Assessment of the Economic Impact of Additional Combined Sewer Overflow Controls in the Massachusetts Water Resources Authority Service Area

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EXECUTIVE SUMMARY

In 1998, the United States Environmental Protection Agency (EPA) approved a change to water quality standards for certain waters affected by combined sewer overflows (CSOs) in the Massachusetts Water Resources Authority (MWRA) service area. The approval was based on a finding that investments in additional CSO controls would cause "substantial and widespread economic and social impact." This report examines whether such a finding should still be made today, given current local economic and social conditions.

Comparison of average household sewer costs with the median household income (MHI) of service area communities was a key element of the analysis underlying EPA's 1998 finding. According to EPA regulatory guidance, a finding that sewer costs exceed 2% of MHI provides important support for the conclusion that additional controls would cause "substantial and widespread economic and social impact." With this 2% threshold, EPA acknowledges that sewer costs can reach a level beyond which any further increase in the cost of this basic necessity would cause significant economic and social impacts.

However, sewer service is just one of a set of basic necessities whose costs influence the overall economic burden on a community's households. The greater are the costs of such necessities, the greater is the economic burden, and the greater will be the economic and social impact of an increase in sewer rates. Our analysis focuses on the economic burden from shelter costs. Three factors motivate our focus on the cost of shelter: it is one of the largest components of the cost of basic necessities; it is the most significant determinant of variation in the cost of basic necessities; and, more so than other necessities, the burden from the cost of shelter is closely related to that from sewer charges, with the two burdens being indistinguishable for many households.

We compare shelter cost burdens in the MWRA service area (expressed as a share of MHI) with those that typically would be experienced in metropolitan areas nationwide if sewer charges were to rise to EPA's 2% threshold. We find that the economic burden in the MWRA service area is far greater than that which typically would be associated with reaching EPA's 2% threshold, and that the MWRA service area is an outlier among U.S. metropolitan areas:

- *In 2003, the actual shelter cost burden in the MWRA service area as a whole exceeded the burden that would be associated with reaching EPA's 2% threshold in nearly 95% of sampled U.S. metropolitan areas. Shelter cost burdens were even higher in Boston and Chelsea.*

- *Shelter cost burdens in the MWRA service area have increased dramatically since EPA's 1998 finding, and sensitivity analyses suggest that these burdens will likely remain high, relative to burdens in other metropolitan areas, well into the future.*

Our analysis focuses on burdens facing median income households. Given differences between the income distribution in the MWRA service area and the typical distribution in

metropolitan areas nationwide, the relative burdens on lower income households in the service area, compared with burdens on similar households in other metropolitan areas, are even greater.

Together with other analyses of conditions in the MWRA service area, this report provides rigorous evidence that additional CSO control investments in the MWRA service area would cause "substantial and widespread economic and social impact."

1. Introduction

In February 1998, the United States Environmental Protection Agency (EPA) approved a change to water quality standards for certain receiving waters affected by combined sewer overflows (CSOs) in the Massachusetts Water Resources Authority (MWRA) service area.[1] EPA approved this change based on a finding that additional investments in CSO controls would cause "substantial and widespread economic and social impact."[2]

EPA's finding was supported by the application of two economic analyses set forth in its *Interim Economic Guidance for Water Quality Standards Workbook* (hereafter, the *Guidance*).[3] These analyses are referred to as the municipal preliminary screener (hereafter, the preliminary screener) and the secondary test. The preliminary screener involves the calculation of the average cost of sewer services for a household, expressed as a percentage of a community's median household income (MHI). For this screener, higher percentages imply that additional CSO controls would cause greater economic impacts. The secondary test involves the calculation of a score that is the average of six additional indicators of a community's socioeconomic condition.[4] Lower secondary test scores imply weaker socioeconomic conditions, and thereby increased likelihood that additional controls would cause substantial economic impact.

EPA applied these two analyses to evaluate conditions in Boston and Chelsea — two communities of particular concern to EPA — and in the entire MWRA service area.[5] For the

[1] Letter from John DeVillars, Regional Administrator, U.S. Environmental Protection Agency (EPA) Region 1, to David Struhs, Commissioner, Massachusetts Department of Environmental Protection (February 27, 1998).

[2] Such a finding is one of several possible bases for demonstrating that a designated water use is infeasible (see 40 C.F.R. § 131.10(g)).

[3] U.S. EPA, *Interim Economic Guidance for Water Quality Standards Workbook*, April 27, 1995, EPA-823-B-95-002, Chapter 2. Available at http://www.epa.gov/ostwater/econ/.

[4] These indicators evaluate: the municipal bond rating, municipal debt per capita, the unemployment rate, median household income, the property tax collection rate, and property tax revenue as a percentage of the market value of taxable property. In applying this test to the MWRA service area, EPA omitted the sixth indicator because state law limits municipal property tax rates, reducing the indicator's effectiveness for evaluating socioeconomic conditions.

[5] EPA focused on Boston and Chelsea because Boston is the largest community in the MWRA service area and Chelsea "is the community which will bear the heaviest cost [from CSO controls] in relation to income levels." Letter from John DeVillars (1998), p. 3.

preliminary screener, EPA forecasted that, in 2005, average sewer charges in Chelsea would be 2.28% of MHI, average sewer charges in Boston would be 1.65% of MHI, and average sewer charges in the MWRA service area as a whole would be 1.25% of MHI.[6] Chelsea's preliminary screener value exceeded the 2% threshold that EPA's *Guidance* establishes as the minimum value associated with a "large" economic impact. The screener values for Boston and the MWRA service area were within the range from 1% to 2% that the *Guidance* considers a "mid-range" impact. For the secondary test, EPA evaluated conditions present in Boston and Chelsea at the time of its analysis in 1998. The secondary test scores indicated "mid-range" socioeconomic conditions in both communities. The results of these two economic analyses supported EPA's 1998 finding that additional CSO controls would cause "substantial and widespread economic and social impact" in the MWRA service area.

1.1. Purpose of investigation

A 2003 application of EPA's secondary test produced scores indicating that economic conditions had not improved in Boston since EPA's 1998 finding, and that conditions had worsened in Chelsea.[7] At the same time, updated estimates of MHI and sewer charges suggest that, in 2005, these communities' preliminary screener values may be below EPA's 1998 projections.

These and other developments in fundamental economic and social conditions since EPA's 1998 finding raise the question of whether additional investments in CSO controls would still cause "substantial and widespread economic and social impact" in the MWRA service area. However, analyses of economic impact should not be limited to the preliminary screener and secondary test set forth in EPA's *Guidance*. Indeed, EPA regulatory guidance states that those

[6] EPA forecasted the preliminary screener values for 2005 because that year was assumed to "be a fair representation of rate impacts during the years of maximum household burden (from sewer charges)." Letter from John DeVillars (1998), Attachment A, Footnote 1.

[7] This updated application of the secondary test examined the same indicators that EPA did in 1998. The updated secondary score for Boston, calculated in July 2003, was 2.2, identical to that calculated by EPA in 1998. Chelsea's secondary score fell from 1.8 in 1998 to 1.4 in 2003, indicating that conditions had worsened. Letter from John DeVillars (1998), Attachments A and B. Metcalf & Eddy, *Final Variance Report for Alewife Brook and the Upper Mystic River*, EOEA No. 10335, July 2003, pp. 6-31 – 6-32.

tests "are not intended to be applied as absolute decision points";[8] and it explicitly allows the application of alternative analyses and criteria that are appropriate to local circumstances, recognizing that "(a)dditional information and tests may be necessary and/or desirable in certain circumstances."[9]

The provision for additional analyses is critical because there are specific, unusual circumstances germane to the MWRA sewer service area[10] (hereafter, the MWRA service area) in which the standard application of analyses in EPA's *Guidance* would fail to identify significantly greater economic impacts than those typically associated with the thresholds set forth in that *Guidance*. As a result of these unusual circumstances, households in the MWRA service area face far greater economic burdens today than would typically be necessary to meet EPA's preliminary screener threshold for a "large" economic impact. These economic burdens are closely related to those directly measured by EPA's preliminary screener, and analyzing them involves only minimal extensions to that screener. Based on such analyses, this report validates EPA's 1998 forecast that additional CSO controls would cause "substantial and widespread economic and social impact" in the MWRA service area.

1.2. Economic impact and its relation to EPA's preliminary screener

A key determinant of the economic impact of additional CSO controls is the social cost of those controls.[11] That is, the economic impact of additional controls is influenced by the goods, services, and/or investments that households and municipalities must forego to fund the controls. For a particular level of investment in additional controls, the more essential the

[8] Memorandum from Tudor Davies, Director of the Office of Science and Technology, U.S. EPA, to Water Management Division Directors: Regions I – X, titled "Economic Guidance for Water Quality Standards – Workbook," April 27, 1995. The manner by which EPA reached its 1998 finding was consistent with this guidance. EPA indicated that, in reaching that finding, the results of the preliminary screeners and secondary tests were considered along with other factors.

[9] Memorandum from Tudor Davies (1995). U.S. EPA, Office of Water, *Guidance: Coordinating CSO Long-term Planning with Water Quality Standards Reviews*, July 31, 2001, EPA-833-R-01-002, p. 31.

[10] See Appendix A for a list of cities and towns in the MWRA sewer service area.

[11] EPA's analyses focus on the costs of additional CSO controls. However, assessment of the controls' costs *and benefits* is necessary to definitively comment on their economic impact. While the analyses presented in this report involve limited extensions to EPA's existing analyses of the costs of additional controls, in Section 5, we briefly discuss the need for benefit-cost analysis to assess economic impacts definitively.

associated foregone goods, services, and/or investments are to a community and its residents, the greater will be the economic impact of those controls.

The significance of the foregone consumption and investment — and hence the economic impact of additional CSO controls — is directly related to the existing level of economic burdens on households. The greater the existing burdens, the greater will be the impact of additional controls. For example, the economic impact of increased sewer charges would be far greater if households do not have adequate income to purchase basic necessities, such as food and shelter, than if the income of those households could support substantial discretionary spending. In the former case, additional sewer charges would cause households to forego basic necessities. In the latter case, the foregone consumption would be less essential.

Economic burdens are commonly measured by comparing costs of particular necessities to resources, or income, available to households or communities. In such measures, higher ratios of costs to income imply greater burdens. EPA's preliminary screener is such a measure in that it evaluates the economic burden from sewer charges by comparing those charges to MHI.[12]

There are also broader and related economic burdens that are associated with a given screener value. These burdens can be evaluated using measurements similar to the preliminary screener. One important broader economic burden is that arising from the cost of basic necessities, which includes the cost of sewer service. Another related economic burden is that experienced by lower income households in a community. Along with the specific burden measured by the screener — that of sewer charges on the median household — these broader and related burdens determine the economic impact that would be associated with additional CSO control investments.

[12] Poverty statistics are another example of such a measure of economic burdens. They determine economic burden, or hardship, by comparing a measure of the cost of maintaining a basic standard of living, the poverty line (or threshold), to household income. The poverty threshold was originally designed to measure the cost of a basic standard of living. Yet, economic research and changes in economic conditions since its development have led a National Research Council (NRC) panel to recommend revisions to that threshold to ensure that poverty statistics continue to measure economic burdens accurately. The analysis set forth in Section 3 involves an extension to EPA's preliminary screener that is similar to a poverty threshold adjustment recommended by the NRC panel in order to ensure that that threshold accurately accounts for important variations in economic burdens across the country. See National Research Council, Panel on Poverty and Family Assistance, Constance Citro and Robert Michael, eds., *Measuring Poverty: A New Approach*, Washington, D.C.: National Academy Press, 1995.

In many cases, both across communities and over time, consistent relationships will exist between preliminary screener values and broader economic burdens, such as those described above. For example, a given preliminary screener value will commonly be associated with a particular level of economic burden arising from the cost of basic necessities, and with a particular burden on lower income households. So long as this consistent relationship exists, measurement of a community's preliminary screener value is sufficient to evaluate economic impact, as that screener value would be an effective proxy for broader economic burdens. It would be an effective proxy because the broader burdens in the community would be similar to those typically associated with its screener value in communities nationwide.

However, there can be situations where the economic burdens in a community are substantially different from those typically associated with its screener value. For example, a community may experience unusually high costs of basic necessities or may have a distribution of household incomes that differs significantly from that in most communities. In these cases, the standard application of EPA's preliminary screener would not be sufficient on its own to distinguish between higher and lower levels of economic impact. This is because the broader economic burdens would cause the economic impact of additional CSO controls to differ significantly from that typically associated with the community's screener value. Consequently, additional analyses of broader economic burdens would be necessary to assess economic impact accurately. It is in situations such as these that the allowance for additional analyses provided by EPA's regulatory guidance is so important.

1.3. Outline of report

This report evaluates particular economic burdens in the MWRA service area that are broader in scope than, and related to, the burdens directly measured by the preliminary screener. Specifically, it evaluates whether the levels of those broader and related burdens are similar to what would typically be associated with a screener value indicating a "large" economic impact. While some may dispute whether EPA has selected appropriate thresholds for its screener, our analysis takes at face value EPA's choice of thresholds and the broader economic burdens that they imply. We perform two extensions of EPA's analysis to compare economic conditions in

the MWRA service area with those typically associated with EPA's 2% screener value threshold for a "large" economic impact. The first extension compares the broader economic burdens arising from the cost of basic necessities in the MWRA service area with those typically associated with a 2% screener value. The second extension explores the implications of evaluating the burdens of particular costs based on their relationship to incomes of lower income households, rather than to the income of the median household.

Section 2 describes three reasons why it is appropriate to conduct the first extension of EPA's analysis to consider broader economic burdens from the cost of basic necessities. First, such broader cost burdens directly influence the level of burden associated with particular sewer charges. Second, to some households, the burden from sewer charges is truly indistinguishable from that arising from other elements of the cost of shelter, which is a predominant element of the cost of basic necessities. Third, while in many cases the burdens associated with the cost of basic necessities may be relatively constant over time and across the United States, these burdens have not only been significantly higher in the MWRA service area than elsewhere in the United States, but they have also increased substantially since EPA's 1998 finding.

Section 3 presents an analysis of the economic burdens arising from the cost of basic necessities in the MWRA service area. This section compares those burdens with the burdens from the cost of basic necessities that typically would be associated with EPA's 2% screener threshold nationwide, and with the burdens in the MWRA service area in 1997, just prior to EPA's 1998 finding.[13] As Section 3.1 describes, in evaluating burdens from the cost of basic necessities, the cost of shelter is used as a proxy for the broader cost of all basic necessities. Three factors motivate our focus on the cost of shelter: it is one of the largest components of the cost of basic necessities; it is the most significant determinant of variation in the cost of basic necessities over time and across the country; and, more so than other necessities, the burden from the cost of shelter is closely related to that from sewer charges, with the two burdens being indistinguishable for many households.

[13] Throughout this report, in evaluating economic conditions at the time of EPA's 1998 finding, and changes since then, we focus on annual data from 1997 rather than 1998. This is because EPA's finding was issued in early 1998 and was in response to analysis and data from 1997.

Sections 3.2 and 3.3 describe the means by which we estimate the two components of shelter cost burdens in the MWRA service area and in a sample of 80 metropolitan areas nationwide: shelter costs themselves and the MHIs of the communities in which those costs are borne. Having established actual shelter cost burdens in 80 metropolitan areas nationwide, Section 3.4 describes the development of a distribution of shelter cost burdens that *would be present* in those 80 metropolitan areas *if sewer charges were to increase to the point of meeting EPA's 2% screener threshold*. This distribution is developed based on actual shelter cost burdens in each area, information regarding existing sewer charges in metropolitan areas nationwide, and assumptions regarding how changes in sewer charges would affect shelter costs.

Section 3.5 evaluates shelter cost burdens in Boston and Chelsea, and in the MWRA service area as a whole. Actual shelter cost burdens in those areas are compared with the distribution of shelter cost burdens that would be present in 80 metropolitan areas nationwide if their sewer charges increased to the point of meeting EPA's 2% screener threshold, as described above. Section 3.5 also evaluates how shelter cost burdens have changed since 1997 in Boston, Chelsea, and the entire MWRA service area. Economic burdens in the MWRA service area are found to be well above those that typically would be associated with EPA's 2% threshold.

Section 3.6 explores the robustness of the findings presented in Section 3.5. It considers the effect of assumptions throughout the analysis on the ultimate conclusions regarding economic burdens in the MWRA service area and how they have changed since 1997. Section 3.6 also evaluates the implications for those conclusions of directly measuring the costs of all basic necessities, rather than using shelter costs as a proxy for those costs.

Section 4 considers whether the findings described above would be materially different if a measure of the income of lower income households, rather than the median household income, were used to evaluate burdens in the MWRA service area. This section explores the relationship between the income of the median household and that of lower income households in the MWRA service area. This relationship is then compared with the same relationship observed in all metropolitan areas in the United States to evaluate whether particular burdens on median

households in the MWRA service area imply greater burdens on lower income households than would typically occur elsewhere in the United States.

The analyses described above involve limited and straightforward extensions of analyses in EPA's *Guidance*. They evaluate whether economic conditions in the MWRA service area are similar to those typically associated with a preliminary screener value that indicates a "large" economic impact. Section 5 places these analyses in the context of broader analyses of both benefits and costs, without which the true economic impact of additional CSO controls cannot be assessed definitively. Section 6 revisits the conclusions of our analyses.

Four appendices follow Section 6. Appendix A provides a list of the towns and cities that comprise the MWRA sewer service area. Appendices B and C elaborate on methods used to estimate shelter costs and MHI, respectively, which are first discussed in Sections 3.2 and 3.3. Appendix D presents the resulting estimates of shelter cost burdens in the sample of 80 metropolitan areas nationwide, and in the MWRA service area.

1.4. Summary of findings

The analyses presented below validate EPA's 1998 finding that, by 2005, conditions in the MWRA service area will be such that additional CSO controls would cause "substantial and widespread economic and social impact." Indeed, by examining economic burdens on households that include the cost of basic necessities, we find that the MWRA service area already bears economic burdens well above those typically associated with a preliminary screener value that indicates a "large" economic impact. In particular, our analysis focuses on the shelter cost burden, which serves as a proxy for the burden from the cost of all basic necessities.

Economic burdens in Boston and Chelsea are especially severe. In 2003, actual shelter cost burdens in both cities were near the maximum burden that any of the sample of 80 metropolitan areas examined in our analysis *would experience* if their sewer charges rose to the point of meeting EPA's 2% screener threshold. While economic burdens from the cost of shelter

are more severe in Boston and Chelsea, burdens well above those typically associated with EPA's 2% threshold are widespread throughout the MWRA service area. Indeed, the actual shelter cost burden in the MWRA service area as a whole exceeds that which would be associated with EPA's 2% threshold in nearly 95% of the 80 metropolitan areas examined in our analysis.

Economic burdens in Boston, Chelsea, and the entire MWRA service area increased much more since 1997 than they would have if sewer charge burdens had increased to the extent that EPA projected in 1998, and other determinants of economic burdens had remained at levels observed in the mid-1990s. Thus, the economic impact of further CSO controls would not only be substantially greater than would be experienced in the vast majority of metropolitan areas, were they to meet EPA's 2% threshold, it would also be more substantial and widespread than was indicated by EPA's 1998 projection. Also, the unusually high level of economic burden in the MWRA service area will persist well into the future. Considering shelter cost burdens, in particular, our analysis finds that it is highly unlikely that those burdens will return to their 1997 level within the next five years. It is even more unlikely that those burdens will return to lower levels that still would be associated with a finding of a "large" economic impact elsewhere in the United States.

