NBSIR 80-1977

Forecasting Lead Paint Abatement Costs: A Computerized Approach

Robert E. Chapman and Kimberly A. Barnes

Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Washington, D.C. 20234

March 1980

Final Report

Sponsored by the:
Office of Policy Development and Research
Department of Housing and Urban Development
Washington, D.C. 20410
FORECASTING LEAD PAINT
ABATEMENT COSTS: A
COMPUTERIZED APPROACH

Robert E. Chapman and Kimberly A. Barnes

Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Washington, D.C. 20234

March 1980
Final Report

Sponsored by the:
Office of Policy Development and Research
Department of Housing and Urban Development
Washington, D.C. 20410
PREFACE

This research was conducted under the sponsorship of the Department of Housing and Urban Development by the Applied Economics Group, of the Center for Building Technology, at the National Engineering Laboratory, National Bureau of Standards. This report provides public and private decision makers with a computerized procedure for estimating the costs of lead-based paint abatement. This procedure is based on lead-based paint abatement cost figures collected during an extensive field test program in which lead-based paint hazard abatement activities were carried out in approximately 200 dwelling units.

Appreciation is extended to Dr. Harold E. Marshall, Applied Economics Group, and Dr. John S. McConnaughey, formerly with the Applied Economics Group, who reviewed the economic aspects of this paper. Appreciation is also extended to Mssrs. William G. Hall, Center for Applied Mathematics, and A. Philip Cramp and David Waksman, Center for Building Technology, for their many helpful comments concerning the treatment of certain technical issues presented in the paper. Special appreciation is extended to Dr. Joseph G. Kowalski, formerly with the Applied Economics Group, whose stimulating discussions provided guidance and encouragement throughout this effort.
ABSTRACT

This report describes a computerized procedure for estimating the cost of eliminating the lead-based paint hazard from buildings. This procedure is based on the results of an extensive field test program in which lead-based paint hazard abatement activities were carried out in approximately 200 dwelling units in three cities. The computerized cost estimation procedure which emerged is particularly useful because it takes into consideration both variations in the condition of the dwelling unit as well as in the prices for labor and materials. As a result, it permits the least costly abatement technique to be identified under a wide variety of circumstances. In addition, when contract cost estimates are desired, the computer program groups dwelling units together into contracts in such a way that the sum of the expected bid prices is minimized.

This report is intended to serve as a user's manual for local programs concerned with the problem of estimating lead-based paint abatement costs. Specific cases with respect to the preparation of cost estimates for individual dwelling units or of budget estimates for program managers, policy makers, or other decision makers, are treated.

Keywords: Applied economics; building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF DIAGRAMS</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>SI CONVERSION UNITS</td>
<td>viii</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Purpose</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Scope and Approach</td>
<td>2</td>
</tr>
<tr>
<td>2. DESCRIPTION OF THE COMPUTER PROGRAM</td>
<td>3</td>
</tr>
<tr>
<td>2.1 What the Computer Program Does</td>
<td>4</td>
</tr>
<tr>
<td>2.2 Requirements of the Computer Program</td>
<td>7</td>
</tr>
<tr>
<td>2.2.1 Data Needs</td>
<td>7</td>
</tr>
<tr>
<td>2.2.2 Obtaining the Necessary Data</td>
<td>10</td>
</tr>
<tr>
<td>2.3 Contract Cost Estimates</td>
<td>11</td>
</tr>
<tr>
<td>2.3.1 Determining the Least-Cost Abatement Technique</td>
<td>11</td>
</tr>
<tr>
<td>2.3.2 Estimating Contract Markup and Forming Contract Packages</td>
<td>13</td>
</tr>
<tr>
<td>2.3.3 Determining the Final Abatement Techniques and Printing Out Results</td>
<td>14</td>
</tr>
<tr>
<td>2.4 Program Cost Estimates</td>
<td>15</td>
</tr>
<tr>
<td>3. ACCESSING THE COMPUTER PROGRAM</td>
<td>19</td>
</tr>
<tr>
<td>3.1 Introduction to FACTS</td>
<td>19</td>
</tr>
<tr>
<td>3.2 Running the FACTS Program</td>
<td>20</td>
</tr>
<tr>
<td>3.3 How to Interpret the Computer Output</td>
<td>26</td>
</tr>
<tr>
<td>4. SUMMARY</td>
<td>29</td>
</tr>
<tr>
<td>APPENDIX A DESCRIPTION OF ABATEMENT TECHNIQUES</td>
<td>30</td>
</tr>
<tr>
<td>A.1 Barrier Materials</td>
<td>30</td>
</tr>
<tr>
<td>A.1.1 Gypsum Wallboard</td>
<td>30</td>
</tr>
<tr>
<td>A.1.2 Plywood Paneling</td>
<td>31</td>
</tr>
<tr>
<td>A.1.3 Cementitious Coating</td>
<td>31</td>
</tr>
</tbody>
</table>
### TABLE OF CONTENTS (cont.)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1.4</td>
<td>Gypsum Veneer Plaster</td>
<td>31</td>
</tr>
<tr>
<td>A.1.5</td>
<td>Vinyl-Coated Fabric</td>
<td>31</td>
</tr>
<tr>
<td>A.1.6</td>
<td>Cement-Coated Fiberglass</td>
<td>32</td>
</tr>
<tr>
<td>A.1.7</td>
<td>Melamine Coated Hardboard</td>
<td>32</td>
</tr>
<tr>
<td>A.1.8</td>
<td>Aggregate Filled Paint</td>
<td>32</td>
</tr>
<tr>
<td>A.1.9</td>
<td>Gypsum Plaster with Metal Lath</td>
<td>32</td>
</tr>
<tr>
<td>A.1.10</td>
<td>Gypsum Impregnated Jute Fabric</td>
<td>33</td>
</tr>
<tr>
<td>A.1.11</td>
<td>Plywood on Floors</td>
<td>33</td>
</tr>
<tr>
<td>A.2</td>
<td>Paint Removal Methods</td>
<td>34</td>
</tr>
<tr>
<td>A.2.1</td>
<td>Infra-Red Heating Device</td>
<td>34</td>
</tr>
<tr>
<td>A.2.2</td>
<td>Solvent-Based Paint Remover</td>
<td>34</td>
</tr>
<tr>
<td>A.2.3</td>
<td>Electrical Heat Gun</td>
<td>35</td>
</tr>
<tr>
<td>A.2.4</td>
<td>Hand Scraping</td>
<td>35</td>
</tr>
<tr>
<td>A.2.5</td>
<td>Propane Torch</td>
<td>35</td>
</tr>
<tr>
<td>A.2.6</td>
<td>Dip Tank Method</td>
<td>35</td>
</tr>
<tr>
<td>A.3</td>
<td>Replacement of Components</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APPENDIX B</td>
<td>REFERENCING THE FACTS LIBRARY</td>
<td>37</td>
</tr>
<tr>
<td>APPENDIX C</td>
<td>SAMPLE COMPUTER RUNS</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.1</td>
<td>Forecasting Abatement Costs for an Individual Dwelling Unit or Contract</td>
<td>45</td>
</tr>
<tr>
<td>C.2</td>
<td>Forecasting Abatement Costs for a Major Program</td>
<td>59</td>
</tr>
<tr>
<td>APPENDIX D</td>
<td>LISTING OF COMPUTER PROGRAM</td>
<td>62</td>
</tr>
<tr>
<td>REFERENCES</td>
<td></td>
<td>78</td>
</tr>
</tbody>
</table>
LIST OF DIAGRAMS

<table>
<thead>
<tr>
<th>Diagram</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Flowchart for Computer Time-Sharing Program</td>
<td>5</td>
</tr>
</tbody>
</table>

LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Wage and Material Price Data</td>
<td>8</td>
</tr>
<tr>
<td>2.2</td>
<td>Input Data Requirements</td>
<td>12</td>
</tr>
<tr>
<td>2.3</td>
<td>Number of Dwelling Units by Type/Age Category</td>
<td>16</td>
</tr>
<tr>
<td>2.4</td>
<td>Dwelling Unit Data Form for Making Cost Estimates at the Program Level</td>
<td>18</td>
</tr>
<tr>
<td>3.1</td>
<td>Wage and Material Price Data</td>
<td>22</td>
</tr>
<tr>
<td>3.2</td>
<td>Dwelling Unit Data Form</td>
<td>23</td>
</tr>
</tbody>
</table>
Most Common SI Units and their Equivalent Values in Customary Units

