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Future Accrual of Capital Repair and Replacement Needs of Public Housing

Final Report

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Chapter 1

Introduction and Overview of Results

In June 1983, the U.S. House of Representatives mandated the U.S. Department of Housing and Urban Development to conduct a study to determine the physical renovation needs of the nation's Public and Indian Housing stock and to estimate the cost of correcting deficiencies and subsequently maintaining that housing stock in adequate physical condition. The Housing and Community Development Act of 1987 repeated that mandate. Congressional and HUD interest was spurred by concern that the current Comprehensive Improvement Assistance Program (the major existing program for funding the modernization of Public Housing) might not be meeting the needs of certain segments of the aging inventory.

Beginning in December 1983, Abt Associates Inc. of Cambridge, Massachusetts, designed and conducted a comprehensive survey of the modernization needs of a representative sample of Public and Indian Housing developments throughout the country. Some 2,194 dwelling units and 3,120 residential buildings at 1,000 Public Housing developments were inspected by more than 80 architects and engineers utilizing specially designed methods of measuring and costing modernization needs.

The inspections involved the count and measurement of the individual components of each of 101 observable building systems, which represent an inclusive list of the physical aspects of a project (e.g., boilers, windows, floors, sidewalks, etc.). The inspections also included a rating of the repair/replacement actions which were needed for each of the observed components. These repair/replacement actions ranged from no action needed, to minor repair, to total replacement of all components of a system. For each possible system action, the R.S. Means Company developed an associated cost to perform that action (with appropriate adjustments for builder overhead/profit on differing size jobs and different geographic construction costs). The data base which resulted from the inspections contains approximately 277,000 individual observations on 101 different systems in each of the sampled developments. This cross sectional evaluation of the condition of the Public Housing stock as of mid-1985 is the primary data base for the Modernization Needs Study.

The first report of the Modernization Needs Study was prepared by Abt Associates and assessed the current (backlog) level of modernization required for the health, safety, building integrity, and viability of the Public Housing stock.[1] That report provided estimates of the (1) repairs and replacements needed on the current physical components of projects (FIX), (2) additions and upgrades to the current physical components (ADDs), (3) reconfiguration actions to improve long-term project viability (REDESIGN),

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[1] <u>Study of the Modernization Needs of the Public and Indian Housing Stock -- National, Regional and Field Office Estimates: Backlog of Modernization Needs</u>, Bain, Dixon, <u>et</u>. <u>al</u>., Abt Associates Inc., Cambridge, MA, March 1988.

(4) actions to increase energy efficiency and reduce energy costs (ENERGY CONSERVATION), (5) modifications to Public Housing units and common spaces to make them more accessible to the handicapped (ACCESSIBILITY), (6) the abatement of lead-based paint hazards (LEAD-BASED PAINT ABATEMENT), and (7) the cost of modernizing the Indian housing stock.

This second report in the Modernization Needs series, "Future Accrual of Capital Repair and Replacement Needs of Public Housing," examines the amount of funds that will be needed in the future to repair and replace developments' physical components as they wear out and the implications of different funding levels on projected needs. In addition, an appendix to this report presents revised estimates of the 1985 FIX backlog. Such revisions were necessitated by the identification of systematic errors in the underlying data base and estimating procedures that were used to generate the original Abt statistics.

Two additional reports from the Modernization Needs Study are scheduled to be released at a later date. The third report, "Project Characteristics Associated with the Modernization Needs of Public Housing," will analyze the relationship between repair and replacement needs and the characteristics of housing developments, including age, type of building, location, and type of occupancy. The fourth report, "Evaluation of the Comprehensive Improvement Assistance Program," will examine PHA, project manager, and field office responses to questions about the effectiveness of the CIAP.

1.1 Scope of Report

The principal objective of this report is to estimate, on a yearly basis, the additional repair and replacement needs that will accrue in Public Housing over the next fifteen years. We begin by making a deliberate over-simplifying assumption that the repair and replacement needs found at the time of the 1985 inspections have all been met and that future needs are addressed in a timely fashion. On the basis of these assumptions, we estimate the needs that will arise in each subsequent year as a result of the physical aging of building components. These "baseline" accrual forecasts, in combination with the estimated backlog, provide a critical starting point for understanding the minimum level of expenditures that would be required to repair and maintain the Public Housing stock. These "baseline" estimates provide us the benchmarks to make estimates under other assumptions.

We then relax our initial assumptions in order to examine the accrual that would occur under more realistic circumstances. Such estimates are used to update the original Abt backlog estimates to account for the additional needs that may have occurred since 1985. They are also used to estimate accrual on the other categories of needs identified in the first report, and to assess the long-term implications of alternative appropriation levels.

The baseline accrual estimates presented in this report reflect three distinct types of needs: (1) age-related accrual associated with the systems and physical configurations that were present at the time of the Abt inspections (AGE Accrual); (2) estimates associated with extraordinary events such as fires, vandalism, or natural disasters (EXTRAORDINARY Needs); and (3) accrual associated with ADDs (ADDs Accrual) and other categories of the backlog. As described in Chapter 2, our estimating procedures differ according to the type of need explored, although each employed the cost and inspection data which were developed by Abt Associates.

1.2 Baseline Accrual Forecasts

Exhibit 1.1 presents our baseline estimates of the costs of meeting the ongoing capital repair and replacement needs of Public Housing over the next 15 years, assuming that all existing (FIX) deficiencies have been corrected and that Mandatory ADDs have been addressed.[2] All costs have been expressed in 1988 dollars, and have been adjusted to reflect the net increase in the size of the Public Housing stock that has occurred since 1985.

The first column in the chart depicts the accrual that would be associated with the stock as currently configured. Such accrual results from the predictable failure of building components from aging and wear and tear (i.e., AGE Accrual). The second column presents the accrual that would occur as a result of Mandatory ADDs (ADDs Accrual). The third column represents a total of columns 1 and 2, and is presented for illustrative purposes only. Several potentially significant costs are not included in the sum, including costs associated with extraordinary events and costs associated with other possible ADDs events.

The AGE Accrual estimates (Column 1) were generated by an Accrual Forecasting Model which used information on the current ages, conditions, and expected lifetimes of all existing building systems to predict component failure and replacement needs in future years. These age-related needs range from $1,113 million (or $857 per unit) in the initial year to $1,532 million in the fifteenth year (or $1,179 per unit).

Column 2 presents the projected accrual needs associated with Mandatory ADDs.[3] As before, these baseline accrual estimates assume that the ADDs actions have been addressed. The projected ADDs accrual reflects the additional aged-related needs that will arise over time to keep these additional building components in good repair. Estimated accrual ranges from

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[2] The ADDs identified by the PHA's were rated by the on-site inspectors on a scale of 1 to 5. The inspector's second opinion (ISO) ratings of 1 or 2 indicated agreement with the need stated by the PHA. ISO ratings of 3 or higher indicate no opinion or disagreement with the PHA. Mandatory ADDS have been defined to include ISO categories 1 and 2 required by Code or Modernization Standards. For estimates of the additional accrual that would be associated with other ADDs actions, see Exhibit 3.7.

[3] Because of the higher likelihood that mandatory ADDs events will have taken place, the accrual costs associated with these have been presented in Exhibit 1.1. The presentation of the accrual costs associated with other ADDS events in Exhibit 3.7 allows for the inclusion of other ADDs into any projected total accrual cost.

Exhibit 1.1

Estimated Baseline Accrual Needs by Year: 1988 Dollars
(millions)

	AGE Accrual	Mandatory ADDs Accrual [1]	AGE Plus Mandatory ADDs Accrual
Year 1	$1,113	$12	$1,125
Year 2	$1,145	$13	$1,158
Year 3	$1,179	$13	$1,192
Year 4	$1,212	$14	$1,226
Year 5	$1,245	$14	$1,259
Year 6	$1,277	$15	$1,292
Year 7	$1,311	$16	$1,327
Year 8	$1,345	$17	$1,362
Year 9	$1,378	$17	$1,395
Year 10	$1,409	$18	$1,427
Year 11	$1,439	$19	$1,458
Year 12	$1,468	$20	$1,488
Year 13	$1,494	$21	$1,515
Year 14	$1,516	$23	$1,539
Year 15	$1,532	$24	$1,556

[1] The ADDs identified by the PHA's were rated by the on-site inspectors on a scale of 1 to 5. The inspector's second opinion (ISO) ratings of 1 or 2 indicated agreement with the need stated by the PHA. ISO ratings of 3 or higher indicate no opinion or disagreement with the PHA. Mandatory ADDS have been defined to include ISO categories 1 and 2 required by Code or Modernization Standards. For estimates of the additional accrual that would be associated with other ADDs actions, see Exhibit 3.7. This estimate is based on the assumption that all recommended mandatory ADDs actions had been fully implemented.

a minimum of $12 million in Year 1 -- when the ADDs components are new - to $24 million by the end of the forecast period. These aggregate statistics translate into per-unit annual averages of $9 and $18, respectively.

Periodically, repair needs arise from unpredictable extraordinary events such as fires, natural disasters, or vandalism. Because of their unpredictability, it is impossible to estimate with any certainty the amount of these repair needs which might arise in any year. For purposes of this study, we estimated the costs of meeting these types of repair needs in the year proceeding the inspection to be $515 million, or $397 per unit. This estimate was derived by assuming that the same proportion of observed extraordinary repair needs arose in the prior year as the proportion of Age-related repair needs estimated to have occurred in the prior year based on the Age-related accrual model. Additionally, because of the nature of these events, some portion of the cost of the repairs associated with them would be reimbursed through insurance (or self-insurance) funds, and would not be a charge to modernization funds. The extent of insurance coverage or availability of non-CIAP funds for these events was beyond the scope of this study.

1.3 Accrual Under More Realistic Assumptions

The baseline accrual forecasts depict the ongoing repair and replacement expenditures that would be required under an adequately funded, well maintained system. These forecasts assume that all existing deficiencies have been corrected and that future repair and replacement needs are addressed on a timely basis.

The second part of the study examines accrual under a more realistic set of assumptions and, in particular, estimates the ongoing accrual that is likely to occur under existing funding levels. This enables us to address two separate issues: (1) what is the probable backlog in 1988?; and (2) how is this backlog likely to change in future years under alternative funding scenarios?

The procedures which were used to derive these forecasts are less precise than those which underlie the baseline accrual estimates, and are based on a number of key assumptions that could affect the results significantly. As a result, the statistics presented here should be interpreted with caution, and only used to establish broad benchmarks for the probable impact of future appropriation levels. The key assumptions are: (1) actual PHA spending on modernization conforms to the categories approved by HUD Field Offices. In the absence of actual PHA spending information, data from the Field Office Data Entry Modernization Approval Data System (FODEMADS) were used to estimate expenditures; and (2) recent patterns of expenditure between types of categories (Fix, Mandatory ADDs, etc.) remain the same into the future.

Exhibit 1.2 presents estimates of the backlog of modernization needs in Public Housing in 1985 and 1988. The original Abt estimates have been adjusted to correct for systematic errors in the underlying data base (see Appendix D), and then updated to reflect 1988 prices and the current size of

Exhibit 1.2

Revised Backlog Estimates

	1985 Original Backlog (1985 $)[1]	1988 Updated Backlog (1988 $)[2]	1988 Unfunded Backlog (1988 $)[3]
FIX	$8,520.0	$11,918.8	$9,919.6
Mandatory ADDS			
ISO 1 & 2	$881.0	$778.1	$571.4
3	$408.3	$432.1	$432.1
4	$170.3	$180.2	$180.2
5	$105.7	$111.9	$111.9
Project Specific ADDs			
ISO 1 & 2	$5,470.4	$5,487.0	$5,162.4
3	$2,028.1	$2,146.3	$2,146.3
4	$1,211.9	$1,282.5	$1,282.5
5	$584.1	$618.1	$618.1
Misc. ADDs			
No ISOs	$515.4	$545.4	$545.4
Other ADDs	$6.1	$6.5	$6.5
HUD Prohibited	$104.8	$110.9	$110.9
Redesign	$2,063.0	$2,123.0	$2,057.9
Lead Abatement	$446.0	$448.9	$372.7

[1] The Backlog of Modernization Needs report prepared by Abt Associates reported a FIX estimate of $9,307 million. Subsequent corrections in the data base and estimation procedures led to a revised estimate of $8,520 million expressed in 1985 dollars. No other categories of the original report have been affected by the data revisions.

[2] All estimates have been revised to 1988 dollars, an 5.83 percent increase. The FIX estimate has been increased by 3.17 percent to account for additions to the inventory between 1984 through 1988. Estimated accrual and costs of delay have been added to all categories. The FIX estimate does not contain possible accrual costs associated with extraordinary events.

[3] This is the result of subtracting the unexpended but approved CIAP funds from the updated Backlog estimate.

Exhibit 1.2 (Continued)

	1985 Original Backlog (1985 $)	1988 Updated Backlog (1988 $)	1988 Unfunded Backlog (1988 $)
Energy[4]	$939.0	$745.2	$601.3
Handicapped[5]	$232.0	$241.8	$233.6

[4] As suggested in the original Backlog Report, the ENERGY study estimate is used rather than the ENERGY ADDs estimates.

[5] As suggested in the original Backlog Report, the HANDICAPPED estimate of this report is based upon the HANDICAPPED ACCESSIBILITY estimate and one half of the estimate of HANDICAPPED ADDs, ISO 1 and 2.

the housing stock. The statistics also incorporate the net effects of ongoing accrual and modernization expenditures that have occurred since 1985.

Since Abt designed and conducted the survey of modernization needs in 1985, legislative and potential regulatory requirements for lead-based paint abatement have been considerably broadened. The cost of lead abatement activities may be substantially higher than the cost estimated in this report. Similarly, the 504 regulations governing the required availability of handicapped accessible units were issued in 1988. The cost reported may not accurately reflect the implications of the 504 regulations.

According to our estimates, modernization needs associated with categories other than FIX have remained relatively constant over time and, in real terms, have actually declined. However, estimated FIX needs rose from $8,520 million in 1985 to $11,919 million in 1988 as described below. Measured in 1988 dollars, the backlog grew at an average annual rate of 8.7 percent.

The increase in the estimated FIX backlog reflects a 3 percent growth of the Public Housing stock, as well as a significant difference between ongoing FIX accrual (about $1.3 billion per year) and assumed annual expenditures on FIX-type needs ($512 million per year).[4] Ongoing accrual arose from two different sources: (1) normal age-related accrual as estimated by the accrual model; and (2) postponed capital replacements (cost of delay) which gave rise to needs that would not be observed if repairs had been made on a timely basis (e.g., roofing beams damaged by long-lasting leaks in the roof). The last source of accrual increased annual costs by about 8.7 percent, and would not occur under an adequately funded, well maintained system.

Exhibit 1.3 projects changes to the existing FIX backlog under alternative assumptions regarding future CIAP appropriations. To control for inflation, all costs have been measured in 1988 dollars. Appropriation levels have been expressed as a percentage of the total funds available in 1988 (i.e., $1,749 million). Thus, the "100% increase" scenario represents a doubling of 1988 CIAP funding, adjusted for inflation.

Based on program experience, the projections assume that approximately 84% of annual appropriations are available for meeting the modernization costs considered by this study. They also assume that the allocation of CIAP funding across the various categories of need will remain as they have in the recent past.

As shown in the exhibit, if appropriations remain at their current levels (in real terms) and if the patterns of modernization expenditures also continue as they were in 1987, the FIX backlog will rise from $11,918.8 million in 1988 to $18,021.2 million in 2000. The annual appropriations

[4] Both the accrual and expenditure data have been translated into 1988 prices.

Exhibit 1.3

Estimated Public Housing Backlog in Selected Years Under Different Funding Levels (in millions, 1988 $)

Estimation Year	Annual Funding Level: Current Level[1] 1995	Current Level[1] 2000	100% Increase[2] 1995	100% Increase[2] 2000	150% Increase[3] 1995	150% Increase[3] 2000
FIX	$15,224.8	$18,021.2	$11,071.5	$7,112.9	$8,792.1	$1,412.2
Mandatory ADDs						
ISO 1 & 2	$212.8	$0.0	$0.0	$0.0	$0.0	$0.0
ISO 3	432.1					
ISO 4	$180.2		Unchanged		Unchanged	
ISO 5	111.9					
Project Specific ADDs						
ISO 1 & 2	$4,642.2	$3,993.6	$4,064.5	$2,700.2	$3,775.5	$2,052.8
ISO 3	2,146.3					
ISO 4	$1,282.5		Unchanged		Unchanged	
ISO 5	618.1					
Misc. ADDs						
No ISO	545.4					
Others	$6.5		Unchanged		Unchanged	
HUD Prohibited	110.9					
Redesign	$1,953.9	$1,824.2	$1,838.4	$1,565.7	$1,780.6	$1,436.15
Lead Abatement	$180.2	$0.0	$0.0	$0.0	$0.0	$0.0
Energy	$386.6	$118.7	$135.4	$0.0	$9.8	$0.0
Handicapped	$245.5	$225.6	$228.4	$187.4	$219.9	$168.2

[1] Non-Indian, Hard Cost Appropriations of $1,476 annually between 1989 and the year 2000.

[2] Non-Indian, Hard Cost Appropriations of $2,952 annually between 1989 and the year 2000.

[3] Non-Indian, Hard Cost Appropriations of $3,689.9 annually between 1989 and the year 2000.

directed towards FIX ($1,048 million) will not offset the new accrual needs that arise in every year (between $1,113 and $1,532 million). However, the annual growth of the backlog (3.5 percent per year) will be considerably less than the increase observed between 1985 and 1988 (8.7 percent per year). Due to the relatively long lag between allocations and expenditures, the dramatic increase in CIAP funding that occurred in 1987 had only a small effect on actual spending during the 1985-1988 period.

Increasing funding levels significantly above the current level would reduce the existing backlog over time. For example, doubling current expenditures (i.e. a 100 percent increase) would reduce the backlog by roughly 40 percent over the 12-year period. Increasing funding by 150 percent would eliminate the FIX backlog by the turn of the century. Again, the composition of CIAP expenditures is assumed to remain as it was observed in 1987-88. Obviously, if the allocation of expenditures between categories changes, the projected FIX backlog would be affected.

It is also important to recognize that the scenarios which have been presented in the chart show only part of the overall funding picture. While the existence of a sizable FIX backlog will necessitate funding levels that are considerably above those required to meet ongoing accrual needs, once the backlog has been funded, appropriations could drop to their "steady-state" maintenance levels. The projections presented in Exhibit 1.3 assume a six-year lag between the initial appropriation and the spending of all appropriated funds.[5] As a result, the FIX backlog can be fully funded considerably before the existing backlog has been eliminated.

According to our estimates, if appropriations remain at their current levels and if the patterns of modernization expenditures continue as they were observed in 1987-88, the backlog will never be fully funded. However, "full funding" of the FIX backlog would be achieved by 1996 if annual appropriations were increased over 1988 levels by 150 percent, and by 1994 if appropriations were tripled. Once the backlog was fully funded, appropriations for FIX events could drop to the level required to meet ongoing accrual needs, which would be about $1,500 million per year.

1.4 Contents of the Report

The remainder of this report is organized into three chapters and a number of supporting appendices. Chapter 2 describes the study methodology. Chapter 3 presents the baseline accrual estimates. Chapter 4 projects changes to the existing backlog that would arise under alternative funding levels. Appendix A presents estimates of the baseline AGE accrual needs by building system; Appendix B describes the specific replacement actions that were forecast by the baseline Accrual Forecasting Model, along with the expected system lives; Appendix C contains a technical description of the accrual model; and Appendix D presents the revised 1985 FIX backlog estimates.

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[5] This lag reflects the recent experience under CIAP.

Chapter 2

Methodology

This chapter describes the procedures which were used to derive baseline estimates of the annual ongoing capital repair and replacement needs in Public Housing. Three types of needs are projected: (1) ongoing needs associated with the wear and tear of building systems as currently configured (AGE Accrual); (2) extraordinary needs associated with fires, vandalism, and other acts of God (EXTRAORDINARY Accrual); and (3) additional accrual associated with modifications to the existing stock as a result of ADDs (ADDs Accrual). These baseline accrual estimates assume that all existing deficiencies have been corrected (including ADDs), and that future repair and replacement needs are made on a timely basis.

The heart of our methodology is the Accrual Forecasting Model, which predicts the age-related repair and replacement needs of the stock as currently configured. The model takes information on the age, condition, and mix of building components in the existing stock, and uses well-established forecasting techniques to project capital repair and replacement needs for future years. These projections comprise the baseline AGE Accrual estimates. In addition, by varying certain key assumptions regarding the initial age and condition of building systems, the Accrual Forecasting Model can be used to estimate accrual associated with other types of needs (e.g., EXTRAORDINARY events and ADDs).

This chapter begins with an overview of the underlying data base. It then describes the Accrual Forecasting model, and enumerates the specific steps that were involved in estimating the baseline AGE accrual needs. It then describes our procedures for producing baseline estimates of the annual accrual associated with extraordinary events, ADDs, and other types of needs. A more detailed technical description of the forecasting model is presented in Appendix C.

2.1 The Data Base

The starting point for this investigation was the Modernization Needs data base constructed by Abt Associates to determine the physical condition of the Public Housing stock and the costs associated with correcting any identified deficiencies. The data base incorporates the results of physical inspections of 2,194 dwelling units and 3,120 buildings at a representative sample of 1,000 Public Housing developments. Each observation was weighted to ensure that the sample results reflect the conditions in the overall stock of Public Housing, which contains approximately 1.3 million units in over 11,000 projects.

At each development in the sample, inspectors examined and rated the condition of 101 possible architectural and engineering systems (inclusive of all physical aspects of a development).[6] Systems reflect observable components of the building (e.g., foundation, boiler, stairs), the unit (e.g., kitchens, bathrooms, interior doors) and the site (e.g., roads, sidewalks, earthwork). Subsystems are also identified when there are significant cost or physical differences among types or sizes within a given systems category. (For example, there are distinctions between concrete, masonry, wood, and stone retaining walls.)