The above findings are based on the use of shelter costs as a proxy for the cost of all necessities. However, sensitivity analyses indicate that an analysis that directly measures the cost of all necessities would reach similar conclusions.

In the Boston metropolitan area, there is an unusually low ratio of the income of lower income households to that of the median household. As a result, a given economic burden, expressed as a share of MHI, implies more severe burdens on lower income households in the MWRA service area than it would imply for similarly situated households in most metropolitan areas nationwide. For example, in the Boston primary metropolitan statistical area (PMSA), EPA's 2% threshold for a "large" economic impact is associated with a higher burden on the 20th percentile household's income than is the case in 86% of all metropolitan areas nationwide. In metropolitan areas nationwide, a 2% burden on the median household's income typically implies

a burden equal to 4.5% of the 20th percentile household's income. In comparison, in the Boston PMSA, a burden equal to 2% of MHI implies a burden of 4.9% on the 20th percentile household. In Suffolk County, which includes Boston and Chelsea, a 2% burden on the median household's income would result in a burden of 6.1% on the 20th percentile household's income. Given the distribution of household income in the MWRA service area, the above findings regarding the unusually high level of economic burdens from the cost of basic necessities in the MWRA service area would be even stronger if those burdens were evaluated in relation to the income of lower income households.

Our analysis verifies EPA's 1998 prediction that additional CSO controls would cause "substantial and widespread economic and social impact" in the MWRA service area. However, developments in economic conditions that underlie this conclusion are somewhat different from those that EPA predicted. Unexpected, unusual, and substantial changes in overall economic burdens from the cost of basic necessities — arising from factors other than increased sewer charges — have led to conditions where the economic impact of additional CSO controls would be even greater than EPA forecasted in 1998. Moreover, economic burdens at the time of EPA's 1998 finding were already well above levels that typically would be associated with a finding of a "large" economic impact, based on EPA's methodology.

2. Importance of broader economic burdens for interpreting the preliminary screener

An array of economic conditions are associated with a given preliminary screener value. Some of these conditions are more important than others in defining the overall economic impact associated with a given screener value.[14] Of these conditions, one that is both important and closely related to the screener is the economic burden associated with the cost of basic necessities, or the basic cost of living. Not only are sewer charges a component of the cost of basic necessities, but the burden associated with a given share of income being devoted to sewer charges depends critically on the share of income that must be devoted to other necessities.

[14] For example, some may argue that the sewer charge burden on the ten percent of households with the highest incomes is a less significant determinant of the overall economic impact associated with a given screener value than the sewer charge burden on the ten percent of households with the lowest incomes.

The greater are the costs of other necessities as a share of MHI, the greater will be the economic burden associated with sewer charges equal to a given percent of MHI. Likewise, the economic burden associated with a particular screener value will be less the lower are the costs of other necessities as a share of MHI. For example, one could expect a household to be indifferent between the first two of the following scenarios, but to prefer either of the first two scenarios to the third: (1) having a sewer bill equal to 2% of MHI and an electric bill equal to 1% of MHI; (2) having a sewer bill equal to 1% of MHI and an electric bill equal to 2% of MHI; and (3) having a sewer bill equal to 0.5% of MHI and an electric bill equal to 3% of MHI. The fact that a household would be indifferent between the first two scenarios implies that the burden on that household associated with two different preliminary screener values (*i.e.*, 2% and 1% of MHI) can be identical, depending on other cost burdens borne by the household. Moreover, the fact that all households would prefer the first two scenarios to the third implies that higher burdens can be associated with lower screener values, again depending on other costs associated with the screener values.

In evaluating the economic impact associated with a particular screener value, another reason to consider the broader costs of basic necessities borne by households is the fact that, for some households, the economic burden of sewer charges is truly indistinguishable from the burden arising from some of these other costs. For example, most renters do not receive sewer bills directly, but instead are charged indirectly through their rent. Consequently, not only would a renter be indifferent between a one hundred dollar increase in annual rent caused by increased sewer bills and the same increase arising from increased property taxes, the renter could not distinguish between the two sources of rent increases.

In light of the above, it is important to consider the results of EPA's preliminary screener in the context of the broader set of closely related, basic costs of living borne by households. EPA has set thresholds of 1% and 2% for the preliminary screener value that it associates with "mid-range" and "large" economic impacts, respectively. The low level of the thresholds suggests that, in setting them, EPA considered the broader economic burdens associated with those values. However, unless the relationship between the costs of other necessities and MHI is the *same* across the entire country and *does not change* over time, the same screener value can

imply *very different* economic impacts in different parts of the country and/or over time in the same location. Given that EPA's preliminary screener and its associated thresholds are meant to be applied nationwide, in evaluating a particular community's screener value, it is reasonable to consider whether the broader burdens associated with that value differ from the broader burdens typically associated with that value nationwide, both at present and historically.

The broader cost burdens (expressed as a percent of MHI) that are associated with a given preliminary screener value have the potential to change over time and to vary across the country in any given year. This is because the costs of basic necessities, relative to MHI, can change over time and vary across the country. Accounting for such variation in overall cost burdens is important for assessing economic hardship. Indeed, the poverty threshold, another measure of economic hardship, is updated annually to reflect changes in the general price level. Moreover, as a National Research Council (NRC) panel tasked with evaluating the poverty threshold in the mid-1990s stated, "(t)here is wide agreement that it is desirable to adjust poverty thresholds for differences in prices."[15]

Modest changes in the cost of other necessities should not alter significantly an interpretation of the preliminary screener value, when it is considered in the context of broader cost burdens. In many communities, the relationship between the cost of basic necessities and MHI may be quite similar to that typically observed nationwide. Also, over time, there may be little change in these burdens. In fact, if costs increase at a slower rate than income, the broader burdens associated with a given screener value may actually decrease over time.

Circumstances in the MWRA service area make it a significant exception, as is demonstrated in Section 3. The overall burdens actually experienced in the MWRA service area have been significantly higher than those that typically would be associated with a screener value indicating a "large" economic impact elsewhere in the United States. In addition, due to developments since EPA's 1998 finding, the overall economic burden associated with a given screener value in the MWRA service area today is much greater than would have been associated with the same value in the MWRA service area at the time of EPA's finding.

[15] Citro and Michael (1995), p. 182.

3. Comparison of broader economic burdens in the MWRA service area with those typically associated with EPA's 2% screener threshold for a "large" economic impact

The cost of basic necessities in the MWRA service area has long been greater than that in most other United States metropolitan areas.[16] For example, the American Chamber of Commerce Researchers Association Cost of Living Index is one of the few indices that, over an extended period of time, have compared the cost of maintaining a particular standard of living in numerous cities throughout the United States.[17] In each year since the index was first developed for Boston in 1991, the cost of living index for Boston has exceeded the average cost of living measured in all surveyed cities by more than 30 percent. It is important to explore how this higher cost of living may affect the economic impact of investments in additional CSO controls.

3.1. Basis for using shelter cost burdens as a proxy for broader economic burdens

To assess rigorously the potential implications of the higher cost of living in the MWRA service area for the economic impact of additional CSO controls, our analysis uses shelter costs as a proxy for the cost of all basic necessities. There are three reasons to do so: the size of shelter costs; their contribution to variation in the cost of all necessities; and the fact that sewer charges and other elements of shelter costs are closely related and, for some households, indistinguishable.

The cost of shelter is one of the largest, if not the largest, components of the total cost of necessities. An NRC panel on poverty estimated that the cost of housing accounts for 44% of the cost of all basic necessities needed to avoid economic deprivation.[18]

The cost of shelter is also the most significant single determinant of variation in the cost of living both across the country and over time. This is because the cost of shelter accounts for

[16] Throughout this report, "metropolitan area" specifically refers to an area designated by the U.S. Office of Management and Budget (OMB) as either a metropolitan statistical area (MSA) or a primary metropolitan statistical area (PMSA), which are referred to collectively as (P)MSAs.

[17] American Chamber of Commerce Researchers Association, *Cost of Living Index*. For each city, this index is calculated by first determining the cost of maintaining a particular "standard of living present in a professional and/or managerial household." A city's index value is then determined by comparing the calculated cost of living in that city with the average cost of living calculated for all surveyed cities in the United States. See http://www.coli.org.

[18] Citro and Michael (1995), p. 197.

such a large share of the cost of all necessities and it varies more than any other category of household expenditure. A 1992 study of Bureau of Labor Statistics (BLS) price data found that variation across the country in the cost of shelter, excluding utilities, was greater than variation in any other component of the Consumer Price Index (CPI).[19] The cost of utilities also varied considerably. In contrast, the same study found that prices of other necessities, such as food and transportation, varied much less throughout the country.

Due to these considerations, an analysis that focuses on variation in the cost of shelter, including utilities, is sufficient to determine if variation in the overall cost of necessities across the country or over time may materially affect the economic impacts associated with a given preliminary screener value. This focus on shelter costs is consistent with the only recommendation that the NRC panel on poverty made regarding the need to account for geographic variation in the cost of necessities when measuring economic hardship. That panel recommended that geographic adjustments to the poverty threshold be based on differences in shelter costs.[20]

A focus on the cost of shelter in this analysis is also appropriate given the close relationship between sewer charges and shelter costs. Sewer charges are one component of the overall cost of shelter. Moreover, for many households, sewer charges are embedded in rental costs, and their contribution to those costs cannot be directly discerned. Consequently, the economic burden on these households arising from sewer charges is truly indistinguishable from economic burdens arising from other determinants of rental costs.

In the analysis presented below, the economic burden from shelter costs is defined as a standardized shelter cost (see Section 3.2) expressed as a percent of MHI. We compare this burden in the MWRA service area with that in other U.S. metropolitan areas. This comparison is made to evaluate whether existing burdens in the MWRA service area exceed those typically associated with a 2% screener value, which would indicate a "large" economic impact.

[19] M. Kokoski, P. Cardiff, and B. Moulton, "Interarea Price Indices for Consumer Goods and Services: An Hedonic Approach Using CPI Data," Preliminary draft, Bureau of Labor Statistics, Washington, D.C., 1992, as cited in Citro and Michael (1995), p. 188. Throughout this report, all references to the CPI refer to that for all urban consumers.
[20] Citro and Michael (1995), p. 183.

To estimate the shelter cost burden in the MWRA service area, relative to what typically would be associated with a preliminary screener value indicative of a "large" impact, one must:

- Estimate shelter costs in both the MWRA service area and in a representative sample of metropolitan areas.
- Estimate MHI in each of those areas.
- Estimate how much higher shelter costs, as a share of MHI, would be in the representative sample of metropolitan areas if sewer charges in those areas increased to the point that preliminary screener values would indicate a "large" impact.

The above steps are addressed in Sections 3.2, 3.3, and 3.4, respectively. Section 3.5 brings together the estimates developed in those sections, and compares actual shelter cost burdens in the MWRA service area with those that would be associated with a preliminary screener value indicating a "large" economic impact in other metropolitan areas.

3.2. Estimation of shelter costs based on HUD Fair Market Rents

To estimate shelter costs in the MWRA service area and in metropolitan areas nationwide, we rely on data from the U.S. Department of Housing and Urban Development (HUD). These data, referred to as Fair Market Rents (FMRs), are calculated annually for more than 300 metropolitan areas and 2,300 non-metropolitan areas throughout the United States.[21] They represent the gross rental cost of the 40th percentile — and for a limited number of areas, the 50th percentile — of all rental housing units with particular, standardized characteristics.[22] These rents reflect the cost of all utilities, including sewer service, with the exception of telephone service.[23]

The FMR data have many desirable attributes for comparing shelter costs across the United States and over time, two of which are discussed briefly below (see Appendix B for a more complete description of FMRs). First, because it tracks the 40th percentile rent, the FMR should be reasonably representative of shelter costs for typical and lower income households. It

[21] Available at http://www.huduser.org/datasets/fmr.html, downloaded February 2, 2004.
[22] Prior to 1995, the FMR was the 45th percentile rent. Since 2001, the FMR has been the median rent in a limited number of areas.
[23] In many cases, utility costs are indirectly reflected in rents analyzed by HUD. When HUD analyzes rents that do not reflect utility costs, HUD adds in those costs to determine the gross rental costs used in calculating FMRs.

should not be as influenced by changes in the cost of shelter for higher income households as would a measure of average shelter costs. Second, in calculating FMRs, HUD only considers two-bedroom units with particular characteristics.[24] Thus, HUD attempts to minimize the extent to which inter-area differences in FMRs reflect differences in housing attributes, such as size or quality. The appropriateness of using FMRs as a measure of shelter costs is also supported by the fact that HUD's approach to calculating FMRs was largely adopted by the NRC panel on poverty in its calculation of inter-area variation in shelter costs in 1990.[25]

As sewer service is more common in metropolitan areas, this analysis focuses on a comparison of economic burdens in the MWRA service area with those in other metropolitan areas.[26] While HUD estimates FMRs for more than 300 metropolitan areas, the method by which it does so suggests that the FMR data for a smaller set of 80 metropolitan areas may form the most reliable basis of comparison for evaluating shelter costs in the MWRA service area.[27] Periodically, HUD updates the FMR for each metropolitan area using detailed data on rents specific to that area, including data from the Census, American Housing Survey, and phone surveys. To develop FMRs for each year between these updates, HUD applies annual adjustments to the prior year's FMR. For 80 metropolitan areas, these adjustments are based on changes in the CPI for shelter and utilities for the corresponding metropolitan area, or for a broader metropolitan area within which it is located.[28] In contrast, the annual adjustments made to the FMRs of the remaining metropolitan areas are based on changes in metropolitan rents that are estimated at a regional level. Moreover, the 80 areas described above disproportionately include the most populous metropolitan areas, whose FMRs are more frequently updated by the American Housing Survey or phone surveys.[29] Therefore, the FMRs for the 80 metropolitan

[24] Public housing units, units less than 2 years old, and units that fail a housing quality test are not included in the distribution of rents from which the 40th percentile is calculated.
[25] Citro and Michael (1995), p. 195.
[26] The 2001 American Housing Survey indicates that 85% of occupied housing units in (P)MSAs had public sewer service, and 86% of all housing units with public sewer service were in (P)MSAs. U.S. Department of Commerce (DOC), Census Bureau, *American Housing Survey for the United States: 2001*, Table 2-4. Available at http://www.census.gov/prod/2002pubs/h150-01.pdf.
[27] The Boston PMSA, of which the MWRA service area is a part, is one of these 80 metropolitan areas.
[28] The BLS maintains CPIs for 27 metropolitan areas, some of which are MSAs and others of which are consolidated metropolitan statistical areas (CMSAs). Within a CMSA, there is more than one PMSA. HUD uses each metropolitan area's CPI to adjust the FMR(s) for the (P)MSAs associated with that CPI.
[29] In 1999, these 80 areas included 14 of the 15 (P)MSAs with more than one million households, and 33 of the 43 (P)MSAs with more than 500,000 households. U.S. DOC, Census Bureau, 2000 Census Summary File 3, Table P14.

areas may be more reliable than those for the remaining areas. In 1999, these 80 metropolitan areas comprised 45% of the U.S. population and 57% of the population in all metropolitan areas.[30] While we focus on these 80 areas in comparing economic burdens in the MWRA service area to those in other metropolitan areas, our findings regarding the relative level of economic burdens in the MWRA service area would be strengthened by including all metropolitan areas in that comparison.[31]

3.2.1. Estimation of shelter costs in Boston, Chelsea, and the MWRA service area

As EPA considered conditions in the cities of Boston and Chelsea in making its 1998 finding, this analysis examines conditions in those cities, relative to conditions in other metropolitan areas. It also examines conditions in the entire MWRA service area. While a HUD FMR is calculated for the Boston PMSA, none is calculated for specific areas within that PMSA, such as Boston, Chelsea, or the MWRA service area. Thus, FMR estimates must be developed for the MWRA service area as a whole, as well as for Boston and Chelsea.

Estimates of these FMRs can be developed based on HUD's Boston PMSA FMR and Census data on rents in the PMSA, the city of Boston, Chelsea, and the MWRA service area as a whole. Census data can be used to estimate relationships between the level and growth rates of rents in the Boston PMSA, and the levels and growth rates of rents in Boston, Chelsea, and the MWRA service area. These relationships can then be used to adjust the HUD FMR for the Boston PMSA to values appropriate for Boston, Chelsea, and the MWRA service area.

As is detailed in Appendix B, we considered three plausible methods of estimating FMRs for each area based on these relationships. For the MWRA service area as a whole, we also considered a fourth method, simply assuming that the service area's FMR is identical to that for the PMSA as a whole. This assumption is reasonable because the MWRA service area accounted for 76% of all two-bedroom, renter-occupied housing units (*i.e.*, the units considered in calculating the FMR) in the Boston PMSA in 1999.[32] Given Chelsea and Boston's smaller

[30] U.S. DOC, Census Bureau, 2000 Census Summary File 3, Table P1.
[31] See Section 3.4.
[32] Boston and Chelsea respectively accounted for 26% and 1.5% of all two-bedroom, renter-occupied units in the Boston PMSA. U.S. DOC, Census Bureau, 2000 Census Summary File 3, Table H67.

populations, this assumption is unreasonable for those cities. Thus, for each year, we considered three plausible estimates of the FMR for Boston, three plausible estimates of the FMR for Chelsea, and four plausible estimates of the FMR for the MWRA service area as a whole.

For the MWRA service area as a whole, we adopt only one of the four plausible FMR estimates: that which equals the Boston PMSA FMR. This decision is based on the MWRA service area's share of rental units in the PMSA and the fact that, of the four plausible estimates evaluated, this choice would lead to the lowest estimate of shelter cost burdens in the MWRA service area as a whole. As there is less basis *ex ante* to favor a particular estimation method for Boston and Chelsea, throughout the remainder of this analysis, we adopt the range of the three plausible FMR estimates for each city, rather than adopting a single point estimate.

Figure 1 presents the 1997 and 2003 cumulative distribution of annual FMRs in the 80 metropolitan areas that we use as a basis for evaluating economic burdens in the MWRA service area. For a given point on each line, the y-axis value indicates the share of all 80 metropolitan areas whose FMR, in annual terms, was no greater than the cost that is indicated by the corresponding value on the x-axis. For example, the estimated 1997 MWRA FMR of $10,068 was higher than FMRs in 86% of the 80 metropolitan areas examined.[33] By 2003, the estimated MWRA FMR had risen to a level that was higher than FMRs in 95% of those 80 metropolitan areas.[34] Indeed, as is shown in Figure 2, the growth rate of shelter costs in the MWRA service area between 1997 and 2003 was also higher than that in 95% of the 80 metropolitan areas.

