results as of December 31, 2023, is provided in Section 7 of the report.

Note: Because actual experience will not unfold exactly as predicted, actual results can be expected to differ from the results presented herein. The Signal Light process, like other actuarial modeling, is not intended to provide absolute results, but rather to identify anticipated trends and to compare various outcomes, under a given methodology. The results produced by the Signal Light reporting process do not:

- predict the financial condition of PERA, or
- indicate PERA's ability to pay benefits in the future, or
- provide any guarantee of PERA's future financial soundness.

[2] A −5.75% investment return, represents one standard deviation to the left of the mean expected return, as discussed on page 17 of this report.

# Section 1: Background

In accordance with C.R.S. § 24-51-204(7.5), each year the PERA Board of Trustees (Board) requests their actuarial service provider to "perform a sensitivity analysis to determine when, from an actuarial perspective, model assumptions are meeting targets and achieving sustainability". This Sensitivity Analysis, currently known as Signal Light reporting, has been produced by Segal using the December 31, 2023, actuarial valuation as a basis in conjunction with a projection modeling tool. This report provides a format for communicating the Plan's funding progress and providing certain actionable information to both PERA and the General Assembly for making decisions with respect to the Plan's funding.

PERA's long-term goals generally focus on the level of funding leading up to the year 2048. However, emerging experience in the next five to ten years can materially affect the pathway to achieving those goals. This report focuses primarily on the factors that lead to PERA meeting its long-term funding goals (Sections 3–5), but also examines a short-term view and the emerging experience that impacts the long-term pathway (Section 6).

The intended purpose of the Signal Light process is to help assess the Plan's funding progress and to provide information to decision makers to help ensure that the applicable pension liabilities and funding mechanisms are managed in a manner that promotes sustainability. The Signal Light process should be viewed as an enhancement to the actuarial valuation process by providing additional evaluation metrics to assess the need for further, in-depth analysis of the risks to the Plan's sustainability. The actuarial valuation process is a key component of managing a long-term liability whose ultimate value is based upon uncertain future events. As the ultimate value of future cash flows cannot be predicted with certainty, pension liabilities are managed in the short-term through the continuous monitoring of economic and demographic assumptions, with a keen eye on the identification, measurement, and management of risks.

The Signal Light process, like other actuarial modeling, is not intended to provide absolute results. The intended purpose of the Signal Light process is to identify anticipated trends and to compare various outcomes, under a given methodology, rather than to predict some future state of events. The results produced by the Signal Light process do not predict the financial condition of the Plan or the Plan's ability to pay benefits in the future and do not provide any guarantee of future financial soundness of the Plan. Because actual experience will not unfold exactly as expected, actual results can be expected to differ from the results presented herein. To the extent actual experience deviates significantly from the assumptions, results could be significantly better or significantly worse than the expected outcomes indicated in this report.

Actuarial assumptions are a key component of both the snapshot measurements in the actuarial valuation process and the projection of future valuation results. Actual experience can be expected to vary from year to year, even if, on average, the actuarial assumptions are met over the long term. The variability of certain key measures can have a significant impact on the date the Plan will reach full funding (actuarial assets equal to or greater than the actuarial accrued liability). The key variables include investment return, active membership growth, individual pay increases for active members, and demographic experience (e.g., post-retirement mortality, timing of retirement, etc.).

Of these variables, investment return is the most significant variable and the most volatile. The active membership growth and pay increase variables (when viewed in combination represent growth in total payroll) also are very important, but not nearly as significant as the investment return variable. Mortality and other demographic assumptions may change over the long term in unanticipated ways, but, in this study, we are primarily modeling the variation of total experience and not possible changes in the valuation assumptions. However, Section 4 does include an analysis of the impact of an alternate set of certain demographic assumptions (i.e., retirement, turnover, and disability incidence rates, as well as rates of individual salary increase).

The standard deviation is a statistical measure of variability, providing a basis for determining how widely the result of any single year, or multiple years, is expected to vary from the expected result. It can also be used to assess the probability of results occurring within a certain range. For example, if the expected rate of investment return is 7.25% annually, the standard deviation is 13.0%, and returns follow the normal distribution, there is a 68% probability that the actual investment return in any one year will be between one standard deviation higher or lower than the expected return. The resulting range is −5.75% to +20.25%. The standard deviation and resulting ranges of annualized return become smaller over longer periods of time. However, the ranges of total return become larger as the time period increases.

While the underlying assumption is that the non-investment variables outlined in this study follow the normal distribution, the interaction between actual experience – investment volatility, in particular – and the Plan's projected cash flow can yield non-normally distributed results. To best demonstrate this interaction, we have modeled investment return variation and the sensitivity of other assumptions using a technique called stochastic modeling. Under this approach, annual portfolio returns were simulated using expected returns, standard deviations, and covariances of the asset classes held in the fund. Annual increases in total payroll and demographic gains and losses were simulated using the mean and standard deviation for each variable determined based on historical experience.

As noted previously, one aspect of the actuarial valuation process is the continuous monitoring of the assumptions and methods used in the valuation process. Over time, PERA's actuaries will periodically re-evaluate the assumptions and methods, with the PERA Board's review and/or approval, to reflect updated experience and changes in future expectations. As such, each year's update to the Signal Light results will incorporate the PERA Board's assumptions and methods set as of the most recent valuation date.

The variability of investment returns and other experience will affect the projected full funding date (the point at which the actuarial value of assets equals the actuarial accrued liabilities) of each of the Plan's five divisions (State, School, Local Government, Judicial, and DPS). This methodology and Signal Light reporting tool are used to communicate the significance of the variability in achieving funding goals, with the intent that policymakers would have a more understandable picture of both the current funded status of the Plan and the probability of conditions that will improve or weaken that status in the future. The process reflects the possibility of actual future experience varying from that assumed in the long-term. The assumed investment return is a key variable in that it has the greatest potential for variability and has the most significant effect on the Plan's projected funded status. A similar methodology can be used to evaluate the potential impact of the variability in actual experience versus that assumed for other variables (discussed later).

The Signal Light reporting compares the projection of each division's funded ratio over certain time periods and assigns a color to indicate the relative strength of the result. The colors and corresponding criteria are as follows:

**Status Definitions – Long-Term View**

| Status | Definition |
|---|---|
| **Dark Green** | 100% funded by 2041<br>(30 years from 2011 [December 31, 2010]) |
| **Green** | 100% funded by 2048<br>(30 years from 2018 [December 31, 2017]) |
| **Light Yellow** | 100% funded by 2058<br>(40 years from 2018 [December 31, 2017]) |
| **Yellow** | 100% funded by 2068<br>(50 years from 2018 [December 31, 2017]) |
| **Orange** | Solvent but more than 50 years<br>to reach 100% funded |
| **Red** | Insolvent after 2043<br>(after 20 years from December 31, 2023) |
| **Dark Red** | Insolvent by 2043<br>(within 20 years of December 31, 2023) |

The **Dark Green** through **Yellow** status definitions provide the benchmark year by which the division would be expected to be 100% funded. For example, the **Dark Green** status measures whether the division would be 100% funded by 2041, which is the division's target for full funding as initiated through the passage of Senate Bill 2010-001. The **Orange** through **Dark Red** status definitions provide the number of years that the solvency of the division is measured. For example, the **Dark Red** status measures whether the division would be insolvent within 20 years of the December 31, 2023, valuation date. Each year, as more experience is gathered and users become more familiar with the tool, these criteria and thresholds will be reviewed to determine if adjustments are appropriate.

The methodology for determining the results of the Signal Light reporting with respect to investment returns is based on stochastic modeling to account for asset volatility and negative cash flow. Stochastic modeling projects future cash flows by simulating investment portfolio return scenarios and projecting valuation results into the future. The 30-year capital market assumptions, provided by the Board's investment consultants in the Asset-Liability Study Follow-Up presentation (September 2019) are used with PERA's target asset allocation to simulate 5,000 investment portfolio return scenarios. The simulated investment returns, along with open group liability forecasts, are used to model the projected funded ratio, which reflect the timing of investment returns. The probabilities of achieving the Signal Light funded ratio levels are determined based upon the simulated trials and include the effect of "path dependency".

While it is useful to understand the long-term funded status if future experience exactly follows the assumptions, the Signal Light methodology provides sensitivity analysis of the long-term funding progress relative to some key variables. An example of the resulting output for the long-term investment return assumption of the State Division is shown in the following table:

**Long-Term View Signal Lights for State Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Assumes Active Membership Grows by 0.25% per Year**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 1,484 | 30% | 43% |
| Green | 100% funded by 2048 (30 years from 2018) | 644 | 13% | |
| **Light Yellow** | **100% funded by 2058 (40 years from 2018)** | **654** | **13%** | 54% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 555 | 11% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 1,499 | 30% | |
| Red | Insolvent after 2043 (after 20 years) | 140 | 3% | 3% |
| Dark Red | Insolvent by 2043 (within 20 years) | 24 | 0% | |

* Based on 5,000 simulations

The Signal Light chart quantifies the probability of achieving the benchmark for each Signal Light status. PERA has requested that these signals be monitored annually for all divisions. The results for each division are shown in Section 3. If a dramatic shift in status occurs, additional analysis might need to be performed. **Given the volatility associated with investment returns and the standard deviation of the expected return from year to year, changes in the Signal Light color from year to year are to be expected and the results should be viewed with this knowledge.**

Note that the Signal Light reporting reflects variations in the variables considered (investment return, population growth, salary increases, etc.); to the extent that a given scenario triggers one or more AAP adjustments, the model reflects an appropriate change to the benefit structure (i.e., the AI cap) and employer and member contributions over the remainder of the projection period. However, no "external" changes to the benefit structure, actuarial assumptions, or methods are assumed to occur. This is unlikely if a PERA division were to be in the **Red** or **Dark Red** status for a number of years. One purpose of the Signal Light reporting process is to provide information in advance to allow for adjustments to be made in a timely manner.

The Signal Light color is assigned by equating the probability of meeting various status definitions to the return percentiles from the stochastically modeled portfolio returns. Percentiles based on 30-year geometric returns using Aon's capital market assumptions are:

- 95th percentile: 11.3% return
- 75th percentile: 9.0% return
- 50th percentile: 7.5% return
- 25th percentile: 5.8% return
- 5th percentile: 3.4% return

For the State Division, the probabilities of meeting each status criteria line up with the geometric return percentiles as follows:

| Status | Probability of Meeting | Equivalent Return Percentile | 30-Year Return Band at Percentile |
|---|---|---|---|
| **Dark Green** | 30% | 70th | 8.67% or more |
| **Green** | 13% | 57th | 7.85% to 8.66% |
| **Light Yellow** | **13%** | **44th** | **7.06% to 7.84%** |
| **Yellow** | 11% | 33rd | 6.37% to 7.05% |
| **Orange** | 30% | 3rd | 2.88% to 6.36% |
| **Red** | 3% | N/A | Less than 2.87% |
| **Dark Red** | 0% | N/A | N/A |

For example, in the table above, the probability of meeting **Light Yellow** status (including **Dark Green** and **Green**) is 56% (30% + 13% + 13%), which equates to the 44th percentile. Therefore, the Signal Light color assigned to the State Division is **Light Yellow** because the 7.25% investment return assumption falls within the range of 7.06% to 7.84% (or, the 44th percentile).

