Society of Actuaries

Mortality Improvement Scale BB Report

September 2012

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Caveat and Disclaimer

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Section 1. Executive Summary

1.1 Summary of Report Objectives

The Society of Actuaries' Retirement Plans Experience Committee's (RPEC) primary objectives in releasing this report at this time are threefold:

1. To present to potential users of Scale AA the results of recent analyses performed by RPEC that show that the rates of mortality improvement in the US over the recent past have differed quite substantially from those predicted by Scale AA;
2. To provide an alternative to Scale AA, called Scale BB, that is based on more recent data and newly developed techniques, and that can be used immediately without any changes to existing valuation software; and
3. To provide users and developers of actuarial software lead time prior to the release of the next generation of pension mortality improvement scales, which, in keeping with newer techniques, are likely to be two-dimensional.

1.2 Overview

As part of its periodic review of retirement plan mortality experience, RPEC initiated a Pension Mortality Study in 2010. This study, which is still in progress, includes a comprehensive review of recent mortality experience of uninsured retirement plans in the United States. The SOA anticipates publishing a new set of retirement plan mortality tables and mortality improvement rates in late 2013, or early 2014, that would be the successors to the RP-2000 tables and Scale AA[1].

At an early stage of its analysis, the Mortality Improvement Sub-team of RPEC noticed that mortality improvement experience in the United States since 2000 has differed from that anticipated by Scale AA. In particular, there was a noticeable degree of mismatch between the Scale AA rates and actual mortality experience for ages under 50, and the Scale AA rates were lower than the actual mortality improvement rates for most ages over 55. Given that the Pension Mortality Study is still many months from completion, RPEC is publishing an interim improvement Scale BB, which can be used by pension actuaries as an alternative to Scale AA for the projection of base mortality rates beyond calendar year 2000.

Scale BB was developed using certain techniques that have not been used previously in the construction of mortality improvement scales published by the SOA. These techniques, including the analysis of US mortality trends on a two-dimensional (age and calendar year) basis, are described in Sections 4 and 5. These important new techniques notwithstanding, the final

[1] Scale AA, originally developed for use with the Group Annuity Reserving (GAR) 1994 table, was reviewed and recommended by RPEC for continued use beyond 2000 with the publication of the RP-2000 mortality tables [12].

gender-specific Scale BB rates published in this report vary solely by age, and hence can be used with existing pension valuation software.

RPEC recognizes that there is a wide range of opinion with respect to future levels of mortality in the United States and that the assumptions underlying any set of mortality improvement rates must necessarily reflect some degree of subjectivity. RPEC characterizes the assumptions that underpin Scale BB (including a 1.0% long-term rate of mortality improvement and limited cohort effects) as middle-of–the road, being neither overly optimistic nor too pessimistic with respect to future longevity improvements in the United States.

In light of the nearly continuous pattern of increasing longevity in the United States over the past century, the Committee recommends that actuaries incorporate adequate provisions for future mortality improvement into their calculations. Taking into consideration the methodology used to develop Scale BB (Section 5.3) and RPEC's preference for generational projection of mortality over static approximations (Section 7.1), the committee encourages users of Scale BB to do so on a fully generational basis.

RPEC asked actuaries at a number of consulting firms to help assess the financial impact of switching from Scale AA to Scale BB. In each case, the actuaries were asked to perform valuations as of January 1, 2013 on various types of pension and post-retirement benefit plans using the RP-2000 Combined Healthy base mortality table, first with Scale AA, and then with Scale BB, both applied on a generational basis. RPEC found that when valuing retirement plans whose primary forms of benefit payment were non-increasing annuities (using a 6% discount rate), switching from Scale AA to Scale BB increased past service obligations in the 2% to 4% range.

Scale BB is being released as an interim mortality improvement scale pending completion of the full Pension Mortality Study, anticipated in late 2013 or early 2014. RPEC encourages all actuaries considering the use of Scale BB to review carefully the results summarized in this report.

Members of RPEC
(Members of the Mortality Improvement Sub-team are denoted with a *. Members who joined RPEC after the release of the Scale BB exposure draft are denoted with a $^{+}$.)

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1.3 Special Recognition of Others Not Formally on RPEC

The Mortality Improvement Sub-team expresses its special appreciation to JJ Carroll, Steven Ekblad, Dr. Brian Ivanovic and Allen Pinkham, all employees of Swiss Re, and Michael Morris from the Social Security Administration for their valuable contributions throughout this project. Special thanks also go to a number of actuaries at Aon Hewitt and Towers Watson who helped develop the transitional mortality improvement rates and the conversion of those two-dimensional rates into the age-only rates that make up Scale BB.

The Committee would also like to thank numerous other actuaries at Aon Hewitt, Buck Consultants, EFI Actuaries, Mercer, Milliman, Segal and Towers Watson for their help in assessing the financial impact of changing from Scale AA to Scale BB.

Finally, RPEC would like to express its appreciation to the many organizations that contributed retirement plan data for use in this report and the ongoing Pension Mortality Study.

Section 2. Background

2.1 Evolution of this Project

In June 2010, RPEC initiated a comprehensive analysis of pension plan mortality experience in the United States. The ultimate goal of this project is to publish an updated version of RP-2000 and a replacement for mortality projection Scale AA. That analysis is ongoing, with an anticipated completion date of late 2013 or early 2014.

Pension mortality tables published by the SOA no longer include explicit margins for future mortality improvement. Actuaries are now expected to use an appropriate mortality projection scale to factor in expected longevity improvements. To facilitate the process, the SOA now publishes a recommended mortality improvement scale with each new base mortality table.

Realizing that any new pension mortality table will require the concurrent release of an appropriate mortality improvement scale, RPEC created a sub-team to study mortality improvement issues in the United States. At its early stages, the analysis done by the Mortality Improvement Sub-team was based entirely on US population data, including mortality data received directly from the Social Security Administration (SSA) [16] and other publicly available sources[2] such as the Human Mortality Database (HMD) [9]. The Sub-team later compared the recent mortality improvement experience of the SSA to that of two very large public plans. All three sets of mortality improvement experience were consistent, and RPEC concluded that the SSA data formed an appropriate basis for developing a new mortality improvement scale for US retirement plan purposes.

2.2 Historical Review of Scale AA

In 1995, the SOA published a series of new mortality tables, along with related commentary [20], [21] and [22]. In addition to the release of the GAM-94 and UP-94 base mortality tables, these reports introduced Scale AA, which was to be used for the projection of mortality improvements beyond 1994. Scale AA was based entirely on the historic mortality experience of the SSA and the Civil Service Retirement System (CSRS) between 1977 and 1993, by age and gender, with a minimum rate of 0.5% for ages under 85.

In July 2000, RPEC published the RP-2000 Mortality Tables Report [12]. As part of the analysis, RPEC examined trends in non-disabled mortality rates for various data sets (including Federal Civil Service and SSA). As a result, RPEC recommended the continued use of Scale AA for the projection of mortality rates beyond the year 2000.

[2] Given the paucity of large sets of consistent, long-term pension-specific mortality data, most pension mortality improvement research still relies primarily on population data.

Section 3. Comparison of Recent US Mortality Experience to Scale AA

3.1 Methodology and Sources of Data

The Committee analyzed mortality improvement trends using the so-called "best-fit log-linear" (BFLL) methodology. For a given age, *x*, the BFLL methodology first calculates the slope, *s*, of the least-squares regression line through the natural logarithms of the base mortality rate for each calendar year in the selected observation period. The BFLL average mortality improvement rate for age *x* over the selected observation period is equal to $1 - e^s$, where e is the base of the natural logarithm. (See Chapter 4 of [12])

Three sources provided data that RPEC considered large enough and consistent enough to develop US mortality improvement trends.

- The SSA provided tables of gender-specific US general population mortality rates for all ages and for all calendar years from 1900 through 2007.
- The Office of Personnel Management (OPM) provided data covering 1984 through 2009 for retirees covered by CSRS and FERS.
- The California Public Employee Retirement System (CalPERS) provided data on active and retired participants covering the period 1997 through 2007.

RPEC also reviewed the US mortality rates available in the Human Mortality Database (HMD) [9]. Finding them to be quite similar to those provided by the SSA, the Committee concluded that it was not necessary to include the HMD rates in the comparisons to Scale AA.

