

Continuous Mortality Investigation

Mortality sub-committee

Working Paper 1

**An interim basis for adjusting the “92” Series mortality
projections for cohort effects**

December 2002

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Introduction

1. The rate of improvement in male pensioner mortality since the publication of the “92” Series tables has been significantly faster than anticipated in the projection factors that formed part of those tables. Given this the CMI has further analysed the available data and this report describes a revised set of mortality projections, which can be applied to all the projected base tables contained in the CMI’s “92” Series.
2. This report is designated as a “Working Paper”. It reports on work in progress, which will not be published in a CMIR (a blue book) until that work is complete. It is intended that the CMI will produce a series of Working Papers. Their purpose will be to bring matters of importance to the attention of offices more quickly than could be done via a CMIR. Such matters might be developments in the experiences monitored or, as in this case, in the work being done. Working Papers may be produced before a project is complete in order to give offices up to date information and to provide them with details of possible future developments.
3. The “92” Series improvement factors are described in *C.M.I.R.* 17, page 89. The newly updated projections are based on work done in the first half of 2002. This work is not yet complete. The updated projections have been produced relatively quickly with the intention that offices could use the suggested adjustments in their 2002 year-end valuations if they think it appropriate. The longer-term aim of the CMI is to have a rather more considered and robust projection methodology available for the next set of tables which will probably be based on the 1999-2002 quadrennium. However, these tables will not be available until 2004 at the earliest and, in view of the developing mortality experience, it is felt necessary to suggest possible adjustments to the “92” Series tables now.
4. This report has been prepared for the Mortality Sub-committee of the CMI by a working party consisting of Angus Macdonald, Richard Willets, Adrian Gallop, Tony Leandro and Rajeev Shah. A draft of this report, which has been approved by the Mortality Sub-committee, was distributed to CMI contributing offices and to Appointed Actuaries prior to the Birmingham Life Convention held on 3-5 November 2002. At a session at that Convention the contents of this paper were presented, and discussed. The technical points raised in that discussion and in several written

contributions received by the CMI are detailed in Working Paper 2, which is to be distributed at the same time as this report.

5. The new projections described in this report are based on a new analysis of data that the CMI has collected over the past 50 years. The examination of this data and corresponding UK population data, which is described below, shows clear evidence of cohort effects in past mortality improvements and that these effects are now becoming significant in the pensioner population. That is, rates of improvement in mortality have been different for lives born in different past periods. In particular, lives born in the few years either side of 1926 have experienced particularly rapid improvements since the early 1980s. The revised projections presented in this report are based on the mortality improvements observed for this generation extending into future years. Given the interim nature of the projections produced herein the impact of other cohorts has not been modelled since their financial impact will be limited during the period up to the publication of further results.
6. In projecting such features there are obvious problems in choosing a suitable period over which they are assumed to continue (“the cohort period”) and therefore a range of projections has been prepared. The “Short Cohort” projection extends the 1926 cohort period to 2010 while the “Medium Cohort” and “Long Cohort” projections extend it to 2020 and 2040 respectively.
7. The new projections apply to the “92” Series base tables. Their derivation is described below. Each set of projection factors can be applied to the appropriate base tables in the “92” Series. At this stage, no distinction is made between males and females or between lives and amounts.
8. The resulting two-way tables are used in the same way as the original “92” Series tables. It is intended that the adjusted tables will use the “92” Series naming convention but have a suffix; “*sc*” will denote the Short Cohort projection, “*mc*” the Medium Cohort and “*lc*” the Long Cohort projections. Thus PMA92(U=2003) becomes PMA92(U=2003)*mc* when the Medium Cohort projection factors have been applied.
9. In addition to this report the CMI is issuing a spreadsheet of the three sets of updated mortality improvement factors and an update of the STP will be issued. This last item will be free to current STP licence holders.
10. Towards the end of the time allotted to do the work required to produce this report it emerged that some of the data contributing offices had discovered problems with data already submitted to the CMI and used in our work. At that stage, this report would have been significantly delayed if we had had to repeat all the work previously done. We examined the experience of the revised data sets (i.e. with the problem offices adjusted) and concluded that the changes, whilst significant, were not large enough to invalidate the revised mortality projections then being considered. Appendix A of this report contains tables that describe the experience we have observed. With two

exceptions, each of the tables contained in that appendix relate to observed data that have been adjusted for these data problems. The exceptions are Appendix A4.3, which shows the effect of the data changes, and Appendix A3. Appendix B contains contour maps and graphs that, in part, describe pensioner graduations. These graduations (see paragraph 15) were based on the data sets before these late adjustments were made.

11. Appendix C contains sample annuity values calculated on the new projection bases and details of the financial effects of moving from a basis of 90% of the “92” Series projections to the cohort projection bases contained in this report.

Background

12. The development of the experience of various CMI investigations is shown in Appendix A1. This shows how the 100A/Es, calculated on various tables and at various ages, have changed over time. Appendices A1.1 and A1.2 show the level of improvement in mortality in the assured lives experience for males (by quadrennium from 1959 to 1998 and for each of 1998, 1999 and 2000) and for females (by quadrennium from 1975 to 1998 and for each of 1998, 1999 and 2000) respectively. Appendices A1.3 and A1.5 show similar information but for life office pensioners. In this case the comparison basis is the appropriate pensioner base table from the “92” Series tables. Similarly, Appendices A1.4 and A1.6 compare the actual pensioner mortality experience with the appropriate projected “92” Series tables. Since we are looking at how underlying mortality has changed, only the ‘lives’ experience is used. As a general observation it is the case that the experience of female mortality has been in line with the projected “92” Series tables but male mortality has improved more rapidly than the improvement contained in those tables. It is also true that mortality measured by amounts has improved more quickly than mortality as measured by lives. This is discussed in paragraph 45 below.

13. After consideration of
 - (a) these results,
 - (b) the paper by Richard Willets (SIAS: Mortality in the Next Millennium) and
 - (c) the various population projections produced by the GAD in recent years

it was decided to look at the CMI data to see if cohort effects were present and if allowance should be made for these effects in any update to the mortality projections.

14. The largest data set that the CMI has relates to assured lives. This data, which relates to males aged from 10 to 100, has been collected annually since 1924 but for years earlier than 1947 is incomplete. The data available is the number of deaths and the corresponding exposed to risk at each age for each calendar year. The data relates to lives that were issued with endowment and/or whole of life policies. Unlike other CMI investigations this class of business has not changed greatly since 1947. However, it should be noted that most endowments mature before age 65 and that the

business mix, in this data set, above and below that age may be quite different. Despite this, this data set is extensive and credible and was therefore used as a starting point for the investigation into cohort effects.

15. The first task was to look for patterns in the data. This required ‘random noise’ to be removed. Various approaches were tried but the one that was settled upon was to graduate the two-dimensional surface in the three-dimensional space (the “surface graduation”) represented by the data i.e. graduate the crude mortality rates by age and calendar year. This work was undertaken by a team led by Iain Currie of Heriot-Watt University. The graduation method used fitted two-dimensional splines to the data. Besides producing a set of q_x that are smooth both by age and year, this approach has the considerable advantage of imposing no preconceptions about ‘shape’ on the graduation. Thus the results produced are entirely driven by the data. A second advantage is that the method does not over-smooth the data and so does not remove features in the data that may interest us. A consequence of this is that we may still, to some extent, be left with random noise in the graduation but this appears not to have been too much of a problem in the subsequent analysis.
16. The graduation technique used by Iain Currie’s team is new and was developed specifically for this project. It was used first to provide a surface graduation of the set of crude q_x derived from the assured lives data. A description of their method is given in the paper detailed in the References section at the end of this report.
17. The next problem was how to identify salient features in the graduated surface. The method finally settled upon is to define an improvement factor as $1 - \frac{q_{x,t}}{q_{x,t-1}}$, where t is the calendar year, and to plot the changes in this value on a contour map, as shown in Appendix B1.1. This plots calendar year on the x -axis, age on the y -axis and, in the ranges shown, highlights cells with similar improvement rates in the same colour. Diagonals in this appendix, bottom left to top right, show cells for succeeding ages for the same year of birth. The strong diagonal features, seen as diagonal bands of same colour contours, are clear evidence of cohort (i.e. year of birth) related effects in the improvement rates. In particular, the cohort centred on births in 1926 is the most pronounced, especially after 1980. Work carried out by the GAD on the general population shows similar cohort effects and their contour map is shown in Appendix B2. Different techniques were used to produce the underlying improvement factors and they are not directly comparable. However, it is clear that they are showing much the same picture.
18. In order to better see the ‘ridge’ features at the centre of the cohorts revealed in Appendix B1.1, certain local peaks in the improvement rates were identified. These peaks are cells where the values plotted are greater than in vertically adjacent cells; are greater than 1.5%; and where there is an associated peak in an adjacent age and calendar year. These peaks are denoted by “▲” symbols.

The pensioner investigation

19. The CMI's largest data set (i.e. covering the most lives) relating to pensioner or annuitant mortality is that of the life office pensioner investigation. This dates back to 1948. Before 1958, this was based on 'lives' only. Since that date 'amounts' data have also been collected. Unfortunately, we have not been able to locate the basic annual data prior to 1983. Data before that date are available in respect of some years but mostly these data have been aggregated into quadrennia, which are not suitable for the cohort analysis.
20. The data are collected in respect of current pensioners of schemes written under a group contract providing deferred annuities for employees; and in respect of pensions purchased from life offices by trustees of managed funds or deposit administration schemes, even if they were purchased from offices other than those writing contracts or giving investment services during the period of deferment. Pensions guaranteed for a certain period are included (but drop out of the investigation on death) and joint life (i.e. last survivor) pensions are included until the death of the pensioner. Data are split into lives that retire at or after normal retirement age and those that retire before that age. A summary of the data collected for the period 1992 to 1999 for these investigations is given in Appendix A2.1.

The work described in the report only relates to data in respect of normal retirements.

21. The mortality improvement factors derived from the surface graduation, as described in paragraph 15, of male assured lives were applied to the PML92 base table to see if this provided a better fit for the normal retirement pensioner mortality experience over the 1992-1999 period. These 100A/Es are shown in Appendix A3. This shows that the fit is not much better than using the "92" Series projections. Appendix A3 does, however, show that the pensioners' experience has been improving faster than the assured lives experience.
22. It was decided to look at the data for the period 1992 to 1999 more closely. During this period a number of offices entered and left the investigation and some changed, significantly, the nature of the data they provided. Since we were looking at trends it was felt that these discontinuities might mask the changes that we were trying to identify. For this reason a set of 'Loyal Offices' was identified. These offices contributed data throughout the period. Details of this data set are given in Appendix A2.2. For identification purposes, the whole data set is referred to as 'All Office' in this report.
23. Iain Currie was then asked to carry out a surface graduation of the 1983-1999 pensioner 'lives' experience, for pensioners who retired at or after normal retirement age, using his spline fitting method. He did this for both the All Office and Loyal Office experiences.