3.3. Estimation of median household income

While shelter costs in the MWRA service area are among the highest in the United States, the relationship between those costs and household incomes must be considered to evaluate the economic burden associated with them. Indeed, incomes tend to be higher in areas with higher

[33] When all 331 (P)MSAs in the United States are considered, the estimated 1997 MWRA service area FMR is higher than FMRs in 96% of those metropolitan areas. The averages of the 1997 FMR estimates for Boston and Chelsea are, respectively, higher than FMRs in 93% and 86% of those metropolitan areas.

[34] When all 331 (P)MSAs in the United States are considered, the estimated 2003 MWRA service area FMR is higher than FMRs in 99% of those metropolitan areas. The averages of the 2003 FMR estimates for Boston and Chelsea are, respectively, higher than FMRs in 98% and 94% of those metropolitan areas.

shelter costs, reducing the economic burdens imposed by higher costs. Consistent with EPA's preliminary screener, we use MHI to measure income in each metropolitan area. In Section 4, we explore the implications of evaluating economic burdens based on relationships between costs and incomes of lower income households, rather than MHI.

The Census Bureau only reports MHI for metropolitan areas and cities in Census years, including 1999. Therefore, MHI estimates must be developed for non-Census years. Moreover, even in 1999, an MHI estimate for the MWRA service area as a whole must be developed based on the MHIs of underlying towns, cities, and counties. We evaluated several plausible methods for estimating MHI in non-Census years and estimating the MWRA service area MHI in all years. The methods ultimately chosen to estimate MHI were found to be the most desirable based on their precision and accuracy. Appendix C provides a complete description of the methods evaluated and the basis for our adoption of specific methods for estimating MHI.

For each metropolitan area and city, 1999 Census MHI data are used as a "base year" for estimating MHI in other years.[35] To scale these 1999 values to other years, two different methods are used because limitations in available data prevent the use of the first method for years after 2000. For the years up to 2000, MHI is estimated by adjusting the 1999 MHI based on Census Bureau MHI estimates for the associated county(ies), which are available for 1995 and 1997 through 2000.[36] After 2000, it is assumed that MHI grew from its 2000 level at an annual rate equal to core price inflation in the local area.[37] EPA's 1998 analysis uses a method similar to this second method, except it bases its estimates on overall, rather than core, inflation.

[35] The 1999 MWRA service area MHI estimate is essentially a household-weighted average of the MHIs of cities and towns in the service area. See Appendix C for a description of how this estimate is developed.

[36] U.S. DOC, Census Bureau, *Small Area Income and Poverty Estimates (SAIPE)*. Available at http://www.census.gov/hhes/www/saipe.html, downloaded February 6, 2004.

[37] Core inflation is inflation in the price of all items except food and energy, as measured by the CPI. The CPI applied to each metropolitan area is that estimated by the BLS either for the area itself (for MSAs), or for the CMSA within which the area is located (for PMSAs).

3.4. Estimation of the distribution of shelter cost burdens associated with EPA's 2% screener threshold nationwide

Having estimated shelter costs and MHI in 80 metropolitan areas nationwide, we express shelter costs in each area as a percent of that area's MHI. This serves as a proxy for the typical share of household income that must be devoted to shelter and is therefore unavailable for other use, including additional investments in CSO controls.[38] Appendix D presents estimates of shelter cost burdens in 1997 and 2003 for the 80 metropolitan areas and the MWRA service area.

Shelter costs include the cost of utilities, such as sewer service. It is unlikely that any of these 80 metropolitan areas have sewer charges that meet the 2% preliminary screener threshold for a "large" economic impact.[39] Therefore, the economic burdens expressed by the ratios of shelter costs to MHI are not indicative of those that would be associated with a preliminary screener value of at least 2%.

To estimate the shelter cost burden that would be present in each metropolitan area if each area met the 2% preliminary screener threshold, we make two conservative assumptions.[40] First, we assume that any increase in sewer charges would be completely passed through as an increase in shelter costs. Second, as we do not have data on actual sewer charges in all 80 metropolitan areas, we assume that average charges per household in each area, expressed as a percent of MHI, equal only the 10th percentile of the ratios of sewer charges to MHI reported in 1998 and 2002 surveys of sewer charges in over 120 cities.[41] This 10th percentile is 0.34% of MHI. Therefore, we assume that, when expressed as a percent of MHI, sewer charges — and hence shelter costs — would be 1.66 percentage points (*i.e.*, 2% - 0.34%) higher in each of the

[38] Because the FMR represents the 40th percentile rent and is being compared with median household income, this proxy may understate the actual share of household income that the typical household must devote to shelter costs. Data on median rent of the same quality as the HUD FMRs are unavailable.

[39] While data on sewer charges for all 80 metropolitan areas are unavailable, surveys of sewer charges in over 120 cities conducted by Raftelis Financial Consulting in 1998 and 2002 found no cities in which sewer charges exceeded 2% of MHI. See http://www.raftelis.com/survey.htm.

[40] The assumptions are conservative in that they lead to higher estimated shelter cost burdens being associated with the 2% screener threshold than would other plausible assumptions. Therefore, for a given community to show that its actual burdens are equal to those typically associated with meeting the 2% threshold, the burdens that the community must demonstrate would be higher than if alternative, plausible assumptions were made about the distribution of shelter cost burdens associated with the 2% threshold.

[41] Raftelis Financial Consulting conducted these surveys. See http://www.raftelis.com/survey.htm. The 10th percentile is chosen as a highly conservative assumption about existing sewer charges that is not affected by extreme outliers.

80 metropolitan areas if each area met the 2% preliminary screener threshold for a finding of a "large" economic impact.

Adjusting upward by 1.66 percentage points the ratio of shelter costs to MHI for each metropolitan area yields a distribution of shelter cost burdens in 80 metropolitan areas that would be associated with meeting the 2% preliminary screener threshold. This distribution of shelter cost burdens from 1995 to 2003 is presented in Figure 3. In Figure 3, the five lines represent particular percentiles of the distribution of shelter cost burdens. For example, in 1997, 50% of the 80 metropolitan areas would have had shelter costs at or below 18.4% of MHI if sewer charges increased to the point of meeting EPA's 2% preliminary screener threshold.

Figure 3 depicts the distribution of shelter cost burdens associated with the 2% threshold in 80 metropolitan areas nationwide. Because the remaining metropolitan areas do not have CPIs, our method of estimating MHI after 2000 cannot be used for those areas. Yet, for the years prior to 2001, we can examine differences in the distribution of burdens associated with the 2% threshold in the 80 areas and that in all 331 metropolitan areas to determine if the distribution of burdens in the 80 areas is representative of that in all metropolitan areas. Figure 4 shows that the distribution of burdens in the 80 areas likely overstates that in all metropolitan areas in the United States, particularly with respect to the upper end of the distribution. Therefore, a comparison of the actual shelter cost burden in the MWRA service area with the distribution of burdens in the 80 metropolitan areas will understate the relative level of burden in the MWRA service area, compared with that in all metropolitan areas nationwide.

3.5. Comparison of burdens in the MWRA service area with the nationwide distribution of burdens associated with EPA's 2% screener threshold

The distribution developed in Section 3.4 allows a basis of comparison for evaluating how *actual economic burdens* in the MWRA service area relate to those burdens that *would be present in metropolitan areas nationwide if sewer charges increased to a level consistent with a preliminary screener value of 2%*, EPA's threshold for a "large" impact. This comparison will reveal whether the MWRA service area already experiences a greater economic burden than would be experienced in most metropolitan areas if they met the 2% threshold. As EPA's 1998

examination of conditions in the MWRA service area focused on conditions in Boston and Chelsea, the economic burdens in those two communities are addressed first, followed by consideration of the burdens in the entire MWRA service area.

3.5.1. Economic burdens in Boston

Figure 5 presents the shelter cost burden in Boston since 1995, along with the distribution of shelter cost burdens that would be associated with meeting EPA's 2% threshold in the 80 metropolitan areas examined.[42] As was noted in Section 3.2.1, a range of estimates of the shelter cost burden in Boston is presented, corresponding to three plausible assumptions regarding the relationship between the FMR for the city of Boston and that for the Boston PMSA. In 1997, the shelter cost burden in Boston was 25% of MHI. In that year, this burden was significantly higher than the burden that would have been associated with meeting EPA's 2% threshold in more than 90% of the 80 metropolitan areas examined. The shelter cost burden in Boston grew by 7 to 9 percentage points from 1997 to 2003. By 2003, the shelter cost burden in Boston was between 32% and 34% of MHI, a range that included the maximum burden that would have been borne by any of the 80 metropolitan areas, were they to meet EPA's 2% threshold.[43] The maximum burden among the 80 metropolitan areas was 33% of MHI.

3.5.2. Economic burdens in Chelsea

Figure 6 presents the shelter cost burden in Chelsea since 1995, along with the distribution of shelter cost burdens that would be associated with meeting EPA's 2% threshold in the 80 metropolitan areas examined. As was noted in Section 3.2.1, a range of estimates of the shelter cost burdens in Chelsea are presented, corresponding to three plausible assumptions

[42] The 1997 and 2002 Boston PMSA FMRs were based on actual surveys, rather than the application of a CPI-based adjustment to a prior year's FMR. Between those years, rents were adjusted based on growth in the Boston CPI. Because growth in shelter costs was so significant over this period, there may be downward bias in the estimated values between 1997 and 2002. Consequently, for the MWRA service area, Boston, and Chelsea, we do not present estimates of shelter cost burdens in the years between 1997 and 2002. Data necessary to estimate 1996 MHI is unavailable. Therefore, estimates of 1996 shelter cost burdens are also omitted. Communication with Lynn Rodgers, U.S. Department of Housing and Urban Development, February 11, 2004.

[43] Boston's shelter costs are also remarkable when compared with individual cities, rather than entire metropolitan areas. The 2000 Census offers the most recent data on shelter costs in individual cities and can be used to calculate the 40th percentile Census-reported gross rents for all cities nationwide. As Appendix B describes, these 40th percentile rents are similar, but not identical to FMRs. In 1999, Boston had a higher actual shelter cost burden (expressed as a percent of MHI) than would have been associated with the 2% threshold in 84% of the other 61 cities with more than 100,000 households. This comparison likely does not reflect the full increase in shelter costs that occurred from 1997 to 2003. U.S. DOC, Census Bureau, 2000 Census Summary File 3, Tables P14 and P53.

regarding the relationship between the FMR for Chelsea and that for the Boston PMSA. In 1997, the shelter cost burden in Chelsea was between 28% and 29% of MHI, significantly higher than that in Boston. By 2003, the estimated shelter cost burden in Chelsea had grown by between 2 and 8 percentage points to between 31% and 36% of MHI.[44] In both 1997 and 2003, the range of estimated shelter cost burdens in Chelsea included the maximum burden that would have been borne by any of the 80 metropolitan areas examined, were they to meet EPA's 2% threshold. That maximum burden was 28% of MHI in 1997 and 33% of MHI in 2003.

3.5.3. Economic burdens in the entire MWRA service area

While the above results clearly indicate that economic burdens in Boston and Chelsea are well above those that typically would be associated with a preliminary screener finding of a "large" economic impact, this is also the case for the MWRA service area as a whole. As Figure 7 shows, the shelter cost burden in the MWRA service area as a whole was more than 20% of MHI in 1997, higher than the burden that would have been associated with a 2% screener value in more than 70% of the 80 metropolitan areas in that year. By 2003, the shelter cost burden in the MWRA service area had grown by 5 percentage points to more than 25% of MHI. This was higher than the shelter cost burden that would have been associated with a 2% screener value in nearly 95% of the 80 metropolitan areas in 2003.

In our analysis, we assume that shelter costs in the MWRA service area are equal to those in the Boston PMSA. Yet, as Appendix B describes, this assumption may underestimate actual shelter costs in the MWRA service area, and growth therein. Therefore, the shelter cost burden in the MWRA service area in 2003 is likely greater than that presented in Figure 7.

3.5.4. Comparison of 2003 MWRA service area burdens with EPA's 1998 projections

In its 1998 finding, EPA projected that increases in sewer charges would cause preliminary screener values in 2005 to be consistent with a "large" economic impact in Chelsea, and a "mid-range" economic impact in Boston and the MWRA service area as a whole. The

[44] Census data indicates that, in 1999, Chelsea's shelter cost burden was greater than would have been associated with the 2% threshold in more than 95% of the other 1,134 cities that had at least as many households as Chelsea. This comparison likely does not reflect the full increase in shelter costs that occurred from 1997 to 2003. U.S. DOC, Census Bureau, 2000 Census Summary File 3, Tables P14 and P53.

above analysis demonstrates that, while sewer charges in the MWRA service area may not yet exceed the 2% threshold for a "large" economic impact, broader economic burdens in Boston, Chelsea, and the entire MWRA service area are well above those that would be present in the vast majority of other metropolitan areas, were they to meet EPA's 2% threshold. Therefore, additional CSO controls would result in a "large" economic impact throughout the MWRA service area.

While economic burdens are more severe in Boston and Chelsea, burdens well above those typically associated with EPA's 2% threshold are widespread throughout the entire MWRA service area. Moreover, since 1997, burdens in Boston, Chelsea, and the entire MWRA service area have increased far more than they would have if the sewer charge burden had increased to the extent that EPA projected in 1998 and other determinants of economic burdens had remained at levels observed in the mid-1990s.

In 1997, shelter cost burdens, excluding the cost of sewer service, were 24.0% of MHI, 26.9% of MHI, and 19.7% of MHI in Boston, Chelsea, and the MWRA service area, respectively. In its 1998 finding, EPA projected that, by fiscal year 2005, sewer charges would increase to 1.7% of MHI in Boston, 2.3% of MHI in Chelsea, and 1.3% of MHI in the MWRA service area as a whole.[45] If other components of total shelter cost burdens remained at their 1997 levels, as a percent of MHI, this projection would imply that, by 2005, total shelter cost burdens would rise to 25.7% of MHI in Boston, 29.2% of MHI in Chelsea, and 21.0% of MHI in the MWRA service area as a whole. As is described above, by 2003, actual shelter cost burdens in all three communities had far exceeded these levels. In Boston, the burden was between 32% and 34% of MHI. In Chelsea, the burden was between 31% and 36% of MHI. In the MWRA service area as a whole, the burden was more than 25% of MHI. Thus, this analysis suggests that the economic impact of further CSO controls in the MWRA service area would not only be substantially greater than that which would be experienced in most metropolitan areas, were they to meet EPA's 2% threshold, it would also be more substantial and widespread than was indicated by EPA's 1998 projection.

[45] Letter from John DeVillars (1998).

The above analysis verifies EPA's 1998 prediction that additional CSO controls would cause "substantial and widespread economic and social impact" in the MWRA service area, although the changes in economic conditions that underlie this conclusion are somewhat different from those that EPA predicted. Unexpected, unusual, and substantial changes in economic burdens from the cost of basic necessities — arising from factors other than increased sewer charges — have led to conditions where the economic impact of additional CSO controls would be even greater than EPA forecasted in 1998. Moreover, economic burdens in 1997 were already well above levels that typically would be associated with a finding of a "large" economic impact, based on EPA's methodology.

3.5.5. Persistence of economic burdens

Consideration of possible future changes in shelter cost burdens, which are a predominant component of economic burdens from the cost of basic necessities, indicates that the unusually high level of economic burden in the MWRA service area will persist well into the future. Sensitivity analyses reveal that it is highly unlikely that the shelter cost burden in the MWRA service area will return to the level observed in 1997 within the next five years. Moreover, before the increase in shelter costs that occurred after 1997, the MWRA service area already had a shelter cost burden well above the typical burden nationwide, as was described in Section 3.5.3. Thus, even if the shelter cost burden returns to the level observed in 1997 within a reasonable period of time, that level would still be higher than the burden typically associated with EPA's 2% preliminary screener threshold.

The rates of future growth in shelter costs and MHI are uncertain. Therefore, the implications of various assumptions regarding future growth in MHI and shelter costs for economic burdens in the MWRA service area are explored. Tables 1 and 2, respectively, present the pairs of growth rates in shelter costs and MHI that would be necessary to lead to two possible outcomes within five years (by 2009) for Boston, Chelsea, and the entire MWRA service area: (1) shelter cost burdens returning to the levels present in each community in 1997; and (2) shelter cost burdens returning to the median shelter cost burden that would be associated with EPA's 2%

screener threshold nationwide.[46] Because FMR data is available up to 2004, possible annual FMR growth rates presented in the tables relate to annual growth from 2004 to 2009.[47] On the other hand, in light of uncertainty regarding the level of MHI after the 1999 Census, possible annual MHI growth rates presented in the tables relate to annual growth from 1999 to 2009.

To put the range of possible MHI growth rates in Tables 1 and 2 into context, Census data indicate that the city of Boston experienced 3.1% annual average growth[48] in MHI from 1989 to 1999, while the Chelsea MHI grew at an annual average rate of 1.8%.[49] Our estimates indicate that the MHI of the MWRA service area as a whole grew at an annual average rate of 3.3% during this period. Therefore, future increases in MHI will almost certainly be insufficient to return Boston, Chelsea, and the MWRA service area as a whole to the shelter cost burden that was present in 1997 without shelter costs declining at a significant rate. For example, if the MWRA service area MHI grows at an annual average rate of 3% over this decade, shelter costs would have to *fall* faster than an average rate of 3.2% *each year* from 2004 to 2009 for the shelter cost burden in the service area as a whole to return to its 1997 level by 2009. Shelter costs would have to decline at an even faster rate to return Boston, Chelsea, and the MWRA service area as a whole to the shelter cost burden that typically would be associated with a screener value of 2%. Thus, our analysis indicates that the unusual economic burdens in the MWRA service area will likely persist for years to come.

[46] This median burden is no less than that which would be present in 50% of the 80 metropolitan areas if their sewer charges increased to the 2% threshold associated with a "large" economic impact. Thus, even if the burden in the MWRA service area declined to this level, that burden would still be consistent with a "large" economic impact.
[47] For Boston and Chelsea, the 2004 FMR is set equal to the average of the plausible estimates of those FMRs, as described in Section 3.2.1.
[48] Throughout this report, the term "annual average growth" refers to the compound annual growth rate (CAGR) associated with growth during a given period.
[49] U.S. DOC, Census Bureau, 2000 Census Summary File 3, Table P53, and 1990 Census Summary Tape File 3, Table P080A.

Table 1. Maximum annual average growth in FMR from 2004 to 2009 to return to the 1997 shelter cost burden by 2009, given particular growth in MHI

Assumed Annual Average Growth in MHI from 1999 to 2009*	Annual Average Growth in FMR from 2004 to 2009, Given Particular Growth in MHI		
	Boston	Chelsea	MWRA Service Area
0.0%	-9.7%	-7.5%	-8.8%
0.5%	-8.8%	-6.5%	-7.9%
1.0%	-7.8%	-5.6%	-6.9%
1.5%	-6.9%	-4.7%	-6.0%
2.0%	-6.0%	-3.7%	-5.1%
2.5%	-5.1%	-2.8%	-4.2%
3.0%	-4.2%	-1.8%	-3.2%
3.5%	-3.2%	-0.9%	-2.3%
4.0%	-2.3%	0.1%	-1.3%
4.5%	-1.3%	1.0%	-0.4%
5.0%	-0.4%	2.0%	0.6%

*From 1989 to 1999, annual average growth in the MHI of Boston, Chelsea, and the MWRA service area as a whole was 3.1%, 1.8%, and 3.3% (estimate) respectively.