Viewed another way, the Signal Light color assigned to a division is based on when the probability of meeting or exceeding a particular Signal Light status is at the same probability of meeting or exceeding the investment return assumption. The current 7.25% assumption falls at the 47th percentile, meaning there is a 53% probability of meeting or exceeding the 7.25% assumption based on 30-year geometric returns using Aon's capital market assumptions. For example, for the State Division, the 53% probability falls within the **Light Yellow** status.

It is also worth noting that the method assumes variability and independence of all the modeled variables. For example, it is assumed that asset returns are independent from payroll growth. This assumption is likely not the case, but the statistical methodology to determine the interrelationships would be extremely complex and beyond the scope of this study. For the "all variables" portion of the study, the probability shown is based on a stochastic simulation of each variable determined independently. In this way, the results provide a general sense of the relative volatility of the ultimate funding status of the Plan in the presence of natural variability.

# Section 2: Changes in Expected Full Funding Dates

## Valuation Basis

Based on our analysis of experience gains and/or losses and plan provision and/or assumption changes during the annual actuarial valuation and projection processes, Segal is able to report on the factors that contributed to increases or decreases in the projected full funding dates for each division from the previous year's results. The table that follows shows the full funding dates for the past two valuations. Note that these results are determined without respect to the impact of any potential adjustments from future AAP triggers. We refer to this as being determined on a "valuation basis".

### Estimated Projected Year the Funding Ratio Reaches 100% – Valuation Basis

| Division Trust Fund | December 31, 2023 Valuation | December 31, 2022 Valuation |
|---|---|---|
| State | 2047 (23 Years) | 2055 (32 Years) |
| School | 2051 (27 Years) | 2057 (34 Years) |
| Local Government | 2038 (14 Years) | 2046 (23 Years) |
| Judicial | 2032 (8 Years) | 2035 (12 Years) |
| Denver Public Schools | 2033 (9 Years) | 2036 (13 Years) |

The following table shows the factors that contributed to the net change in "Projected Full Funding Year", not including the one year decrease due to the passage of time:

### Increase/(Decrease) in Projected Full Funding Year

| | State | School | Local Government | Judicial | DPS |
|---|---|---|---|---|---|
| Investment return | (5) | (6) | (8) | (3) | (3) |
| Total payroll | (6) | (4) | (3) | 0 | (1) |
| Demographics | 3 | 4 | 3 | 0 | 1 |
| Assumption changes | N/A | N/A | N/A | N/A | N/A |
| **Total** | **(8)** | **(6)** | **(8)** | **(3)** | **(3)** |

Note the results in the table above could be observed to be slightly different based upon the order that the factors are observed. For this purpose, we have performed this reconciliation in the order as shown above.

The following are a few observations from the reconciliation of the projected full funding dates for each division:

- The market value asset return of 13.4% for the 2023 Plan Year was a significant driver behind the change in full funding dates. The greater-than-expected market value investment return decreased the number of years until full funding.
- All divisions experienced salary increase losses in 2023 to some degree, meaning that increases in individuals' salaries were larger than expected. This translated to larger-than-expected increases in total payroll, which drives relatively higher projected contributions over the projection period. These higher projected contributions were also a significant contributor to the change in full funding dates for most divisions.
- Also contributing to small changes in the full funding date, moderate demographic losses during the 2023 Plan Year for all divisions occurred due to actual experience differing from expected assumptions. Based on the current actuarial assumptions, the plan population experienced a lower level of termination of employment than expected for State, School, and Local Government, along with the aforementioned higher-than-expected pay increases for individual active members across all divisions.

## Signal Light Basis

Beginning in 2024, for purposes of Signal Light reporting, the projection model is adjusted to accommodate certain changes to liabilities and contributions that may result in the future. The most significant source of potential change is from AAP triggers expected to happen over time based on projections for each division. As of December 31, 2023, there are two additional AAP triggers (from an AAP test ratio less than 98%) that would further decrease the AI cap and increase member and employer contributions. There are multiple triggers available to increase the AI cap and decrease contribution rates if the AAP test results in a ratio of 120% or more. In addition to modeling potential future AAP changes, the Signal Light basis also contemplates any projected changes to employer Amortization Equalization Disbursement and Supplemental Amortization Equalization Disbursement (AED/SAED) rates, which can occur when a division's projected funded ratio exceeds 103% or drops below 90%.

Estimated Projected Year the Funding Ratio Reaches 100%

| Division Trust Fund | Valuation Basis | Signal Light Basis | Difference |
|---|---|---|---|
| State | 2047 (23 Years) | 2046 (22 Years) | (1) |
| School | 2051 (27 Years) | 2050 (26 Years) | (1) |
| Local Government | 2038 (14 Years) | 2035 (11 Years) | (3) |
| Judicial | 2032 (8 Years) | 2032 (8 Years) | 0 |
| Denver Public Schools | 2033 (9 Years) | 2033 (9 Years) | 0 |

If all assumptions emerge as expected, a less-than-98% AAP test ratio is projected to trigger with the December 31, 2035, actuarial valuation (12 years after the current valuation date) and again with the December 31, 2044, actuarial valuation. After the legacy UAAL base (from December 31, 2017) is fully amortized, a series of consecutive greater-than-120% AAP test ratios are projected to occur beginning with the December 31, 2047, actuarial valuation, which gradually dial back contribution rates and increase the AI cap.

# Section 3: Sensitivity on Investment Return Assumption

For this analysis, we have used the 30-year capital market assumptions provided by the Board's investment consultants in the Asset-Liability Study Follow-Up presentation in September 2019. In that analysis, the midpoint of expected investment returns over a 50-year time horizon, using a 2.30% price inflation assumption, was 7.47% (with a standard deviation over this time horizon of 1.84%). This implies that there is a 50% probability of returns averaging less than 7.47% and a 50% probability of returns averaging more than 7.47% over a 50-year time period. The current long-term rate of return assumption of 7.25%, adopted effective with the December 31, 2016, actuarial valuation and reaffirmed at the November 15, 2019, Board meeting, is at approximately the 47th percentile. This implies that there is a 53% probability that the 50-year average rate of return will be 7.25% or more. Below is a breakdown of 30-year capital market assumptions and analysis most recently reviewed by the PERA Board upon which their investment policy and this section is based.

| Asset Classes[3] | Long-Term Asset Allocation[3] | Expected Nominal Return[3] | Expected Risk[3,4] |
|---|---|---|---|
| Global Equity | 53.0% | 8.00% | 19.00% |
| Fixed Income | 23.0 | 3.60 | 5.00 |
| Real Estate | 8.5 | 6.65 | 20.00 |
| Private Equity | 8.5 | 9.60 | 24.50 |
| Opportunity Fund[5] | 6.0 | 7.12 | 9.46 |
| Cash | 1.0 | 2.70 | 2.00 |
| Inflation | | 2.30 | |
| **Total Fund:** | | | |
| Expected Return | | 7.47% | |
| Expected Risk | | 13.00% | |

[3] Based on the existing long-term asset allocation and the 30-year capital market assumptions as of the first quarter 2019, as provided by PERA's investment consultant, Aon Hewitt. This assumption set was used in the 2019 asset liability study and displayed in the "Asset-Liability Study Follow-Up" presentation, dated September 13, 2019.

[4] Expected risk is represented by the standard deviation of results.

[5] Effective January 1, 2020, the asset class titled "Opportunity Fund" was changed to "Alternatives" within PERA's asset allocation.

The next five tables show the Signal Light results based on stochastically simulated investment returns.

**Long-Term View Signal Lights for State Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Assumes Active Membership Grows by 0.25% per Year**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| **Dark Green** | 100% Funded by 2041 (30 years from 2011) | 1,484 | 30% | 43% |
| **Green** | 100% funded by 2048 (30 years from 2018) | 644 | 13% | |
| **Light Yellow** | **100% funded by 2058 (40 years from 2018)** | **654** | **13%** | 54% |
| **Yellow** | 100% funded by 2068 (50 years from 2018) | 555 | 11% | |
| **Orange** | Solvent but longer than 50 years to reach 100% funded | 1,499 | 30% | |
| **Red** | Insolvent after 2043 (after 20 years) | 140 | 3% | 3% |
| **Dark Red** | Insolvent by 2043 (within 20 years) | 24 | 0% | |

* Based on 5,000 simulations

The State Division table above provides the following information:

- **Best-case scenarios:** Of the 5,000 simulations ran, 1,484, or 30%, resulted in the State Division Trust Fund being fully funded by 2041, meeting the criteria for **Dark Green** status. An additional 644 scenarios resulted in being fully funded no later than 2048, meeting the criteria for **Green** status. Therefore, 43% of the 5,000 simulations resulted in the State Division meeting a criteria for one of the green status definitions.

- **Worst-case scenarios:** Of the 5,000 simulations, 164, or 3%, resulted in the depletion of the State Division Trust Fund.

As mentioned in Section 1 of this report, note that the Signal Light reporting reflects variations in the variables considered (investment return, population growth, salary increases, etc.); to the extent that a given scenario triggers one or more AAP adjustments, the model reflects an appropriate change to the benefit structure (i.e., the AI cap) and employer and member contributions over the remainder of the projection period. However, no "external" changes to the benefit structure, actuarial assumptions, or methods are assumed to occur. This is unlikely if a PERA division were to be in the **Red** or **Dark Red** status for a number of years.

**Long-Term View Signal Light Results for School Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Assumes Active Membership Grows by 1.00% per Year**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 1,201 | 24% | 35% |
| Green | 100% funded by 2048 (30 years from 2018) | 559 | 11% | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 567 | 11% | 59% |
| **Yellow** | **100% funded by 2068 (50 years from 2018)** | **504** | **10%** | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 1,887 | 38% | |
| Red | Insolvent after 2043 (after 20 years) | 261 | 6% | 6% |
| Dark Red | Insolvent by 2043 (within 20 years) | 21 | 0% | |

* Based on 5,000 simulations

**Long-Term View Signal Light Results for Local Government Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Assumes Active Membership Grows by 1.00% per Year**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 2,431 | 49% | 58% |
| **Green** | **100% funded by 2048 (30 years from 2018)** | **456** | **9%** | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 500 | 10% | 40% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 458 | 9% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 1,057 | 21% | |
| Red | Insolvent after 2043 (after 20 years) | 94 | 2% | 2% |
| Dark Red | Insolvent by 2043 (within 20 years) | 4 | 0% | |

* Based on 5,000 simulations

**Long-Term View Signal Light Results for Judicial Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Assumes Active Membership Grows by 0.25% per Year**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| **Dark Green** | **100% Funded by 2041 (30 years from 2011)** | **2,833** | **57%** | 65% |
| **Green** | 100% funded by 2048 (30 years from 2018) | 428 | 8% | |
| **Light Yellow** | 100% funded by 2058 (40 years from 2018) | 439 | 9% | 34% |
| **Yellow** | 100% funded by 2068 (50 years from 2018) | 351 | 7% | |
| **Orange** | Solvent but longer than 50 years to reach 100% funded | 901 | 18% | |
| **Red** | Insolvent after 2043 (after 20 years) | 47 | 1% | 1% |
| **Dark Red** | Insolvent by 2043 (within 20 years) | 1 | 0% | |

