Appendixes

About the Appendixes

We divided the appendixes into the following sections:

- **Plan-by-Plan Summary of Results:** Provides more detailed results for each individual plan.
- **Certification Letter:** Shows the signing actuaries' certification of results – required by Actuarial Standards of Practice.
- **Model Overview and Methods:** Explains how we arrived at our results.
- **Assumptions and Data:** Describes what we needed to implement our forward-looking model.
- **Model Verification and Validation:** Describes how we checked our model for reasonability.
- **Sensitivity Analysis:** Demonstrates how the results could change if we used different assumptions or methods.

Plan-by-Plan Summary of Results

We provide plan-specific information here since the main body of the report is highly summarized.

Figure A.1.1 shows summary statistics to give an idea about the size and maturity of each plan.

Figure A.1.1

2008 Summary Statistics										
(Dollars in Millions)	PERS 1	PERS 2/3	TRS 1	TRS 2/3	SERS 2/3	PSERS 2	LEOFF 1	LEOFF 2	WSPRS 1/2	Total
Active Count	11,663	150,005	6,061	60,463	51,774	3,981	421	16,626	1,085	302,079
Vested Inactive Count*	56,852	43,537	36,838	11,010	12,473	1	8,135	1,783	949	171,578
Present Value of All Benefits	$14,227	$22,621	$10,937	$7,693	$2,940	$323	$4,383	$6,596	$900	$70,619
Present Value of Earned Benefits	$13,915	$14,065	$10,794	$4,529	$1,906	$30	$4,354	$3,786	$719	$54,098
Actuarial Value of Assets	$9,853	$16,693	$8,262	$5,681	$2,303	$39	$5,592	$5,053	$870	$54,345
Funded Status	71%	119%	77%	125%	121%	127%	128%	133%	121%	100%

**Includes retirees.*

We present the following graphs for each plan under both the continuation of "past practice" (less than 100 percent of ARC and assumed future benefit improvements) and "current law" (100 percent of ARC and no future benefit improvements) projection scenarios:

- **Employer Contribution Rates:** Shows the possible range of employer contribution rates in the future. We show the 5th, 25th, 50th, 75th, and 95th percentiles.
- **Funded Status:** Illustrates the possible range of funded status in the future. We show the 5th, 25th, 50th, 75th, and 95th percentiles.

PERS

- **Pay-As-You-Go:** Demonstrates the probability of running out of assets in the future as well as the 95th percentile of pay-as-you-go costs. These pay-as-you-go costs are in addition to the normal annual contributions paid into the plan.
- **Member Contribution Rates** (if applicable): Exhibits the possible range of Plan 2 member contribution rates in the future (Plan 1 and Plan 2 for WSPRS). We show the 5th, 25th, 50th, 75th, and 95th percentiles.

Figure A.1.2

Projected PERS Total Employer Contribution Rate - Current Law

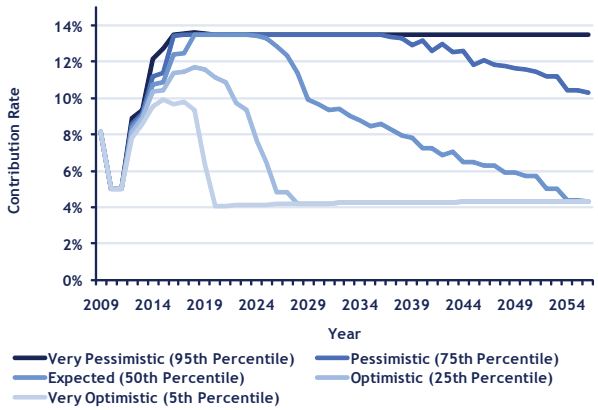


Figure A.1.3

Projected PERS Total Employer Contribution Rate - Past Practice

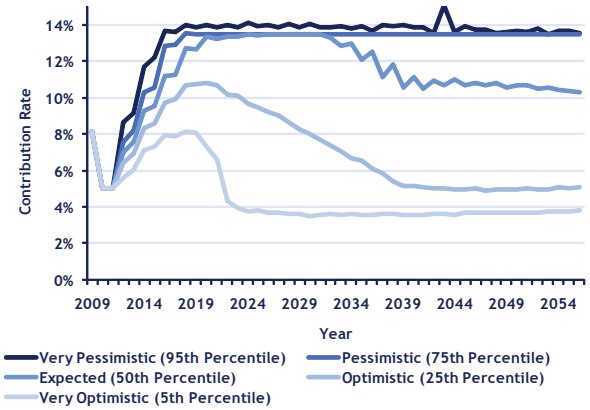


Figure A.1.4

Projected PERS 1 Funded Status - Current Law

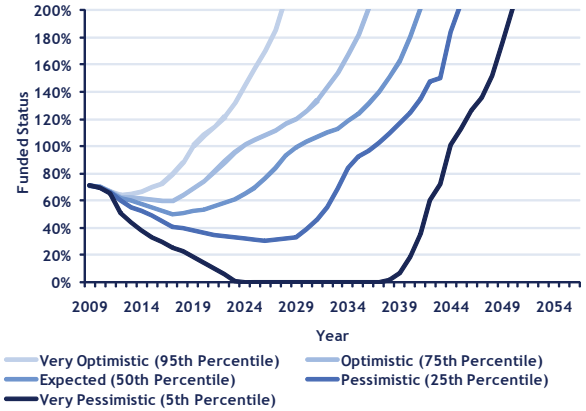
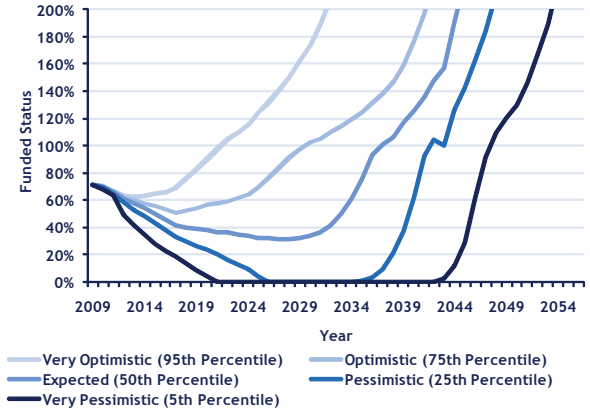


Figure A.1.5

Projected PERS 1 Funded Status - Past Practice



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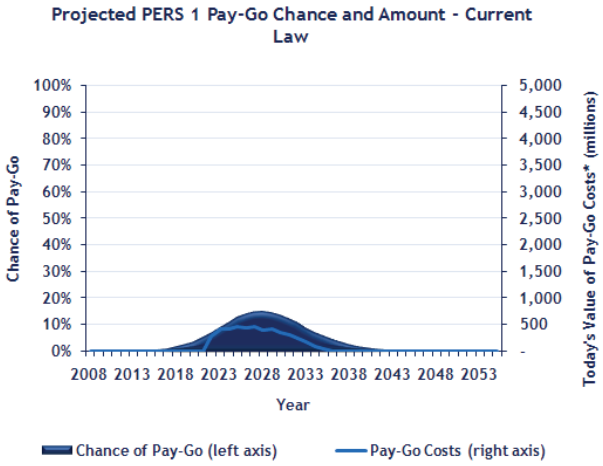
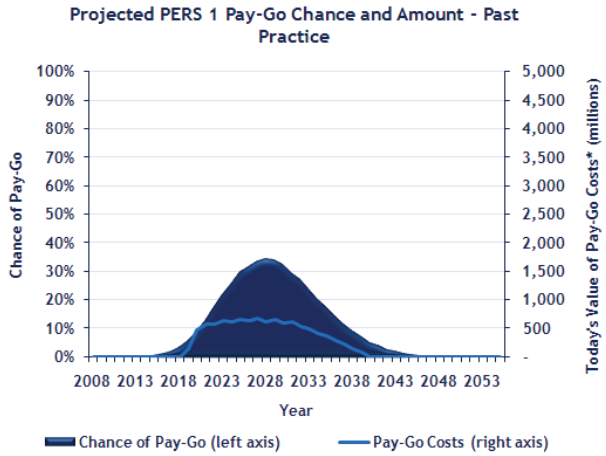


*Pay-Go Costs on top of Normal Pension Costs.

Figure A.1.7



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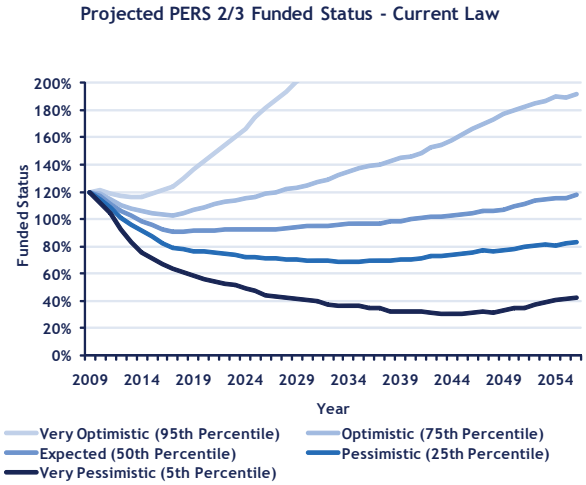

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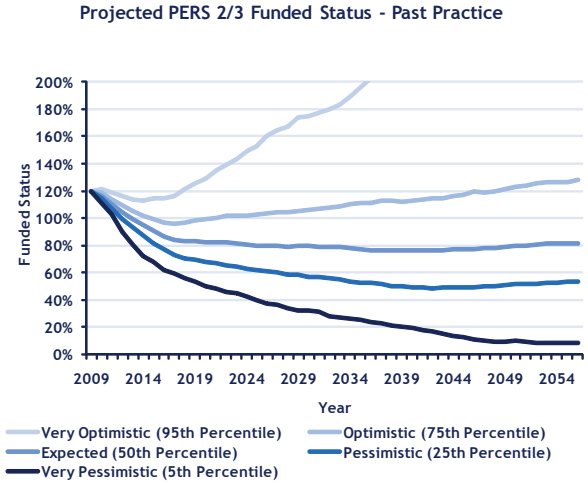

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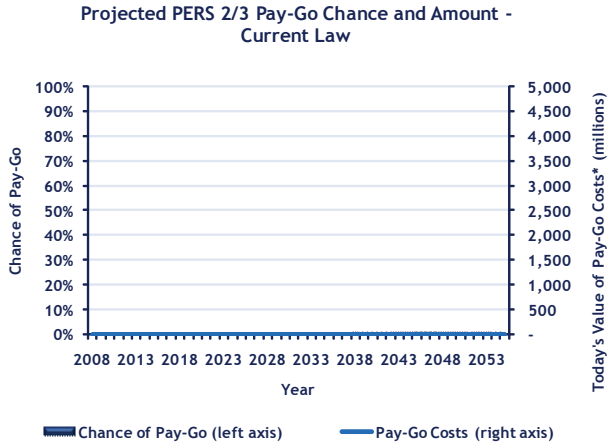

*Pay-Go Costs on top of Normal Pension Costs.

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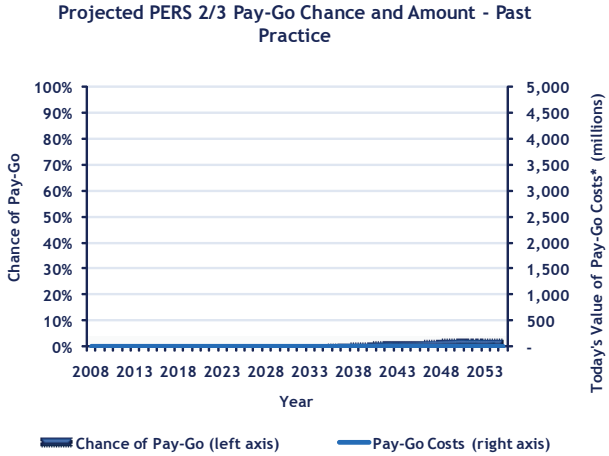

*Pay-Go Costs on top of Normal Pension Costs.

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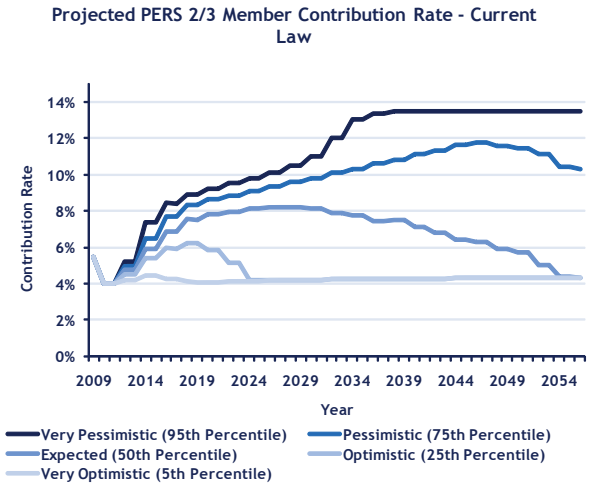

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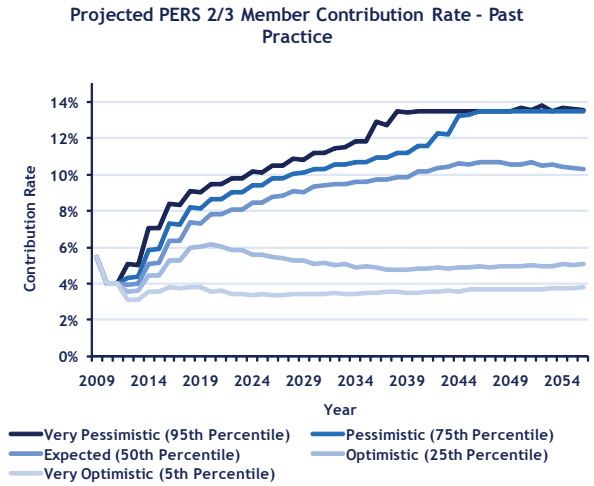