24. Appendices B1.2 and B1.3 show how these two pensioner surface graduations fit with the assured lives graduation shown in Appendix B1.1. The pensioner part of these appendices shows rather different cohort effects in the All Office and Loyal Office experiences although the peak improvements occur in the same cohort. Improvements in excess of 4.2% p.a. are only seen from 1994, even for the 1926 generation.
25. By 1999 the All Office graduation illustrated in Appendix B1.2 shows the 1926 cohort effect applying to almost every age, while the Loyal Office graduation (Appendix B1.3) seems to apply to a more reasonable range of ages. Looking at these illustrations of the data it is felt that the All Office experience may not be usable, with the cohort effect being too wide by 1999. It is felt that this may be a result of the lack of homogeneity in the All Office experience. As a result, the new projections described in this report have been based on the Loyal Office experience.
26. It is instructive to see how the pensioner experience unfolded during the period 1992 to 1999. Appendix B3 shows a series of contour maps tracing past mortality improvements from 1967 to 1992 that were used to produce the “92” Series projections, and the actual and projected experience thereafter. These maps relate to ‘lives’ retiring at or after normal retirement age, from the All Office data set.
27. Appendix B3.1 shows the All Office annualised improvement factors derived from quadrennial experience from 1967 to 1986 and annual experience from 1987 to 1992. From 1993 onwards, the improvements according to the “92” Series projection basis are shown.
28. Appendix B3.2 replaces the crude mortality improvement rates for 1984 to 1992 with improvement rates derived from Iain Currie’s graduated mortality rates for All Offices for those years. Even though the data is being examined in this new way, this appendix shows that the “92” Series projections do not necessarily look out of line with the data available to 1992. The 1926 cohort effect is hardly visible but it can be seen creeping into the picture at ages below 65 between 1985 and 1992.
29. In Appendix B3.3 these improvement factors are replaced with those derived from the Loyal Office graduation and extended from 1992 to 1999. Improvement factors derived from the original “92” Series projections are shown for years after 1999. This appendix shows that the 1926 cohort effect has ‘grown’ significantly and is now clearly visible in the experience to 1999. It is also clear that the “92” Series projections are out of line with actual improvements seen to 1999.
30. Looking at the assured lives contour maps (Appendices B1.1 to B1.3), it can be seen (although not conclusively) that the cohort effect observed in the pensioner data had probably been working its way through younger ages (i.e. below age 60) in calendar years prior to 1992. Thus this effect had not been clearly seen in previous CMI pensioner experiences for normal retirements, which related mainly to ages above 60

and, consequently, this feature was not reflected in previous CMI mortality projections.

31. Appendix B3.4 replaces the improvement factors for 2000 onwards with the Medium Cohort projection described in the next section. Appendices B3.5 and B3.6 are similar but use the Long Cohort and Short Cohort projections from 2000 onwards.

How the new projections were produced

32. The “92” Series projections have been used as the starting point and further mortality improvements, designed to reflect the cohort effect, were superimposed onto them. All of this has been done by adjusting the annual improvement rates (see para. 17 above), which are then converted to cumulative improvement factors starting in 1992. These improvement factors are then applied to the base “92” Series tables. It should be noted that all the contour maps contained in the appendices show annual improvement rates, whereas the line graphs shown in Appendices B7.1 to B7.4 are, in effect, showing cumulative improvement rates from 1992 to the date shown.
33. Only the effects of the cohort centred on births in 1926 (the cohort peak) have been modelled. The “width” (see paragraph 34) of this generation is based on the Loyal Office surface graduation but improvements from 1993 to 1999 are based on the All Office surface graduation. Improvements after 1999 are based on the 1999 observations and do not allow for any acceleration in the improvement rates from the 1999 level. From 2001, the improvement rates reduce linearly to the end of the cohort period where they equal those derived from the original “92” Series projections.
34. Between 1992 and 2000 the cohort includes births between 1910 and 1942 but after 2000 the ‘width’ of the cohort effect is reduced so that by the end of the cohort period it includes only one year, which relates to lives born in 1926. Therefore, the cohort starts off (from 1992 to 2000) as a band 33 years wide (i.e. for lives born between 1910 and 1942) but reduces to the 1926 generation by the end of the cohort period.
35. For the Medium Cohort projection the cohort period extends to 2020 while for the Short Cohort and Long Cohort projections the cohort period extends to 2010 and 2040 respectively. These projections, which run from 1992, are illustrated in Appendices B4.1, B4.2 and B4.3 respectively.

The resulting mortality rates

36. The mortality experience of contributing CMI offices over 1992-1999 is compared to the current “92” Series projection basis as well as to the cohort projections in Appendix A4.1. During this period all three cohort projections show the same 100A/Es. The Appendix shows comparisons for both the All Office and the Loyal

Office experiences and, as expected, for the male experiences shows that the cohort projections give a better fit than the “92” Series projections.

37. Appendix A4.2 shows the fit of the 100A/Es by age bands over the period 1996-1999 for the Loyal Offices using the revised data. As expected, the table shows that the cohort projection basis gives a much better fit to the mortality experience at all ages. This is particularly true for ages between 60 and 80 where the cohort centred on the 1926 generation passes through the data during this period.
38. Paragraph 10 described data problems experienced during the production of this report. Appendix A4.3 shows the 100A/Es for the original and the revised data sets, both for the All Office and the Loyal Office experiences. The original “92” Series projection basis was used to calculate these 100A/Es. As the data revisions increase the 100A/E by only two percentage points for 1998 and 1999, the surface graduations based on the original data set would be little affected and can still be used.
39. Appendices B5.1 and B5.2 show survival probabilities from age 60 for lives born in 1932 and 1972 respectively. The three cohort projection bases are shown as are the PML92(B=1932) survival probabilities for the 1932 case. Similarly, PML92(B=1972) is used for the 1972 case. These graphs show how, from 2000 on, the three cohort projection bases affect the survival probabilities.
40. Appendix B6 shows, for the Medium Cohort projection, survival probabilities for differing years of birth. The ‘rectangularisation’ of the curve is clearly seen.
41. Appendix B7.1 shows the ratios of q_x in different calendar years to those in 1992. The 1992 values are shown as a straight line across the page at 100%. Values for other years are shown as a proportion of the 1992 values. The table is PML92 to which the original “92” Series projection factors have been applied. The kink at age 60 is the junction of the curve of improvement factors assumed to be applicable above that age with the constant improvement factor assumed to be applicable at lower ages. Appendix B7.2 shows the same type of ratios but with the Short Cohort projection applied to the PML92 table. In this case, the dip in the curve caused by the cohort adjustment can be clearly seen. The kink is also still visible. Appendices B7.3 and B7.4 show the same information for the Medium Cohort and Long Cohort projections. In each case the dip gets deeper but also the main upward curve, from age 60 to 110, shifts to the right as the cohort adjustment works its way into higher ages. This is particularly so for the Long Cohort projection where the curve now merges with the PML92 base table beyond age 110.

The economic effect of the new projection factors

42. The 1999 annual All Office returns produced by the CMI show that male pensioner mortality is better than the original “92” Series projections by some 10% (see Appendix A4.1). For this reason we have used 90% of the projected “92” Series

pensioner tables as a proxy for the current mortality bases of an average UK life office. Appendices C1 to C3 show male annuity rates based on this assumption (i.e. 90% of PML92 using the “92” Series projection) and also those calculated using the revised mortality rates derived from the various cohort projections already described. Appendices C1 to C3 are based on interest rates of 0%, 3% and 5% respectively. Appendices C4 to C6 show the ‘cohort basis’ annuities as a percentage of the annuity values calculated using the 90% of PML92 basis with the “92” Series projection.

43. Care needs to be taken with Appendices C1 to C6 when looking at older ages for years where the percentage in Appendices C4 to C6 is less than 100. In these cases, the cohort adjustment has not affected the ‘new basis’ annuity values and the comparison is between 100% of PML92 and 90% of the same table. It can be seen that these results tend to 90%.
44. The percentage increases in annuity rates compared to the 90% of PML92 basis for year of use 2000 indicate the increased reserves needed if an office using that basis were to switch to the new projection basis. For example, if the average age of an office’s portfolio was 70 and reserves were currently calculated using 90% of PML92 and interest at 3%, then the increase in reserves would be 8% for the Medium Cohort projection and 13% and 5% respectively for the Long Cohort and Short Cohort projections.

Amounts and Females

45. Most of the work described in this report relates to lives data. In particular, the surface graduations described in paragraph 15 were produced for lives data only. In the time available, detailed consideration of amounts data was not possible. It is clear from a comparison between Tables PEN 1.4a and PEN 1.4b and between Tables PEN 2.4a and PEN 2.4b of *C.M.I.R.* **19** that improvements in mortality when measured by amounts has been faster than improvements measured by lives. This was known when the “92” Series tables were produced but, at that time, it was agreed that it would be uncomfortable to publish different improvement factors for lives and amounts. It is generally accepted that lives with a higher income enjoy better mortality than the general population and for this reason amounts mortality is better than lives mortality. However, it is not clear why mortality measured by amounts should improve more quickly than mortality measured by lives. It may be that the difference between the income spread amongst the pensioner population has widened and that this is having an effect; it may be that the composition of various pensioner classes of lives are changing over time; or it may be due to other reasons.
46. Appendix A4.1 shows the all age 100A/Es for each year from 1992 to 1999 for both lives and amounts from both the All Office and Loyal Office experiences. The comparison basis is the appropriate base table from the “92” Series with both the original “92” Series and the new cohort projection factors applied to give a set of projected q_x for each year.

47. At this stage it is felt that the projection rates described in this report are applicable to both lives and amounts.
48. It is also the case that most of the cohort work has been done with male data. It has been the case that the “92” Series mortality projections have worked better for females than for males. This is true of both the amounts and the lives experiences although these are quite volatile. Male mortality has been improving more quickly than female mortality. Again, this was observed at the time the “92” Series tables were produced but it was felt that this feature should not be reflected in separate mortality projections for males and females. Appendix A4.1 shows the results, for females, of comparing the actual experience against tables derived from applying both the “92” Series and the new cohort projection factors to the base “92” Series tables. It is not clear that the cohort adjusted projection factors improve the sequence of 100A/Es when compared with the original “92” Series projection. Therefore it would seem appropriate for offices to continue to use the “92” series improvement factors, without adjustment, for females should they wish to do so.

Future work

49. As was explained in the introduction, this report represents “work in progress”. Much has yet to be done before the next set of tables are produced. Various avenues of research are yet to be explored. These might include a close examination of the mortality experience of other countries, statistical projection techniques, seeking the views of a panel of medical experts and looking more closely at the work of demographers in this area.
50. It is also intended to hold two meetings (possibly at Staple Inn) during 2003, one to discuss the work contained in this report and a second to discuss the technical aspects of mortality projections in particular. It is hoped to have contributors from various related fields to help inform the second meeting.

A final word

51. The projections described in this report are an expression of opinion based upon the work done and judgements made by the authors. It is accepted that other judgements can be made. In a period of rapidly improving mortality rates almost all UK mortality projections made in the past 50 years have understated subsequent improvements. The Mortality sub-committee feels that the work contained in this report should be considered by actuaries when making allowance for future improvements in the mortality of UK life office pensioners.
52. It is clear that the mortality experiences of CMI contributing offices vary and that each must apply their own judgement to the allowance they make for future mortality improvements in order to reflect their own experience.

List of appendices

- A1.1 – Assured lives, males, experience 1959 to 2000
- A1.2 – Assured lives, females, experience 1975 to 2000
- A1.3 – Pensioners, males, experience 1983 to 1999
- A1.4 – Pensioners, males, experience against projected tables 1992 to 1999
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- A2.1 – Pensioner data, All Offices, 1992 to 1999
- A2.2 – Pensioner data, Loyal Offices, 1992 to 1999
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- A4.1 – Old and New projections by year. Males & females; lives & amounts; All & Loyal Offices
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- B1.1 – Contour map of assured lives, graduated age specific improvement rates
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- B6 – Graph of survival probabilities for lives born in 1932, 1952, 1972, 1992, 2002 & 2010 for the Medium Cohort projection
- B7.1 – Ratio of q_x , various calendar years, PML92c92, “92” Series projections
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- B7.4 – Ratio of q_x , various calendar years, PML92c92, Long Cohort projection

- C1 to C6 – Annuity rates and percentage changes, old basis to new

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Appendix A1.1

Assured lives, males, durations 2 and over, 1959 to 2000: actual deaths for different periods expressed as a percentage of those expected using AM92.