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>INTERNATIONAL (SI) UNIT</th>
<th>U.S. CUSTOMARY UNIT</th>
<th>APPROXIMATE CONVERSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH</td>
<td>meter (m)</td>
<td>foot (ft)</td>
<td>1 m = 3.2808 ft</td>
</tr>
<tr>
<td></td>
<td>millimeter (mm)</td>
<td>inch (in)</td>
<td>1 mm = 0.0394 in</td>
</tr>
<tr>
<td></td>
<td>square meter (m²)</td>
<td>square yard (yd²)</td>
<td>1 m² = 1.1960 yd²</td>
</tr>
<tr>
<td></td>
<td>square millimeter (mm²)</td>
<td>square inch (in²)</td>
<td>1 mm² = 10.764 ft²</td>
</tr>
<tr>
<td></td>
<td>cubic meter (m³)</td>
<td>cubic yard (yd³)</td>
<td>1 m³ = 1.5500 ft³</td>
</tr>
<tr>
<td></td>
<td>cubic millimeter (mm³)</td>
<td>cubic inch (in³)</td>
<td>1 mm³ = 6.1024 ft³</td>
</tr>
<tr>
<td>AREA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>liter (L)</td>
<td>gallon (gal)</td>
<td>1 L = 1.0567 ft³</td>
</tr>
<tr>
<td></td>
<td>milliliter (mL)</td>
<td>fluid ounce (ft oz)</td>
<td>1 mL = 0.0338 fl oz</td>
</tr>
<tr>
<td>VELOCITY, SPEED</td>
<td>meter per second (m/s)</td>
<td>foot per second (ft/s or f.p.s.)</td>
<td>1 m/s = 3.2808 ft/s</td>
</tr>
<tr>
<td></td>
<td>kilometer per hour (km/h)</td>
<td>mile per hour (mile/h or m.p.h.)</td>
<td>1 km/h = 0.6214 mile/h</td>
</tr>
<tr>
<td>ACCELERATION</td>
<td>meter per second squared (m/s²)</td>
<td>foot per second squared (ft/s²)</td>
<td>1 m/s² = 3.2808 ft/s²</td>
</tr>
<tr>
<td>MASS</td>
<td>metric ton (t) [1000 kg]</td>
<td>short ton [2000 lb]</td>
<td>1 t = 2.2046 short ton</td>
</tr>
<tr>
<td></td>
<td>kilogram (kg)</td>
<td>pound (lb)</td>
<td>1 kg = 2.2046 lb</td>
</tr>
<tr>
<td></td>
<td>gram (g)</td>
<td>ounce (oz)</td>
<td>1 g = 0.0353 oz</td>
</tr>
<tr>
<td>DENSITY</td>
<td>metric ton per cubic meter (t/m³)</td>
<td>ton per cubic yard (ton/yd³)</td>
<td>1 t/m³ = 0.8428 ton/ft³</td>
</tr>
<tr>
<td></td>
<td>kilogram per cubic meter (kg/m³)</td>
<td>pound per cubic foot (lb/ft³)</td>
<td>1 kg/m³ = 0.0624 lb/ft³</td>
</tr>
<tr>
<td>FORCE</td>
<td>kilonewton (kN)</td>
<td>ton-force (tonf)</td>
<td>1 kN = 0.1124 tonf</td>
</tr>
<tr>
<td></td>
<td>kilonewton meter (kN·m)</td>
<td>ton-force foot (tonf·ft)</td>
<td>1 kN·m = 0.3688 tonf·ft</td>
</tr>
<tr>
<td>PRESSURE, STRESS</td>
<td>megapascal (MPa)</td>
<td>ton-force per square inch (tonf/in²)</td>
<td>1 MPa = 0.0725 tonf/in²</td>
</tr>
<tr>
<td></td>
<td>kilopascal (kPa)</td>
<td>ton-force per square foot (tonf/ft²)</td>
<td>1 kPa = 0.1443 tonf/ft²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pound-force per square inch (lbf/in²)</td>
<td>1 kPa = 0.0725 lbf/in²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pound-force per square foot (lbf/ft²)</td>
<td>1 kPa = 0.1443 lbf/ft²</td>
</tr>
<tr>
<td>WORK, ENERGY, QUANTITY OF HEAT</td>
<td>megajoule (MJ)</td>
<td>kilowatthour (kWh)</td>
<td>1 MJ = 0.2778 kWh</td>
</tr>
<tr>
<td></td>
<td>joule (J)</td>
<td>foot-pound-force (ft·lbf)</td>
<td>1 J = 0.7376 ft·lbf</td>
</tr>
<tr>
<td>POWER, HEAT FLOW</td>
<td>kilowatt (kW)</td>
<td>horsepower (hp)</td>
<td>1 kW = 1.3410 hp</td>
</tr>
<tr>
<td>RATE</td>
<td>watt (W)</td>
<td>British thermal unit (Btu)</td>
<td>1 W = 3.4121 Btu/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>foot-pound-force per second (ft·lbf/s)</td>
<td>1 W = 0.7376 ft·lbf/s</td>
</tr>
<tr>
<td>COEFFICIENT OF HEAT TRANSFER [U-value]</td>
<td>watt per square meter kelvin (W/m²·K)</td>
<td>Btu per square foot degree Fahrenheit (Btu/ft²·°F)</td>
<td>1 W/m²·K = 0.1761 Btu/ft²·°F</td>
</tr>
<tr>
<td>THERMAL CONDUCTIVITY [k-value]</td>
<td>watt per meter kelvin (W/m·K)</td>
<td>Btu per square foot degree Fahrenheit (Btu/ft²·°F)</td>
<td>1 W/m·K = 0.5778 Btu/ft²·°F</td>
</tr>
</tbody>
</table>

NOTES: (1) The above conversion factors are shown to three or four places of decimals.
(2) Unprefixed SI units are underlined. (The kilogram, although prefixed, is an SI base unit.)

1. INTRODUCTION

Through the "Lead-Based Paint Poisoning Prevention Act" of 1971, Congress has delegated to the Department of Housing and Urban Development the leadership role in developing the technical information needed to determine procedures which will improve the efficiency with which funds are allocated to eliminate high levels of lead-based paint (LBP) in housing. To accomplish this goal the Experimental Hazard Elimination Program (EHEP) was formulated by the Department of Housing and Urban Development with the technical assistance of the National Bureau of Standards. In this program 20 LBP hazard abatement techniques were demonstrated in approximately 200 dwelling units in Washington, D.C., Atlanta, Georgia, and Boston, Massachusetts. EHEP was divided into two phases. The first phase was carried out in Washington, D.C., and Atlanta, Georgia. Phase II was carried out in Boston. Phase II differed from Phase I in that an experimental design was rigorously defined and controlled so that variations in abatement technique costs could be analyzed with regard to such important factors as type and condition of housing as well as prevailing supply and demand conditions for construction skills and materials. EHEP was intended to help accomplish the goal mentioned above in four ways. First, it enabled the experimental LBP abatement techniques to be evaluated in field deleading operations. Second, through the collection of cost data, it established a framework for estimating the costs of future LBP hazard abatement operations. Third, it provided a data base against which procedures for estimating abatement costs could be tested for accuracy and ease of application. Fourth, through the development of procedures for estimating LBP abatement costs, it permitted a computer time-sharing program which identifies the least-cost means for eliminating the LBP hazard from a dwelling unit to be developed.

1.1 Purpose

The purpose of this report is to describe the computerized cost estimating procedure, identify its data requirements, show how it may be run on a time-sharing terminal, and provide guidelines for interpreting its output. The computerized cost estimating procedure is particularly useful because it takes into consideration variations in the condition of the dwelling unit as well as in the prices for labor and materials. As a result, it permits the least costly abatement technique to be identified for each set of considerations. Two types of estimates are possible with the computerized procedure. First, the procedure may be used to develop a baseline forecast for an overall program. These estimates will of necessity be only crude guidelines for budgetary purposes. The second type of estimate is referred to as a contract cost estimate.

Contract cost estimates are based on dwelling unit specific information and are much more reliable. Past empirical studies have demonstrated
that if dwelling unit specific information is used, estimated costs are usually within 5 to 10 percent of the actual cost. In addition, when contract cost estimates are desired, the computer program groups dwelling units together into contracts in such a way that the sum of the expected bid prices is minimized.

This report is intended to serve as a user's manual for those who are concerned with the problem of estimating LBP abatement costs. Specific cases with respect to the preparation of cost estimates for individual dwelling units or of budget estimates for program managers, policy makers, or other decision makers, are treated. Throughout this report the emphasis is placed on how the procedure can be used to estimate LBP abatement costs under a wide variety of circumstances.

1.2 Scope and Approach

The general plan of this report is to briefly describe the computer program, state the requirements of the program, and show how the computer program may be accessed. Specifically this user's manual is organized as follows:

Chapter 2 describes the computer program, its capabilities and its limitations. The data requirements for using the computerized procedure to estimate abatement costs at the individual dwelling unit level and for forecasting the costs of a major LBP abatement program are then identified. Guidelines are also given on how and where to obtain the necessary data should it not already be available. A description of how the computer program identifies the least-costly abatement technique follows. Next an explanation is given of how the computer program groups dwelling units into contract packages in such a way that the sum of the bid prices is minimized. The case in which cost estimates for a major abatement program are required is then treated.

Chapter 3 introduces the user to the Federal Agencies' Computer Time-Sharing System's (FACTS) library of programs. A step by step procedure for running the program via FACTS and interpreting its output is then given.

This report also contains four technical appendices. These appendices provide background information in three subject areas.

Appendix A discusses some of the engineering properties of the various LBP abatement techniques. It is included as a guide to when and where the application of a particular LBP abatement technique would be appropriate.

Appendix B extends the discussion of the FACTS library of programs to include a detailed description of how the user enters the FACTS library and establishes a user file.
Appendix C provides examples of what the actual input and output statements from the computer terminal should look like. Sample computer runs are given to show how this procedure can be used to provide (1) baseline cost estimates for a major abatement program, and (2) contract or individual dwelling unit cost estimates.

Appendix D consists of a listing of the computer program as it is stored in the FACTS library.

Although the results of the computerized cost estimation procedure are based on information which can be readily measured or checked, it is important to point out that some judgmental decisions are inevitable. There is no substitute for professional experience. The use of this procedure is not intended to do away with input from experienced individuals but to complement it. However, the use of this procedure does reduce to a minimum the reliance on decisions which are purely judgmental and hence can neither be confirmed nor denied. Thus a real strength of this procedure is being able to quickly identify any discrepancies should they result, determine how serious they are and take them into consideration in future cost estimates.

2. DESCRIPTION OF THE COMPUTER PROGRAM

The computer program discussed in this chapter is written in the BASIC\(^1\) language. Although the program is written in BASIC it is not necessary for the user to know how to use BASIC in order to run the program. The program is designed to provide a maximum amount of flexibility to the user and includes many check mechanisms which significantly reduce the chance of a user error. The program itself includes a procedure for calculating the expected costs (installation, overhead and profit) of six methods of covering over LBP on wall surfaces and ceilings\(^2\), four methods of paint removal on trim surfaces\(^3\), and the replacement of defective or deteriorated doors, door frames, or windows and frames. The six barrier materials analyzed in the computer program are: 1) cementitious coating, 2) gypsum veneer plaster; 3) gypsum wallboard, 4) cement-coated fiberglass, 5) plywood paneling, and 6) vinyl-coated fabric. The four paint removal methods are: 1) electrical heat gun; 2) infrared-heating device; 3) hand scraping; and 4) solvent-based paint remover. Two types of cost estimates are possible with the computer program.

---


2 Five additional methods for covering over LBP on wall surfaces and ceilings are discussed in Appendix A.

3 Two additional paint removal methods are discussed in Appendix A.
In the first type, the program permits the user to input specific information on anticipated contract packages of dwelling units. (For example, the square feet of wall area, linear feet of trim, and number of doors, frames and windows requiring treatment.) The program then identifies the least-cost combination of abatement techniques for each dwelling unit. The original "set" of dwelling units is then divided up in such a way that the sum of the expected bid prices of the resultant "contract packages" is minimized. The expected bid price and the markup ratio for each contract is then printed out as are the dwelling units in that contract. This information is most useful in the short term planning or scheduling of LBP abatement activities.

In the second type, the user inputs information on representative or "statistical" dwelling units for a given dwelling unit type and age category. The computer program calculates the expected costs for each technique and then averages them. It then prints out the expected cost for wall and trim abatement and the markup ratio. If the dwelling unit's age/type category (e.g., Pre 1940 single family attached) was identified, it is also printed out. This information may be used to make baseline estimates for planning purposes, budgetary allocations and other long range activities upon which LBP abatement work might impinge.