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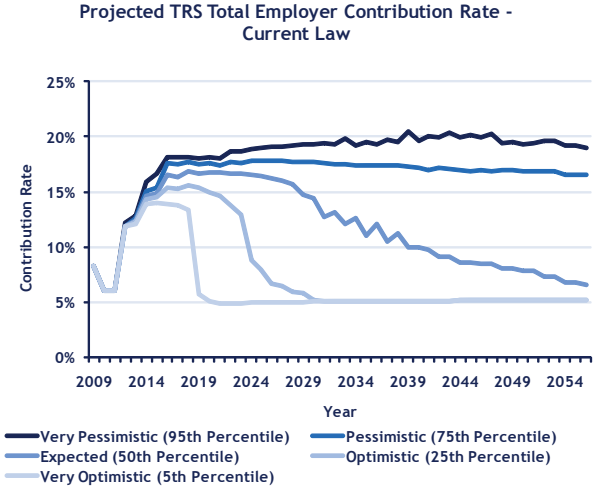

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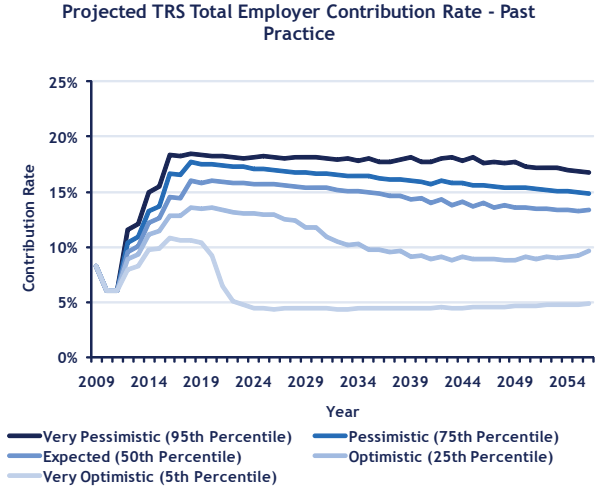

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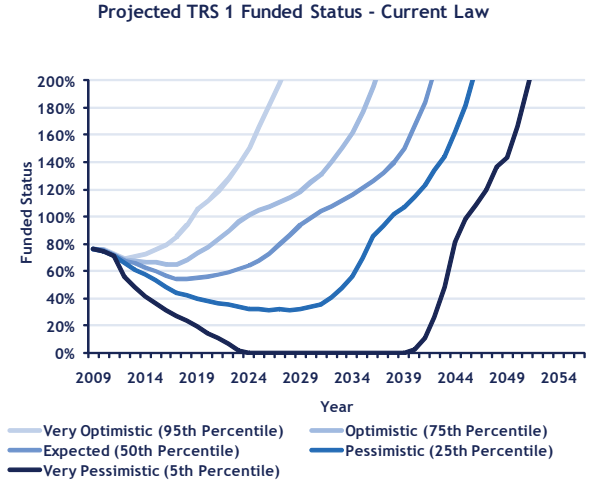

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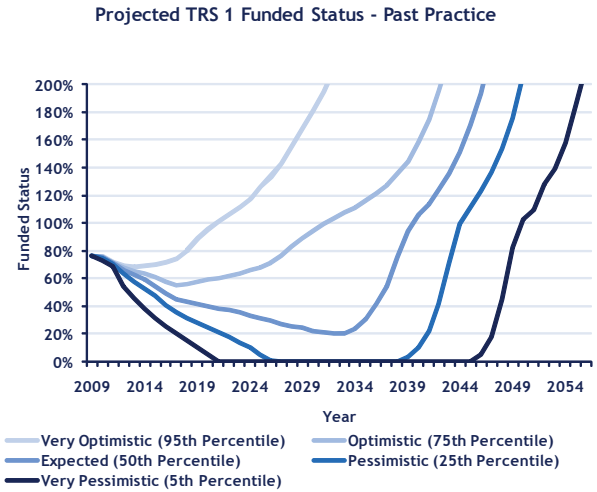

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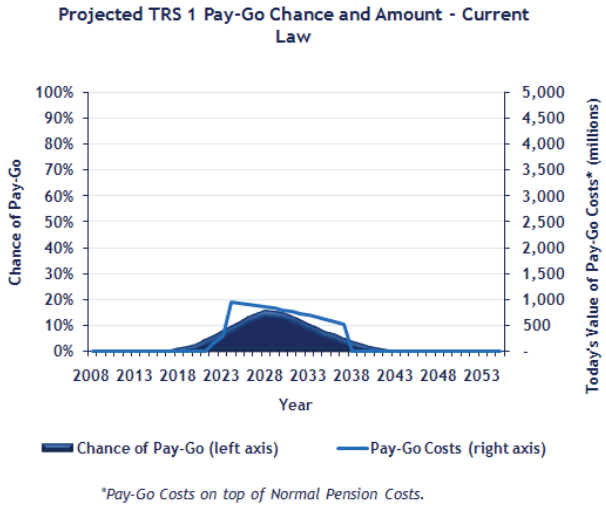

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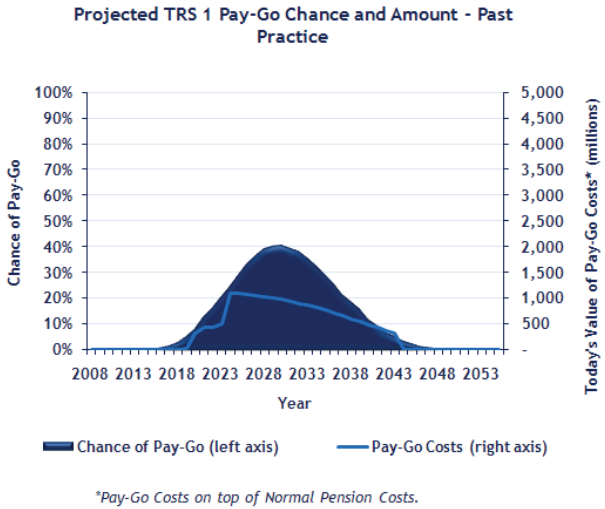

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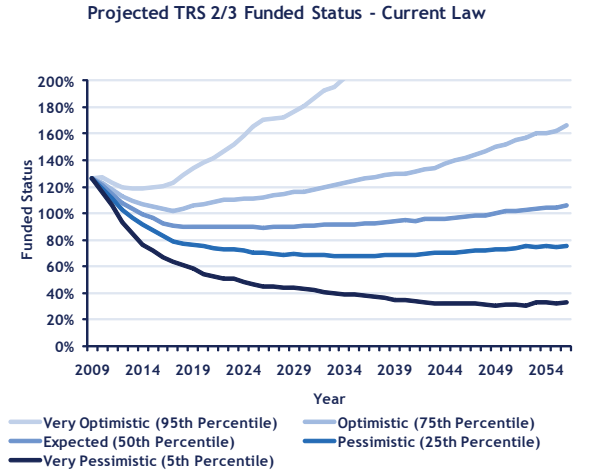

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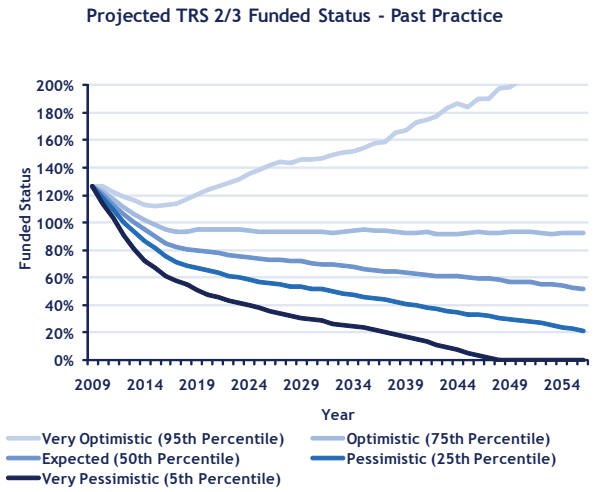

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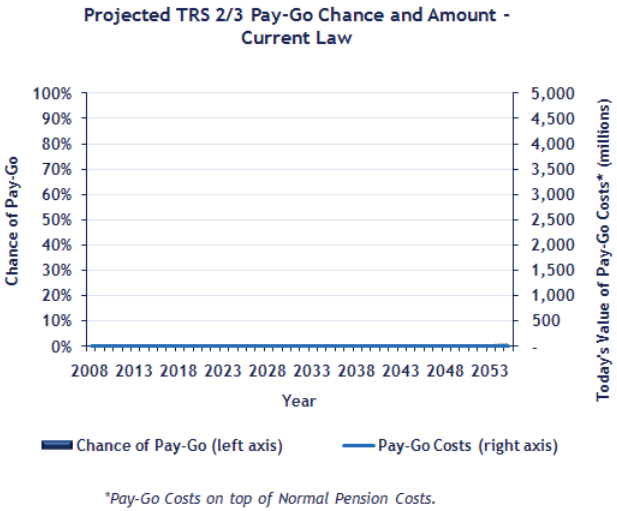

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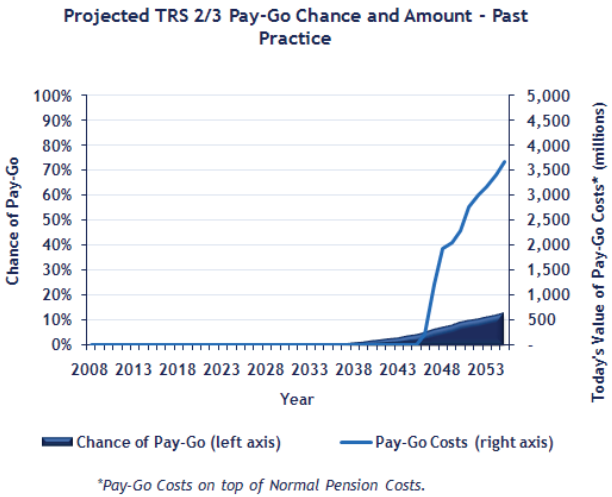

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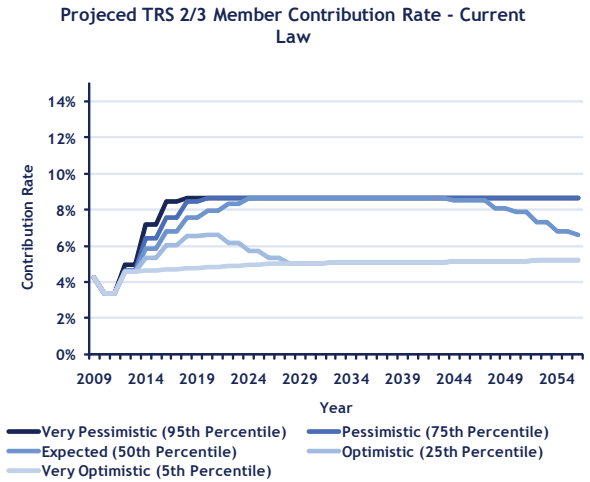

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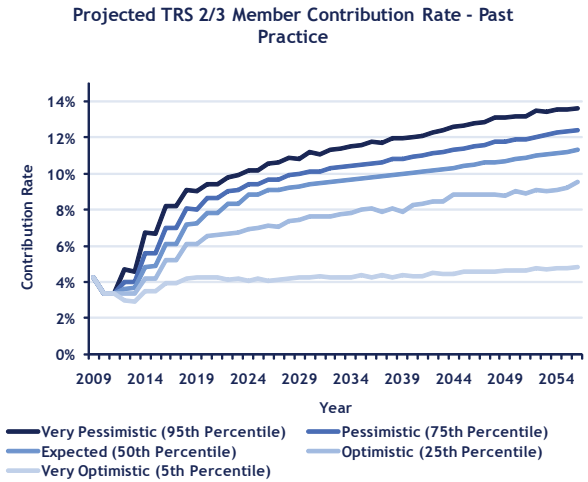

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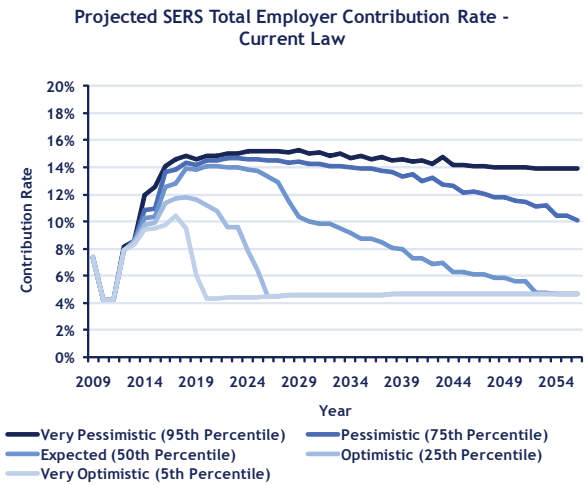

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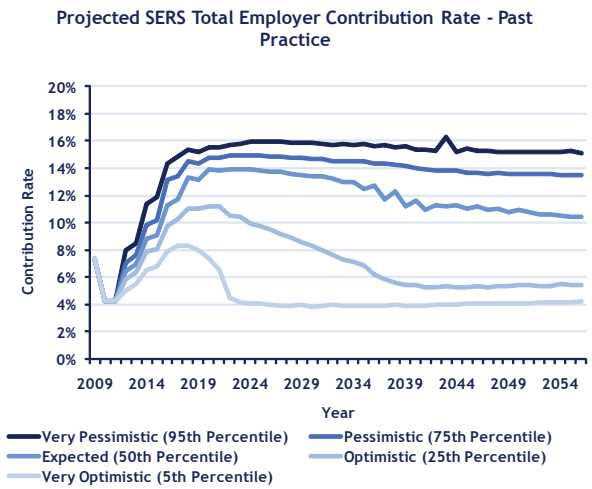

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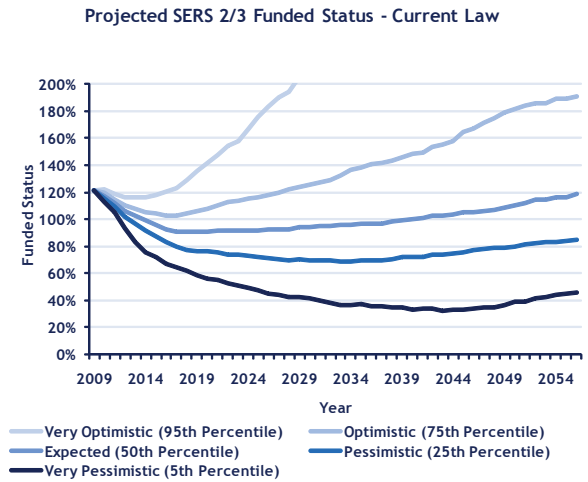