3.2 Comparisons over the Period 1994 – 2007

The Committee first applied the BFLL methodology to just the SSA rates for ages 20 through 99, and over an observation period covering 1994 through 2007. Figures 1(M) and 1(F) compare the average gender-specific SSA mortality improvement rates over the period 1994 – 2007 to the Scale AA rates.

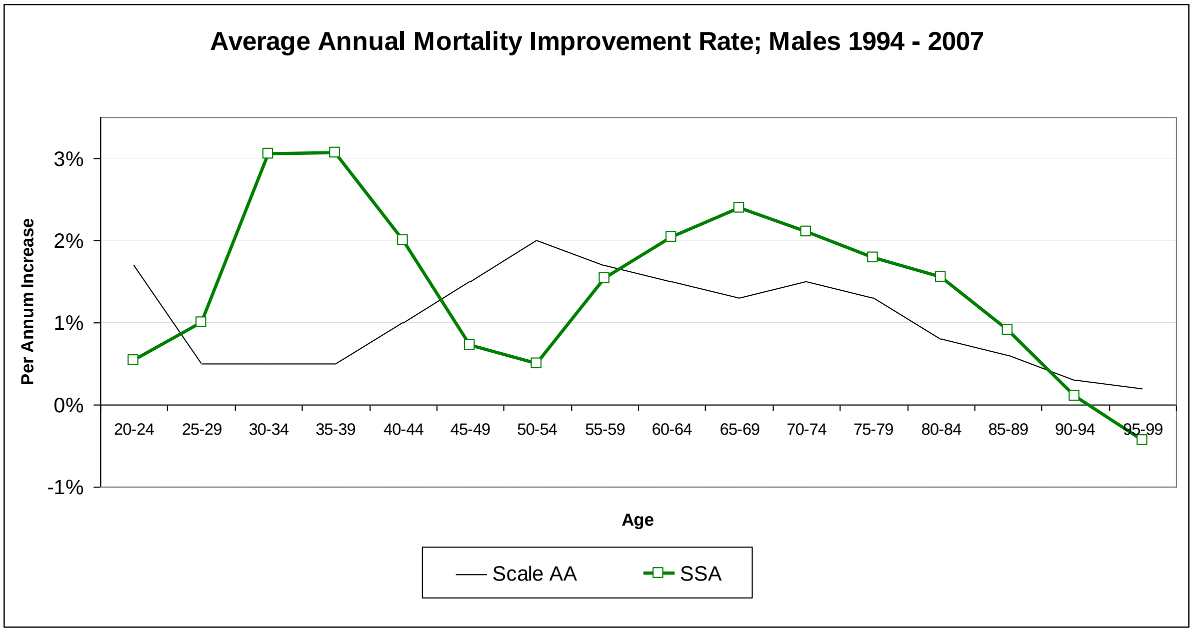

Figure 1(M)

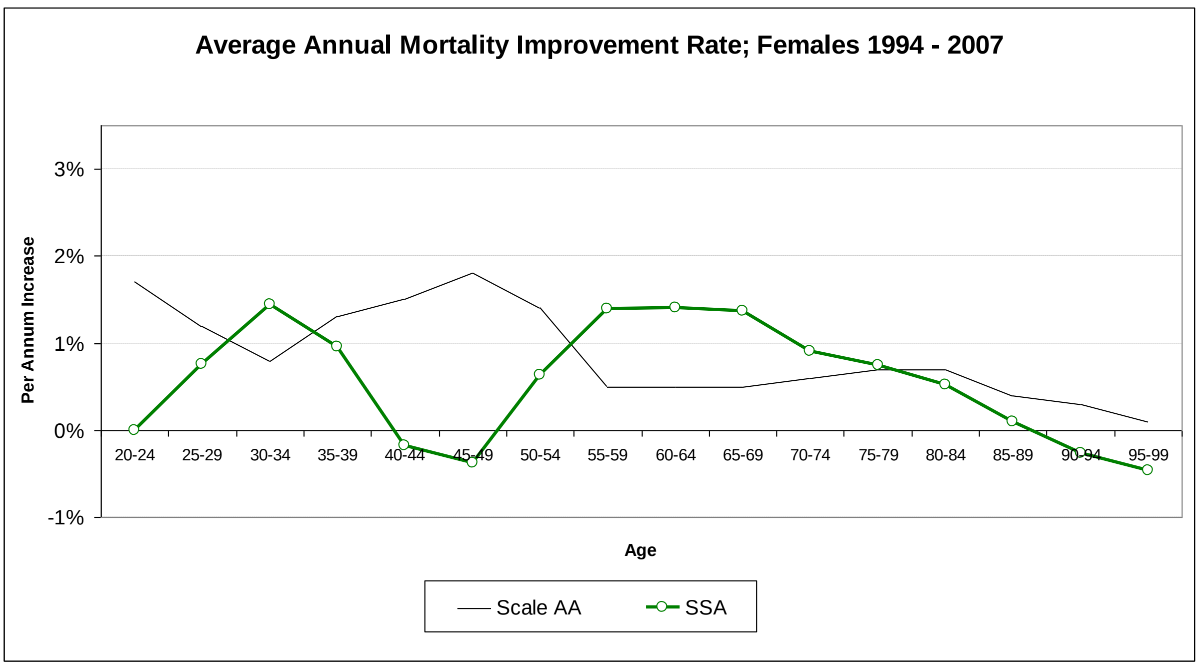

Figure 1(F)

Figures 1(M) and 1(F) show that there was a significant degree of mismatch between the Scale AA rates and the average 1994 – 2007 SSA mortality improvement experience at ages under 55 for both males and females. The figures also show that Scale AA rates were smaller than the SSA mortality improvement rates between ages 55 and 89 for males, and between ages 55 and 79 for females.

3.3 Comparisons over the Period 1998 – 2006

The Committee then supplemented its SSA results with the data submitted by OPM and CalPERS, and developed BFLL mortality improvement rates for all three groups covering the period 1998 through 2006. The results of that analysis, summarized in figures 2(M) and 2(F), confirmed that the mortality improvement patterns of OPM and CalPERS were generally consistent with those of the SSA, and that the same types of mismatches with Scale AA identified in Section 3.2 above continued to appear with all three groups over the 1998 – 2006 timeframe.

These results were also consistent with a recent SOA study of mortality experience under group pension contracts issued primarily in the United States [13]. That study reported that between 2001 and 2006, overall mortality rates improved 2.5% faster than Scale AA on a "by lives" basis, with female mortality rates improving slightly faster than male rates over that period.

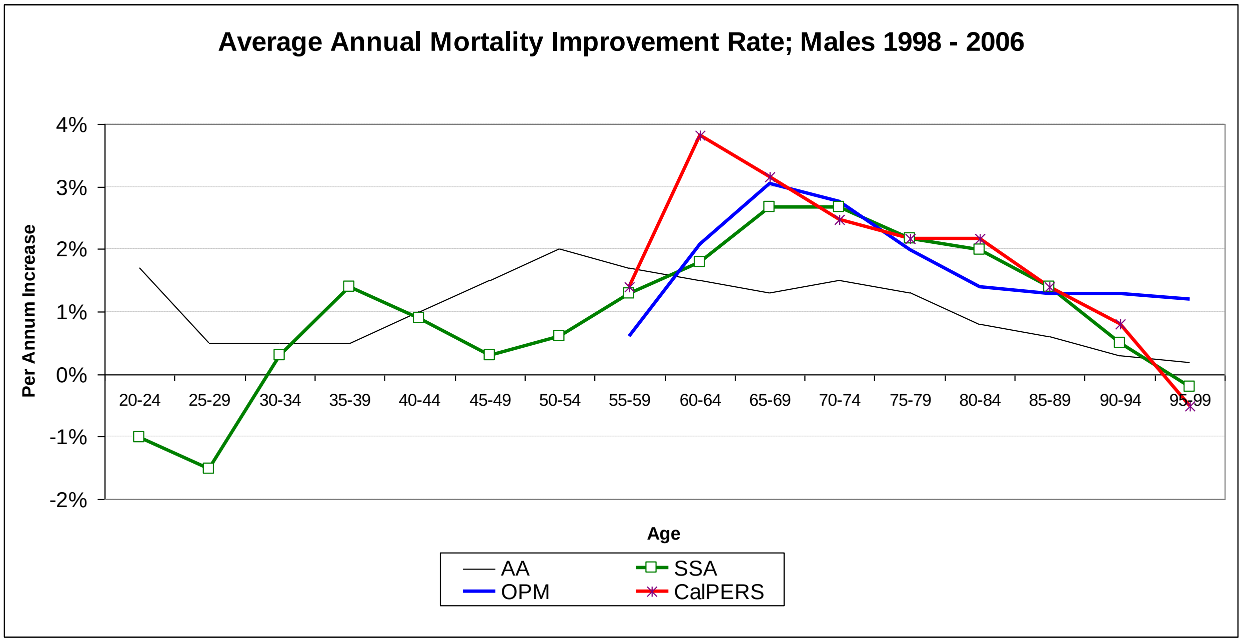

Figure 2(M)