2.1 What the Computer Program Does

As a first step in seeing what the computer program does, we shall refer to Diagram 2.1. Diagram 2.1 is a flowchart of the computer program; it shows the basic input requirements, the sequence in which calculations take place, and the program outputs.

Notice that there are two "branches" in Diagram 2.1. One branch treats the case where cost estimates for a major program are desired. The second branch deals with cases in which cost estimates for individual dwelling units or contract packages are desired. Since both branches of the flowchart are the same up to block A, we shall assume that the computer program has already been called up and data on wage rates and material prices entered. In the description which follows, the term "key factor" is used to denote a specific piece of information which affects abatement technique cost or markup.

Suppose the user enters a 1 in block A (see Diagram 2.1), indicating that a cost estimate for a major LBP abatement program is desired. The computer will then request information on the "statistical" dwelling unit. Detailed discussions of the term "statistical" dwelling unit are presented in Sections 2.2 and 2.4. Once all data have been entered, the computer calculates the direct costs for each wall and trim technique based on the representative ("statistical") values of the key factors. These direct cost figures are then averaged. A markup ratio based on the representative values of the key factors
START

Input Wage & Material Cost Data

(A) Contract or Program Costs

Contract

Program

Input Data "Statistical" DU

Calculate Average Direct Costs

Calculate Expected Bid Price

Output Expected Bid Price

STOP

DIAGRAM 2.1

FLOWCHART FOR COMPUTER TIME-SHARING PROGRAM
is also calculated. (The markup ratio assumes that, on the average, three dwelling units will be in each contract.) The markup ratio is then used to calculate the total cost (i.e., the sum of direct costs, overhead costs, and profit) of deleading the "statistical" dwelling unit. The user may then use this figure to determine the costs of that portion of the deleading program. Once the cost information has been printed out, the user has the option of either stopping or performing cost estimates for other categories (building type/age).

In the event that the user wished to make contract cost estimates, the computer program would operate in a slightly different manner. However, before explaining this section of the flowchart, it is important to recognize several constraints. First, the user should place the dwelling units into groups of from one to ten dwelling units.

Second, all dwelling units within a group should be relatively close to each other so that the distance between dwelling units will not enter as a complicating factor in making up contract packages.

Let us now return to the flowchart. In response to the computer's question in block A, a 0 is entered, to indicate that contract cost estimates are desired. (Recall from the previous discussion that information on wage rates and material prices would have been entered prior to reaching block A). The computer then asks for how many dwelling units the user will be inputting data. Suppose the user has eight dwelling units for which he wants cost estimates. The computer first requests information on all the dwelling unit specific key factors for

---

1 The size of the contract package used in the "program" portion of the computerized procedure is closely related to the economic concept of economies of scale. In brief there are two types of economies of scale. They are: 1) intra-unit (increasing the number of square feet, linear feet or components in a given dwelling unit) scale economies; and 2) inter-unit (increasing the number of dwelling units in the contract) scale economies. Although intra-unit scale economies exert a strong and favorable effect on the costs of LBP hazard abatement, the effects of inter-unit scale economies exert a perverse impact on abatement costs. This is primarily due to the fact that the contractors who perform LBP abatement work tend to be rather small. Consequently, carrying out work in a large number of dwelling units may result in coordination and scheduling problems which significantly increase costs. Past empirical studies have concluded that it is wise to keep contract packages small. (For an in depth discussion of this topic see Robert E. Chapman and Joseph G. Kowalski, Lead Paint Abatement Costs: Some Technical and Theoretical Considerations, National Bureau of Standards, Technical Report 979, February 1979.)

2 The computer will not accept information on more than ten dwelling units at any one time. Thus if 50 dwelling units required deleading, at least five groups of ten dwelling units would have to be formed.
dwelling unit number one. The cost of each abatement technique is then calculated and the one which minimizes direct costs is identified. (This procedure is followed for both wall and trim surfaces.) The computer then returns to the user and requests information on the second dwelling unit.

This input loop continues until all data regarding specific dwelling units have been input. As a next step, the computer groups the dwelling units into "preliminary" contract packages based on the values of the key factors and other decision criteria implicit in the program. The objective here is to reduce the expected markup ratio to as small a number as possible. The computer program then tests to see if the sum of the expected bid prices for the "preliminary" contract packages can be reduced by removing a dwelling unit from one contract package and placing it in another. Once this search routine finds that no further reductions in the overall bid price can be achieved, the dwelling units are assigned to contract packages and the program enters the output routine. The output routine first prints the least-cost technique for both wall and trim surfaces for each dwelling unit and gives expected cost. This is done for each contract (see Appendix C for an example). For example, the first contract might have dwelling units number 1, 3, 6 and 7; the second dwelling units 2 and 8; and the third dwelling units 4 and 5. The expected markup ratio for each contract is also given in order to facilitate policy analysis by program decision makers. (This information is useful for policy analysis because if markup ratios are consistently high, it may be possible to achieve a reduction in program costs by operating in a cost plus fixed fee contracting mode.)

2.2 Requirements of the Computer Program

2.2.1 Data Needs

The first step in applying the EHEP cost models involves determining the minimum data requirements to exercise the models. Through experience gained in EHEP, we have found that data needs can be divided into three basic categories. These categories are:

(1) data on wage rates;
(2) data on material prices; and
(3) data on the dwelling unit.

These three categories reflect job specific requirements as well as prevailing supply and demand conditions in the labor and product markets. (Within each category there may be some variation in the amount of data required to exercise the models for different abatement techniques due to differences in the key factors affecting technique cost.)

Notice that in Table 2.1 the individual labor skills are identified. A close look at Table 2.1 shows that six skill types can be used in LBP abatement activities. It is important to point out that the figure required is the average hourly base wage rate.
Costs for six materials are also needed unless doors, door frames, or windows and frames are to be replaced. The first four materials are associated with LBP abatement techniques applied to walls and ceilings. The materials listed are gypsum wallboard, plywood paneling, vinyl-coated fabric and cement-coated fiberglass. Averages based on recent purchases will usually suffice. In the event that a similar product is used, such as prefinished gypsum wallboard instead of gypsum wallboard, melamine paneling instead of plywood paneling, or gypsum jute instead of cement-coated fiberglass, then its price should be substituted. This flexibility should help in assessing the cost impacts of alternative methods of LBP abatement on expected contract costs. Unless a prefinished product (e.g., plywood paneling) is used, finish painting is usually required; a cost for flat latex and semi-gloss enamel (oil base) is therefore also included.

Data on wages and data on material prices are referred to as contract specific since, unless specific skills or materials are needed in a particular dwelling unit, these data will remain constant for the whole contract package. (In general these data will remain constant over many contracts). This bit of information should prove quite useful to the user of the computer program. This is because it will permit the user to hold this set of prices constant over many computer runs and thus will reduce terminal input requirements. A sample of a worksheet which we have found quite useful in keeping a running tabulation on these data types is shown in Table 2.1. (Since the computer program assumes that any abatement technique "could" be least costly, enough information must be input to insure that an estimate for each technique can be calculated.)

### Table 2.1 Wage and Material Price Data

<table>
<thead>
<tr>
<th>Average Hourly Wage Rate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CARPENTER</td>
<td></td>
</tr>
<tr>
<td>PAINTER</td>
<td></td>
</tr>
<tr>
<td>PLASTERER</td>
<td></td>
</tr>
<tr>
<td>PAPER HANGER</td>
<td></td>
</tr>
<tr>
<td>APPRENTICE CARPENTER</td>
<td></td>
</tr>
<tr>
<td>LABORER</td>
<td></td>
</tr>
<tr>
<td>Material Prices</td>
<td></td>
</tr>
<tr>
<td>GYPSUM WALLBOARD - (4' x 8' sheet)</td>
<td></td>
</tr>
<tr>
<td>PLYWOOD PANELING - (4' x 8' sheet)</td>
<td></td>
</tr>
<tr>
<td>VINYL-COATED FABRIC - (SQUARE YARD)</td>
<td></td>
</tr>
<tr>
<td>CEMENT-COATED FIBERGLASS - (SQUARE YARD)</td>
<td></td>
</tr>
<tr>
<td>FLAT LATEX WALL PAINT - (GALLON)</td>
<td></td>
</tr>
<tr>
<td>SEMI-GLOSS ENAMEL (OIL BASE) (GALLON)</td>
<td></td>
</tr>
<tr>
<td>If Needed</td>
<td></td>
</tr>
<tr>
<td>UNFINISHED DOOR - (NEW - EACH)</td>
<td></td>
</tr>
<tr>
<td>UNFINISHED DOOR FRAME - (NEW - EACH)</td>
<td></td>
</tr>
<tr>
<td>UNFINISHED WINDOW AND FRAME - (NEW - EACH)</td>
<td></td>
</tr>
</tbody>
</table>
Dwelling unit specific data may be divided into two basic types: those concerned with the deleading of walls and ceilings, and those concerned with the deleading of trim surfaces. Specific dwelling unit data which are needed to perform deleading cost estimates for wall areas include:

- the gross square feet of wall area;\(^1\)
- the net square feet of wall area;\(^2\)
- if the wall is in an unsound condition\(^3\); if cabinet work or pantry work is to take place; or if wallpaper stripping is to take place.

Dwelling unit data required to perform deleading cost estimates for trim surfaces include:

- the linear feet of windows and frames requiring deleading;
- the linear feet of doors and frames requiring deleading;
- the linear feet of miscellaneous trim requiring deleading; and
- the number and type of windows, doors, door frames, and/or miscellaneous trim requiring replacement.

2.2.2 Obtaining the Necessary Data

Once all of the factors needed to make the desired cost estimate have been identified, it is possible to map out a strategy for systematically and efficiently measuring their values.

\(^1\) The gross square feet of wall area is defined as the total wall area including openings for windows, doors, and cabinets. It is equal to the perimeter of the room times the ceiling height.

\(^2\) The net square feet of wall area is defined as the wall area remaining after the area for all openings, such as doors, windows and cabinets has been subtracted from the gross square feet of wall area.