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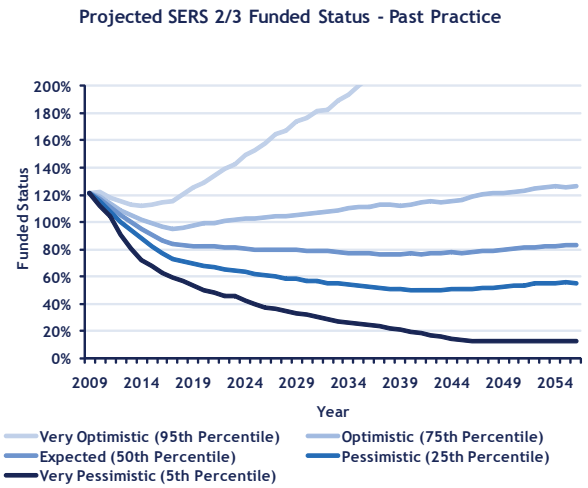

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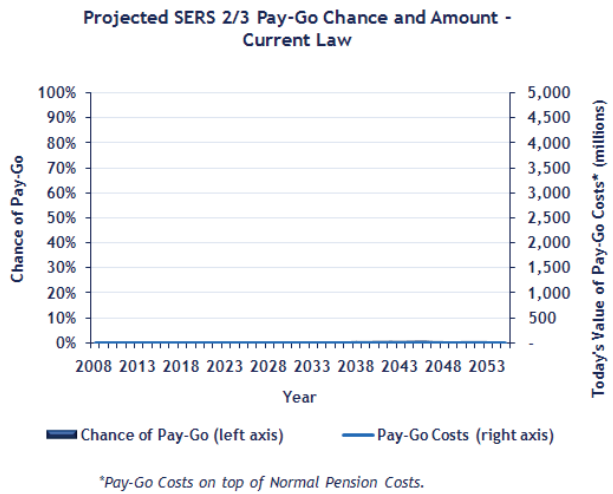

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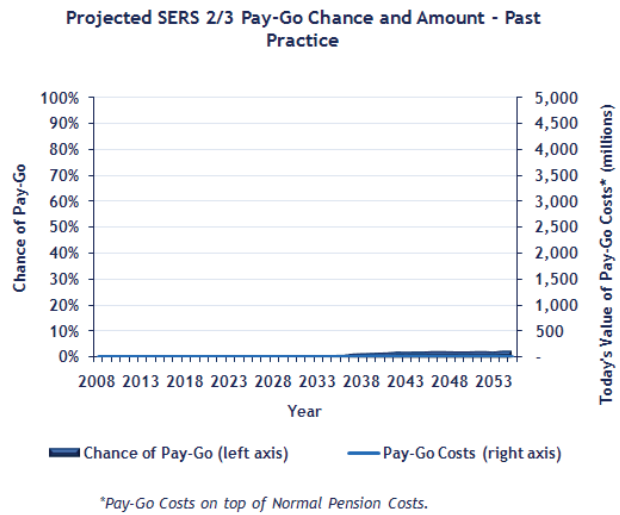

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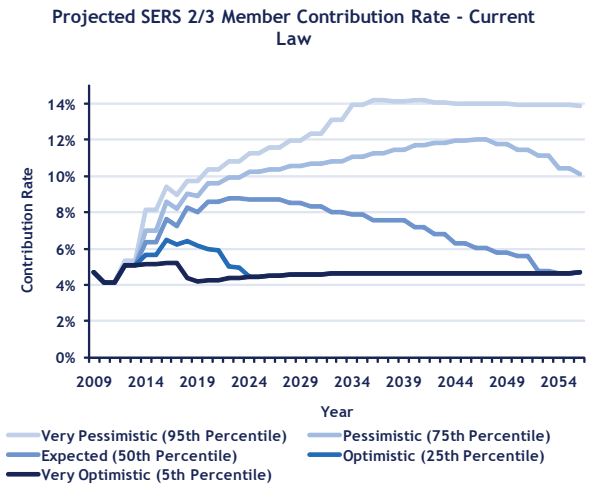

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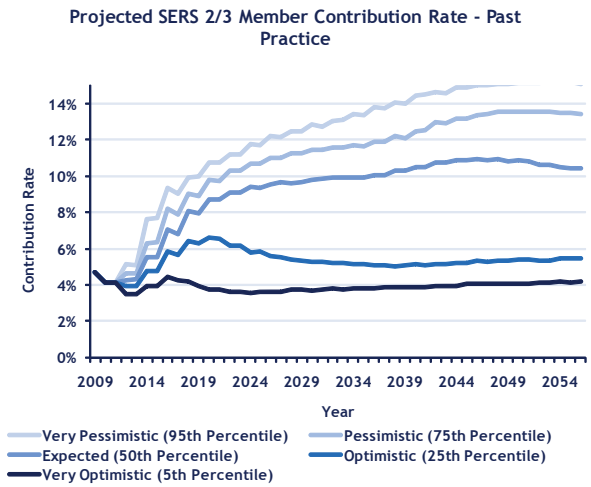

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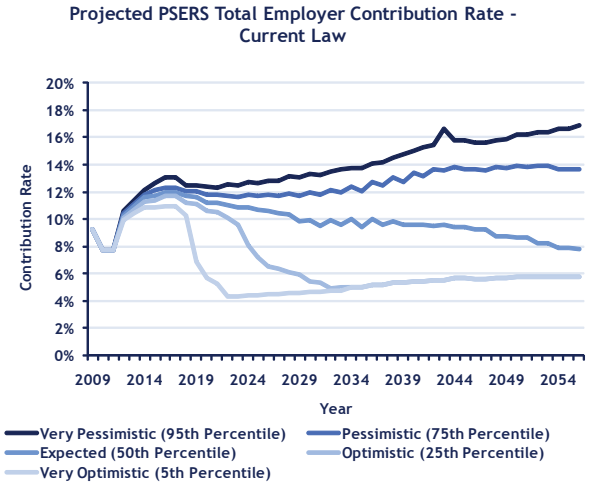

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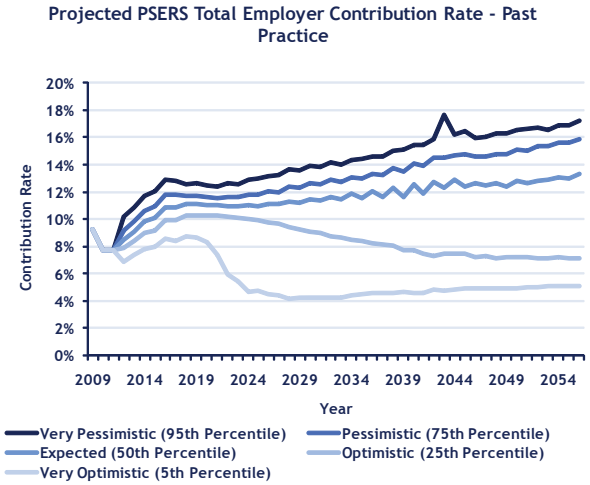

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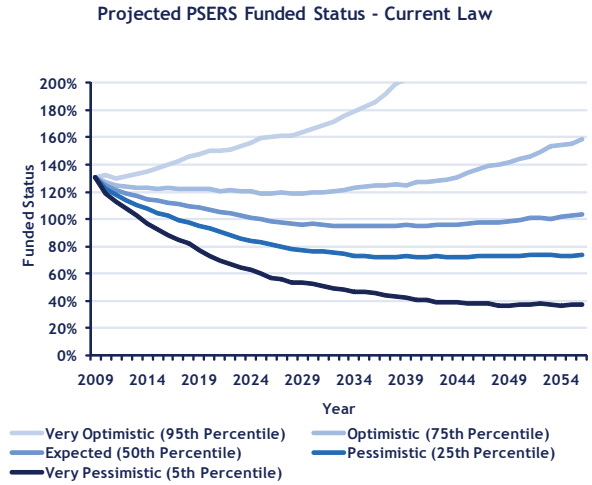

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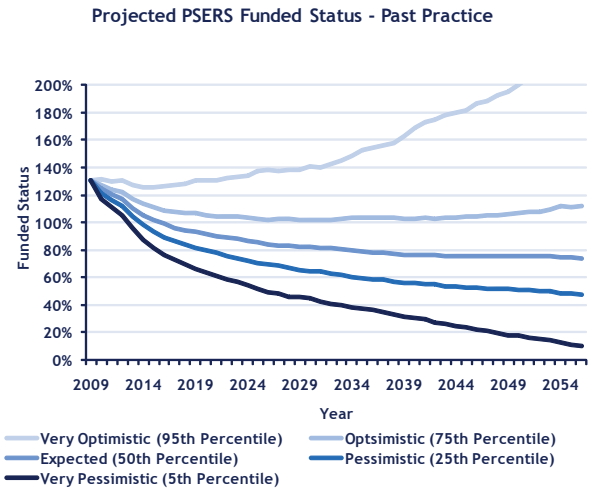

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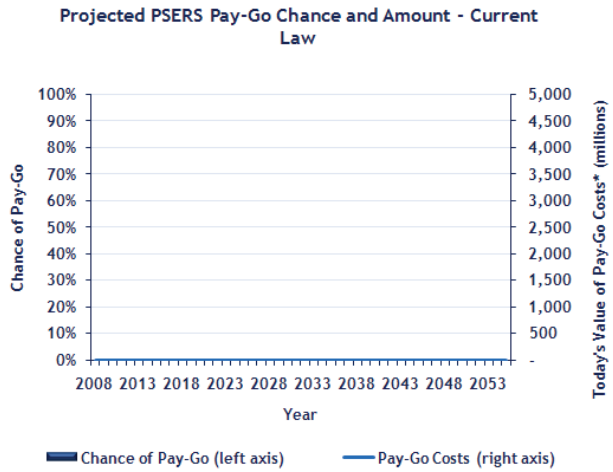
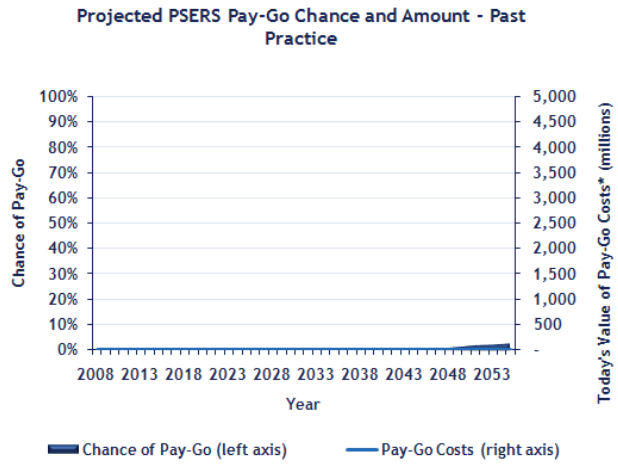


*Pay-Go Costs on top of Normal Pension Costs.

Figure A.1.39



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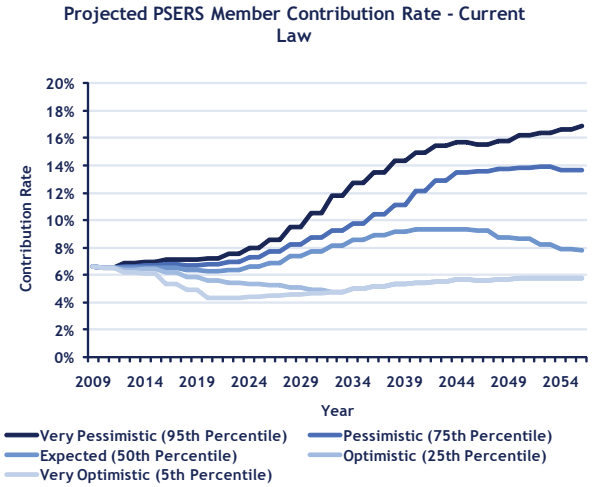

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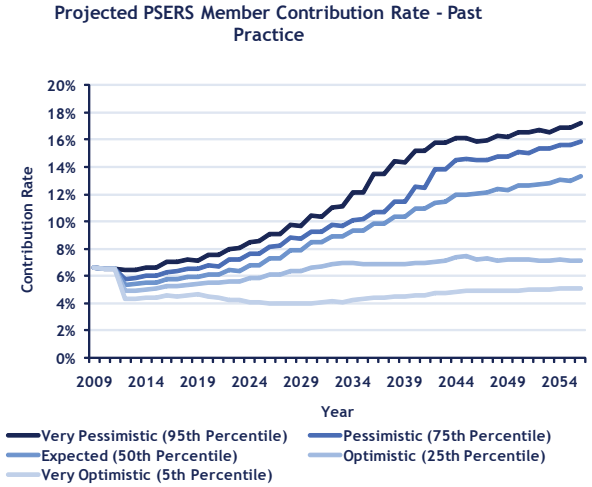

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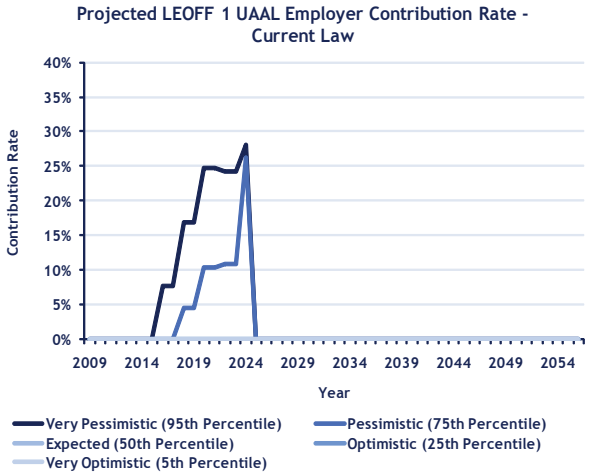

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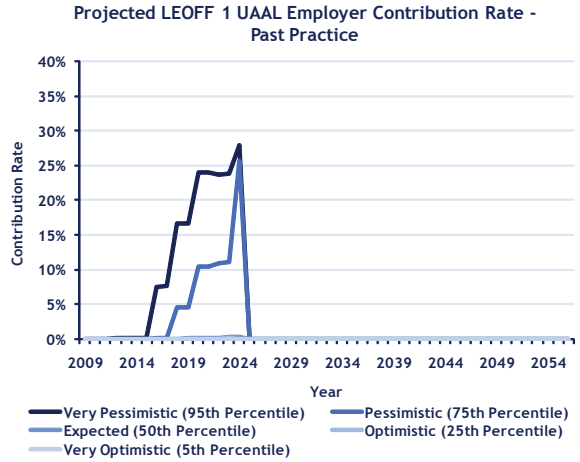