The inspection procedure resulted in a data base of roughly 277,000 observations, where each observation contained information on the size or specification of the system (e.g., square footage of wall space, number of windows), as well as an associated "fix level," a code indicating the nature of the repair required to restore the system to acceptable condition.[7] A fix code of zero always indicated "no action required." Fix codes greater than zero indicated that various repairs and replacements were needed, with higher levels typically representing more extensive and/or expensive actions. Exhibit 2.1 shows a typical classification scheme for boilers, although the meaning of fix levels (other than zero) may be different for other systems.

The data base also includes a specialized cost estimation file which can be used to calculate the cost of completing all required replacements and repairs. For each system/subsystem and fix level, there is a unique unit cost associated with correcting the associated deficiency. That unit cost, in turn, can be multiplied by the quantity involved to derive an estimated cost of repair. For example, interior solid wooden doors cost $322 each; if 100 such doors require replacement in a given development, the total costs of correcting these deficiencies would be $32,200. All repair and replacement costs are assumed to be additive and independent of other actions. As a result, total modernization needs within a given project can be derived by summing up the estimated repair and replacement costs of the different systems in the project's sites, buildings, and units.

The primary data base of 277,000 system-level observations developed by Abt Associates had been subjected to only partial data evaluation and correction procedures. Supplemental data cleaning procedures initiated as part of the accrual analysis uncovered systematic errors in certain weighing and imputation procedures that necessitated a number of significant changes to the original data base. As described in Appendix D, the use of this revised data base had a significant impact on the level and distribution of the estimated FIX backlog. The figure reported by Abt in its National Estimate Report was $9,307 million. The revised data base and estimation procedures yielded an estimate of $8,520 million.

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[6] For a detailed description of the inspection process, see Modernization Needs of the Public and Indian Housing Stock: Training Manual, D. Bain, et al., Abt Associates.

[7] For a description of the specific repair/replacement actions within each system, see Inspection Handbook: Observable Systems, Abt Associates, April 18, 1985.

Exhibit 2.1

Fix Level Definitions for Boilers, System 65

Fix Level	Condition Description
0	No action required; system in good condition
1	Minor component needs repair or replacement
2	One of the major components has failed
3	Two of the major components have failed
4	Entire boiler should be replaced

2.2 Overview of the Accrual Forecasting Model

The Accrual Forecasting Model (AFM) uses survival modeling techniques to develop estimates of aggregate failure and replacement rates for the different systems and to forecast the cost of recurring needs that are a predictable function of system age.[8] The model relies on hazard rate curves, or functions, which specify the probability that a given system fails as a function of system age.

Survival models are based upon well-developed techniques and concepts found in probability theory,[9] and forecast the probability of an event -- death or failure -- based on the age of the component. While failure is typically viewed as a once-in-a-lifetime event, survival models can also be used to model successive overhauls of a machine. In this case, each overhaul event is predicted by different models, or by the same model, with the age of the individual system reset to zero after each successive failure.

The Accrual Forecasting Model uses concepts from survival modeling to estimate the number of building systems which will fail in a given year, and to derive an expected cost. The heart of the AFM is the notion that systems wear out over time. This notion is captured in a relationship that predicts whether a system will need repairs or replacement in any particular year based on the age of that system and its expected lifetime.[10] Such predicted relationships are applied to each system/subsystem observation in the data base to estimate aggregate repair needs in each of fifteen future years. The model changes age and repair status after each year is simulated to reflect the predicted consequences of the needed repairs and replacements of the stock.

Several key parameters are embedded in the forecasts. The first relates to the existing backlog of FIX modernization needs. The model starts with the assumption that all existing needs have been met, i.e., the starting point is a stock in good repair. The model also calculates the future accrual as if subsequent repairs and replacements are made on a timely basis, so that backlog never accumulates. Replacements occur within six months of the predicted failures, and the ages of the replacement components are set to zero; repairs and major overhauls occur on an as-needed basis, but the affected systems continue to age. Finally, the model assumes that the repair and replacement needs of different systems are independent, and that their failure rates and associated repair and replacement costs can be treated in a separate and additive manner.

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[8] See Appendix C for a technical description of the model.

[9] See, for example, Elandt-Johnson, R.C. and Johnson, N.L., Survival Models and Data Analysis, John Wiley and Sons, Inc., 1980.

[10] There are about 150 such relationships; one for each system/subsystem with variations for whether the system was in a family or elderly project.

2.3 Developing the AGE Accrual Forecasts

The development and implementation of the AFM was a four-stage process, and involved:

- establishing the definition of accrual events;
- selecting the best estimates of system lives;
- imputing the ages of systems with missing information; and
- adjusting the accrual forecasts to reflect the size of the stock and the level of construction costs in 1988.

This section discusses each of these activities in turn.

2.3.1 Defining Accrual Events

The first step in developing the accrual model was to identify the different FIX levels that would be included in the simulations. Not all FIX levels in the original modernization needs survey are accrual events that would occur under a well-funded system. Some repair/replacement events included in the inspection survey represent ordinary maintenance items, for example, replacing selection buttons in an elevator cab or repairing a minor component of a boiler.[11] Others would never be observed in a well managed project, because they result from the failure to address a lower-level condition in a timely fashion. For example, if the roof were resurfaced as needed, roof structure damage (such as rotting support beams) should never occur. Finally, there are some FIX level conditions that reflect extraordinary events which are not a normal function of system age, for example, "settling, buckling or displacement of the building foundation" or damage caused by fires and vandalism. While such unexpected events will

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[11] The distinction between maintenance and capital repairs was applied in the original design of the inspection instrument (although irregularly) in that these maintenance items were typically expunged from the inspector's coding sheets. For instance, screen doors could be coded only as being in good condition (fix level zero) or being in need of complete replacement. Clearly, one or more of the screens in a screen door can be cut or torn and need replacement, but this possibility was omitted in the instrument because it was not part of modernization needs or accrual, even if it accurately described the condition of the system. However, the rule was not applied uniformly, so the final modernization needs data contained numerous observations on routine maintenance. Abt Associates corrected for this in their estimation procedure of the backlog by screening out repairs under $100.

undoubtedly occur in future years, they are not a predictable function of system age.[12]

To identify the specific repair and replacement events that were included in the AFM, we assembled a panel of housing practitioners from both the public and private sectors who were familiar with building maintenance and operations, as well as with the unique management environment of Public Housing. The panel was asked to categorize the different FIX levels within each system and subsystem into the following types of events:

(1) repairs and replacements which, under an adequately funded and well-maintained system, would be covered under routine project maintenance (the M events);

(2) repairs and replacements that are the result of postponed maintenance/replacement and would not be expected to occur if needs were addressed on a timely basis (the S events);

(3) ongoing capital replacement needs directly related to system age (the A events); and

(4) extraordinary repair and replacement needs that arise over time, but are not related to system age and, therefore, cannot be forecast as a recurring event (the E events).

The last two repair and replacement categories represent actions that are considered in the baseline accrual estimates.

The classification scheme devised by our panel was subsequently submitted to technical representatives of the study's Research Advisory Group. Several changes were initiated as a result of their review. The final classifications on which the model is based are presented in Appendix B.

2.3.2 Estimating Expected Lives

The next step in developing the necessary information to run the model was to estimate an expected life --or frequency of replacement/repair -- for every defined accrual event. The system inspection data base provided a profile of the condition of the stock at a point in time. Although the inspectors obtained some information on system age and the age of recently replaced components, the data do not indicate the frequency of replacements or whether a given system had ever been replaced. The data set also lacks information on how long the observed repairs and replacements had been needed,

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[12] In addition, some FIX level conditions are redundant with other replacement events in the forecast. For example, FIX levels 2 and 3 for boilers (shown in Exhibit 2-1) are redundant in a forecast. FIX level 2 requires the replacement of one minor component; FIX level 3 indicates that two minor components need to be replaced. For purposes of the forecast, only the first event was simulated.

making it difficult to distinguish between accrual events that occurred in the survey year (1985) and the backlog of needs that were carried over from the past.

Since we did not have direct observations on the ages at which systems failed, we relied on an iterative approach in establishing the expected lives of the various building systems. This approach was taken because of the absence of applicable industry standards on the lives of physical systems and the fact that commonly used rules of thumb are often driven by tax considerations which are irrelevant for Public Housing. It was also difficult to incorporate the effects that the unique environment and needs of Public Housing might have on the useful lives of physical systems.

Our procedure for establishing useful lives relied on cross-sectional estimates derived from the data themselves, as well as on the opinions of an expert panel assembled specifically for this study and the technical representatives of the study's Research Advisory Group. Four different sources of information were considered, including:

- regression estimates based on the inspection data;
- available industry estimates;
- comparisons of model predictions against the actual survey data; and
- expert opinion.

By examining each of these sources, and by assessing the reasonableness of the accrual forecasts that resulted from different assumptions, we derived an estimate of the expected lifetime of each system and subsystem included in the model. These estimates are also presented in Appendix B.

The first step in the estimation of expected lifetimes was the derivation of a series of regression equations relating the current status of the system (i.e., needs replacement, does not need replacement) to system age and project type (i.e., family versus elderly). Such equations enabled us to calculate an implied expected lifetime for the different systems for both family and elderly projects. Age data, however, were available for only about half of the 101 systems. Furthermore, even with information on project age, the underlying sample was too small to generate statistically reliable estimates in many cases. As a result of these limitations, this procedure produced estimated lifetimes for only 20 different systems.

These direct empirical estimates were then compared to expert opinions and information on industry standards that had been assembled by Abt Associates. In many instances, the estimates were consistent, and we selected a mid-range value. In other cases, large discrepancies appeared to be related to differing definitions of the accrual event. In such cases, the empirically derived estimates were generally preferred. One complication in comparing the empirical estimates with expert opinion was the absence of a consensus among the experts on differences in the expected lives of systems in family and elderly projects. Again, in these cases, the empirically derived estimates were preferred. For those systems for which we had no empirical information, we used the midpoint of the expert opinions.

Another check on the reasonableness of every estimate was provided by the AFM itself. By using the model to predict the 1985 accrual of a particular system, the predicted annual accrual was compared with the actual needs observed by the inspectors. This step enabled us to identify systems and subsystems where the assumed expected lifetime over-estimated actual needs. For non-essential systems (i.e., systems where repairs would not be addressed immediately), we increased the expected life whenever the predicted 1985 accrual was significantly greater than the actual 1985 needs observed (accrual plus backlog).

The resulting set of expected lives by building system were then presented to the same panel of experts who participated in the initial definition of accrual events and to technical representatives of the Research Advisory Group. The expected lifetime estimates chosen for use in the model were selected on a system-by-system basis. In some cases, there was a single opinion from an expert who was thought to have the most relevant experience; in others, the choice represented a composite or compromise among the differing views. Generally, however, we were able to arrive at a group consensus regarding the most reasonable estimate.

2.3.3 Imputing System Age

The next step in the estimation process was to calculate an expected age for those systems and observations where such data were missing. While the Accrual Model is driven by the underlying age distribution of building components, the Abt survey only recorded the ages of "major" systems -- typically defined as those with a relatively long expected life. Such systems represent only about half of all building components, and account for less than 37 percent of current repair and replacement needs. Furthermore, about one-quarter of the age entries were missing for major systems. To correct for these deficiencies, we developed an imputation routine that used the building age, recent modernization expenditures, and the survival models to fill in the missing age entries with, essentially, their expected values.

We began by using information on the age of the building and the expected life of the system to impute an "expected" age of the observed building component, assuming all previous repairs and replacements had been made on a timely basis. For example, refrigerators are assumed to last an average of fifteen years. If the building were ten years old, we assumed that the average refrigerator was also ten years old. However, if the building were twenty years old, we assumed that the average refrigerator was a second generation replacement and assigned it an expected age of five.

These imputation procedures do not account for the fact that some of the projects in the sample had incurred substantial renovation costs in the relatively recent past. As shown in Exhibit 2.2, some 28 percent of all

Exhibit 2.2

Per Unit Modernization Expenditures Between 1981-1984

Per Unit Expenditures	Percent of Projects	Percent of Units
None	27.8%	16.0%
$1 - 2,499	32.2	47.6
$2,500 - 4,999	20.5	17.7
$5,000 - 7,499	3.9	8.4
$7,500 - 9,999	6.9	3.0
$10,000 - 19,999	3.5	4.5
$20,000 or more	5.2	2.8
Total	100.0%	100.0%

Source: Modernization Needs Survey

developments (and 16 percent of all units) expended no modernization funding over the 1981 to 1984 period. Another 32 percent of projects (and 48 percent of units) expended funding that amounted to less than $2,500 per unit over the entire four-year period. At the other extreme, however, about 9 percent of all developments (and 7 percent of units) spent more than $10,000 per unit, an amount which clearly falls into the category of substantial rehabilitation. While some of these expenditures may have been devoted to management improvements, these developments would presumably have a higher proportion of relatively new systems than might otherwise be expected on the basis of project age.

To account for the effects of recent modernization, we modified the imputation routine to assign an age of two years if aggregate modernization expenditures exceeded $5,000 per unit between 1981 and 1984.[13] In effect, this procedure assumed that all items with missing age data had been replaced in 1983 (the midpoint of the four-year period). This adjustment could tend to underestimate the accrual estimates in the initial forecast years. However, the number of affected projects was relatively small and, even for these projects, systems with an age entry were not subjected to the procedure.

2.3.4 Updating the Baseline Accrual Estimates

The final step in the development of the AGE accrual forecasts was to adjust the model's projections to assume a baseline year of 1988. This involved two separate calculations. To begin with, we used the Boeckh Index of Construction Costs to translate costs into 1988 dollars. The figures presented in the original Abt report were in 1985 dollars. Unless otherwise noted, the figures reported herein have been inflated by 5.8 percent to account for the increase in construction costs between 1985 and 1988.[14] In addition, we increased the model's forecasts by another 3.17 percent to account for a net addition (about 40,000 units) to the stock since the time of the Abt survey.

2.4 Estimating the Impact of Extraordinary Events

The procedures described above were used to estimate age-related accrual associated with the stock as currently configured (i.e., AGE accrual). The second type of accrual that is included in our baseline forecasts reflects additional needs attributable to "extraordinary" events such as fires,

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[13] This adjustment was not made for projects with missing data on previous modernization expenditures (about half of the total sample).

[14] The costs contained in the Modernization Needs data base represent prices in mid-1984. Abt inflated these costs by 3 percent to bring them up to mid-1985 dollars. Between August 1984 and August 1988, the Index for Residences increased from 111.9 to 122.9 (9.8 percent); the Index for Apartments, Hotels, and Office Buildings increased from 111.2 to 120.6 (or 8.5 percent). Based on an average of these indexes, the figures presented in this report have been inflated by 9.0 percent above their 1984 levels (or 5.8 percent above the costs reported by Abt).

vandalism, or "acts of God." While such events cannot be predicted at the project level, they can be expected to occur in the stock as a whole throughout the year.

We began by making the simplifying assumption that the special needs that arose in the survey year (1985) were typical of the types of extraordinary replacement and repairs that can be expected to occur in the future. According to our estimates (described more fully in Chapter 3), extraordinary repair and replacement items amounted to about $1,667 million in 1985 (or about $1,820 million when expressed in 1988 dollars). While some of these needs were undoubtedly new (i.e., they occurred in the survey year), an unknown proportion of the required expenditures reflect accumulations from earlier years.

To estimate the size of the average backlog, we took the age distribution of systems and projects in 1985, and used the Accrual Forecasting Model to predict the annual accrual due to wear and tear (AGE accrual) that occurred within that year. This predicted accrual was then compared to the backlog of age-related needs which was actually observed in 1985. The ratio of the predicted accrual to the observed backlog was used to estimate the proportion of extraordinary needs that occurred in 1985.

In order to derive this backlog ratio, it was necessary to account for the fact that many age-related needs represent events that have moved from the category of ordinary accrual (A) into a more severely deteriorated condition (S) as a result of postponed maintenance or repairs. By definition, these "S" events will be more expensive than the corresponding accrual (or maintenance) actions which they replaced. Since the Accrual Forecasting Model does not enable systems to enter into an "S" condition, such graduated events (S) are not included in our estimates of predicted age-related accrual. However, the "S" events are clearly age-related, and must be included in the backlog.

Accordingly, the ratio of predicted to observed replacement events (α) was derived as follows:

$$\alpha = \frac{\hat{A}}{A + S^*}$$

where $\hat{A}$ was the predicted accrual for 1985; A was the observed backlog of A events; and S* was the backlog of S events priced at the costs of the lower level A (or M) events. Using S* as opposed to S in the denominator assigns equal weights to the A and the S events within a given system, and generates a backlog estimate based on the observed frequency of component failures which controls for differences in the relative costs of the two kinds of events.

Exhibit 2.3 presents the data which were used to derive the backlog ratio (α). The first line shows the predicted age-related repair and replacement needs in 1985, given the current ages of building systems. The next two lines depict the actual needs of projects at the time of the inspection (where deferred maintenance events are priced as ordinary accrual actions). The fourth row measures the ratio of predicted to actual needs, an estimate of the

Exhibit 2.3

Calculation of the Proportion of Age-Related Needs Occurring in 1985
(1985 dollars)

(1)	Predicted Age-Related Accrual in 1985	$1,043
(2)	Observed Age-Related Backlog in 1985	
	Ordinary Accrual	$3,509
	Deferred Maintenance (Priced at the Cost of Ordinary Accrual)	$ 182
	Total Age-Related Backlog	$3,691
(3)	Ratio of Predicted Accrual to Total Backlog	0.283

size of the average backlog. According to these estimates, about 28 percent of the observed "age-related" repair and replacements needs in Public Housing developments reflect needs that occurred in 1985, while the remaining 72 percent reflect a backlog of needs carried over from earlier years.

The above ratio relates to the types of age-related replacements and repairs that were considered in the previous section. However, assuming that the relative size of the backlog was roughly the same for extraordinary repairs, one can derive an 1985 "accrual" for these items as well. The observed backlog of extraordinary needs at the time of the Abt survey was approximately $1,667 million. Updating this estimate to reflect the current size of the housing stock and 1988 construction prices yields an aggregate total of $1,820 million. Assuming that 28 percent of these needs occurred within the year, annual accrual of extraordinary events would be $515 million (i.e., 0.283 x $1,820), or $397 per unit per annum.

2.5 Estimating ADDs Accrual

In principal, the Accrual Forecasting Model could have been used to project the annual accrual that would arise with the addition of any new (or altered) building components as a result of various ADDs events. In practice, however, this approach did not prove feasible. The form and content of the ADDs data was not compatible with the basic Modernization Needs data base that was used to develop the model and to generate the AGE Accrual estimates. As a result, we had to develop an alternative approach which was based on aggregate ADDs cost estimates, as opposed to detailed information regarding the specific systems and actions involved.

We began by assuming that the overall depreciation rate on building components affected by ADDs would be identical to the depreciation rate of existing building components. We then used the Accrual Forecasting Model to estimate this depreciation rate for existing building components and, finally, applied this rate to various estimates of the initial ADDs improvements. The specific steps involved are described in more detail below.

(1) Estimate Total Replacement Cost of Accrual Components

As a first step, we estimated the total replacement cost of the AGE accrual components (RC) by assuming that every system affected by accrual was replaced (or, more specifically, received the highest "allowable" FIX level). In estimating this replacement cost, we excluded lower-level accrual actions when multiple events (or FIX levels) were allowed. Thus, for example, while the accrual model might allow for a major overhaul of a particular system, to avoid "double counting," only the replacement event was modeled.

(2) Estimate Depreciation Rate for Accrual Events

Next, we used the Accrual Forecasting model to estimate RA(t), the annual accrual that would occur in year "t" if each building component susceptible to accrual began with a zero age (i.e., each system is new). This annual accrual was then used to derive a depreciation rate, defined as follows:

DEPRECIATION RATE(t) = RA(t)/RC

where RA(t) was forecasted accrual in year "t" assuming that each system was new in t=o; and RC was the aggregate replacement cost of the AGE accrual components.

(3) Forecasting ADDs Accrual

In the final step, we applied the estimated depreciation rate to the initial costs of various types of ADDs. In particular, for each ADDs category considered, total accrual in year "t" was derived as follows:

AA(t,i) = RATE(t) * ADD(i)

where ADD(i) was the total ADDs backlog needs in category "i".

Exhibit 2.4 presents the estimated depreciation rates that underlie our analysis of ADDs accrual. These rates range from a low of 0.013 in Year 1 (indicating that 1.3 percent of the initial investment will depreciate and need to be repaired or replaced within the first year) to 0.026 by Year 15 (indicating that 2.6 percent of the initial investment will need to be replaced within that year).

2.6 Estimating Other Types of Accrual

The methodology that was used to estimate ADDs accrual was also used to estimate the accrual that would occur in the event that other components of the backlog are addressed, including REDESIGN, LEAD ABATEMENT, ENERGY, and HANDICAPPED improvements. The forecasts for these events are again based on the depreciation rates presented in Exhibit 2.4

Exhibit 2.4

Estimated Depreciation Rate of
Building Components Affected
by FIX Actions
(Fraction of Initial Replacement Cost)

	Depreciation
Year 1	0.0129
Year 2	0.0135
Year 3	0.0141
Year 4	0.0148
Year 5	0.0154
Year 6	0.0161
Year 7	0.0169
Year 8	0.0177
Year 9	0.0185
Year 10	0.0195
Year 11	0.0205
Year 12	0.0216
Year 13	0.0228
Year 14	0.0242
Year 15	0.0257

Chapter 3

Baseline Accrual Forecasts

This chapter presents our baseline accrual forecasts. Section 3.1 describes the distribution of current needs (backlog) according to the major categories of repair and replacement events that were developed as part of this study. The next three sections present our baseline estimates of the additional needs that would occur over the next 15 years (accrual) assuming that all existing deficiencies have been corrected and that all recommended ADDs and other actions have been implemented. Section 3.2 focuses on ongoing AGE accrual needs which are a normal function of system aging and wear and tear. These estimates are broken down by year, HUD field office, building component, and project type. Section 3.3 describes the additional needs that could arise due to extraordinary events such as fires and vandalism, while Section 3.4 examines other kinds of accrual.

3.1 Breakdown of Current Needs by Type of Repair

Before examining the estimated future needs of the Public Housing stock, it is useful to examine how the modernization needs revealed by the on-site inspections in 1985 are distributed over the four major categories of repairs and replacements which were developed for the accrual analysis.[15] These categories include:

(1) repairs and replacements which, under an adequately funded and well-maintained system, would be covered under routine project maintenance (the M events);

(2) repairs and replacements that are the result of postponed maintenance/replacement and would not be expected to occur if needs were addressed on a timely basis (the S events);

(3) ongoing capital repair and replacement needs directly related to system age (the A events); and

(4) extraordinary repair and replacement needs that arise unpredictably and are not related to system age (the E events).