Age group (nearest ages)	1959-62	1963-66	1967-70	1971-74	1975-78	1979-82	1983-86	1987-90	1991-94	1995-98	1998	1999	2000
21-25	174	150	141	126	118	121	103	113	107	113	50	116	109
26-30	122	128	114	116	101	98	101	88	92	90	96	93	89
31-35	135	129	115	110	104	100	98	101	105	91	91	98	92
36-40	158	158	142	134	130	114	108	100	106	94	101	87	99
41-45	182	186	174	159	146	133	121	108	99	94	91	88	96
46-50	196	196	191	179	161	148	134	118	101	91	104	83	83
51-55	203	198	189	182	171	155	132	114	100	90	87	84	77
56-60	202	196	185	170	158	150	133	114	97	89	85	82	83
61-65	198	195	178	165	155	144	136	118	104	88	82	82	74
66-70	175	173	164	150	140	129	118	107	99	91	90	85	76
71-75	161	162	159	151	139	132	114	108	100	92	92	87	79
76-80	161	156	148	144	143	134	119	110	100	92	88	84	84
81-85	153	146	139	136	130	128	119	108	103	96	97	96	91
86-90	145	142	130	130	127	115	112	103	98	95	88	89	86
91-95	134	128	118	112	119	104	99	88	91	83	80	71	70
96-100	115	101	111	101	89	65	68	55	43	46	40	49	30
All ages	186	182	172	161	151	141	127	113	100	90	88	84	80

Appendix A1.2

Assured lives, females, durations 2 and over, 1975 to 2000: actual deaths for different periods expressed as a percentage of those expected using AF92.

Age group (nearest ages)	1975-78	1979-82	1983-86	1987-90	1991-94	1995-98	1998	1999	2000
21-25	132	116	107	106	88	64			
26-30	138	108	95	100	89	88	52	119	54
31-35	117	107	96	100	99	85	90	76	66
36-40	131	102	102	112	103	91	78	60	80
41-45	151	116	113	117	105	92	81	81	81
46-50	156	128	128	116	107	96	95	104	89
51-55	146	138	115	107	101	94	86	86	94
56-60	134	129	112	112	98	90	86	84	93
61-65	132	117	117	104	95	89	89	82	84
66-70	122	113	99	104	94	87	78	90	93
71-75	133	116	101	99	102	95	97	96	100
76-80	155	118	106	106	98	103	112	108	108
81-85	152	169	137	115	107	112	123	108	106
86-90	148	143	165	116	100	114	118	118	111
91-95				102	104	110	97	129	117
96-100							78	84	72
All ages	141	125	115	109	100	95	93	93	95

Appendix A1.3

Life office pensioners, All Offices, males, lives, normal retirements, 1983 to 1999: actual deaths for individual years expressed as a percentage of those expected using PML92(C=1992).

Age group
(nearest
ages)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
61-65	133	122	146	122	138	124	120	114	115	96	98	104	88	80	72	80	82
66-70	126	120	116	112	114	109	102	101	105	99	94	88	80	79	69	76	68
71-75	120	117	116	109	115	114	107	100	99	103	98	96	95	86	79	83	75
76-80	116	112	115	111	110	108	105	104	105	99	100	95	91	89	81	84	77
81-85	114	116	115	110	113	105	104	103	103	103	102	95	94	90	88	89	88
86-90	116	107	113	112	108	105	104	100	103	102	102	96	98	96	89	90	86
91-95	113	103	113	100	104	107	106	98	101	99	100	103	102	96	96	95	92
96-100	88	115	119	111	95	102	98	101	101	78	84	91	119	77	89	101	88
61-100	118	115	116	110	112	109	105	102	103	101	100	95	94	89	84	87	82

Appendix A1.4

Life office pensioners, All Offices, males, lives, normal retirements, 1992 to 1999: actual deaths for individual years expressed as a percentage of those expected using the projected rates for the relevant calendar year from the PML92 table.

Age group (nearest ages)	1992	1993	1994	1995	1996	1997	1998	1999
61-65	96	101	111	96	90	83	95	101
66-70	99	97	92	87	87	78	88	81
71-75	103	100	100	101	93	88	94	86
76-80	99	101	99	96	95	87	92	86
81-85	103	104	97	97	94	94	96	96
86-90	102	104	98	101	100	93	96	92
91-95	99	101	105	105	99	99	99	96
96-100	78	84	92	121	79	91	104	91
61-100	101	102	98	98	95	90	95	91

Appendix A1.5

Life office pensioners, All Offices, females, lives, normal retirements, 1983 to 1999: actual deaths for individual years expressed as a percentage of those expected using PFL92(C=1992).

**Age group
(nearest
ages)**

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
61-65	132	139	134	108	124	131	126	92	116	141	88	94	75	66	51	88	71
66-70	116	107	101	97	116	108	104	101	109	107	92	98	79	85	94	97	68
71-75	100	94	95	97	109	94	108	101	103	106	90	85	90	76	67	92	77
76-80	107	98	99	96	99	95	100	100	102	99	89	91	99	86	84	83	78
81-85	101	103	106	109	97	101	103	99	109	109	94	93	96	94	91	87	91
86-90	115	99	106	115	105	104	106	108	108	106	96	90	100	104	92	104	97
91-95	102	142	122	121	106	108	123	106	120	111	102	100	108	99	92	109	110
96-100	94	92	106	115	90	123	119	106	118	101	103	103	103	85	108	95	98
61-100	108	104	104	104	105	102	106	102	108	107	93	92	96	90	86	94	87

Appendix A1.6

Life office pensioners, All Offices, females, lives, normal retirements, 1992 to 1999: actual deaths for individual years expressed as a percentage of those expected using the projected rates for the relevant calendar year from the PFL92 table.

Age group (nearest ages)	1992	1993	1994	1995	1996	1997	1998	1999
61-65	141	91	100	83	75	59	105	87
66-70	107	94	103	85	94	106	112	81
71-75	106	92	88	96	82	74	104	89
76-80	99	91	95	104	92	91	92	87
81-85	109	95	96	100	99	97	94	100
86-90	106	97	91	103	108	97	110	104
91-95	111	103	102	110	102	95	113	116
96-100	101	103	104	104	87	110	98	101
61-100	107	95	95	100	96	92	102	97

Appendix A2.1 – Life office pensioners, All Offices, exposed to risk and actual deaths, retirements at or after normal retirement age.

	Males				Females			
	Lives		Amounts		Lives		Amounts	
	Exposed to risk	Deaths	Exposed to risk	Deaths	Exposed to risk	Deaths	Exposed to risk	Deaths
1992	232,448	14,881	295,519,419	10,182,202	83,207	3,300	64,197,027	1,349,343
1993	295,428	18,072	432,894,642	12,898,545	102,817	3,439	87,045,411	1,451,384
1994	219,793	13,435	333,107,424	11,075,299	81,731	2,930	71,868,159	1,457,800
1995	230,854	13,903	335,109,135	12,679,247	89,712	3,331	83,288,735	1,622,816
1996	218,731	12,633	342,500,108	12,275,300	88,379	3,139	87,020,813	1,763,879
1997	218,230	11,851	361,234,109	12,432,052	90,116	3,049	93,195,888	1,744,794
1998	165,228	10,439	238,320,642	10,554,098	68,287	2,855	59,282,335	1,705,515
1999	313,902	14,978	746,107,078	20,975,695	132,563	3,813	166,128,900	2,687,591

Appendix A2.2 - Life office pensioners, Loyal Offices, exposed to risk and actual deaths, retirements at or after normal retirement age.

	Males				Females			
	Lives		Amounts		Lives		Amounts	
	Exposed to risk	Deaths	Exposed to risk	Deaths	Exposed to risk	Deaths	Exposed to risk	Deaths
1992	177,777	12,162	227,297,256	8,475,598	65,688	2,677	50,482,797	1,090,661
1993	172,664	11,150	231,020,043	7,646,122	65,453	2,404	51,946,872	908,983
1994	168,040	11,083	257,541,298	9,229,429	65,122	2,494	57,312,557	1,113,382
1995	164,361	10,618	271,022,970	10,355,762	64,761	2,614	60,226,026	1,252,254
1996	163,864	9,875	287,976,100	10,356,866	65,173	2,526	63,543,174	1,325,154
1997	163,754	9,535	305,067,481	10,772,729	66,006	2,514	67,060,713	1,433,284
1998	139,785	9,228	222,086,616	9,771,224	60,386	2,616	54,796,628	1,571,049
1999	135,377	9,006	226,999,854	10,369,902	60,272	2,599	56,839,049	1,504,690

Appendix A3

Life office pensioners, All Offices, normal retirements: actual deaths expressed as a percentage of those expected using the assured lives graduated improvement factors applied to the appropriate “92” Series table.

	Males		Females	
	Lives PLM92	Amounts PMA92	Lives PFL92	Amounts PFA92
1992	101	101	107	109
1993	102	98	95	93
1994	99	97	96	101
1995	99	104	101	95
1996	96	98	97	97
1997	92	94	94	88
1998	95	94	102	107
1999	91	88	99	89

Note: This table uses data prior to the late adjustments for data problems. See paragraph 10.

Appendix A4.1

Life office pensioners, All Offices, normal retirements: actual deaths expressed as a percentage of those expected using the “92” Series or cohort projection factors applied to the appropriate “92” Series tables.

	Males				Females			
	Lives		Amounts		Lives		Amounts	
	“92” Series	Cohort projection	“92” Series	Cohort projection	“92” Series	Cohort projection	“92” Series	Cohort projection
	PML92	PML92	PMA92	PMA92	PFL92	PFL92	PFA92	PFA92
1992	101	101	101	101	107	107	109	109
1993	102	102	99	99	95	95	93	93
1994	98	99	97	99	95	96	100	102
1995	98	100	104	107	100	102	94	97
1996	95	98	98	102	96	99	96	101
1997	91	94	93	98	92	96	87	93
1998	95	100	95	101	102	107	108	116
1999	91	98	88	98	98	105	88	98

Life office pensioners, Loyal Offices, normal retirements: actual deaths expressed as a percentage of those expected using the “92” Series or cohort projection factors applied to the appropriate “92” Series tables.

	Males				Females			
	Lives		Amounts		Lives		Amounts	
	“92” Series	Cohort projection	“92” Series	Cohort projection	“92” Series	Cohort projection	“92” Series	Cohort projection
	PML92	PML92	PMA92	PMA92	PFL92	PFL92	PFA92	PFA92
1992	103	103	104	104	106	106	109	109
1993	98	98	92	93	95	95	86	87
1994	101	102	99	100	98	99	94	96
1995	101	103	104	107	103	105	98	101
1996	96	99	98	102	100	102	96	100
1997	94	98	95	101	98	102	95	101
1998	97	102	95	101	104	109	108	116
1999	98	104	96	104	103	110	97	106

Appendix A4.2

Life office pensioners, males, normal retirements, 1996 to 1999: actual deaths expressed as a percentage of those expected using the "92" Series or cohort projection factors applied to the PML92 table.