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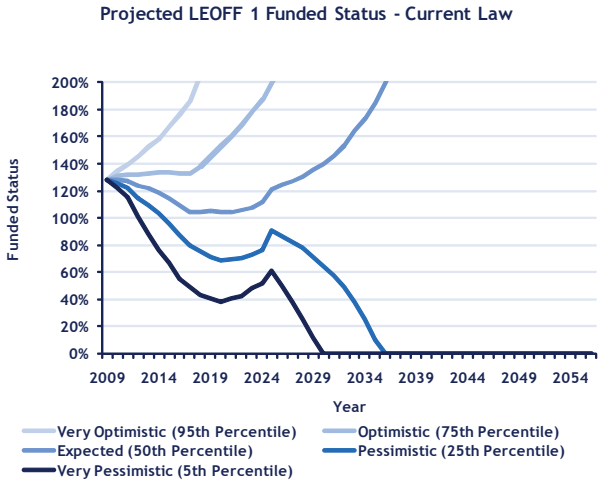

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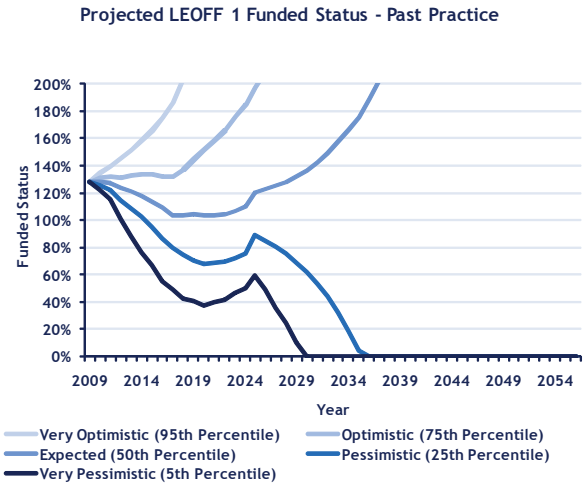

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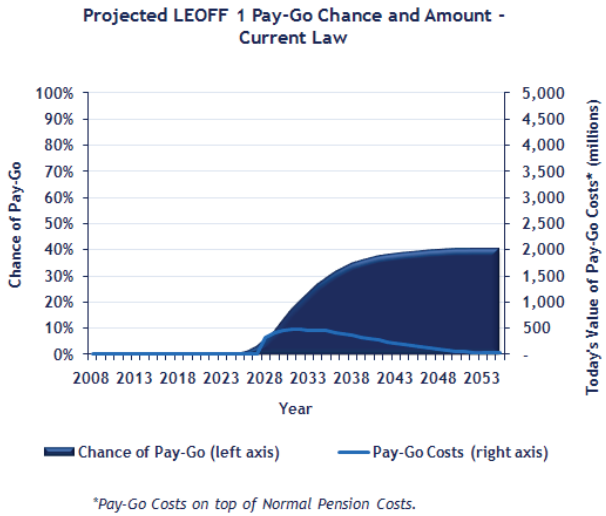

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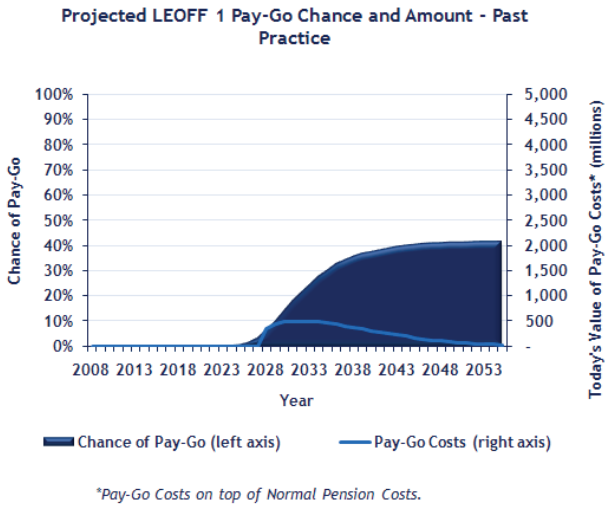

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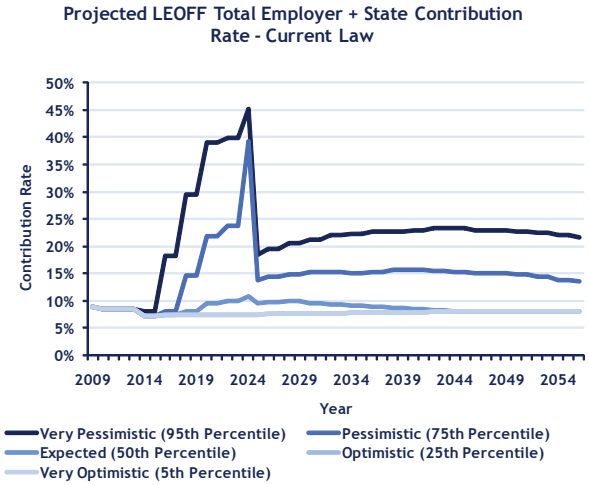

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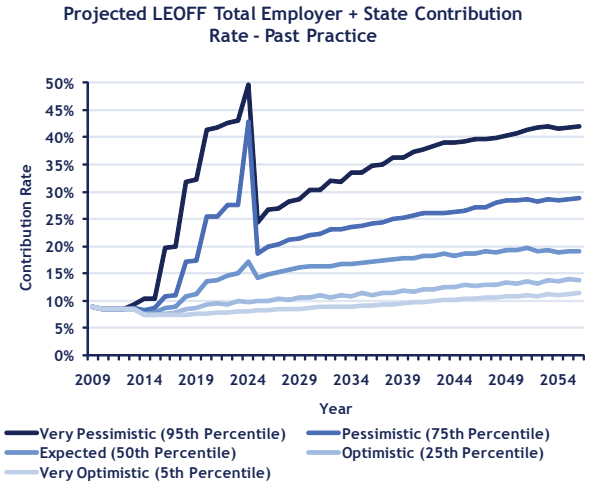

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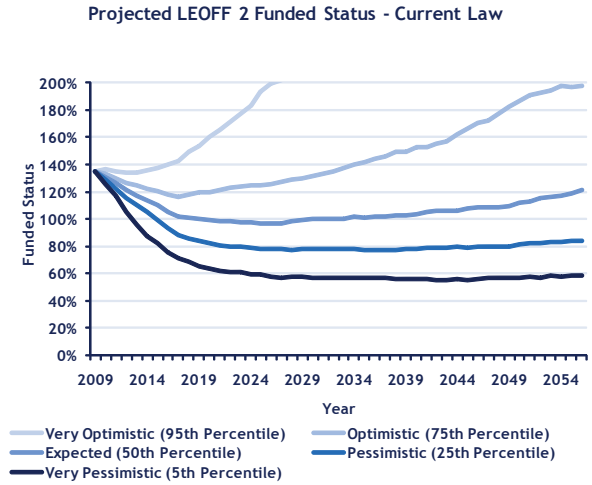

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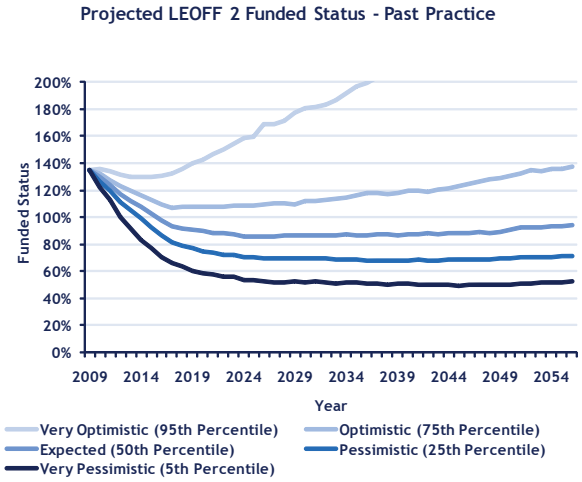

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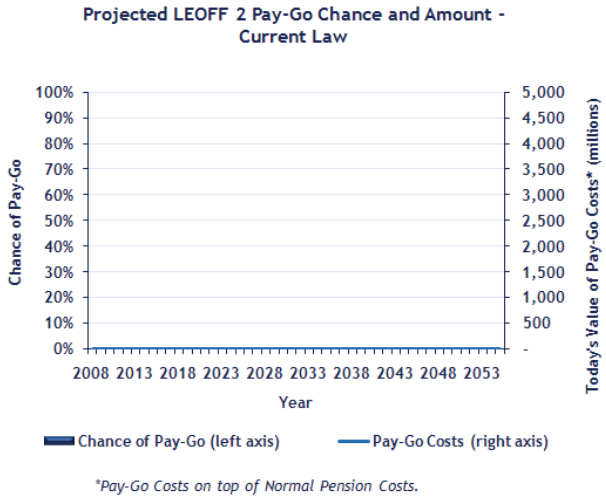

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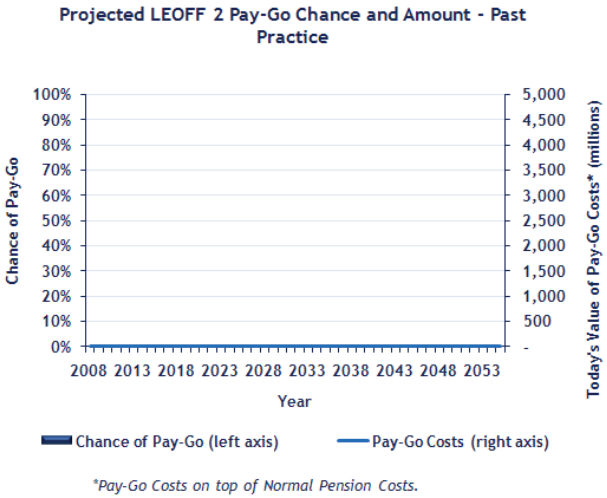


Figure A.1.54

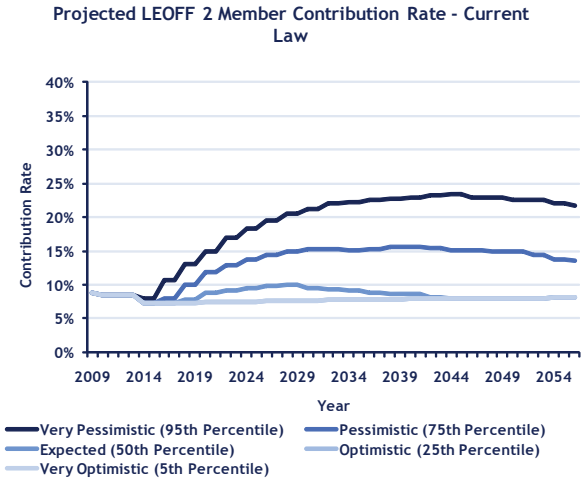
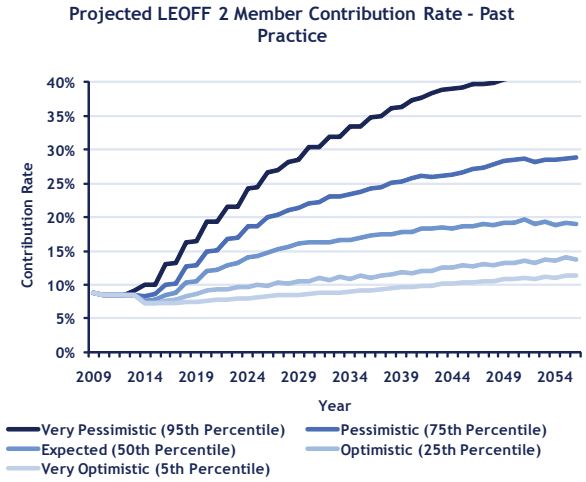


Figure A.1.55



WSPRS

Figure A.1.56

Projected WSPRS 1/2 Total Employer Contribution Rate - Current Law

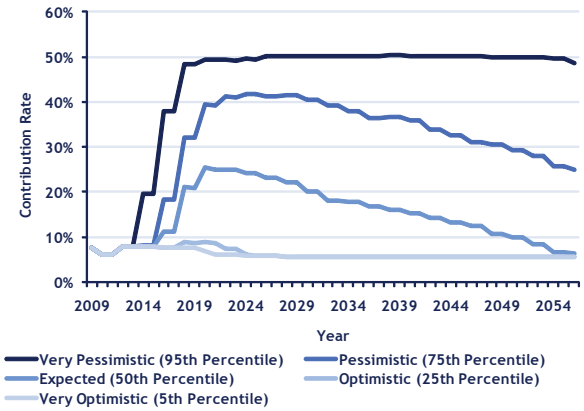


Figure A.1.57

Projected WSPRS 1/2 Total Employer Contribution Rate - Past Practice

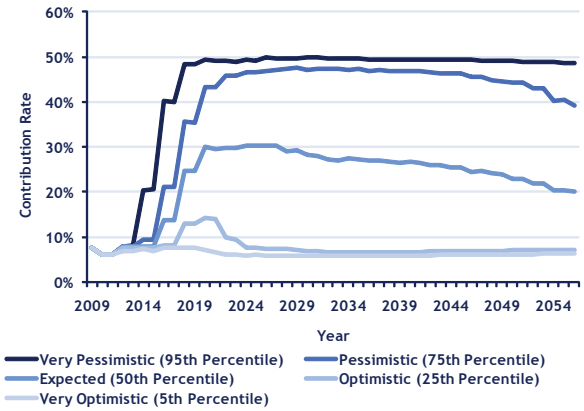


Figure A.1.58

Projected WSPRS 1/2 Funded Status - Current Law

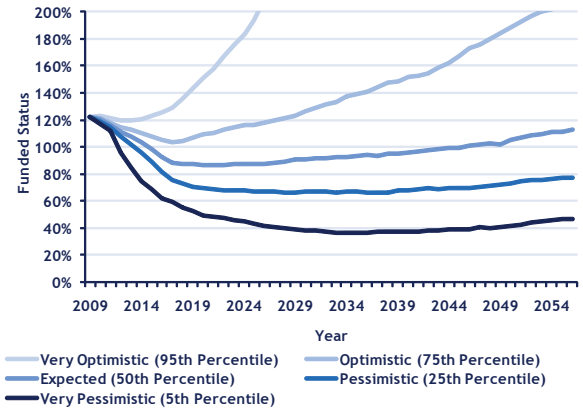


Figure A.1.59

Projected WSPRS 1/2 Funded Status - Past Practice

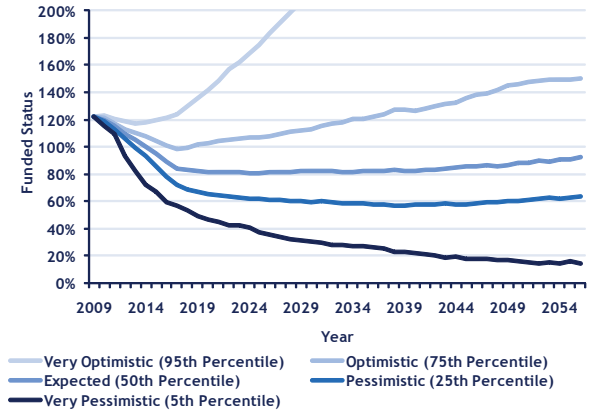


Figure A.1.60

Projected WSPRS 1/2 Pay-Go Chance and Amount - Current Law

*Pay-Go Costs on top of Normal Pension Costs.