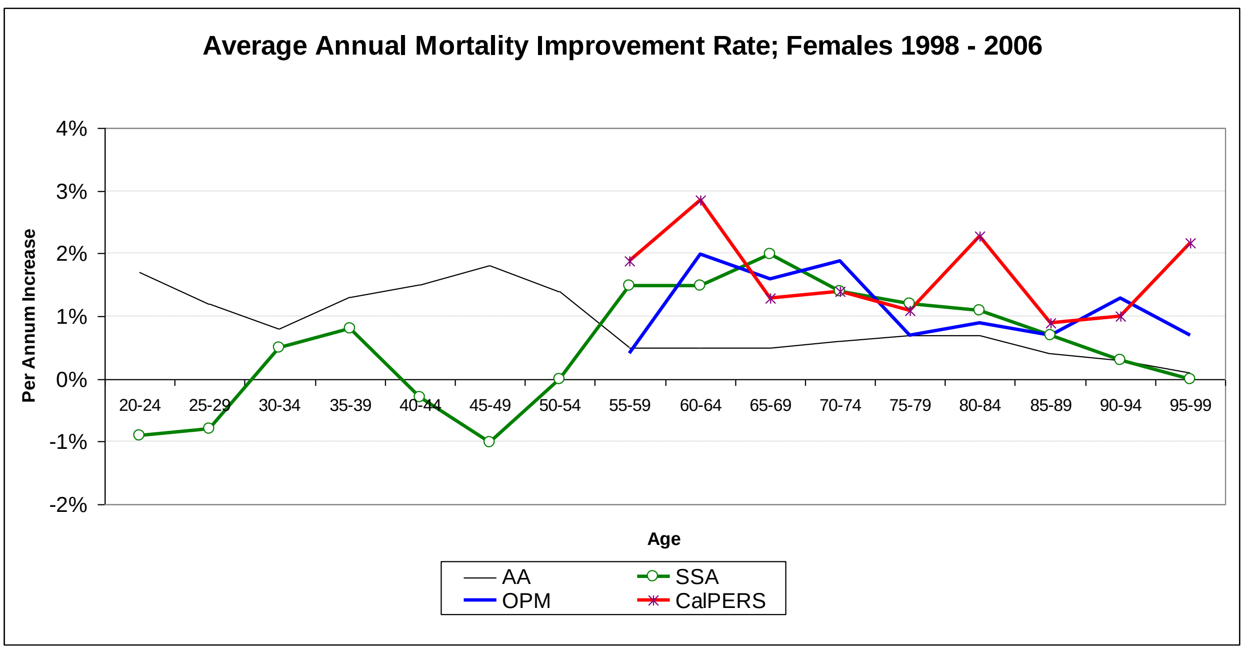

Figure 2(F)

Section 4. New Approaches for Developing Mortality Improvement Scales

4.1 Two-Dimensional Mortality Improvement Rates

Since the release of Scale AA nearly two decades ago, actuaries have developed a number of new approaches for producing mortality improvement scales. For example, recent work has been done by the Continuous Mortality Investigation (CMI) group of the Institute and Faculty of Actuaries in the United Kingdom [2] – [8] and a recent SOA study [10].

In contrast to the gender-specific Scale AA rates that are functions solely of age, a number of recently developed mortality improvement scales vary by both age and calendar year (CY). These rates can be arranged into a two-dimensional array that reflects for a given age, *x*, and CY, *y*, the **change** in underlying mortality rates at age x between CY *y-1* and CY *y*.

The resulting two-dimensional array can be smoothed and colorized to create a so-called “heat map” of mortality improvement rates. Figures 3(M) and 3(F) are examples of heat maps based on SSA data, with calendar years 1950 through 2005 shown on the x-axis and ages 50 through 100 shown on the y-axis. For example, the green coloration of the cell for age 60 and CY 2003 highlighted in Figure 3(M) below means that male mortality rates at age 60 decreased by approximately 1.50% between 2002 and 2003.

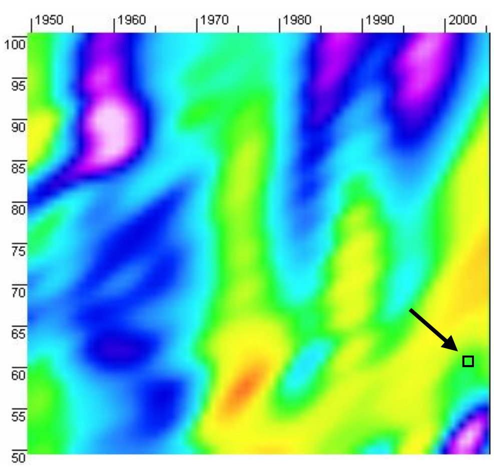

Figure 3(M)

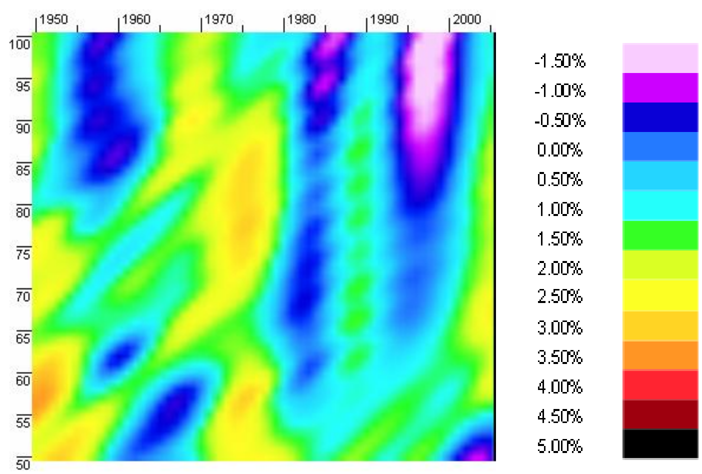

Figure 3(F)

Heat maps such as the ones in Figures 3(M) and 3(F) are useful in helping to identify various types of mortality improvement trends. For example, very clear vertical patterns of unusually high or low mortality improvement indicate “period” effects, while 45° diagonal patterns of unusually high or low mortality improvement indicate year-of-birth “cohort” effects. Interestingly, the US mortality improvement rates shown above reveal very few purely horizontal patterns (“age” effects), even though all of the past mortality improvement scales used by US pension actuaries have been functions of age only.

RPEC notes that the SSA uses a two-dimensional model of mortality improvement for its cost projections, and similar to the CMI model highlighted in Section 5.2, the SSA blends historical experience with expectations of future long-term mortality improvement rates. See [15] for additional details related to the SSA methodology.

4.2 Blending Actual Mortality Improvement Experience with Expected Future Mortality Improvement Rates

Unlike Scale AA, which was based on a purely retrospective analysis of mortality trends, a number of more recent mortality projection scales have been constructed by blending actual past experience with an assumed long-term rate of future mortality improvement. The topic of future mortality trends is currently the subject of extensive study and intense debate around the globe. See, for example, [10], [14], [25] and other resources available at www.soa.org/pension-mortality.

The wide range of opinion on these topics has led to the development of mortality projection models that provide users with varying degrees of discretion in the selection of future mortality improvement trends. The "core" version of the new CMI model, for example, requires the selection of a single "long-term rate" of mortality improvement to which the current levels of mortality improvement grade over time, while the "advanced" version of that model permits a great deal of flexibility with respect the selection of future mortality improvement assumptions [6], [7] and [8].