Age	Loyal Offices		All Offices	
	"92" Series	Cohort projection	"92" Series	Cohort projection
51-55	148	148	196	197
56-60	114	117	147	151
61-65	89	96	94	103
66-70	87	98	83	94
71-75	93	105	90	101
76-80	94	101	90	97
81-85	98	100	95	98
86-90	98	98	95	95
91-95	103	103	98	98
96-100	97	97	92	92

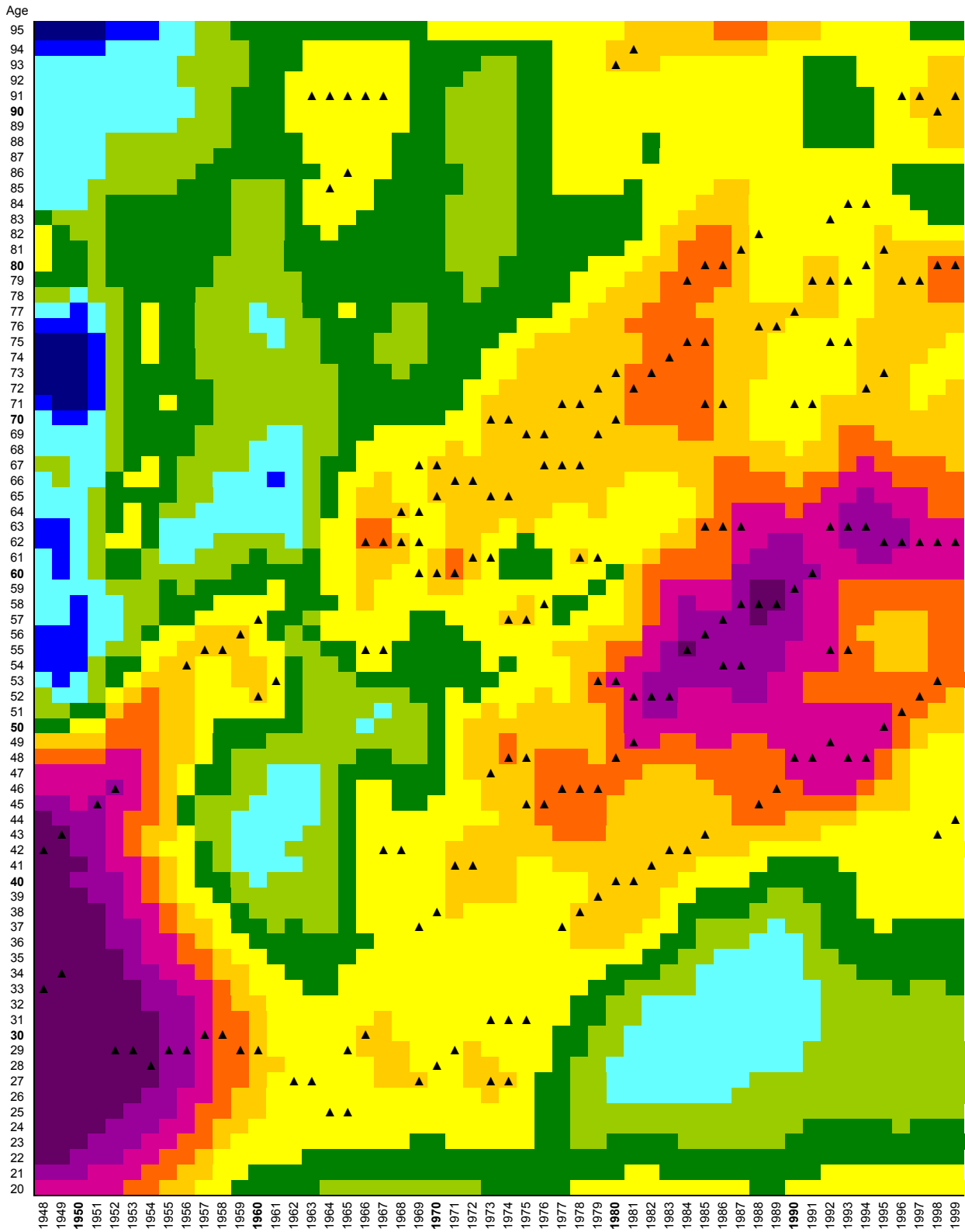
Appendix A4.3

Life office pensioners, lives, normal retirements: actual deaths expressed as a percentage of those expected using the “92” Series projection factors applied to the appropriate “92” Series table: results before and after late data changes.

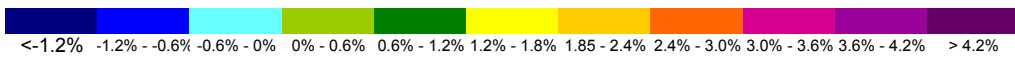
	Males				Females			
	All Offices		Loyal Offices		All Offices		Loyal Offices	
	Old data PML92	New data PML92	Old data PML92	New data PML92	Old data PFL92	New data PFL92	Old data PFL92	New data PFL92
1992	101	101	103	103	107	107	106	106
1993	102	102	98	98	95	95	95	95
1994	98	98	101	101	95	95	98	98
1995	98	98	101	101	100	100	103	103
1996	95	95	96	96	96	96	100	100
1997	91	91	94	94	92	92	98	98
1998	93	95	95	97	100	102	102	104
1999	89	91	95	98	96	98	102	103

Appendix B1.1

Permanent assurances, males, all data: percentage improvement factors in graduated age specific mortality rates.



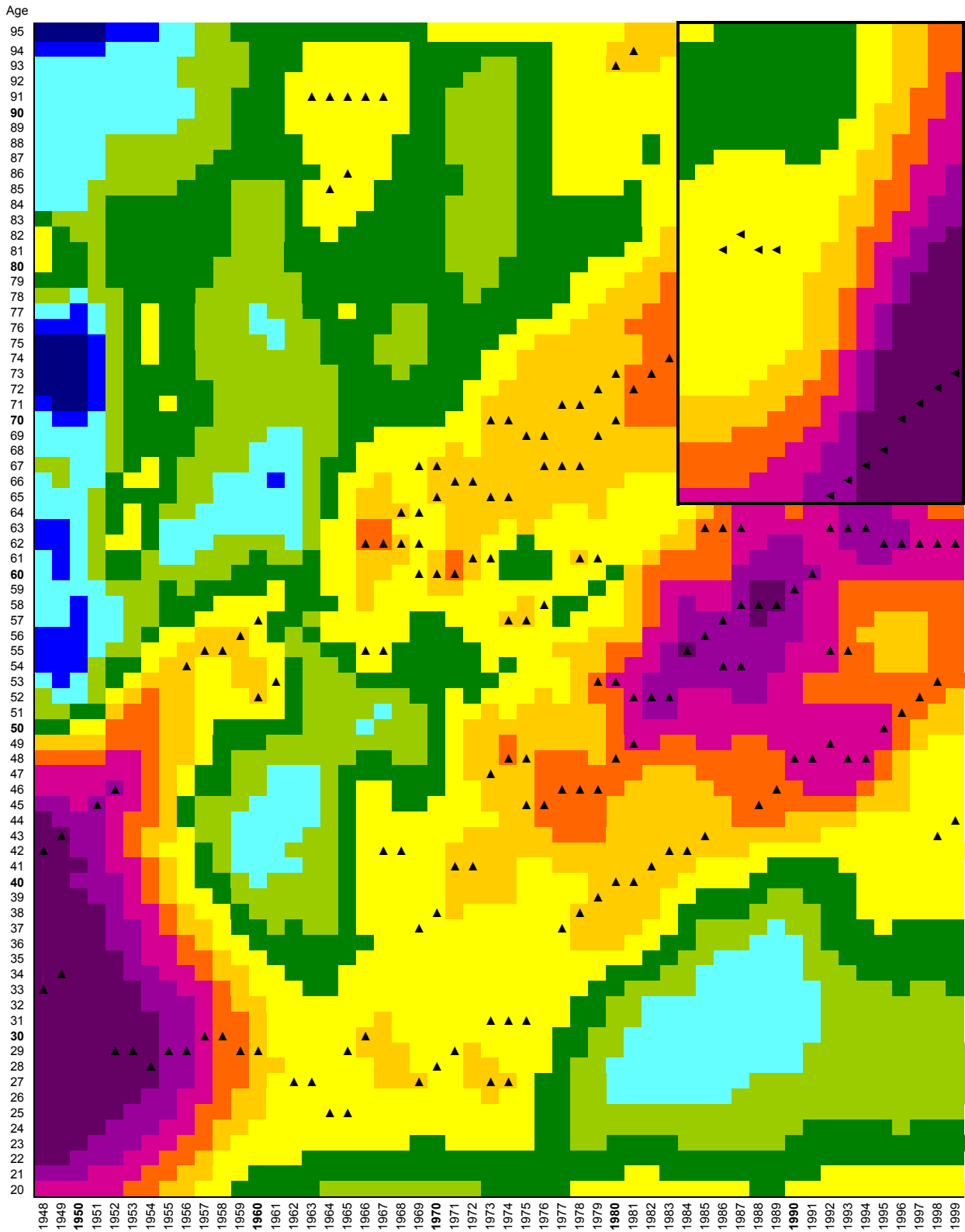
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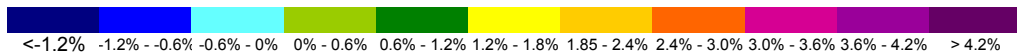
▲ Local peak > 1.5%

Appendix B1.2

Permanent assurances, males, all data: percentage improvement factors in graduated age specific mortality rates. Top right hand corner relates to Life Office Pensioners, "All Offices" graduated experience



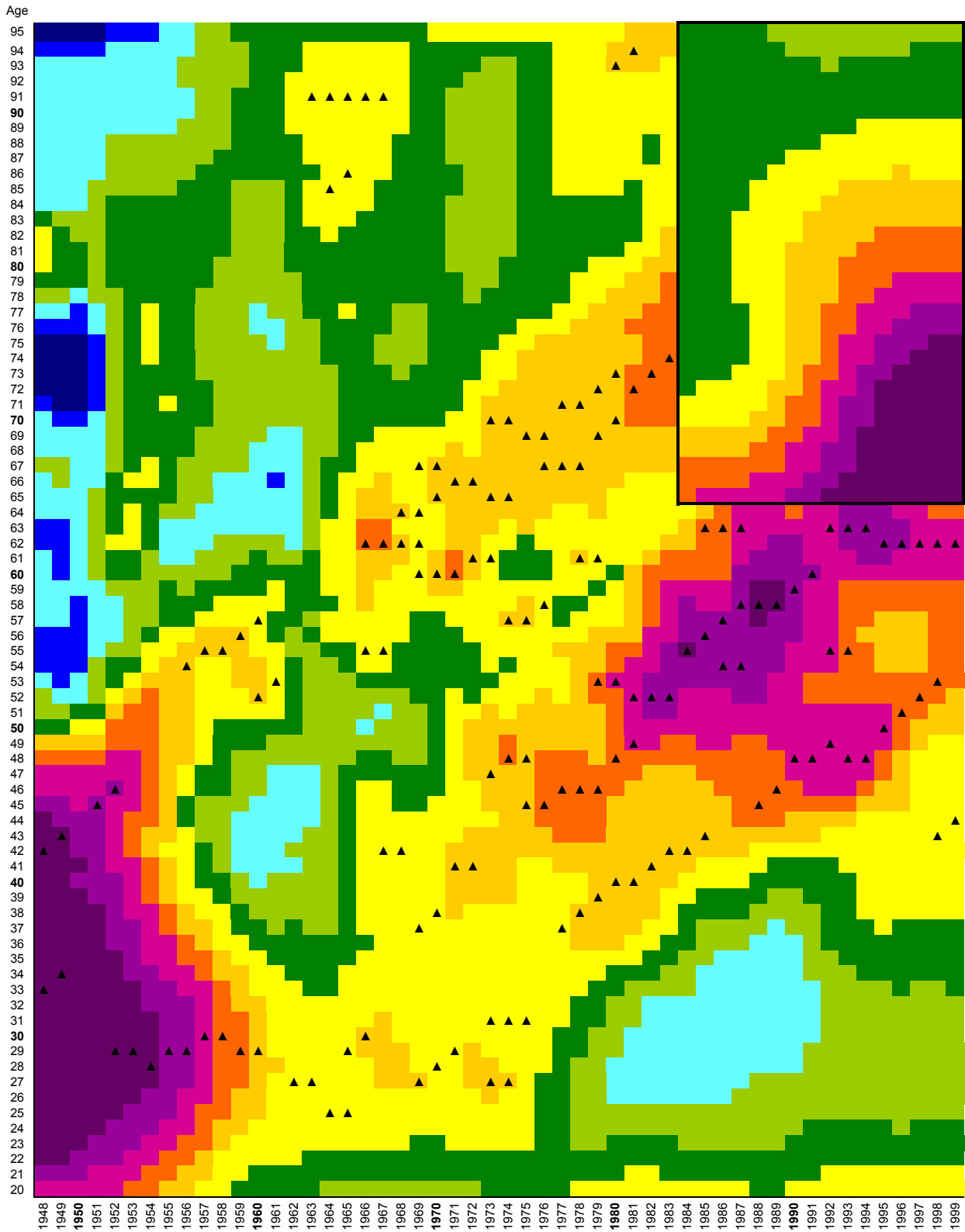
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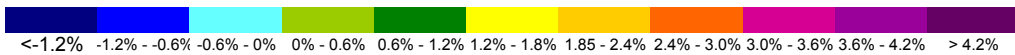
▲ Local peak > 1.5%