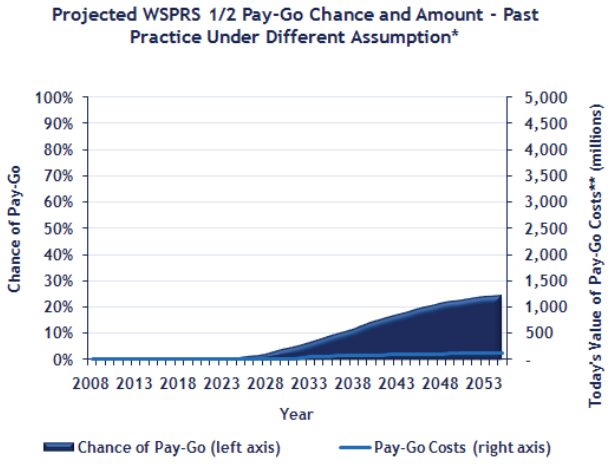
Figure A.1.61.1

Projected WSPRS 1/2 Pay-Go Chance and Amount - Past Practice

*Pay-Go Costs on top of Normal Pension Costs.

Note: Please see Figure A.1.61.2 for how these results could change under a lower assumed maximum employer contribution rate. We assume 50 percent of pay in this analysis.

Figure A.1.61.2



Under assumed maximum employer contribution rate of 30 percent of pay. Please see assumption and data section for more detail.

*** Pay-Go Costs on top of Normal Pension Costs.*

Figure A.1.62

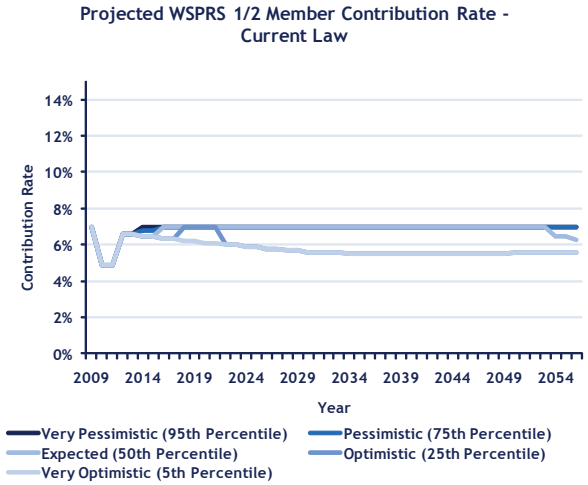
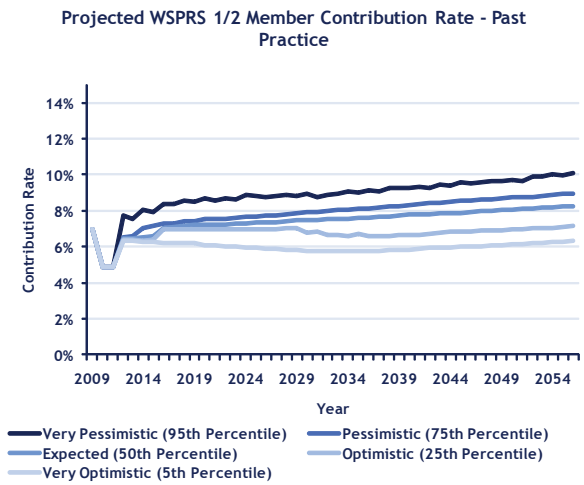


Figure A.1.63



Certification Letter

Office of the State Actuary

"Securing tomorrow's pensions today."

Actuarial Certification

2010 Risk Assessment

August 31, 2010

This report documents the results of an actuarial assessment of the financial risks of the retirement plans defined under Chapters 41.26, 41.32, 41.35, 41.37, 41.40, and 43.43 of the Revised Code of Washington as of the date of this certification. We prepared this analysis to support the strategic planning efforts of the Select Committee on Pension Policy. However, we understand that other readers will use the information in this public report. We advise such readers to review the primary purpose of the report, not use the report for other purposes, and to seek professional guidance in their interpretation of the report.

The primary purpose of this assessment is to identify and quantify the financial risks of the above mentioned retirement plans through use of a customized and dynamic asset-liability model. This assessment does not address all risks to the retirement systems. We intend readers to use the results of this assessment to evaluate which financial risks require additional risk management. Such management will require additional analysis not included in this report.

The results of this analysis will change in the future as actual experience emerges. We plan to monitor this experience and update our model as necessary. We also plan to quantify additional risks not covered in the current model in the future. Please replace this report in the future when the results of a more recent assessment become available.

This risk assessment involved a projection of future actuarial valuation results using both stochastic and deterministic methods on an open-group basis (projection includes future new entrants). Please see the 2008 Actuarial Valuation Report (AVR) for the data, assumptions, and methods used in determining the initial actuarial valuation results for this projection. Please see the Appendix of this report for a description of the data, assumptions, and methods used to project actuarial valuation results beyond the initial results of the 2008 AVR.

We updated the results of the 2008 AVR to reflect recent changes to plan provisions and asset data. Plan provisions reflect changes from the 2008 and 2009 Legislative Sessions. We did not include supplemental contribution rates from the 2010

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Legislative Session. Participant data reflects retirement system census data through June 30, 2008. Asset data reflects investment returns through June 30, 2010.

The Department of Retirement Systems provided unaudited 2008 member and beneficiary data to us. We checked the data for reasonableness as appropriate based on the purpose of this assessment. The Washington State Investment Board (WSIB) provided audited asset information as of June 30, 2009. We relied on all the information provided as complete and accurate. In our opinion, this information is adequate and substantially complete for purposes of this assessment.

We relied on the capital market assumptions (CMAs) from the WSIB to perform our asset projections. We reviewed the CMAs for reasonableness as appropriate based on the purpose of this assessment. In our opinion, the CMAs are reasonable for purposes of this assessment.

The risk assessment summarized in this report involves the interpretation of many factors and the application of professional judgment. We believe that the data, assumptions, and methods used in the underlying assessment are reasonable and appropriate for the primary purpose stated above. The use of another set of data, assumptions, and methods, however, could also be reasonable and could produce materially different results. Another actuary may review the results of this analysis and reach different conclusions.

In our opinion, all methods, assumptions, and calculations are reasonable and are in conformity with generally accepted actuarial principles and applicable standards of practice as of the date of this publication.

The undersigned, with actuarial credentials, meet the Qualification Standards of the American Academy of Actuaries to render the actuarial opinions contained herein and are available to provide extra explanations as needed.

Sincerely,

Matthew M. Smith, FCA, EA, MAAA
State Actuary

Troy A. Dempsey, ASA, MAAA
Actuary

Model Overview and Methods

This risk assessment required OSA to build a customized asset-liability model. Before explaining what the model is, we believe it's important to consider the context around the model's purpose. We will:

- Explain where this model fits into decision making.
- Show a high-level overview of the model's pieces.
- Explain how the model works.
- Explain what goes into the model.
- Explain what the model provides.

Recipe for a Good Decision

Consider an aeronautical engineer building an airplane, or a structural engineer building a skyscraper. Would you like to hear them say, "I put a lot of nails in there and my gut is telling me it will hold up"?

Would you like to hear them say, "based on expected weather conditions, it will hold up"?

Probably not. You want to know that they've built their product with information and decisions that reduce the likelihood of "failure" to an acceptable level.

Information has evolved over time with decision-makers demanding more, and information-providers having more tools available. Actuarial information has followed a similar path.

Intuition: A long time ago, decision-makers made decisions solely on intuition. We've all made mistakes implementing this method. So, we easily see the need for information to inform our decision.

Best-Estimate: The simplest information is to create the future path most likely to occur. Based on whether this path is good or bad, a decision is made. This is the most common information used in decisions. It is regularly used as:

- A family's budget.
- An individual's retirement plan.
- The cost provided in fiscal notes for legislation.

Unfortunately, the actual result usually does not end up matching the estimate. The best-estimate can almost be misleading and can lead to a sense of control that isn't really there. This creates a need for information about the impact if things turn out differently.

Scenarios: Sometimes called "sensitivity analysis", other possible paths are determined. This gives the decision maker extra information for how things could turn out differently from the best-estimate. However, the scenarios can never be exhaustive, and the decision maker lacks information about the likelihood or chances these scenarios will occur.

Simulation: Sometimes called "stochastic projections," "dynamic projections," or "Monte Carlo simulation," many statistically equally likely paths are created. This provides the decision maker with all known information at this point in time. Namely, it provides:

- The best guess at what will occur.
- The range of outcomes that could occur.

- The likelihood of the range of outcomes occurring.

Both types of engineers mentioned at the beginning of this section use simulation to inform their decisions. Actuaries have begun using simulation more and more over the past few decades. Of course, extra information comes at a cost, and the bigger the decision (peoples' lives, large amounts of money at stake), the more necessary complete information becomes.

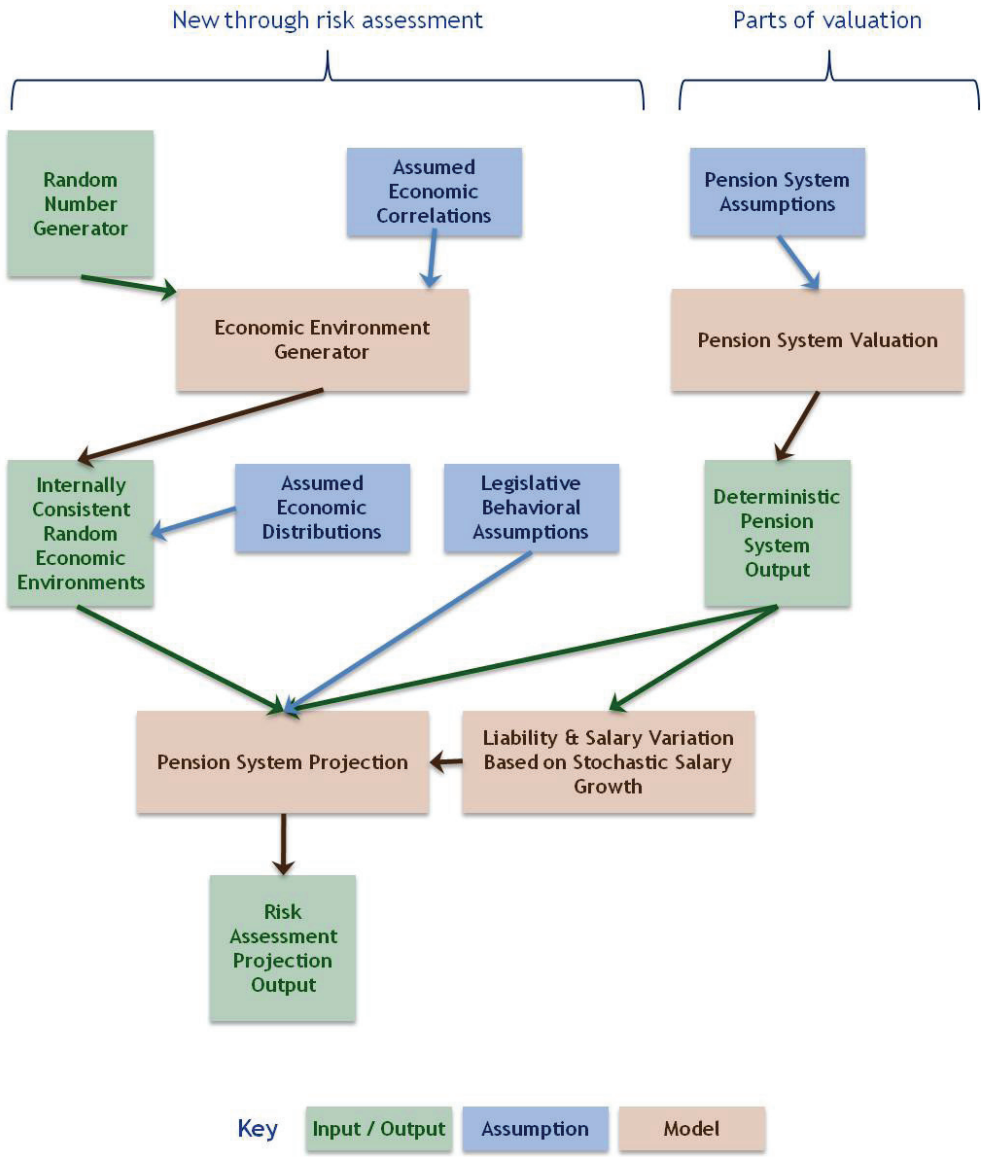
A model is a decision aid, not a decision maker. A model will never forecast the future perfectly. A healthy dose of common sense and intuition, in combination with a good model, is the recipe for the best decision.

Risk Assessment Model Overview

The following flowchart shows the major pieces of the model. We describe each of these major pieces below.