Table 2. Maximum annual average growth in FMR from 2004 to 2009 to return by 2009 to the typical* shelter cost burden associated with the 2% screener threshold nationwide, given particular growth in MHI

Assumed Annual Average Growth in MHI from 1999 to 2009**	Annual Average Growth in FMR from 2004 to 2009, Given Particular Growth in MHI		
	Boston	Chelsea	MWRA Service Area
0.0%	-15.0%	-15.1%	-10.6%
0.5%	-14.1%	-14.3%	-9.7%
1.0%	-13.2%	-13.4%	-8.8%
1.5%	-12.4%	-12.6%	-7.9%
2.0%	-11.5%	-11.7%	-7.0%
2.5%	-10.7%	-10.8%	-6.1%
3.0%	-9.8%	-10.0%	-5.2%
3.5%	-8.9%	-9.1%	-4.2%
4.0%	-8.0%	-8.2%	-3.3%
4.5%	-7.1%	-7.3%	-2.4%
5.0%	-6.2%	-6.4%	-1.5%

*Defined as the average of median shelter cost burdens associated with the 2% screener threshold from 1997 to 2003, as presented in Figure 3.

**From 1989 to 1999, annual average growth in the MHI of Boston, Chelsea, and the MWRA service area as a whole was 3.1%, 1.8%, and 3.3% (estimate) respectively.

3.6. Evaluation of the robustness of findings

The conservative nature of assumptions underlying the analysis presented in Section 3.5, and assessments of the sensitivity of its results support the conclusion that those results are

robust. In fact, the analysis may understate the economic impact of additional CSO controls in the MWRA service area. Below, we assess the implications of various assumptions that were made in estimating the relative shelter cost burdens in the service area. We also consider the implications of directly measuring the costs of additional necessities other than shelter.

3.6.1. Cascading effect of conservative assumptions

For many inputs to our analysis of shelter cost burdens in the MWRA service area, we considered a number of plausible assumptions. Except in cases where there was a compelling empirical or theoretical basis to support a particular choice among the alternatives, or where it was tractable to present the implications for our analysis of a range of plausible assumptions, we adopted those assumptions that would *minimize* the likelihood of finding a *high* shelter cost burden in the MWRA service area. For example, in the case of estimating MHI for the MWRA service area after 2000, we assumed that MHI grew at the rate of core inflation for the area, or an annual average rate of 3.6%.[50] We adopted this assumption, which was largely consistent with the method that EPA used in 1998, even though data on growth in both Massachusetts per-capita income and income tax collections since 2000 would support assumptions of much lower growth.[51] In addition, our estimate of the nationwide distribution of shelter cost burdens associated with EPA's 2% screener threshold is almost certainly overstated, due to underlying assumptions regarding existing nationwide sewer charges and the extent to which changes in sewer charges affect shelter cost burdens. Consequently, actual shelter cost burdens in the MWRA service area, as compared with those typically associated with EPA's 2% screener threshold, are likely even more exceptional than is indicated in our analysis.

The adoption of highly conservative assumptions for numerous inputs to our analysis has a multiplicative effect. This multiplicative effect, often referred to as "cascading conservatism,"

[50] U.S. Department of Labor (DOL), BLS, CPI for all items less food and energy, Boston-Brockton-Nashua, MA-NH-ME-CT area (Boston), Series ID CUURA103SA0L1E. Available at http://www.bls.gov/cpi/home.htm, downloaded February 24, 2004.

[51] After growing at an annual average rate of 7.4% from 1997 to 2000, Massachusetts per-capita income growth slowed to an annual average rate of 1.8% from 2000 to 2003. After growing at an annual average rate of 8.0% from 1997 to 2000, Massachusetts income tax receipts *declined* at an annual average rate of 3.9% from 2000 to 2003. U.S. DOC, Bureau of Economic Analysis, Regional Economic Accounts, State and Local Personal Income Data. Available at http://www.bea.gov/bea/regional/statelocal.htm, downloaded July 26, 2004. Commonwealth of Massachusetts, Department of Revenue, Monthly Report of Tax Collections. Available at http://www.massdor.com/stats/RevRpt/index.htm.

will lead to a high likelihood that our analysis has significantly understated the shelter cost burden in the MWRA service area, in both absolute and relative terms. In the context of findings that the MWRA service area is experiencing economic burdens greater than those typically associated with a finding of a "large" economic impact, this conservatism makes those findings even more compelling.

3.6.2. Robustness of findings to direct measurement of the costs of all necessities

The analysis in Section 3.5 reveals two exceptional characteristics of shelter cost burdens in the MWRA service area, and in Boston and Chelsea in particular. First, shelter cost burdens in the MWRA service area were among the highest in the nation in both 1997 and 2003. Second, between 1997 and 2003, those burdens increased significantly.

Our use of shelter costs as a proxy for overall economic burdens arising from the cost of basic necessities is appropriate, given the reasons offered in Section 3.1. However, we considered whether our findings would be affected significantly by directly measuring the costs of other necessities, such as food and clothing, in evaluating economic burdens. These costs vary less among metropolitan areas and — at least in the MWRA service area — did not increase from 1997 to 2003 at the same rate as did shelter costs.[52] Therefore, in theory, it might be possible that overall economic burdens in the MWRA service area are not as exceptional as are shelter cost burdens, and that they did not increase significantly from 1997 to 2003. But, sensitivity analyses make clear that our findings would not be significantly affected if the cost of necessities other than shelter were directly incorporated in a measure of economic burdens. These analyses reveal that the cost of non-shelter necessities would have to be unreasonably large to sufficiently offset the effect of shelter costs on both the difference between economic burdens in the MWRA service area and those elsewhere in the United States, and the increase in burdens in the MWRA service area since 1997.[53]

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[52] The Boston CPI for all items less shelter grew at an annual average rate of 2.4% during this period, well below the concurrent 8.2% annual average growth in the Boston PMSA Fair Market Rent.

[53] For example, the cost of non-shelter necessities would have to be the same nationwide and exceed *average* annual household expenditures on *all* non-housing items — not just necessities — for the overall economic burden from the cost of basic necessities in the MWRA service area to fall to the median burden associated with EPA's 2% threshold nationwide. Thus, direct measurement of the cost of all necessities would not alter the findings in Section 3.5. U.S. DOL, BLS, *Consumer Expenditures in 2002*, February 2004, p. 3, Table A. Available at http://www.bls.gov/cex/csxann02.pdf.

4. Effect on findings of replacing median household income with a lower income measure

In evaluating the economic burdens presented by the costs of necessities, there are a number of options for measuring the resources to which those costs can be compared. EPA's preliminary screener uses a community's MHI to measure resources. Alternatively, EPA could use the income of a household at a lower percentile of the income distribution. This would measure more directly economic burdens on the most disadvantaged households, which may experience the greatest economic impacts within a community. In the context of its affordability criteria for small drinking water systems, in which EPA uses MHI to evaluate economic burdens of water bills, EPA asked the Environmental Economics Advisory Committee (EEAC) of its Science Advisory Board whether alternative measures of income should be used. In response, the EEAC recommended that EPA consider evaluating the burdens of water bills on income levels below the median.[54]

Consideration of the implications of relating costs to incomes of lower income households, rather than to MHI, can be important for all types of cost burdens, such as the shelter cost burdens described above. Yet, the general implications of the choice of an income measure can be demonstrated in the context of burdens specifically measured by the preliminary screener.

In the context of EPA's preliminary screener threshold, if sewer charges are 2% of MHI, this implies a higher burden on lower income households that is associated with the same level of overall community burden, as measured by the screener. The median ratio of MHI to income of the 20th percentile household in metropolitan areas nationwide indicates that a 2% screener value typically would be associated with a 4.5% burden on a community's 20th percentile household.[55]

In relating costs to MHI, the screener may fail to differentiate varying economic burdens among communities if the communities have the same MHI, but significant differences in the incomes of lower income households. For example, if all households in the lowest income quintile of one community have incomes less than 50% of that community's MHI, a 2% screener

[54] U.S. EPA Science Advisory Board, Environmental Economics Advisory Committee, *Affordability Criteria for Small Drinking Water Systems: An EPA Science Advisory Board Report*, December 2002 (EPA-SAB-EEAC-03-004), p. 11. Available at http://www.epa.gov/sab/pdf/eeac03004.pdf.

[55] Based on 2000 Census data on income distributions in the 331 (P)MSAs nationwide, provided by the Census Bureau upon request. Email communication with Kirk Davis, U.S. DOC, Census Bureau, March 4, 2004.

value would imply that average sewer charges would be at least 4% of the incomes of 20% of that community's households. In contrast, if all households in the lowest income quintile of a second community have incomes less than 40% of that second community's MHI, then the same 2% screener value would imply that average sewer charges would be at least 5% of the incomes of 20% of that second community's households. Despite both communities having the same screener value, before any potential subsidization of rates, a greater share of households in the second community would face sewer charges of at least 4% of their incomes than would be the case in the first community.

The above example demonstrates that the same preliminary screener value can be associated with a wide range of economic burdens on lower income households in a community. To the extent that communities subsidize lower income households to make sewer services more affordable, the same preliminary screener value may be assigned to a group of communities in which the need for subsidization varies significantly. Nonetheless, in many communities, relationships between MHI and incomes of lower income households may be similar enough that comparison of sewer charges with a lower percentile of household incomes would add little additional information regarding economic impacts, relative to that provided by the preliminary screener. The situation in the MWRA service area, however, is such that the relative burdens on lower income households are higher than in other communities nationwide.

The lowest quintile of household incomes falls further below the median in the MWRA service area than it does in most metropolitan areas nationwide. Consequently, burdens like those described in Section 3, expressed as a share of MHI, imply unusually large burdens on lower income households in the MWRA service area relative to what typically would be the case nationwide. While precise data on the income distribution in the MWRA service area are unavailable, that distribution can be inferred from data on income distributions in the Boston PMSA and counties served by the MWRA.[56] According to the 2000 Census, a 2% screener value in the Boston PMSA would be associated with a 4.9% burden when average sewer bills are compared to the income of the 20th percentile household. In other words, the average sewer bill

[56] 2000 Census data indicates that, in 1999, the MWRA service area accounted for nearly two-thirds of all households in the Boston PMSA. U.S. DOC, Census Bureau, 2000 Census Summary File 3, Table P14.

would be no less than 4.9% of the incomes of 20% of Boston PMSA households. This burden exceeds that on the 20th percentile household associated with the same screener value in 86% percent of all 331 metropolitan areas nationwide. It is 0.44 percentage points (or 10%) above the 4.5% median burden on 20th percentile households that is associated with EPA's 2% threshold in those metropolitan areas. Therefore, the screener threshold for a "large" economic impact in the Boston PMSA would have to be reduced to 1.8% of MHI to make the associated burden on the 20th percentile household the same as the burden on such households that typically would be associated with a 2% screener value in metropolitan areas nationwide.

The income distribution in Suffolk County, which contains Boston and Chelsea, indicates that the burden on the 20th percentile household associated with a 2% preliminary screener threshold is likely even more severe in the MWRA service area than in the Boston PMSA as a whole. In particular, a sewer bill equal to 2% of the MHI in Suffolk County would impose a 6.1% burden on the income of that county's 20th percentile household. Thus, the screener threshold for a "large" economic impact in Suffolk County would have to be reduced to 1.5% of MHI for the associated burden on the 20th percentile household to be the same as the burden on such households that typically would be associated with a 2% screener value in metropolitan areas nationwide.

The above analysis implies that overall economic burdens in Boston, Chelsea, and the entire MWRA service area are even greater than indicated in Section 3.5. That section evaluated economic burdens by comparing the costs of basic necessities to MHI. Associated burdens on lower income households in the MWRA service area are greater than would be expected in most other metropolitan areas nationwide, given similar burdens on their median households.

5. Role of benefit-cost analysis in definitively assessing economic impact

In evaluating the economic impact of additional CSO controls in the MWRA service area, we have conducted analyses involving straightforward and limited extensions of those recommended in EPA's *Guidance*. These analyses show that economic burdens in the MWRA service area are well above those that typically would lead to a finding of "substantial and

widespread economic and social impact," based on the framework set forth in EPA's *Guidance*. However, a definitive assessment of the economic impact of additional CSO controls requires evaluation of both their costs *and benefits.* Indeed, correctly implementing elements of analyses recommended in the *Guidance* requires a broader role for benefits analysis than the *Guidance* itself acknowledges.

Whether additional CSO controls have positive or negative economic impacts, and the magnitude of those impacts, depends on whether and to what extent the controls' benefits outweigh benefits from other uses of the resources foregone to pay higher sewer bills. The impact of increased sewer bills on a community will depend as much (or more) on what they get in return as on what they are already paying for sewer services, which is a primary determinant of the preliminary screener value. It is therefore ultimately not possible to separate questions regarding the economic impact of additional controls from questions regarding the benefits of those controls. If we ignore benefits, and focus exclusively on costs, we risk designing "fast trains to the wrong station."

Given the framework set forth in EPA's *Guidance* to evaluate economic impact, failure to consider *both* benefits and costs of CSO controls can lead to two types of undesirable results. First, communities may not implement investments that can make them better off, despite their high cost. Second, communities may make significant investments that yield little water quality improvement and — due to their cost — limit opportunities for future investments that could yield substantially greater social improvements, including other investments in water quality.

This second undesirable result suggests that benefits analysis is necessary even to implement appropriately EPA's existing framework for evaluating economic impacts. The idea that there is some limit to the share of households' resources that reasonably should be devoted to water quality improvements is implicit in EPA's preliminary screener threshold. As a result, an investment in additional CSO controls may require a community to forego other investments in water quality improvements. For example, in the MWRA service area, investments in additional CSO controls may reduce the level of resources available for future water quality improvements at the municipal level and for certain investments in the MWRA's existing

infrastructure. Thus, an appropriate accounting of the cost of proposed CSO controls should include not only the consumption and investments that households must forego to fund the controls today, but also the benefits of other investments in water quality improvements that may be foregone as well. Without measuring the benefits of these other opportunities to improve water quality, the full cost of the proposed controls cannot be known. Moreover, without measuring the benefits of the additional controls being proposed, one cannot know if the environmental improvements associated with them are greater than would result from other investments that those controls may foreclose. Particularly for communities like those in the MWRA service area that have already made substantial investments in water quality improvements, given the remaining finite resources available for such investments, consideration of the relative benefits of additional pollution control efforts is essential to ensuring the attainment of the highest possible water quality.

6. Conclusion

In 1998, EPA found that investments in additional CSO controls in the MWRA service area would cause "substantial and widespread economic and social impact." This finding relied, in part, on a forecast of particular economic conditions expected to be present in 2005. The forecast focused on economic burdens specifically attributable to sewer costs, expressed as the ratio of the average household sewer charge to median household income — a measurement that is referred to as the preliminary screener value. Since 1998, favorable developments in median household incomes and sewer charges in MWRA communities have raised the question of whether economic and social impacts of additional controls would be as substantial and widespread as EPA projected in 1998.

Additional analyses involving limited extensions to those originally employed by EPA show that, despite the favorable developments cited above, additional CSO controls would cause even more substantial and widespread economic and social impacts than EPA projected in 1998. Economic burdens in the MWRA service area associated with the cost of basic necessities, and shelter costs in particular, are well above those typically associated with a 2% preliminary screener value that — as set forth in EPA's *Guidance* — indicates a "large" economic impact.

Within the MWRA service area, shelter cost burdens in Boston and Chelsea are especially onerous. In 2003, actual shelter cost burdens in both cities were above those that would be experienced in more than 95% of a sample of 80 metropolitan areas nationwide if sewer charges in those areas rose to the level of EPA's 2% screener threshold. While shelter cost burdens are higher in Boston and Chelsea, burdens well above those that typically would be associated with EPA's 2% threshold are widespread throughout the MWRA service area. Indeed, the actual shelter cost burden in the MWRA service area as a whole exceeds that which would be associated with EPA's 2% threshold in nearly 95% of the 80 metropolitan areas examined in our analysis.

Economic burdens arising from the cost of basic necessities in Boston, Chelsea, and the entire MWRA service area also increased much more since 1997 than they would have if the sewer charge burden had increased as EPA projected in 1998 but other determinants of those broader economic burdens had remained at levels observed in the mid-1990s. Thus, our analysis indicates that the economic impact of further CSO controls would not only be substantially greater than would be experienced in most metropolitan areas *if* they met EPA's 2% threshold, it would also be more substantial and widespread than EPA forecasted in 1998.

The unusually high level of economic burdens in the MWRA service area will persist well into the future. In particular, our analysis finds that it is highly unlikely that shelter cost burdens will return to their 1997 levels within the next five years. Further, if shelter cost burdens do eventually decline to their 1997 levels, they would still exceed levels that typically would be associated with a finding of a "large" economic impact.

Finally, in the Boston metropolitan area, the ratio of the income of lower income households to that of the median household is below that found in 86% of metropolitan areas nationwide. Consequently, a given economic burden expressed as a share of MHI, such as is described above, implies more severe burdens on lower income households in the MWRA service area than it does on lower income households in most metropolitan areas nationwide.

Our analysis verifies EPA's 1998 prediction that additional CSO controls would cause "substantial and widespread economic and social impact" in the MWRA service area, but the changes in economic conditions that underlie this conclusion are different from those that EPA predicted. Unexpected, unusual, and substantial changes in economic burdens from the cost of basic necessities — arising from factors other than increased sewer charges — have led to conditions where the economic impact of additional CSO controls would be even greater than EPA forecasted in 1998. Moreover, at the time of EPA's forecast, burdens were already well above levels that typically would be associated with a finding of a "large" economic impact, based on EPA's methodology.