Appendix B1.3

Permanent assurances, males, all data: percentage improvement factors in graduated age specific mortality rates. Top right hand corner relates to Life Office Pensioners, "Loyal Offices" graduated experience



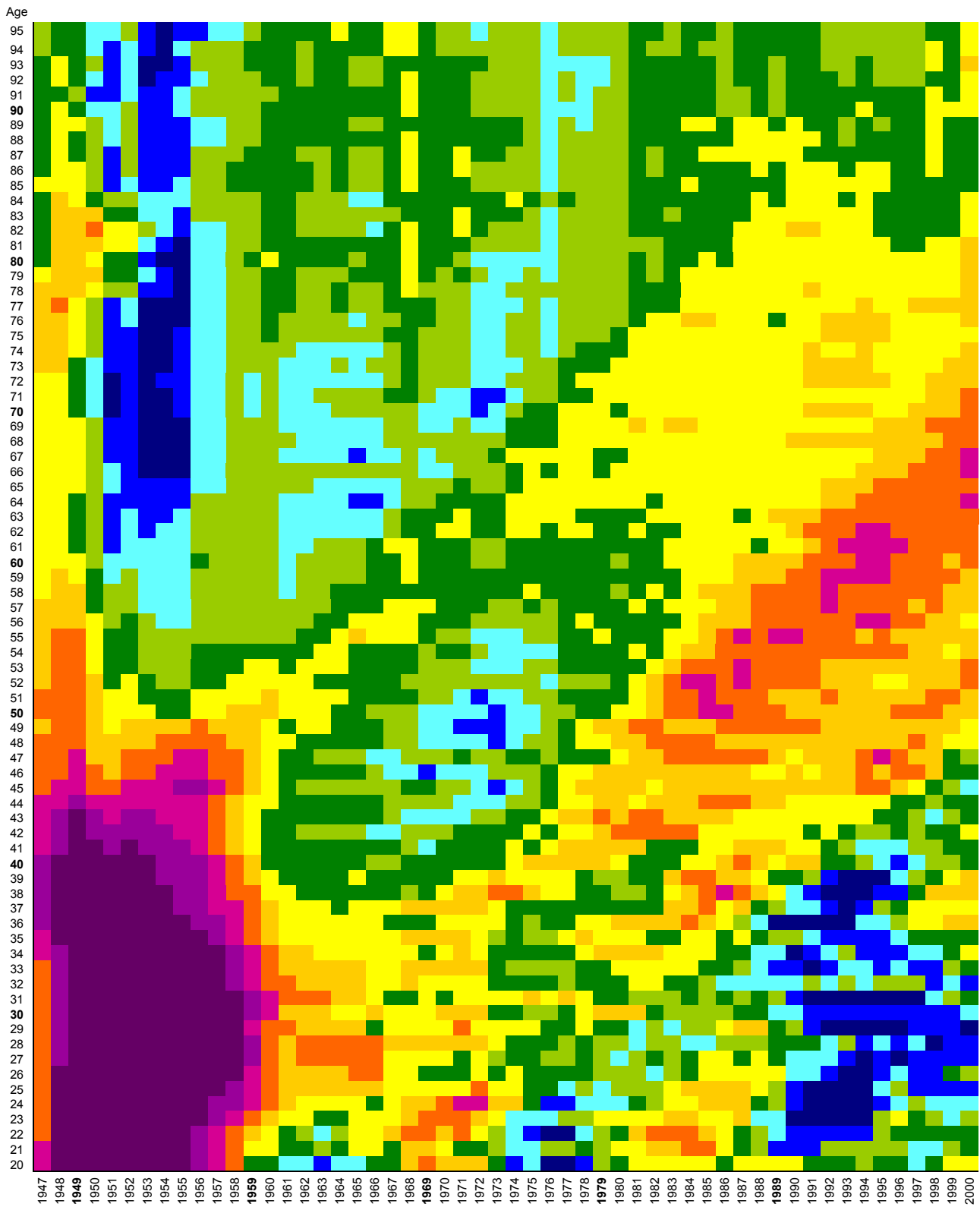
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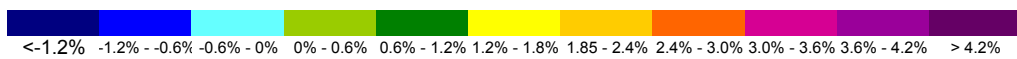
▲ Local peak > 1.5%

Appendix B2

GAD contour map of England and Wales improvement rates for male lives



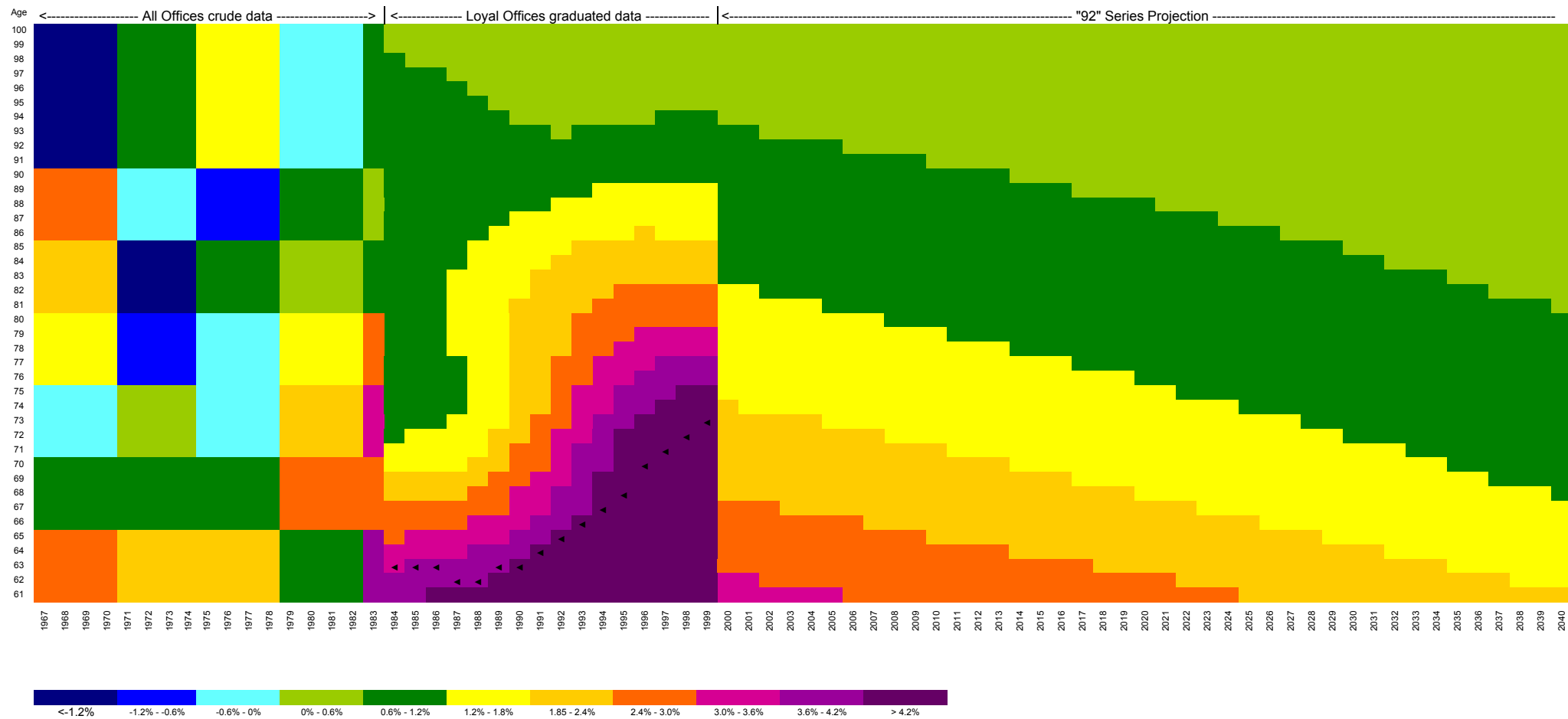
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▲ Local peak > 1.5%

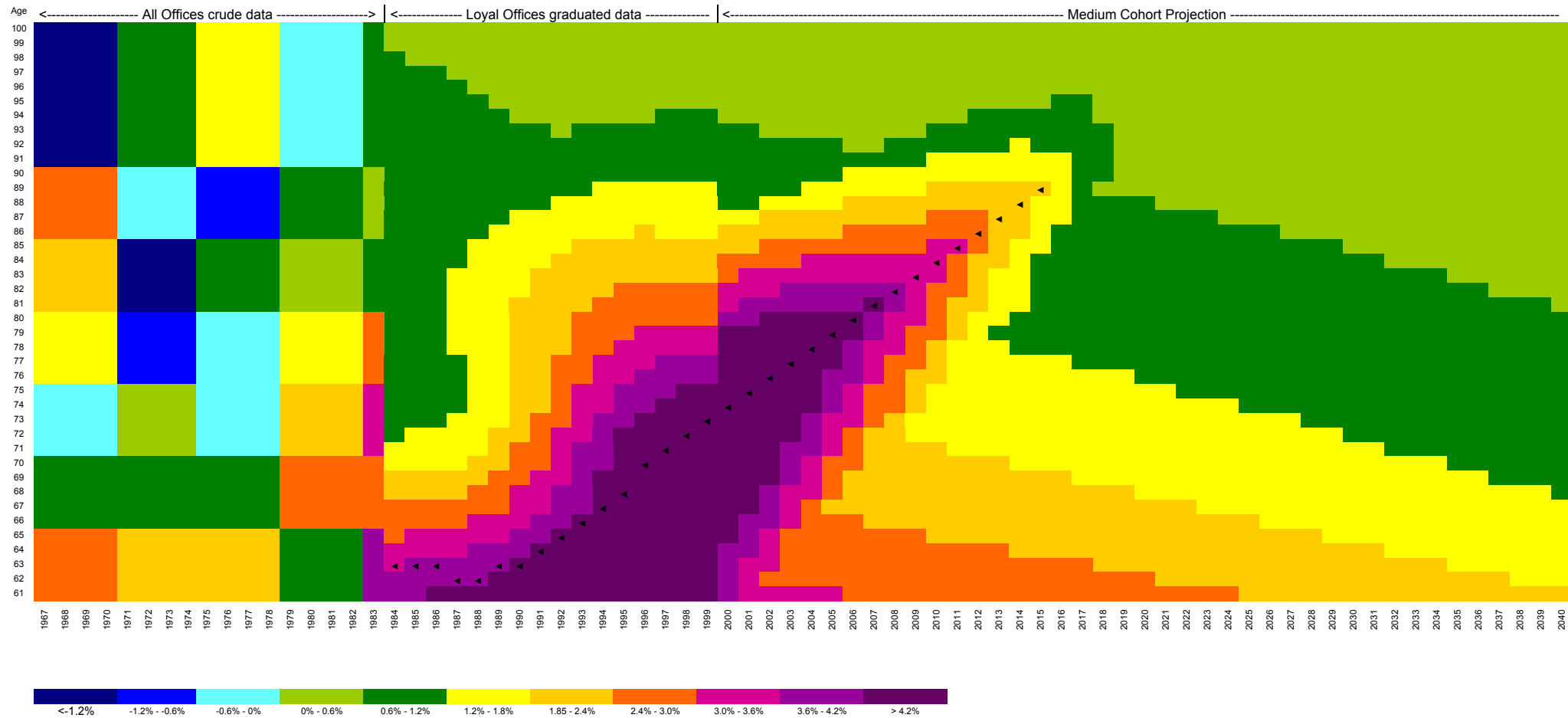
Appendix B3.3

Life office pensioners, males, normal retirements, lives, "All Offices" experience: mortality improvements: quadrennial data to 1983, graduated annual data from 1984 to 1999, "92" Series projections thereafter.