Exhibit 3.1 breaks down the repair and replacement needs which were observed in 1985 into these four mutually exclusive categories.

As shown in the exhibit, of the needed repairs and replacements identified at the time of the on-site inspection in 1985, ordinary maintenance

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[15] The rational for and extensive validation procedure used to create the classification of the observed conditions are presented in Section 2.3.1.

Exhibit 3.1

FIX Modernization Needs by Source in 1985[1]
(1985 dollars)

Type of Need	Total FIX Backlog (millions)	Percent of Current Needs	Per Unit Costs (dollars)
Maintenance (M)	$2,842	33.3%	$2,259
Replacements Attributable to Deferred Maintenance (S)	502	5.9%	399
On-Going Capital Replacements (A)	3,509	41.2%	2,790
Extraordinary Replacements/ Repairs (E)	1,667	19.6%	1,325
Total	$8,520	100.0%	$6,773

Source: ICF Estimates

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[1] The Backlog of Modernization Needs report prepared by Abt Associates reported a FIX estimate of $9,307 million. Subsequent corrections to the data base and estimation procedures led to a revised estimate of $8,520 million in 1985 dollars. No other categories of the original backlog report have been affected by the data revisions.

represents about 33 percent. Another 6 percent reflect conditions that can be attributed to deferred or postponed repairs or replacements, i.e., they would not have occurred if timely maintenance and replacement had taken place. Neither of these two repair and replacement categories represent events that are considered in our baseline forecasts of future needs since they would not occur under an adequately funded and well managed system. However, they do affect the estimates presented in Chapter 4, which project annual accrual under alternative funding levels.

Ongoing capital replacements and repairs -- which are the focus of the Accrual Forecasting Model -- account for 41 percent of the needs observed at the time of the original inspections. As described in Chapter 2 (Section 2.3), a sizable portion of these needs (72 percent) represents a carry-over from previous years. Extraordinary events account for the remaining 20 percent of the existing backlog although, again, not all of these needs arose in 1985.

3.2 Baseline AGE Accrual

Exhibit 3.2 presents annual estimates of ongoing AGE accrual. These projections assume that all existing needs are met, that the stock remains as currently configured, and that subsequent routine (and non-routine) accrual and maintenance needs are met as they arise. The estimates refer only to those replacement/repair events that are a normal function of system aging because of wear and tear, and only on those components that existed at the time of the 1985 on-site inspection. Separate estimates of needs arising from extraordinary events (such as fire and vandalism) or the implementation of ADDs or other actions are presented in subsequent sections.

The first column in the exhibit depicts the annual total; the second column presents the 95 percent confidence intervals associated with the aggregate accrual estimates; and the third column expresses the estimated AGE accrual costs on a per-unit per-annum basis. All projected costs are expressed in 1988 dollars, reflect regional variations in construction prices, include an allowance for contractor overhead and profit, and have been adjusted to reflect the (net) increase in the number of Public Housing units that has occurred since 1985.

Ongoing replacement needs rise from a low of $1,113 million immediately after existing deficiencies have been corrected (shown as year 1 in the table) to a high of $1,532 million by the 15th year. These estimates have a probable range of +/- 7.5 percent in any year, or ± $84 million in Year 1 and ± $115 million in Year 15. Per-unit AGE accrual costs range from $857 to $1,179 over the 15-year forecast period. Lower values in the initial years reflect the assumption that the existing backlog has been addressed and that the stock begins with an above-average mix of newly replaced components.

Exhibit 3.2

Baseline AGE Accrual Needs by Year
(1988 Dollars)

Year	Total Accrual: Total Amount (millions)	Total Accrual: 95% Confidence Interval (millions +/-)	Per-unit Accrual
1	$1,113	$84	$857
2	$1,145	$86	$882
3	$1,179	$89	$907
4	$1,212	$91	$933
5	$1,245	$94	$958
6	$1,277	$96	$983
7	$1,311	$99	$1,009
8	$1,345	$101	$1,036
9	$1,378	$104	$1,061
10	$1,409	$106	$1,085
11	$1,439	$108	$1,108
12	$1,468	$111	$1,130
13	$1,494	$113	$1,150
14	$1,516	$114	$1,167
15	$1,532	$115	$1,179

Source: ICF Estimates

3.2.1 Geographic Distribution

Exhibit 3.3 shows the distribution of projected AGE repair and replacement needs by HUD region and field office for the fifth and fifteenth year. In each year, we present the location's aggregate needs (expressed in 1988 dollars) and relative needs (expressed as a share of the national total). We also present information on the proportion of Public Housing units that are located in each field office. Note that the sample size for many locations is extremely small (see column 1), which could make the accrual estimate in those areas subject to considerable error.

As is evident from the chart, the relative shares of the different regions and field offices are relatively constant over time, and are highly correlated with their overall share of Public Housing units. Regions II and IV each account for over 20 percent of projected AGE accrual needs. At the other extreme, the projected needs in Regions VIII and X are less than 2 percent of the national total.

Variations among the different regions also reflect differences in average per unit AGE accrual costs. As shown in Exhibit 3.4, the highest unit costs are found in Region IX, where they are projected to be about $1,300 per unit per annum in year 5. Regional differentials in unit costs tend to decline over time. However, even at the end of the forecasting period, unit costs in Region IX remain relatively high, due in part to the regional differences in construction prices that are embedded in the forecasts and in part to the characteristics of the region's housing stock.

3.2.2 Baseline AGE Accrual Needs by Building Component

Exhibit 3.5 breaks down aggregate and average per-unit AGE accrual needs into broad system types, including: (1) building systems (roofs, exterior walls, windows, boilers, elevators, etc.); (2) unit systems (kitchens, baths, interior doors, interior ceilings and walls, etc.); and (3) site systems (earthwork, sidewalks and curbs, parking, roads, utility distribution systems, etc.). A more detailed breakdown by individual systems is presented in Appendix A.

Over 60 percent of all projected AGE accrual needs are system components located within units. While each such accrual action (e.g., the replacement of a refrigerator) tends to be less expensive than other actions associated with either building or site components (e.g., the replacement of a project's utility distribution system), the greater number and frequency of such events makes them the largest contributor to overall replacement needs. Building located systems, such as roofs, elevators, and boilers, account for about one third of total needs, while site-specific systems, such as roadways, sidewalks, and infrastructure, contribute less than 4 percent.

3.2.3 Baseline AGE Accrual Needs by Project Type

Exhibit 3.6 presents estimates of per-unit AGE accrual needs by project type (i.e., whether projects are predominantly occupied by the elderly or by

Exhibit 3.3

Baseline AGE Accrual Needs Within HUD Regional and Area Offices: Selected Years (1988 Dollars, in Millions)*

	No. of Projects Sampled	Baseline Accrual Needs Year 5 $	Year 5 %	Year 15 $	Year 15 %	Percent of Total Units
Region I						
Boston, MA	53	$29.978	2.41	$41.299	2.70	2.8%
Hartford, CT	22	$16.837	1.35	$21.794	1.42	1.5%
Manchester, NH	12	$7.336	0.59	$11.615	0.76	0.8%
Providence, RI	15	$8.335	0.67	$9.634	0.63	0.8%
Regional Total	102	$62.487	5.02	$83.343	5.51	5.9%
Region II						
Buffalo, NY	8	$32.411	2.60	$52.098	3.40	2.0%
New York, NY	70	$185.093	14.87	$206.392	13.47	12.6%
Newark, NJ	53	$48.234	3.88	$55.694	3.64	3.8%
San Juan, PR	41	$53.316	4.28	$65.516	4.28	5.0%
Regional Total	172	$319.055	25.64	$379.701	24.79	23.4%
Region III						
Baltimore, MD	15	$27.908	2.24	$32.723	2.14	1.9%
Charleston, WV	7	$4.441	0.36	$7.232	0.47	0.5%
Philadelphia, PA	57	$54.942	4.41	$64.465	4.21	4.0%
Pittsburgh, PA	30	$27.756	2.23	$32.006	2.09	2.5%
Richmond, VA	16	$17.929	1.44	$22.931	1.50	1.6%
Washington, DC	22	$18.233	1.47	$20.999	1.37	1.2%
Regional Total	147	$151.211	12.15	$180.358	11.77	11.7%
Region IV						
Atlanta, GA	28	$39.396	3.17	$59.067	3.86	4.5%
Birmingham, AL	19	$43.218	3.47	$41.529	2.71	3.3%
Columbia, SC	6	$11.335	0.91	$15.309	1.00	1.2%
Greensboro, NC	40	$31.181	2.51	$46.401	3.03	3.0%
Jackson, MI	9	$10.762	0.86	$15.132	0.99	1.0%
Jacksonville, FL	17	$46.622	3.75	$53.232	3.48	3.3%
Louisville, KY	12	$24.060	1.93	$27.608	1.80	2.0%
Knoxville, TN	17	$13.661	1.10	$19.347	1.26	1.2%
Nashville, TN	10	$29.173	2.34	$28.203	1.84	2.0%
Regional Total	158	$249.413	20.04	$305.833	19.97	21.5%

Exhibit 3.3 (Continued)

	No. of Projects Sampled	Baseline Accrual Needs Year 5 $	Year 5 %	Year 15 $	Year 15 %	Percent of Total Units
Region V						
Chicago, IL	55	$67.866	5.45	$77.265	5.04	6.1%
Cincinnati, OH	10	$13.801	1.11	$18.144	1.18	1.1%
Cleveland, OH	26	$29.271	2.35	$35.672	2.33	2.4%
Columbus, OH	5	$11.021	0.89	$14.069	0.92	0.8%
Detroit, MI	32	$18.663	1.50	$22.482	1.47	1.6%
Grand Rapids, MI	9	$6.815	0.55	$11.859	0.77	0.7%
Indianapolis, IN	24	$14.061	1.13	$19.397	1.27	1.4%
Milwaukee, WI	19	$11.325	0.91	$16.984	1.11	1.0%
Minn/St Paul, MN	12	$24.740	1.99	$21.117	1.38	1.7%
Regional Total	192	$197.566	15.87	$236.993	15.47	16.6%
Region VI						
Dallas, TX	7	$30.983	2.49	$52.051	3.40	2.7%
Houston, TX	7	$7.804	0.63	$11.301	0.74	0.7%
Little Rock, AR	8	$15.932	1.28	$24.339	1.59	1.2%
New Orleans, LA	15	$32.142	2.58	$39.121	2.55	2.5%
Oklahoma City, OK	7	$9.433	0.76	$14.832	0.97	1.0%
San Antonio, TX	15	$16.548	1.33	$23.893	1.56	1.8%
Regional Total	59	$112.845	9.07	$165.540	10.81	9.9%
Region VII						
Des Moines, IA	9	$3.819	0.31	$5.050	0.33	0.3%
Kansas City, MO	11	$12.663	1.02	$21.864	1.43	1.2%
Omaha, NE	18	$5.912	0.48	$7.572	0.49	0.6%
St. Louis, MO	16	$14.824	1.19	$18.851	1.23	1.2%
Regional Total	54	$37.219	2.99	$53.337	3.48	3.3%
Region VIII						
Denver, CO	10	$16.715	1.34	$17.871	1.17	1.3%
Region IX						
Honolulu, HI	10	$5.407	0.43	$6.747	0.44	0.5%
Los Angeles, CA	14	$24.985	2.01	$30.822	2.01	1.5%
Phoenix, AZ	11	$6.427	0.52	$6.103	0.40	0.4%
Sacramento, CA	4	$10.891	0.88	$6.741	0.44	0.4%
San Francisco, CA	22	$26.806	2.15	$29.311	1.91	1.7%
Regional Total	61	$74.519	5.99	$79.726	5.20	4.4%

Exhibit 3.3 (Continued)

	No. of Projects Sampled	Baseline Accrual Needs				Percent of Total Units
		Year 5		Year 15		
		$	%	$	%	
Region X						
Anchorage, AK	5	$1.634	0.13	$1.868	0.12	0.1%
Portland, OR	10	$8.313	0.67	$8.976	0.59	0.5%
Seattle, WA	26	$13.619	1.09	$17.175	1.12	1.3%
Regional Total	41	$23.567	1.89	$28.020	1.83	1.9%
National Total	996	$1,244.602	100.00	$1,531.726	100.00	100.0%

Source: ICF Estimates

* These figures are based upon a sample of projects and are subject to sampling error.

Exhibit 3.4

Per Unit Baseline AGE Accrual Needs
by HUD Area Office: Selected Years
(1988 Dollars, in Millions)*

	Year 5	Year 15
Region I		
Boston, MA	$ 826	$1,138
Hartford, CT	$ 852	$1,103
Manchester, NH	$ 723	$1,144
Providence, RI	$ 820	$ 948
Regional Average	$ 818	$1,105
Region II		
Buffalo, NY	$1,239	$1,991
New York, NY	$1,126	$1,256
Newark, NJ	$ 983	$1,135
San Juan, PR	$ 823	$1,012
Regional Average	$1,048	$1,248
Region III		
Baltimore, MD	$1,146	$1,344
Charleston, WV	$ 631	$1,027
Philadelphia, PA	$1,068	$1,253
Pittsburgh, PA	$ 860	$ 992
Richmond, VA	$ 856	$1,095
Washington, DC	$1,147	$1,321
Regional Average	$ 995	$1,187
Region IV		
Atlanta, GA	$ 680	$1,020
Birmingham, AL	$ 997	$ 958
Columbia, SC	$ 703	$ 949
Greensboro, NC	$ 802	$1,194
Jackson, MI	$ 844	$1,186
Jacksonville, FL	$1,083	$1,236
Louisville, KY	$ 933	$1,071
Knoxville, TN	$ 845	$1,197
Nashville, TN	$1,131	$1,094
Regional Average	$ 891	$1,093

Exhibit 3.4 (Continued)

	Year 5	Year 15
Region V		
Chicago, IL	$ 856	$ 974
Cincinnati, OH	$1,016	$1,336
Cleveland, OH	$ 958	$1,168
Columbus, OH	$1,048	$1,338
Detroit, MI	$ 927	$1,116
Grand Rapids, MI	$ 752	$1,308
Indianapolis, IN	$ 793	$1,094
Milwaukee, WI	$ 852	$1,278
Minn/St. Paul, MN	$1,131	$ 966
Regional Average	$ 915	$1,097
Region VI		
Dallas, TX	$ 872	$1,464
Houston, TX	$ 857	$1,242
Little Rock, AR	$1,038	$1,585
New Orleans, LA	$1,006	$1,224
Oklahoma City, O	$ 715	$1,125
San Antonio, TX	$ 694	$1,001
Regional Average	$ 875	$1,283
Region VII		
Des Moines, IA	$ 872	$1,153
Kansas City, MO	$ 796	$1,375
Omaha, NE	$ 769	$ 985
St. Louis, MO	$ 986	$1,254
Regional Average	$ 865	$1,240
Region VIII		
Denver, CO	$ 996	$1,065
Region IX		
Honolulu, HI	$ 917	$1,144
Los Angeles, CA	$1,312	$1,619
Phoenix, AZ	$1,199	$1,138
Sacramento, CA	$2,402	$1,487
San Francisco, CA	$1,187	$1,298
Regional Average	$1,298	$1,389

Exhibit 3.4 (Continued)

	Year 5	Year 15
Region X		
Anchorage, AK	$1,410	$1,611
Portland, OR	$1,234	$1,332
Seattle, WA	$ 837	$1,055
Regional Average	$ 975	$1,159
National Average	$ 958	$1,179

Source: ICF estimates

* These figures are based upon a sample of projects and are subject to sampling error.

Exhibit 3.5

Baseline AGE Accrual Estimates by System Location: Selected Years
(1988 dollars)

	Accrual Costs (millions)	%	Per Unit Costs
Year 5			
Unit	$ 773	62.1%	$ 595
Building	$ 426	34.2%	$ 328
Site	$ 45	3.6%	$ 35
Total Cost	$1,244	100.0%	$ 958
Year 15			
Unit	$ 927	60.5%	$ 713
Building	$ 549	35.8%	$ 423
Site	$ 56	3.7%	$ 43
Total Cost	$1,532	100.0%	$1,179

Exhibit 3.6

Per Unit Baseline AGE Accrual Needs by Project Type
(1988 dollars)

	Year 5	Year 15
Project Type		
Elderly	$ 786	$1,023
Family	$1,075	$1,285
Year Project Built		
Post 1970	$ 719	$1,319
1960-1969	$1,153	$ 986
1950-1959	$ 915	$1,146
Pre-1950	$1,159	$1,296
Structure Type		
Single-Family/Mixed	$ 960	$1,218
Low Rise	$ 982	$1,193
High Rise	$ 944	$1,110
PHA Size (Number of Dwelling Units)		
Less Than 100 Units	$ 821	$1,075
100-499 Units	$ 803	$1,169
500-1,249 Units	$ 904	$1,172
1,250-6,499 Units	$ 918	$1,134
More Than 6,500 Units	$1,075	$1,231
New York City	$1,128	$1,258
All Units	$ 958	$1,179

Source: ICF Estimates

families); project age; structure type (single-family, low rise/mixed, and high rise); and PHA size.

The differentials for family and elderly units are quite pronounced, especially in the initial years. According to our estimates, annual AGE accrual in family units -- which account for about 60 percent of the total stock -- will amount to $1,075 per unit in the fifth year and $1,285 per unit by the end of the forecast period. Projected expenditures in elderly units are considerably lower than they are in family units in the fifth year, averaging only $786 per unit. However, by the fifteenth year, the differential between family and elderly units declines, with elderly units averaging $1,023 per year.

The lower needs for elderly units reflect a combination of three factors. First, as described in Chapter 2, systems in family projects were often assumed to have a shorter expected life (or greater frequency of repair) due to the greater amount of wear and tear typically inflicted on such units. Second, elderly units are typically smaller, which reduces their accrual needs. Third, elderly units tend to be in newer developments than the family units. This last characteristic explains why the differential narrows over time: as projects age, they approach their steady-state replacement cycles which are similar for family and elderly projects.

Differentials by the current age of the development also tend to decline with the passage of time. In the fifth year, projects that were built after 1970 (which would be less than 20 years old) have projected AGE replacement needs that are about 30 percent less than projects which were built before 1960 (which would be over 30 years old). However, this differential is reversed by the fifteenth year, when newer developments are between 20 and 30 years old and many of their building systems require replacement or major overhaul.

While differences by structure type are relatively small and vary over time, AGE related accrual needs appear to vary with the size of the PHA. In the fifth year, predicted accrual costs are about 25 percent lower in the smallest authorities than they are in the largest PHAs. While this general pattern persists throughout the forecast period, the differential between the costs of large and small PHAs declines over time. Presumably, the large differential in the initial years can be attributable to variations in the age of the housing stock.

3.3 Baseline Accrual Associated With Extraordinary Events

This section examines future repair and replacement needs in Public Housing arising from "extraordinary" events such as "acts of God," fires, or vandalism. While such events cannot be predicted at the project level, they can be expected to occur in the stock as a whole. As a result, the age-related accrual estimates that were presented in the previous section, taken alone, will underestimate the actual needs of Public Housing in the years to come if some account is not taken of these "extraordinary" events that occasionally occur.

Although the random nature of extraordinary replacement events makes them inherently difficult to model, some insights to their general magnitude can be gained by estimating the levels which occurred in 1985. The cost of items associated with extraordinary events in that year amounted to $1,667 million (see Exhibit 3.1). As described in Chapter 2, we estimate that about 72 percent of these needs were carried over from previous years, and that 28 percent were "new" (i.e., they occurred within the year).

The highly variable nature of these extraordinary events makes project- or even PHA-based contingency planning relatively difficult. In addition, it is difficult to determine whether the 1985 annual estimate of $472 million (i.e. 0.283 x $1,667 million) was unusually high or low. If 1985 was a typical year, the cost of extraordinary accrual in 1988 dollars would be about $515 million (after adjusting for inflation and the growth of the housing stock), or about $397 per unit per year. Because we have no empirical information that could be used to estimate systematic variations in these events, we can only assume that the experience of the year of the on-site inspection will be repeated in subsequent years. There is no information within the context of this study, however, as to how much of the cost of such events would be the responsibility of the PHAs and how much would be covered by other funding sources such as insurance payments.

3.4 Additional Sources of Accrual

The final component of our baseline accrual estimates reflects the ongoing accrual that would occur in the event that all other categories of needs identified in the Backlog Report are addressed immediately preceding the forecasting period. As described in Chapter 2, due to the nature of available data, the Accrual Forecasting Model cannot be used to directly forecast ADDs events or the on-going accrual associated with energy conservation, redesign, or handicapped access. However, if we assume that the depreciation rate on building components affected by FIX and all other actions are roughly the same, we can derive estimates of the annual accrual that would arise under various assumptions regarding the categories of needs involved.

Such baseline estimates are presented in Exhibit 3.7, which projects accrual in the fifth and fifteenth year for mandatory and project-specific ADDs, as well as for the other categories of needs that were considered in the Abt report. The first two columns present aggregate annual totals. The next two columns present costs on a per-unit per-annum basis. Only ISO 1 and 2 ADDs actions are considered, since it is unlikely that HUD area offices would approve expenditures in the other ISO categories. In addition, we have eliminated Energy ADDs and Assessibility ADDs since they are captured in the more broadly defined Energy and Handicapped Accessibility categories.

Exhibit 3.7

Projected ADDs Accrual in Selected Years[1]
(1988 dollars)

Cost Category	Aggregate Costs ($ millions) Year 5	Aggregate Costs ($ millions) Year 15	Per-Unit Costs Year 5	Per-Unit Costs Year 15
ADDs Required by Code or Modernization Standards[2]				
ISO=1 or 2	$14.3	$ 24.0	$11	$ 18
Project Specific ADDs				
ISO=1 or 2	$89.2	$148.8	$69	$115
Redesign	$33.6	$ 56.1	$25.9	$ 43.2
Lead Abatement	$ 7.3	$ 12.1	$ 5.6	$ 9.3
Energy	$15.2	$ 25.4	$11.7	$ 19.6
Handicapped Accessibility	$ 4.2	$ 7.0	$ 3.2	$ 5.4

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[1] These estimates assume that all of the recommended actions are performed at once. In reality, accrual will occur only on those items which are "added" to the inventory.