Figure 1

Cumulative Distribution of Fair Market Rents in 80 (P)MSAs Nationwide
1997 and 2003

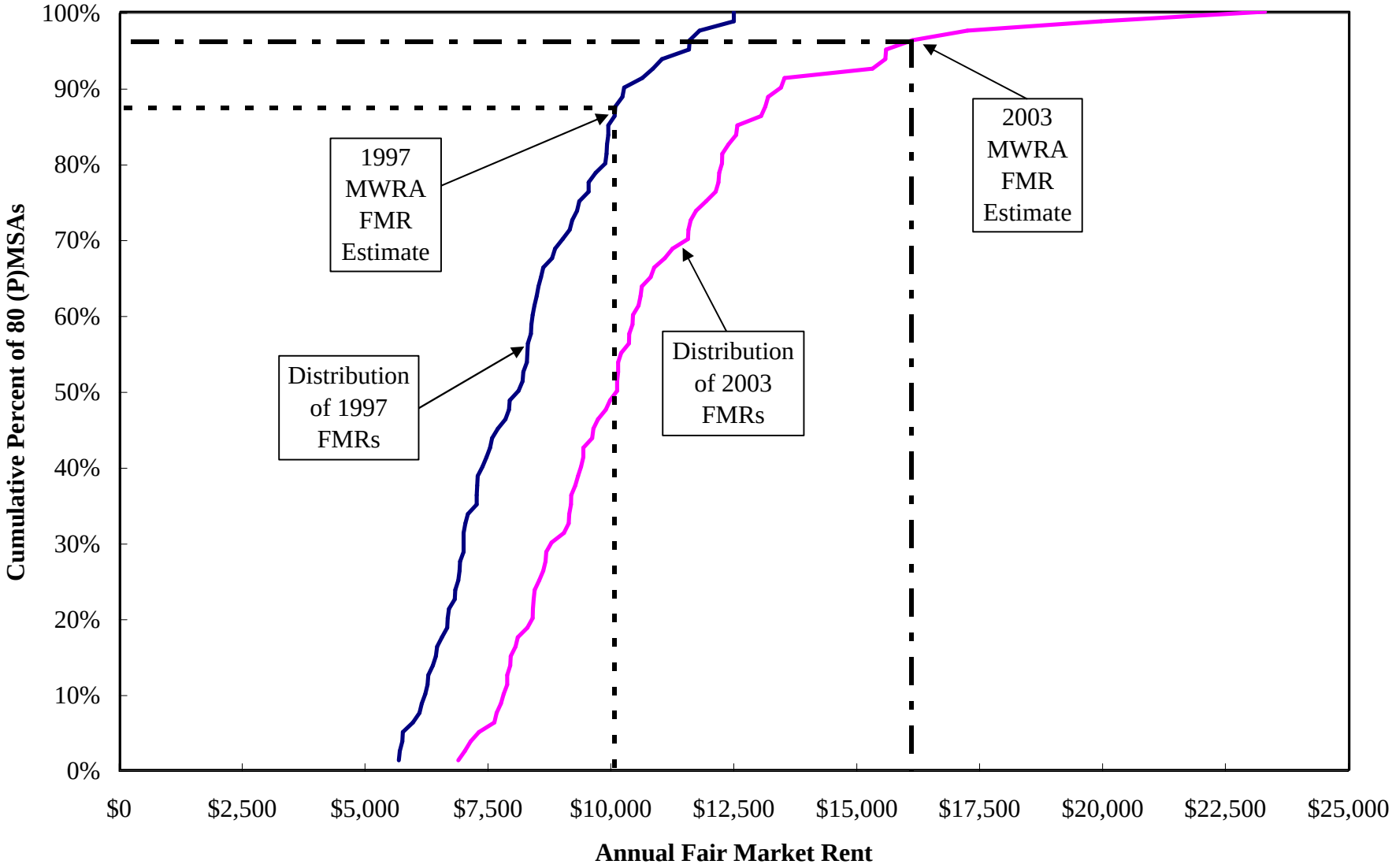


Figure 2

Cumulative Distribution of Compound Annual Growth in Fair Market Rents from 1997 to 2003 in 80 (P)MSAs Nationwide

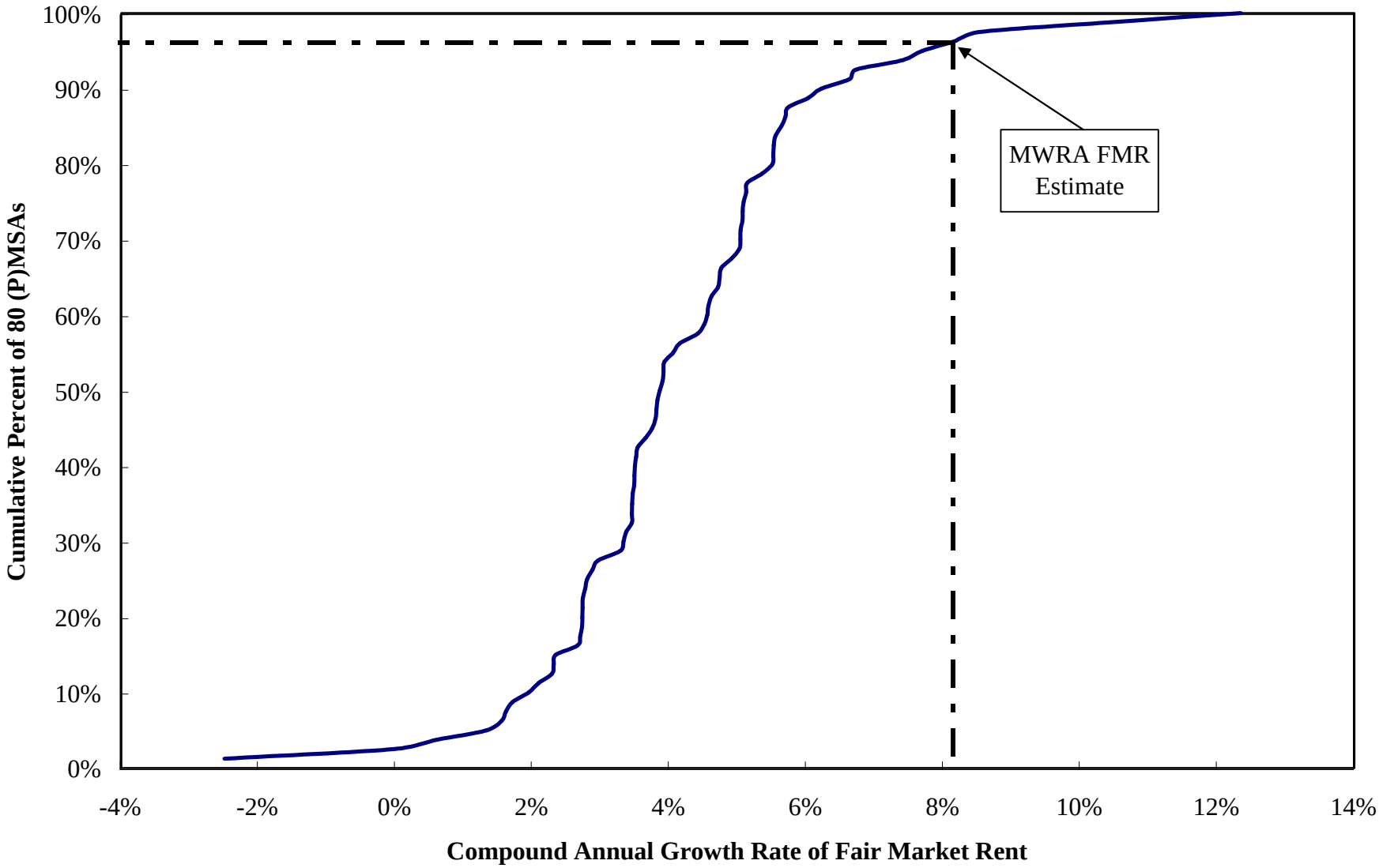


Figure 3

Distribution of Shelter Cost Burdens Associated with Meeting EPA 2% Threshold in 80 (P)MSAs Nationwide

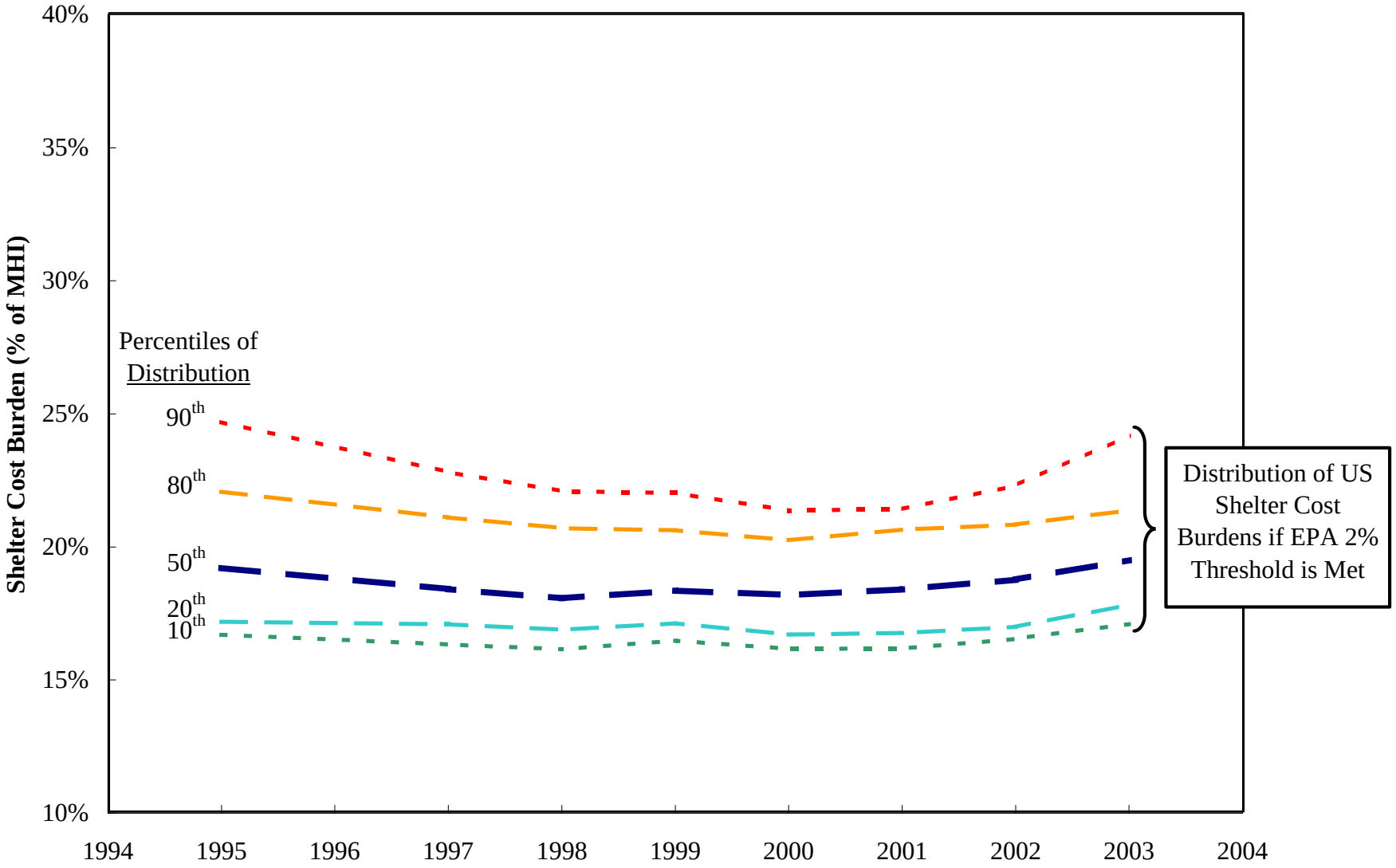


Figure 4

Distribution of Shelter Cost Burdens Associated with Meeting EPA 2% Threshold in 80 and 331 (P)MSAs Nationwide

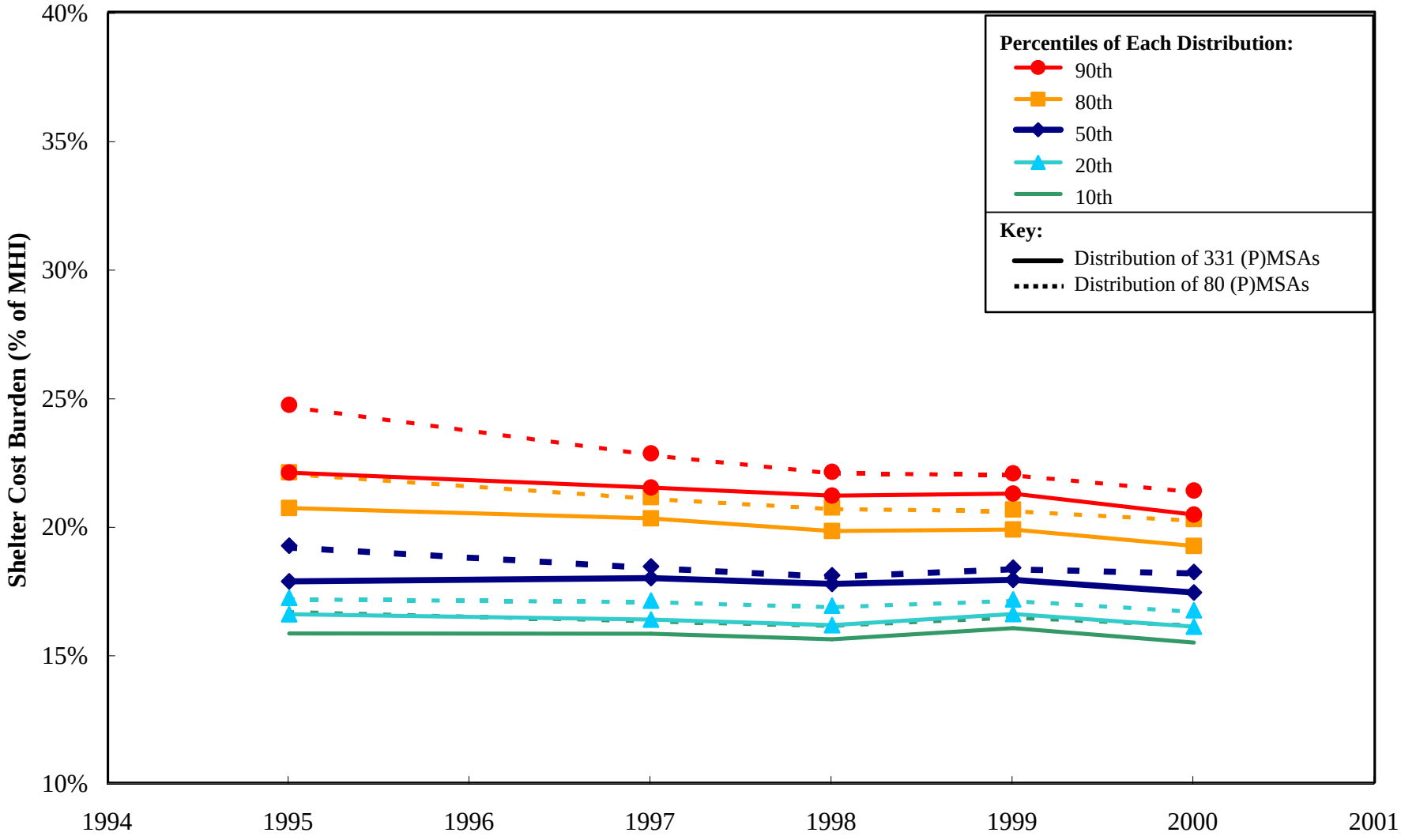


Figure 5

Shelter Cost Burden in the City of Boston
Compared with the Nationwide Distribution Associated with Meeting EPA 2% Threshold

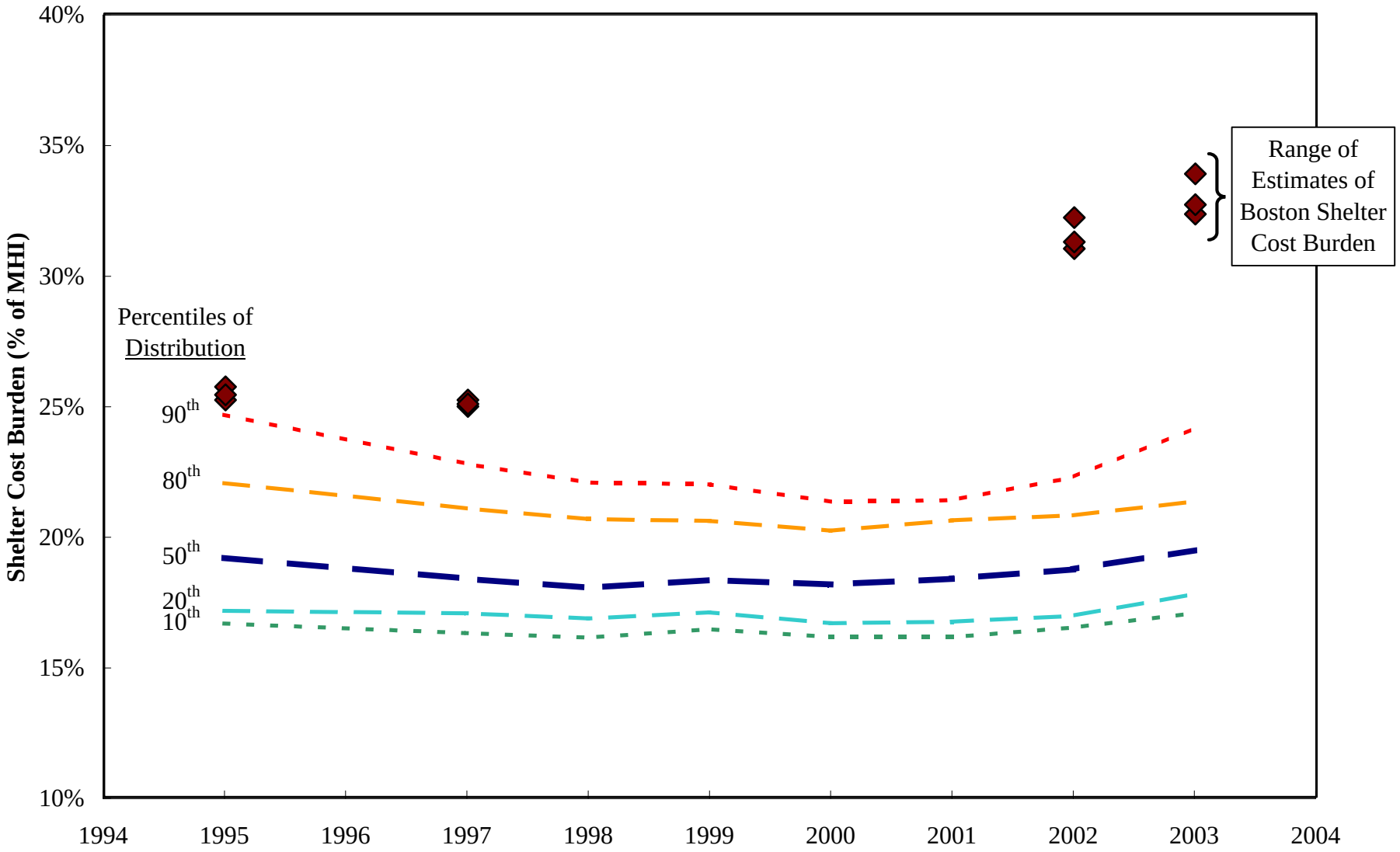


Figure 6

Shelter Cost Burden in the City of Chelsea
Compared with the Nationwide Distribution Associated with Meeting EPA 2% Threshold