Section 5. The Development and Suggested Use of Scale BB

5.1 Overview

There were two major phases in the development of Scale BB: (1) the creation of "transitional" two-dimensional arrays of future mortality improvement rates; and (2) the conversion of those two-dimensional rates into gender-specific, age-only rates. Those two phases, along with further details about certain key assumptions selected by RPEC, are discussed more fully below.

5.2 Phase 1: Creation of "Transitional" Two-Dimensional Arrays of Mortality Improvement Rates

Both of the techniques described in Section 4, namely the use of two-dimensional arrays of mortality improvement rates and the blending of past and expected future mortality improvement rates, were used in Phase 1. The following steps outline the process followed by RPEC.

- Step 1: Two-dimensional tables of gender-specific mortality improvement rates were developed based on actual SSA mortality rates through calendar year 2007, the most recent date such data were available.

- Step 2: RPEC selected a future long-term mortality improvement rate of 1.0% per annum for all ages up to, and including, 90. The long-term rates over age 90 were assumed to grade down linearly to 0.0% by age 120. (See Section 5.5 for a more detailed discussion of RPEC's selection of this 1.0% long-term rate.)

- Step 3: The advanced version of the CMI model [3], [4] was used as the basis for blending the historical rates from Step 1 with the assumed future long-term rates in Step 2. With the exception of the "cohort convergence period" assumption, which establishes how many years into the future observed year-of-birth cohort effects are to be projected, RPEC adopted all of the CMI core model assumptions for these two-dimensional tables. (Recall that cohort effects show up as 45° diagonal patterns in heat maps; see Figure 3(M) for example.) Due to uncertainties regarding the extent and persistence of year-of-birth effects in the United States population, the Committee decided to limit the CMI model cohort convergence period assumption to ten years. (See Section 5.6 for a more detailed discussion of RPEC's selection of a 10-year cohort convergence period.)

Following CMI's methodology, the age/year-specific mortality improvement rates through 2007 (derived from the SSA data) were graduated using a two-dimensional P-spline model, and then stepped back two years to avoid any potential distortions from the "edge effects" that can be a feature of that graduation technique [3]. Consequently, the final calendar year of actual SSA mortality improvement rates incorporated into the resulting two-dimensional arrays is 2005, and the first calendar year of projection is assumed to be 2006. Using the convergence periods described in Step 3 above, the transitional arrays attain their long-term rates in calendar year 2025. (See item A3 in [11] for a link to the actual two-dimensional arrays.)

Heat maps of the resulting two-dimensional transitional arrays of projected mortality improvement through CY 2050 are shown in Figures 4(M) and 4(F), respectively. These heat maps illustrate the resulting smooth transition from recent historical mortality improvement rates to the assumed long-term rate of 1.0%.

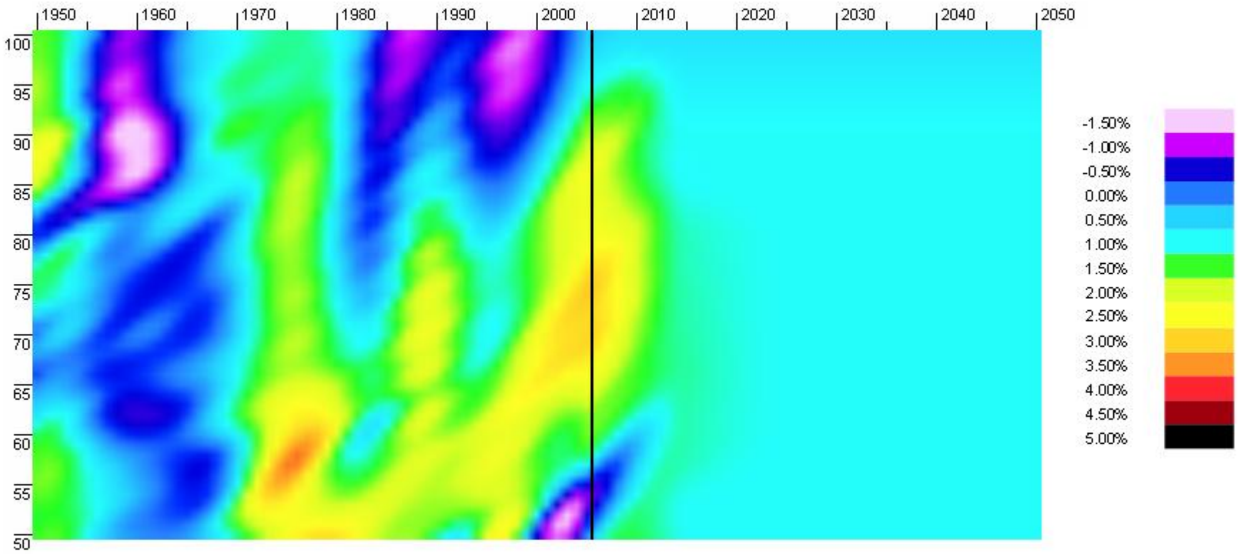

Figure 4(M)

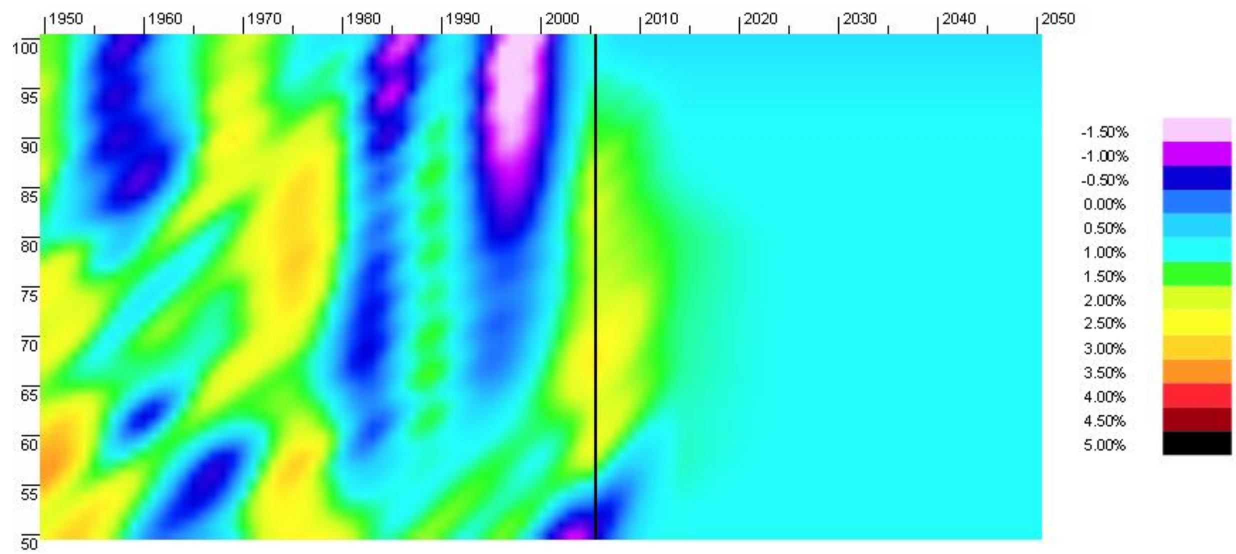

Figure 4(F)

5.3 Phase 2: Conversion of Two-Dimensional Rates to "Age-Only" Rates

The Committee recognizes that few pension valuation systems are currently designed to accommodate two-dimensional mortality improvement assumptions efficiently, and that certain actuarial applications might not require the additional level of precision that would result from the use of two-dimensional mortality improvement rates. Based on those considerations, RPEC decided to develop one-dimensional (age-only) tables of gender-specific mortality improvement rates that approximate the financial impact of the transitional two-dimensional rates, assuming both sets of rates were applied on a generational basis.

To develop the age-only rates, RPEC produced a set of gender-specific CY 2013 deferred-to-age-62 annuity values using the full set of transitional two-dimensional rates described in Section 5.2 above, applied to the RP-2000 Combined Healthy base rates. RPEC then determined the age-only mortality improvement rates that, when applied to the RP-2000 Combined Healthy base rates on a generational basis, produced deferred-to-age-62 annuity values (assuming a 6.0% discount rate) that were approximately equal to, but generally slightly less than, those deferred annuity values calculated using the transitional two-dimensional arrays.