\(^3\) An unsound wall is defined as any wall which exhibits one or more of the following characteristics: (1) crumbling plaster, (2) bulging, (3) efflorescence, (4) delamination from lath or structure members, and (5) holes greater than four inches in diameter. If none of these five characteristics are present, then the wall is defined as sound. Should the wall require furring prior to the application of a particular barrier material, this cost will have to be added onto the cost of that LBP hazard abatement technique. Previous studies have concluded that such cases should not exceed 10 percent of the total and will most likely be less than 5 percent of the total. See Douglas R. Shier and William G. Hall, Analysis of Housing Data Collected in a Lead-Based Paint Survey in Pittsburgh, Pennsylvania -- Part II, National Bureau of Standards, NBSIR 77-1250, May 1977.
One major source of data which should not be overlooked is the dwelling unit survey. Surveys are almost always conducted at the start of an abatement program to determine the incidence of LBP in housing. Published information on conducting a LBP survey provides us with valuable insight into how the survey can complement the cost estimation effort.\(^1\) The importance of collecting data at this time cannot be overstressed since it permits very detailed information on specific characteristics of the dwelling unit to be documented at little or no extra expense to the overall program. Experience gained during EHEP indicated that a three man team could rapidly survey a dwelling unit and make measurements which greatly enhanced the quality and accuracy of the cost estimates.\(^2\) One exercise which was particularly useful was the preparation of a floor plan for the dwelling unit being surveyed. It was found that using a piece of graph paper helped the team member sketch the floor plan accurately. One of the other team members then assists in measuring the size of the rooms, the height of the ceiling, the size and location of all doors and windows, window sill height and information on cabinets. It was found that these elements could easily be placed on the floor plan using the standard architectural notations. Another benefit of the LBP survey is that it helps to identify potential problem areas, such as, unsound substrates, deteriorated trim or nonfunctional doors or windows. Careful documentation of this information during the survey permits an estimate of the required repairs and component replacements to be made.

The dwelling unit survey is particularly important when forecasts for the costs of a major LBP abatement program are needed. This is because within most urban areas the housing stock is quite varied. Previous studies have also shown that within this varied stock of housing differing amounts of LBP are expected to be found. Therefore, in order to establish a credible baseline cost estimate, it seems reasonable that forecasts for budgeting, scheduling and other programmatic purposes should take these differences into consideration as much as possible.

Probably the most important step is to divide the housing stock into several well defined types. For example, the following housing types might be used: multifamily low rise, multifamily high rise, single family attached, single family detached one story, single family detached two or more stories. Associated with each housing type would then be an age group. Commonly used age groups are: Pre 1940, 1940 to 1960, and Post 1960. All dwelling units could therefore be grouped into one of these 15 type/age categories. As the survey progresses,


\(^2\) It is anticipated that the members of the survey team can learn enough about what to look for during the survey as part of the inspector training period described in the report by Hall and Slovic.
information collected on individual dwelling units can be used to establish estimates (averages) of the expected amounts of deleading work to take place in any dwelling unit by category (i.e., type and age). These "statistical" dwelling units can then be used to generate baseline cost estimates for the program. For example, if there were 2000 pre 1940 single family attached dwelling units and the expected bid price for deleading the "statistical" pre 1940 single family attached dwelling unit was $1250, then $2.5 million would be a good indicator of the expected costs for that portion of the program. The use of "statistical" dwelling units to produce baseline program cost estimates should give program administrators, and other public officials, some insight into the magnitude of the anticipated program, as well as facilitate the scheduling of the actual deleading work. These estimates should also provide the community with a means of gauging the impact that the program will have on the community and, to some extent, the local housing market.

The input data requirements for the computer program discussed in the previous subsections are summarized in Table 2.2.1

2.3 Contract Cost Estimates

As mentioned earlier, there are two branches, Contract and Program, in the computerized procedure for estimating LBP abatement costs. Although there are several similarities, for example, the same equations are used in estimating the direct cost of each wall and trim technique, the way in which building and economic factors are combined differs significantly between Contract and Program cost estimates. In this section we shall examine the process by which the computer program arrives at a contract cost estimate, where specific dwelling units are to be deleded. Section 2.4 will draw on this explanation and highlight the differences between Contract and Program cost estimation.

2.3.1 Determining the Least-Cost Abatement Technique

We have already seen that the direct cost of each wall and trim abatement technique may be estimated with a small number of key factors. These key factors, when combined with certain weighting values, form the basis for the cost estimating equation for a particular abatement technique.2

---

1 The term "XRF READING" which appears in Table 2.2 refers to the lead content of the paint film in milligrams per square centimeter (mg/cm²), as measured by a portable x-ray fluorescence analyzer.

### Table 2.2 Input Data Requirements

**Nature of data as a function of the type of cost estimate desired**

<table>
<thead>
<tr>
<th>Data Requirement</th>
<th>Program</th>
<th>Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpenter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Painter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plasterer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper Hanger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apprentice Carpenter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laborer</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gypsum Wallboard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood Paneling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl-Coated Fabric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement-Coated Fiberglass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat Latex Wall Paint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-Gloss Enamel (Oil Base)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Needed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unfinished Door</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unfinished Door Frame</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unfinished Window and Frame</td>
<td></td>
<td></td>
</tr>
<tr>
<td>** Dwelling Unit**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Sq. Ft. of Wall Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Ft. of Doors and Frames</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Ft. of Windows and Frames</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Ft. of Miscellaneous Trim</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wainscoting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pantry Work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wallpaper on Walls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Needed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Doors to Replace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Door Frames to Replace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Windows and Frames to Replace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XRF Reading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Lead Content: (\text{mg/cm}^2))</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Based on "statistical" observed value in the particular dwelling unit.*
In some cases the process of calculating direct costs must be
done in two parts. In these cases, the material cost per square foot
is computed first based on its own set of key factors. It is used
as an input, that is a key factor, in the equation for direct cost
per square foot. In some cases direct cost is based on productivity
and the average wage rate. The computer program then selects the least
costly technique for deleading walls.  

This same process is followed for the four techniques for deleading
trim, with the exception of the fact that there is a separate equation
for each trim component (i.e., doors and frames, windows and frames,
and miscellaneous trim). The total direct cost is the sum of these
components plus finish painting costs. After all dwelling units are
completed for this set of estimates, the program moves on to the
markup calculation.

2.3.2 Estimating Contract Markup and Forming Contract Packages

In order to get an estimate for markup, a specific contract or
collection of dwelling units is needed. In our calculations it is
assumed that it would be administratively desirable to have at least
two dwelling units in each contract. Furthermore, due to the way the
key factors in the markup calculation are combined (some have positive
and some have negative effects), certain combinations of two or more
dwelling units may actually lower the markup ratio and therefore lower
the bid price of that contract.

To group the dwelling units together in the best possible pairs,
the computer program calculates a markup differential applied to the
direct cost of every pair of dwelling units, ranks two pairs, and

1 More specifically, data is input into the computer program on one
dwelling unit at a time. Once all necessary data has been input,
the program begins by calculating the direct cost per square foot
of gypsum wallboard. This value is stored in a special variable
where it is then compared with the direct cost of the other wall
techniques as the direct cost per square foot for each one is
estimated. If the new value is smaller, it is stored in the
variable, otherwise the value remains unchanged. The costs of all
techniques are estimated and compared in this manner until the
least-cost technique for deleading walls is determined. Note that
when a switch takes place, the name of the new technique is also
stored in a special character variable so that the name of the least-
cost method can also be identified. A final step is the multipli-
cation of the per square foot cost by the number of gross square feet
of wall area and the addition of any painting costs.

2 Again see Robert E. Chapman and Joseph G. Kowalski, Lead Paint Abate-
ment Costs: Some Technical and Theoretical Consideration, National
chooses those pairs that either reduce markup or cause it to increase as little as possible. If cost estimates are desired for an odd number of dwelling units, the one left after the preliminary two-unit contracts are formed remains in a contract by itself.

The process described above is repeated to see if any further reduction in markup/bid price can be achieved by grouping any of the preliminary two-unit contracts into a four-unit contract or a three-unit contract if costs for an odd number of dwelling units are being estimated. In this iteration, except for the case of a remaining single dwelling unit contract, no grouping takes place unless there is a definite decrease in contractor markup/bid price. If a single-unit contract resulted from the first iteration, it is joined to that other contract which results in the smallest increase in markup/bid price. Once this analysis has been conducted for each of the preliminary contract packages a final assignment will be made. From this point on no dwelling unit will be switched from one contract to another; further reductions in markup/bid price, however, may be possible through a switch in abatement technique. This is the subject of the next section.

2.3.3 Determining the Final Abatement Techniques and Printing Out Results

There is one final test the program performs which has the potential for further reductions in markup/bid price. Because of contractors' general familiarity with gypsum wallboard and plywood paneling, the use of either of these techniques could cause them to lower their markup and, in effect, reduce the bid price. It is necessary then, to determine if substituting gypsum wallboard or plywood paneling for the technique which minimizes direct cost would result in a lower bid price for the contract. In other words, would the reduction in markup more than compensate for the higher per square foot direct cost. The computer performs this comparison by examining direct cost and markup differentials. If the gain (reduction in markup) from a switch to gypsum wallboard or plywood paneling is greater than the cost (higher per square foot direct cost), the original technique is replaced. Otherwise the technique which minimized direct cost is kept, and the program moves on to the next dwelling unit. The program examines each dwelling unit within its particular contract. The process is repeated until all contract packages have been analyzed. The end result of this process may be viewed as a stable solution because no further reductions in bid price can be accomplished. Consequently the sum of the bid prices for each contract may be viewed as the lowest possible for the given values of the relevant key factors.

After deciding on the final abatement techniques and contract packages, the total direct cost and the wall and trim technique chosen for each dwelling unit within a contract is printed out. Finally the contract bid price and markup ratio for each contract is printed. Once this has been done, all cost estimation associated with this set of dwelling units is complete.
2.4 Program Cost Estimates

The computer program may also be used in cases where a program manager or policy maker needs LBP abatement cost estimates for planning or budgetary purposes. The same basic wage and material data used in the contract estimating case are still required. The fundamental difference is that figures for a representative or "statistical" dwelling unit are used rather than figures for a specific dwelling unit. Recall that a "statistical" dwelling unit is one in which the dimensions and characteristics are based on averages computed from an actual sample of houses in a particular building type/age category.

The other major difference in input concerns the values for key factors, such as occupancy status and substrate condition, which take on a value of 1 or 0 when making contract cost estimates. When making policy estimates however, the program informs the user that percentages are required for these factors. This information should also be based on an actual sample of houses. If this information is not available, the percentages used as input could be based on previous studies in combination with expert judgement.

A table like Table 2.3 should prove useful in developing the input values of the key factors for each "statistical" dwelling unit. Table 2.3 shows the number of dwelling units in each type/age category. Table 2.3 is useful because it conveniently divides up the stock of housing into well defined categories. Information from the survey, especially the sample floor plan (Diagram 2.2), may then be used to calculate the value of specific key factors for each of the dwelling units.