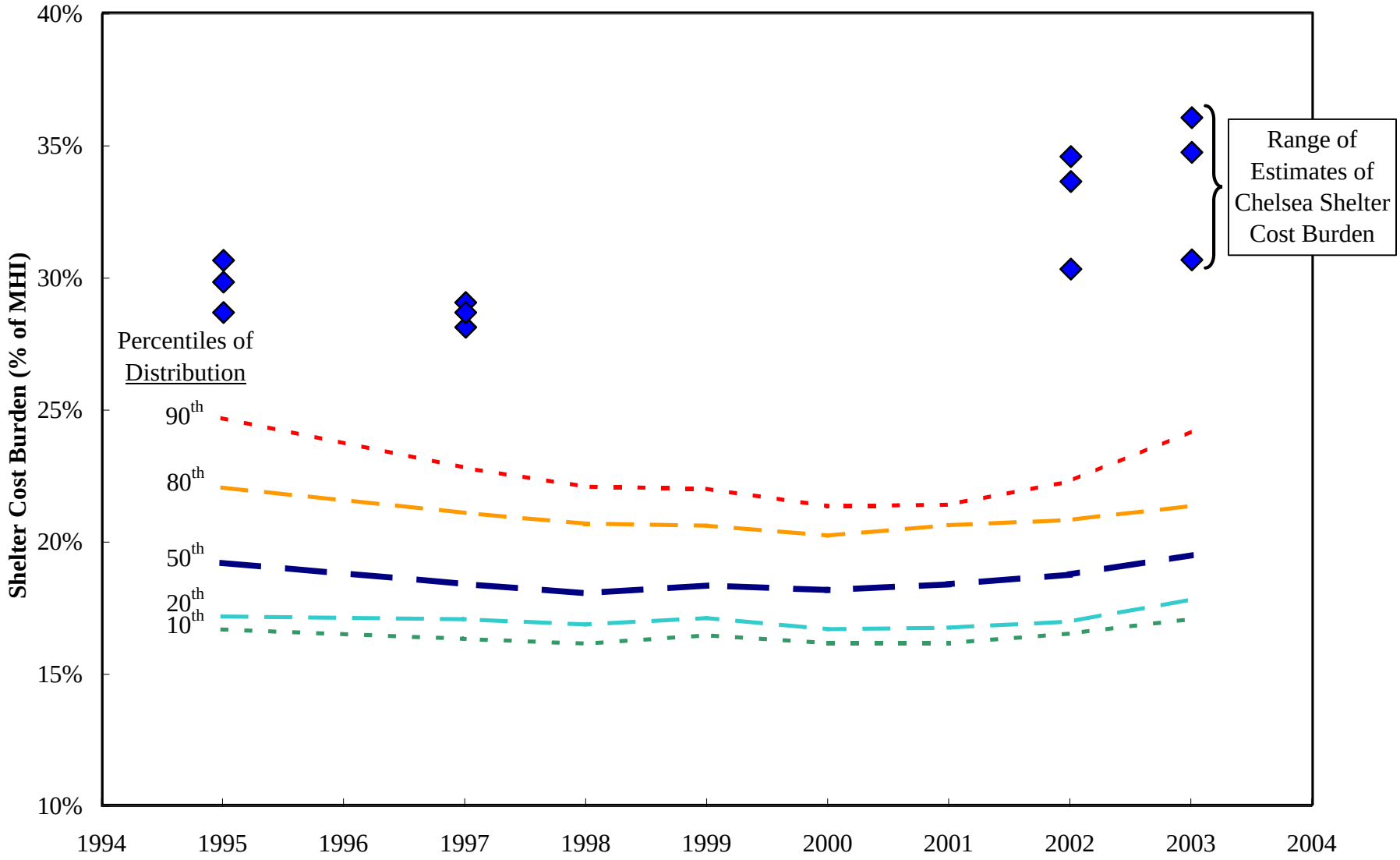
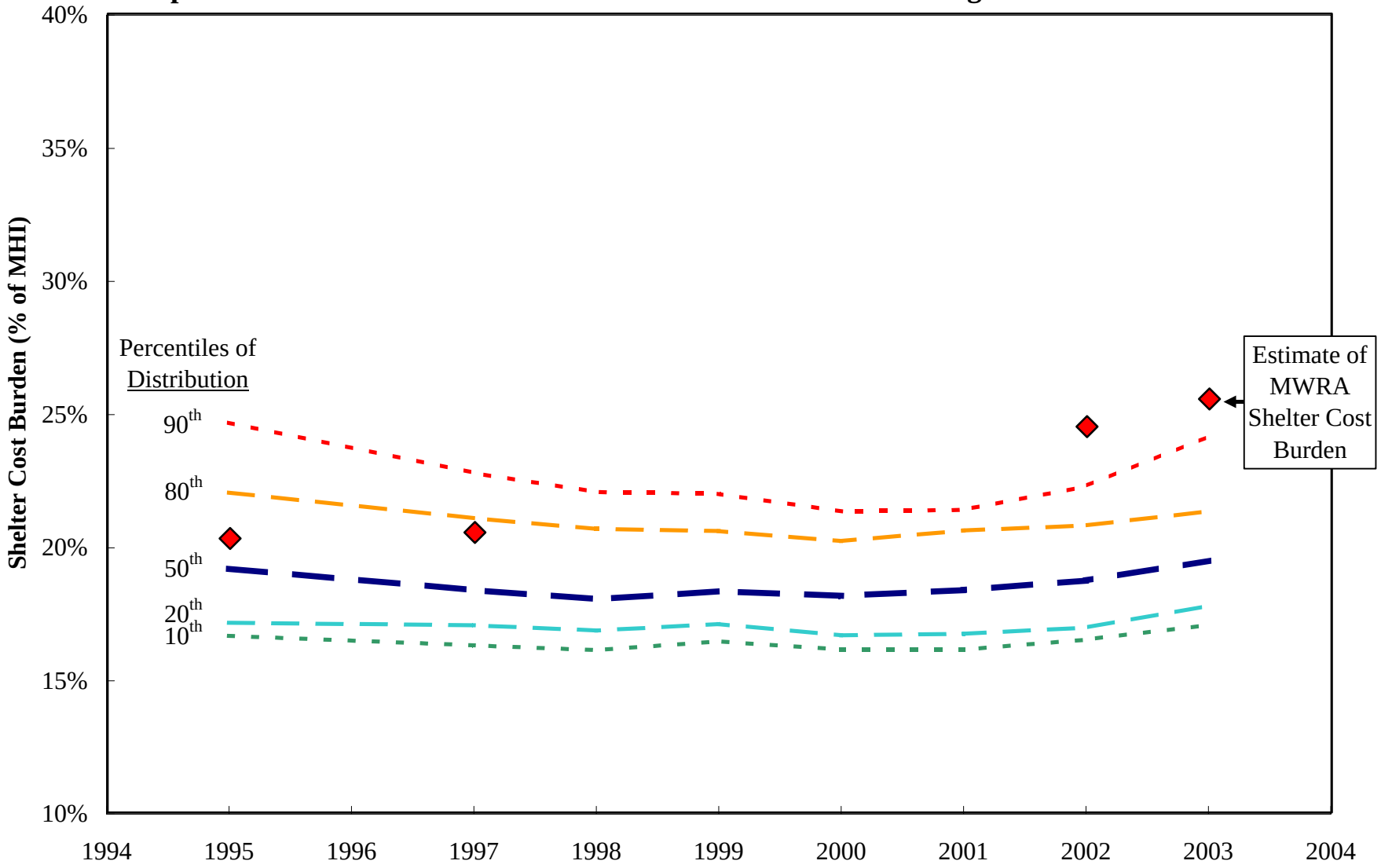


Figure 7

Shelter Cost Burden in the MWRA Service Area
Compared with the Nationwide Distribution Associated with Meeting EPA 2% Threshold



APPENDIX A

Communities in the MWRA Sewer Service Area

The MWRA sewer service area includes 43 cities and towns that have been receiving sewer service from the MWRA since 1995 or earlier. This subset of the MWRA service area accounted for more than 78% of the entire MWRA service area population in 2002. Table A-1 lists the cities and towns in the MWRA sewer service area, sorted by their population in 2002.

Table A-1. MWRA Sewer Service Area Communities

City or Town	2002 Population	City or Town	2002 Population
Boston	589,281	Norwood	28,844
Cambridge	101,807	Stoughton	27,227
Quincy	89,187	Melrose	26,963
Newton	83,880	Wellesley	26,671
Somerville	76,922	Milton	26,010
Framingham	66,827	Wakefield	24,817
Waltham	59,073	Belmont	24,045
Brookline	57,032	Reading	23,680
Malden	56,155	Dedham	23,378
Medford	55,137	Walpole	23,199
Weymouth	54,754	Burlington	22,923
Revere	47,496	Stoneham	22,165
Arlington	42,140	Wilmington	21,629
Woburn	38,003	Canton	21,341
Everett	37,772	Winchester	21,093
Chelsea	34,913	Hingham	20,221
Braintree	33,917	Winthrop	18,235
Watertown	32,857	Ashland	15,392
Natick	32,384	Westwood	14,181
Randolph	31,044	Bedford	12,647
Lexington	30,663	Holbrook	10,877
Needham	29,197		
Total Population: 2,135,979			

APPENDIX B

HUD Fair Market Rents (FMRs) and the Estimation Methodology for Boston, Chelsea, and MWRA Service Area FMRs

This appendix provides background on HUD Fair Market Rents (FMRs) and the methodology employed to develop estimates of FMRs for Boston, Chelsea, and the MWRA service area as a whole.

B-1. HUD Fair Market Rents

FMRs are calculated annually by HUD for more than 300 metropolitan areas and 2,300 non-metropolitan counties.[1] Generally, the geographic dimensions of metropolitan areas for which HUD develops FMRs are based on the most current U.S. Office of Management and Budget (OMB) definitions of metropolitan statistical areas (MSAs) and primary metropolitan statistical areas (PMSAs). However, for certain metropolitan areas where HUD considers the OMB definition to be larger than the appropriate housing market area definition, HUD subdivides those areas for the purposes of calculating FMRs.

FMRs measure monthly "gross rents," which include the cost of all utilities, except telephone service. For a given metropolitan area, the FMR is drawn from the distribution of rents of all 2-bedroom, standard-quality units occupied by recent movers (renters who moved into their unit within the past 15 months). Public housing units, newly constructed units (less than 2 years old), and units that fail a housing quality test are excluded from the distribution.

The FMR is the 40th percentile rent from the distribution of rents described above, with the exceptions that, prior to 1995, the FMR was the 45th percentile rent and, since 2001, the FMR in 39 metropolitan areas has been the median rent. The FMR for the Boston metropolitan area is the 40th percentile rent. In our analysis, the FMRs that track the median rent are adjusted downward to make them more comparable to other areas' FMRs (see Section B-2).

[1] Unless noted, information on FMRs in this appendix was obtained from HUD documentation and conversations with HUD personnel. For the documentation, see http://www.huduser.org/datasets/fmr.html.

For each metropolitan area, HUD's method of calculating FMRs involves the periodic calculation of a "base year" FMR, and the application of annual adjustments to that base year estimate. To develop base year FMRs, HUD relies on three data sources: the decennial Census, the American Housing Survey (AHS), and random digit dialing (RDD) telephone surveys. The AHS is conducted for the 44 largest metropolitan areas on a revolving schedule of 11 areas annually. HUD conducts RDD surveys annually for 60 selected, generally larger metropolitan areas. In some cases, base year FMRs are developed from RDD surveys by local governments.

In April of each year, HUD publishes proposed FMRs for the next fiscal year. Following a 60-day public comment period, an FMR may be revised if public comment and statistically valid data suggest a revision is necessary. Final FMRs are published each October. To estimate a proposed FMR in years other than base years, HUD first applies an adjustment factor to the base year FMR, and then extrapolates the result to the mid-point of the fiscal year in which the FMR is to be used. This process is discussed in further detail below.

There are two broad types of adjustment factors: adjustment factors based on the Consumer Price Index (CPI); and regional adjustment factors based on data collected by HUD.

- **CPI-based Adjustment Factors:** The Bureau of Labor Statistics (BLS) maintains CPIs for 10 MSAs and 17 Consolidated Metropolitan Statistical Areas (CMSAs), within which there are 71 PMSAs. HUD uses CPI-based adjustment factors for rent and utilities to adjust the FMRs for 80 of these 81 MSAs and PMSAs.[2]

- **Regional Adjustment Factors:** For areas without CPI surveys, FMRs are adjusted based on regional adjustment factors developed by HUD through RDD surveys. There are 20 such regional adjustment factors: one for metropolitan areas and one for non-metropolitan areas within each of 10 HUD-defined geographic regions.

[2] The BLS began to report CPIs for the Phoenix MSA in 2002. HUD has not included Phoenix among the metropolitans areas for which FMRs are adjusted based on CPI data.

HUD updates a base year FMR using either a regional or CPI-based adjustment factor. Adjustment factors are only available up to the end of the year prior to that in which the estimate is being made. Therefore, using national CPI data, HUD applies a trending factor to the adjusted FMR to estimate the appropriate value for the midpoint of the fiscal year for which the FMR is being estimated. For example, to estimate an FMR for 2005 using a December 2002 AHS-based FMR, HUD first updates the 2002 base year FMR from December 2002 to December 2003 using either a CPI-based or regional adjustment factor. The resulting estimate is then adjusted further, using a trending factor, to arrive at a value for April 2005.

B-2. Adjusting FMRs that track the median rent rather than the 40th percentile rent

In 2001, HUD's FMRs for 39 metropolitan areas began to track the median rent rather than the 40th percentile rent. Of these 39 areas, 23 are among the 80 metropolitan areas whose shelter cost burdens are used as a basis for evaluating burdens in the MWRA service area. If no adjustment were made to these 23 metropolitan areas' FMRs after 2000, the relative shelter cost burden in these 23 areas would be overstated because the ratio of FMR to MHI would measure a median rent as a share of MHI, rather than the 40th percentile rent as a share of MHI. FMR data maintained by HUD makes it possible to adjust these FMRs so that they are more comparable to 40th percentile rents. While FMRs after 2001 only track median rents in these areas, in 2001 HUD calculated both the median and 40th percentile rent for each area. In our analysis, for each area, all median rent estimates from 2001 to 2003 are scaled downward by the ratio of the 2001 40th percentile rent to the 2001 median rent.

B-3. Estimation of FMRs for Boston, Chelsea, and the MWRA service area

HUD's FMR for the Boston metropolitan area is developed for the whole Boston PMSA. Therefore, FMRs must be estimated for Boston, Chelsea, and the MWRA service area as a whole. We consider three possible estimation methods (Methods 1 through 3) for each area that are based on the Boston PMSA FMR and Census data. For the MWRA service area, a fourth estimation method is considered, which is to assume that the MWRA service area FMR is identical to the Boston PMSA FMR (Method 4). While this is a plausible assumption for the MWRA service area as a whole, given the large share of rental housing units in the Boston PMSA that are located within the MWRA service area, we did not consider this method for

Boston or Chelsea, because their shares of the rental housing units in the Boston PMSA are relatively small.[3]

Data on gross rents in Boston, Chelsea, the MWRA service area, and the Boston PMSA as a whole are available from both the 1990 and 2000 Census. In combination with the Boston PMSA FMRs, Census gross rent data can be used to estimate FMRs in Boston, Chelsea, and the MWRA service area. In this analysis, the 40th percentile Census-reported gross rent for each of the specified areas is calculated for 2-bedroom renter-occupied housing units in which rent was paid. The method employed to calculate the 40th percentile rent is identical to that used by the Census to calculate percentiles of the rent distribution. In many respects, the resulting estimates are consistent with what would be calculated using the HUD FMR methodology. However, the Census gross rents are reported for all housing units. HUD FMRs are derived from rents reported for non-public housing units that are more than 2 years old, pass a housing quality test, and are occupied by recent movers. These aspects of HUD's methodology could not be replicated, given available data.

Since the boundaries of the Boston PMSA changed from 1989 to 1999, the 40th percentile Census-reported rents for the Boston PMSA in 1989 and 1999 are calculated based on the cities and towns included in the PMSA in 1999. This is necessary to ensure that the calculated growth in Boston PMSA rents reflects actual changes in rents and not changes in the composition of the PMSA. The calculated 40th percentile Census-reported rents from 1989 and 1999 for the Boston PMSA, Boston, Chelsea, and the MWRA service area are used to estimate relationships between the levels of and growth in Boston PMSA FMRs, and the levels of and growth in FMRs in each of the other three areas. Table B-1 presents the calculated 40th percentile Census-reported rents for the Boston PMSA, Boston, Chelsea, and the MWRA service area in 1989 and 1999, and relationships that are used in our estimation methods.

[3] The MWRA service area, Boston, and Chelsea respectively account for 76%, 26%, and 1.5% of the Boston PMSA's 2-bedroom renter-occupied housing units. U.S. Census Bureau, 2000 Census Summary File 3, Table H67.

Table B-1. Census monthly gross rent data for Boston, Chelsea, the MWRA Service Area, and the Boston PMSA

		Boston	Chelsea	MWRA Service Area	Boston PMSA
[A]	40th Percentile Rent in 1989	$582	$562	$642	$633
[B]	40th Percentile Rent in 1999	$757	$642	$833	$799
[C]	**Relationship 1:** Rent as a Fraction of Boston PMSA Rent in 1999	**0.95**	**0.80**	**1.04**	
[D]	Compound Annual Growth Rate (CAGR) of Rent from 1989 to 1999	2.66%	1.34%	2.63%	2.35%
[E]	**Relationship 2:** Area Rent CAGR Divided by Boston PMSA Rent CAGR	**1.13**	**0.57**	**1.12**	
[F]	**Relationship 3:** Area Rent CAGR Minus Boston PMSA Rent CAGR	**0.31%**	**-1.02%**	**0.28%**	

Source: Analysis of data presented in U.S. Census Bureau, 2000 Census Summary File 3, Table H67, and 1990 Census Summary Tape File 3, Table H034.

From the relationships between the levels and growth rates of rents shown in rows [C], [E], and [F] of Table B-1, three methods are used to develop estimates of the FMRs in Boston, Chelsea, and the MWRA service area as a whole. As was mentioned above, there is a fourth plausible method for the MWRA service area as a whole, assuming that FMRs in the MWRA service area are identical to the Boston PMSA FMRs in each year. All four methods are described below.

Method 1: An area's FMR is assumed to maintain the same proportional relationship to the Boston PMSA FMR in all years.

The FMR for a given area in all years is calculated as the Boston PMSA FMR in that year times the ratio of that area's 40th percentile Census-reported rent in 1999 to the Boston PMSA 40th percentile Census-reported rent in 1999 (Row [C] in Table B-1).

Method 2: Annual growth in an area's FMR is assumed to maintain the same proportional relationship to annual growth in the Boston PMSA FMR in all years.

The 1999 FMR for a given area is calculated using Method 1. After 1999 (and up to 1999, for estimating FMR in earlier years), growth in the FMR for that area is assumed to equal a constant fraction of observed growth in the Boston PMSA FMR. This fraction is the 1989 to 1999 compound annual growth rate (CAGR) of the 40th percentile Census-reported rent in that area divided by the 1989 to 1999 CAGR of the 40th percentile Census-reported rent in the Boston PMSA (Row [E] of Table B-1).

Method 3: Annual growth in an area's FMR maintains the same, fixed percentage point difference relative to annual growth in the Boston PMSA FMR in all years.

The 1999 FMR for a given area is calculated using Method 1. After 1999 (and up to 1999, for estimating FMR in earlier years), growth in the FMR for that area is assumed to equal the observed Boston PMSA FMR growth rate plus the difference between growth rates observed in the Census-reported rents. This difference is the 1989 to 1999 CAGR of the 40th percentile Census-reported rent in that area minus the 1989 to 1999 CAGR of the 40th percentile Census-reported rent in the Boston PMSA (Row [F] of Table B-1).

Method 4: The area's FMR is assumed to equal the Boston PMSA FMR in all years. This method is only deemed plausible for the MWRA service area as a whole.

Table B-2 presents the 2003 FMR estimates for Boston, Chelsea, and the MWRA service area as a whole resulting from the application of the above estimation methods.