Given that RPEC expects to release a new mortality improvement scale by early 2014, the committee decided to simplify the overall shape of the age-only improvement scale. The resulting rates, designated Scale BB, are presented along with Scale AA rates in Figures 5(M) and 5(F) below. A full table of Scale BB rates is included in Appendix A.

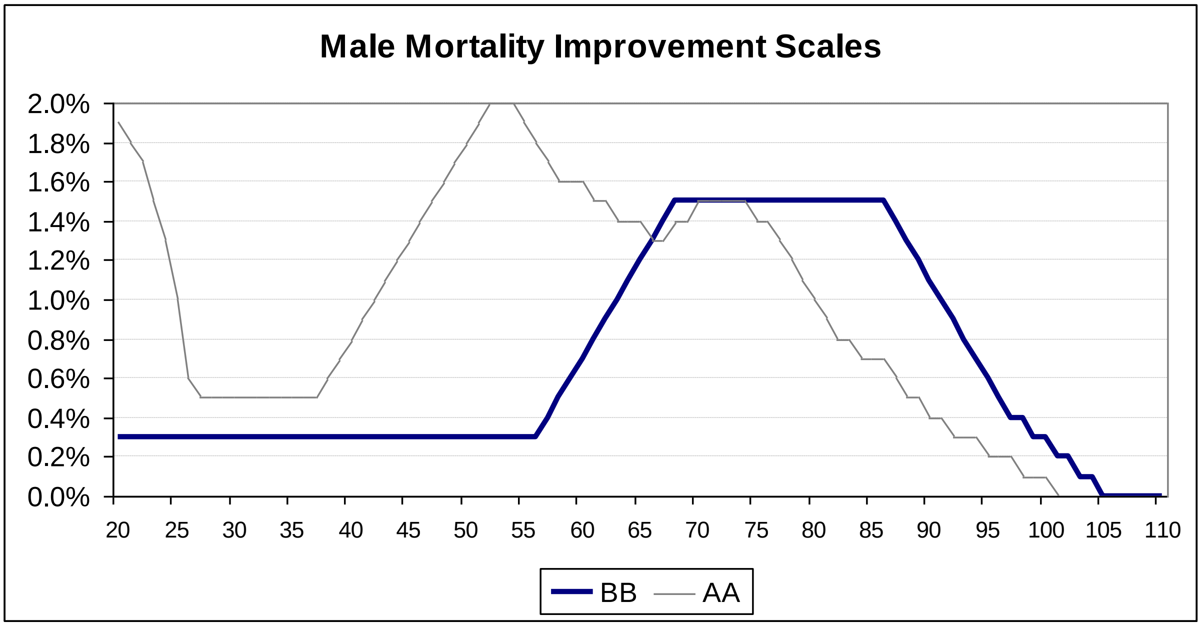

Figure 5(M)

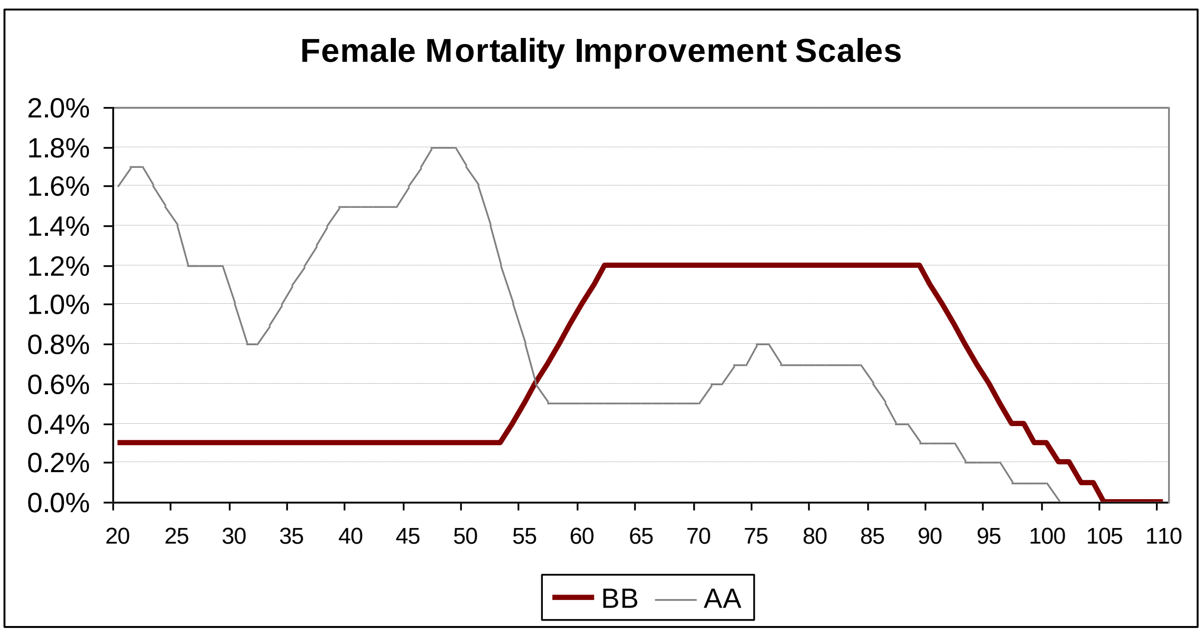

Figure 5(F)

Recall that the mortality improvement rate at age *x* affects annuity values at all ages *x* **and younger**. Scale BB was developed from the two-dimensional rates by first finding the mortality improvement rates at ages 90 and above that produced 2013 annuity values approximately equal to those produced using the full set of two-dimensional rates. Once those preliminary mortality improvement rates at ages 90 and above were determined, the process was continued for ages below 90, working from the oldest ages down to the youngest ages. Scale BB represents a simplified version of those preliminary age-only mortality improvement rates.

5.4 Comparison of Scale BB Rates to 2000 – 2007 SSA Mortality Experience

Figures 6(M) and 6(F) present a comparison of Scale BB rates to actual recent SSA mortality improvement experience. The dotted lines in those graphs represent the average annual mortality improvement rates between 2000 and 2007 based on the BFLL methodology described in Section 3.1 applied to SSA base mortality rates for that period.

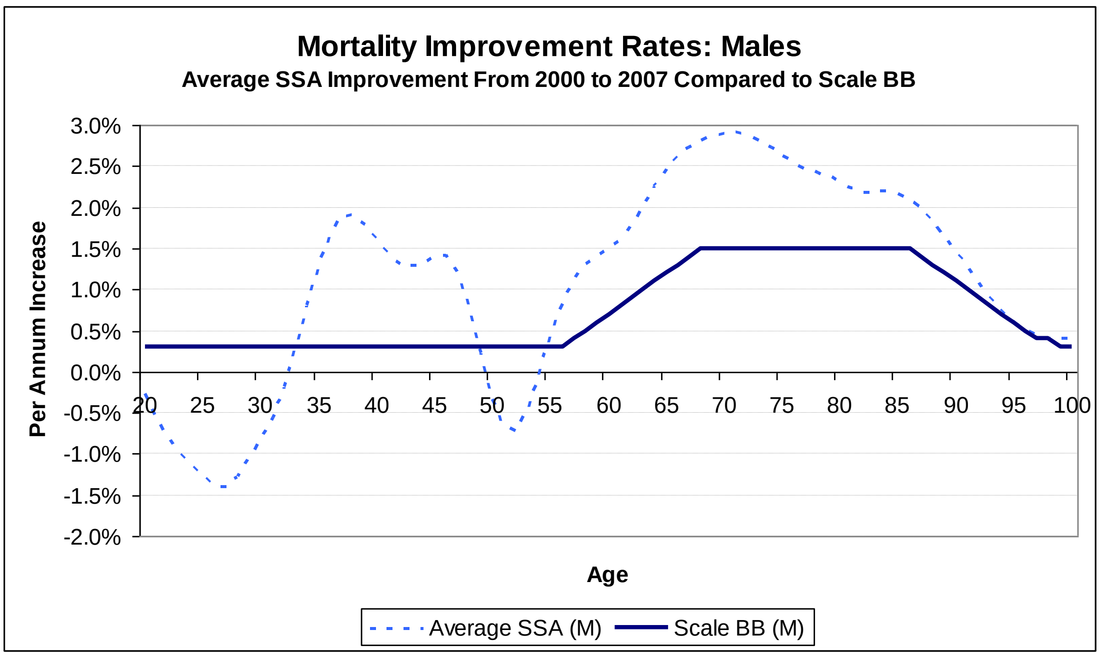

Figure 6(M)