Once the appropriate categories have been established, statistical methods of sampling may be used to insure that the values of the key factors for the "statistical" dwelling unit are representative of the population (i.e., the type/age category). (Should the LBP program office be recording the dwelling unit statistics on an automatic data processing (ADP) system, it would not be necessary to rely on statistical methods sampling since averages could be easily tabulated by the ADP system.) For example, if the survey revealed that 750 Pre 40 single family attached dwelling units would require deleading, it would not be necessary to calculate the values of the key factors for all 750 dwelling units and average them to get their values in the "statistical" dwelling unit. In most cases a random sample of 30 dwelling units should be enough to estimate a representative value of each key factor for the "statistical" dwelling unit.

If prior information on the standard deviation of each key factor for the population (type/age category) is available, a specific value of the sample size can be established. This value may be either larger or smaller than 30 and may vary among the key factors.1 Should the

1 For a thorough discussion see Mary Natrelia, Experimental Statistics, National Bureau of Standards, Handbook 91, August 1963.
### TABLE 2.3

NUMBER OF DWELLING UNITS BY TYPE/AGE CATEGORY

<table>
<thead>
<tr>
<th>Dwelling Unit Type</th>
<th>Pre 1940</th>
<th>1940-1960</th>
<th>Post 1960</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifamily Low Rise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multifamily High Rise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Family Attached</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Family Detached One Story</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Family Detached Two or More Stories</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
total number of dwelling units in a category be small, it is possible to base the average on all available data rather than just a randomly selected subset. (Note, if the number of dwelling units to be done is quite small, it might be better to use the contract cost estimation routine. This approach would be superior in that it would provide not only an estimate but the contract assignment as well.)

A table of random numbers may then be used to select the random sample. For example, you may choose to write down the first 50 three digit random numbers which occur in the table. You should then go through and rule out all those over 750 since you have only 750 dwelling units. Similarly you should also rule out any repetitions. In the event that you now have less than 30 random numbers you should continue where you left off in the table until you have generated the 30 needed to do the experiment. (An alternative way of selecting the random numbers is to go through the table as described above and choose only those numbers which are less than 750 and which have not already been recorded.) Assuming that you have a set of 30 random numbers, you are now in a position to sample from the set of dwelling unit data. This may be done by numbering each dwelling unit, in this case from 1 to 750, and identifying those whose number match one of the random numbers selected from the table of random numbers.

Once you have selected the random sample of dwelling units, the values of each of the (dwelling unit) key factors should be tabulated. The values of a particular key factor are then averaged and recorded in Table 2.4. Table 2.4 may then be used as a reference when inputting data on the "statistical" dwelling unit into the computer program.

Once the data have been input, the program continues as it did when making contract cost estimates by calculating per unit direct costs for each wall and trim technique. Painting costs are then computed. It is important to point out that instead of determining which technique is the least costly, the direct costs of all six different wall techniques and all four trim techniques are averaged. One cost for deleading walls and one cost for deleading trim results. The corresponding painting costs are then added to these average values to get total direct cost.

The final step is the computation of a markup ratio. The markup ratio is based on the values input on the statistical dwelling unit. Since a value for the total net square feet and linear feet in the contract is required in order to complete the markup estimating equation, a contract package size of three dwelling units is assumed. As soon as the markup ratio has been calculated it is multiplied by the total direct cost. The result is a total cost figure which includes an allowance for the contractor's overhead and profit. Once the cost information for this "statistical" dwelling unit has been printed, the user may either stop or perform another cost estimate for a different "statistical" dwelling unit (type/age category) based on the same wage and material data.
TABLE 2.4 DWELLING UNIT DATA FORM  
FOR MAKING COST ESTIMATES  
AT THE PROGRAM LEVEL

<table>
<thead>
<tr>
<th>DU/AGE CATEGORY</th>
<th>PRE 40 SINGLE FAMILY ATTACHED</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL AREA - (GROSS SQUARE FEET)</td>
<td>___________________________</td>
</tr>
<tr>
<td>DOORS AND FRAMES - (LINEAR FEET)</td>
<td>___________________________</td>
</tr>
<tr>
<td>WINDOWS AND FRAMES - (LINEAR FEET)</td>
<td>___________________________</td>
</tr>
<tr>
<td>MISCELLANEOUS TRIM - (LINEAR FEET)</td>
<td>___________________________</td>
</tr>
<tr>
<td>OCCUPANCY - (PERCENT OCCUPIED)</td>
<td>___________________________</td>
</tr>
<tr>
<td>WAINSCOTTING - (PERCENT WALL AREA)</td>
<td>___________________________</td>
</tr>
<tr>
<td>SUBSTRATE CONDITION - (PERCENT UNSOUND)</td>
<td>___________________________</td>
</tr>
<tr>
<td>PANTRY WORK - (PERCENT NEEDING IT)</td>
<td>___________________________</td>
</tr>
<tr>
<td>WALLPAPER REMOVAL - (PERCENT HAVING &gt;2 LAYERS)</td>
<td>___________________________</td>
</tr>
<tr>
<td>XRF READINGS - (DOORS)(^a)</td>
<td>___________________________</td>
</tr>
<tr>
<td>XRF READINGS - (WINDOWS)(^a)</td>
<td>___________________________</td>
</tr>
<tr>
<td>XRF READINGS - (MISCELLANEOUS)(^a)</td>
<td>___________________________</td>
</tr>
</tbody>
</table>

**IF NEEDED**

| REPLACEMENT DOORS - (NUMBER) | ___________________________ |
| REPLACEMENT DOOR FRAMES - (NUMBER) | ___________________________ |
| REPLACEMENT WINDOWS AND FRAMES - (NUMBER) | ___________________________ |

\(^a\) The term "XRF READING" refers to the lead content of the paint film in milligrams per centimeter (mg/cm\(^2\)).
3. ACCESSING THE COMPUTER PROGRAM

3.1 Introduction to FACTS

The Federal Agencies' Computer Time-Sharing System (FACTS) is a library of programs aimed at facilitating the use of computers to solve construction related problems. The FACTS library is part of the Remote Access Multi-User System (RAMUS), a nationwide interactive time-sharing computer and telecommunications network developed and operated by the General Services Administration (GSA). The RAMUS and FACTS systems are available to all Federal agencies and their authorized contractors. Before we proceed with a discussion of FACTS, it is important to outline how FACTS and RAMUS are related. RAMUS consists of four basic parts:

1. An executive system that acts as a master control center;
2. Permanent files that contain a number of standard programs and subroutines available for use by all subscribers;
3. User files that contain user-developed programs and serve as a temporary storage area for data to be used by the computer in solving specific problems;
4. A processing section that makes the actual calculations.

FACTS consists of two basic parts:

1. a library of engineering programs; and
2. an executive system that permits the user to access those library programs through RAMUS.

The advantage that FACTS offers over the basic RAMUS system is that it greatly facilitates the use of RAMUS by persons without computer experience. This is because the FACTS library programs have been written in such a way that the user is given step-by-step instructions on their use in the course of using them.

The FACTS executive system also permits the user to establish a user file. The user file will contain a program which is an exact copy of the computer program stored in the FACTS library. The user file may then be referenced directly to provide the desired cost estimates.

---

In the next section we shall see how the program may be run once a user file has been established. However, before the computer program can be referenced and a user file established, the agency (or authorized contractor) must subscribe to the RAMUS service. Any agency or authorized contractor wishing to subscribe to the RAMUS service should initiate the administrative procedure by writing to:

Agency Services Coordination Division
ADTS, GSA
1776 Peachtree Street, NW
Atlanta, GA 30309

This letter should include the following information:

1. The date the agency wishes to begin RAMUS service;
2. The number and type of terminals which will be used;
3. The average number of hours per day of terminal connect time;
4. The estimated program storage requirements;
5. The name, address, and telephone number of the agency, the person to be contacted for information pertaining to RAMUS usage; and
6. The billing address and appropriate fund citation.

Item number 2 in the list above requests information about the type of office terminal to be used. In order to use RAMUS, the terminal should be either the Automatic Send/Receive Model 33 or 35 Teletype-writer, or any fully compatible equipment. The office terminal communicates with RAMUS by means of a telephone (voice grade) circuit; either FTS, WATS, or leased lines may be used. Once the user has received an identification code and password, he enters the FACTS library via RAMUS. (This procedure is analogous to checking a book out of a library and using the information in the book to solve a particular problem.)

3.2 Running the FACTS Program

Throughout this section it is assumed that the user has already established a user file in which a copy of the FACTS program is stored. Once the user has signed onto the system, the terminal should respond with an output similar to that printed below.

---

1 Details of how the user enters the FACTS library of programs, retrieves the lead paint cost estimation procedure, and establishes a copy in the user file are given in Appendix B.

2 Underlining indicates a user input.
Recall that at the end of each statement, e.g., OLD, you must press the nonprinting carriage return character. This tells the computer to proceed. Note that the program name, KAH00, refers to the name of the program being stored in your user file. When you establish your user file (see Appendix B) you will be asked to provide a name for the program which you wish to store. KAH00 was the program name selected in this case.

As soon as you enter RUNBIC after the computer has printed READY the program will begin requesting input information. Suppose that Table 3.1 corresponds to the input data we have collected on wages and material prices. The computer printout would then look like that presented immediately after Table 3.2. Note very carefully that 1) wages and material prices are entered one at a time after each question mark, ?, and 2) dollar signs are not used (i.e., 8.50 and not $8.50).

After the last material price data has been entered, the computer will ask if program or contract cost estimates are desired. The printout shown above indicates that contract cost estimates are desired. The program then asks the user how many dwelling units are in the "preliminary" contract. Recall that no more than 10 dwelling units can be input at any one time. (In addition, the "preliminary" contract should contain dwelling units which are geographically close together.) The program then asks the user to check the input data for errors. If no errors have been made, the program begins requesting input information on dwelling unit number 1. Table 3.2 summarizes the relevant input data for dwelling unit number 1.