* Based on 5,000 simulations

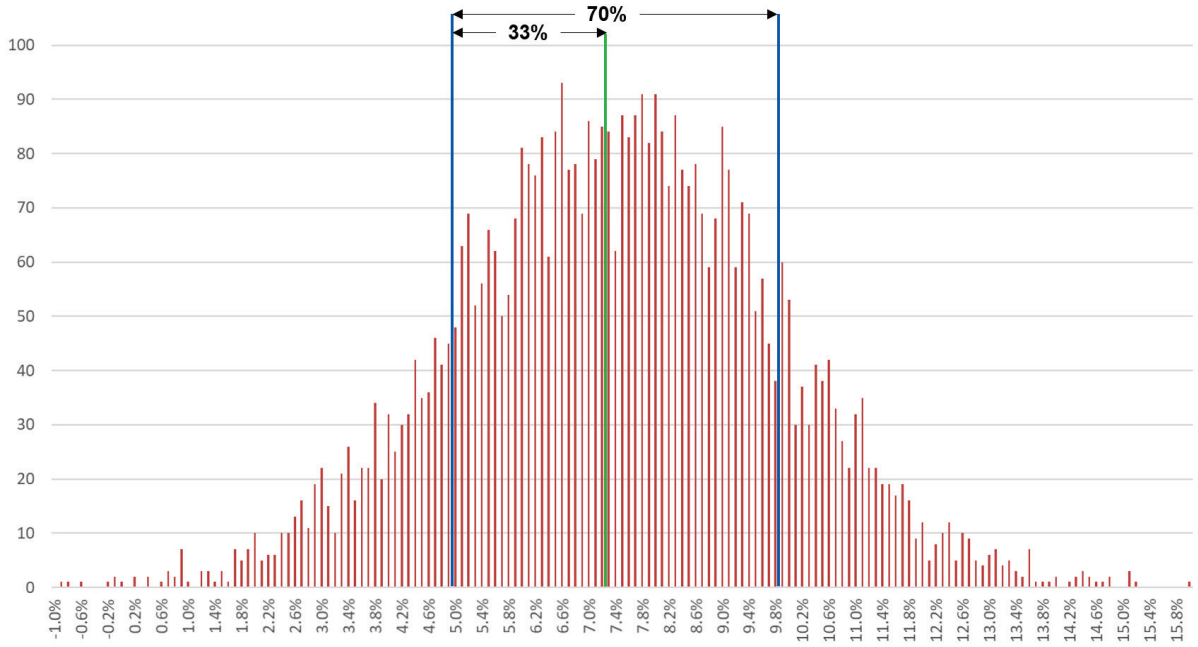
**Long-Term View Signal Light Results for Denver Public Schools Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Assumes Active Membership Grows by 1.00% per Year**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| **Dark Green** | **100% Funded by 2041 (30 years from 2011)** | **2,751** | **55%** | 67% |
| **Green** | 100% funded by 2048 (30 years from 2018) | 599 | 12% | |
| **Light Yellow** | 100% funded by 2058 (40 years from 2018) | 544 | 11% | 33% |
| **Yellow** | 100% funded by 2068 (50 years from 2018) | 395 | 8% | |
| **Orange** | Solvent but longer than 50 years to reach 100% funded | 711 | 14% | |
| **Red** | Insolvent after 2043 (after 20 years) | 0 | 0% | 0% |
| **Dark Red** | Insolvent by 2043 (within 20 years) | 0 | 0% | |

* Based on 5,000 simulations

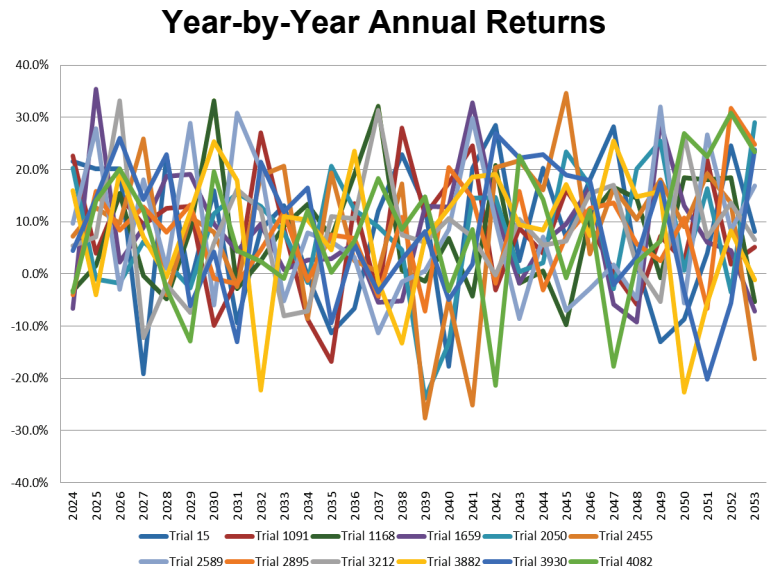
The 50th percentile based on 30-year average geometric returns using Aon's capital market assumptions is 7.5% (with a mean of 7.4%). However, the 5,000 simulated portfolio returns include a wide array of outcomes, which are reflected in the stochastic analysis and depicted in the histogram below (30-year geometric average returns, rounded to the nearest 0.1%).

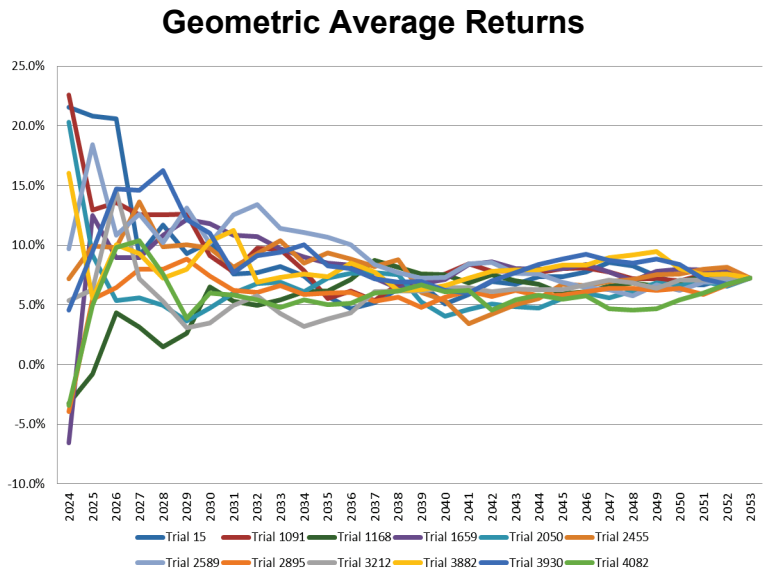
**30-year Geometric Averages from 5,000 Simulated Portfolio Returns**




With the capital market assumptions for each asset class assumed to be normally distributed, the results of the 5,000 simulated portfolio returns approximate a normal distribution. In the chart above, the largest cluster of outcomes were near the mean return of 7.4% and the majority are within one standard deviation from the mean (between 5.0% and 9.8%), which represents about 70% of all outcomes. However, that leaves about 30% of outcomes that fall outside of that range (i.e., below 5.0% or above 9.8%). In addition, about one-third of the 30-year average geometric returns fall between 5.0% and PERA's assumed rate of investment return of 7.25%.

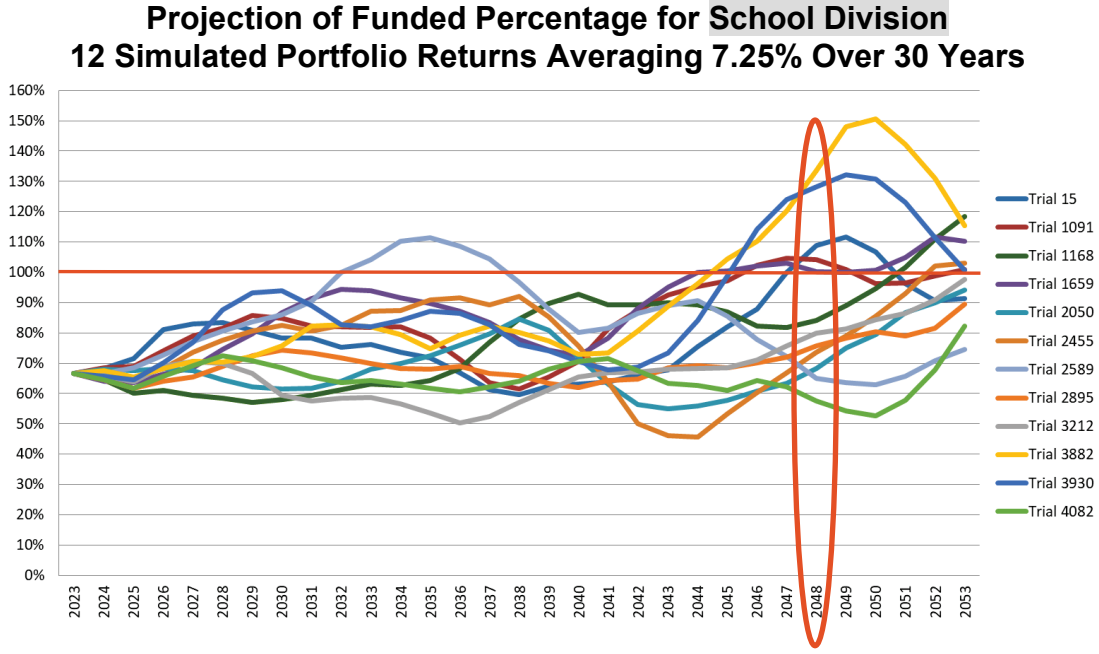
Annual year-to-year volatility within an individual trial can have a material impact on projected funded percentages, even for scenarios that have similar average returns, because of projected cash flows (member and employer contributions into the Plan relative to benefit payments, refunds, and administrative expenses paid out of the Plan). To demonstrate this, consider the following 12 portfolio simulations (out of the 5,000 used in the stochastic analysis), which all have 30-year average returns of 7.25% – PERA's assumed rate of investment return.




The graph above on the left shows year-by-year portfolio returns and is meant to illustrate the degree of volatility that can be found within the simulated portfolio return scenarios. The graph on the right shows the compound geometric average returns through each year and illustrates how the volatility within each scenario is offsetting, resulting in geometric average returns that converge to 7.25% for each of the 12 simulations.

A single $1,000 initial investment accumulates to $8,164 in 30 years in each of the return simulations above. However, the PERA Division Trust Funds have more complex cash flows, which can lead to vastly different outcomes over long periods of time. The graph below shows the projected School Division funded percentage over the same 30-year projection period, illustrating a wide array of outcomes based on the timing and volatility of annual portfolio returns. Note that in some scenarios, the School Division Trust Fund does not meet its funding policy goal of full funding by 2048, despite the average rate of return meeting the assumption over the period.



# Section 4: Sensitivity on Other Assumptions

While actual investment return is the most critical driver of future full funding dates, many other assumptions are used in the actuarial valuation and projections. Variances in these assumptions over the long-term could also have an impact on the date of full funding. Important non-investment assumptions include salary increases and population growth (when viewed in combination represent growth in total payroll), as well as other demographic assumptions (including mortality, retirement, and withdrawal).