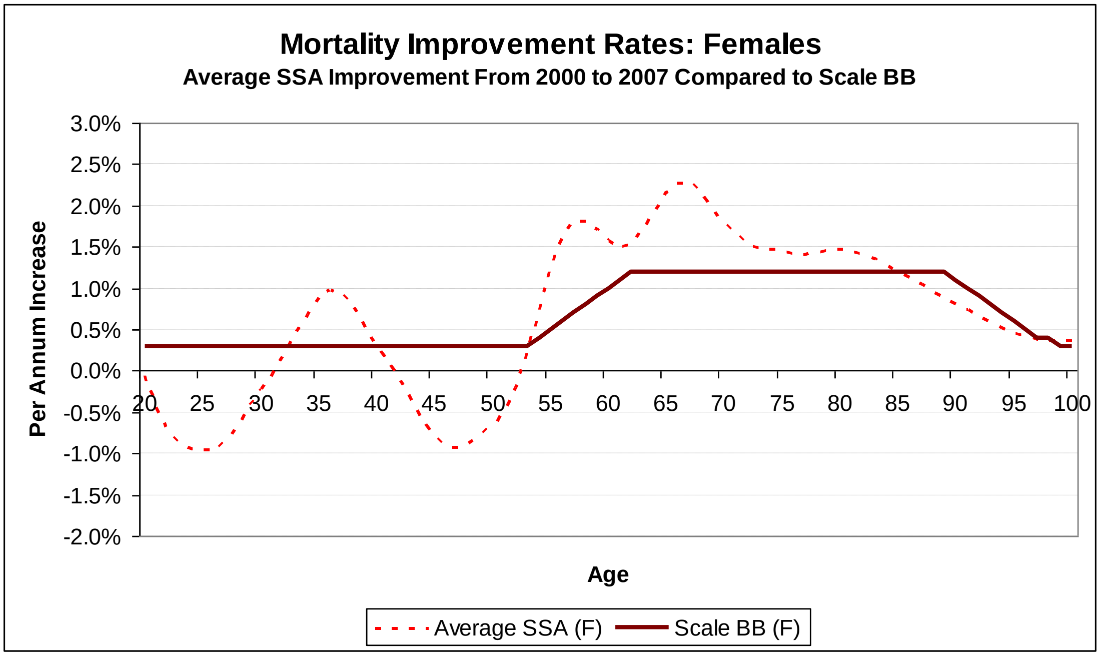

Figure 6(F)

The dotted lines in Figures 6(M) and 6(F) exhibit the variability of recent SSA mortality improvement experience across a wide range of ages. The Scale BB flat rate of 0.3% at ages less than 55 is primarily a consequence of the deferred-to-age-62 annuity matching process described in Section 5.3. Despite being lower than rates found in many other mortality projection scales, RPEC believes that the 0.3% rate at younger ages is consistent with the relatively low levels of recent SSA mortality improvement exhibited at those ages. Nevertheless, the 0.3% annual rate for younger ages should be understood by users of Scale BB as not necessarily RPEC's best estimate of future mortality improvement at those ages, but rather as the rate that produces appropriate deferred annuity values when applied generationally with the full set of BB mortality improvement rates. For ages greater than 55, Scale BB rates are generally lower than the corresponding recent SSA experience. That is not surprising since Scale BB is based on a blending of these historic rates with an assumed future long-term rate of 1.0%.

5.5 Selection of 1.0% Long-Term Rate of Mortality Improvement

The assumption regarding the long-term rate of mortality improvement is a key component of the CMI methodology that underpins Scale BB. RPEC's selection of a 1.0% rate was based on a review of historical SSA mortality improvement rates and scholarly research dealing with future mortality trends in the United States.

With respect to historical SSA rates, long-term averages of mortality improvement in the United States have generally been very close to 1.0%. For example, between the period 1950 and 2000, the age-sex-adjusted death rate in the US declined at an average rate of 1.06% per year [23], while over the more recent time period covering 1979 and 2007, the total age-sex-adjusted death rate declined at an average rate of 0.93% per year [24].

The SSA also makes assumptions with respect to the future level of mortality improvement in the US. The average age-sex-adjusted mortality improvement rates disclosed in the 2011 Trustees Report [24] were 0.32%, 0.78% and 1.31%, for the low-, intermediate- and high-cost assumption sets, respectively. It is important to note, however, that the percentages in the prior sentence are averaged over all ages, and that the SSA incorporates an "age gradient" into its long-term MI rate assumption, with long-term rates that tend to decrease with advancing age. For example, the age-sex-adjusted long-term MI rates in the 2011 Trustees Report for ages 65 and over was 0.72% under the intermediate cost assumption set.

Given the wide range of opinions with respect to future levels of mortality in the United States, RPEC decided to give particular credence to the recommendations of the Technical Panel of outside experts appointed by the Social Security Advisory Board who, every four years, publish an independent report on the assumptions and methods used by the SSA. The 2007 Technical Panel [18] recommended that the average long-term mortality improvement rate under the intermediate-cost set of assumptions be increased to a flat 1.0%, and the 2011 Technical Panel recommended adoption of a new mortality projection methodology that equates to a flat, long-term rate of 1.26% [17], [19].

RPEC characterizes the 1.0% long-term rate as middle-of-the road, being neither overly optimistic nor too pessimistic with respect to future longevity improvements in the United States. The committee also acknowledges the subjective nature of any long-term mortality improvement rate and, therefore, suggests in Section 7.4 an approach for developing adjusted two-dimensional arrays for users who believe a different set of assumptions is more appropriate for their specific application.

5.6 Selection of 10-Year Cohort Convergence Period

In addition to assumptions regarding the long-term rate of mortality improvement, the new CMI models include parameters relating to the future impact of certain age/period and cohort effects. These assumptions not only determine the impact that age, period and year-of-birth have on future mortality improvement rates, they also influence the timeframe over which near-term mortality improvement rates grade into the long-term rates. Implicit in the core version of the CMI model [7] is an assumption that cohort effects in the UK will continue for up to 40 years into the future.

RPEC considered a number of different cohort convergence periods while developing the transitional two-dimensional mortality improvement arrays described in Section 5.2. While Figures 3(M) and 3(F) exhibit some indication of patterns along 45° slopes, the cause, extent and persistence of those cohort-like effects in the US population continues to be an area of ongoing research by professional demographers. Considering Figure 3(F), for example, it was not clear to RPEC whether the pattern of relatively high levels of mortality improvement for females after CY 2000 indicates the reemergence of dormant cohort effects or the start of a new period effect. Based on these types of issues, RPEC opted for a relatively short 10-year cohort convergence period for purposes of the interim Scale BB.

5.7 Suggested Use of Scale BB

Scale BB was designed to be applied directly to calendar year 2000 mortality rates, such as those for non-disabled lives published in the RP-2000 report [12]. In particular, there is no need for actuaries to split the post-2000 projection of mortality rates into separate Scale AA and Scale BB periods.

RPEC recognizes that the application of Scale BB rates starting in the year 2000 creates post-2000 base mortality rates that differ from those developed using Scale AA. Since the individual gender/age-specific Scale BB rates were fairly consistent with the corresponding averages of post-2000 SSA mortality improvement experience (especially at ages 55 and above), the Committee concluded that this consequence of applying Scale BB to CY 2000 base rates was not unreasonable.

RPEC encourages users of Scale BB to do so on a fully generational basis. First, Scale BB was specifically designed to be used in this manner (see Section 5.3). Second, the standard duration-based approximation techniques were shown to be somewhat less reliable with Scale BB than they were with Scale AA. Finally, static approximations have limitations compared to full generational projections (see Section 7.1).

Section 6. Estimated Financial Impact of Switching from Scale AA to Scale BB

6.1 Overview of Costing Project

RPEC asked actuaries at a number of consulting firms to help assess the financial impact of switching from Scale AA to Scale BB. In each case, the actuaries were asked to simulate valuations on various types of pension and post-retirement benefit plans as of January 1, 2013 using the RP-2000 Combined Healthy base mortality table, first with Scale AA and then with Scale BB, both applied on a generational basis.