Once all data on dwelling unit number 1 has been entered, the computer will request the user to check over the input data in case any errors have been made in entering the data. The output from the terminal in this case is shown immediately after Table 3.2.
### TABLE 3.1 WAGE AND MATERIAL PRICE DATA

#### AVERAGE HOURLY WAGE RATE

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Wage Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpenter</td>
<td>9.18</td>
</tr>
<tr>
<td>Painter</td>
<td>9.67</td>
</tr>
<tr>
<td>Plasterer</td>
<td>9.12</td>
</tr>
<tr>
<td>Paper Hanger</td>
<td>8.50</td>
</tr>
<tr>
<td>Apprentice Carpenter</td>
<td>5.68</td>
</tr>
<tr>
<td>Laborer</td>
<td>5.62</td>
</tr>
</tbody>
</table>

#### MATERIAL PRICES

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum Wallboard - (4' x 8' sheet)</td>
<td>2.40</td>
</tr>
<tr>
<td>Plywood Paneling - (4' x 8' sheet)</td>
<td>8.00</td>
</tr>
<tr>
<td>Vinyl-Coated Fabric - (Square Yard)</td>
<td>4.75</td>
</tr>
<tr>
<td>Cement-Coated Fiberglass</td>
<td>3.00</td>
</tr>
<tr>
<td>Latex Flat Wall Paint - (Gallon)</td>
<td>9.00</td>
</tr>
<tr>
<td>Semigloss Enamel (Oil Base) - (Gallon)</td>
<td>11.00</td>
</tr>
</tbody>
</table>

**IF NEEDED**

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfinished Door - (New-Each)</td>
<td>--</td>
</tr>
<tr>
<td>Unfinished Door Frame - (New-Each)</td>
<td>--</td>
</tr>
<tr>
<td>Unfinished Window and Frame - (New-Each)</td>
<td>--</td>
</tr>
<tr>
<td>TABLE 3.2 DWELLING UNIT DATA FORM</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>ADDRESS</strong></td>
<td></td>
</tr>
<tr>
<td>102 Main Street</td>
<td></td>
</tr>
<tr>
<td><strong>WALL AREA</strong> - (GROSS SQUARE FEET)</td>
<td>450</td>
</tr>
<tr>
<td><strong>DOORS AND FRAMES</strong> - (LINEAR FEET)</td>
<td>39</td>
</tr>
<tr>
<td><strong>WINDOWS AND FRAMES</strong> - (LINEAR FEET)</td>
<td>40</td>
</tr>
<tr>
<td><strong>MISCELLANEOUS TRIM</strong> - (LINEAR FEET)</td>
<td>66</td>
</tr>
<tr>
<td><strong>OCCUPANCY</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>WAINSCOTTING</strong> - (PERCENT WALL AREA)</td>
<td>0</td>
</tr>
<tr>
<td><strong>SUBSTRATE CONDITION</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>PANTRY WORK</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>WALLPAPER REMOVAL</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>XRF READINGS</strong> - (DOORS)</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td><strong>XRF READINGS</strong> - (WINDOWS)</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td><strong>XRF READINGS</strong> - (MISCELLANEOUS)</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td><strong>IF NEEDED</strong></td>
<td></td>
</tr>
<tr>
<td><strong>REPLACEMENT DOORS</strong> - (NUMBER)</td>
<td></td>
</tr>
<tr>
<td><strong>REPLACEMENT DOOR FRAMES</strong> - (NUMBER)</td>
<td></td>
</tr>
<tr>
<td><strong>REPLACEMENT WINDOWS AND FRAMES</strong> - (NUMBER)</td>
<td></td>
</tr>
</tbody>
</table>
RUNBIG

KAH00  10:18  ATL MON  08/14/78

WAGE RATE INFORMATION

INPUT WAGE RATE PER HOUR FOR CARPENTER  
? 9.18
INPUT WAGE RATE PER HOUR FOR PAINTER  
? 9.67
INPUT WAGE RATE PER HOUR FOR PLASTERER  
? 9.12
INPUT WAGE RATE PER HOUR FOR PAPERHANGER  
? 8.50
INPUT WAGE RATE PER HOUR FOR APPRENTICE CARPENTER  
? 5.68
INPUT WAGE RATE PER HOUR FOR LABORER  
? 5.62

MATERIAL PRICE INFORMATION

INPUT PRICE OF 4 FT BY 8 FT SHEET OF GYPSUM WALLBOARD  
? 2.40
INPUT PRICE OF 4 FT BY 8 FT SHEET OF PLYWOOD PANELING  
? 8.00
INPUT PRICE PER SQUARE YARD OF VINYL-COATED FABRIC  
? 4.75
INPUT PRICE PER SQUARE YARD OF CEMENT-COATED FIBERGLASS  
? 3.00
INPUT PRICE PER GALLON OF LATEX FLAT WALL PAINT  
? 9.00
INPUT PRICE PER GALLON OF SEMI-GLOSS ENAMEL (OIL BASE)  
? 11.00
TYPE 1 IF THERE ARE ANY DOORS, DOOR FRAMES OR WINDOWS AND FRAMES THAT NEED TO BE REPLACED, Ø IF NOT  
? Ø

IF PROGRAM COST ESTIMATES ARE DESIRED, TYPE 1, IF CONTRACT COST ESTIMATES ARE DESIRED, TYPE Ø  
? Ø

INPUT NUMBER OF DWELLING UNITS TO BE DONE (MUST BE <= 10)  
? 10

STOP FOR A MINUTE AND CHECK THE DATA YOU HAVE JUST INPUT  
IF ANY ERROR WAS MADE IN ENTERING IT, YOU MAY TYPE 1 TO REPEAT INPUT STATEMENTS; IF NOT, TYPE Ø TO CONTINUE  
? Ø
DWELLING UNIT NUMBER 1

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? 102 MAIN STREET

INPUT CROSS SQUARE FEET OF WALL AREA
? 450

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 39

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 40

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 66

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED
(TYPE AS A DECIMAL, E.G., 0.25 FOR 25 PERCENT)
? Ø

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? Ø

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS,
Ø IF NOT
? Ø

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? Ø

INPUT AVERAGE XRF READING
? 3.0

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT IF THERE IS AN ERROR,
TYPE 1 TO REPEAT INPUT STATEMENTS IF NOT, TYPE Ø
? Ø

25
If no errors were made while the data on dwelling unit number 1 were being input, the program will proceed to the next dwelling unit. This process continues until the data on all 10 dwelling units have been input (see Diagram 2.1). The program then groups the dwelling units into contract packages in such a way that the sum of the bid prices is minimized.

3.3 How to Interpret the Computer Output

In the previous section we saw how the data on a specific dwelling unit as well as wages and material prices were entered into the computer program. Assuming once again that we wish contract cost estimates on the 10 dwelling units discussed in the previous section and that data on each dwelling unit has been input into the computer, an output similar to that which follows will result.

<table>
<thead>
<tr>
<th>DWELLING UNIT 8</th>
<th>116 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>CEMENTITIOUS COATING</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$ 477.892</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DWELLING UNIT 4</th>
<th>108 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>CEMENTITIOUS COATING</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$ 355.398</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DWELLING UNIT 9</th>
<th>118 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>GYPSUM WALLBOARD</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$ 914.903</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DWELLING UNIT 6</th>
<th>112 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>GYPSUM WALLBOARD</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$ 942.53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTRACT 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTRACT PRICE</td>
<td>$3123.88</td>
</tr>
<tr>
<td>MARKUP RATIO</td>
<td>1.16098</td>
</tr>
</tbody>
</table>
CONTRACT 2

DWELLING UNIT 7
WALL TECHNIQUE
TRIM TECHNIQUE
DIRECT COST
CEMENTITIOUS COATING
ELECTRIC HEAT GUN
$ 586.713
114 MAIN STREET

DWELLING UNIT 5
WALL TECHNIQUE
TRIM TECHNIQUE
DIRECT COST
CEMENTITIOUS COATING
ELECTRIC HEAT GUN
$ 685.026
11Ø MAIN STREET

CONTRACT PRICE $ 1735.34
MARKUP RATIO 1.36454

CONTRACT 3

DWELLING UNIT 2
WALL TECHNIQUE
TRIM TECHNIQUE
DIRECT COST
CEMENTITIOUS COATING
ELECTRIC HEAT GUN
$ 783.331
1Ø4 MAIN STREET

DWELLING UNIT 1
WALL TECHNIQUE
TRIM TECHNIQUE
DIRECT COST
CEMENTITIOUS COATING
ELECTRIC HEAT GUN
$ 696.741
1Ø2 MAIN STREET

CONTRACT PRICE $ 2082.18
MARKUP RATIO 1.40681

CONTRACT 4

DWELLING UNIT 10
WALL TECHNIQUE
TRIM TECHNIQUE
DIRECT COST
CEMENTITIOUS COATING
ELECTRIC HEAT GUN
$ 754.359
12Ø MAIN STREET

DWELLING UNIT 3
WALL TECHNIQUE
TRIM TECHNIQUE
DIRECT COST
VENEER PLASTER
ELECTRIC HEAT GUN
$ 846.427
1Ø6 MAIN STREET

CONTRACT PRICE $ 2351.66
MARKUP RATIO 1.46907

IF YOU WISH TO DO MORE COST ESTIMATES TYPE 1, IF NOT TYPE Ø

RUNNING TIME: 38.8 SECS I/O TIME: 261.3 SECS

READY
BYE
OFF AT 11:04
You will notice that four contracts resulted in this case. Contract number 1 has four dwelling units in it (dwelling units 8, 4, 9 and 6); contracts 2 through 4 have two dwelling units each.¹

In each contract the dwelling unit number and address is given on the top line. On the second and third lines the least cost wall technique and least cost trim technique are given. The direct cost of deleading the dwelling unit is given on the fourth line. For example, dwelling unit number 8 is located on 116 Main Street, the least-cost wall technique is cementitious coating, the least-cost trim (paint removal) technique is the electric heat gun, and the total direct cost is approximately $480. After this information has been presented for each dwelling unit the contract price (expected bid price) and the expected markup ratio are printed out in the lower right hand corner. For example, in contract package number 1, the expected bid price is approximately $3125 with a markup ratio of 1.16 (that is, a 16 percent markup for overhead and profit).

The output shown above indicates that all 10 dwelling units can be deleading for approximately $9300, including contractor markup. The nature of the information input on each dwelling unit and the output from the computer program should greatly facilitate budgeting, the preparation of specifications, and the establishment of which dwelling units should be in each contract package.

¹ All of the input information which is associated with the output presented above is given in Appendix C.1. Appendix C.1 should also prove useful to those readers interested in examining a complete computer run prior to making any contract cost estimates on their own. (Appendix C.2 is intended to serve as a model for those readers interested in performing baseline program cost estimates.)
4. SUMMARY

This report describes a computerized cost estimation procedure based on the results of the Experimental Hazard Elimination Program (EHEP). The data requirements associated with the EHEP computerized cost estimation procedure are discussed as are means through which these data can be obtained. A discussion of the Federal Agencies' Computer Time-Sharing System (FACTS), where the EHEP procedure is in permanent storage, was also presented. Guidelines for how to reference the procedure via FACTS and create a "copy" in a user file were presented as were examples of actual computer runs. A sample output providing contract package assignments and cost estimates for 10 dwelling units was presented. This example was used to illustrate how the output identified not only the least costly technique for deleading walls and trim but facilitated the budgeting, specifications writing, and contract packaging, tasks in the typical local or regional lead paint abatement program office.
APPENDIX A: DESCRIPTION OF ABATEMENT TECHNIQUES

This appendix is intended to supply background information on three basic methods of lead-based paint (LBP) abatement. The three abatement methods are subdivided into individual abatement techniques. The abatement techniques are then described individually in some detail, with regard to their composition, method of application, and/or any special skill or material/equipment requirements.