[2] Mod Standards consist of items required for health and safety or systems integrity.

Chapter 4

Updated Backlog Estimates and Future Estimates Under Alternative Funding Scenarios

The previous chapter presented estimates of the ongoing accrual that would occur under the artificial assumptions that all existing deficiencies had been corrected, that future needs would be corrected as they arose, and that all recommended ADDS and other project improvements had been made in their entirety. These baseline accrual estimates depict the continuing repair and replacement needs of a fully funded, well managed system. Combined with estimates of the existing FIX backlog, the baseline FIX accrual represents the minimum expenditures required to address the ongoing capital repair and replacement needs of Public Housing as it existed in 1985. The baseline accrual estimates on ADDS and other categories represent the on-going costs if the various additions and modifications of the stock had been undertaken.

The needs identified at the time of the on-site inspections in 1985 have only partially been addressed since that time, only a part of the recommended ADDS and other actions have been implemented, and additional needs have grown both through accrual and as a result of delaying repairs and replacements. As a result, this chapter relaxes the "initial fix-up" assumptions of the earlier chapter, updates the 1985 estimates, and projects the impact of changes in future funding levels on those needs based upon more "real life" assumptions.

4.1 Additional Capital Accrual Needs Since 1985: A Backlog Update

The necessary ingredients for updating the original Backlog estimates to their probable level in 1988 include: information on the amounts of funds expended on repairs and replacements between 1985 through 1988; an accrual estimate that is based upon the actual ages of system components as they existed in 1985; and a method to estimate the additional costs incurred as a result of not fully repairing and replacing components as they were needed. The general computational approach to updating the 1985 Backlog estimate was to take the 1985 estimate, add in the accrual that was estimated to have occurred in the next three years, subtract the funds that had been spent during the period, and add to that figure the estimated costs entailed in delaying making all needed repairs and replacements. Thus:

$$B_i = B_{i-1} + A_i - E_i + C_i$$

where B = Backlog, A = Accrual, E = Expenditures,
C = Cost of Delay, and i = Year

The following describes how these ingredients were derived and presents an updated estimate of the Modernization Needs of Public Housing.

4.1.1 Estimating Modernization Needs Expenditures

Although no project level information is directly available on the amount of funds expended upon the various backlog categories, the Field Office Data Entry for Modernization Approvals Data System (FODEMADS) allows for an approximate estimation on a national basis. The FODEMADS system contains information on the amount of Comprehensive Improvement Assistance Program (CIAP) funds approved for the modernization of Public Housing, including information on how the funds were to be used, for each year since 1981. Through a two step process, this information was converted into national estimates of expenditures on the Backlog categories between 1986 through 1988.

The first step was to convert the categories of funding approvals maintained and used in the FODEMADS system to the categories used in the Modernization Needs Backlog estimates. Based upon data system definitions, interpretations of CIAP handbooks, and HUD field office usage, a crosswalk between the FODEMADS categories of CIAP approvals and the Modernization Needs categories used for the Backlog estimates was established. Exhibit 4.1 portrays that crosswalk. For example, 54 percent of the General Energy funds in FODEMADS are allocated to FIX.

Certain adjustments in the overall CIAP allocations had to be made in order to calculate the amount of the allocation which was available for the type of public housing expenses that are estimated in this report. The overall allocations ($1,749 million in 1988) contain funds for Indian Housing (3.1 percent in 1988) and for administrative and management costs (12.9 percent in 1988) which are not applicable to the cost estimates of this study. Adjustment procedures were used which eliminated these non- applicable funds and resulted in estimates of the "hard cost" appropriation funds which were available.

It should be noted that in the calculations to update or project the estimates, expenditures are applied only to ADDS categories ISO 1 & 2. Current CIAP procedures require HUD inspection and approval of proposed project modernization plans. In this study, the Modernization Needs inspectors' specific agreement with the PHA's indication of need implies the likelihood that these estimated expenditures would be approved by HUD.

The second step was to estimate, based upon the amount of funds available in a given year, how much was actually spent on the category. This step was necessary because it takes several years after approval for all of the funds to actually be spent. Recent experience suggested that 25% of the funds approved were spent one year after approval, 42% the second year, 22% the third, 6% the fourth, 3% the fifth, and 2% the six year. This spending rate was used to estimate the total funds expended from a given year on a particular category. Exhibit 4.2 presents the resulting estimates.

Funds, however, can be expended either to reduce the backlog or to fund the new needs (accrual) which continue to arise. For purpose of this updating it was assumed that the available funds would be spent in the same

Exhibit 4.1

Crosswalk Between FODEMADS Approval Categories and Modernization Needs Categories

Modernization Needs Categories[1]	CIAP Approval Categories in FODEMADS						
	Special Energy	General Energy	Handicapped Access	Lead Abatement	Safety & Health	Modern. Standards	Long Term Viability
FIX[2]		54%	27%	27%	90.6%	90.6%	36.3%
MANDATORY ADDS		6%	3%	3%	9.4%	9.4%	3.7%
PROJECT SPECIFIC ADDS							50%
MISC. ADDS[3]							
REDESIGN							10%
LEAD ABATEMENT				70%			
ENERGY[4]	100%	40%					
HANDICAPPED[5]			70%				

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[1] All funds went to the ADDS categories, ISO 1 & 2. They were assumed to have been funded because of the agreement with the PHA by the inspector.

[2] The CIAP categories do not distinguish between FIX and MANDATORY ADDS. An estimate was made as to what portion of each of the CIAP categories went to the combination of FIX and MANDATORY ADDS. Their individual contribution was estimated as the ratio of their individual contribution to the total of FIX and MANDATORY ADDS in the Backlog estimate. In the case of FIX, the ratio was 90.63% and, in the case of MANDATORY ADDS, the ratio was 9.37%. For example, it was estimated that 30 percent of the CIAP Handicapped Access funds were spent on FIX and MANDATORY ADDS repairs and replacements. Of that 30 percent, 90.63 percent (or 56 percent) went to FIX and 9.37 percent (or 6 percent) went to MANDATORY ADDS.

[3] There is no counterpart in FODEMADS Approval Categories and it was assumed that it was highly unlikely that HUD would approve expenditure on these items.

[4] As suggested in the original Backlog Report, the ENERGY study estimate is used rather than the ENERGY ADDs estimate.

[5] As suggested in the original Backlog Report, the HANDICAPPED estimate of this report is based upon the HANDICAPPED ACCESSIBILITY estimate and one half of the estimate of HANDICAPPED ADDS, ISO 1 and 2.

Exhibit 4.2

FODEMADS Non-Indian, Hard Cost Approvals and Estimated Modernization Needs Appropriations and Expenditures
(1988$, in millions)

Non-Indian Hard Cost FODEMADS Approvals[1]	1985	1986	1987	1988
Spec. Purp. Energy	$38.2	$11.5	$27.4	$28.8
General Energy	$67.4	$42.5	$92.4	$101.1
Handicapped	$1.0	$1.0	$5.9	$6.8
Lead Abatement	$9.9	$6.9	$37.3	$75.6
Safety and Health	$167.7	$276.8	$264.0	$285.9
Mod. Standards	$236.8	$96.2	$606.5	$657.1
Long Term Viability	$191.4	$218.9	$296.4	$320.8
	$712.3	$653.7	$1,329.8	$1,476.0

Estimated Modernization Needs Appropriations	1985	1986	1987	1988
FIX	$475.6	$442.6	$958.4	$1,048.3
MANDATORY ADDS	$49.2	$45.8	$99.1	$108.4
PROJECT SPECIFIC ADDS	$95.7	$109.4	$148.2	$160.4
REDESIGN	$19.1	$21.9	$29.6	$32.1
LEAD ABATEMENT	$6.9	$4.8	$26.1	$52.9
ENERGY	$65.1	$28.5	$64.3	$69.2
HANDICAPPED	$0.7	$0.7	$4.1	$4.7
	$712.3	$653.7	$1,329.8	$1,476.0

Estimated MOD NEEDS Expenditures Year	1986	1987	1988	Estimated Unspent Funds
FIX	$482.0	$469.0	$584.4	$1,999.2
MANDATORY ADDS	$49.8	$48.5	$60.4	$206.7
PROJECT SPECIFIC ADDS	$97.9	$97.6	$114.8	$325.4
REDESIGN	$19.6	$19.5	$23.0	$65.1
LEAD ABATEMENT	$13.5	$10.1	$11.8	$76.2
ENERGY	$122.7	$75.9	$58.2	$143.9
HANDICAPPED	$1.5	$1.1	$1.7	$8.2
TOTAL	$787.0	$721.7	$854.1	$2,824.7

[1] Adjustments to the total CIAP Allocations were made in order to remove funds allocated for Indian Housing and for Administrative (soft costs) costs.

proportion in any given year that accrual need was to the backlog need of that year.

4.1.2 Estimating "Real Life" Accrual

As described in Chapter 2, the Accrual Forecasting Model was used to predict the FIX accrual that would be expected in 1985 given the 1985 ages of the various building components. That model predicted a FIX accrual amount based on the 1985 ages of the components as $1,239.4 million. That estimate is used as the starting point for estimating the "real life" FIX accrual during 1986 and subsequent years.

If one examines Exhibit 3.2, the baseline AGE accrual estimate at year 5, $1,245 million, is the closest category to the Model accrual estimate for 1985 and best represents the probable accrual on the public housing stock during 1986. The estimates for subsequent years from that exhibit are good approximations for the "real life" accrual in the years after 1986 and are used for their estimation.

The accrual estimates for the various ADDS categories, as well as the REDESIGN, ENERGY, HANDICAPPED, and LEAD ABATEMENT categories, are calculated differently. On the one hand, accrual can take place only on those components which are actually added as components to the Public Housing stock. The amount of funds spent between 1986 through 1988 on these components is used as the accrual base. On the other hand, because the components are being added to the existing stock, their accrual rate is for new components. Such rates were presented in Exhibit 2.4 and are applied to the base to estimate accrual costs for the years after installation. These estimates are presented in Exhibit 4.3.

4.1.3 Estimating the Cost of Delay

Because sufficient funds have not been available to fund all of the necessary accrual that has taken place since 1985, some portion of the public housing components require higher levels of repair then they would if all necessary actions had taken place on schedule, i.e., accrual (A) events have deteriorated into higher cost (S) events. The calculation of that cost of delay was done by comparing the average difference in the costs of performing the "A" (Accrual) events as contrasted with the higher level "S" (Shouldn't Occur) events. According to that comparison, the failure to undertake needed accrual actions in a timely fashion results in a 8.7 percent increase in costs. For purpose of the update of the Backlog, the cost of delay is estimated by multiplying the unfunded portion of accrual in the year by 8.7 percent.

4.1.4 Extraordinary Events

Updating the costs of correcting the conditions resulting from acts of nature, vandalism, fire, and other extraordinary events is not possible because of the lack of accurate information. Although it is estimated that

Exhibit 4.3

Estimated Public Housing Non-FIX Accrual[1]
(1988$, in millions)

Year	1986	1987	1988
MANDATORY ADDS	$0.6	$1.3	$2.1
PROJECT SPECIFIC ADDS	$1.3	$2.6	$4.2
REDESIGN	$0.3	$0.5	$0.8
LEAD ABATEMENT	$0.2	$0.3	$0.5
ENERGY	$1.6	$2.6	$3.5
HANDICAPPED	$0.0	$0.0	$0.1
	$3.9	$7.4	$11.2

[1] Zero amounts indicate that accrual is less than $50 thousand for the period.

costs of $515 million arose during 1985 as a result of these events, we do not know whether such cost should be expected to occur every year in the future.

Further complicating the estimation problem is the absence of any information on past expenditure patterns to correct such conditions and the source of the funds for such expenditures. Given the nature of the events, some portion of the costs of repairs has been and will continue to be paid for by non-CIAP funds. The absence of any expenditure and funding information means that no estimate can be made of what portion, if any, of the extraordinary backlog has been repaired, what net accrual costs, if any, should be added to any period for the repair of these conditions, and, what sources of funds has been or should be responsible.

For purposes of the update, the costs identified with the extraordinary events have been left in as part of the 1985 FIX obligation but no provision has been made for further costs to accrue for these events. While it is probable that some further cost will accrue, there is no basis to estimate that cost. It ranges from a possible maximum of $515 million (if no non-CIAP funds are available for funding) to a minimum of no obligation (if, for example, all costs are paid for by insurance reimbursements or other off-budget sources). For those wishing to adjust the updated backlog estimates to reflect additional costs for extraordinary event accrual, it is suggested that some fraction of the 1985 estimate of $515 million be used as an annual addition. We have no information as to what would be the most appropriate proportion to use.

4.1.5 An Updated Backlog Estimate

The calculation of new backlog estimates for the years between 1986 through 1988 are presented in Exhibit 4.4. The Backlog - Start figure in the first column (1986) of each category is the Backlog estimate from the 1985 on-site inspection expressed in 1988 dollars and adjusted for both inventory increases and data corrections. The accrual figures represent the accrual estimated to have occurred during 1986. The Cost of Delay is the estimate of the higher levels of repair that will have to be undertaken as a result of not fully meeting the accrual needs during the year. The Expenditure figure in each category is the amount of funds estimated to have been spent in 1986. The Backlog - End is the result of subtracting the Expenditures from the sum of Backlog - Start, Accrual, and Cost of Delay. The Backlog - End of 1986 then becomes the Backlog - Start for 1987. The calculation proceeds similarly for each succeeding year.

Exhibit 4.5 summarizes all of the events during the period 1986 through 1988 to yield an updated Backlog estimate for each of the relevant categories. In addition, it provides an estimate of the approved but unexpended funds which are available as of January 1, 1989, for each category. This is an estimate of the unexpended pipeline of funds. The last column in the exhibit is an estimate of the unfunded backlog (backlog minus the unexpended pipeline).

Exhibit 4.4

Estimated Public Housing Backlog Balances
(1988$, in millions)

Year	1986	1987	1988
FIX			
Backlog - Start	$9,302.5	$10,168.9	$11,083.4
Accrual	$1,245.0	$1,277.0	$1,311.0
Cost of Delay	$103.4	$106.5	$108.7
Expenditures	$482.0	$469.0	$584.4
Backlog - End	$10,168.9	$11,083.4	$11,918.8
MANDATORY ADDS			
Backlog - Start	$932.4	$883.3	$836.2
Accrual	$0.6	$1.3	$2.1
Cost of Delay	$0.1	$0.1	$0.2
Expenditures	$49.8	$48.5	$60.4
Backlog - End	$883.3	$836.2	$778.1
PROJECT SPECIFIC ADDS			
Backlog - Start	$5,789.3	$5,692.8	$5,598.0
Accrual	$1.3	$2.6	$4.2
Cost of Delay	$0.1	$0.2	$0.4
Expenditures	$97.9	$97.6	$114.8
Backlog - End	$5,692.8	$5,598.0	$5,487.8
REDESIGN			
Backlog - Start	$2,183.3	$2,164.0	$2,145.0
Accrual	$0.3	$0.5	$0.8
Cost of Delay	$0.0	$0.0	$0.1
Expenditures	$19.6	$19.5	$23.0
Backlog - End	$2,164.0	$2,145.0	$2,123.0
LEAD ABATEMENT			
Backlog - Start	$472.0	$458.7	$448.9
Accrual	$0.2	$0.3	$0.5
Cost of Delay	$0.0	$0.0	$0.0
Expenditures	$13.5	$10.1	$11.8
Backlog - End	$458.7	$448.9	$437.7
ENERGY			
Backlog - Start	$989.5	$868.5	$795.4
Accrual	$1.6	$2.6	$3.5
Cost of Delay	$0.1	$0.2	$0.3
Expenditures	$122.7	$75.9	$58.2
Backlog - End	$868.5	$795.4	$741.0
HANDICAPPED			
Backlog - Start	$274.0	$272.5	$271.4
Accrual	$0.0	$0.0	$0.1
Cost of Delay	$0.0	$0.0	$0.0
Expenditures	$1.5	$1.1	$1.7
Backlog - End	$272.5	$271.4	$269.8

Exhibit 4.5

Revised Backlog Estimates
(in millions)

	Original Backlog Estimate (in 1985 Dollars)[1]	Revised Backlog Estimate (in 1988 Dollars)[2]	Estimated Backlog As Of 1/1/89[3]	Estimated Unexpended Funds As Of 1/1/89	Estimated Unfunded Backlog As Of 1/1/89
FIX	$8,520.0	$9,302.5	$11,918.0	$1,999.2	$9,919.6
Mandatory ADDS					
ISO 1 & 2	$881.0	$932.4	$778.1	$206.7	$571.4
3	$408.3	$432.1	$432.1		$432.1
4	$170.3	$180.2	$180.2		$180.2
5	$105.7	$111.9	$111.9		$111.9
Project Specific ADDS					
ISO 1 & 2	$5,470.4	$5,789.3	$5,487.0	$325.4	$5,162.4
3	$2,028.1	$2,146.3	$2,146.3		$2,146.3
4	$1,211.9	$1,282.5	$1,282.5		$1,282.5
5	$584.1	$618.1	$618.1		$618.1
Misc. Adds					
No ISOs	$515.4	$545.4	$545.4		$545.4
Other ADDS	$6.1	$6.5	$6.5		$6.5
HUD Prohibited	$104.8	$110.9	$110.9		$110.9
REDESIGN	$2,063.0	$2,183.3	$2,123.0	$65.1	$2,057.9
LEAD ABATEMENT	$446.0	$472.0	$448.9	$76.2	$372.7
ENERGY	$939.0	$989.5	$741.0	$143.9	$597.0
HANDICAPPED	$245.0	$274.0	$269.8	$8.2	$261.5

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[1] The Backlog of Modernization Needs report prepared by Abt Associates reported a FIX estimate of $9,307 million. Subsequent corrections to the data base and estimation procedures led to a revised estimate of $8,520 million in 1985 dollars. No other categories of the original backlog report have been affected by the data revisions.

[2] All estimates have been revised to 1988 dollars, an 5.83 percent increase. The FIX estimate has been further increased by 3.17 to account for additions to the inventory. Adjustments for inventory increases are inappropriate for categories other than FIX. Those categories entail adding a component to the stock that existed in 1985.

[3] The FIX Backlog estimate does not contain possible accrual cost associated with extraordinary events for the years 1986 through 1988.

Since Abt designed and conducted the survey of modernization needs in 1985, legislative and potential regulatory requirements for lead-based paint abatement have been considerably broadened. The cost of lead abatement activities may be substantially higher than the cost estimated in this report. Similarly, the 504 regulations governing the required availability of handicapped accessible units were issued in 1988. The cost reported may not accurately reflect the implications of the 504 regulations.

According to these estimates, modernization needs associated with categories other than FIX have declined slightly during the three years, with moderate inroads on the actions associated with ISO 1 & 2 accounting for most of that gain. Over the same period, however, estimated FIX needs rose from $8,520 million (in 1985 dollars) to over $11,918 at the start of 1989. Only 23 percent of the $3,398 million increase was the result of inflationary and inventory increases. Fully 77 percent of the increase was attributed to accrual and costs associated with repair delays.

4.2 Backlog Estimates Under Alternative Future Funding Levels

It is extremely difficult to estimate with any degree of accuracy the impact of future funding levels on the physical status of the public housing stock. The large number of alternative funding decisions available at various levels makes such estimations speculative at best. By making some simplifying assumptions, however, some very rough estimates of the changes in the Backlog estimates which would occur under different funding scenarios can be undertaken.

The same methodology and calculations that were used to update the Backlog estimate from 1985 to 1988 will be employed. Instead of using expenditure estimates based upon past CIAP approvals, however, various levels of expenditures will be selectively determined. For purpose of this simulation it will be assumed that the funds determined to be available will continue to be distributed to the various Backlog categories in the same proportion as they have in the recent past. If, during the simulation, the backlog of a category is eliminated, the excess funds will be applied against the FIX Backlog. The results of the simulations are presented in Exhibits 4.6 through 4.10, which project changes to the 1988 Backlog estimates at select periods over the next 12 years at 100%, 150%, 200%, 250%, and 300% of the level of approved funding that existed in 1988, respectively.

Exhibit 4.6 indicates the consequences on the backlog of continuing the funding level of 1988 into the foreseeable future. In 1988, records indicate approximately $1,476 million was available for meeting hard cost public housing modernization. At that level of funding, the FIX backlog would continue to grow although at a declining rate. Between 1990 and 1995 the backlog would increase by 21 percent, from $12,558 million to $15,225 million. From 1995 to the year 2000 the backlog would grow by 18 percent to slightly over $18,000 million. The other backlog categories would decrease moderately over time. The Backlog for MANDATORY ADDS (ISO 1 and 2) would be entirely eliminated by the year 1997, as would the LEAD ABATEMENT Backlog estimate.

Exhibit 4.6

Estimated Public Housing Backlog and Unfunded Backlog in Selected Years at Continuation of 1988 Funding Level[1] (in millions)

Modernization Needs	As Of 1/90 Estimated Backlog	As Of 1/90 Unfunded Backlog	As Of 1/95 Estimated Backlog	As Of 1/95 Unfunded Backlog	As Of 1/2000 Estimated Backlog	As Of 1/2000 Unfunded Backlog
FIX	$12,558.0	$10,326.2	$15,224.8	$12,823.6	$18,021.2	$15,287.7
MANDATORY ADDS						
ISO 1 & 2	$697.3	$466.6	$212.8	$0.0	$0.0	$0.0
ISO 3	$432.1					
ISO 4	$180.2		Unchanged			
ISO 5	$111.9					
PROJECT SPECIFIC ADDS						
ISO 1 & 2	$5,356.7	$5,008.7	$4,642.2	$4,279.7	$3,993.6	$3,631.1
ISO 3	$2,146.3					
ISO 4	$1,282.5		Unchanged			
ISO 5	$618.1					
MISC. ADDS						
NO ISO	$545.4					
OTHERS	$6.5		Unchanged			
HUD PROHIBITED	$110.9					
REDESIGN	$2,096.8	$2,027.2	$1,953.9	$1,881.4	$1,824.2	$1,751.7
LEAD ABATEMENT	$412.1	$309.5	$180.2	$60.6	$0.0	$0.0
ENERGY	$683.3	$532.7	$385.6	$229.1	$118.7	$0.0
HANDICAPPED	$266.7	$256.9	$245.5	$234.8	$225.6	$214.9

[1] Appropriations of $1,476 million per year from 1989 through the year 2000.