In addition, adverse experience could occur in most/all of the assumptions (e.g., low population and salary growth, and other actuarial losses), which when combined, would extend the date the Plan is projected to reach full funding. However, variations in these assumptions do not have as significant an impact as those resulting from variations in the investment return. These demographic assumptions add to the uncertainty associated with investment return, making outcomes at the extreme ranges somewhat more likely.

A normal distribution was used for both of these non-investment assumptions. For the payroll growth assumption (again, representative of population growth and salary increases), the expected mean used for this study is the current assumption for total payroll growth, which is 3%. For the other demographic assumptions, we assume that actual experience is expected to match the current assumptions, so the mean is zero, meaning 0.0% gain and 0.0% loss. PERA's historical data is used to develop the mean and standard deviations of total payroll and demographic gain and loss.

| Assumption | Expected Mean | Standard Deviation[6] Over 1-Year Period | Standard Deviation[6] Over 50-Year Period |
|---|---|---|---|
| Payroll increase | 3.00% | 3.00% | 0.42% |
| Demographic experience | 0.00% | 0.81% | 0.11% |

These means and standard deviations are then used to simulate year-by-year deviations from the assumptions for each of the 5,000 trials in the simulation. In this way experience for all variables can be modeled in a more random, stochastic fashion. Following is a chart of each assumption's expected mean value and standard deviation, over a 1-year period and over a 50-year period. Due to the limited impact these other variables have on the outcomes, they are evaluated individually only for the State and School Divisions.

[6] Based on the actual experience over 30 years (1994-2023).

**Long-Term View Signal Light Results for State Division**
**(Based on Deviations in Total Payroll Growth)**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 0 | 0% | 97% |
| Green | **100% funded by 2048 (30 years from 2018)** | **4,856** | **97%** | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 144 | 3% | 3% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 0 | 0% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 0 | 0% | |
| Red | Insolvent after 2043 (after 20 years) | 0 | 0% | 0% |
| Dark Red | Insolvent by 2043 (within 20 years) | 0 | 0% | |

* Based on 5,000 simulations

**Long-Term View Signal Light Results for State Division**
**(Based on Other Demographic Gains and Losses[7])**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 1 | 0% | 97% |
| Green | **100% funded by 2048 (30 years from 2018)** | **4,838** | **97%** | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 161 | 3% | 3% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 0 | 0% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 0 | 0% | |
| Red | Insolvent after 2043 (after 20 years) | 0 | 0% | 0% |
| Dark Red | Insolvent by 2043 (within 20 years) | 0 | 0% | |

* Based on 5,000 simulations

[7] Could include mortality, retirement, and withdrawal gains and losses.

**Long-Term View Signal Light Results for School Division**
**(Based on Deviations in Total Payroll Growth)**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 0 | 0% | 17% |
| Green | 100% funded by 2048 (30 years from 2018) | 863 | 17% | |
| **Light Yellow** | **100% funded by 2058 (40 years from 2018)** | **4,116** | **83%** | 83% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 21 | 0% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 0 | 0% | |
| Red | Insolvent after 2043 (after 20 years) | 0 | 0% | 0% |
| Dark Red | Insolvent by 2043 (within 20 years) | 0 | 0% | |

* Based on 5,000 simulations

**Long-Term View Signal Light Results for School Division**
**(Based on Other Demographic Gains and Losses[8])**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 0 | 0% | 33% |
| Green | 100% funded by 2048 (30 years from 2018) | 1,673 | 33% | |
| **Light Yellow** | **100% funded by 2058 (40 years from 2018)** | **3,322** | **67%** | 67% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 5 | 0% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 0 | 0% | |
| Red | Insolvent after 2043 (after 20 years) | 0 | 0% | 0% |
| Dark Red | Insolvent by 2043 (within 20 years) | 0 | 0% | |

* Based on 5,000 simulations

[8] Could include mortality, retirement, and withdrawal gains and losses.

Over a long projection period, experience gains and losses due to salary increases, population growth and other demographic experience are expected to be relatively concentrated around the expected mean value. Furthermore, experience studies throughout the projection period will result in changes to assumptions, with the expectation that each revised assumption set, should reduce actuarial gains and losses resulting from the prior assumption set. Because of the relatively limited impact that these variables have on the overall funding results, this translates to minimal variability among the possible outcomes. In each scenario, the investment returns are assumed to be 7.25% each year in the future, and with no variation to total payroll growth and demographic gain and loss variables, the projected number of years to reach 100% funded for the State Division and School Division is 22 years (2046) and 26 years (2050), respectively. Thus, all of the last four tables have a high probability of meeting the respective status definitions (based on deviations of non-investment experience only) with slight variability.

When total payroll growth for the State Division is reviewed, we find that there are 144 (out of 5,000) scenarios that cause the year of expected full funding to move more than two years (i.e., past 2048) and therefore fall into the **Light Yellow** status. The average total payroll growth loss over the first 24 years of those 144 scenarios is 1.20%; compared to the assumption of 3.00% represents an average increase in total payroll of 1.80% for those 144 scenarios.

All of the above analysis is based on the premise that the current demographic assumptions represent the mean expected outcome. Actuarial assumptions are designed to target an average future outcome, understanding that there will be deviations from year-to-year that generate annual gains and losses over time. However, systemic shifts may occur over time that cause emerging experience to differ from expectations one direction more than the other. For example, a tendency for members to stay employed longer than historically observed or life expectancies exceeding predictions. In these cases, changes to actuarial assumptions are required, which accelerates what would otherwise emerge as consistent gains or losses and causes an immediate increase or decrease in actuarial liabilities. The impact of these types of changes typically exceeds the impact from “normal” volatility in emerging experience as illustrated earlier.

The 2020 Experience Analysis reflected a situation where the most recent historical experience – particularly related to turnover and retirement decrements – was different than expected pursuant to the actuarial assumptions in use at that time. This analysis led to recommended updates to the actuarial assumptions. In accordance with common practice, each of the recommended assumptions were set in between the prevailing assumption and the noted experience. By employing the practice of moving actuarial assumptions toward the noted trend, but not recognizing 100% of recent trend, the actuarial valuation and funding process do not “overreact” to short-term, or more recent experience only.

Presume, for illustrative purposes, that the noted historical experience preceding the 2020 Experience Analysis was, in fact, fully indicative of future trends. In this case, further changes in actuarial assumptions to mitigate future actuarial losses would be required. To quantify the potential impact this could have, we have created projections that use alternative turnover, retirement, disability incidence, and salary increase assumptions based entirely on the most recent historical experience leading up to the 2020 Experience Analysis (calendar years 2016 to 2019). Note that the next full experience study is scheduled for Fall 2024.

The following charts illustrate the Signal Light results based on stochastically simulated investment returns for the State and School Divisions using hypothetical actuarial assumptions

that fully reflect noted experience occurring during the four valuation years prior to the 2020 Experience Analysis.

**Long-Term View Signal Lights for State Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Using Hypothetical Actuarial Assumptions Fully Reflecting 2016-2019 Experience**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 1,458 | 29% | 41% |
| Green | 100% funded by 2048 (30 years from 2018) | 587 | 12% | |
| **Light Yellow** | **100% funded by 2058 (40 years from 2018)** | **625** | **12%** | 55% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 534 | 11% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 1,597 | 32% | |
| Red | Insolvent after 2043 (after 20 years) | 192 | 4% | 4% |
| Dark Red | Insolvent by 2043 (within 20 years) | 7 | 0% | |

* Based on 5,000 simulations

**Long-Term View Signal Lights for School Division**
**Stochastic Modeling of Investment Return – Open Group Projection Basis**
**Using Hypothetical Actuarial Assumptions Fully Reflecting 2016-2019 Experience**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 1,035 | 21% | 30% |
| Green | 100% funded by 2048 (30 years from 2018) | 457 | 9% | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 510 | 10% | 62% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 483 | 10% | |
| **Orange** | **Solvent but longer than 50 years to reach 100% funded** | **2,115** | **42%** | |
| Red | Insolvent after 2043 (after 20 years) | 393 | 8% | 8% |
| Dark Red | Insolvent by 2043 (within 20 years) | 7 | 0% | |

* Based on 5,000 simulations

Compared to the baseline Signal Light results, application of the hypothetical demographic assumptions result in the State Division remaining in **Light Yellow** status but inching closer to **Yellow** status and the School Division dropping from **Yellow** to **Orange** status. For the State Division, the probability of falling into one of the green statuses declines from 43% to 41%. For the School Division, the probability of falling into one of the green statuses declines from 35% to 30%.

Compared to the baseline projection of the projected number of years until 100% funded, application of the hypothetical demographic assumptions based upon a replication of recent (2016-2019) experience would cause the State Division to decrease from 22 years to 20 years whereas the School Division would remain the same at 26 years. Using these alternate assumptions in connection with the December 31, 2023, actuarial valuation would result in AAP test ratio of 97.53% and thereby triggering member and employer contribution increases and a decrease to the AI cap effective July 1, 2025. In addition, the last remaining AAP would be expected to trigger in the December 31, 2025, actuarial valuation, with contribution increases and a decrease to the AI cap effective July 1, 2027. These earlier AAP triggers (compared to those expected in 12 and 21 years under the baseline) result in the State Division reaching 100% funded slightly earlier than compared to the baseline and result in no change in projected full funding year for the School Division.

As part of the Board's ongoing gauging of the performance of the actuarial assumptions compared to actual plan experience, the next experience study, which will be based on the 4-year period January 1, 2020, through December 31, 2023, is scheduled to occur later in 2024.

# Section 5: Sensitivity on All Assumptions

To complete the Signal Light analysis, we have aggregated the sensitivity of these other actuarial assumptions with the investment rate of return for all five divisions. All three variables were modeled stochastically (and determined independently from one another) for each of the 5,000 trials. The number of scenarios meeting the status definitions were adjusted based on the relationship of the investment return-only results under this normal distribution condition compared to the stochastically modeled results.

**Long-Term View Signal Light Results for State Division**
**Assumes Active Membership Grows by 0.25% per Year**
**Based on All Assumptions[9]**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 1,473 | 29% | 42% |
| Green | 100% funded by 2048 (30 years from 2018) | 652 | 13% | |
| **Light Yellow** | **100% funded by 2058 (40 years from 2018)** | **637** | **13%** | 52% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 530 | 11% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 1,411 | 28% | |
| Red | Insolvent after 2043 (after 20 years) | 256 | 5% | 6% |
| Dark Red | Insolvent by 2043 (within 20 years) | 41 | 1% | |

* Based on 5,000 simulations

[9] Assumes each of the variables are stochastically modeled independently of one another.