The valuation results submitted by the volunteers included approximately 15,000 annuitants (retirees and surviving beneficiaries) and 35,000 participants not yet in payment status. The plan benefit formulas included final average salary, career average salary and flat dollar, as well as retiree medical plans. Results were developed primarily using the Standard Unit Credit cost method, though two plans used the Entry Age Normal method. Projected Unit Credit results were also developed for pension plans with final average salary formulas. Each set of results was developed at three different discount rates: 4%, 6% and 8%.

6.2 Analysis and Observations for Valuations Performed Using a 6% Discount Rate

For defined benefit (DB) pension plans whose primary forms of benefit payment are non-increasing annuities, moving from Scale AA to Scale BB generally increased Standard Unit Credit accrued liability (calculated using a 6% discount rate) by 2% – 4%. The actual amount of increase varied based on a number of factors, including the plan type and the demographic profile of the covered group. The following Table 1 shows the range of increases in accrued liability resulting from a move to Scale BB for each combination of gender and participant status.

Table 1 – Switching from Scale AA to Scale BB:
Approximate Percentage Increase in Standard Unit Credit Accrued Liability

	Participants Not in Payment Status	Annuitants
Males	1.8% – 2.1%	2.4% – 3.0%
Females	3.0% – 4.2%	3.0% – 3.6%

The liability increase percentages are higher for females than for males, as the relative increase in moving from Scale AA to Scale BB is greater for females than for males, especially after age 60. (Compare Figures 5(M) and 5(F).) The liability increase percentages for female participants not in payment status tended to be slightly larger than those for female annuitants. The smallest level of cost increases generally occurred with male participants not in payment status.

The increase percentages for Standard Unit Credit normal cost were generally about the same as, or no more than 0.2% higher than, the accrued liability increase results for participants not in payment status.

6.3 Sensitivity of Results at Different Discount Rates

Section 6.2 summarized valuation results developed using a 6% discount rate. Liabilities were also determined at discount rates of 4% and 8%. The financial impact of changing from Scale AA to Scale BB is inversely proportional to the discount rate used. An increase (decrease) of 2% in the discount rate was observed to decrease (increase) the ends of the ranges shown in Table 1 by about 20% – 30%, with annuitants tending to be at the lower end of the range and participants not yet in payment status tending to the higher end. Using a 4% discount rate, for example, the estimated range of accrued liability increase for male annuitants would be about 3.0% – 3.6%.

6.4 Sensitivity of Results to Post-Retirement Increases

RPEC also received simulated valuation results for one pension plan that provided an annual cost-of-living adjustment (COLA) of 3% for retirees, and several retiree medical plans. The inclusion of the 3% annual COLA increased the estimated cost of switching from Scale AA to Scale BB by approximately 1 to 2 percentage points relative to similar plans valued without a COLA.

RPEC observed relatively high liability increases for uncapped post-retirement medical plans, generally in the 6% – 9% range. Not surprisingly, capped post-retirement medical plans had significantly lower sensitivity, with the impact of switching from Scale AA to Scale BB depending heavily upon specific plan provisions.

6.5 Sensitivity of Results to Primary Form of Benefit Payments

RPEC's sample of DB plans also included several where single lump sum was the primary form of benefit payment. For purposes of this costing exercise, RPEC assumed no change in the underlying value of the lump sum payable. Under this assumption, the change in liability was due solely to the change in pre-retirement mortality rates. The financial impact of switching to Scale BB for those plans tended to be negligible, generally less than 0.5% in either direction. If the amount of the lump sum was also increased to reflect the change in mortality projection scales, the estimated financial impact of switching from Scale AA to Scale BB would be similar to that for plans whose primary forms of benefit payments were annuities.

Section 7. Other Items and Considerations

7.1 Approximation of Generational Mortality by Projected Static Tables

The developers of both the GAR-94 and RP-2000 tables noted that results calculated using generational annuities could be approximated by those produced using projected static tables, where the number of years of projection was equal to the sum of (1) the number of years between the valuation date and the base table rates and (2) the duration of the underlying obligation being valued. See Appendix G of [20] and Chapter 7 of [12] for details.

RPEC found that this approximation method tended to be somewhat more variable under Scale BB than it was under Scale AA. In particular, the developers of the RP-2000 tables stated that using this technique with RP-2000 and Scale AA generally resulted in present values that were ±0.5% of the values calculated using full generational mortality improvement; see Chapter 7 of [12]. Similar analysis with RP-2000 and Scale BB showed that the range of variation from the full generational basis increased to ±1.0%.

This increased variability notwithstanding, a number of other issues related to the use of duration-based static approximations have been identified since its introduction in 1994. While this technique has been shown to work quite well when used to value a specific type of obligation for a given covered group, pension valuations typically involve many different types of measurements (e.g., current service cost, accumulated benefit obligation, projected benefit obligation, etc.) and often require accurate allocation of obligations among different subgroups. Each combination of measurement type and covered subgroup produces its own specific duration which, in theory, would require its own statically projected mortality table. Furthermore, each of those tables would theoretically need to be updated each year to reflect the passage of one more year from the date of the base table. The use of generational projection avoids the need for this additional work.

For these reasons, along with the fact that Scale BB was specifically designed to be used on a generational basis, RPEC continues to recommend the use of fully generational mortality tables over static approximations for most applications dealing with the measurement of pension obligations. That said, the committee acknowledges that for certain administrative applications (e.g., specifying the basis for actuarially equivalent optional forms) and for various regulatory purposes, the use of projected static tables might be appropriate. The use of static approximations might also be appropriate for the valuation of smaller retirement plan populations, or for plans whose primary form of benefit payment is lump sum.

7.2 Mortality Improvement Scale G2

In September 2011, the Joint AAA/SOA Payout Annuity Valuation Table Committee released new base mortality rates and a new mortality improvement scale, denoted G2, for the valuation of individual annuities [1]. The Payout Annuity Valuation Committee also used SSA data as its primary source for US mortality improvement and, as a result, Scale G2 bears a strong visual resemblance to Scale BB, especially at ages greater than 65.

RPEC seriously considered Scale G2 as a possible interim mortality improvement scale for US pension purposes instead of introducing another new projection scale like BB. RPEC's analysis showed that relative to Scale BB, Scale G2 tended to understate immediate annuities for both genders at ages greater than 50 and overstate deferred-to-age-62 annuity values for males at ages below 50. The differences were significant enough for RPEC to conclude that Scale BB would be a better projection scale than G2 for pension-related applications.

7.3 The Future of Mortality Improvement Scales in the United States

Based on the research performed by RPEC on mortality improvement scales, indications are that the use of two-dimensional scales is becoming much more prevalent around the world. With Scale BB, RPEC was able to create a one-dimensional (age-only) scale that approximated the financial impact of using a full two-dimensional scale, but like many approximations, the results are closer at some ages and further away at others.

RPEC anticipates that when the current Pension Mortality Project is completed in late 2013 or early 2014, the recommended replacement for Scale AA will likely be two-dimensional tables of gender/age/calendar year mortality improvement rates. RPEC encourages the developers of actuarial software to start reviewing the implications of such a change and consider modifying their systems to handle more complex mortality improvement assumptions.

7.4. Suggested Approach for Possible Modification of Two-Dimensional Arrays

The specific assumptions selected by RPEC for the two-dimensional arrays of mortality improvement described rates in Section 5.2 (from which Scale BB was developed) necessarily reflect some degree of subjectivity. The committee recognizes that given the uncertainties inherent in estimating future mortality levels, some actuaries might conclude that a set of long-term mortality improvement rates different than that described in Section 5.2 might be more appropriate for the particular application at hand. Users of Scale BB and the two-dimensional rates might also have the need to assess the sensitivities associated with the use of these rates.

As described in Section 4, the key concept underlying the development of two-dimensional arrays of mortality improvement rates is the blending of observed historic mortality improvement rates with anticipated future long-term rates. In the CMI model adopted by RPEC, this is accomplished by smoothly blending from two years prior to the most current year of observed historic data to the year in which the long-term rates are fully phased in, with the assumed cohort and age/period effects reflected in the intervening years. This blending period for the two-dimensional arrays described in Section 5.2 starts in calendar year 2005 and ends in calendar year 2025.