At a funding level of $2,214 million (Exhibit 4.7), 50 percent higher than the 1988 level, the FIX Backlog amount starts decreasing by 1995. Thus between 1995 and the year 2000, the FIX Backlog decreases from $13,246 to $12,723. The unfunded FIX Backlog at this level of funding is reduced to $8,387.8 by the year 2000. This level of funding has a more dramatic impact upon the other Backlog categories. MANDATORY ADDS, LEAD ABATEMENT, and ENERGY are all completed, while significant impact is made on others.

Funding levels 100 percent above the 1988 level (Exhibit 4.8) provide even larger reductions in all of the various Backlog categories. The FIX Backlog estimate is reduced to $7,113 million by the year 2000 with sufficient monies in the pipeline to reduce the unfunded FIX Backlog to $1,333. Only PROJECT SPECIFIC ADDS, REDESIGN, and the HANDICAPPED categories have outstanding Backlogs by the year 2000 at this level of funding.

At funding levels 150 percent (Exhibit 4.9) and 200 percent (Exhibit 4.10) above the 1988 level, unfunded backlog and accrual is eliminated in all need categories. At 150 percent funding, all backlog and accrual would be funded by the year 1997. At the higher level of funding, 200 percent, it would occur in the year 1994.

Exhibit 4.7

Estimated Public Housing Backlog and Unfunded Backlog in Selected Years at 50% Increase Over 1988 Funding Level[1] (in millions)

	As Of 1/90		As Of 1/95		As Of 1/2000	
Modernization Needs	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog
FIX	$12,558.0	$9,802.0	$13,245.8	$9,077.2	$12,722.8	$8,387.8
MANDATORY ADDS						
ISO 1 & 2	$697.3	$412.4	$16.4	$0.0	$0.0	$0.0
ISO 3	$432.1					
ISO 4	$180.2		Unchanged			
ISO 5	$111.9					
PROJECT SPECIFIC ADDS						
ISO 1 & 2	$5,356.7	$4,928.5	$4,353.3	$3,809.6	$3,347.1	$2,803.3
ISO 3	$2,146.3					
ISO 4	$1,282.5		Unchanged			
ISO 5	$618.1					
MISC. ADDS						
NO ISO	$545.4					
OTHERS	$6.5		Unchanged			
HUD PROHIBITED	$110.9					
REDESIGN	$2,096.8	$2,011.1	$1,896.1	$1,787.4	$1,695.0	$1,586.3
LEAD ABATEMENT	$412.1	$283.0	$84.7	$0.0	$0.0	$0.0
ENERGY	$683.3	$498.1	$260.6	$26.0	$0.0	$0.0
HANDICAPPED	$266.7	$254.5	$237.0	$220.9	$206.5	$190.4

[1] Appropriations of $2,214 million per year from 1989 through the year 2000.

Exhibit 4.8

Estimated Public Housing Backlog and Unfunded Backlog in Selected Years at 100% Increase of 1988 Funding Level[1] (in millions)

	As Of 1/90		As Of 1/95		As Of 1/2000	
Modernization Needs	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog
FIX	$12,558.0	$9,277.9	$11,071.5	$5,587.4	$7,112.9	$1,332.9
MANDATORY ADDS						
ISO 1 & 2	$697.3	$358.2	$0.0	$0.0	$0.0	$0.0
ISO 3	$432.1					
ISO 4	$180.2		Unchanged			
ISO 5	$111.9					
PROJECT SPECIFIC ADDS						
ISO 1 & 2	$5,356.7	$4,848.3	$4,064.5	$3,339.5	$2,700.2	$1,975.2
ISO 3	$2,146.3					
ISO 4	$1,282.5		Unchanged			
ISO 5	$618.1					
MISC. ADDS						
NO ISO	$545.4					
OTHERS	$6.5		Unchanged			
HUD PROHIBITED	$110.9					
REDESIGN	$2,096.8	$1,995.1	$1,838.4	$1,693.4	$1,565.7	$1,420.7
LEAD ABATEMENT	$412.1	$256.6	$0.0	$0.0	$0.0	$0.0
ENERGY	$683.3	$463.5	$135.4	$0.0	$0.0	$0.0
HANDICAPPED	$266.7	$252.1	$228.4	$206.9	$187.4	$165.9

[1] Appropriations of $2,952 million per year from 1989 through the year 2000.

Exhibit 4.9

Estimated Public Housing Backlog and Unfunded Backlog in Selected Years at 150% Increase Over 1988 Funding Level[1]
(in millions)

	As Of 1/90		As Of 1/95		As Of 1/2000	
Modernization Needs	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog
FIX	$12,558.0	$8,753.8	$8,792.1	$1,737.8	$1,412.2	$0.0
MANDATORY ADDS						
ISO 1 & 2	$697.3	$304.0	$0.0	$0.0	$0.0	$0.0
ISO 3	$432.1					
ISO 4	$180.2		Unchanged			
ISO 5	$111.9					
PROJECT SPECIFIC ADDS						
ISO 1 & 2	$5,356.7	$4,768.1	$3,775.5	$2,869.3	$2,052.8	$0.0
ISO 3	$2,146.3					
ISO 4	$1,282.5		Unchanged			
ISO 5	$618.1					
MISC. ADDS						
NO ISO	$545.4					
OTHERS	$6.5		Unchanged			
HUD PROHIBITED	$110.9					
REDESIGN	$2,096.8	$1,979.1	$1,780.6	$1,599.4	$1,436.5	$0.0
LEAD ABATEMENT	$412.1	$230.1	$0.0	$0.0	$0.0	$0.0
ENERGY	$683.3	$428.8	$9.8	$0.0	$0.0	$0.0
HANDICAPPED	$266.7	$249.8	$219.9	$193.0	$168.2	$0.0

[1] Appropriations of $3,689.9 per year from 1989 through the year 2000.

Exhibit 4.10

Estimated Public Housing Backlog and Unfunded Backlog in Selected Years at 200% Increase Over 1988 Funding Level[1] (in millions)

	As Of 1/90		As Of 1/95		As Of 1/2000	
Modernization Needs	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog	Estimated Backlog	Unfunded Backlog
FIX	$12,558.0	$8,229.6	$6,507.4	$0.0	$0.0	$0.0
MANDATORY ADDS						
ISO 1 & 2	$697.3	$249.8	$0.0	$0.0	$0.0	$0.0
ISO 3	$432.1					
ISO 4	$180.2		Unchanged			
ISO 5	$111.9					
PROJECT SPECIFIC ADDS						
ISO 1 & 2	$5,356.7	$4,687.9	$3,486.5	$0.0	$0.0	$0.0
ISO 3	$2,146.3					
ISO 4	$1,282.5		Unchanged			
ISO 5	$618.1					
MISC. ADDS						
NO ISO	$545.4					
OTHERS	$6.5		Unchanged			
HUD PROHIBITED	$110.9					
REDESIGN	$2,096.8	$1,963.0	$1,722.9	$0.0	$0.0	$0.0
LEAD ABATEMENT	$412.1	$203.6	$0.0	$0.0	$0.0	$0.0
ENERGY	$683.3	$394.2	$0.0	$0.0	$0.0	$0.0
HANDICAPPED	$266.7	$247.4	$211.3	0.0	$0.0	$0.0

[1] Appropriations of $4,427.9 million per year from 1989 through the year 2000.

Appendix A

Baseline Accrual Forecasts by Building System: Selected Years

Appendix A:
Total and Per-Unit Accrual by System for Selected Years

No.	Name	Year 5 Total (millions)	Year 5 Per Unit	Year 15 Total (millions)	Year 15 Per Unit
2	Stairs	$17.8	$13.68	$25.9	$19.98
3	Exterior Walls	$76.8	$59.14	$119.5	$91.96
4	Exterior Doors	$22.0	$16.93	$30.2	$23.26
5	Storm/Screen Doors	$25.4	$19.54	$25.8	$19.85
6	Windows	$75.8	$58.32	$110.0	$84.60
7	S/S Windows	$46.3	$35.66	$47.0	$36.15
8	Window Security	$8.3	$6.40	$13.0	$10.00
9	Canopies	$37.5	$28.90	$43.1	$33.21
10	Parapet Wall	$1.0	$0.74	$2.2	$1.67
11	Fire Escapes	$0.8	$0.64	$1.7	$1.29
13	Appurtenant Struc.	$0.1	$0.07	$0.1	$0.07
15	Roof Coverings	$168.7	$129.90	$197.3	$151.86
16	Ceiling/Soffits	$16.5	$12.67	$24.0	$18.40
17	Roof Drainage	$1.0	$0.73	$1.3	$0.97
18	Chimneys	$4.0	$3.10	$4.0	$3.06
20	Penthouses	$0.2	$0.13	$0.3	$0.23
24	Floor Finishes	$139.5	$107.36	$150.1	$115.55
26	Radiators	$10.6	$8.18	$20.0	$15.39
27	Local HV Unit	$30.2	$23.27	$45.6	$35.13
29	Temp Controls	$2.4	$1.86	$2.5	$1.93
31	Bldg Lighting	$5.5	$4.27	$6.9	$5.34
32	Signal/Comm	$2.8	$2.19	$0.7	$0.56
34	Smoke Detector	$11.4	$8.80	$10.2	$7.87
35	Kit Cabin/Sinks	$127.9	$98.43	$151.9	$116.96
36	Kitchen Stoves	$39.0	$29.99	$40.9	$31.47
37	Refrigerators	$44.1	$33.97	$46.3	$35.64
38	Bathroom Fixtures	$100.9	$77.68	$138.0	$106.25
39	Bathroom Access.	$14.2	$10.96	$19.4	$14.93
41	Mail Facilities	$2.6	$1.98	$2.8	$2.14
42	Compactors	$40.1	$30.88	$40.4	$31.09
44	Mnt. Office Eq.	$0.0	$0.02	$0.1	$0.05
45	Mnt. Fac. Eq.	$0.4	$0.33	$0.9	$0.66
47	Roadways	$1.5	$1.18	$2.6	$1.98
48	Parking	$0.7	$0.53	$1.1	$0.84
49	Sidewalks	$9.4	$7.26	$10.1	$7.79
50	Retaining Walls	$0.7	$0.57	$0.9	$0.72
51	Soft Site Dev.	$0.3	$0.25	$0.4	$0.28
52	Free Bldg	$3.2	$2.43	$4.2	$3.25
56	Elevator Shaft	$6.1	$4.72	$6.4	$4.94
57	Elevator Cab	$4.5	$3.46	$5.8	$4.48
58	Elev Mach Room	$0.4	$0.32	$1.0	$0.77
59	Fuel Oil Stor	$0.2	$0.12	$0.3	$0.26

Appendix A: (Continued)

No.	Name	Year 5 Total (millions)	Year 5 Per Unit	Year 15 Total (millions)	Year 15 Per Unit
60	Fuel Oil Trn Sys	$0.0	$0.03	$0.1	$0.07
61	Pur Steam SS	$0.0	$0.02	$0.0	$0.01
63	Bottled Gas Sys	$0.0	$0.02	$0.1	$0.04
64	Heat Exchanger	$0.0	$0.02	$0.1	$0.06
65	Boilers	$16.2	$12.47	$23.0	$17.68
66	Furnace	$1.7	$1.34	$2.5	$1.95
67	Flue Exhaust	$0.6	$0.44	$1.3	$1.02
68	Combust Air Sys	$0.6	$0.46	$1.4	$1.06
69	Boiler Rm Pipe	$2.8	$2.19	$6.8	$5.27
71	Hot Water Circu	$0.7	$0.51	$0.8	$0.62
72	Blowdown & WT	$0.1	$0.04	$0.1	$0.07
73	Cond & Feed Sys	$0.2	$0.14	$0.3	$0.24
74	Space Temp Cntl	$0.1	$0.04	$0.1	$0.04
75	Zone Valve	$0.1	$0.04	$0.1	$0.05
76	Bldg Heating Risers	$1.0	$0.80	$3.7	$2.87
77	Vent & Exhaust	$2.7	$2.09	$3.2	$2.43
78	Heat Pumps	$75.6	$58.19	$76.6	$58.98
79	Gas Supply	$0.1	$0.05	$0.1	$0.06
80	Bldg Gas	$0.8	$0.65	$1.5	$1.13
81	Hot Water Genr	$17.9	$13.81	$21.6	$16.63
82	Bldg H&C Water	$11.5	$8.84	$24.9	$19.18
83	Cold Water S/S	$0.3	$0.20	$0.4	$0.30
84	Sewer Ejectors	$0.0	$0.02	$0.1	$0.05
85	Sump Pumps	$0.4	$0.29	$0.5	$0.37
87	Fire Pumps	$1.2	$0.91	$1.3	$1.00
89	Smoke & Vent	$0.1	$0.09	$0.1	$0.09
93	Emer Light-batt	$0.0	$0.03	$0.1	$0.08
94	Site Heat Dist	$3.5	$2.72	$3.0	$2.31
95	Site Gas Dist	$0.1	$0.09	$0.2	$0.16
96	Site Cold Water D	$0.1	$0.07	$0.2	$0.13
97	Site Hot Water D	$1.4	$1.11	$1.2	$0.96
98	Well Water Sys	$0.0	$0.00	$0.0	$0.00
99	Site Power Dist	$0.3	$0.24	$0.3	$0.26
100	Site San Dist	$0.0	$0.00	$0.0	$0.01
101	Water Tanks	$3.5	$2.66	$1.5	$1.17

Appendix B

Accrual Actions and Expected Lives

Appendix B
Definitions of Replacement Actions by System

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment[1]	Fix Level	Condition Description	Repair/Replacement Event
1	Foundations				M	1	Cracks in wall; peeling paint, graffitied or marred wall requiring paint. NA for Type 5.	Patch/repair cracks and/or repaint exposed foundation wall.
					E	2	Evidence of settling, buckling or wall displacement in 1-30% of building foundation.	Replace affected foundation.
					E	3	Evidence of settling, buckling, or wall displacement in 31-60%.	Replace affected foundation.
					E	4	Evidence of settling, bucking, or wall displacement in more than 60% of building foundation.	Replace all building foundations.
2	Stairs				M	2	Selected nosing is chipped, damaged or missing; rail missing segments or inadequate for stair width. (NA for Type 2)	Patch stair, renovate existing rail, add nosing, refinish wood.
		10,20 30,40			A* E	3	Treads systematically deformed, rail inadequate, deformed, or damaged.	Patch stair, replace < 50% treads or risers, replace rails, refinish.
		10,20 30,40	25	25	A E	4	Stringers damaged, stairs and supports missing > 50%.	Remove and replace stair structure.
3	Exterior Walls				M	1	Surface intact but evidence of weathering: Occasional peeling paint; cracked joints, loss of caulking; general deterioration of mortar.	1. Brick: Repoint selected areas and recaulk joints. 2. Concrete Block: Repoint and recaulk. 3. Glass Block: Recaulk joints. 4. Precast Panel: Patch and recaulk. 5. Metal/Glass Curtain Wall: Recaulk and refinish trim. 6-10. Surface materials on frame: Paint, no preparation and recaulk. 11. Stone: Repoint.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
		10-60,90,110 70,80,100	 25	 25	M A	2	Surface substantially marred by graffiti, pollution, smoke/fire damage, or widespread peeling, chipped or bubbling paint; missing elements of siding or trim.	1. Brick: Clean and recaulk plus minor action costs. 2. N.A. 3. Glass Block: Clean and recaulk. 4. Precast Panel: Clean, patch and recaulk. 5. 6-10. Surface Materials on Frame: Prep (scrape, prime, etc.) and paint; recaulk. 11. Stone.
		10 60-100	25	25	A E	3	Evidence of general moisture penetration on masonry; portions of surface severely damaged (or missing) by water, fire or vandalism.	1. Brick: Waterproof all surfaces, clean, repoint and recaulk plus minor moderate action costs. 2. N.A. 3. N.A. 4. N.A. 5. N.A. 6-10. Surface Materials on Frame: Replace less than 20% of the surface; prep, recaulk and repaint. 11. Stone.
					E	4	Brick, block, stone, or glazing are missing, cracked or have lost integrity; breakage of glass block; siding has lost integrity.	Indicate percentage of wall type to be replaced.
4	Exterior/ Common Doors				M	2	Door has poor fit and/or inoperable or missing hardware.	Recondition: Replace hardware, remove, repair fit, rehang, repaint and/or reglaze, as appropriate.
			60	30	A	3	Door has lost its integrity as a result of vandalism, water damage, or deterioration but frame is intact; missing door.	Replace Door: Replace hardware and door (jamb is reused); paint doors.
			60	30	A	4	Frame is warped, bent or severely damaged from fire, vandalism or water and has buckled, warped, or broken.	Replace Door and Frame: Replace door, frame and hardware; paint doors.
5	Storm/Screen Doors		15	7	A	4	Broken elements; outdated system; storm/screen door has lost basic integrity; infiltration possible.	Remove and replace with new door.
6	Windows		30	30	A	4	Missing windows, broken elements other than glass; rotted frame or sash; general deterioration of joints.	Replace entire window unit.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
7	Storm/Screen Windows		15	7	A	4	System has lost basic integrity and permits infiltration; sash is bent or rotted.	Remove, replace with new sash frame, screens, etc.
8	Window Security		40	40	A	4	Existing window security devices non-functional or in need of substantial repair.	Replace indicated window security devices.
9	Canopies		20	20	A	2	Canopy structure in disrepair: Evidence of leaks or weather deterioration of surface; isolated structural elements loose, missing or deformed.	Repair damaged canopy: Reroof, add gutters; repair/replace column; reanchor; paint.
					S	4	Canopy structurally unsound and unsafe; structural elements non-functional or deteriorating; roofing material deteriorated; highly non-functional.	Replace canopy with new structure.
10	Parapet Wall		25	25	A	1	Parapet wall and coping have surface deterioration and evidence of weathering--deteriorated grout, cracks in stucco, peeling paint.	Repair parapet wall and coping--repoint, recaulk, paint, patch stucco, etc.
					S	2	General surface deterioration and small section (10%) of parapet wall have lost their integrity.	Repair as indicated and replace 10% of parapet wall and coping.
					S	3	General surface deterioration and 11-50% of parapet wall/coping has lost integrity.	Repair as indicated and replace 11-50% of parapet wall/coping.
					E	4	More than half (50%) of parapet wall/coping has deteriorated structurally and lost its integrity.	Replace all parapet wall/coping.
11	Fire Escapes				M	2	Fire escapes intact but surface is rusted, chipped, peeling, etc.	Refinish fire escape.
					M	3	Occasional elements (railings, landing step, etc.) are deteriorated or missing, loose connections.	Repair/replace selected elements and refinish; reanchor.
			40	40	A	4	Fire escape system is structurally unsound and dangerous.	Replace fire escape.
12	Railings				M	1	Chipped and peeling paint, rusting; occasional broken weld.	Refinish: Repaint; spot welding.

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					M	2	Up to 25% of railings are missing or deteriorated and not structurally sound.	Replace 25% of railings.
					S	3	Half of railings are missing or deteriorated and not structurally sound.	Replace 26-50% of railings.
					S	4	All railings are missing or deteriorated and not structurally sound.	Replace all railings.
13	Appurtenant Structures	10,30-60 20	5	5	M A	2	Structure intact but exterior surface is weathered (peeling or chipped paint); hardware broken or missing; minor roof leaks.	Repair surface materials: Paint, caulk, replace hardware; reroof.
		10,30-60			E	4	Structure has lost basic integrity; deteriorated; severe fire or water damage.	Replace structure.
14	Roof Structure				E	4	Roof system has buckled or deteriorated and lost structural integrity; severe water or fire damage.	Replace roof structure (or identifiable portion of).
15	Roof Coverings				M	2	Roof is still serviceable; a few leaks but not serious in nature; base felts in good condition and not waterlogged; insulation, if present, is sound, dry, properly attached; isolated cracking; bare spots on aggregate-surface roofs; damaged shingled areas; metal section loose.	Repair 20% roof areas.
		10-30 50	40	40	A* A	3	Surface-wide problems such as blistering, alligatoring but no cracks or evidence of moisture penetration; felts in sound condition and not waterlogged. (Asphalt or wood shingles have not been previously resurfaced.) NA - 6-9.	Resurface over existing roof covering.
			40	40	A	4	Evidence of advanced deterioration and water penetration; felts have disintegrated/disbonded; insulation wet or poorly attached; numerous leaks of a serious nature. (Asphalt or wood shingles have been previously resurfaced.)	Remove existing roof covering system and install new roof.
16	Ceiling, Soffits				M	2	Surface intact but simple aging and deterioration: Minor holes and cracks; aging or blistered paint, flaking, minor strains.	Paint or replace selected tiles: Spackle and repaint entire ceiling or soffit.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
		10-40			M	3	Portion of ceiling material has been damaged: Paint flaking (<25% of surface); major stains, holes, cracks. Basic structural integrity is OK.	Paint with special prep work: Some special prep (scraping, patching, feathering, taping) to ceiling before resurfacing. Patch holes, seal stains, skim coat plaster, retape joints.
		10-40	25	25	A	4	Surface and ceiling/soffit system have lost integrity: Major holes, fire or water damage, cracks, sags, flaking paint or concrete slab surface-wide; non-functional suspension system.	Replace surface and ceiling/soffit material: Replaster; rewallboard.
17	Roof Drainage	10-13 20-23			E M	1	Minor damage to drainage system.	Repair system.
		10-13 20-23			E A*	2	20-60% of accessories damaged or missing.	Replace 20-60% of accessories.
		10-13 20-23	25	25	E A	4	Majority (>60%) of roof accessories missing or damaged and most of roof drainage system is non-functional.	Replace accessories.
18	Chimneys				M	1	Chimney structurally sound but deteriorated mortar and potential moisture penetration.	Rake out and repoint mortar joints; waterproof.
			25	25	A	4	Chimney structurally unsound.	Replace, rebuild chimney.
19	Hatches/ Skylights				M	4	Hatch door non-functional; structure bent, twisted, damaged beyond repair; closing/locking mechanism broken or missing.	Replace hatch/skylight.
20	Penthouses				A*	1	Door not securable.	Replace door.
			30	30	A	3	Evidence of moisture penetration and door not secure.	Moisture proof penthouse and replace door.
					E	4	Structure not intact--substantial fire, wind or water damage; severe deterioration.	Rebuild penthouse.
21	Walls				M	1	Surface intact but exhibits simple aging or deterioration: Minor holes (nails); discolored paint; failing occasional grout; loss of panel adhesion to wall.	Resurface: Surface material needs to be restored with minimal prep work: Repaint; replace occasional failing grout; clean tile; refasten paneling.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
					M	2	Surface has occasional damage but no loss of partition integrity: Holes in isolated locations (e.g., from door knobs); drywall joints have popped; <10% of tiles missing; discolored/deteriorated paper/vinyl wall covering.	Major prep work required before resurfacing: Replace 10% of tiles; prime and seal for water damage; repair and spackle joints; patch holes; remove existing wallpaper or vinyl wall covering and rewallpaper or repaint.
					E	3	Considerable damage to surface and portion of partition: Major holes or cracks through 10-25% of partition; 10-25% of tiles missing.	Resurface with partial partition. Replacement: Portions of partitions (<25% total surface) have lost integrity and need replacement. Replace sections of dry wall or replaster; replace 10-25% of tiles.
					E	4	Partition has lost integrity: Substantial fire or water damage; settling or buckling of partitions.	Replace partition and surface.
22	Ceilings				M	1	Surface intact but simple aging and deterioration: Minor holes and cracks; aging or occasional blistered paint, flaking; minor stains; <10% missing or damaged tiles.	Paint or replace selected tiles: Spackle and repaint entire ceiling; replace <10% tiles.
					E	2	Portion of ceiling materials has been damaged: Paint flaking (<50% of surface); missing 10-50% of tiles; major wall stains, holes, bulges, cracks. Basic structural integrity OK.	Paint with special prep work: Some special prep (scraping, patching, feathering, taping) to ceiling before resurfacing. Patch holes, seal stains, skim coat plaster, retape joints, replace 10-50% of tiles.
					E	4	Surface and ceiling system material have lost integrity: Major holes, fire or water damage, cracks, sags, flaking paint on concrete slab surface-wide; non-functional suspension system.	Replace surface and ceiling material: Repair/replace ceiling system and resurface; drywall over or scrape/prep and seal flaking paint, rehang suspension system for acoustical tile; scrape, readhere ceiling tiles.
23	Unit Interior Doors				M	2	Door intact but ajar in frame; some hardware damaged or missing.	Replace hardware and rehang door.
					M	3	Door has lost its integrity as a result of fire or water damage, vandalism, or deterioration (buckling, holes, cracks, surface scars). Jamb intact.	Replace hardware and door (frame is retained); paint wood doors.
					E	4	Jamb has lost its integrity--broken, warped, deteriorated, buckled, etc.	Replace frame, door and hardware; paint wood doors.