Figure A.2.1

Risk Assessment Model Overview Flowchart



How the Model Works and What is Needed

In this section, we explain the model in three levels of increasing detail – **basics**, **intermediate**, and **advanced**.

Basics

We created a dynamic projection of the pension system using simulation. The purpose of this model is to create a large number (2,000) of equally likely fifty-year economic environments, and see how the pension system responds. Since each of the paths is assumed to be equally likely, comments can be made about the probability of certain events occurring.

To accomplish this goal, the model has two parts.

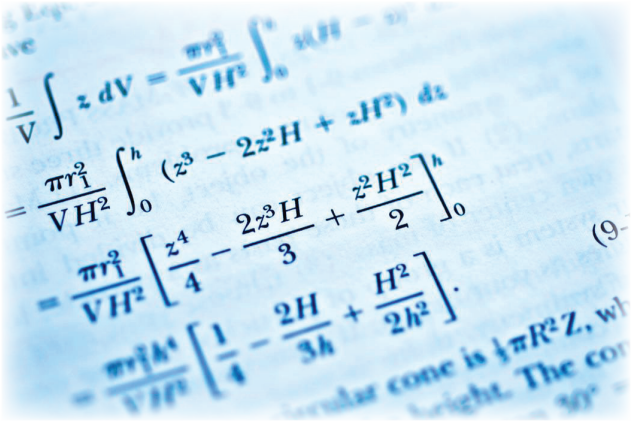
1. The **economic environment generator**, which creates the equally likely economic situations that the pension system will encounter.
2. The **pension system projection**, which models how the systems would react when they encounter each of these economic environments.

Intermediate

The general process we follow to create statistically equally likely simulations is called "Monte Carlo Simulation." We provide an example of how we implement Monte Carlo Simulation below.

We start with our projection spreadsheet and allow certain events to occur randomly. For example, if inflation were to occur randomly in our model, we would measure past inflation and make a reasonable prediction about the likelihood of future inflation levels. A simplified example would be that inflation could take one of three future values: 2.5 percent, 3.5 percent, or 4.5 percent per year. Excel would generate a random number between 0 and 1 for each year of the projection. If the number was between 0 and 0.33, we would assign 2.5 percent inflation for the year. If the number was between 0.33 and 0.67 we would assign 3.5 percent inflation for the year. And, if the number was between 0.67 and 1, we would assign 4.5 percent inflation for the year. We would repeat the process in year two keeping in mind that inflation shows a large positive correlation to the previous year's inflation and a reversion to its long-term mean. After this process is complete for each year in the projection and the results have been recorded, a simulation has been run.

Then, this process is repeated so that a large number of simulations have been run (generally between 1,000 and 10,000). The idea is that each of these path-dependent simulations is equally likely to occur. We then sort these simulations so that we can see how many behave a certain way. For example, if we ran 1,000 simulations and the contribution rate in 2012 was 5 percent or higher in 100 of the simulations, we would say that there is a 10 percent chance that the contribution rate will be at least 5 percent in 2012 (alternatively, there will be a 90 percent chance it will be below 5 percent).



Advanced

Economic Environment Generator

For each fifty-year economic environment, we use Excel's RAND (or random number) function to generate fifty random numbers (between 0 and 1) for each economic variable - excluding inflation and population growth. These fifty random variables represent random economic events each year during the fifty-year projection.

If these economic variables were truly random, we would stop here. However, since most of these economic variables show correlation to another economic variable, we need to modify the random variables to reflect their assumed correlation. We do this using **Cholesky Decomposition**. A general description of the decomposition can be found at Wikipedia here: http://en.wikipedia.org/wiki/Cholesky_decomposition.

As an example, consider investment returns and real revenue growth. Assume the investment return's random number for year one is 0.90, and real revenue growth's random number for year one is 0.20. We found that real revenue growth increases and decreases similarly to investment returns in the same year (positive correlation with no lag). We would alter the 0.20 random number for real revenue growth upward toward 0.90. The magnitude of the change would depend on the magnitude of the correlation (stronger correlation would lead to more change).

A numerical example can help explain:

1. Both random numbers would be converted to Z-Values.
   a. Investment random number = 0.90 ➜ Z-Value = 1.28
   b. Real Revenue Growth random number = 0.20 ➜ Z-Value = -0.84
2. The 2-Variable simplifying equation for Cholesky Decomposition can be used to correlate the real revenue growth to investment returns [Correlated Z-Value = Correlation x Investment Z-Value + Square Root (1- Correlation^2) x Real Revenue Z-Value.
   a. Correlated Revenue Z-Value = 0.30 x 1.28 + Square Root (1 – 0.30^2) x -0.84 = -0.42.
3. The correlated Z-Values are converted back to correlated random numbers.
   a. Investment Z-Value = 1.28 ➜ correlated random number = 0.90.
   b. Real Revenue Z-Value = -0.42 ➜ correlated random number = 0.34.

The Cholesky Decomposition is the complete correlation process for normally distributed random variables in our model. However, for the non-normally distributed random variables, we apply an additional process. We use the Fleishman Power Transformation Method to adjust the method for the skew and kurtosis of the given non-normal random variable. This is done by adjusting the correlation input into the Cholesky Decomposition matrix upward, and modifying the Z-Values after the correlation. A fuller explanation of the method, with formulas, can be found in this article from Vale & Maurelli, 1983: http://www.springerlink.com/content/u334757q3x152512/.

After this adjustment process, the end result is fifty economic variables that are internally consistent (correlated correctly) and in the form of a percentile (number between zero and one). We then use these values to select an equivalent percentile from the assumed probability distribution of each economic variable to produce a single fifty-year economic environment (excluding inflation and population growth).

To model annual inflation and population growth over a single fifty-year projection, we apply an autoregressive time series formula (below) with the random numbers generated above. (We select the parameters of the time series model to approximate the range of observed values, shape of the distribution of observed values, and observed inter-correlations we expect. See the "*Assumptions and Data*" section for further details).

Autoregressive Time Series Formula

[Value = Mean Reversion x Long-Term Average + (1 – Mean Reversion) x Last Period's Value + Normally Distributed Random Number x Standard Deviation]

We repeat this process 2,000 times. The end result is 2,000 fifty-year economic environments ready for use in the pension system projection.

Pension System Projection

The projection model projects the status of the pension system over a fifty-year period, given an economic environment.

The required inputs for the projection model include the following items:

- **Random Economic Environment:** From the economic environment generator.
- **Assumed Legislative Decisions:** Both decision variables affect the state of the pension system. Variables include (1) percent of contributions made and (2) percentage growth in liabilities from future benefit improvements. The formulas are outlined in the "Assumptions and Data" section.
- **Pension System Output:** We use deterministically projected benefit payments, salaries, and liabilities from our annual actuarial valuation of the pension system. We also create and use factors that estimate the change in benefits or salaries based on stochastic nominal salary growth. Details about the assumptions and methods used to generate this output can be found in the June 30, 2008, Actuarial Valuation Report.

In each year of the projection:

1. First we run the annual actuarial valuation. The most pertinent measures are calculated (point in time calculation using an "as of" date). Examples include (but not limited to):
   a. Liabilities.
   b. Assets.
   c. Funded Status.
   d. Recommended Contribution Rate.
2. Next we input an internally consistent economic environment (from the economic environment generator). Examples include:
   a. Nominal investment return for the year.
   b. Inflation for the year.

c. Population growth for the year.

d. Real revenue growth (adjusted for population) for the year.

3. Pension system cash flows respond to economic environment, recommended contribution rate, and legislative behavior.

a. The present value of active liabilities and salaries are adjusted based on the ratio of observed cumulative salary growth divided by expected cumulative salary growth.

b. Annual benefit payments and salaries are adjusted based on factors created to estimate the cash flows when cumulative salary growth is different than expected. The factors are linear and based on differences in cash flows when our valuation software is run at different levels of salary growth for each year.

c. Percent of recommended contributions made is calculated. The actual contribution rate that is made, paid over all salary, is the amount of cash inflow.

d. Benefits are paid and are a cash outflow.

i. If not enough assets are available to cover benefit payments, we assume a mandatory contribution from the state is made to cover the excess of the benefit payments over the assets on hand.

ii. We adjust LEOFF 1 benefit payments based on actual inflation observed in the model. LEOFF 1 is the exception since they have an uncapped post-retirement COLA and almost the entire population is retired.

e. The investment return cash flow is based on the random investment return, the market value of assets, contributions, and benefit payments for the year.

f. The Legislature is assumed to increase benefits consistent with "creep" and, based on a random component, may increase benefits consistent with "spike". See the body of the report for a description of creep and spike. The value of liabilities, benefit payments, and supplemental rate increases are all affected.

This process is repeated fifty times to get one fifty-year projection. We save statistics and measurements for risk analysis. At this point one simulation has been run and saved. We repeat this process 2,000 times, so that we have 2,000 simulations and we save the same output data for each simulation

What the Model Provides

We have saved 2,000 fifty-year strings of each statistic or variable that was of interest from the simulations. Examples include (but not limited to):

- Contribution rates.
- Funded status.
- Pay-as-you-go contributions.
- Percent of General-Fund State revenue used by contributions.

Since each of these fifty-year strings are assumed to be equally likely to occur, we can start to analyze how often particular events occur and why they occur. We can analyze the output in two ways:

- **Forward looking:** You ask the question: "How likely is a particular event to occur?" For example, if the funded status is above 110 percent in 6,000 of the 10,000 simulations we conclude that there is approximately a 60 percent chance of this event occurring.
- **Backward looking:** You ask the question: "Given that the funded status goes above 110 percent, what had to take place for that to happen?" For example, we can look at the simulations that had the event occur and determine what generally happened to achieve that metric.

Assumptions and Data

To create these projections, we need to set assumptions for all unknown future events. Specifically, we need to create assumptions for each variable outlined in the previous section, including the variable's:

- Expected Value.
- Standard Deviation.
- Correlation.

For each assumption we present in the following sections, we use the same categories:

- **Used** – Tells how we use the assumption in the model.
- **Data** – Lists the data available for assumption setting.
- **Expectation** – Shows the expected value of the assumption; what the assumed distribution is centered around.
- **Standard Deviation** – Lists the standard deviation of the assumption (if applicable).
- **Distribution/Formula** – Explains how the volatility of the assumption surrounds the expectation.

We provide a summary of the percentiles for the following assumptions:

- Investment Returns.
- Real Revenue Growth.
- Real Salary Growth.
- Percent of Contributions Made.

We also provide the formulas for modeling the following assumptions:

- Inflation.
- Population Growth.
- Benefit Improvements.

- **Correlation** – Shows the correlation of the assumption to other variables.

We gained insights through representatives at the Office of Financial Management (OFM), Washington State Investment Board (WSIB), the Pension Funding Council (PFC) workgroup, and the Economic and Revenue Forecast Council (ERFC). Feedback from these content-area experts helped us assess the general reasonability of our assumptions.

Investment Returns

Used: To model actual investment returns in the projections.

Data: We used two main sources of data.

The first source of data is the WSIB's Capital Market Assumptions (CMAs).

The second source of data is an 84-year history of investment returns. Returns from 1926 through 1981 are estimated based on the WSIB's current asset allocation. Returns from 1982 through the present are based on actual returns. We did not use this data to set an assumption, but instead used it as a reasonability check. **Figure A.3.1** summarizes the data.

Figure A.3.1

Actual and Estimated Historical Investment Returns		
Investment Return Range	Number of Data Points	Percent of Data in Range
-32% to -29%	1	1.2%
-29% to -26%	0	0.0%
-26% to -23%	2	2.4%
-23% to -20%	0	0.0%
-20% to -17%	0	0.0%
-17% to -14%	2	2.4%
-14% to -11%	2	2.4%
-11% to -8%	1	1.2%
-8% to -5%	5	6.0%
-5% to -2%	3	3.6%
-2% to 1%	5	6.0%
1% to 4%	9	10.7%
4% to 7%	3	3.6%
7% to 10%	7	8.3%
10% to 13%	5	6.0%
13% to 16%	9	10.7%
16% to 19%	9	10.7%
19% to 22%	5	6.0%
22% to 25%	3	3.6%
25% to 28%	4	4.8%
28% to 31%	4	4.8%
31% to 34%	2	2.4%
34% to 37%	1	1.2%
37% to 40%	0	0.0%
40% to 43%	0	0.0%
43% to 46%	0	0.0%
46% to 49%	1	1.2%
49% to 52%	1	1.2%
Total	84	100.0%

Expectation: We relied on the WSIB's CMAs. The median one-year return is 7.81 percent.

Distribution: We relied on the WSIB's CMAs. **Figure A.3.2** shows a sample of the distribution.

Figure A.3.2

Assumed Investment Distribution		
Likelihood	Percentile	Annual Investment Return
1 in 10,000	MIN	-88.1%
1 in 100	1	-23.6%
1 in 20	5	-14.2%
1 in 10	10	-9.5%
1 in 4	25	-1.6%
1 in 2	50	7.8%
1 in 4	75	18.0%
1 in 10	90	28.0%
1 in 20	95	34.6%
1 in 100	99	49.2%
1 in 10,000	MAX	458.5%

Correlation: None. We assumed investment returns are not correlated to any other variable we are modeling.

Inflation

Used: To model the post-retirement Cost of Living Adjustments (COLAs). For LEOFF 1 we stochastically varied benefit payments based on inflation after retirement. For all systems besides LEOFF 1 we stochastically modeled the systems based on inflation as a component of nominal salary growth. Inflation is also used as a building block for nominal revenue growth (population growth + inflation + real revenue growth) and nominal salary growth (inflation + real salary growth).

Data: We used a 94-year history of the regional (Seattle-Tacoma-Bremerton) Consumer Price Index (CPI) from the Bureau of Labor Statistics (BLS). **Figure A.3.3** summarizes the data.

Figure A.3.3

Historical Inflation		
Annual Inflation Range	Number of Data Points	Percent of Data in Range
-12% to -10%	1	1.1%
-10% to -8%	2	2.1%
-8% to -6%	1	1.1%
-6% to -4%	1	1.1%
-4% to -2%	1	1.1%
-2% to 0%	7	7.4%
0% to 2%	23	24.5%
2% to 4%	27	28.7%
4% to 6%	12	12.8%
6% to 8%	6	6.4%
8% to 10%	2	2.1%
10% to 12%	4	4.3%
12% to 14%	3	3.2%
14% to 16%	0	0.0%
16% to 18%	2	2.1%
18% to 20%	0	0.0%
20% to 22%	1	1.1%
22% to 24%	0	0.0%
24% to 26%	1	1.1%
26% to 28%	0	0.0%
Total	94	100.0%

Expectation: We expect inflation to average 3.5 percent over the fifty-year projection period. We developed this expectation based on a 60 percent weighting of short-term inflation (30 years) and a 40 percent weighting of long-term inflation (94 years).