Since the body of this appendix is formed of excerpts from publications in which these abatement techniques are described in greater detail the interested reader is referred to the two reports by Boone et. al.¹

A.1 BARRIER MATERIALS

The complete stripping of LBP from surfaces as well as the removal and replacement of building components which are coated with LBP are defined here as LBP elimination methods. The effectiveness of such methods is essentially total. However, the application of these methods to large wall surfaces appears to be both impractical and prohibitively expensive. The application of materials, which are intended to act as barriers, is frequently the most reasonable approach to the abatement of LBP on planar surfaces. The effectiveness of barrier materials is therefore a function of the degree to which they prevent access to the existing LBP which they cover. The material's strength, durability and permeance are the primary characteristics that establish its effectiveness in LBP abatement.

A.1.1 GYPSUM WALLBOARD

Gypsum wallboard is a product which is composed of a thick layer of gypsum to which paper or other materials are bonded to provide a finished or finishable surface. It is intended for use on walls, ceilings, or partitions, and can be applied directly to existing surfaces or to wood or metal furring strips.

It can be applied directly to existing walls with adhesives and nails. The installed wallboard is prepared for painting by finishing the joints between the sheets with joint tape and compound. Nail heads are then covered with compound and both areas are sanded to a smooth finish.

A.1.2 PLYWOOD PANELING

This product is a 5/32 inch (4 mm) thick lauan mahogany plywood panel which has been treated with a multiple coat catalyzed varnish finish. The material is supplied in 4 x 8 feet panels (1.2 x 2.4 m) and is applied to existing walls with either fasteners or an adhesive. Pre-formed strips are used to cover vertical butted seams and as a molding at the ceiling line. Wood baseboards are applied over the paneling along the floor line.

A.1.3 CEMENTITIOUS COATING

The cementitious coating consists of portland cement, sand, and acrylic resin to which water is added to make a slurry. It can be tinted to desired colors by the addition of pigments recommended by the manufacturer.

The cementitious coating is viscous and has a rough texture. It can be applied by brush or roller or any other equipment designed to apply viscous filled coatings.

The surface must be clean and free from loose particles. Glossy surfaces must be roughened with an abrasive, and chalky surfaces sealed with a sealer to ensure good adhesion. The applied coating has a final thickness of about 1/16-inch (about 1.6 mm).

A.1.4 GYPSUM VENEER PLASTER

This product is a component pre-packaged material which becomes plastic when mixed with water so that it can be trowel applied to form a highly polished finish or can be worked to achieve a textured finish. It may be applied to solid plaster walls which have first been treated with a vinyl polymer bonding compound to improve adhesion to the existing painted surfaces. The finished thickness of the plaster is approximately 1/8-inch (3.2 mm) thick. Skilled workmen are required for the satisfactory application of this product.

A.1.5 VINYL-COATED FABRIC

Vinyl-coated fabric is basically similar to wallpaper or vinyl-clad paper. Its strength and durability exceed that of the other two materials because of its combination of vinyl surface and textile fabric backing.

Vinyl-coated fabric may be installed on any wall surface that is free of dirt, grease, oil and moisture. The method used for hanging vinyl-coated fabric is the same as used for hanging wallpaper. The adhesive used depends upon the weight of the vinyl-coated fabric. These fabrics normally resist soiling and staining even by objects such as crayon, lipstick, or ink. A mild detergent and a sponge usually will remove most soils and stains. These fabrics conform to the bends and contours
of most surfaces and are installed readily by workmen who are familiar with wallpaper installation using ordinary hand tools and equipment.

A.1.6 CEMENT-COATED FIBERGLASS

This product consists of glass fabric impregnated with portland cement. It is applied to walls in the same manner as wallpaper, with a waterbase adhesive. As the portland cement absorbs moisture from the environment it hardens and becomes a fairly rigid and penetration-resistant material. A protective coating should be applied if the material is to be used in wet areas.

A clean substrate in good repair is necessary for adequate adhesion. The covering will, however, bridge minor voids and mask minor substrate imperfections.

The following barrier materials were used in Phase I of EHEP but were dropped from consideration during the Phase II deleading operations because of excess cost, logistical problems or similarities with other techniques that were used in Phase I.

A.1.7 MELAMINE-COATED HARDBOARD

This product is a 1/4-inch (6.4 mm) thick tempered hardboard to which a 1-1/2 mil (.038 mm) thick melamine film has been laminated to provide a serviceable, decorative finish. The material is supplied in 4 x 8 feet panels (1.2 x 2.4 m) and is applied to existing walls with fasteners or an adhesive. Pre-formed strips are used to cover vertical butted seams and as a molding at the ceiling line. Baseboards are applied over the paneling at the floor.

A.1.8 AGGREGATE FILLED PAINT

This coating is a latex based product which contains sand or other mineral aggregate which provides a thick finish comparable in texture to sand finish plaster.

Filled paint is viscous. The product used was formulated for application by airless spray equipment, but it and most other formulations can be applied using a brush or roller. It requires no mixing or thinning and it can be applied successfully to any surface which is free of dirt, oil or grease. Primers are not required for use on previously painted surfaces and thicknesses as high as 20 mils (0.02 inch or 0.05 cm) can be obtained with one coat. The finish texture, ranging from smooth to coarse, depends upon the aggregate quantity and particle size.

A.1.9 GYPSUM PLASTER WITH METAL LATH

Gypsum plaster is applied to a metal lath which serves as a support for the plaster and a means of adhesion to the surface being treated. The lath is a netting of 20 gauge galvanized steel which is fastened to a surface with nails, staples or screws.
The plaster is usually applied in two stages resulting in a final thickness of 1/2-inch (1.3 cm). In the first application, wood fiber is added to the gypsum plaster to improve its working characteristics by making it easier to apply and to increase its adhesion to the metal lath. This first coat is applied by trowel to a uniform thickness of about 3/8-inch (1 cm). The plaster sets up (hardens) rapidly and must be applied quickly. Highly calcined gypsum plaster is used for the second or top-coat. This plaster contains a retarder which delays hardening so that the desired finish (smooth or textured) can be achieved. The final coat is about 1/8-inch (0.3 cm) thick. The finished dried surface is usually painted.

The application of plaster to lath should be done by skilled workmen. The temperature of the work area and surface should be above 50°F and adequate ventilation (for proper drying of the plaster) should be provided.

A.1.10 **GYPSUM IMPREGNATED JUTE FABRIC**

This wall covering product consists of jute fabric which is impregnated with uncrystallized gypsum (hydrated calcium sulfate). It is applied to walls in the same manner as wallpaper, with a water base adhesive which is recommended by the manufacturer of the fabric. As the gypsum absorbs moisture from the air, it hydrates, hardens and becomes a fairly rigid and penetration-resistant material. A protective coating can be applied if the material is to be used in wet areas.

A clean substrate in good repair is necessary for adequate adhesion. The covering will, however, bridge minor voids and mask minor substrate imperfections.

A.1.11 **PLYWOOD ON FLOORS**

Plywood may be used to cover-up lead painted exterior wood decks on porches. Warped and rotted boards are replaced with new or sound ones and a 15 lb. (6.8 kg) roofing felt is put down as an underlayment before installing the plywood.

Four by 8 feet (1.2 x 2.4 m) sheets of 3/8-inch (9.5 mm) A-B grade, exterior or marine plywood are used. All edges are treated with wood preservative and the sheets are nailed or screwed to the existing deck with their A grade surface up. All exposed edges are covered with wood trim and the new surface is painted with one coat of primer and two coats of exterior paint.

Skilled workmen are required to install plywood on existing porch decks with satisfactory workmanship. Although the job can be done with hand tools, it can be accomplished much more easily with ordinary power tools such as electric drills and saws.
A.2 PAINT REMOVAL METHODS

The safety of workmen and dwelling occupants is a primary consideration in the implementation of paint removal methods. Procedures should be taken to avoid the inhalation or absorption of lead fumes or dust. In addition, attention should be given to the potential fire hazard associated with the use of open flame paint removal techniques.

A.2.1 INFRA-RED HEATING DEVICE

The infra-red heating device used in Phase II of EHEP consists of a propane burner whose flame is recessed in a metal reflector covered with a metal grid. When the flame is lit, the grid is heated. The device is held near the surface that is to be stripped. The heat radiating from the grid causes the paint to soften, swell and/or blister so that it can be removed easily from its substrate with metal scrapers.

This device is somewhat less hazardous than a propane torch because the open flame is recessed. Completely portable, it uses one pound disposable propane cylinders or a 25 pound refillable propane tank. The process of heating and scraping can be carried out by a single workman.

A.2.2 SOLVENT-BASED PAINTRemover

A number of "industrial grade" paint removers may be used to remove LBP from windows, doors and other wood trim components. These viscous liquids are applied to both horizontal and vertical surfaces by brush, allowed to react with the lead paint coatings and then removed along with the softened paint using various metal scrapers.

Paint removers are extremely variable in their ability to penetrate and react with multiple layers of dried paint. The effectiveness of the remover depends not only on its own composition but also on the nature of the multi-layered coating to which it is applied. Most removers will react with only 2 to 4 layers of paint at a time. In such cases where more than that number of layers of paint is present, the remover-paint agglomeration must be removed and fresh remover applied as often as necessary to achieve complete removal.

Generally, the reaction time for paint removers is about one-half hour. The remover-paint waste, which is scraped from the treated surfaces, is collected on polyethylene drop clothes and discarded. Prior to light sanding and repainting, the surface is wiped with a water-saturated rag in order to remove any residue of remover-paint mixture.

Proper precautions regarding open flames, adequate ventilation and avoidance of contact with skin is necessary to assure the safe use of this class of products.
A.2.3 **ELECTRICAL HEAT GUN**

Another technique for removing paint from doors, windows and other wood surfaces by means of heat generation is a portable flameless electric hot air blowing device. It is quite effective in removing paint from wood substrates as demonstrated in laboratory tests; it also presents an apparent low risk of fire and injury to operators or bystanders.