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24	Floor Finish				M	1	Stained carpeting; dull, dirty tile floor; surface scratched wood floor; worn paint on concrete; <10% of resilient tile missing.	Shampoo carpeting; clean and polish resilient tile; sand and refinish wood floors; paint concrete; replace missing tile.
		10			M	2	Occasional broken or missing tiles; deteriorated, flaking grout.	Ceramic Tile only: Replace <10%, regrout entire surface.
		30,40	30	30	A	3	Worn surface, minor splintering, cracks or holes in sections (<25%).	Wood only: Replace damaged sections (<25%), refinish wood surface.
		10,20 30,40 50,60 70	75 20 12	75 15 10	A S A A	4	Carpet worn, severely stained; holes, cracks in sheetgoods; tile is popping or >10% missing; wood is buckling or warping and severe splintering.	Replace Flooring.
25	Interior Construction				M	1	Interior finishes worn and exhibit simple aging; discolored paint or paper; occasional floor finish deteriorated.	Refinish: Repaint or rewallpaper; replace occasional missing tiles.
					M	2	Occasional wall, ceiling, and/or floor damage.	Repair: Occasional surface damage in walls, ceilings and/or floors; repair doors; ceiling leaks.
					E	3	Substantial damage to selected interior surfaces and systems.	Repair and replace: Extensive surface damage requires replacement of half of surfaces; replacement of selected M&E systems.
					E	4	Extensive water or fire damage; serious vandalism; mechanical and electrical systems not functioning.	Replace with all new interior construction including surfaces, mechanical and electrical systems.
26	Radiation	100			M	2	Moderate leaks not warranting radiator replacement, missing or severely damaged radiator cover. (NA for 2, 3)	Replace or repair indicated component.
		100 200,300,901-6 801-06	50 25 20	50 23 20	A A A	4	Radiation system is beyond economic repair.	Replace entire system.
27	Local HV Unit				M	2	One major component is faulty and needs to be replaced (fan, coil, flue (breeching), cabinet, blower motor).	Replace the indicated component.
			25	25	A	4	Two or more major components faulty, require replacement.	Replace entire system.
28	Air Terminals				M	4	Register is missing or physically abused.	Replace entire system.

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29	Temperature Controls	100 200	25	25	M A	4	Temperature control is inoperative due to abuse, age, corrosion; or is missing.	Replace the temperature control.
30	Dwelling Unit Electrical				E	4	Greater than 30% of the wall wiring needs to be replaced (overload and/or burn out).	Replace branch wiring, outlets, fixtures.
31	Building Lighting				M	1	Exterior entry light faulty beyond repair.	Replace with exterior entry light.
			10	8	A	2	Building-mounted site lighting faulty, beyond repair.	Replace building site lighting.
			25	25	A	3	Up to half of interior fixtures are damaged, requiring replacement.	Replace half of interior fixtures and associated system elements.
					A*	4	More than half of interior fixtures need replacement resulting from physical abuse or deterioration.	Replace all fixtures and associated system elements.
32	Signalling/ Communications /Security		30	30	A	2	Need for replacement of in-unit signalling component.	Replace appropriate component.
			30	30	A	3	Central portion of system dysfunctional.	Replace appropriate central system.
33	Master TV System	1			M	2	Antenna dysfunctional.	Replace antenna.
		2			M	3	Amplifier dysfunctional.	Replace amplifier.
					X	4	Mast/dish dysfunctional; system beyond economic repair.	Replace system.
34	Fire/Smoke Detection		40	10	A	2	Detector(s) need replacement.	Replace faulty detector(s).
			40	20	A	3	Annunciator needs replacement.	Replace annunciator.
35	Kitchen Cabinet/Sink				M	1	Cabinet paint peeling, minor holes and nicks; occasional door fronts or drawers missing but cabinet base in sound condition; sink fittings loose, leaking or non-functional.	Refinish existing cabinets; replace occasional doors; and/or replace fittings.
					A*	2	Cabinets in good condition; countertop worn, delaminated, deteriorated; sink chipped or cracked or generally deteriorated.	Remove and replace countertop with new countertop and backsplash; remove and replace sink and fittings.

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					A*	3	Cabinet paint peeling, minor holes and nicks; occasional door fronts or drawers missing but cabinet base in sound condition; countertop worn, delaminated, deteriorated; sink chipped or cracked or generally deteriorated; fittings loose, leaking or non-functional.	Refinish existing cabinets; replace occasional doors; replace countertop, sink and fittings.
			25	20	A	4	Water, fire, or vandalism damage to counter surface and cabinet base; majority of doors and drawers missing or broken; cabinet base has lost its integrity.	Remove and replace sink and cabinet system.
36	Kitchen Stoves		15	15	A	4	Stove missing or non-functional where PHA provides appliances.	Replace stove.
37	Kitchen Refrigerators		15	15	A	4	Refrigerator missing or non-functional where PHA provides appliances.	Replace refrigerator.
38	Bathroom Fixtures				M	1	All plumbing fixtures intact, but fittings are broken or non-functional.	Install new fittings on lavatory and bathtub (include new shower head).
					A*	2	One fixture is chipped, rusted, cracked, or deteriorated.	Replace one fixture (lavatory or toilet).
					A*	3	Two fixtures are chipped, rusted, cracked, or deteriorated.	Replace lavatory and toilet.
			40	25	A	4	Bathtub chipped, rusted, or deteriorated. If public facility, 3 or more fixtures chipped, rusted, or deteriorated.	Replace tub and any other fixtures that have deteriorated.
39	Bathroom Accessories				A*	2	Several (2-3) accessories missing or broken.	Replace 2-3 non-functioning, missing, or broken accessories.
			40	25	A	4	Majority of accessories missing or broken.	Replace all accessories.
40	Laundry Facilities				M	2	Electrical service unsafe <u>or</u> water supply/drain in disrepair <u>or</u> vent non-functional.	Repair electrical service <u>or</u> water supply/drain <u>or</u> vent.
					M	4	At least 2 components (electrical service, water supply/drain, vent) non-functional.	Replace all components.
41	Mail Facilities		50	10	A	4	Mailboxes missing or damaged and not securable.	Replace mailboxes.

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42	Compactor				M	1	Chute door dysfunctional.	Replace chute door.
					A*	2	Pump or motor or entire piston-cylinder dysfunctional, require replacement.	Major overhaul or replacement of one major component.
					A*	3	Pump and motor or piston-cylinder and ram with guides dysfunctional, require replacement.	Major overhaul or replacement of 2 major components.
			10	10	A	4	Entire system is beyond economic repair.	Replace entire system.
43	Incinerators				M	1	Chute door is dysfunctional.	Replace chute door.
					M	2	Burner system faulty.	Replace/repair burners.
					X	3	Stack has fallen apart or separated from building if on exterior; brick at incinerator is fully cracked; some flue brick requires replacement.	Replace stack; repair major brick.
					X	4	Entire system is beyond economic repair.	Replace entire system and stack.
44	Management Office Equipment Package				M	2	Minor damage to countertops or built-ins.	Repair damaged areas.
			50	50	A	3	Substantial damage to countertops or payment booth area, if present.	Replace countertop or safe or booth.
					E	4	All built-ins have lost integrity from fire, water damage or vandalism.	Replace all built-ins.
45	Maintenance Facilities Equipment Package				M	2	Minor damage to facilities and surfaces; chipped or aging paint.	Minor repair to facilities; refinish and/or repaint.
			30	30	A	3	Damage to less than half of facilities.	Major repair or replace of less than half of facilities.
					A*	4	Extensive damage to all built-in facilities.	Replace all maintenance facilities.
46	Earthwork				M	1	Spot erosion: Surface erosion; poor drainage; gulleys; ponding; etc. in isolated locations; minor settlement of backfill around buildings.	Spot regrading of up to 10% of observed site area.

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					S	2	Substantial erosion: Surface erosion; poor drainage; gulleys; ponding; etc. on 11-50% of observed site area.	Regrade 11-50% of site.
					S	3	Erosion of majority of site: Systemic, large problem areas of surface erosion; poor drainage; gulleys; ponding; etc. on more than half the observed site area.	Regrade most of the observed area of the site (>50%).
47	Roadways				M	1	Spot deterioration of surface; pot holes; curb displacement in selected areas; occasional severe cracks or concrete displacement.	Patch where necessary (<10% of surface); repair potential hazards; replace swail areas (<10% of road); regravel <10% of road.
		10			A*	2	Deterioration, settlement, or surface alligatoring of 10-50% of roadway and curbs; occasional dysfunctional light, drain.	Repair selected holes, curbs, lights, drains, and resurface 10-50% of paved roadways. Modest surface preparation and regraveling of 10-50% of unpaved roads.
		10 20	25 15	25 15	A	3	Deterioration, settlement, or surface alligatoring of 51-100% of roadway with selected holes and curb displacement; approximately 50% of lights and occasional drains dysfunctional.	Resurface entire paved roadway and reset or replace curbing, replace half of lighting, repair drains. Surface preparation and regraveling of unpaved roads.
					S	4	Entire road surface and base deteriorated and hazardous; most lights and drains dysfunctional.	Demolish existing roadway and reconstruct new base and surface. Regrading and regraveling of all unpaved roads. Replace associated lighting, curbs, drainage.
48	Parking				M	1	Spot deterioration of surface; pot holes; curb displacement in selected areas; occasional severe cracks or concrete displacement; isolated ponding areas.	Patch <10% of surface; repair pot holes, sunken areas or swails; reset/replace <10% of curbing.
					A*	2	Deterioration of 10-50% of parking surface and curbing.	Repair selected holes or pond areas and resurface 10-50% of parking. Modest surface preparation and regraveling of 10-50% of unpaved parking lot.
			25	25	A	3	Deterioration of 51-100% of parking surface and curbing.	Resurface parking lot and reset/replace curbing. Surface preparation and regraveling of 51-100% of unpaved parking lot.

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					S	4	Entire parking lot, including base, has deteriorated.	Demolish existing lot and reconstruct new gravel base and wearing course; complete regrading and regraveling of unpaved lots.
49	Pedestrian Paving				M	1	Spot deterioration of <10% of surface; severe cracks or displacement; sunken areas or holes; cracked mortar; spalled concrete; lights intact.	Spot repair (<10%) of pedestrian areas: Patch bituminous; reset or replace concrete sections; repair mortar in brick areas.
					A*	2	Deterioration of significant areas (10-50%) of pedestrian paving surface; occasional lights require replacement.	Resurface significant portion (10-50%) of pedestrian areas.
			15	15	A	3	Deterioration of more than half of pedestrian paving surface; up to half of the lights require replacement; occasional damage to railings at stairways.	Resurface more than half of pedestrian areas.
					S	4	Surface and base of pedestrian areas deteriorated--system-wide cracking, heaving, sunken areas; more than half of lights and railings at stairs require replacement.	Demolish and reconstruct new pedestrian walkways.
50	Retaining Walls	11-14 21-24,41-43 31,32	20 15 10	20 15 10	A	2	Occasional deterioration: Occasional cracking, seepage, surface damaged but wall has basic integrity.	Fill cracks, repaint or clean; reset portions; regrout.
					S	4	Wall has lost integrity: Heaving affecting entire wall; foundation or leverage failure.	Remove existing and replace.
51	Soft Site Development				M	1	SSS: Existing soft soft site generally in good condition but some worn landscaped areas. HSS: Minor damage or deterioration (or missing elements) of enclosure system; peeling paint or rusted site furniture.	SSS: Reseed, replant small areas (<10%) of site. HSS: Repair, refinish occasional enclosures/fencing; general paint touch-up of site furniture.
					M	2	SSS: 10-30% Landscaped areas are deteriorated and much of the growth is dead/dying. HSS: Minor damage or deterioration of enclosure system; peeling paint or rusted site furniture.	SSS: Reseed, replant 10-30% of the site. HSS: General repair/maintenance to HSS elements.
		10-40 100-400	 20	 20	S A	3	SSS: 31-60% Landscaped areas deteriorated. HSS: Several major components deteriorated.	SSS: Reseed, replant 31-60% of site. HSS: Replace approximately 50% of elements.

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					S	4	SSS: Greater than 60% of landscaped areas are deteriorated. HSS: Essentially all components worn, damaged or missing.	SSS: Reseed, replant 100% of the site. HSS: Replace total recreation/sitting area; replace total enclosure system; repair/replace drains, etc.
52	Site-Wide Freestanding Structures (Exterior)				M	1	Facility generally in good condition but some minor elements (doors) broken or missing; some weathering of exterior wall; electrical service adequate but exterior lighting dysfunctional.	Paint, where appropriate; fix doors; repair roof leaks; repair lighting as needed.
			20	20	A	2	A major component (exterior wall, roof, windows or doors) has deteriorated; other elements generally in good condition.	Replace wall surface, windows, roof, or doors; general maintenance on other elements.
					S	3	Severe deterioration of exterior closure: Grouting of brick surfaces has deteriorated; evidence of water penetration; siding has lost its integrity; substantial roof leaks to interior.	Major rehabilitation of exterior closure system: Replace exterior surfaces; replace roof.
					S	4	Structure and exterior enclosure have lost their integrity; severe structural damage from water/fire, settlement or vandalism.	Replace basic structure and exterior closure system (essentially new construction).
53	Waterproofing				E	2	Dampness: Continuously damp foundation creating moisture conditions that are a health or potential structural integrity problem.	Waterproof foundation.
					E	3	Standing water on floor or in crawl space: Substantial collection of subsurface water from grade or a subsurface stream above the bottom of the footing causing deterioration of foundation structure.	Waterproof foundation and install underdrain outside of foundation wall or from crawl space, or sump pump.
54	Slab				E	2	0-20% of slab is broken or has buckled.	Patch and replace 0-20% of building slab.
					E	3	21-50% of building slab is broken or has buckled.	Replace building slab as required.
					E	4	More than half of slab has broken, buckled and lost its original integrity.	Replace entire slab.
55	Wood Frame				M	2	Minor deterioration (cracking) of	Bracing and gussets; shore up floor and

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
							structural members or evidence of minor sagging or deflection; evidence of termite damage and potential structural unsoundness.	replace a few columns or beams.
					E	4	Major systematic deflection or floor failure; severe fire damage with loss of structural integrity in floor.	Replace entire floor framing system.
56	Elevator Shaft and Doorways				M	1	Any electrical item such as the stop switch, limit switch(es), leveling switches, etc. except travelling cables, are dysfunctional, compensation chain rope damaged or missing.	Replace the dysfunctional item(s) and perform all adjustments necessary.
			15	10	A	2	Door gibs, hangers or hinges damaged, vane dysfunctional, counterweight guard missing, governor tension sheave guard, spring or weight dysfunctional or missing, sheave bearings are noisy, travelling cables insulation sheath frayed, wires internally broken, selector tape broken, counterweight or cab rail anchors loosening, 10% of doors are damaged, piston/cylinder seal leaks but piston surface is not scored, counterweight tie rods cracked, pins are bent. [Note: observe the "ropes" (cables) for fraying, excessive rouge, deficient lubrication from the core. Do not include this observation here but use with evaluation of cables in O/S 58.] Buffers are leaking or spring is broken.	Replace/repair 50% of the listed observations and perform all necessary adjustments.
					S	3	The majority of the observations listed under "Moderate" are observed or up to 50% of the doors are damaged, or piston/cylinder is severely scored or guide rails are damaged as a result of missing rubber on cab rollers.	Replace/repair the missing or dysfunctional components and perform all necessary adjustments.
					S	4	The majority of the observations listed under "Major" are observed, and/or 51% of doors need to be replaced, or entire system is beyond economic repair.	Replace and adjust the system.
57	Elevator Cab				M	1	Light fixture, fan, display lamps, selector buttons, telephone, handrails, toe guard missing or dysfunctional.	Replace the indicated component(s).

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					M	2	20% or more of cab interior finish is damaged, door, guides, motor and drive are faulty, cab rollers are Worn.	Replace the indicated components and perform all necessary adjustments.
			30	15	A	3	Safety blocks, rollers, cables, cab frame needs welding, floor finish needs replacement all as a result of urine corrosion.	Replace the components and waterproof the floor if necessary.
					S	4	Entire system is beyond economic repair.	Replace entire system.
58	Elevator Machine Room Equipment				M	1	Worm thrust bearing knocks, brake pads are worn, brake pin knocks, controller relays burnt-out, worm gear seals leak, bedplate has a minor crack, hydraulic fittings leak, governor guard missing, hoist ropes guard missing, governor power interlock dysfunctional, resistors not mounted or burnt-out, worm gear not oiled, commutator brushes worn or missing.	Replace/repair indicated component(s) and perform all necessary adjustments.
			30	25	A	2	Brake drum scored, commutator on motor or motor generator shiny, not chocolate brown, drive sheave vee groove worn, worm gear has eccentric wear, brake solenoid dysfunctional, motor generator bearings noisy, cooling fan damaged, wye-delta relays burnt out, solid state relay boards dysfunctional, hydraulic slide valve dysfunctional, or major overhaul or replacement of one to two <u>major components</u>: <u>Motor</u> or <u>motor generator</u> burnt-out, <u>ropes</u> are frayed, crowned and excessive rouge present, <u>worm and worm gear</u> teeth excessively worn indicated visually and audibly (backlash), <u>drive sheave</u> beyond undercutting, <u>controller</u> dysfunctional, <u>hydraulic pump set</u> dysfunctional, <u>hydraulic reservoir</u> severely corroded.	Replace brake drum, turn and undercut commutator(s), turn and undercut drive sheave vee-groove, align worn and worn gear, replace/repair dysfunctional component(s) and perform all necessary adjustments.
					S	3	Majority of repair actions under "Moderate" are needed <u>and</u> a major component needs major overhaul or replacement <u>or</u> three major components are dysfunctional.	Replace/repair dysfunctional components and perform all necessary adjustments.