Formula: We modeled inflation as an autoregressive time series. The parameters of the time series are:

- Long-Term Average = 3.50%
- Rate of Mean Reversion = 42%
- Random Standard Deviation = 3.00%

Formula: Current Year's Inflation = 0.42 x 3.50% + 0.58 x Last Year's Inflation + 0.03 x Normally Distributed Random Number

Correlation: We assumed inflation would have a 0.54 correlation to inflation one year ago. We developed this assumption based on a 60 percent weighting of short-term correlation (30 years) and a 40 percent weighting of long-term correlation (94 years).

Population Growth

Used: As a building block to determine the annual nominal growth of revenue.

Data: We used a 39-year history and a 21-year projection of population growth from OFM. **Figure A.3.4** shows the summarized data.

Figure A.3.4

Historical Washington Population Growth		
Population Growth Range	Number of Data Points	Percent of Data in Range
-0.4% to -0.2%	0	0.0%
-0.2% to 0%	1	2.6%
0% to 0.2%	0	0.0%
0.2% to 0.4%	0	0.0%
0.4% to 0.6%	1	2.6%
0.6% to 0.8%	2	5.1%
0.8% to 1%	1	2.6%
1% to 1.2%	6	15.4%
1.2% to 1.4%	2	5.1%
1.4% to 1.6%	6	15.4%
1.6% to 1.8%	4	10.3%
1.8% to 2%	6	15.4%
2% to 2.2%	0	0.0%
2.2% to 2.4%	3	7.7%
2.4% to 2.6%	2	5.1%
2.6% to 2.8%	0	0.0%
2.8% to 3%	1	2.6%
3% to 3.2%	1	2.6%
3.2% to 3.4%	1	2.6%
3.4% to 3.6%	0	0.0%
3.6% to 3.8%	1	2.6%
3.8% to 4%	1	2.6%
4% to 4.2%	0	0.0%
Total	39	100.0%

Expectation: We relied on OFM's 21-year projection of population growth. We used the average growth rate of 1.1 percent per year as our expected value.

Formula: We modeled population growth as an autoregressive time series. The parameters of the time series are:

- Long-Term Average = 1.10%
- Rate of Mean Reversion = 35%
- Random Standard Deviation = 0.80%

Formula: Current Year's Population Growth = 0.35 x 1.10% + 0.65 x Last Year's Population Growth + 0.008 x Normally Distributed Random Number

Correlation: We assumed population growth would have a 0.78 correlation to population growth one year ago. We developed this assumption based on historical data.

Real Revenue Growth (After Population Growth)

Used: To model annual changes in the state's available General Fund-State revenue.

Data: We used three sources of data.

The first source of data is a forty-year revenue history from the ERFC.

Figure A.3.5

Real Revenue Growth (After Population Growth)		
Annual Real Revenue Growth Range	Number of Data Points	Percent of Data in Range
-6% to -4%	2	5.0%
-4% to -2%	4	10.0%
-2% to 0%	4	10.0%
0% to 2%	12	30.0%
2% to 4%	8	20.0%
4% to 6%	8	20.0%
6% to 8%	0	0.0%
8% to 10%	2	5.0%
Total	**40**	**100.0%**

The second source of data is a four-year Washington Revenue forecast from the ERFC based on their June 2010 Forecast.

Figure A.3.6

Short-Term ERFC Projected Washington Revenue Growth		
Fiscal Year	Washington Revenue	Revenue Growth
2009	13,089,078	
2010	13,680,001	4.5%
2011	15,602,361	14.1%
2012	16,653,689	6.7%
2013	17,429,209	4.7%

The third source of data is a thirty-year national economic forecast from the ERFC based on their June 2010 forecast.

Figure A.3.7

Long-Term ERFC Projected National Real GDP Growth					
Fiscal Year	Real GDP	Real GDP Growth	Fiscal Year	Real GDP	Real GDP Growth
2009	12,902		**2025**	20,105	2.7%
2010	13,363	3.6%	**2026**	20,626	2.6%
2011	13,770	3.0%	**2027**	21,140	2.5%
2012	14,230	3.3%	**2028**	21,661	2.5%
2013	14,707	3.3%	**2029**	22,186	2.4%
2014	15,125	2.8%	**2030**	22,760	2.6%
2015	15,558	2.9%	**2031**	23,315	2.4%
2016	15,998	2.8%	**2032**	23,873	2.4%
2017	16,412	2.6%	**2033**	24,441	2.4%
2018	16,822	2.5%	**2034**	25,042	2.5%
2019	17,253	2.6%	**2035**	25,663	2.5%
2020	17,704	2.6%	**2036**	26,304	2.5%
2021	18,149	2.5%	**2037**	26,961	2.5%
2022	18,621	2.6%	**2038**	27,618	2.4%
2023	19,096	2.6%	**2039**	28,296	2.5%
2024	19,578	2.5%	**2040**	29,010	2.5%

Expectation: Over the next four years we expect nominal (total) revenue growth to average 7.5 percent. We relied on the ERFC's four-year Washington State revenue forecast for this assumption. Beyond four years, we expect real revenue growth to equal 1.5 percent per year based on historical data. When inflation and population growth are added to the real component, we arrive at the expected nominal revenue growth of 6.1 percent per year.

Distribution: We created an assumed distribution for real revenue growth that can be seen in **Figure A.3.8**.

Figure A.3.8

Assumed Real Revenue Growth Distribution		
Likelihood	Percentile	Annual Real Revenue Growth (After Inflation and Population Growth)
1 in 200	MIN	-4.3%
1 in 100	1	-4.2%
1 in 20	5	-3.7%
1 in 10	10	-3.3%
1 in 4	25	0.3%
1 in 2	50	1.3%
1 in 4	75	3.9%
1 in 10	90	4.0%
1 in 20	95	4.3%
1 in 100	99	8.3%
1 in 200	MAX	9.3%

Correlation: We assumed real revenue growth is correlated to same-year nominal investment returns. We assumed a 0.30 correlation based on historical data (above).

Percent of Contributions Made

Used: To estimate the percent of the actuarially required contribution (or recommended contribution) that will be made.

Data: We used a twenty-year history for PERS, TRS, LEOFF, and WSPRS. We used a seven-year history for SERS.

Expectation: Based on past experience, we expect approximately 80 percent of contributions to be made for PERS, TRS, and SERS. We expect approximately 98 percent of contributions to be made for LEOFF and WSPRS.

Figure A.3.9

Recommended and Adopted Employer Contribution Rates [1]															
	PERS			TRS			SERS			LEOFF			WSPRS		
	Rec. Rate[2]	Adopt. Rate[3]	%Rec.[4]	Rec. Rate[2]	Adopt. Rate[3]	%Rec.[4]	Rec. Rate[2]	Adopt. Rate[3]	%Rec.[4]	Rec. Rate[2]	Adopt. Rate[3]	%Rec.[4]	Rec. Rate[2]	Adopt. Rate[3]	%Rec.[4]
1991	7.10%	7.10%	100%	12.60%	12.60%	100%				16.88%	16.88%	100%	21.47%	21.47%	100%
1992	7.47%	7.47%	100%	12.60%	12.60%	100%				16.44%	16.44%	100%	15.53%	15.53%	100%
1993	7.47%	7.27%	97%	12.60%	12.08%	96%				16.44%	12.99%	79%	15.53%	17.16%	110%
1994	7.19%	7.19%	100%	12.43%	12.43%	100%				13.54%	13.54%	100%	16.02%	16.02%	100%
1995	7.19%	7.19%	100%	12.43%	12.43%	100%				13.54%	13.54%	100%	16.02%	16.02%	100%
1996	7.21%	7.21%	100%	12.05%	12.05%	100%				13.22%	13.22%	100%	14.56%	14.56%	100%
1997	7.21%	7.21%	100%	12.05%	12.05%	100%				13.22%	13.22%	100%	14.56%	14.56%	100%
1998	7.32%	7.32%	100%	11.75%	11.75%	100%				9.20%	9.20%	100%	11.01%	11.01%	100%
1999	7.32%	7.32%	100%	11.75%	11.75%	100%				9.20%	9.20%	100%	11.01%	11.01%	100%
2000	4.36%	4.36%	100%	8.38%	8.38%	100%				2.33%	2.33%	100%	0.00%	0.00%	100%
2001	4.36%	4.10%	94%	8.38%	6.74%	80%				2.33%	2.16%	93%	0.00%	0.00%	100%
2002	3.21%	1.54%	48%	5.38%	2.57%	48%				2.31%	1.80%	78%	0.00%	0.00%	100%
2003	3.21%	1.10%	34%	5.38%	1.05%	20%				2.31%	2.02%	87%	0.00%	0.00%	100%
2004	2.05%	1.18%	58%	2.22%	1.17%	53%	1.74%	0.85%	49%	2.02%	2.02%	100%	0.00%	0.00%	100%
2005	2.05%	1.18%	58%	2.22%	1.17%	53%	1.74%	0.85%	49%	2.02%	2.02%	100%	0.00%	0.00%	100%
2006	5.73%	3.32%	58%	6.73%	3.64%	54%	7.56%	3.69%	49%	2.88%	2.70%	94%	4.51%	4.51%	100%
2007	5.73%	3.32%	58%	6.73%	3.64%	54%	7.56%	3.69%	49%	2.88%	3.11%	108%	4.51%	4.51%	100%
2008	7.72%	6.66%	86%	9.91%	6.43%	65%	9.17%	6.27%	68%	3.24%	3.43%	106%	7.75%	7.70%	99%
2009	7.72%	6.66%	86%	9.91%	6.43%	65%	9.17%	6.27%	68%	3.24%	3.53%	109%	7.75%	7.70%	99%
2010	7.84%	5.13%	65%	10.79%	5.98%	55%	8.12%	5.27%	65%	3.04%	3.38%	111%	8.57%	6.17%	72%

[1] *This table presents data used to develop our assumption on future contributions and is not intended to be a history of actual rates collected. The data is highly summarized and excludes supplemental rates.*

[2] *Initial total employer contribution rates recommended in the actuarial valuation before any assumption or policy changes.*

[3] *Total employer contribution rate adopted.*

[4] *Percent of recommended rate adopted.*

Distribution: We created a normal distribution centered around the historical mean. The parameters below characterize the random variables we used to model each system:

- **PERS, SERS**
  - Mean = 82%
  - Standard Deviation = 10%
  - Correlation = 0.80 to prior year's value.
  - Assumed system maximum employer contribution rate = 13.50%
- **TRS**
  - Mean = 77%
  - Standard Deviation = 10%
  - Correlation = 0.85 to prior year's value.
  - Assumed system maximum employer contribution rate = 18.00%
- **PSERS**
  - Mean = 82%
  - Standard Deviation = 10%
  - Correlation = 0.80 to prior year's value.
  - Assumed system maximum employer contribution rate = 30.00%
- **LEOFF***
  - Mean = 98% for LEOFF 1, 100% for LEOFF 2
  - Standard Deviation = 1% for LEOFF 1, 0% for LEOFF 2
  - Correlation = 0.30 to prior year's value.
  - Assumed system maximum employer contribution rate for LEOFF 1 = 30.00%

** Revised May 5, 2011, to show LEOFF 1 and LEOFF 2.*

- **WSPRS**
  - Mean = 99%
  - Standard Deviation = 1%
  - Correlation = 0.10 to prior year's value.
  - Assumed system maximum employer contribution rate = 50.00%

Correlation: We found the following approximate historical correlations:

- **PERS, TRS**
  - 0.40 correlation to revenue growth 2 years ago.
  - 0.45 correlation to investment returns 2 years ago.
  - 0.80 correlation to last year's contribution pattern.
  - -0.35 correlation to change from last year's contribution to this year's recommended contribution.
- **LEOFF, WSPRS**
  - 0.30 correlation to revenue growth 2 years ago.
  - 0.30 (0.60 in WSPRS) correlation to investment returns 2 years ago.

Benefit Improvements

Used: To estimate the increase in liabilities over time associated with adopting future benefit improvements.

Data: We used a 22-year history for PERS, TRS, LEOFF, and WSPRS. We used a nine-year history for SERS. We excluded many benefit improvements for various reasons (cost not identified in fiscal notes, one-time event we don't believe will repeat in the future, etc.). For this reason, we believe our assumption conservatively estimates future benefit improvements if past practices continue.

We found the data contained a general small "creep", defined as improvements up to 0.20 percent of liabilities, with occasional large "spikes" in excess of 0.20 percent of liabilities. We also found that nearly all "spikes" applied to both past and future service credit.