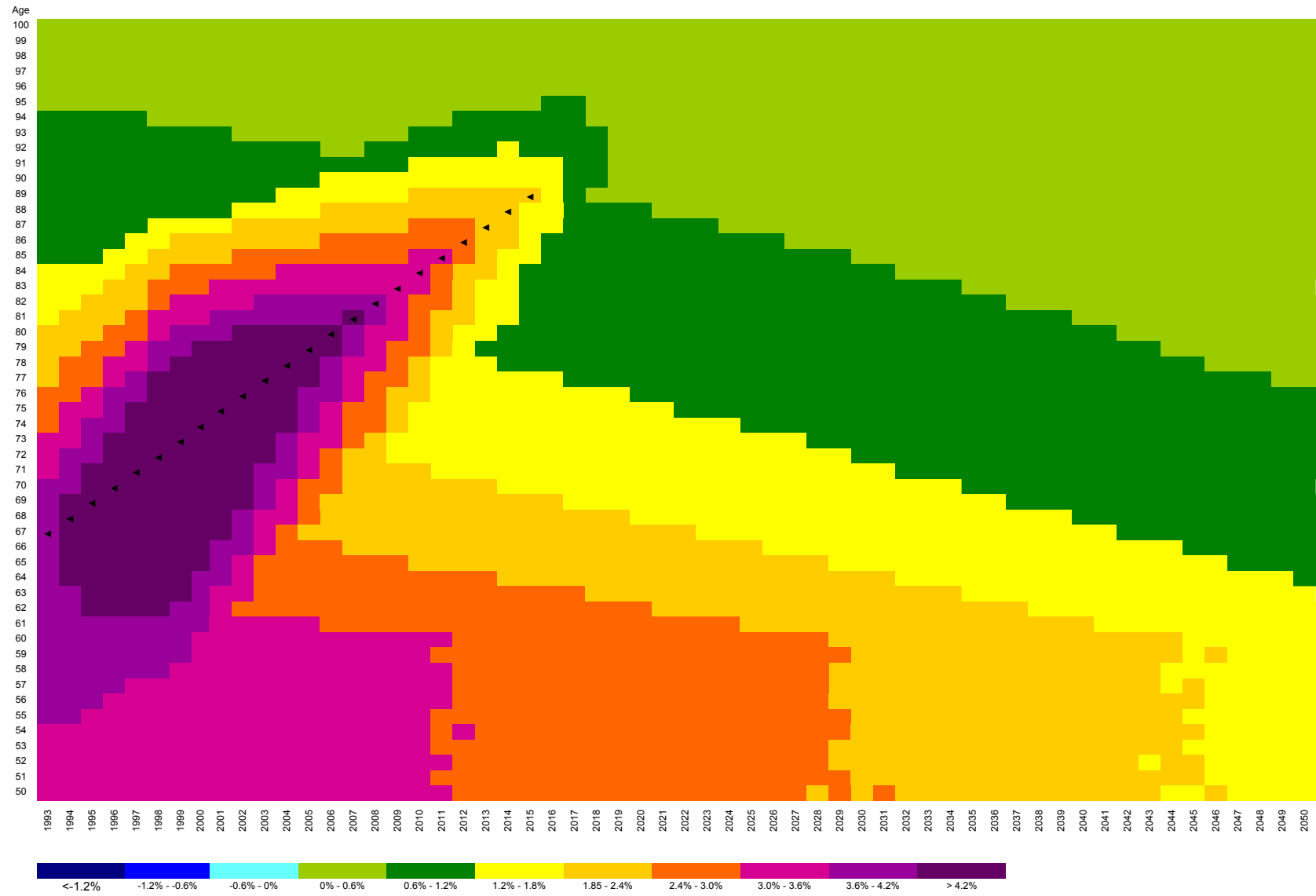


Appendix B3.4

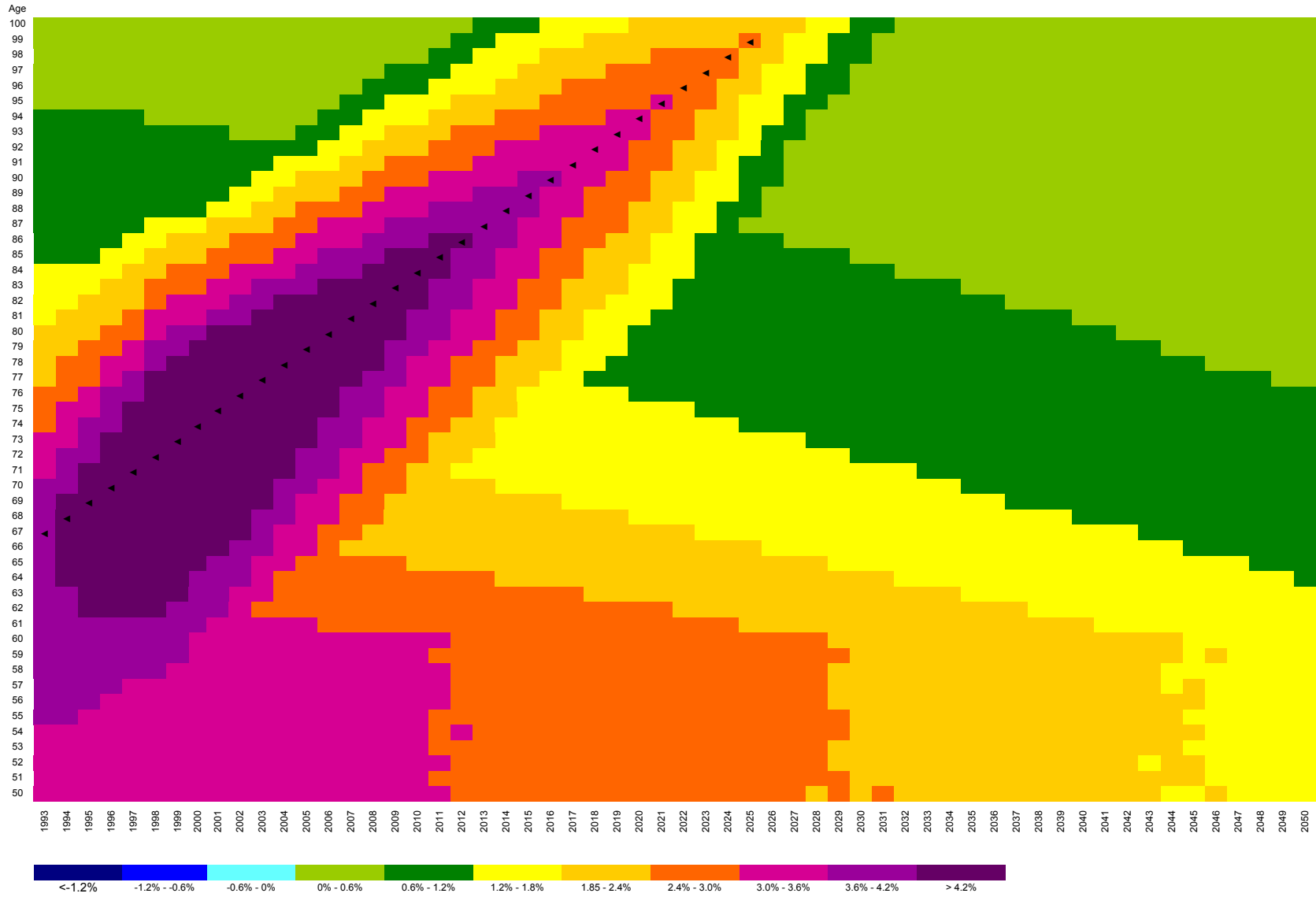
Life office pensioners, males, normal retirements, lives, "All Offices" experience: mortality improvements: quadrennial data to 1983, graduated annual data from 1984 to 1999, Medium Cohort Projection thereafter.



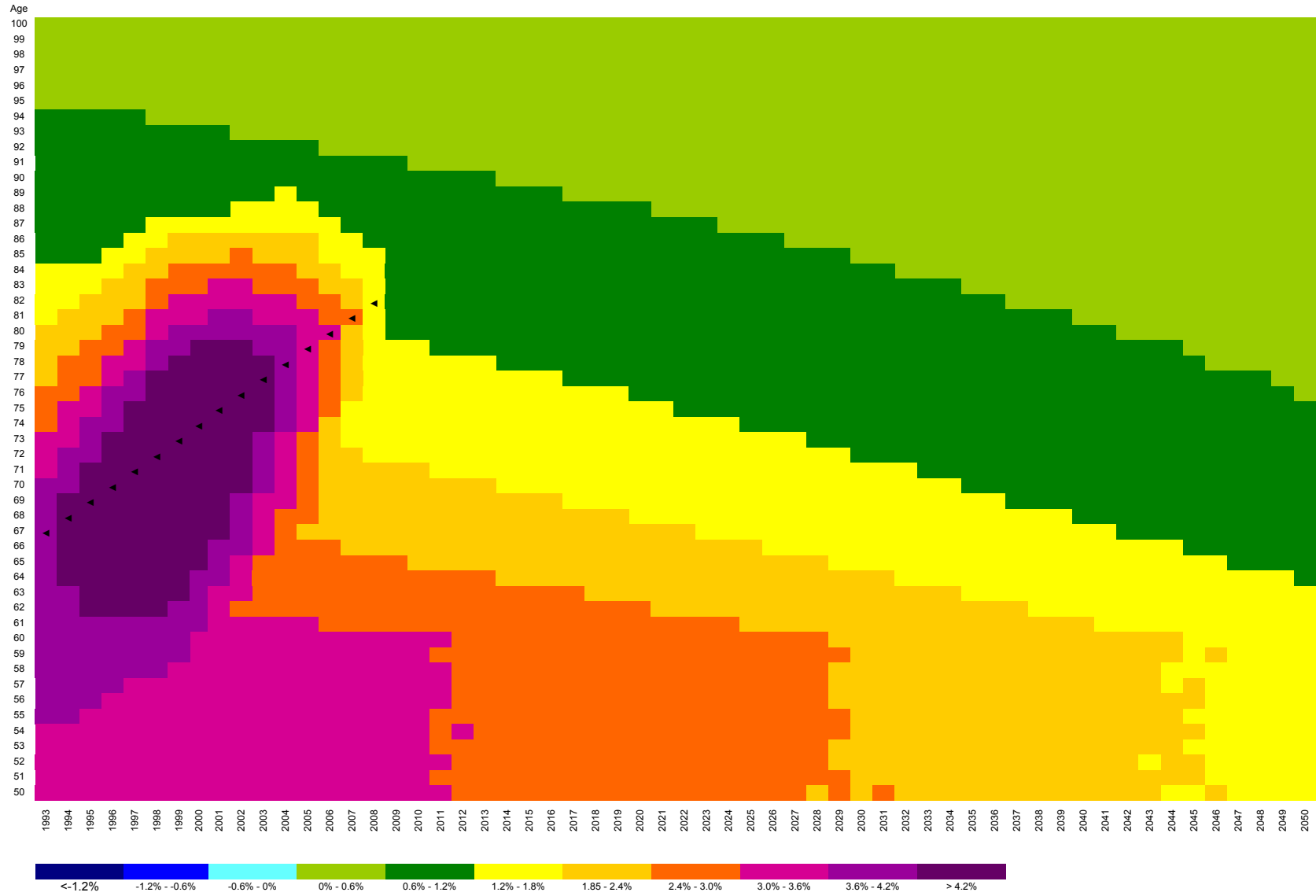
Appendix B4.1 Life office pensioners, males, normal retirements, lives: mortality improvements: Medium Cohort Projection.