**Long-Term View Signal Light Results for School Division**
**Assumes Active Membership Grows by 1.00% per Year**
**Based on All Assumptions[10]**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 1,225 | 25% | 36% |
| Green | 100% funded by 2048 (30 years from 2018) | 548 | 11% | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 551 | 11% | 56% |
| **Yellow** | **100% funded by 2068 (50 years from 2018)** | **495** | **10%** | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 1,762 | 35% | |
| Red | Insolvent after 2043 (after 20 years) | 386 | 7% | 8% |
| Dark Red | Insolvent by 2043 (within 20 years) | 33 | 1% | |

* Based on 5,000 simulations

**Long-Term View Signal Light Results for Local Government Division**
**Assumes Active Membership Grows by 1.00% per Year**
**Based on All Assumptions[10]**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 2,434 | 49% | 58% |
| **Green** | **100% funded by 2048 (30 years from 2018)** | **457** | **9%** | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 510 | 10% | 39% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 421 | 9% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 995 | 20% | |
| Red | Insolvent after 2043 (after 20 years) | 174 | 3% | 3% |
| Dark Red | Insolvent by 2043 (within 20 years) | 9 | 0% | |

* Based on 5,000 simulations

[10] Assumes each of the variables are stochastically modeled independently of one another.

**Long-Term View Signal Light Results for Judicial Division**
**Assumes Active Membership Grows by 0.25% per Year**
**Based on All Assumptions[11]**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 2,833 | 57% | 65% |
| Green | 100% funded by 2048 (30 years from 2018) | 416 | 8% | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 442 | 9% | 33% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 311 | 6% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 887 | 18% | |
| Red | Insolvent after 2043 (after 20 years) | 110 | 2% | 2% |
| Dark Red | Insolvent by 2043 (within 20 years) | 1 | 0% | |

* Based on 5,000 simulations

**Long-Term View Signal Light Results for Denver Public Schools Division**
**Assumes Active Membership Grows by 1.00% per Year**
**Based on All Assumptions[11]**

| Status | Definition | Number of Scenarios Meeting* | Probability of Meeting | |
|---|---|---|---|---|
| Dark Green | 100% Funded by 2041 (30 years from 2011) | 2,744 | 55% | 67% |
| Green | 100% funded by 2048 (30 years from 2018) | 582 | 12% | |
| Light Yellow | 100% funded by 2058 (40 years from 2018) | 527 | 11% | 33% |
| Yellow | 100% funded by 2068 (50 years from 2018) | 398 | 8% | |
| Orange | Solvent but longer than 50 years to reach 100% funded | 745 | 14% | |
| Red | Insolvent after 2043 (after 20 years) | 4 | 0% | 0% |
| Dark Red | Insolvent by 2043 (within 20 years) | 0 | 0% | |

* Based on 5,000 simulations

[11] Assumes each of the variables are stochastically modeled independently of one another.

A metric established in Senate Bill (SB) 18-200 to gauge whether PERA is on track to achieve full funding by 2048 is having at least a 67% likelihood of such occurrence when measured periodically. The benchmark of a "67% probability of PERA achieving full funding by 2048" does not necessarily coordinate and may even conflict with the structure of the AAP test and any resulting adjustments also legislated within SB 18-200. Based on the analysis in this section, the probability of PERA (in aggregate) being 100% funded by 2048 is approximately 42%. The probabilities of each PERA division being 100% funded by 2048 are:

| Division Trust Fund | Signal Light Probability of 100% Funded by 2048 |
|---|---|
| State | 42% |
| School | 36% |
| Local Government | 58% |
| Judicial | 65% |
| Denver Public Schools | 67% |
| All Divisions Combined | 42% |

In the above Signal Light reporting analysis, a scenario is counted as meeting a certain status definition if: 1) the funded percentage in the specified year is greater than or equal to 100%; 2) the funded percentage beyond the specified year remains greater than 100%; and 3) the funded percentage prior to the specified year is always greater than 0%. For purposes of evaluating the SB 18-200 goal of full funding by 2048, this method of counting scenarios and determining probabilities is conservative. By counting ANY scenarios that achieve full funding by 2048 (including those that eventually drop back below 100% subsequent to 2048[12]), the probability of PERA (in aggregate) being 100% funded by 2048 is approximately 56% instead of 42%. The probabilities of each PERA division being 100% funded by 2048 would also be greater as shown below:

| Division Trust Fund | Alternative Probability of 100% Funded by 2048 |
|---|---|
| State | 56% |
| School | 50% |
| Local Government | 74% |
| Judicial | 81% |
| Denver Public Schools | 85% |
| All Divisions Combined | 56% |

[12] For example, a scenario where the funded percentage on December 31, 2047, exceeds 100% but on December 31, 2050, has fallen below 100%.

By counting scenarios that achieve full funding prior to 2048 (including those that subsequently drop back below 100%, even if prior to 2048[13]), the probabilities would be even greater. The probability for PERA (in aggregate) would be approximately 62% and by Division would be:

| Division Trust Fund | Alternative Probability of 100% Funded by 2048 |
|---|---|
| State | 61% |
| School | 56% |
| Local Government | 82% |
| Judicial | 88% |
| Denver Public Schools | 91% |
| All Divisions Combined | 62% |

[13] For example, a scenario where the funded percentage on December 31, 2044, exceeds 100% but on December 31, 2047, has fallen below 100%.

# Section 6: Short-Term View

The Signal Light analysis and this report primarily focus on long-term projections over a period of 30 or more years. However, a look at the near-term can also provide valuable information about the impact of certain risks to PERA. On a one-year basis, this section examines the expected AAP ratio projected to December 31, 2024, and stress tests how actual demographic and investment experience during 2024 would affect the projected ratio. Looking out over the next ten years, this section models the likelihood of triggering future AAP adjustments based on stochastically modeled investment experience under different demographic scenarios.

## One-Year Analysis

The one-year projection of the AAP ratio can be modeled with three key variables for experience during the year:

- Market value investment return for the year – baseline assumption is 7.25%
- Increase in total payroll for the year – baseline assumption is 3.00%
- Level of demographic gain/loss for the year[14] – baseline assumption is 0.00%

By rolling forward the December 31, 2023, actuarial valuation results and relying on the baseline assumptions outlined above for experience during 2024, the expected AAP ratio as of December 31, 2024, is 104.4%. This reflects an approximate 4.89% return on the actuarial value of assets due to an assumed 7.25% market value return on assets and recognizing a portion of deferred investment losses. An AAP ratio of 104.4% as of December 31, 2024, would not result in any additional AAP adjustments effective July 1, 2026.

In order for the projected AAP ratio as of December 31, 2024, to be lower than 98% or greater than 120% (and therefore trigger a series of AAP adjustments), experience for 2024 of any single variable above (assuming the other two variables meet their respective assumptions for the year) would need to be:

| Variable | AAP Ratio of 98% or Less | AAP Ratio of 120% or More |
|---|---|---|
| Market value investment return | Worse than −23.5% | Better than 70.2% |
| Year-over-year change in total payroll | Lower than 8.1% decrease | Higher than 35.0% increase |
| Demographic experience | More than 4.7% loss | More than 9.5% gain |

For context, there is only one occurrence of one of the variables falling outside of the thresholds outlined above in the last 30 years: a −26.0% market value investment return in 2008. The

[14] Note, to prevent double-counting, the level of demographic gain/loss would not include any gain or loss from salary experience that contributed to the total increase in payroll.

lowest year-over-year change in total payroll was a 2.5% decrease, which occurred in 2012. The largest demographic loss (as a percentage of actuarial accrued liability) was 2.2% in 2002.

In order for the projected AAP ratio to be lower than 98%, experience for 2024 of any two variables above (assuming the third variable meets expectations) would be:

- 0% market value investment return and 5.5% or lower decrease in payroll
- 0% market value investment return and 3.6% or more demographic loss

- 0% increase in total payroll and −9.1% or lower market value investment return
- 0% increase in total payroll and 2.5% or more demographic loss

- 1% demographic loss and –17.0% or lower market value investment return
- 1% demographic loss and 5.7% or lower decrease in payroll

Similarly, in order for the projected AAP ratio to be greater than 120%, experience for 2024 of any two variables above (assuming the third variable meets expectations) would be:

- 20% market value investment return and 38.6% or higher increase in payroll
- 20% market value investment return and 7.6% or more demographic gain

- 6% increase in total payroll and 58.5% or higher market value investment return
- 6% increase in total payroll and 7.6% or more demographic gain

- 1% demographic gain and 63.7% or higher market value investment return
- 1% demographic gain and 38.2% or more increase in payroll

Note that not all of the three static parameters above (0% investment return, flat year-over-year payroll, and a 1% loss from demographic experience or 20% investment return, 6% increase in payroll, and a 1% gain from demographic experience) are “equally likely”, but they do represent anecdotal metrics for “worse-than-expected” and “better-than-expected” experience in a given year. For context, over the last 30 years, a market value return of 0% or lower has occurred five times, a 1% or more demographic loss has occurred five times, and a 0% or lower decrease in total payroll has occurred four times. A market value return of 20% or greater has occurred four times, a 1% or more demographic gain has occurred two times, and a 6% or higher increase in total payroll has occurred eight times.

For illustrative purposes and using this deterministic model, we can assume that each variable is 100% correlated and operates under a normal distribution, which will serve to provide a general sense of the relative volatility of the ultimate funding status of the Plan in the presence of natural variability. In other words, if the investment return is assumed to occur at the mean value of 7.25%, then experience for total payroll increase and demographic gain/loss also occur at their mean values of 3% and 0%, respectively. Similarly, when the investment return is modeled at plus one-half standard deviation from the mean (equivalent to an annual return of 14.63%), the total increase in payroll and demographic experience also are modeled at plus

one-half standard deviations from those variables' respective means, or an increase in payroll of 4.50%[15] and demographic gain of 0.41%, respectively.

We have determined that based on one-year values for mean and standard deviation, experience for 2024 at or worse than 1.22 standard deviations to the left of the mean would result in a projected AAP ratio lower than 98%. This equates to:

- −7.1% or lower market value investment return;
- 0.7% or lower decrease in total payroll; and
- 1.0% or more demographic loss.

Putting this in estimated probabilistic terms, 1.22 standard deviations or more to the left of the mean is expected to occur 11% of the time under the normal distribution.

Similarly, we have determined that based on one-year values for mean and standard deviation, experience for 2024 at or better than 2.59 standard deviations to the right of the mean would result in a projected AAP ratio greater than 120%. This equates to:

- 41.0% or higher market value investment return;
- 10.8% or more increase in total payroll; and
- 2.1% or more demographic gain.

Again, putting this scenario in terms of estimated probability, 2.59 standard deviations or more to the right of the mean is expected to occur 0.5% of the time under the normal distribution.

The reality is that more than three variables are involved in the actual asset and liability experience for the current year and as previously discussed these variables are unlikely to be perfectly correlated (and more likely to have little correlation) with one another. However, for purely illustrative purposes, this exercise does give some sense as to what types of circumstances, as measured within the December 31, 2024, actuarial valuation, that would trigger additional AAP adjustments, in either direction, to be effective July 1, 2026.