Figure A.3.10

Percent Liability Increase From Benefit Improvements By Plan										
Year	All Systems	PERS 1	PERS 2/3	TRS 1	TRS 2/3	SERS 2/3	PSERS 2	LEOFF 1	LEOFF 2	WSPRS
1989	2.24%	4.08%	0.00%	3.37%	0.00%			0.00%	0.00%	0.00%
1990	0.00%	0.00%	0.00%	0.00%	0.00%			0.00%	0.00%	0.00%
1991	0.00%	0.00%	0.00%	0.00%	0.00%			0.00%	0.00%	0.00%
1992	0.37%	0.76%	0.00%	0.58%	0.00%			0.00%	0.00%	0.00%
1993	0.52%	0.00%	0.00%	0.00%	0.00%			0.00%	17.99%	0.00%
1994	0.16%	0.26%	0.00%	0.37%	0.00%			0.00%	0.00%	0.00%
1995	0.86%	2.38%	0.00%	1.06%	0.00%			0.00%	0.00%	0.00%
1996	0.00%	0.00%	0.00%	0.00%	0.00%			0.00%	0.00%	0.03%
1997	0.00%	0.00%	0.00%	0.00%	0.00%			0.00%	0.00%	0.00%
1998	0.70%	1.45%	0.00%	1.48%	0.00%			0.00%	0.00%	0.00%
1999	0.06%	0.00%	0.00%	0.00%	0.50%			0.00%	0.00%	1.03%
2000	2.39%	0.00%	6.45%	0.00%	7.67%			0.00%	2.91%	0.00%
2001	0.09%	0.00%	0.00%	0.00%	0.00%			0.00%	0.00%	8.07%
2002	0.01%	0.04%	0.00%	0.00%	0.00%	0.00%		0.03%	0.00%	0.00%
2003	0.03%	0.00%	0.03%	0.00%	0.01%	0.08%		0.00%	0.30%	0.00%
2004	0.17%	0.01%	0.62%	0.01%	0.00%	0.00%		0.00%	0.10%	0.00%
2005	0.12%	0.00%	0.00%	0.02%	0.00%	0.00%		0.21%	1.25%	0.00%
2006	0.13%	0.09%	0.02%	0.03%	0.11%	0.24%		0.51%	0.31%	1.08%
2007	3.25%	3.28%	3.89%	3.31%	6.20%	4.26%		0.00%	0.15%	0.00%
2008	0.09%	0.02%	0.03%	0.08%	0.65%	0.00%	0.00%	0.00%	0.00%	0.00%
2009	0.10%	0.05%	0.08%	0.00%	0.02%	0.04%	0.00%	0.56%	0.16%	0.71%
2010	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%	0.02%
Average	**0.52%**	**0.56%**	**0.51%**	**0.47%**	**0.69%**	**0.51%**	**0.00%**	**0.06%**	**1.09%**	**0.50%**

Expectation: Based on past experience, we modeled approximately a 0.5 percent increase in the Present Value of Future Benefits (PVFB) per year for PERS, TRS, SERS, PSERS, and WSPRS. We modeled approximately a 1.0 percent increase in PVFB per year for LEOFF 2. We modeled approximately a 0.05 percent increase in PVFB per year for LEOFF 1.

Distribution: We created an assumption that incorporates the "creep" and "spikes" seen in the historical data. Overall the "creep" and "spike" added together equal our expectation.

Figure A.3.11 shows our benefit improvement assumption.

Correlation: The spikes tend to drive the benefit improvement data. Due to the limited number of spikes in the data, we did not observe a strong statistical correlation between benefit improvements and any other variable we are modeling. However, this does not mean a correlation does not exist. For example, two of the spikes relate to gain-sharing benefits (a benefit improvement directly tied to investment returns).

Formula: Even though we did not observe a statistically valid correlation, we implemented a formula based on economic conditions to model future benefit improvements. If past practices continue, we assume the Legislature will adopt more benefit improvements during good economic times and less during bad economic times. To model this we used the formula:

Spike = Spike Probability x Spike Amount x Current Year Revenue Percentile / 0.50

This formula means that during the worst economic times, no spike will occur. During the best economic times the spike will double. During average economic times the spike assumptions in **Figure A.3.11** will hold.

Figure A.3.11

Average Historical Creep & Spike in Liabilities								
	PERS 1	PERS 2/3	TRS 1	TRS 2/3	SERS 2/3	LEOFF 1	LEOFF 2	WSPRS
Annual Creep	0.06%	0.03%	0.06%	0.04%	0.06%	0.03%	0.07%	0.04%
Spike	1.84% Every 3.7 Years	3.45% Every 7.3 Years	1.5% Every 3.7 Years	3.55% Every 5.5 Years	2.05% Every 4.5 Years	0.22% Every 7.3 Years	3.74% Every 3.7 Years	2.53% Every 5.5 Years
Spike Probability	27%	14%	27%	18%	22%	14%	27%	18%

Real Salary Growth

Used: To model annual changes in system salary. Real salary growth affects the present value of liabilities and future salaries (contribution rates), benefit payments, and contributions collected.

Data: We used a 26-year history of salary growth for PERS, TRS, LEOFF, and WSPRS. We used an eight-year history for SERS and a one-year history for PSERS. We excluded PERS data in 2000 since the creation of SERS made it difficult to track the actual year-to-year change.

Figure A.3.12

Real Salary Growth By System							
Year	PERS	SERS	PSERS	TRS	LEOFF	WSPRS	Total
1983	-6.25%			-10.06%	-4.24%	-12.89%	-7.72%
1984	-2.47%			0.00%	-0.87%	5.86%	-1.65%
1985	7.61%			4.80%	4.51%	2.84%	6.35%
1986	0.35%			-0.03%	1.87%	-7.89%	0.28%
1987	2.35%			-0.28%	-0.81%	3.42%	1.16%
1988	1.74%			3.77%	5.47%	1.49%	2.42%
1989	1.42%			2.88%	0.33%	1.74%	1.63%
1990	1.55%			2.03%	3.37%	0.86%	1.60%
1991	2.26%			4.54%	0.00%	4.97%	2.36%
1992	-4.41%			-2.28%	-0.98%	-4.15%	-3.61%
1993	-1.14%			0.02%	-0.18%	-1.73%	-0.71%
1994	-2.58%			-2.83%	0.81%	-1.48%	-2.36%
1995	-0.06%			-1.63%	1.16%	1.83%	-0.29%
1996	-0.53%			0.86%	0.27%	1.56%	-0.14%
1997	-0.56%			-2.44%	1.21%	4.82%	-0.92%
1998	-1.49%			-0.36%	2.08%	1.64%	-0.99%
1999	0.20%			-2.65%	0.81%	1.68%	-0.52%
2000				2.39%	1.40%	-2.14%	1.42%
2001	0.33%	-5.05%		-1.74%	-0.16%	-1.51%	-0.68%
2002	0.89%	1.24%		0.04%	1.38%	-0.67%	0.52%
2003	-0.92%	1.92%		1.03%	-0.46%	-2.20%	0.07%
2004	0.10%	0.01%		-0.36%	2.18%	-2.04%	0.08%
2005	1.10%	0.40%		0.76%	2.61%	3.26%	1.09%
2006	2.43%	0.92%		0.47%	1.91%	4.20%	1.79%
2007	-0.49%	0.16%		2.35%	-0.27%	-0.54%	0.22%
2008	2.35%	1.78%	-0.58%	1.90%	1.71%	0.91%	2.13%

Expectation: We expect annual real salary growth to equal 0.50 percent for all systems besides LEOFF 2. We expect LEOFF 2 to experience 1.00 percent real salary growth per year.

Distribution: We created assumed distributions for real salary growth that can be seen in **Figure A.3.13**. We created one distribution for PERS, SERS, and PSERS. We also created separate distributions for TRS, LEOFF, and WSPRS.

Figure A.3.13

Summarized Assumed Distributions				
Percentile	PERS, SERS, PSERS	TRS	LEOFF	WSPRS
MIN	-5.87%	-9.76%	-4.22%	-12.65%
1	-5.48%	-7.96%	-3.40%	-11.40%
5	-4.25%	-2.48%	-0.93%	-6.72%
10	-2.17%	-2.24%	-0.82%	-2.94%
25	-0.20%	-1.01%	-0.16%	-1.44%
50	0.64%	0.33%	1.01%	1.44%
75	1.89%	2.29%	1.92%	2.83%
90	2.70%	3.63%	3.01%	4.75%
95	2.76%	4.65%	4.24%	5.17%
99	6.28%	5.03%	5.25%	5.88%
MAX	7.99%	5.10%	5.49%	6.10%

Correlation: We assumed real salary growth is correlated to real revenue growth two years ago. We assumed a 0.60 correlation.

Miscellaneous

We assumed generational mortality improvements consistent with 50 percent of Scale AA (a standard mortality projection scale from the Society of Actuaries). The rate of improvement is consistent with the 2008 AVR (performed on a closed-group basis), but the generational length of growth is more appropriate for the open group projection we employed in our model. The generational length of growth perpetually continues throughout the fifty-year projection whereas the 2008 AVR is projected to a static year meant to approximate the closed group population.

We also assumed new entrants would become slightly older over time due to the aging of the baby boomers, decreasing fertility rates and improving life spans. We modeled new entrants entering three years older than the current average new entrant age.

Model Verification and Validation

We intend this model to provide a basis for understanding and implementing a risk management process. This model provides a significant increase in information about the range of outcomes the pension system could experience in the future. The importance of the model lies in this large step forward; it's much more important to know the general range of outcomes that could occur than to worry about whether a specific risk measure is slightly higher or lower than the "actual" value. We built the model with this purpose in mind, and this section explains how we checked our model to make sure we implemented it with enough "precision for the decision" at hand (concept based on a quote from Robert McCrory).

We followed a thorough reasonability procedure to check that we implemented our methods as intended. The list below explains most of the major steps we took to ensure reasonability.

1. We analyzed the randomness of the random numbers that are input into the economic environment generator. We made sure the numbers were indeed uniformly distributed between zero and one, and that they demonstrated no correlation.
2. We analyzed the characteristics of the correlated random numbers for reasonability. We reviewed the range of numbers generated, the shape of the distribution of numbers generated, and the range of inter-correlations that we expected to see.
3. We analyzed the characteristics of the stochastic variables. We reviewed the range of values generated, the shape of the distribution of values generated, and the range of inter-correlations that we expected to see.
4. We analyzed sample simulations to make sure we input the stochastic variables correctly, the calculations reacted correctly to the stochastic variables, and to make sure the results seemed reasonable.
5. We stress tested the model to ensure that it is robust and that the calculations can handle extreme situations that may arise in a given simulation. We stress tested the model by entering extreme values, changing the current status of the pension systems, and creating specific scenarios.
6. We compared model output to past pension projections, such as the 2009 Report on Financial Condition. This demonstrated we are consistently applying our methods and not introducing errors.
7. We performed sensitivity analysis on our assumptions and methods to see how

the model reacts. We reviewed the results to ensure that the model reacts reasonably. Please see additional information on our sensitivity analysis in the next appendix section.

8. The Pension Funding Council solicited an outside actuarial review of the model. As of the date of this publication, the audit has been underway for two months (from the date of initial receipt of information), but is not yet complete. We appreciate the comments we received from the actuarial auditor thus far on assumptions and methods. At this point, we are very confident in the reasonability of the results from our model and the associated findings. We will consider any further comments from the actuarial auditor as we update the model in the future. Please see the next paragraph for an explanation of the on-going nature of this model.

We intend to use this type of analysis, and therefore, this model, on a regular basis in the future. We plan to continually monitor and update the assumptions and methods used as necessary. We will also continue to monitor and ensure the model has assumptions and methods that produce the precision needed for the decisions at hand.

Sensitivity Analysis

Consistent with the Verification and Validation section, we perform sensitivity analysis on our assumptions and methods. We do this for the following primary reasons:

- To check our model for reasonable reactions to different assumptions or methods.
- To determine how much time we should spend refining a given assumption or method. If we change the assumption or method significantly and the results hardly change, it's likely not worth spending too much time refining it.
- To provide readers with a sense of how the results change under different assumptions.

We performed numerous sensitivity runs. Below, we show a few of these and how they affected the results of the model:

1. **Different Investment Return Distribution** – The current model uses the log stable distribution. This run shows how the results would change if the lognormal distribution were used.
2. **Different Investment Return Method** - The current model uses the log stable distribution. This run shows how the results would change if a "regime-switching" model were used. The regimes, which were set up to match the historical Cumulative Distribution Function (CDF), are:
   a. **Boom** – When in this regime, the expected return is 26.0 percent and the standard deviation is 13.2 percent. The maximum return is 50.0 percent and the minimum return is 10.0 percent. There is a 20 percent chance of staying in the Boom regime, a 75 percent chance of moving to a Normal regime, and a 5 percent chance of moving to the Recession regime.
   b. **Normal** – When in this regime, the expected return is 4.7 percent and the standard deviation is 11.3 percent. The maximum return is 26.0 percent and the minimum return is -16.0 percent. There is a 72 percent chance of staying in the Normal regime, a 25 percent chance of moving to the Boom regime, and a 3 percent chance of moving to the Recession regime.
   c. **Recession** - When in this regime, the expected return is -30.3 percent and the standard deviation is 1.0 percent. The maximum return

is 0.0 percent and the minimum return is -35.0 percent. There is a 0 percent chance of staying in the Recession regime, a 50 percent chance of moving to the Normal regime, and a 50 percent chance of moving to a Boom regime.

3. **Lower Investment Distribution for Ten Years** – The current model assumes the same distribution for the fifty-year period. This run shows how the results would change if the first ten years had an investment return distribution that was shifted downward by 100 basis points (1 percent), reverting back to the current distribution after the ten-year period.

4. **Lower Percent of Contributions Made Assumption** – Under the continuation of past practices, the current model assumes a fraction* of recommended contributions will be made – 82, 77, 98, 100, and 99 percent for PERS/SERS/PSERS, TRS, LEOFF 1, LEOFF 2, and WSPRS respectively on average. This run shows how the results would change if 5 percent less were contributed.

** Revised May 5, 2011, to show LEOFF 1 and LEOFF 2.*

5. **Higher Benefit Improvement Assumption** – Under the continuation of past practices, the current model assumes benefit improvements will occur over time – approximately 0.05 percent annual liability increase for LEOFF 1, 1.0 percent for LEOFF 2, and 0.5 percent for the remaining systems. This run shows how the results would change if benefits improved at a 25 percent higher rate than currently assumed.

Figure A.5.1

Sensitivity of Model to Assumptions and Methods

Category (from scorecard in report body)	Current Results	Lognormal Investment Return Distribution	Regime-Switching Investment Return Model	Lower Short-Term Investment Distribution	Lower Contribution Assumption	Higher Benefit Improvement Assumption
:e Pensions will Consume More than 8% of GF-S	18%	16%	17%	23%	19%	19%
ance GF-S Consumption will Exceed	9.9%	9.6%	9.6%	10.1%	9.9%	10.0%
ance Employer Contribution Rate will Exceed	20.1%	19.9%	20.2%	20.6%	20.2%	20.6%
:e of PERS 1, TRS 1 in Pay-Go	41%	42%	38%	48%	46%	46%
:e of Open Plan in Pay-Go	13%	12%	11%	14%	14%	22%
ance Annual Pay-Go Cost in PERS 1, TRS 1 Exceed	$1.7	$1.7	$1.7	$1.7	$1.7	$1.8
ance Annual Pay-Go Cost in Open Plans Exceed	$4.0	$4.1	$4.0	$4.4	$4.1	$6.7
:e of Total Funded Status Below 60%	34%	33%	30%	38%	37%	40%