Appendix B4.2 Life office pensioners, males, normal retirements, lives: mortality improvements: Long Cohort Projection.

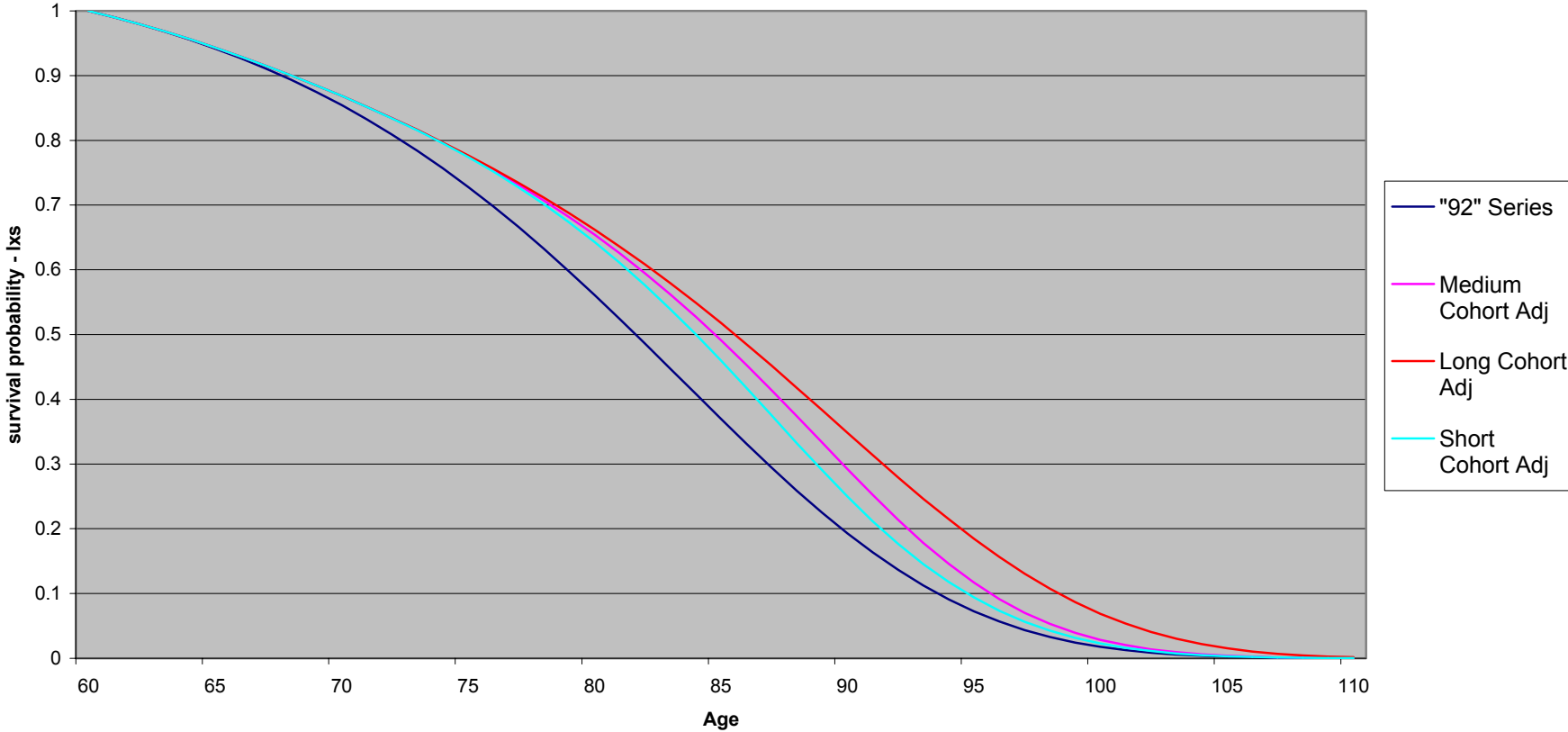


Appendix B4.3 Life office pensioners, males, normal retirements, lives: mortality improvements: Short Cohort Projection.



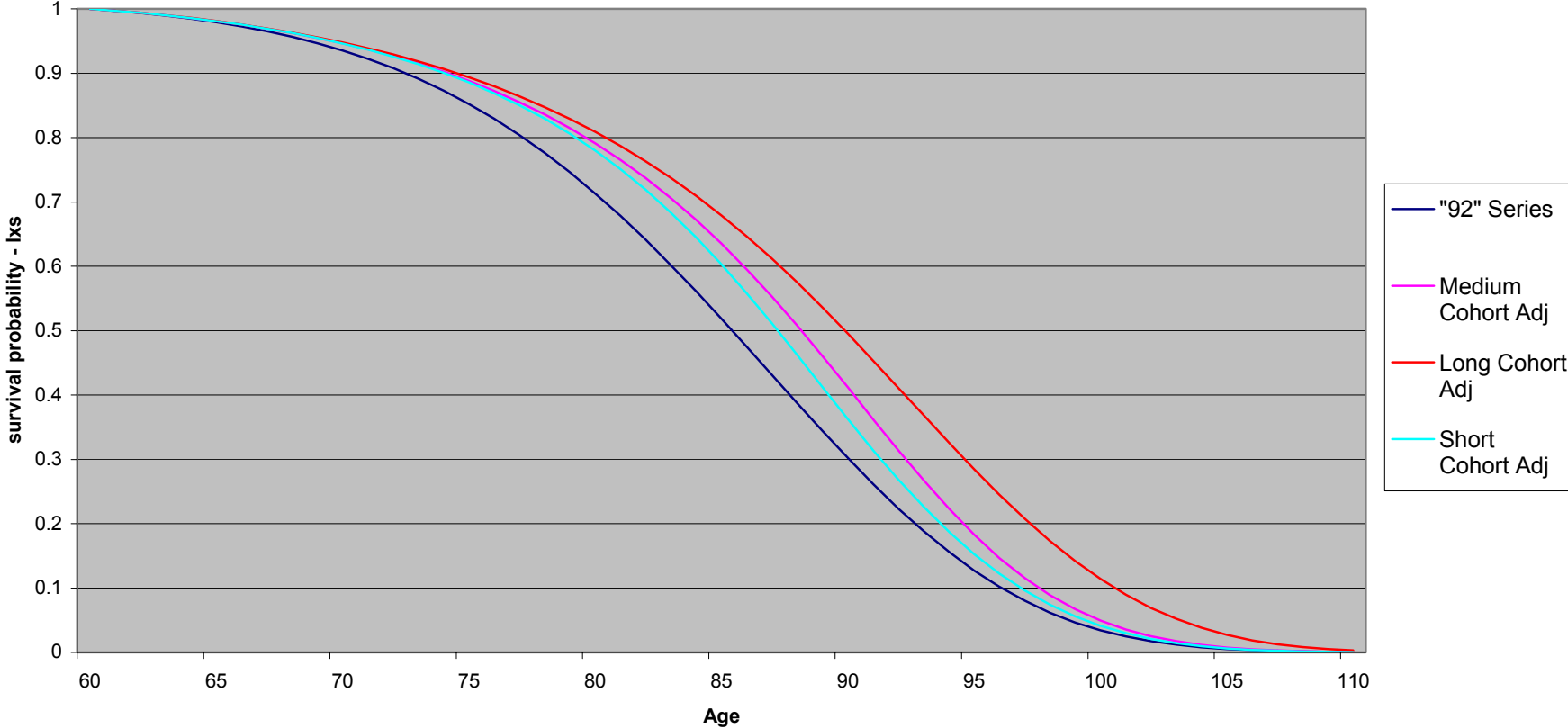
Appendix B5.1

Life office pensioners, males, lives : survival probabilities for year of birth 1932



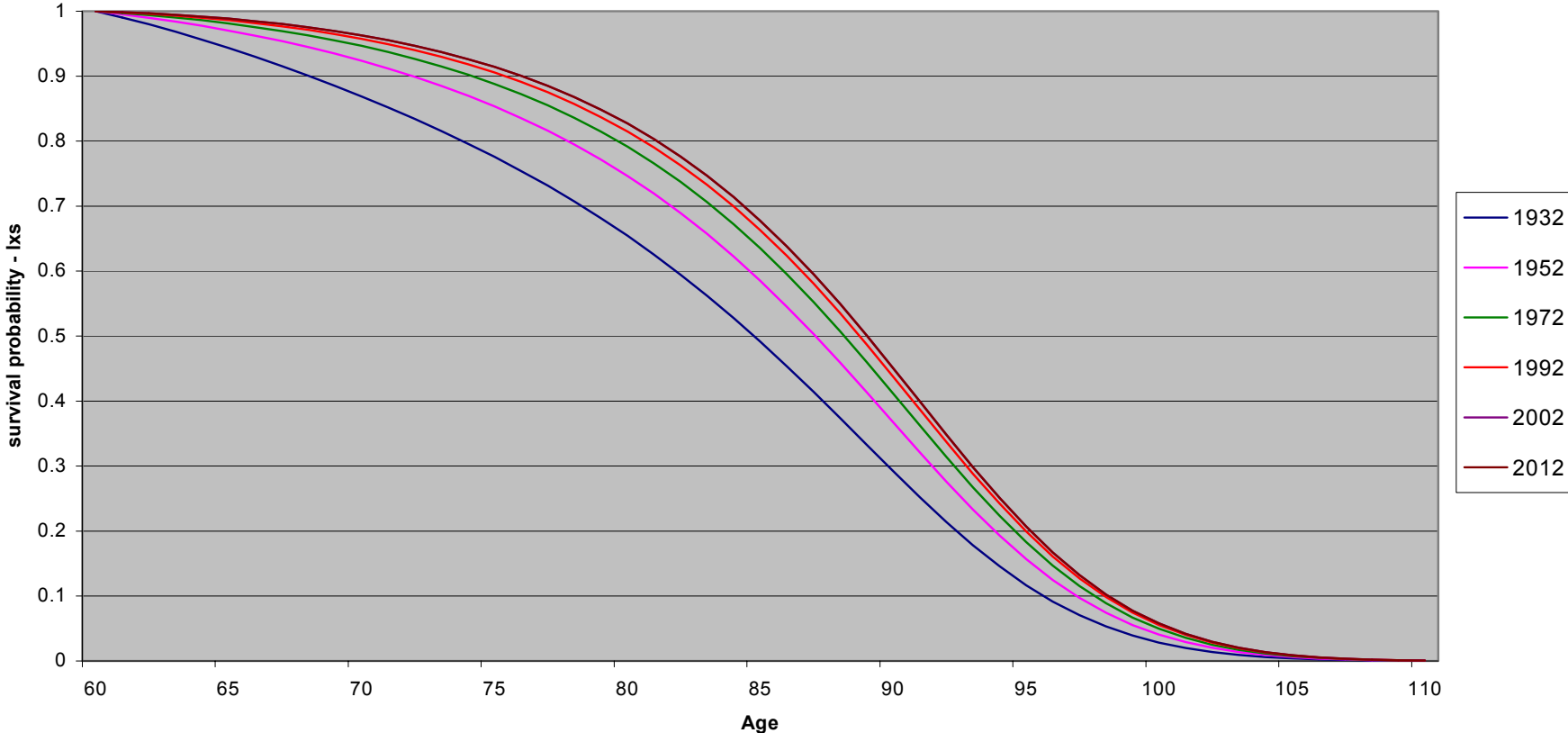
Appendix B5.2

Life office pensioners, males, lives : survival probabilities for year of birth 1972



Appendix B6

Life office pensioners, males, lives: survival probabilities by year of birth



Appendix C1 – Male annuity rates based on the PML92 table at 0%, with the following mortality improvement factors applied.