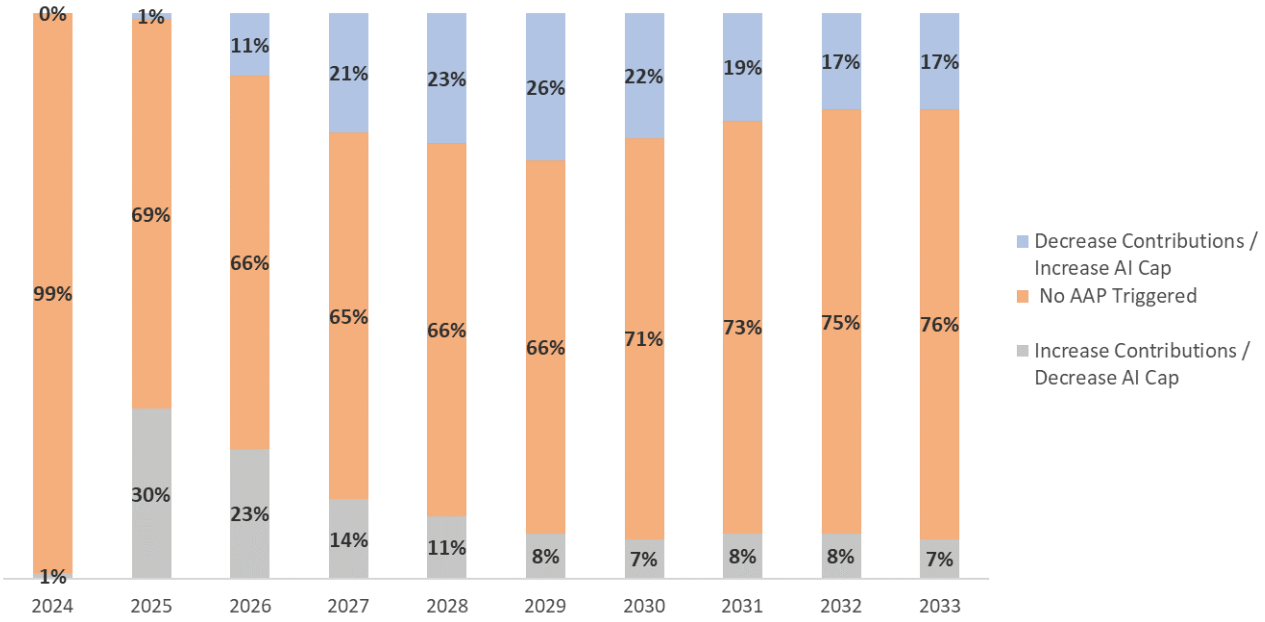
[15] A standard deviation of 3.00% for total payroll growth relative to expected was calculated based on 30 years of historical covered payroll increases for 1994-2023 compared to the existing assumption for payroll growth in effect for each year.

# Ten-Year Analysis

## Scenario: Baseline Liability Forecast

Using the 5,000 stochastically modeled investment return simulations and the baseline open group liability projection results, we have estimated the PERA AAP ratio in each scenario for the following ten valuation years. Based on these results, the probability in each year of the AAP test triggering contribution increases and a reduction in the AI cap (from an AAP ratio below 98%) or triggering contribution decreases and an increase in the AI cap (from an AAP ratio exceeding 120%) are determined and illustrated in the following graphic:

**Likelihood of Triggering Automatic Adjustment Provision**
**Baseline Liability Forecast**



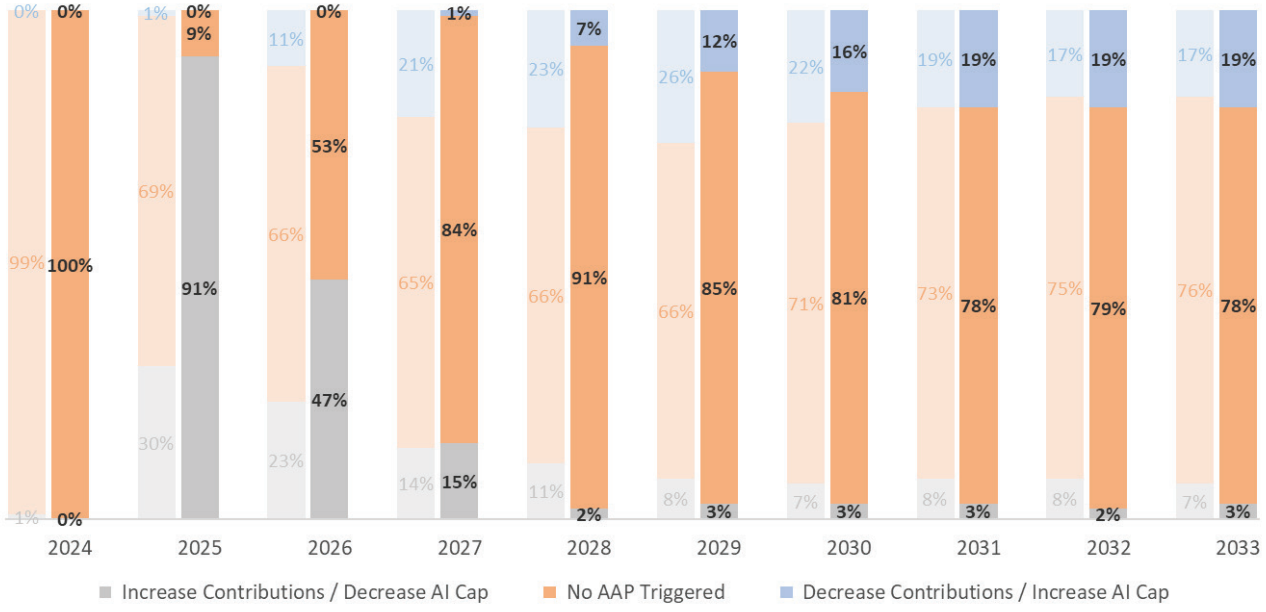

Note that the model used for this scenario and those that follow, each year's results are determined based on results from prior years. The probabilities shown in any one year consider the impact of any potential AAP changes that may have triggered in any prior. For example, the 23% probability of triggering the 98% (lower) boundary of the AAP assessment in the 2026 valuation year considers that 30% of trials triggered an AAP adjustment increasing contributions and lowering the AI cap in the prior valuation year.

Keep in mind that this Signal Light report uses, for all analyses, the plan's actuarial value of assets; a smoothed value of assets, which recognizes the differences between the actual and expected investment experience for each year, in equal amounts, over a four-year period. Although somewhat mitigated by the 2021 and 2023 investment gains, due to the significant investment loss of 2022 there is a net loss yet to be recognized. As the remaining net investment loss is reflected over the next two years, the likelihood of the AAP ratio falling below the 98% (lower) boundary diminishes while the likelihood of the AAP ratio assessment triggering the 120% (upper) boundary begins to increase.

## Scenario: Baseline Liability Forecast Reflecting a −5.75% Investment Return for 2024

To better illuminate possible outcomes given a "less-than-assumed" return for 2024, using the baseline static liability forecast, we reflected a −5.75% investment return (represents one standard deviation to the left of the current assumption) for 2024 and applied the same 5,000 investment return simulations to all subsequent years to generate a new series of AAP ratios. Based on these results, the probability in each year of the AAP test triggering contribution increases and a reduction in the AI cap (from an AAP ratio below 98%) or triggering contribution decreases and an increase in the AI cap (from an AAP ratio exceeding 120%) are determined and illustrated in the following graphic ("baseline" results are shown on the left bar for comparison):

**Likelihood of Triggering Automatic Adjustment Provision**
**Baseline Liability Forecast Reflecting a −5.75% Investment Return for 2024**

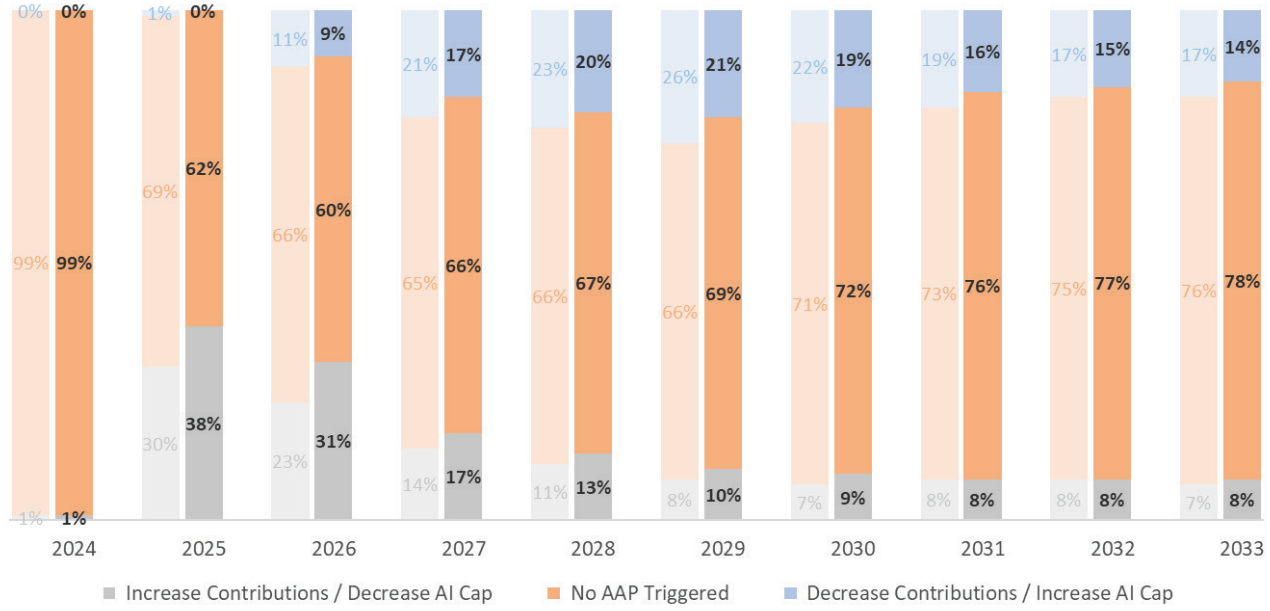



A less-than-assumed investment return for 2024 produces a relatively greater unfunded actuarial accrued liability, which increases the actuarially determined employer contribution (ADC) value in the AAP test. The ADC value is used in the denominator in the AAP ratio, so larger values initially cause relatively lower ratios. When compared to the baseline projections, this scenario produces more outcomes that result in AAP ratios below 98%, triggering contribution increases and AI cap decreases. In other words, a "known" return of −5.75% for 2024 is not enough to cause an AAP ratio below 98% in the December 31, 2024, actuarial valuation, but would create a situation where an AAP ratio below 98% is highly likely in the December 31, 2025, actuarial valuation.