Table B-2. Estimates of Monthly FMRs in 2003

Method	Boston	Chelsea	MWRA Service Area
Method 1	$1,273	$1,079	$1,400
Method 2	$1,334	$918	$1,462
Method 3	$1,287	$1,040	$1,414
Method 4	N/A	N/A	$1,343

We adopt the fourth method for estimating FMRs in the MWRA service area as a whole. This decision is based on the MWRA service area's share of rental units in the Boston PMSA and the fact that, of the four plausible estimates evaluated, this choice would lead to the *lowest* estimate of shelter cost burdens in the MWRA service area as a whole. The Census data suggest that this choice leads us to underestimate shelter cost burdens in the MWRA service area. As there is less basis *ex ante* to favor a particular estimation method for Boston and Chelsea, throughout our analysis, we present the range of estimates produced using Methods 1 to 3, rather than presenting only a single point estimate.

APPENDIX C

Median Household Income Estimation Methodology

The analyses presented in this report require estimation of MHIs in Boston, Chelsea, the MWRA service area, and several metropolitan statistical areas and primary metropolitan statistical areas ((P)MSAs) nationwide. This appendix describes the methods used to estimate MHIs and the basis for selecting the estimation methods.

C-1. Data available for MHI estimation

Each decennial Census reports the MHI for geographic areas including cities and (P)MSAs. These data are used for 1999 MHI in Boston, Chelsea, and all (P)MSAs considered in our analysis. Because 1999 is the only year for which Census data are available in the time period of interest, we must estimate MHI in intercensal years. Moreover, even in 1999, an MHI estimate for the MWRA service area must be developed based on available MHI data for underlying cities, towns, and counties.

EPA's 1998 finding that further CSO controls in the MWRA service area would cause "substantial and widespread economic and social impact" relied, in part, on predictions of 2005 MHI in Boston and Chelsea. EPA's 2005 MHI predictions were based on 1989 Census MHI estimates, extrapolated to 1996 assuming the same rate of increase as was observed in the Massachusetts MHI, and then extrapolated to 1998 assuming the same rate of increase as was observed in the CPI. Annual growth from 1998 to 2005 was assumed to equal the average growth rate from the 1989 Census MHI to the estimated 1998 MHI.[1]

The Census Bureau also provides another data source that can be used to estimate intercensal MHIs: county-level MHI estimates produced by the Small Area Income and Poverty Estimates (SAIPE) project.[2] SAIPE MHI estimates for all counties nationwide are available for

[1] Letter from John DeVillars (1998), p. 2 of Attachments A and B.

[2] There is a significant time lag in the release of SAIPE estimates. When EPA made its determination in 1998, very little data would have been available. According to the SAIPE website, "The model-based procedures provide our best estimates of income and poverty for states and counties for 1993, 1995 through 1999. … The decennial census provides precise estimates every ten years, but they become increasingly out of date with the passage of time." See http://www.census.gov/hhes/www/saipe/nontechdoc/estimdesc.html .

1995 and 1997 to 2000. They are based on a multivariate estimation model that incorporates data from the Census Bureau's Current Population Survey (CPS), the Bureau of Economic Analysis, the decennial Census, and federal individual income tax returns.

There are four reasons why SAIPE MHI estimates are likely preferable to state MHI estimates and CPI data as a basis for estimating MHI in metropolitan areas in intercensal years:

- For estimating the MHIs of Boston and Chelsea, Suffolk County SAIPE MHI estimates are the closest geographic match to those cities.
- For estimating MHIs of (P)MSAs, county-level SAIPE MHI estimates can be aggregated based on the exact composition of those (P)MSAs, which is preferable to relying on data for much larger geographic areas, such as state MHI estimates.
- Area CPIs often are associated with consolidated metropolitan statistical areas (CMSAs), which include multiple PMSAs and are therefore much broader geographically than the areas for which we are estimating MHI.
- Price movements measured by area CPIs are likely to be less correlated with income growth than would be growth in MHI estimates for similar geographic areas.

C-2. Plausible alternatives for estimating Boston and Chelsea MHIs

Intercensal MHIs for Boston and Chelsea can be estimated by scaling 1999 Census MHIs to other years based on observed changes in economic indicators presumed to be closely correlated with Boston and Chelsea MHIs. There are three feasible options for such an indicator: (1) the Suffolk County SAIPE MHI; (2) the Massachusetts MHI; and (3) the Boston-Brockton-Nashua MA-NH-ME-CT area CPI. The Suffolk County SAIPE MHI was chosen because not only is it likely more closely correlated with income growth than are changes in the local price level, as measured by the CPI, it also offers the closest geographic match to the cities of Boston and Chelsea. Because SAIPE data are unavailable after 2000, this method is not feasible for estimating MHI beyond 2000. The method used after 2000 is described in Section C-5.

C-3. Plausible alternatives for estimating (P)MSA MHIs

Several plausible methods can be considered for estimating (P)MSA MHIs. Each method evaluated involves scaling a base year Census MHI estimate by the change in an economic

indicator that is likely correlated with MHI.[3] This general approach is consistent with EPA's approach in the analysis supporting its 1998 finding. The presence of 1989 and 1999 Census MHI data allows empirical testing of the precision and accuracy of each method. For example, a given method can be applied to predict 1999 MHI, based on the 1989 Census MHI. For the 80 metropolitan areas incorporated in our analysis, these predictions can be compared with actual 1999 Census MHIs to estimate each method's variance (a measure of a method's precision) and bias (a measure of whether a method systematically over or underestimates).[4] Our choice of an MHI estimation method is based on the variance and bias associated with each method.

C-3.1. Detailed explanation of plausible estimation methods for (P)MSA MHIs

Each estimation method is described in detail and illustrated with an equation below.

Method 1: Aggregation of scaled base year Census MHIs for each component county.

Each component county's Census-year MHI estimate is scaled to a given year based on the change in its SAIPE MHI estimate from the Census-year to that year. These scaled county estimates are then aggregated to a (P)MSA MHI estimate using a household-weighted average.[5] Based on the availability of data, this method can be used to estimate MHI in 1995 and 1997 to 2000. The following equation illustrates estimation of *Method1_MHI* in estimation year t for (P)MSA a, with n component counties c_i, where H is the number of households, *CMHI* is the Census MHI in base year b, and S is a SAIPE county-level MHI estimate.

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[3] Another plausible alternative that was initially investigated is the weighted average of component county SAIPE MHI estimates in a given year. This method was abandoned because it was found to be less accurate and precise than the alternatives that involve scaling a base year estimate.

[4] In addition to evaluation of variance and bias of alternative MHI estimates in 1989 and 1999, variance and bias were also measured for 1989 to 1999 growth rates implied by those estimates.

[5] Household data are available for 1999 from the 2000 Census. The number of households in other years is estimated by applying the ratio of households to total population in an area in 1999 to the population of that area in each year. Sources: (1) U.S. DOC, Census Bureau, 2000 Census Summary File 3, Table P14. (2) Population Estimates Program, Population Division, U.S. Census Bureau: (MA-99-3b) Population Estimates for Metropolitan Areas and Components, Annual Time Series April 1, 1990 to July 1, 1999, Internet Release Date: October 20, 2000, downloaded February 6, 2004. (3) Population Estimates Program, Population Division, U.S. Census Bureau, 2000 population estimates for counties (available at http://eire.census.gov/popest/data/counties/CO-EST2003-01.php, downloaded February 5, 2004) and for county subdivisions (available at http://eire.census.gov/popest/estimates_dataset.php, downloaded February 12, 2004).

$$Method1\_MHI_{at} = \frac{\sum_{i=1}^{n} H_{c_i t}\left(CMHI_{c_i b}\left(\frac{S_{c_i t}}{S_{c_i b}}\right)\right)}{\sum_{i=1}^{n} H_{c_i t}}$$

Method 2: Aggregation of scaled base year Census MHIs for each component county, assuming incomes follow a lognormal distribution.

Scaling of county-level Census MHI estimates in the manner described for Method 1 results in MHI estimates for each component county. Logarithms of those scaled county estimates are then aggregated to a (P)MSA MHI estimate using the exponential of the household-weighted average. Empirical simulations suggest this method is a better predictor of MHI than simply taking the weighted average if incomes follow a lognormal distribution in each component county. A lognormal income distribution, which reflects the fact that incomes are bounded at the lower end by zero and are therefore skewed to the right, is supported by evidence from income quintile data. For example, in the Boston PMSA the difference between the median and 80th percentile household incomes is almost $15,000 greater than the difference between the median and 20th percentile household incomes.[6]

Based on the availability of data, this method can be used to estimate MHI in 1995 and 1997 to 2000. The following equation illustrates estimation of *Method2_MHI* (see Method 1 for variable definitions).

$$Method2\_MHI_{at} = e^{\left(\frac{\sum_{i=1}^{n} H_{c_i t} \bullet \ln\left(CMHI_{c_i b}\left(\frac{S_{c_i t}}{S_{c_i b}}\right)\right)}{\sum_{i=1}^{n} H_{c_i t}}\right)}$$

[6] Based on 2000 Census data on the income distribution in the Boston PMSA, provided by the Census Bureau upon request. Email communication with Kirk Davis, U.S. Census Bureau, March 4, 2004.

Method 3: Base year (P)MSA Census MHI scaled by change in the average of component counties' SAIPE MHIs.

A Census-year (P)MSA MHI estimate is scaled to a given year based on the change in the average SAIPE MHI estimate for component counties. The scaling factor is estimated by first taking the household-weighted average of a (P)MSA's component county SAIPE MHI estimates in the estimation year and base year, and then taking the ratio of those averages. Based on the availability of data, this method can be used to estimate MHI in 1995 and 1997 to 2000. The following equation illustrates estimation of *Method3_MHI* (see Method 1 for variable definitions).

$$Method3\_MHI_{at} = CMHI_{ab}\left(\frac{\frac{\sum_{i=1}^{n} H_{c_i t}\left(S_{c_i t}\right)}{\sum_{i=1}^{n} H_{c_i t}}}{\frac{\sum_{i=1}^{n} H_{c_i b}\left(S_{c_i b}\right)}{\sum_{i=1}^{n} H_{c_i b}}}\right)$$

Method 4: Base year (P)MSA Census MHI scaled by an average of changes in each component county's SAIPE MHI.

A Census-year (P)MSA MHI estimate is scaled to a given year based on the average of changes in SAIPE MHI estimates for component counties. In contrast to Method 3, the scaling factor in this approach is estimated by first taking the ratio of the estimation year SAIPE MHI to the base year SAIPE MHI for each component county, and then averaging those ratios. Based on the availability of data, this method can be used to estimate MHI in 1995 and 1997 to 2000. The following equation illustrates estimation of *Method4_MHI* (see Method 1 for variable definitions).

$$Method4\_MHI_{at} = CMHI_{ab}\left(\frac{\sum_{i=1}^{n} H_{c_i t}\left(\frac{S_{c_i t}}{S_{c_i b}}\right)}{\sum_{i=1}^{n} H_{c_i t}}\right)$$

Method 5: Base year (P)MSA Census MHI scaled by changes in state-level MHI.

A Census-year (P)MSA MHI estimate is scaled to a given year based on the change in the CPS state MHI estimate.[7] This method applies one of EPA's methods, using data relied upon by EPA. Based on the availability of data, this method can be used to estimate MHI through 2002. The following equation illustrates estimation of *Method5_MHI*, where $STMHI_a$ is the CPS MHI estimate for the state in which (P)MSA *a*'s primary city is located (see Method 1 for other variable definitions).

$$Method5\_MHI_{at} = CMHI_{ab}\left(\frac{STMHI_{at}}{STMHI_{ab}}\right)$$

Method 6: Base year (P)MSA Census MHI scaled by changes in area CPI for all items.

A Census-year (P)MSA MHI estimate is scaled to a given year based on the change in the CPI for all items for the geographic area in which the (P)MSA is located.[8] Like Method 5, this method applies an EPA method, using data relied upon by EPA. Based on the availability of data, this method can be used to estimate MHI through 2003. The following equation illustrates estimation of *Method6_MHI*, where CPI_a is the area CPI for all items that is associated with (P)MSA *a* (see Method 1 for other variable definitions).

$$Method6\_MHI_{at} = CMHI_{ab}\left(\frac{CPI_{at}}{CPI_{ab}}\right)$$

[7] U.S. DOC, Census Bureau, Current Population Survey, Annual Social and Economic Supplements, Table H-8. Available at http://www.census.gov/hhes/income/histinc/h08.html, downloaded July 30, 2004.
[8] U.S. DOL, BLS, CPI for all items for specific urban areas. Available at http://data.bls.gov/labjava/outside.jsp?survey=cu, downloaded February 24, 2004.

C-3.2. Evaluation of plausible estimation methods for (P)MSA MHIs

The results of comparing estimates based on Methods 1 through 6 with actual Census MHIs across the 80 (P)MSAs are shown in Table C-1. These results show that scaling a (P)MSA Census MHI (Methods 3 to 6) is preferable to scaling individual county Census MHI estimates and then aggregating to a (P)MSA MHI (Methods 1 to 2). Of the methods that scale a (P)MSA Census MHI, Method 4's scaling factor results in the lowest variance and least bias for predicting MHI.[9] Method 4 is therefore the most preferred method.

Table C-2 summarizes results across the subset of 19 (P)MSAs with more than four counties. Because many of the methods involve aggregating county estimates, isolating those (P)MSAs composed of numerous counties allows for an evaluation of the sensitivity of each method's performance to the number of counties being aggregated. When evaluated for only this subset of 19 (P)MSAs, Method 4's predictions still have the lowest variance and least bias.

Table C-3 tests these results for the subset of 15 (P)MSAs in New England. Not only are New England (P)MSAs geographically close to the MWRA service area, but they are also the only (P)MSAs in the country that can include both whole counties and parts of counties. Elsewhere, (P)MSAs only include whole counties. We therefore evaluate the performance of each method in predicting MHI only for New England (P)MSAs to ensure that this difference in the composition of (P)MSAs does not significantly alter the relative ranking of methods. In this evaluation, Method 4 is among the top three, closely-grouped alternatives.

Method 4 was ultimately chosen for estimating (P)MSA MHIs based on its performance in predicting MHIs for the 80 (P)MSAs, (P)MSAs with more than four counties, and New England (P)MSAs. While our evaluation of prediction methods for these three groups of (P)MSAs indicates modest differences in each method's ranking for the various groups of (P)MSAs, Method 4 was chosen based on its overall performance and the desire to use a consistent method for estimating MHI in all (P)MSAs.

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[9] In Table C-1, each method is ranked based on variance (*i.e.*, Method 4 is ranked 1 in all comparisons as it has the lowest variance). In addition, the column indicating the percentage of estimates that are lower than the Census MHI provides a measure of bias (*i.e.*, Method 4 has low bias because it underestimates (for 47% of (P)MSAs) almost as often as it overestimates (for 53% of (P)MSAs)).

C-4. Plausible alternatives for estimating MWRA service area MHI

As demonstrated above, the preferred estimation method for (P)MSA MHIs involves scaling a 1999 (P)MSA Census MHI by the weighted average of changes in SAIPE MHI estimates in the (P)MSA's component counties. Because a 1999 Census MHI estimate is not available for the MWRA service area, such a base year MHI estimate must be developed before applying the preferred method for estimating MHI in other years. Alternative estimation methods were evaluated by comparing predicted to actual MHI estimates for the New England (P)MSAs. New England (P)MSAs are a logical group for evaluating each method both because of geographic proximity to the MWRA service area and because, like the MWRA service area, they are composed of both partial and entire counties.

C-4.1. Detailed explanation of plausible estimation methods for MWRA service area base year MHI

The evaluated MHI estimation methods differ with respect to whether they rely on component county or city Census MHIs, and whether they assume incomes have a normal or lognormal distribution. Each of these methods is briefly described below, along with an illustrative equation (for variable definitions, see the explanation of Method 1 in Section C-3.1).

Base Year Method 1: Household-weighted average of component counties' Census MHIs.

$$BaseMethod1\_MHI_{ab} = \frac{\sum_{i=1}^{n} H_{c_i b} CMHI_{c_i b}}{\sum_{i=1}^{n} H_{c_i b}}$$

Base Year Method 2: Household-weighted average of component cities' (p_i) Census MHIs.

$$BaseMethod2\_MHI_{ab} = \frac{\sum_{i=1}^{n} H_{p_i b} CMHI_{p_i b}}{\sum_{i=1}^{n} H_{p_i b}}$$

Base Year Method 3: Exponential of the household-weighted average of the logarithms of component counties' Census MHIs.

As discussed in the explanation of Method 2 in Section C-3.1, this method assumes that incomes are lognormally distributed.

$$BaseMethod3\_MHI_{ab} = e^{\left(\frac{\sum_{i=1}^{n} H_{c_i b} \bullet \ln\left(CMHI_{c_i b}\right)}{\sum_{i=1}^{n} H_{c_i b}}\right)}$$

Base Year Method 4: Exponential of the household-weighted average of the logarithms of component cities' (p_i) Census MHIs.

Similar to Base Year Method 3, this approach assumes incomes are lognormally distributed.

$$BaseMethod4\_MHI_{ab} = e^{\left(\frac{\sum_{i=1}^{n} H_{p_i b} \bullet \ln\left(CMHI_{p_i b}\right)}{\sum_{i=1}^{n} H_{p_i b}}\right)}$$

C-4.2. Evaluation of plausible estimation methods for MWRA service area base year MHI

To measure variance and bias, estimates from these methods were compared with actual Census MHI estimates for 15 New England (P)MSAs. Table C-4 presents the results of this comparison. The preferred method of estimating the MWRA service area base year MHI is Base Method 4, which has the lowest variance and least bias. To estimate MWRA MHI in intercensal years, the preferred base year estimate is scaled by the change in component county SAIPE MHI estimates using the same method that was shown to be preferred for estimating (P)MSA MHIs (Method 4 in Section C-3.1).

C-5. Plausible alternatives for forecasting MHIs beyond 2000

Because SAIPE MHI estimates are unavailable after 2000, another source must be used to estimate MHIs after 2000. Similar to Methods 5 and 6 described in Section C-3.1, plausible forecasting methods scale the estimated 2000 MHI by the change in either the state-level MHI or an area CPI. As the results in Tables C-1 through C-3 show, use of the CPI for all items (Method 6) leads to more precise estimates than use of the state-level MHI (Method 5). In addition, CPIs are available through 2003, while state MHI estimates are only available through 2002. Therefore, even though the CPI tracks price movements rather than income movements, we estimate MHIs from 2000 to 2003 using metropolitan area CPIs.

In addition to the CPI for all items, there are also CPIs for all items less energy and for all items less food and energy (which tracks core inflation).[10] We considered these additional CPIs as a basis for estimating MHIs after 2000. To evaluate which CPI results in the most precise and accurate estimates, 1989 and 1999 MHIs were estimated for 73 (P)MSAs by scaling Census year (P)MSA MHIs by the change in each of the three CPIs associated with those (P)MSAs.[11] These estimates were compared with the Census MHIs for the corresponding year to measure variance and bias.