Age	U=1992				U=2000				U=2010				U=2020				U=2030							
	Med	Long	Short		Med	Long	Short		Med	Long	Short		Med	Long	Short		Med	Long	Short					
	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort
50	31.87	33.13	34.66	32.50	32.89	34.14	35.72	33.49	33.88	35.11	36.74	34.45	34.62	35.82	37.49	35.16	35.16	36.34	38.04	35.68				
55	26.61	27.92	29.36	27.30	27.67	28.99	30.56	28.34	28.72	30.00	31.63	29.34	29.50	30.75	32.41	30.08	30.08	31.30	33.00	30.63				
60	21.63	22.86	23.92	22.28	22.67	24.09	25.68	23.44	23.71	25.08	26.71	24.41	24.50	25.82	27.49	25.15	25.10	26.37	28.07	25.70				
65	17.10	17.83	18.42	17.46	18.04	19.55	20.97	18.88	19.00	20.46	22.12	19.77	19.75	21.13	22.83	20.45	20.32	21.65	23.37	20.96				
70	13.16	13.10	13.33	12.99	13.95	15.26	16.26	14.67	14.78	16.21	17.92	15.49	15.44	16.80	18.53	16.08	15.95	17.25	19.00	16.53				
75	9.88	9.40	9.47	9.39	10.51	11.12	11.64	10.80	11.17	12.36	13.97	11.62	11.70	12.84	14.60	12.10	12.13	13.21	14.99	12.48				
80	7.29	6.72	6.72	6.72	7.75	7.66	7.88	7.57	8.24	8.94	10.19	8.27	8.64	9.33	11.09	8.65	8.96	9.62	11.39	8.95				
85	5.33	4.84	4.84	4.84	5.64	5.22	5.29	5.22	5.98	6.02	6.79	5.65	6.26	6.41	8.05	5.91	6.48	6.63	8.31	6.13				
90	3.90	3.49	3.49	3.49	4.09	3.68	3.68	3.68	4.31	3.96	4.34	3.89	4.49	4.25	5.55	4.06	4.63	4.39	5.85	4.20				

Basis A is 90% of PML92 with the “92” Series adjustment factors applied.

Appendix C2 – Male annuity rates based on the PML92 table at 3%, with the following mortality improvement factors applied.

Age	U=1992				U=2000				U=2010				U=2020				U=2030							
	Med	Long	Short		Med	Long	Short		Med	Long	Short		Med	Long	Short		Med	Long	Short					
	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort	Basis A	Cohort	Cohort	Cohort
50	19.61	20.05	20.51	19.85	20.06	20.50	20.96	20.29	20.48	20.92	21.39	20.71	20.80	21.22	21.70	21.01	21.02	21.44	21.93	21.23				
55	17.38	17.92	18.41	17.69	17.90	18.45	18.99	18.21	18.41	18.94	19.49	18.70	18.78	19.30	19.86	19.06	19.06	19.56	20.12	19.32				
60	14.97	15.56	15.96	15.31	15.54	16.24	16.88	15.96	16.10	16.77	17.42	16.49	16.53	17.17	17.82	16.88	16.84	17.46	18.12	17.17				
65	12.51	12.90	13.14	12.72	13.08	13.94	14.58	13.61	13.65	14.48	15.24	14.14	14.09	14.87	15.64	14.53	14.42	15.17	15.94	14.83				
70	10.13	10.08	10.19	10.02	10.65	11.50	12.00	11.16	11.19	12.12	13.03	11.70	11.61	12.49	13.40	12.08	11.93	12.77	13.68	12.36				
75	7.96	7.63	7.67	7.63	8.41	8.85	9.15	8.65	8.87	9.73	10.69	9.24	9.24	10.06	11.11	9.57	9.53	10.31	11.37	9.84				
80	6.11	5.69	5.69	5.69	6.46	6.41	6.55	6.35	6.82	7.39	8.21	6.89	7.12	7.68	8.85	7.17	7.36	7.89	9.07	7.39				
85	4.61	4.23	4.23	4.23	4.86	4.54	4.59	4.54	5.13	5.19	5.76	4.89	5.35	5.50	6.72	5.10	5.53	5.67	6.91	5.27				
90	3.46	3.12	3.12	3.12	3.63	3.29	3.29	3.29	3.80	3.52	3.83	3.46	3.95	3.77	4.81	3.60	4.07	3.88	5.05	3.72				

Basis A is 90% of PML92 with the “92” Series adjustment factors applied.

Appendix C3 – Male annuity rates based on the PML92 table at 5%, with the following mortality improvement factors applied.

Age	U=1992				U=2000				U=2010				U=2020				U=2030			
	Basis A	Med Cohort	Long Cohort	Short Cohort	Basis A	Med Cohort	Long Cohort	Short Cohort	Basis A	Med Cohort	Long Cohort	Short Cohort	Basis A	Med Cohort	Long Cohort	Short Cohort	Basis A	Med Cohort	Long Cohort	Short Cohort
50	15.08	15.30	15.51	15.20	15.36	15.58	15.79	15.48	15.62	15.84	16.05	15.74	15.80	16.02	16.24	15.92	15.94	16.15	16.37	16.05
55	13.74	14.05	14.30	13.92	14.08	14.40	14.67	14.27	14.41	14.72	15.00	14.59	14.65	14.95	15.23	14.82	14.83	15.12	15.40	14.99
60	12.17	12.54	12.76	12.39	12.57	13.02	13.38	12.86	12.96	13.39	13.75	13.22	13.25	13.66	14.02	13.49	13.47	13.86	14.22	13.69
65	10.46	10.72	10.86	10.60	10.88	11.49	11.88	11.28	11.30	11.88	12.36	11.66	11.62	12.17	12.64	11.95	11.86	12.38	12.85	12.16
70	8.69	8.65	8.72	8.61	9.10	9.75	10.08	9.52	9.52	10.23	10.85	9.94	9.84	10.51	11.12	10.22	10.09	10.72	11.33	10.44
75	7.01	6.74	6.77	6.74	7.37	7.74	7.94	7.58	7.74	8.45	9.15	8.07	8.04	8.71	9.48	8.33	8.27	8.91	9.67	8.54
80	5.49	5.14	5.14	5.14	5.79	5.76	5.87	5.71	6.09	6.59	7.23	6.17	6.34	6.83	7.75	6.41	6.54	7.00	7.92	6.59
85	4.23	3.89	3.89	3.89	4.44	4.17	4.21	4.17	4.67	4.74	5.21	4.48	4.86	5.01	6.02	4.66	5.02	5.16	6.19	4.81
90	3.22	2.92	2.92	2.92	3.37	3.06	3.06	3.06	3.52	3.28	3.55	3.22	3.66	3.50	4.41	3.35	3.76	3.60	4.62	3.46

Basis A is 90% of PML92 with the "92" Series adjustment factors applied

Appendix C4 – New basis male annuity rates as a percentage of annuity rates calculated on 90% of PML92 for the year of use shown - 0%

Age	U=1992			U=2000			U=2010			U=2020			U=2030		
	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort
50	104%	109%	102%	104%	109%	102%	104%	108%	102%	103%	108%	102%	103%	108%	101%
55	105%	110%	103%	105%	110%	102%	104%	110%	102%	104%	110%	102%	104%	110%	102%
60	106%	111%	103%	106%	113%	103%	106%	113%	103%	105%	112%	103%	105%	112%	102%
65	104%	108%	102%	108%	116%	105%	108%	116%	104%	107%	116%	104%	107%	115%	103%
70	100%	101%	99%	109%	117%	105%	110%	121%	105%	109%	120%	104%	108%	119%	104%
75	95%	96%	95%	106%	111%	103%	111%	125%	104%	110%	125%	103%	109%	124%	103%
80	92%	92%	92%	99%	102%	98%	109%	124%	100%	108%	128%	100%	107%	127%	100%
85	91%	91%	91%	93%	94%	92%	101%	114%	94%	103%	129%	95%	102%	128%	95%
90	90%	89%	90%	90%	90%	90%	92%	101%	90%	95%	124%	90%	95%	126%	91%

Appendix C5 – New basis male annuity rates as a percentage of annuity rates calculated on 90% of PML92 for the year of use shown - 3%

Age	U=1992			U=2000			U=2010			U=2020			U=2030		
	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort
50	102%	105%	101%	102%	105%	101%	102%	104%	101%	102%	104%	101%	102%	104%	101%
55	103%	106%	102%	103%	106%	102%	103%	106%	102%	103%	106%	101%	103%	106%	101%
60	104%	107%	102%	105%	109%	103%	104%	108%	102%	104%	108%	102%	104%	108%	102%
65	103%	105%	102%	107%	112%	104%	106%	112%	104%	106%	111%	103%	105%	111%	103%
70	100%	101%	99%	108%	113%	105%	108%	116%	105%	108%	115%	104%	107%	115%	104%
75	96%	96%	96%	105%	109%	103%	110%	121%	104%	109%	120%	104%	108%	119%	103%
80	93%	93%	93%	99%	101%	98%	108%	120%	101%	108%	124%	101%	107%	123%	100%
85	92%	92%	92%	93%	94%	93%	101%	112%	95%	103%	126%	95%	103%	125%	95%
90	90%	90%	90%	91%	91%	91%	93%	101%	91%	95%	122%	91%	95%	124%	91%

Appendix C6 – New basis male annuity rates as a percentage of annuity rates calculated on 90% of PML92 for the year of use shown - 5%

Age	U=1992			U=2000			U=2010			U=2020			U=2030		
	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort	Med Cohort	Long Cohort	Short Cohort
50	101%	103%	101%	101%	103%	101%	101%	103%	101%	101%	103%	101%	101%	103%	101%
55	102%	104%	101%	102%	104%	101%	102%	104%	101%	102%	104%	101%	102%	104%	101%
60	103%	105%	102%	104%	106%	102%	103%	106%	102%	103%	106%	102%	103%	106%	102%
65	102%	104%	101%	106%	109%	104%	105%	109%	103%	105%	109%	103%	104%	108%	103%
70	100%	100%	99%	107%	111%	105%	108%	114%	104%	107%	113%	104%	106%	112%	103%
75	96%	97%	96%	105%	108%	103%	109%	118%	104%	108%	118%	104%	108%	117%	103%
80	94%	94%	94%	99%	101%	99%	108%	119%	101%	108%	122%	101%	107%	121%	101%
85	92%	92%	92%	94%	95%	94%	101%	111%	96%	103%	124%	96%	103%	123%	96%
90	91%	91%	91%	91%	91%	91%	93%	101%	91%	96%	120%	92%	96%	123%	92%