## Scenario: Alternate Liability Forecast Reflecting Flat 0% Payroll Growth

Stress testing results for "worse-than-expected" payroll growth experience, we created an alternate static liability forecast reflecting flat year-over-year payroll and applied the same 5,000 investment return simulations to generate a new series of AAP ratios. Based on these results, the probability in each year of the AAP test triggering contribution increases and a reduction in the AI cap (from an AAP ratio below 98%) or triggering contribution decreases and an increase in the AI cap (from an AAP ratio exceeding 120%) are determined and illustrated in the following graphic ("baseline" results are shown on the left bar for comparison):

**Likelihood of Triggering Automatic Adjustment Provision**
**Alternate Liability Forecast Reflecting Flat 0% Payroll Growth**

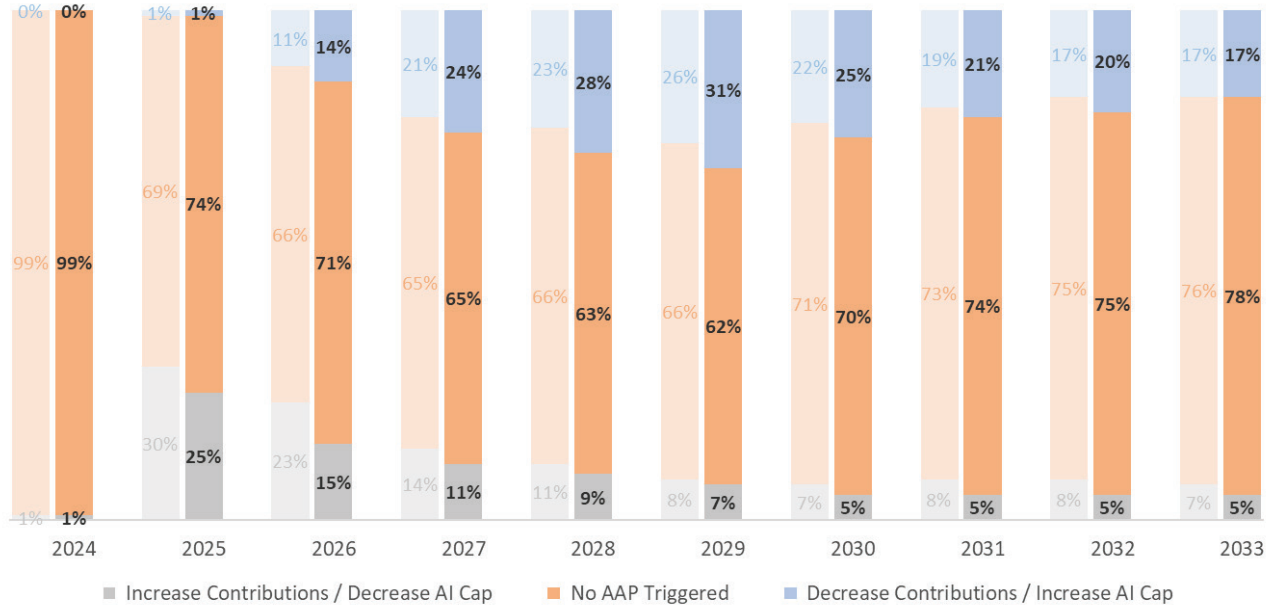



Since contributions are collected as a percentage of payroll, lower levels of future total payroll translate to fewer contributions into PERA, which delays funding progress. When compared to the baseline projections, this scenario produces more outcomes resulting in AAP ratios below 98%, triggering contribution increases and AI cap decreases. Sustained periods of no growth in covered payroll may be unlikely but are not impossible.

## Scenario: Alternate Liability Forecast Reflecting 4% Payroll Growth (1% More Than Assumed)

On the other hand, increases in total payroll greater than expected could emerge under the right circumstances. In this case, relatively higher levels of payroll would translate into more contributions flowing into PERA, which could lead to more outcomes where the AAP test results in ratios that exceed 120%, triggering contribution decreases and AI cap increases. For purposes of testing the sensitivity of higher than assumed payroll growth experience, we ran the projection model with additional increases in payroll each year (above those included in the baseline liability forecast) to achieve annual increases in payroll of 4%. We then applied the same 5,000 investment return simulations to generate a new series of AAP ratios. Based on these results, the probability in each year of the AAP test triggering contribution increases and a reduction in the AI cap (from an AAP ratio below 98%) or triggering contribution decreases and an increase in the AI cap (from an AAP ratio exceeding 120%) are determined and illustrated in the following graphic ("baseline" results are shown on the left bar for comparison):

**Likelihood of Triggering Automatic Adjustment Provision**
**Alternate Liability Forecast Reflecting 4% Payroll Growth**
**(1% More Than Assumed)**

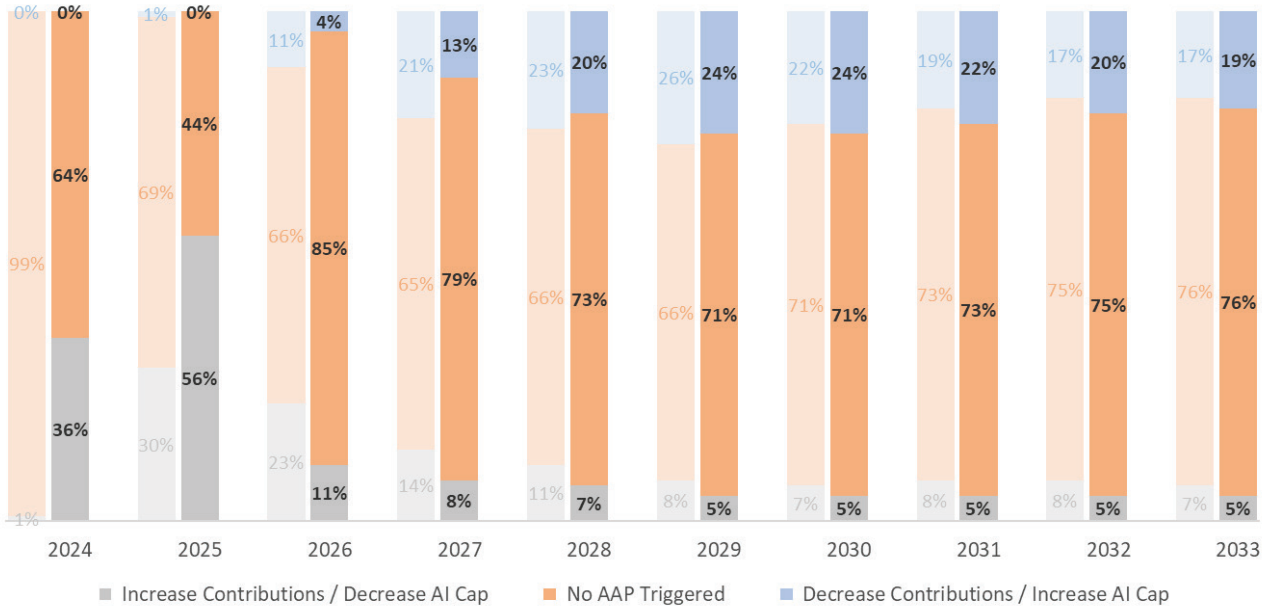



When compared to the baseline projections, this scenario produces fewer outcomes that result in AAP ratios below 98%. In fact, more scenarios that result in AAP ratios above 120%, triggering contribution decreases and AI cap increases, begin to appear.

## Scenario: Alternate Liability Forecast Reflecting a 7.00% Investment Return Assumption

Liability measures in the scenarios above are all based on PERA's investment return assumption of 7.25%. In the next scenario, rather than stress-testing actual experience against the current assumption, we demonstrate the impact that a lower investment return would have on projected AAP tests in the short-term. For this, we created an alternate static liability forecast reflecting a 7.00% investment return assumption, which is 25 basis points below the current assumption, and applied the same 5,000 investment return simulations to generate a new series of AAP ratios. Based on these results, the probability in each year of the AAP test triggering contribution increases and a reduction in the AI cap (from an AAP ratio below 98%) or triggering contribution decreases and an increase in the AI cap (from an AAP ratio exceeding 120%) are determined and illustrated in the following graphic ("baseline" results are shown on the left bar for comparison):

**Likelihood of Triggering Automatic Adjustment Provision**
**Alternate Liability Forecast Reflecting a 7.00% Investment Return Assumption**




A lower investment return assumption initially creates relatively higher actuarial accrued liability and normal cost, which increases the ADC value in the AAP test. The ADC value is used in the denominator in the AAP ratio, so larger values initially cause relatively lower ratios. When compared to the baseline projections, this scenario produces more outcomes that result in AAP ratios below 98%, triggering contribution increases and AI cap decreases.

# Section 7: Conclusions

The Signal Light reporting process provides a sensitivity analysis of each division's actuarial assumptions on certain full funding targets. This analysis reflects the results and plan experience from the December 31, 2023, actuarial valuation.

## Long-Term View

Segal has determined the likelihood of achieving the investment return and certain demographic assumptions based upon:

- The 30-year capital market assumptions, provided by the Board's investment consultants, at the time the Board last reviewed the investment return of 7.25% (Asset Liability Study concluded in November of 2019)
- The resulting likelihoods of achieving certain returns based upon 50-year probability outlooks prepared at the time
- The provisions of SB 18-200, reflecting the AAP, initiating adjustments for
  - employer contributions,
  - member contributions, and
  - annual increases to benefits,

  with the intent to keep PERA on the path to full funding. The baseline liability forecast reflects the first set of adjustments on July 1, 2020, and the second set of adjustments on July 1, 2022. The model dynamically adjusts future contributions and AI cap based on triggers from future AAP ratio assessments in projected valuation years.

Notwithstanding the initiation of the AAP adjustments and subsequent law changes, Segal has kept the Signal Light status definitions basically the same to compare year-over-year results.

Going forward, short-term variations, both positive and negative, are to be expected given the volatility inherent in the actual investment return from year to year. The following tables pertain to the Signal Light analysis based on "all assumptions", as discussed in Section 5. A summary of the change in the Signal Light reporting from last year to this year is summarized in the following table:

**Signal Light Status – Long-Term View**

| Division | December 31, 2023 | December 31, 2022 |
|---|---|---|
| State | Light Yellow | Yellow |
| School | Yellow | Yellow |
| Local Government | Green | Light Yellow |
| Judicial | Dark Green | Dark Green |
| DPS | Dark Green | Dark Green |

In terms of the SB 18-200 goal of achieving 100% funded by 2048 and monitoring whether PERA is on track vis-à-vis a 67% probability, the following table summarizes the probabilities evaluated in this analysis on the conservative basis of counting scenarios:

| Division | Probability of 100% Funded by 2048 |
|---|---|
| State | 42% |
| School | 36% |
| Local Government | 58% |
| Judicial | 65% |
| DPS | 67% |
| All Divisions Combined | 42% |

As mentioned earlier, the 67% probability benchmark does not necessarily coordinate and may even conflict with the structure of the AAP test and any resulting AAP adjustments also legislated within SB 18-200. This process will require continuous monitoring of the assumptions and methods used in the valuation and projections. Segal will evaluate and update these Signal Light results each year incorporating the PERA Board's assumption and method set as of the most recent valuation date.

## Short-Term View

While PERA's goals are largely focused on the long-term, experience in the short-term can have a significant impact on how those long-term goals are achieved. PERA's AAP ratio test is performed annually as part of the actuarial valuation process and the outcome of this test influences the level of future employer and member contributions as well as increases in annuities in payment status. As part of the Signal Light reporting, Segal evaluates the type of short-term plan experience that could cause changes in contributions and the AI cap.

In order for the projected AAP ratio as of December 31, 2024, to be lower than 98% or greater than 120% (and therefore trigger a series of AAP adjustments), actual investment experience for 2024 (assuming other variables meet their respective assumptions for the year) would need to be worse than −23.5% or better than 70.2%, respectively. The worst-case scenario has occurred in a single year in the last 30 years; the market value rate of return over this period has ranged from a low of −26.0% to a high of 24.6%.