Table C-5 summarizes the results of estimating 1989 and 1999 MHIs based on the change in these three CPIs. These results show that MHI estimates based on growth in the CPI for core inflation (all items less food and energy) have the lowest variance and least bias. Therefore, this CPI is chosen as a basis for estimating 2001 to 2003 MHIs.

C-6. Special case of (P)MSAs with excluded counties

As noted in Appendix B, for certain (P)MSAs, in calculating the (P)MSA's FMR, HUD excludes particular counties that are included in the OMB (P)MSA definition. This is done to

[10] U.S. DOL, BLS, CPI for all items, CPI for all items less energy, and CPI for all items less food and energy, reported for specific urban areas. Available at http://data.bls.gov/labjava/outside.jsp?survey=cu, downloaded February 24, 2004.

[11] Due to missing data, only 73 of the 80 (P)MSAs could be included in this exercise.

account for perceived differences in the rental markets within those (P)MSAs. Four of the 80 (P)MSAs that are considered in our analysis are affected by this adjustment.[12]

To measure appropriately the shelter cost burden in each metropolitan area, the FMR and MHI for the area must be based on the same area definition. For purposes of estimating MHIs for these four PMSAs, so that they can be compared with their associated FMRs in our analysis, it is necessary to account for HUD's exclusion of these counties in MHI estimation. As described in Section C-3, the preferred MHI estimation method for (P)MSAs involves scaling a base year MHI by a scaling factor, which is an average of changes in the SAIPE MHI estimates for each component county. Thus, both the base year estimate and the scaling factor may need to be adjusted to account for HUD's exclusion of particular counties from these four PMSAs.

The scaling factor for each PMSA can be adjusted easily by excluding those counties excluded by HUD from our calculation of the scaling factor. However, we do not adjust the base year Census MHI estimate for the entire PMSA to account for the excluded counties. In 1999, the excluded counties accounted for only 2% to 5% of households in their respective PMSAs.[13] Therefore, it is unlikely that the MHI of the remaining 95% to 98% of households would differ from that for the entire PMSA to an extent that would justify the potential error introduced by alternative MHI estimation methods for the remaining households. In fact, even if we were to adopt estimates that would be produced using the best base year MHI estimation method identified in Section C-4, those estimates of 1999 MHI for the remaining households would differ by no more than 0.3% from Census MHI estimates for the entire PMSA.

C-7. Summary of Preferred Methods

Table C-6 summarizes the methods found to be most precise and accurate, which were used to estimate MHI for our analyses.[14]

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[12] Specifically, three counties are excluded from the Chicago, IL PMSA; five counties are excluded from the Cincinnati, OH-KY-IN PMSA; one county is excluded from the Dallas, TX PMSA; and six counties are excluded from the Washington, DC-MD-VA-WV PMSA.

[13] U.S. DOC, Census Bureau, 2000 Census Summary File 3, Table P14.

[14] These methods differ from that recommended in EPA's *Guidance*: extrapolation of Census MHI estimates at the rate of overall price inflation (growth in the CPI for all items). Our evaluation of alternative methods, including EPA's method, suggests that our estimation methods have the greatest precision and accuracy. EPA (1995), p. 2-7.

Table C-1. Performance of Alternative Estimators of 1999 and 1989 MHI and MHI Growth Rates in 80 (P)MSAs

	Number of (P)MSAs with an MHI Estimate[1]	Variance	Rank[2]	% of Estimates < Actual MHI (Measure of Bias)	Growth Rate Variance[3] 1989 to 1999	Rank[2]	1999 to 1989	Rank[2]	% of Growth Rate Estimates < Actual Growth Rate (Measure of Bias) 1989 to 1999	1999 to 1989
1999 Estimates:										
Method 1	79	7,795,001	4	37%	3.03	4	2.67	4	39%	61%
Method 2	79	7,603,487	3	48%	2.93	3	2.59	3	51%	49%
Method 3	75	3,345,834	2	36%	1.36	2	1.19	2	36%	64%
Method 4	75	2,796,001	1	47%	1.25	1	1.09	1	47%	53%
Method 5	76	16,523,998	6	63%	6.30	6	5.50	6	63%	37%
Method 6	73	10,202,770	5	70%	4.61	5	4.03	5	70%	30%
1989 Estimates:										
Method 1	75	4,438,097	3	53%	2.73	3	2.43	3	44%	56%
Method 2	75	4,719,442	4	63%	2.92	4	2.59	4	35%	65%
Method 3	75	1,662,334	2	64%	1.29	2	1.13	2	34%	66%
Method 4	75	1,432,423	1	51%	1.20	1	1.05	1	47%	53%
Method 5	76	8,949,426	6	37%	5.98	6	5.22	6	60%	40%
Method 6	73	5,597,464	5	30%	4.37	5	3.81	5	66%	34%

Indicates the preferred method used in the analyses.

Notes:
1. Due to missing data, the number of (P)MSAs with MHI estimates in these empirical tests ranged from 73 to 79 across the various methods.
2. Rank is based on variance (i.e., the method with the lowest variance has rank 1).
3. For presentation purposes, actual growth rate variances are multiplied by 100,000.

Table C-2. Performance of Alternative Estimators of 1999 and 1989 MHI and MHI Growth Rates in (P)MSAs with More Than 4 Counties

	Number of (P)MSAs with an MHI Estimate[1]	Variance	Rank[2]	% of Estimates < Actual MHI (Measure of Bias)	Growth Rate Variance[3] 1989 to 1999	Rank[2]	1999 to 1989	Rank[2]	% of Growth Rate Estimates < Actual Growth Rate (Measure of Bias) 1989 to 1999	1999 to 1989
1999 Estimates:										
Method 1	19	1,997,891	2	42%	0.81	3	0.72	3	42%	58%
Method 2	19	2,177,725	3	79%	0.76	2	0.68	2	79%	21%
Method 3	19	3,615,589	4	26%	1.09	4	0.95	4	26%	74%
Method 4	19	679,289	1	63%	0.33	1	0.29	1	63%	37%
Method 5	19	12,882,575	6	47%	5.16	5	4.42	5	47%	53%
Method 6	17	11,748,366	5	88%	5.82	6	5.10	6	88%	12%
1989 Estimates:										
Method 1	19	1,144,272	2	47%	0.69	2	0.60	2	53%	47%
Method 2	19	2,310,691	4	84%	1.52	4	1.33	4	16%	84%
Method 3	19	1,689,929	3	74%	1.09	3	0.95	3	26%	74%
Method 4	19	365,447	1	26%	0.36	1	0.31	1	74%	26%
Method 5	19	5,767,711	5	53%	5.16	5	4.42	5	47%	53%
Method 6	17	6,590,840	6	12%	5.82	6	5.10	6	88%	12%

Indicates the preferred method used in the analyses.

Notes:
1. Due to missing data, the number of (P)MSAs with more than 4 counties with estimates based on these methods ranges from 17 to 19 across the various methods.
2. Rank is based on variance (i.e., the method with the lowest variance has rank 1).
3. For presentation purposes, actual growth rate variances are multiplied by 100,000.

Table C-3. Performance of Alternative Estimators of 1999 and 1989 MHI and MHI Growth Rates in New England (P)MSAs

	Number of (P)MSAs with an MHI Estimate	Variance	Rank[1]	% of Estimates < Actual MHI (Measure of Bias)	Growth Rate Variance[2] 1989 to 1999	Rank[1]	1999 to 1989	Rank[1]	% of Growth Rate Estimates < Actual Growth Rate (Measure of Bias) 1989 to 1999	1999 to 1989
1999 Estimates:										
Method 1	15	30,082,994	6	53%	10.74	6	9.54	6	53%	47%
Method 2	15	29,222,165	5	53%	10.41	5	9.25	5	53%	47%
Method 3	15	3,882,017	1	53%	1.91	2	1.72	2	53%	47%
Method 4	15	3,980,440	2	53%	1.93	3	1.74	3	53%	47%
Method 5	15	26,019,847	4	100%	10.14	4	9.17	4	100%	0%
Method 6	15	4,396,178	3	47%	1.77	1	1.58	1	47%	53%
1989 Estimates:										
Method 1	15	18,126,407	6	33%	10.64	6	9.59	6	67%	33%
Method 2	15	18,081,683	5	33%	10.61	5	9.55	5	67%	33%
Method 3	15	2,450,598	2	47%	1.91	2	1.72	2	53%	47%
Method 4	15	2,543,550	3	47%	1.96	3	1.77	3	53%	47%
Method 5	15	17,549,152	4	0%	10.14	4	9.17	4	100%	0%
Method 6	15	2,412,682	1	53%	1.77	1	1.58	1	47%	53%

Indicates the preferred method used in the analyses.

Notes:
1. Rank is based on variance (i.e., the method with the lowest variance has rank 1).
2. For presentation purposes, actual growth rate variances are multiplied by 100,000.

Table C-4. Performance of Alternative 1999 and 1989 Base Year MHI Estimators in New England (P)MSAs

	Number of New England (P)MSAs with an MHI Estimate	Variance	Rank[1]	% of Estimates < Actual MHI (Measure of Bias)
1999 Estimates:				
Base Year MHI Method 1	15	27,232,367	4	40%
Base Year MHI Method 2	15	9,664,501	2	0%
Base Year MHI Method 3	15	26,702,297	3	40%
Base Year MHI Method 4	15	1,254,084	1	53%
1989 Estimates:				
Base Year MHI Method 1	15	14,931,662	4	47%
Base Year MHI Method 2	15	2,217,224	2	20%
Base Year MHI Method 3	15	14,657,228	3	47%
Base Year MHI Method 4	15	814,022	1	73%

Indicates the preferred method used in the analyses.

Notes:
1. Rank is based on variance (i.e., the method with the lowest variance has rank 1).

Table C-5. Performance of 1999 and 1989 MHI Estimators Based on Scaling by Alternative CPIs in 73 (P)MSAs

CPI	Number of (P)MSAs with an MHI Estimate[1]	Variance	Rank[2]	% of Estimates < Actual MHI (Measure of Bias)	Growth Rate Variance[3]				% of Growth Rate Estimates < Actual Growth Rate (Measure of Bias)	
					1989 to 1999	Rank[2]	1999 to 1989	Rank[2]	1989 to 1999	1999 to 1989
1999 Estimates:										
CPI for all items	73	10,202,770	3	70%	4.61	3	4.03	3	70%	30%
CPI for all items less energy	73	8,650,724	2	63%	3.75	2	3.28	2	63%	37%
CPI for all items less food and energy (core inflation)	73	8,642,854	1	56%	3.62	1	3.17	1	56%	44%
1989 Estimates:										
CPI for all items	73	5,597,464	3	30%	4.61	3	4.03	3	70%	30%
CPI for all items less energy	73	4,643,336	2	37%	3.75	2	3.28	2	63%	37%
CPI for all items less food and energy (core inflation)	73	4,575,447	1	44%	3.62	1	3.17	1	56%	44%

Indicates the preferred method used in the analyses.

Notes:
1. Due to missing data, only 73 of the 80 (P)MSAs could be included in this exercise.
2. Rank is based on variance (i.e., the method with the lowest variance has rank 1).
3. For presentation purposes, actual growth rate variances are multiplied by 100,000.

Table C-6. Summary of Methods Used to Estimate Median Household Income

Year(s)	Area(s)	Preferred Method
1999	Boston, Chelsea, and all (P)MSAs	1999 Census MHI
1999	MWRA service area	Household-weighted average of the component cities' Census MHIs, assuming incomes are lognormally distributed (Base Year Method 4)
1995, 1997, 1998, and 2000	Boston and Chelsea	1999 base MHI estimate scaled by change in Suffolk County SAIPE MHI estimate
1995, 1997, 1998, and 2000	MWRA service area and all (P)MSAs	1999 base MHI estimate scaled by a household-weighted average of changes in each component county's SAIPE MHI (Method 4)
2001 to 2003	All areas	2000 MHI estimate grown by change in area CPI for all items less food and energy

APPENDIX D

Estimates of Shelter Cost Burdens in 80 Metropolitan Areas and the MWRA Service Area

The nationwide distribution of shelter cost burdens associated with meeting EPA's 2% threshold is discussed in Section 3.4 and depicted in Figures 3 through 7. Table D-1 presents the 1997 and 2003 shelter cost burdens in the sample of 80 metropolitan areas that underlie that distribution, before they are adjusted to account for EPA's 2% threshold.[1] Thus, these represent actual shelter cost burdens.

Figure D-1 simply presents the data in Table D-1 in graphical format. In this figure, the unique circumstances of the MWRA service area are clearly demonstrated through a comparison of the MWRA service area's actual shelter cost burdens with the actual shelter cost burdens in the remaining metropolitan areas.[2] Each metropolitan area is represented by a single point. Each point's vertical position, measured on the y-axis, indicates the metropolitan area's shelter cost burden in 2003. Its horizontal position, measured on the x-axis, indicates the area's shelter cost burden in 1997. The dashed line includes all points where 2003 shelter cost burdens equal 1997 burdens. Therefore, the further above the dashed line a metropolitan area is, the more its shelter cost burden increased from 1997 to 2003. As Figure D-1 shows, the MWRA service area's actual shelter cost burden in 2003 was higher than that in all but 3 of the other metropolitan areas examined. Moreover, as is indicated by the vertical distance of the MWRA service area's point from the dashed line, from 1997 to 2003, only two other metropolitan areas' shelter cost burdens grew more than did the shelter cost burden in the MWRA service area.

[1] The actual shelter cost burden in the MWRA service area is not included in the distribution presented in Figures 3 through 7, but for comparison it is included at the top of Table D-1. However, the Boston PMSA is included in the nationwide distribution of shelter cost burdens shown in Figures 3 through 7 and Table D-1. For consistency with the geographic definition of other metropolitan areas that make up this distribution, the shelter cost burden for the Boston metropolitan area used in Figures 3 through 7 and Table D-1 is based on the FMR and MHI of the Boston PMSA, rather than those of the MWRA service area.

[2] The shelter cost burden for the Boston PMSA is excluded from Figure D-1.

Table D-1. Shelter Cost Burdens (% of MHI) in 80 Metropolitan Areas

Metropolitan Area[1]	1997	2003	2003 Rank
MWRA Service Area	**20.5%**	**25.5%**	**NA**
Akron, OH	15.5%	17.0%	55
Anchorage, AK	15.8%	15.8%	70
Ann Arbor, MI	15.2%	15.3%	76
Atlanta, GA	15.6%	18.3%	31
Atlantic-Cape May, NJ	20.8%	20.5%	16
Baltimore, MD	15.2%	17.9%	40
Bergen-Passaic, NJ	18.7%	17.8%	42
Boston, MA-NH	19.5%	24.4%	5
Boulder-Longmont, CO	16.7%	18.4%	29
Brazoria, TX	15.4%	16.1%	67
Bremerton, WA	15.8%	17.6%	47
Bridgeport, CT	16.7%	16.7%	57
Brockton, MA	17.1%	19.5%	19
Chicago, IL	18.2%	18.0%	36
Cincinnati, OH-KY-IN	14.7%	16.3%	63
Cleveland-Lorain-Elyria, OH	15.8%	18.6%	26
Dallas, TX	15.8%	17.9%	39
Danbury, CT	15.4%	15.5%	72
Denver, CO	15.3%	17.9%	38
Detroit, MI	14.7%	15.4%	74
Dutchess County, NY	19.8%	19.8%	17
Fitchburg-Leominster, MA	16.4%	17.5%	51
Flint, MI	13.5%	14.8%	78
Fort Lauderdale, FL	21.5%	19.2%	22
Fort Worth-Arlington, TX	15.5%	16.2%	66
Galveston-Texas City, TX	16.0%	16.6%	59
Gary, IN	16.2%	17.6%	46
Greeley, CO	17.0%	18.1%	34
Hagerstown, MD	14.7%	14.7%	79
Hamilton-Middletown, OH	14.5%	14.5%	80
Honolulu, HI	23.7%	17.1%	54
Houston, TX	16.4%	17.7%	44
Jersey City, NJ	24.5%	26.3%	3
Kankakee, IL	15.4%	16.3%	64
Kansas City, MO-KS	13.6%	15.4%	75
Kenosha, WI	14.7%	15.4%	73
Lawrence, MA-NH	16.0%	17.5%	48
Los Angeles-Long Beach, CA	25.9%	23.6%	7
Lowell, MA-NH	15.4%	17.5%	50
Manchester, NH	16.2%	16.6%	60
Miami, FL	26.5%	23.0%	8

Table D-1. Shelter Cost Burdens (% of MHI) in 80 Metropolitan Areas (Continued)

Metropolitan Area[1]	1997	2003	2003 Rank
Middlesex-Somerset-Hunterdon, NJ	16.9%	17.5%	49
Milwaukee-Waukesha, WI	15.5%	15.9%	68
Minneapolis-St Paul, MN-WI	14.6%	16.7%	58
Monmouth-Ocean, NJ	19.3%	18.5%	28
Nashua, NH	15.6%	15.9%	69
Nassau-Suffolk, NY	19.1%	19.0%	24
New Bedford, MA	19.9%	21.1%	14
New Haven-Meriden, CT	20.8%	18.8%	25
New York, NY	26.4%	26.2%	4
Newark, NJ	17.7%	16.4%	62
Newburgh, NY-PA	20.7%	16.5%	61
Oakland, CA	17.7%	22.4%	10
Olympia, WA	17.0%	18.3%	30
Orange County, CA	17.7%	19.4%	21
Philadelphia, PA-NJ	18.1%	18.1%	35
Pittsburgh, PA	15.8%	17.7%	43
Portland-Vancouver, OR-WA	16.2%	18.0%	37
Portsmouth-Rochester, NH-ME	17.1%	18.2%	33
Racine, WI	13.3%	13.5%	81
Riverside-San Bernardino, CA	17.7%	16.9%	56
St Louis, MO-IL	13.5%	15.5%	71
Salem, OR	17.3%	17.6%	45
San Diego, CA	19.4%	21.6%	12
San Francisco, CA	21.1%	31.1%	2
San Jose, CA	17.1%	22.6%	9
Santa Cruz-Watsonville, CA	23.6%	24.2%	6
Santa Rosa, CA	19.6%	21.7%	11
Seattle-Bellevue-Everett, WA	16.2%	18.5%	27
Stamford-Norwalk, CT	17.2%	19.5%	20
Tacoma, WA	16.1%	17.1%	53
Tampa-St Petersburg-Clearwater, FL	19.4%	19.6%	18
Trenton, NJ	17.2%	17.2%	52
Vallejo-Fairfield-Napa, CA	16.9%	20.7%	15
Ventura, CA	16.8%	17.9%	41
Vineland-Millville-Bridgeton, NJ	21.2%	21.4%	13
Washington, DC-MD-VA-WV	16.7%	18.2%	32
Waterbury, CT	18.8%	19.1%	23
Wilmington-Newark, DE-MD	15.7%	15.0%	77
Worcester, MA-CT	18.5%	16.2%	65

Notes:

1. All metropolitan areas except the MWRA service area are either Metropolitan Statistical Areas (MSAs) or Primary Metropolitan Statistical Areas (PMSAs), as defined by the U.S. Office of Management and Budget.

Figure D-1

Actual Shelter Cost Burden in the MWRA Service Area Compared With the Shelter Cost Burdens in 79 Other Metropolitan Areas: 1997 and 2003