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					S	4	75% or more of this system is dysfunctional and beyond economic repair as a result of antiquity and/or availability of compatible replacement parts.	Replace entire machine room equipment.
59	Fuel Oil Storage				M	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	Clean tank, replace a specialty item, repair/replace level gauge assembly, clean out piping.
					M	3	Major components need overhaul or repair.	Patch leaks or reline underground tanks, replace tank heater, specialties and level gauge assembly.
			40	40	A	4	Major components are beyond economic repair; replace system.	Replace tank(s) resulting from excessive leakage caused by corrosion.
60	Fuel Oil Transfer System				A*	2	Pump and/or motor is not functioning, or half of piping is leaking/corroded.	Replace pump and motor set or 50% of piping.
					A*	3	Preheater is not functioning or piping is corroded.	Replace preheater or entire piping and pump set.
			25	75	A	4	All of the components are deteriorated, function improperly, and/or are beyond their useful life.	Replace system.
61	Purchased Steam Supply Station				M	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	Adjust PRV, clean/replace strainers, tighten leaky joints and fittings, repair pipe supports, replace flow meter, overhaul PRV pilot and diaphragm, replace condensate pump (if present, clean separator).
			30	30	A	3	Replacement of a major component.	Replace faulty, leaky PRV rig, replace condensate tank (corrosion) and pump (if both are present).
					S	4	System is beyond economic repair due to age and excessive corrosion caused by steam quality and environment such as a damp room.	Replace major components.
62	Solid Fuel Storage and Conveyance				M	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	Patch/repair damaged retaining walls, broken conveyor belts or drives, repair dryer, lubricate or replace noisy bearings and motors.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
					S	3	Conveyor, bin or dryer(s) deteriorated beyond simple repair.	Patch or replace 70% or more of storage retaining walls, replace conveyor system (stoker), replace dryer(s).
					S	4	Storage bin is excessively corroded or deteriorated, conveyor (stoker) and dryer are beyond useful life and/or are excessively abused and not justifiably repairable.	Replace system.
63	Bottled Gas System				X	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs, and/or replacements.	Adjust, repair or replace a specialty item, repair tank or pipe supports.
			20	20	A	3	Need to replace 50% of the tank(s) resulting from physical abuse and/or corrosion or need to replace piping and specialties resulting from excessive corrosion or beyond useful lives.	Replace 50% of tanks or piping and specialties.
					A*	4	All of the major components are beyond their useful life resulting from excessive corrosion and/or physical abuse.	Replace entire system.
64	Heat Exchanger for Space/ Water Heating				M	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	Clean tubes, control adjustments/ replacements, tighten joints and valve packings, replace head gaskets, repair/ replace strainers, traps, supports.
			35	35	A	3	System operating at low efficiency despite good maintenance; shell exhibits no corrosion.	Retube heat exchanger or replace steam or HW supply and return system.
					S	4	System operates at low efficiency; shell corroded and leaks.	Replace system.
65	Boilers/ Hydronic Packaged Unit				M	1	Need for repair and/or replacement of minor components, with associated system adjustments, repairs and/or replacements.	Clean tubes, "tune up" burner, repair minor leaks in shell or tubes or cast iron sections, repair refractory brick, repair burner, repair minor insulation patches, replace controls and gauges.
					A*	2	One of the major system components (burner, boiler, cast iron sections, insulation, combustion chamber) has deteriorated beyond economic repair.	Major overhaul or replacement of a major component.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
					A*	3	Two of the major systems have deteriorated beyond economic repair.	Major overhaul or replacement of two major components.
			25	25	A	4	Total system is beyond its useful life and/or economic repair.	Replace system.
66	Hot Air Furnace System				M	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	"Tune up" burner, adjust/replace controls, patch small air leaks, secure loose mounts, clean/replace humidifier, lube fan, clean flue, adjust draft controls.
					A*	3	Burner, combustion chamber or fan faulty, beyond economic repair.	Replace the faulty component.
			25	25	A	4	Entire system is beyond economic repair and useful life.	Replace system.
67	Flue Exhaust System				M	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	Patch insulation, repair small leaks in breeching, repair breeching supports, adjust pollution monitoring controls, adjust draft dampers and/or controls, clean breeching and stack, repair noisy fans.
					A*	3	One major component (fan, insulation, breeching/specialties) is deteriorated beyond economic repair.	Replace fan, replace insulation, replace 30% or more of the breeching and specialties.
			25	25	A	4	Breeching is excessively corroded, fan is inoperative, specialties are inoperative, and system is beyond economic repair.	Replace entire system.
68	Combustion Air System				A*	2	Fan or preheater deteriorated beyond repair.	Replace fan or preheater, as indicated.
			25	25	A	4	All major components are excessively worn, or physically abused; system is beyond economic repair.	Replace entire system.
69	Boiler Room Piping				A*	2	Need for repair and/or replacement up to 19% of piping, with associated system adjustments, repairs and/or replacements.	Replace indicated piping.
					A*	3	20-50% of the piping needs replacement from corrosion, leakage.	Replace indicated piping.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
			50	50	A	4	Chronic corrosion of joints, valves and strainers, resulting in excessive leaks or possibility of systemic failures; majority of piping needs replacement.	Replace entire system.
70	Boiler Room Pipe Insulation				M	1	Jacket is torn or loose on 60% or less or insulation is missing on 20% or less.	Secure jacket with high temp. tape or band clamps, patch torn jackets or missing insulation.
					S	2	Insulation is missing or damaged on approximately 21-40% of insulation.	Secure jacket with high temp. tape or band clamps, patch torn jackets or missing insulation.
					S	3	Insulation is missing or damaged on approximately 41-60% of insulation.	Repair damaged or missing insulation.
					S	4	Majority of insulation is damaged from pipe leaks, roof leaks, etc. and 60% or more of the insulation needs to be replaced.	Replace entire insulation.
71	Plant Hot Water Circulation		15	15	A	2	One major component (pump and motor, expansion tank(s), air separator) is deteriorated.	Replace indicated component.
					A*	3	Two major components are deteriorated.	Replace the two indicated components.
					A*	4	All of the major components are deteriorated.	Replace the entire system.
72	Blowdown and Water Treatment				M	2	Need for repair and/or replacement of a minor component, with associated system adjustment, repairs and/or replacements.	Replace injection pump and/or chemical storage tank. Replenish chemical solution, adjust blow-down timer; clean tank and drain, clean clogged lines; tighten leaky joints and fittings.
			25	25	A	3	Blowdown tank or blowdown valves with timer exhibit corrosion.	Replace one component.
					A*	4	Blowdown tank and valves and controls are beyond repair along with the chemical treatment system.	Replace entire system.
73	Condensate and Feedwater System				M	1	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	Replace level controls of tanks and/or boilers/HX; replace feedwater valve(s). Clean/replace steam traps, strainers; tighten leaky joints and fittings; tighten valve packings; patch tank insulation.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
			25	25	A	2	One major component (pumps, tanks, piping) faulty and/or corroded.	Replace indicated component.
					A*	3	Replace two or more major components.	Replace indicated components.
					A*	4	Entire system is deteriorated beyond its useful life and economic repair. All of the major components need replacement.	Replace entire system.
74	Central Spacing Temperature Control		15	15	A	4	Controller is inoperative.	Replace entire system.
75	Building Heating Zone Valve		20	20	A	2	Zone valve, actuator or weatherstat faulty.	Replace either a' faulty zone valve, actuator or weatherstat.
					A*	4	Entire system is old or physically abused and inoperative.	Replace entire system.
76	Building Heating Risers and Distribution				M	1	Need for repair and/or replacement of up to 19% conduit with associated system adjustments, repairs and/or replacements.	Repair supports, patch insulation, patch or replace leaky sections, cap off open-ended ducts, clean clogged return lines that are in good condition.
		101-106 201-202			A* S	2	20-40% of conduit needs work as a result of environmental or internal corrosion, abuse, etc. or conduit is not insulated properly.	Replace indicated runs and insulate all exposed conduit.
		101-106 201-202			A* S	3	41-70% of conduit needs work as a result of environmental or internal erosion, abuse, etc. or conduit is not insulated properly.	Replace indicated runs and insulate all exposed conduit.
		101-106 201-202	75	75	A S	4	Greater than 70% replacement need indicates a systemic problem, thus system is not economically repairable.	Replace entire system.
77	Ventilation and Exhaust Systems		15	15	A	2	Fan is inoperative. NA for Type 2.	Replace fan.
					S	3	Fan is inoperative; up to 10% of ductwork is corroded and needs to be replaced or water/filler media dysfunctional. NA for Type 2.	Replace fan; indicated ductwork or water/filler media.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
					S	4	Total ductwork is corroded, abused and beyond economic repair; or total evaporative cooler system dysfunctional.	Replace entire system. Applicable for local only.
78	Air Conditioning				A*	2	Compressor and/or fan dysfunctional; requires replacement. (NA if single room air conditioning)	Half of the conditioning equipment needs major overhaul or replacement; condensing units or evaporators; pumps (fans).
		101,206 111	15 5	15 5	A	4	Entire system is beyond economic repair and useful life.	Replace entire system.
79	Gas Supply Station		30	30	A	4	Sole or both components and piping are beyond useful life or are unsafe or are inoperative.	Replace PRV rig and pump when both present or the applicable one when only one is present.
80	Building Gas Distribution		30	30	A	1	Replacement or repair of 10% or less of piping and supports due to corrosion or abuse.	Replace indicated piping and supports.
					A*	2	11-30% of piping is corroded from weather, storm leaks, etc. and needs to be replaced; problem is local.	Replace the 11-30% of piping and supports.
					S	4	Corrosion and leakage is systemic if beyond 30% of replacement.	Replace entire distribution.
81	Domestic Hot Water Generation				M	1	Need for repair and/or replacement of <u>one</u> minor component, with associated system adjustments, repairs and/or replacements. Approximately 10% needs replacement. NA for SFAD or in-unit.	Adjust/replace temperature controls; clean heat exchanger; "tune up" burner; tighten leaky fittings and valve packings; replace gaskets; replace small circulating pumps or other peripherals; patch insulation; clean solar panels.
					A*	2	Need for repair and/or replacement of several minor components, with associated system adjustments, repairs and/or replacements. Approximately 30% needs replacement. NA for SFAD or in-unit.	Adjust/replace temperature controls; clean heat exchanger; "tune up" burner; tighten leaky fittings and valve packings; replace gaskets; replace small circulating pumps or other peripherals; patch insulation; clean solar panels.
					A*	3	Major component requires major overhaul or replacement. Approximately 50% needs replacement. NA for SFAD or in-unit.	Replace either the burner(s) or all of the peripherals and tank insulation or retube heat exchanger or replace combustion chamber; replace solar panels.
			20	20	A	4	System is beyond economic repair.	Replace system.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
82	Building Domestic Hot and Cold Water Distribution				M	1	Need for repair and/or replacement of up to 19% of total piping or up to 30% insulation, with associated system adjustments, repairs and/or replacements.	Repair/replace indicated piping and insulation; repair small leaks; repair/replace pipe supports.
					A*	2	20-40% of total piping needs replacement as a result of corrosion and/or physical abuse.	Replace indicated piping and insulations.
					A*	3	Complete hot or cold water distribution system needs replacement.	Replace hot or cold water distribution.
			50	50	A	4	Hot and cold water system is corroded and suffers from excessive leaks.	Replace entire hot and cold water distribution.
83	Domestic Cold Water Supply Station				M	2	Need for repair and/or replacement of a minor component, with associated system adjustments, repairs and/or replacements.	Replace pump seal, repack valve glands, replace water softener treatment media.
					A*	3	One major component (pump and motor, brine tank, house tank) if faulty.	Replace indicated component.
			30	30	A	4	Entire system is beyond economic repair as a result of corrosion, wear and tear or physical abuse.	Replace system.
84	Sewage Ejectors				A*	2	Unit is inoperative due to faulty and major component, or tank leaks excessively.	Replace the tank, pump or motor.
					A*	3	Pump and motor are inoperative and beyond repair.	Replace pump and motor.
			50	50	A	4	System is beyond economic repair.	Replace all system.
85	Sump Pumps				A*	2	Motor inoperative.	Replace motor.
			20	20	A	4	System is beyond economic repair.	Replace all of the components.
86	Building Sanitary Waste and Vent Distribution				M	1	Need for repair and/or replacement of up to 19% of piping, with associated system adjustments, repairs and/or replacements.	Replace affected piping.
					S	2	20-40% of the piping leaks from corrosion or its free area is clogged from unremovable corrosion.	Replace affected piping.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
					S	3	41-70% of piping leaks from corrosion, or its free area is clogged from unremovable corrosion.	Replace affected piping.
					S	4	Basement runs and risers are all clogged, deteriorated, and leak; if this is 71% or greater, problem is systemic.	Replace the entire system including vent stacks.
87	Fire Pumps				A*	2	Either pump or motor inoperative.	Replace indicated component.
			20	20	A	4	System is beyond repair and/or useful life.	Replace system.
88	Fire Suppression System	100 202-206			M X	2	Extinguisher and/or sprinkler head(s) and/or tamper flow switches are damaged or missing.	Replace appropriate component.
		202-206			E	3	Sprinkler/standpipe station is dysfunctional.	Overhaul/replace sprinkler/standpipe station.
89	Smoke and Ventilation Control				M	2	Static pressure controls and components are dysfunctional.	Replace sensors and controls; repair supply/relief dampers.
			15	15	A	3	Fan motor dysfunctional.	Replace the fan motor.
					S	4	Entire system is beyond economic repair.	Replace the entire system.
90	Power Transformer Station				E	2	Switch gear failed.	Replace switch gear.
					E	3	Transformer failed.	Replace transformer.
					E	4	Transformer and switch gear failed.	Replace transformer, switchgear, and wiring.
91	Electric Distribution Center				E	4	Panel is "burnt-out" or physically abused; service feeders burnt out.	Replace entire panel. Panel and service.
92	Building Power Wiring				M	3	Up to 50% of the wire or conduit needs to be replaced as a result of a detectable cause such as an equipment failure, incinerator fire, copper-to-aluminum connections, etc.	Replace affected wire and copper to aluminum connections with copper to copper.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
					S	4	More than 50% of wire needs to be replaced as a result of systemic overload or service does not meet local codes for D.U. ampacity rating.	Replace entire wiring within building.
93	Emergency Lights and Power	1			M	1	Emergency light unit faulty.	Replace unit.
		11-23			M	2	Cracked block, thrown rod, bearings, valves, fuel pump and/or injectors gone.	Repair/replace indicated component(s) with associated system adjustments, repairs and/or replacement.
		11-23	35	35	A	4	Multiple minor and major components of generator dysfunctional; generator beyond economic repair.	Replace generator.
94	Site Heating Distribution				M	1	1-19% of piping damaged from ground shifts or local water table corrosion.	Replace damaged piping; patch insulation where damaged; repair pipe supports where accessible.
					A*	2	20-40% of piping externally damaged from ground shifts or local water table corrosion.	Replace damaged piping; patch insulation where damaged; repair pipe supports where accessible.
					A*	3	41-60% of piping externally damaged from ground shifts or local water table corrosion.	Replace damaged piping; patch insulation where damaged; repair pipe supports where accessible.
			40	40	A	4	Piping is internally corroded and leaks in 40% or greater pipe runs indicating systemic corrosion or greater than 60% of piping externally damaged.	Replace entire system.
95	Site Gas Distribution				M	1	1-19% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
					A*	2	20-40% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
					A*	3	41-60% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
			40	40	A	4	Piping is internally corroded and leaks in 40% or greater pipe runs indicating systemic corrosion or greater than 60% of piping externally damaged.	Replace the entire system.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
96	Site Domestic Cold Water Distribution				M	1	1-19% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged pipes.
					A*	2	20-40% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
					A*	3	41-60% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
			40	40	A	4	Piping is internally corroded and leaks in 40% or greater pipe runs indicating systemic corrosion or greater than 60% of piping externally damaged.	Replace the entire system.
97	Site Domestic Hot Water Distribution				M	1	1-19% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
					A*	2	20-40% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
					A*	3	41-60% of piping externally damaged from ground shifts or local water table corrosion.	Replace the damaged piping.
			40	40	A	4	Piping is internally corroded and leaks in 40% or greater pipe runs indicating systemic corrosion or greater than 60% of piping externally damaged.	Replace entire system.
98	Well Water System				A*	2	Pump and motor faulty.	Replace pump and motor.
			30	30	A	3	Casing and screen deteriorated.	Replace casing and screen.
			30	30	A	4	System is beyond economic repair and/or useful life, but wells are still active.	Replace entire system.
99	Site Power Distribution, Wiring				M	1	Less than 20% of wiring needs to be replaced as a result of external abuse (e.g., trees, weather).	Replace damaged wire and supports or conduit.
					A*	2	20-40% of wiring and supports need to be replaced.	Replace damaged wire and supports or conduit.

System Number	System Name	Subsystems (if applicable)	Life Expectancy Elderly	Life Expectancy Family	Model Treatment	Fix Level	Condition Description	Repair/Replacement Event
					A*	3	41-70% of wiring and supports need to be replaced.	Replace damaged wire and supports or conduit.
			40	40	A	4	Entire system needs to be replaced.	Replace entire system.
100	Site Sanitary Distribution				M	1	1-19% of system requires replacement.	Replace indicated portion of system.
					A*	2	20-40% of system requires replacement.	Replace indicated portion of system.
					A*	3	41-70% of system requires replacement.	Replace indicated portion of system.
			65	65	A	4	Greater than 70% of system requires replacement.	Replace the entire system.
101	Water Tank				M	1	Inside water line on wood shows evidence of algae growth, water level float inoperative, heat trace on riser pipe inoperative, riser pipe has a small leak, tank leaks in a couple of seams, heat controls dysfunctional.	Clean and chlorinate tank, replace float switch assembly, replace heat trace, repair leak in riser pipe, tighten band clamps to stop seam leak, replace heater thermostat.
					A*	2	Moderate amount of repair required on tank.	Moderate repair.
					A*	3	Steam or electric tank heater corroded or dysfunctional, tank band clamps severely corroded at threads.	Replace tank heater, replace band clamps.
					A	4	Wood is rotted through and tank is structurally unsound.	Replace entire system.

1 A represents an age-related accrual event.

A* represents an age-related accrual event that is captured by another accrual action. As a result, the A* event is redundant for forecasting purposes.

M represents routine maintenance.

S represents an event that would not occur had necessary repairs been done on a timely basis.

E represents an extraordinary replacement event due to vandalism, fire, or acts of God.

X represents an event that was never observed. As a result, such events were excluded from the analysis.

Appendix C

Survival Models Used in the AFM

Appendix C

Survival Models used in the AFM

This appendix provides an overview of some of the theoretical principles and empirical estimation steps that went into the development of the survival models used in the AFM. There are several kinds of survival models that are commonly used in forecasting. The Accrual Forecasting Model uses a particular variety of survival model that we have called an "approach curve." An approach curve predicts the average failure rate for a population of individuals or items of constant size. The size is fixed, even though the members of the population are mortal, because each member is replaced at failure. Thus, this model is appropriate for predicting the replacement rate of systems in the existing public housing stock, not because the housing stock is presumed to be of constant size, but because the model is to forecast accrual only for units that are currently in place.

The first two sections of this appendix discuss the theory of survival modeling and describe the theoretical derivation of what we have called "approach" curves from the survival distribution and hazard rate functions. The next two sections describe the application of our survival models within the AFM. The last section of this appendix briefly describes some of the estimation procedures and results that were used to establish parameter values for these models.

Overview of Survival Models

A survival model forecasts the probability of an event, usually death or failure, of an individual or the frequency of that event within a homogeneous set of individuals. In the AFM the individuals are site, building, and unit systems; and approach curves are the type of survival model used to forecast their aggregate failure rates. Approach curves predict the future failure rate of an individual unit and all of its probable, subsequent replacement units. Unlike other commonly used survival models, they do not assume that failed units leave the system. By contrast, two survival that assume that failed units leave the population are:

- **The hazard rate function.** This function finds the probability of failure as a function of age. As a forecasting tool it is used, for example, to compute life insurance premiums; but it is also valuable as regression specification to be used to estimate parameter values for survival models.

- **The survival distribution function.** This function is also referred to as the "survival curve." This downward-sloping curve gives the fraction of individuals that survive from birth to any given year.

Survival distribution functions were used during the development of the AFM to obtain some estimates of expected lives, but they are not used, per se, in the forecasting model. Approach curves can be derived from hazard rate functions, as the next section explains in detail.

Approach Curves

Our empirical investigation of the Modernization Needs inspection data showed that the Gompertz distribution provided a good model of the survival of major systems.[1] Exhibit C-1 shows an example of Gompertz hazard rate and survival functions. The expected life of a system with this survival function is E(x) = 5 years. Thus, we could expect a new replacement system to last about five years before it is replaced in turn by the next generation of that system.

The approach curves used in the AFM take account of the replacement of the current system and all successive generations of its replacements. Exhibit C-2 illustrates how approach curves do this. The example system shown in the exhibit starts out as a new installation with age of zero in the first period. As the exhibit shows, the system can either fail or survive between the first and second period. If the system fails, it will be replaced in the second period with a new system. If it survives, it will be one year old in the second period and will have a higher probability of failure.

As the system passes from the second to the third period, it can have an age of one or zero years. The approach curve accounts for this and for the three possible outcomes in the third period. In general the approach curve accounts for the possibility that a system can fail at any age. The replacement systems then start through the same process of probabilistic survival and failure at every age. The approach curve itself is simply the sum of all of these probabilities of failure. It is, therefore, the aggregate probability of failure accounting for the failure of not only the original system, but of all successive replacements.

More formally, the AFM generates approach curves from all of these individual probabilities of failure by using a Markov chain method. With this method we let X be a state vector describing either the frequency distribution of system ages in the population or the probability distribution for a single system. For the example shown in Exhibit C-2 where the population initially has just one brand-new system, we have:

$$X_0 = [1, 0, 0, . . .] \qquad (3)$$

where the first element of X_0 is the probability (in this case, 100 percent) that this system started the first year with age zero. The other elements of X_0, the probabilities that the system has ages 1, 2, etc., are all zero.

A Markov process needs a transition matrix, T, which operates on each period's state vector to produce next period's state vector:

$$X_1 = X_0 * T \qquad (4)$$

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[1]The inspection data recorded ages only for what were defined as "major" systems, about half of all 101 systems.