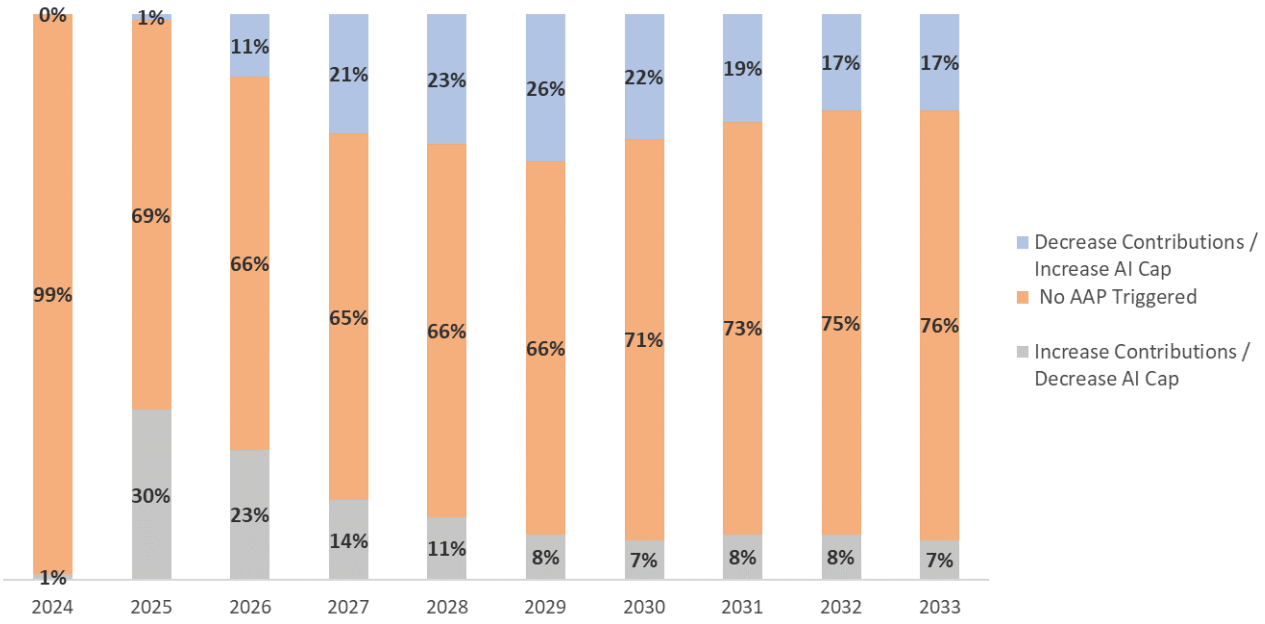
Experience for 2024 related to market value investment return, decrease in total payroll, and level of demographic loss as a percentage of accrued liability would need to be −7.1%, 0.7%, and 1.0% (at or worse than 1.22 standard deviations to the left of the mean), respectively, to result in a projected AAP ratio lower than 98%. In estimated probabilistic terms, 1.22 standard deviations or more to the left of the mean is expected to occur 11% of the time under the normal distribution.

Similarly, experience for 2024 related to market value investment return, increase in total payroll, and level of demographic gain as a percentage of accrued liability would need to be 41.0%, 10.8%, and 2.1% (at or better than 2.59 standard deviations to the right of the mean), respectively, to result in a projected AAP ratio greater than 120%. In estimated probabilistic

terms, 2.59 standard deviations or more to the right of the mean is expected to occur 0.5% of the time under the normal distribution.

It is unlikely that the next actuarial valuation as of December 31, 2024, will result in an AAP ratio that triggers increases to contribution rates and a decrease in the AI cap. Using the investment return simulations from the long-term stochastic analysis, we observe that under the baseline liability forecast there is a 30% likelihood that the AAP ratio will fall below 98% and trigger contribution rate increases and a decrease in the AI cap in connection with the December 31, 2025, actuarial valuation. Scenarios reflecting favorable investment return experience and using the baseline liability forecast yield a 21% likelihood that the AAP ratio will exceed 120% and trigger contribution rate decreases and an increase in the AI cap in year four.

**Likelihood of Triggering Automatic Adjustment Provision**
**Baseline Liability Forecast**



# Section 8: Actuarial Assumptions and Methods and Statistical Approach

For a complete description of the assumptions and methods used, see the Actuarial Valuation and Review as of December 31, 2023.

For all analyses contained in this Signal Light report, the plan's actuarial value of assets (i.e., a smoothed value of assets, which recognizes the differences between the actual and expected investment experience for each year, in equal amounts, over a four-year period) were used.

Additional assumptions used for the projections are as follows:

The statistical methodology was produced in the original sensitivity analysis report completed by Pension Trustee Advisors in 2015, which was initially mandated by Senate Bill (SB) 14-214 and conducted under the direction of the Office of the State Auditor. We have continued this statistical approach as required by C.R.S. § 24-51-204(7.5), with updates as appropriate and at PERA's request.

Variables Studied and Nature of Modeling

The future funding position of PERA depends on many uncertain future events. Because of the uncertainty, it is appropriate to use historical data and expert inputs to estimate the potential variability of these future events and examine the potential impact. Throughout the report, many future events are uncertain and can be analyzed statistically. These include:

- Investment return
- Salary experience[16]
- Growth in the active population[16]
- Mortality experience and other actuarial gains and losses

The modeling in this report is intended to estimate the impact of observed variability in ordinary experience under these sources of risk. We have modeled annual investment return using stochastic modeling. Stochastic projections aggregate thousands of deterministic projections to provide a range of results that can be used to determine likelihood or probability outcomes within a specified range. This approach is used to model complicated distributions such as fund returns with multiple asset classes. In our analysis, the distribution of each asset class was used to model the total fund. The stochastic projections were modeled using 5,000 deterministic trials for each scenario.

[16] For purposes of this Signal Light report, salary increases and active population growth, when viewed in combination, represent growth in total payroll.

The non-investment variables are based on the normal distribution. This model is generally reasonable for modeling variables where for each observation, the outcome is determined by the aggregate result of a large number of individual events with no single dominant driver among the group. This type of model is a better fit for certain components of plan experience than for other components of plan experience.

The following table gives some illustrative examples of items that have an impact on plan funding categorized by how well this type of model fits.

| Events with impact on plan funding that can be modeled as independent events with aggregate experience following a normal distribution | Events with impact on plan funding that are difficult to statistically model |
|---|---|
| Investment returns of individual asset classes over most periods of time | Investment returns that have been affected by a large non-recurring or infrequent event (e.g., a credit crisis or a change in government policy) |
| Year-to-year variation in deaths, retirements, voluntary turnover, and termination for cause | Layoffs, changes in HR policy with an impact on hiring, turnover or retirement patterns, and long-term mortality improvements |
| Variation in inflation component of salary increases and variation in hiring and retention | Structural changes in compensation and staffing policy |
| | Political, economic and environmental changes over time |

The items in the left column have some common elements. These events happen frequently due to a wide variety of specific causes that have a body of data documenting their historical variability. The items on the right can have significant impacts on plan experience and do not occur often enough to make it possible to meaningfully fit a statistical model. It is appropriate to study these types of events as a source of potential impact on a plan, but since it is not possible to empirically quantify these types of events with a statistical model based on historical data and expert inputs, the analysis in this report does not constitute an estimate of the likelihoods of these types of events.

Standard Deviation

Standard deviation is the statistical measure used to quantify the amount of variation on a set of assumptions. While the analysis shows that the average occurrence of an assumption over many years will be near the mean, we need to analyze what possible other outcomes may occur and what is the likelihood of those occurrences.

For example, as shown on page 29 of this report, the one-year standard deviation for the State Division demographic experience is 0.81%. Assuming a normal distribution of this assumption, there is a 68% likelihood that demographic experience in any year will fall within one standard deviation of the mean, between an actuarial gain of 0.81% and an actuarial loss of 0.81%. While one-year time frames have a fairly high range, extending the time horizon to a 50-year period, the standard deviation becomes less volatile and more condensed. The standard deviation over a 50-

year period for demographic experience is approximately 0.11%. Therefore, over a 50-year period, there is a 68% probability that average annual demographic experience will be between an actuarial gain of 0.11% and an actuarial loss of 0.11%. This statistical methodology is used for each of the non-investment independent variables.

Historical data (based on the actual experience over the 30-year period 1994-2023) is used to develop the mean and standard deviations of total payroll and demographic gain and loss. These means and standard deviations are then used to simulate year-by-year deviations from the assumptions for each of the 5,000 trials in the simulation. In this way experience for all variables can be modeled in a more random, stochastic fashion, beginning with the 2024 Signal Light report.

Model Simplifications

Projections used in this Signal Light report are based on a roll forward for each division. Year over year percentage increases in normal cost, active member payroll and benefit payments are determined from the baseline open group forecast used in connection with the annual actuarial valuation. Dynamic changes in a given scenario for potential AAP triggers (i.e., future changes to the AI cap) are estimated based on factors for AAP triggers as of the current year, ten years in the future and twenty years in the future; interim factors are interpolated. It is assumed that the impact of an AI cap change forty years in the future is 0%; therefore, factors for years between twenty-one and thirty-nine are interpolated between the factor determined for year twenty and 0%.

In order to model the effect of the non-investment variables on funding outcomes, we had to relate each one to specific adjustments to a deterministic funding projection model. The variables were incorporated into the projection as follows:

- Demographic gains and losses were assumed to cause a decrease or increase to the accrued liability for each division, which is incorporated into the roll forward calculations. A corresponding decrease or increase in benefit payments subsequent to the year in which the gain or loss was recognized are adjusted by a factor of 60%. In other words, a 1% demographic loss would result in a 1.006 adjustment to projected benefit payments. This approach adjusts future benefit payments for demographic experience such that projected benefit payments in the model are a reasonable percentage of actuarial accrued liability under each scenario.
- Population changes and salary gain/loss were modeled together under one variable for “payroll growth”. Gains and losses on payroll growth were assumed to cause a decrease or increase in the projection of payroll for each division, which is incorporated into the roll forward calculations. Additionally, payroll growth gains and losses were also assumed to cause a decrease or increase to the normal cost for each division, which is incorporated into the roll forward calculations. A corresponding decrease or increase in benefit payments subsequent to the year in which the gain or loss was recognized are adjusted by a factor of 10%. In other words, a 1% demographic loss would result in a 1.001 adjustment to projected benefit payments. This approach adjusts future benefit payments for demographic experience such that projected benefit payments in the model are a reasonable percentage of actuarial accrued liability under each scenario.

The analysis based on all variables was performed by stochastically modeling all variables in tandem, with each variable simulated independently from one another.

Segal results are based on proprietary actuarial modeling software. The actuarial valuation models generate a comprehensive set of liability and cost calculations that are presented to meet regulatory, legislative and client requirements. Deterministic cost projections are based on a proprietary forecasting model. Our Actuarial Technology and Systems unit, comprised of both actuaries and programmers, is responsible for the initial development and maintenance of these models. The models have a modular structure that allows for a high degree of accuracy, flexibility and user control. The client team programs the assumptions and the plan provisions, validates the models, and reviews test lives and results, under the supervision of the responsible actuary.