RPEC has developed a suggested approach for modifying the two-dimensional transitional arrays. This approach, which allows the actuary to select either (1) a long-term rate, *L%*, other than 1.0% or (2) an ending calendar year, *P*, for a post-2005 blending period (greater than 2025), requires the multiplication of each individual mortality improvement rates in the two dimensional arrays by a calendar-year-specific factor, *h(y)*. This factor is identically equal to 1 for all years up to and including 2005, and then grades linearly to *L* in calendar year *P*. All factors are identically equal to *L* after year *P*. Specifically, the formula for the continuous piecewise-linear function *h(y)* is:

$$h(y) = 1.0 \qquad \text{for } y \leq 2005;$$
$$h(y) = 1.0 + (L-1) \times [(y-2005)/(P-2005)] \qquad \text{for } 2006 \leq y < P$$
$$h(y) = L \qquad \text{for } y \geq P$$

Actuaries who are considering the use of these modification factors are encouraged to consult the Q&A document [11] for specific examples.

Conversion of any set of two-dimensional mortality improvement rates to an age-only table – even to one that produces approximately equivalent annuity values at most ages – is a nontrivial undertaking. Users who consider developing modified two-dimensional tables in the manner described above, therefore, should generally be prepared to apply those tables in their full two-dimensional form, and confirm beforehand that their valuation software can accommodate such an assumption.

7.5 Applicability to Non-US Populations

Since the two-dimensional mortality improvement rates in Section 5.2 were developed from US Social Security data, RPEC strongly encourages users to evaluate the appropriateness of applying Scale BB to populations outside the United States.

Section 8. References

RPEC wishes to mention that the Pension Section of the SOA has recently added a new page to its website that contains resources on longevity and mortality issues. Many of the links to the following documents can be found at www.soa.org/pension-mortality.

1. 2012 Individual Annuity Reserving Table: Payout Annuity Report; American Academy of Actuaries, September 2011
2. Continuous Mortality Investigation Revised Working Paper 25; November 2007, Institute of Actuaries and Faculty of Actuaries
3. Continuous Mortality Investigation Working Paper 38: A Prototype Mortality Projections Model: Part One – An Outline of the Proposed Approach; June 2009, Institute of Actuaries and Faculty of Actuaries
4. Continuous Mortality Investigation Working Paper 39: A Prototype Mortality Projections Model: Part One – Detailed Analysis; July 2009, Institute of Actuaries and Faculty of Actuaries
5. Continuous Mortality Investigation Working Paper 41: CMI Mortality Projections Model, Feedback on Consultation and Issue of 'CMI_2009'; November 2009, Institute of Actuaries and Faculty of Actuaries
6. Continuous Mortality Investigation Working Paper 49: The CMI Mortality Projections Model, CMI_2010; November 2010, Institute and Faculty of Actuaries
7. Continuous Mortality Investigation User Guide for the CMI Mortality Projections Model, Version: 'CMI_2010'; November 2010, Institute and Faculty of Actuaries
8. Continuous Mortality Investigation Working Paper 55: The CMI Mortality Projections Model, CMI_2011; September 2011, Institute and Faculty of Actuaries
9. Human Mortality Database; www.mortality.org
10. Purushotham, M, et al., Global Mortality Improvement Experience and Projection Techniques; Society of Actuaries, June 2011
11. Questions and Answers Regarding Mortality Improvement Scale BB; Society of Actuaries
12. RP-2000 Mortality Tables Report; Society of Actuaries, July 2000
13. Report of the Group Annuity Experience Committee Mortality Experience for 2003 – 2006; November 2011
14. Siegel, J., The Great Debate on the Outlook for Human Longevity: Exposition and Evaluation of Two Divergent Views, Society of Actuaries, January 2002 (Presented at the 2005 "Living to 100 and Beyond" Symposium)
15. SSA Actuarial Study #120; Life Tables for the United States Social Security Area 1900 – 2100
16. SSA Base Mortality Rates; rates for calendar years 1900 through 2007; (direct communication from SSA); Tables 1501 and 1502 in the Society of Actuaries' *Mortality and Other Rate Tables* database
17. SSA Office of the Chief Actuary, The Long-Range Demographic Assumptions for the 2012 Trustees Report (April 23, 2012)

18. Technical Panel on Assumptions and Methods (2007); October 2007, Report to the Social Security Advisory Board. Washington, D.C.
19. Technical Panel on Assumptions and Methods (2011) pre-publication copy; September 2011, Report to the Social Security Advisory Board. Washington, D.C.
20. The 1994 Group Annuity Mortality Table and 1994 Group Annuity Reserving Table; Transactions of the Society of Actuaries, 1995, Volume 47
21. The 1994 Uninsured Pensioner Mortality Table; Transactions of the Society of Actuaries, 1995, Volume 47
22. The UP-94 and GAR-94 Tables: Issues in Choosing the Appropriate Table; Transactions of the Society of Actuaries, 1995, Volume 47
23. The 2004 Annual Report of the Board of Trustees, Federal OASDI Trust Funds, March 2004
24. The 2011 Annual Report of the Board of Trustees, Federal OASDI Trust Funds, May 2011
25. Willets, et al., Longevity in the 21st Century; British Actuarial Journal 10, IV, 685-898 (2004)

Appendix A: Scale BB Rates

Age	Males	Females
20	0.30%	0.30%
21	0.30%	0.30%
22	0.30%	0.30%
23	0.30%	0.30%
24	0.30%	0.30%
25	0.30%	0.30%
26	0.30%	0.30%
27	0.30%	0.30%
28	0.30%	0.30%
29	0.30%	0.30%
30	0.30%	0.30%
31	0.30%	0.30%
32	0.30%	0.30%
33	0.30%	0.30%
34	0.30%	0.30%
35	0.30%	0.30%
36	0.30%	0.30%
37	0.30%	0.30%
38	0.30%	0.30%
39	0.30%	0.30%
40	0.30%	0.30%
41	0.30%	0.30%
42	0.30%	0.30%
43	0.30%	0.30%
44	0.30%	0.30%
45	0.30%	0.30%
46	0.30%	0.30%
47	0.30%	0.30%
48	0.30%	0.30%
49	0.30%	0.30%
50	0.30%	0.30%
51	0.30%	0.30%
52	0.30%	0.30%
53	0.30%	0.30%
54	0.30%	0.40%
55	0.30%	0.50%
56	0.30%	0.60%
57	0.40%	0.70%
58	0.50%	0.80%
59	0.60%	0.90%

Age	Males	Females
60	0.70%	1.00%
61	0.80%	1.10%
62	0.90%	1.20%
63	1.00%	1.20%
64	1.10%	1.20%
65	1.20%	1.20%
66	1.30%	1.20%
67	1.40%	1.20%
68	1.50%	1.20%
69	1.50%	1.20%
70	1.50%	1.20%
71	1.50%	1.20%
72	1.50%	1.20%
73	1.50%	1.20%
74	1.50%	1.20%
75	1.50%	1.20%
76	1.50%	1.20%
77	1.50%	1.20%
78	1.50%	1.20%
79	1.50%	1.20%
80	1.50%	1.20%
81	1.50%	1.20%
82	1.50%	1.20%
83	1.50%	1.20%
84	1.50%	1.20%
85	1.50%	1.20%
86	1.50%	1.20%
87	1.40%	1.20%
88	1.30%	1.20%
89	1.20%	1.20%
90	1.10%	1.10%
91	1.00%	1.00%
92	0.90%	0.90%
93	0.80%	0.80%
94	0.70%	0.70%
95	0.60%	0.60%
96	0.50%	0.50%
97	0.40%	0.40%
98	0.40%	0.40%
99	0.30%	0.30%
100	0.30%	0.30%
101	0.20%	0.20%
102	0.20%	0.20%
103	0.10%	0.10%

Age	Males	Females
104	0.10%	0.10%
105	0.00%	0.00%
106	0.00%	0.00%
107	0.00%	0.00%
108	0.00%	0.00%
109	0.00%	0.00%
110	0.00%	0.00%
111	0.00%	0.00%
112	0.00%	0.00%
113	0.00%	0.00%
114	0.00%	0.00%
115	0.00%	0.00%
116	0.00%	0.00%
117	0.00%	0.00%
118	0.00%	0.00%
119	0.00%	0.00%
120	0.00%	0.00%