Exhibit C-1

Hazard Rate and Survival Curves

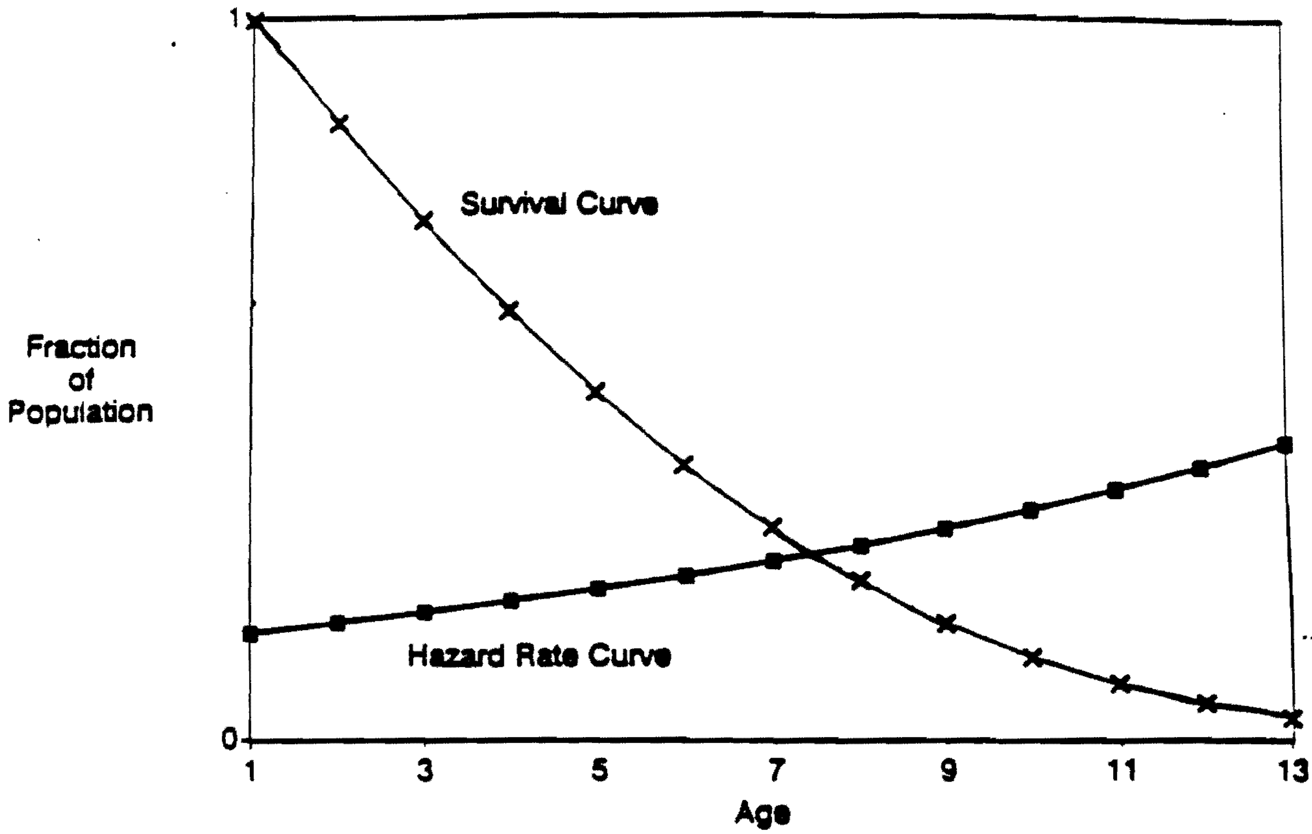
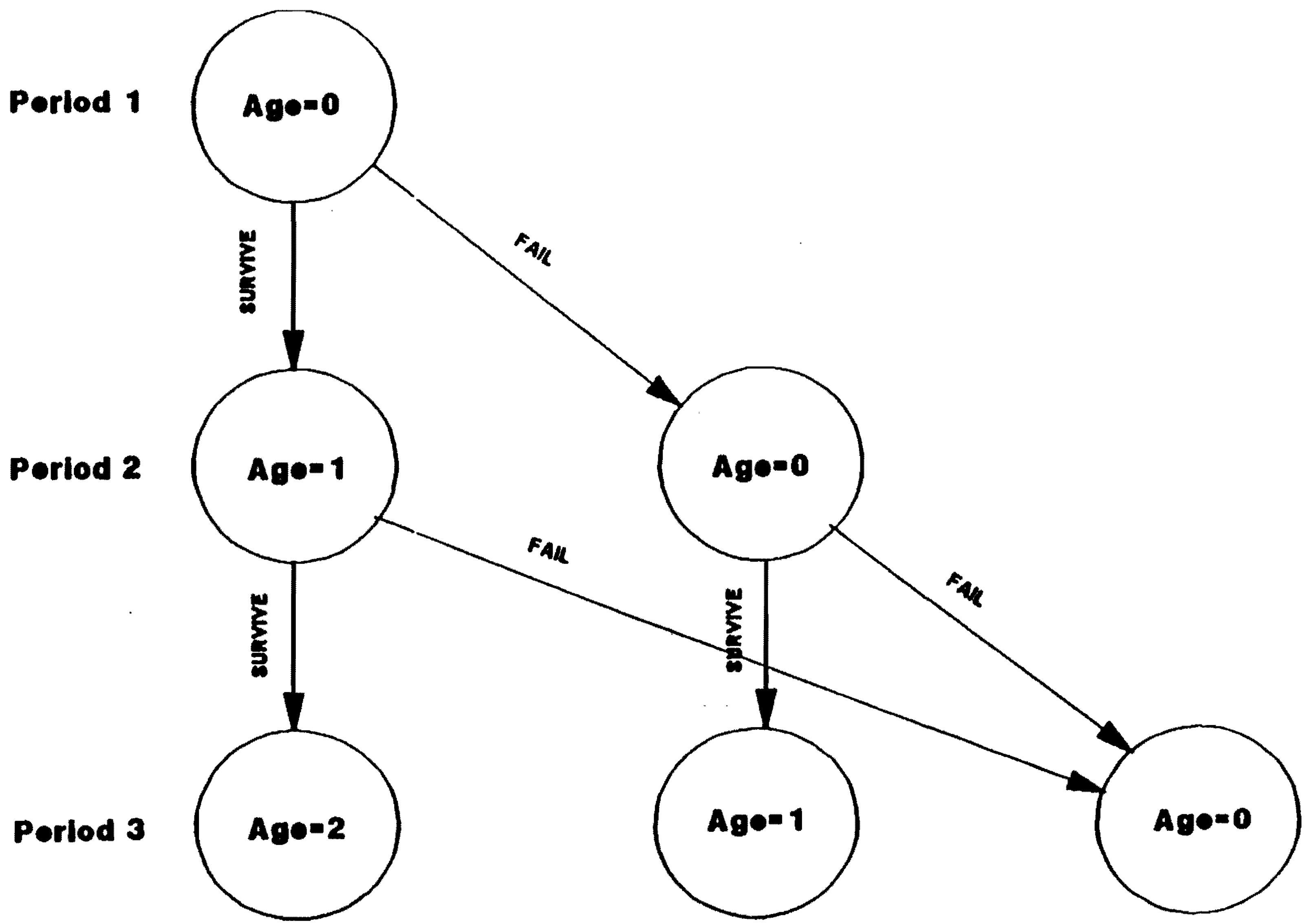


EXHIBIT C-2

APPROACH CURVE FLOW CHART



We construct the T matrix from the hazard rate functions as shown in Exhibit C-3. The top of the exhibit shows the general way that the hazard rate vector elements are used to construct the T matrix; the bottom half shows the actual T matrix derived from the hazard rate function of Exhibit C-1. The columns of T less one year indicate the current-period age of a system, while the rows indicate the age next period. The value in each cell of T in column c and row r is the probability that a system with age c will become an age r system in the next year. Most of these probabilities are zero because the only permissible transitions are aging one more year (the non-zero entries just off the main diagonal) or failing and being replaced by a system with age zero (shown in the first column).

If we use the X_0 state vector from equation 3 and the T matrix shown in Exhibit C-3, we obtain this second-year distribution of the population:

$$X_1 = [0.147,\ 0.853,\ 0\ .\ .\ .\ 0] \qquad (5)$$

The first element of X_1 is the 14.7 percent probability that the system failed and was replaced last year. The second element is the remaining 85.3 percent probability that the system survived to the second year. We can multiply this and subsequent X vectors by the T matrix to obtain the probable age distribution for any future year. For instance, X_{13} looks like this:

$$X_{13} = [0.201,\ 0.172,\ 0.144,\ 0.119,\ 0.096,\ 0.075,\ 0.057,\ 0.042,\ 0.030, 0.020,\ 0.013,\ 0.008,\ 0.005] \qquad (6)$$

Again, the first element of X_{13} is the overall probability of failure for all systems given the probable age distribution from the previous period. At this point the age distribution has become so dispersed that the system is close to what is called "steady state." A steady-state population is characterized by a stable mix of system ages and an equilibrium, long-run failure rate equal to the inverse of the expected life (or mean time to failure).[2] The life expectancy of the system used in this example is five years, notice that the first element of X_{13} has taken on a value very close to 0.20, the long-run equilibrium rate.

When the first elements of successive X vectors are collected in a vector, themselves, as shown in Exhibit C-4, that vector is the aggregate population death rate over time--the approach curve.

Forecasting When the Starting System Age is Available

In the example derivation we have used a system that enters the forecast period with an age of zero. Thus the approach curve derived above is the kind of curve that the forecasting program uses to predict the future experience of a system targeted for replacement in the inspection data. However, many systems recorded in the inspection data have lower fix levels and higher ages. To derive the approach curve for these systems, the model uses a different

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[2]In a steady-state population of fixed size the distribution of ages among individuals will be equal to the survival distribution function divided by the expected life.

Exhibit C-3

Constructing the Transition Matrix from the Hazard Rate Function

$$
T = \left| \begin{array}{cccccccccc}
h(1) & 1-h(1) & . & . & . & 0 & . & . & . & \\
h(2) & 0 & 1-h(2) & & . & . & 0 & . & . & \\
. & . & . & . & . & . & . & . & . & . \\
. & . & . & . & . & . & . & . & . & . \\
h(i) & 0 & . & . & . & 1-h(i) & . & 0 & . & \\
. & . & . & . & . & . & . & . & . & . \\
. & . & . & . & 0 & . & . & . & . & . \\
h(n) & 0 & . & . & . & . & . & . & 1-h(n) &
\end{array} \right|
$$

Example of T

0.147	0.853	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.161	0.000	0.839	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.175	0.000	0.000	0.825	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.191	0.000	0.000	0.000	0.809	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.208	0.000	0.000	0.000	0.000	0.792	0.000	0.000	0.000	0.000	0.000	0.000
0.226	0.000	0.000	0.000	0.000	0.000	0.774	0.000	0.000	0.000	0.000	0.000
0.247	0.000	0.000	0.000	0.000	0.000	0.000	0.753	0.000	0.000	0.000	0.000
0.269	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.731	0.000	0.000	0.000
0.293	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.707	0.000	0.000
0.319	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.681	0.000
0.348	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.652
0.413	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Exhibit C-4

Tabulation of Approach Curve for Example System

Year	Failure Rate
1	0.147
2	0.159
3	0.169
4	0.178
5	0.185
6	0.191
7	0.195
8	0.198
9	0.200
10	0.201
11	0.202
12	0.201
13	0.201

starting X vector. For instance, if the system is four years old we will have:

$$X_1 = [0\ 0\ 0\ 0\ 1\ 0\ .\ .\ .\ .\ .] \qquad (7)$$

and an approach curve with a different shape but otherwise identical derivation. The shape of the approach curve will be different, because the first-year hazard rate for our example system would be 0.191, which is closer to the long-run rate. The curve will not have so far to go to reach the long-run rate. If the starting age is so high that the first-year hazard rate is above the long-run failure rate, the approach curve will actually fall toward the long-run rate.

Forecasting When the System Age is Missing

Both of the examples of the X_0 vector of the initial age distribution apply to major system observations for which system age observations are available. This approach can be carried one step farther to allow for starting age distributions when the age of the system observation at hand is unknown. The X_0 vectors shown above are actually examples of degenerate distributions; all of their probability mass is concentrated on one point. To create an X_0 vector for a minor system the model generates a non-degenerate probability distribution for the missing age observation. This distribution can be obtained by using some additional data and another survival modeling technique.

The extra data are the observations on building ages. With the exception of a few systems, the general building age is a good estimate of the length of time since the first generation of a system was installed. If the building age is much greater than the expected life of the system at hand, then there is a high probability that the observed system is not the original, first-generation system that was installed when the building construction was completed. Moreover, if there was a replacement it could have taken place one, two, etc. years ago with a variety of probabilities. We account for this in the AFM by using the Markov model itself to estimate the probability distribution of the age of the current system. This non-degenerate probability distribution can then be used in vector form as a proxy for the starting system age in the forecast. This probability distribution of system age is derived using the same T matrices described above. Let n be the general building age. Then the model estimates the probability distribution of the age of the current system as:

$$X_n = X_0 * T^n \qquad (8)$$

The vector X_n is then used as the starting age vector in the Markov forecasting process, which proceeds identically in every other respect.

Estimation of Parameters for Survival Curves

The section above explains some of the theory of survival modeling. Typically, the development of a survival model also requires data analysis and statistical estimation. The survival models used in the AFM are based on both subjective and objective factors. The shape of the curves is based on the estimated log-hazard rate curves fit to the inspection data.

The expected life of each function used in the forecast was determined by the expert panel. The data analysis revealed that there was a dependable relationship between the expected life and the slope and intercept of the log-hazard rate function. This relationship was apparent when the regression results were tabled and sorted by system expected life. For system expected lives over the range of 5 to 20 years, the intercepts and slopes exhibited a dependable linear relationship. Moreover, systems with expected lives that were about the same tended, also, to have slopes and intercepts that were very close in value. There were no systems with sufficient observations for regression analysis that yielded expected lives outside of that range, so judgment had to be used to derived intercept and slope estimates.

In any case, the AFM uses a single approach curve to model the failure rate of any system with a given expected life. Therefore, the AFM chooses the slope and intercept parameters from the table shown in Exhibit C-4 and constructs the approach curve using the methodology described above. Exhibits C-5 to C-7 are plots of three selected curves generated by the parameters shown in Exhibit C-4.

Exhibit C-5

Survival Curve Parameters
by Life Expectancy

Life Expectancy	Intercept	Slope
5.00	-1.69000	0.0165000
6.00	-1.90042	0.0189652
7.00	-2.10639	0.0241150
8.00	-2.29475	0.0288243
9.00	-2.47227	0.0332626
10.00	-2.64301	0.0375315
11.00	-2.80698	0.0416310
12.00	-2.96959	0.0456966
13.00	-3.12814	0.0496605
14.00	-3.28669	0.0536245
15.00	-3.44388	0.0575546
16.00	-3.60378	0.0615524
17.00	-3.76639	0.0656180
18.00	-3.93171	0.0697514
19.00	-4.10110	0.0739864
20.00	-4.27455	0.0783230
23.00	-6.50000	0.1839000
25.00	-8.00000	0.2375000
30.00	-8.50000	0.2107000
35.00	-9.00000	0.1923500
40.00	-10.00000	0.1933500
50.00	-11.00000	0.172450
65.00	-12.00000	0.1455400
75.00	-12.50000	0.1314800
100.00	-13.00000	0.0786000

Appendix D

Revisions to the FIX Backlog Estimates

Appendix D

This appendix defines the sources of the difference between the Total Backlog Cost presented in the Abt Modernization Needs Report and the Total Backlog Cost produced by ICF Inc. in the course of conducting the Accrual Study. The backlog cost reported by Abt was 9,307 million dollars in 1985 dollars, as compared to the cost of 8,520 million dollars in 1985 dollars produced by ICF. The factors which impinge on the difference in the Modernization Totals can be thought of as belonging to three families; data changes, procedural changes, and weight changes. Each of these factors will be discussed in Appendix D.

Procedural Changes

The first procedural change to be discussed deals with what has become known as the "$100 Cut Rule." This is a rule which was imposed by Abt in an effort to discriminate between normal operating and maintenance expenses and capital repair expenses. In order to eliminate observations which might be considered normal operating and maintenance expenses, all individual fix observations costing less than $100 prior to weighting were eliminated from the analysis. The problem with this rule is that the $100 limit is an arbitrary figure that ideally should vary according to the location and system of the observation. Due to the complexity of such a revision in the use of the rule, the rule was dropped from the analysis performed by ICF. This had the effect of raising the total FIX estimate.

The second procedural change implemented by ICF was to change the builder's profit function used in calculating the total cost of the fixes. Abt had used the sum of the un-weighted costs in a development as the index into the profit function to determine the builder profit to be added to the costs for the development. This tends to over-estimate the builder profit to be applied to the costs in a development. The builder profit should be calculated on the sum of the weighted costs within a development. This approach was used by ICF and had the effect of reducing the FIX estimate.

For example, according to sampling theory, each of the observed buildings represents some number of unobserved buildings in the total population of buildings within a development. Hence, the correct total to be used in calculating the builder profit is the weighted total, since the weighted total captures the costs associated with those buildings which were not observed. This will lead to a builder profit based on the estimation of the true amount of repair work which needed to be done. If the builder profit were not a function of the cost within the development, then the weighting would not be necessary.

Data Changes

The first of the data changes to be discussed deals with the observations made in several developments in Philadelphia, Pennsylvania. These changes involved the elimination of SITE observations made which should not have been recorded. Specifically, these were instances where a SITE observation booklet was filled out when the dwelling unit observed was an element in a row-house structure., only one unit of which was owned by the PHA. The site observation was not appropriate, as the measurements typically covered the entire row-house structure, or an entire city block.

The second type of data change made by ICF were edits to the quantity field of the observational records. As a result of errors in the data instrument, mismatches in the unit of analysis between cost and quantity files, errors in the computer algorithm that generated the data base, as well as keypunch and coding errors, a significant number of records had unreasonably high or low per-dwelling unit quantities and costs. In order to correct these mistakes, algorithmic procedures were used to insure a reasonable and internally consistent dataset based on the interrelationships between, for example, roof surface and foundation perimeter. In the algorithms, both the upper and lower ends of the quantity distribution were examined and corrected.

In certain systems, the inspector was to note a percentage of the total quantity which was to be fixed, and the quantity used in the FIX estimation was derived from the inspectors's percentage and the total quantity stated in the location's take-off data. In these cases, ICF used the total quantity as opposed to taking a percentage of the total quantity due to the inconsistency in the percentages present in the original Abt FIX file.

The third type of data change made was the elimination of invalid duplicate records. After consultation with Abt, a number of systems were defined for which duplicate records were allowable. For other systems, ICF eliminated the duplicates.

Weight Changes

The changes made to the sub-development weights were to account for buildings and dwelling units that were sampled but, for one reason or another, were not observed in the inspection phase of the study. Therefore, a change to the weights assigned to the observed locations was necessary so that the observed locations would represent the appropriate number of unobserved locations.

Summary

In calculating the national FIX estimate, all of the procedural, data, and weight changes were implemented, producing an estimate of $8,520 million (in 1985 dollars). A breakdown of the backlog estimate by HUD Region and Area Office is given in Exhibit D1.

Exhibit D1

Backlog (1985) Within HUD Regional and Area Offices (1988 Dollars, in Millions)*

	No. of Projects Sampled	FIX Cost (millions)	Percent of Total Cost	Percent of Total Units
Region I				
Boston, MA	53	$175	1.88%	2.8%
Hartford, CT	22	$111	1.19%	1.5%
Manchester, NH	12	$24	0.26%	0.8%
Providence, RI	15	$28	0.30%	0.8%
Regional Total	102	$338	3.63%	5.9%
Region II				
Buffalo, NY	8	$212	2.28%	2.0%
New York, NY	70	$1,065	11.45%	12.6%
Newark, NJ	53	$535	5.75%	3.8%
San Juan, PR	41	$784	8.43%	5.0%
Regional Total	172	$2,596	27.91%	23.4%
Region III				
Baltimore, MD	15	$275	2.95%	1.9%
Charleston, WV	7	$12	0.12%	0.5%
Philadelphia, PA	57	$893	9.60%	4.0%
Pittsburgh, PA	30	$268	2.88%	2.5%
Richmond, VA	16	$102	1.10%	1.6%
Washington, DC	22	$155	1.66%	1.2%
Regional Total	147	$1,704	18.32%	11.7%
Region IV				
Atlanta, GA	28	$220	2.36%	4.5%
Birmingham, AL	19	$168	1.81%	3.3%
Columbia, SC	6	$65	0.70%	1.2%
Greensboro, NC	40	$143	1.53%	3.0%
Jackson, MI	9	$228	2.45%	1.0%
Jacksonville, FL	17	$267	2.87%	3.3%
Louisville, KY	12	$161	1.73%	2.0%
Knoxville, TN	17	$95	1.02%	1.2%
Nashville, TN	10	$115	1.24%	2.0%
Regional Total	158	$1,461	15.71%	21.5%

Exhibit D1 (Continued)

	No. of Projects Sampled	FIX Cost (millions)	Percent of Total Cost	Percent of Total Units
Region V				
Chicago, IL	55	$656	7.05%	6.1%
Cincinnati, OH	10	$90	0.97%	1.1%
Cleveland, OH	26	$212	2.28%	2.4%
Columbus, OH	5	$28	0.30%	0.8%
Detroit, MI	32	$190	2.04%	1.6%
Grand Rapids, MI	9	$40	0.43%	0.7%
Indianapolis, IN	24	$71	0.77%	1.4%
Milwaukee, WI	19	$56	0.60%	1.0%
Minn/St Paul, MN	12	$114	1.22%	1.7%
Regional Total	192	$1,457	15.67%	16.6%
Region VI				
Dallas, TX	7	$139	1.50%	2.7%
Houston, TX	7	$44	0.47%	0.7%
Little Rock, AR	8	$32	0.35%	1.2%
New Orleans, LA	15	$218	2.35%	2.5%
Oklahoma City, OK	7	$97	1.05%	1.0%
San Antonio, TX	15	$70	0.75%	1.8%
Regional Total	59	$601	6.46%	9.9%
Region VII				
Des Moines, IA	9	$27	0.29%	0.3%
Kansas City, MO	11	$83	0.90%	1.2%
Omaha, NE	18	$48	0.52%	0.6%
St. Louis, MO	16	$146	1.57%	1.2%
Regional Total	54	$305	3.28%	3.3%
Region VIII				
Denver, CO	10	$92	0.99%	1.3%
Region IX				
Honolulu, HI	10	$43	0.46%	0.5%
Los Angeles, CA	14	$252	2.71%	1.5%
Phoenix, AZ	11	$37	0.39%	0.4%
Sacramento, CA	4	$68	0.73%	0.4%
San Francisco, CA	22	$220	2.36%	1.7%
Regional Total	61	$619	6.66%	4.4%

Exhibit D1 (Continued)

	No. of Projects Sampled	FIX Cost (millions)	Percent of Total Cost	Percent of Total Units
Region X				
Anchorage, AK	5	$9	0.09%	0.1%
Portland, OR	10	$36	0.39%	0.5%
Seattle, WA	26	$83	0.89%	1.3%
Regional Total	41	$128	1.37%	1.9%
National Total	996**	$9,302	100.0%	100.0%

Source: ICF Estimates

* These figures are based upon a sample of projects and are subject to sampling error. Columns may not total exactly due to rounding error.

** The observations from four developments were dropped from the calculation of this estimate due to the lack of any units being observed in the development. The weights assigned to the remaining observations were modified to correct for their elimination.