A commercially manufactured device consists essentially of an air blower attached to a reinforced flexible plastic hose, with a cylindrical electric heater at the outlet. The heater is heavily insulated, so that it can be hand held while in operation. This apparatus is mounted on a stand which makes it quite mobile. It is capable of producing a strong stream of hot air at temperatures of between 350° and 1000°F (175° and 540°C). The working end of the device is very lightweight and a single workman can perform the continuous operations of heating the paint to its softening point and scraping it off with metal tools. Electrical circuits or portable generators supplying 20 ampere currents at 110-120 volts are required for operation of the hot air blower.

A.2.4 **HAND SCRAPING**

Simple hand tools such as paint scrapers and putty knives may be used to remove loose and flaking paint. Electrical sanders may then be used to achieve the complete removal of paint which are adhered too tightly to those surfaces for hand scraping.

The following paint removal methods were used in Phase I of EHEP but were dropped from consideration during the Phase II deleading operations because of excess cost, potential fire hazards, logistical problems, or similarities with other techniques that were used in Phase I.

A.2.5 **PROpane TORCH**

The open flame produced by a propane torch can be used to heat paint directly to the softening point so that it can be scraped off with metal tools. The process is easily carried out by a single workman using a one pound propane bottle.

Until recently, the use of propane torches had been quite widespread for this purpose. They are now falling into disfavor, however, due to the extreme fire hazard of an open flame (especially in occupied and furnished dwellings) and the health hazard of over-heating paints to the point of vaporization of the pigments.

A.2.6 **DIP TANK METHOD**

Commercial furniture stripping plants have facilities for removing old paint and varnish by totally immersing the object of interest in large tanks containing heated alkaline solvents in an aqueous medium.
Doors may be stripped by this process, requiring two to three hours of treatment during which time they are alternately soaked and scrubbed with heavy bristle brushes. The total stripping time is dependent on the type of paint, the number of paint layers and the temperature and strength of the solvent bath. Doors can be stripped with hinges and other hardware still attached. After the paint is completely removed the doors are washed with water, air dried, planed, and then returned to the dwelling unit where they are reinstalled and repainted.

A.3 REPLACEMENT OF COMPONENTS

Removal of doors, door frames, windows and frames, and other trim components and replacement with new materials is an accepted technique of LBP abatement. Replacement is used primarily when building components have deteriorated or are damaged beyond the point of serviceability. This method, in addition to restoring the building component to serviceability, also provides an opportunity to upgrade the quality of the dwelling unit significantly.

Carpentry skills are required for rehanging, fitting and remounting hardware. Custom carpentry may be required for replacing wooden sash windows and frames in some dwelling units.
APPENDIX B: Referencing The FACTS Library

The purpose of this appendix is to demonstrate how the user can reference the cost estimation procedure via the FACTS library of programs. The appendix is organized in such a way that the user can become familiar enough with the FACTS library to set up a user file. The user file, which is established by following the steps presented in this appendix, contains an exact copy of the cost estimation program. Once a user file has been established it is no longer necessary to repeat each step outlined in this appendix. In particular, in order to obtain the desired cost estimates it is only necessary to "call up" and "run" the program stored in the user file.

Throughout the following discussion it will be assumed that the user has already established his subscription to the RAMUS service. In particular, it is assumed that the user has (1) the telephone number through which the system can be referenced, (2) a user ID and (3) a password.

Before the FACTS library can be referenced, the user must first call RAMUS. Once connected with RAMUS, the computer will request a user ID, a secret password, and the type and name of the program to be used.1 A sample of the type of information requested is shown below. Note, the computer will print over the password so that it can not be deciphered and used by someone else.

GSA 440 TIME-SHARING SYSTEM 1 ON AT - 11:23 PB:04 TTY:60
12/12/78
USER ID-- ___ ___ ___ ___
PASSWORD? ___ ___ ___ ___
TYPE OLD OR NEW: OLD: FACTS***

---

1 At the end of each statement, e.g., B310, you must press the non-printing carriage return character. This tells the computer to proceed. If you make a mistake, e.g., typing B315 instead of B310, you can correct by using the character +. To change B315 to B310, you would type + once and then 0. The line would then look like B315+0. In the event that you do not have enough space to make corrections using the character +, you can press the escape key (ESC). This action will cause the input for that line in the computer program to be requested a second time. If you get in a real bind, hit the BREAK character. This disconnects you from RAMUS.
The computer is now ready to run FACTS. In response to the computer's READY signal, please type RUNBIG. The computer will then ask what level of prompting you wish; in response to the ***?, enter HE as in the sample below.

READY
RUNBIG

FACTS RESPONDING. INDICATE LEVEL OF PROMPTING AT ***? PROMPT
ENTER TO GET

---
AB  ABBREVIATED PROMPTING
FL  FULL PROMPTING
HE  FULL PROMPTING + SYSTEM EXPLANATION

***? HE

The computer will then print the following details on FACTS.

FACTS CONSISTS OF AN EXECUTIVE SYSTEM AND A LIBRARY OF FULLY TESTED ENGINEERING AND SCIENTIFIC COMPUTER PROGRAMS.

THE FACTS EXECUTIVE SYSTEM ALLOWS THE USER TO FULLY UTILIZE THE FACTS LIBRARY OF ENGINEERING AND SCIENTIFIC COMPUTER PROGRAMS BY (1) PROVIDING LIBRARY VISIBILITY, (2) CONSTRUCTING COMMANDS PROGRAMS FOR THE USER WHICH TAKE CARE OF ALL SYSTEM DETAILS THAT ARE NECESSARY FOR SETTING UP AND RUNNING FACTS PROGRAMS AND (3) PROVIDING USER LIBRARY MANAGEMENT. THESE FUNCTIONS ARE ACCOMPLISHED WITHIN SUBLEVELS OF THE EXECUTIVE SYSTEM. SUBLEVEL STATUS IS ACHIEVED THROUGH THE USE OF COMMANDS GIVEN TO THE COMPUTER IN RESPONSE TO THE ***? PROMPT PRINTED IN THE EXECUTIVE SYSTEM COMMAND LEVEL. THE THREE PRINCIPAL FUNCTIONS OF THE FACTS EXECUTIVE SYSTEM ARE AS FOLLOWS:

(1) LIBRARY VISIBILITY IS ACHIEVED THROUGH THE LIST AND BRIEF SUBLEVELS

/LIST SUBLEVEL/-PROVIDES A LIST OF COMPUTER PROGRAMS CURRENTLY AVAILABLE IN THE FACTS LIBRARY. THE FACTS LIBRARY, WHICH IS CONSTANTLY EXPANDING, IS DIVIDED INTO SUBAREAS THAT ARE IDENTIFIED BY EITHER A SINGLE ALPHABET LETTER OR BY A LETTER AND A NUMBER. A LIST OF THE SUBAREAS AND THE NUMBER OF FACTS PROGRAMS IN EACH SUBAREA IS AVAILABLE AS AN OPTION WITHIN THE LIST SUBLEVELS OF THE EXECUTIVE SYSTEM.

/BRIEF SUBLEVEL/-PROVIDES A SHORT DESCRIPTION OF THE Capabilities AND DATA REQUIREMENTS FOR EACH PROGRAM IN THE FACTS LIBRARY.

(2) CONSTRUCTION OF COMMANDS PROGRAMS IS ACHIEVED THROUGH THE CONSTRUCT SUBLEVEL.
/CONSTRUCT SUBLEVEL/-FOR EACH FACTS LIBRARY PROGRAM THAT THE USER WANTS TO RUN, THE COMPUTER CREATES A SMALL COMMANDS PROGRAM TO HANDLE ALL THE DETAILS REQUIRED TO MAKE THE PROGRAM OPERATIONAL. THIS SMALL PROGRAM IS STORED IN THE USERS OWN LIBRARY BY THE COMPUTER AND ITS NAME RECORDED IN A DIRECTORY FILE THAT THE COMPUTER GENERATES FOR THE USER THE FIRST TIME IT CREATES A COMMANDS PROGRAM FOR HIM. EACH TIME THE USER CREATES ANOTHER COMMANDS PROGRAM IT IS ALSO STORED IN HIS LIBRARY AND ITS NAME IS ADDED TO HIS DIRECTORY FILE. THUS, THE USERS DIRECTORY FILE CONTAINS A CURRENT LIST OF THE COMMANDS PROGRAMS THAT ARE IN HIS LIBRARY. COMMANDS PROGRAMS ARE CREATED BY THE FACTS EXECUTIVE SYSTEM BUT THEY ARE RUN UNDER RAMUS IN THE SAME MANNER AS ANY OTHER COMPUTER PROGRAM ON THE RAMUS SYSTEM. A COMMANDS PROGRAM, ONCE GENERATED, CAN BE USED OVER AND OVER AGAIN WITHOUT RETURNING TO THE FACTS EXECUTIVE SYSTEM.

(3)MANAGEMENT OF THE USERS LIBRARY OF COMMANDS PROGRAMS IS HANDLED THROUGH THE DELETE, DIRECTORY AND MESSAGE SUBLEVELS.

/DELETE SUBLEVEL/-PROVIDES THE MECHANISM FOR LISTING THE CONTENT OF THE USERS DIRECTORY FILE(S) AND FOR DELETING COMMANDS PROGRAMS FROM HIS LIBRARY. THE NAMES OF DELETED COMMANDS PROGRAMS ARE REMOVED FROM THE USERS DIRECTORY FILE. THUS, THE DIRECTORY IS ALWAYS CURRENT.

/DIRECTORY SUBLEVEL/-ALLOWS THE USER TO LIST THE CONTENT OF HIS DIRECTORY FILE(S).

/MESSAGE SUBLEVEL/-ALLOWS THE USER TO MAKE COMMENTS ON FACTS DURING THE ACTUAL USE OF THE SYSTEM. MESSAGES ARE REVIEWED AT FREQUENT INTERVALS AND THE USER IS NORMALLY CONTACTED IF ADDITIONAL INFORMATION IS REQUIRED.

NOTE: COMMANDS AND RESPONSES SHOULD BE ENTERED ONLY IN RESPONSE TO PROMPTS: OTHERWISE IT CONFUSES THE COMPUTER. ALSO, THINK BEFORE YOU RESPOND TO A COMPUTER PROMPT, A LITTLE THOUGHT WILL PAY-OFF.

THE FACTS LIBRARY CONSISTS OF A NUMBER OF FULLY TESTED ENGINEERING AND SCIENTIFIC COMPUTER PROGRAMS. THESE PROGRAMS ARE REALLY SUBROUTINES AND EACH CONTAINS A PREAMBLE WHICH DEFINES THE PURPOSE OF THE PROGRAM, THE DATA REQUIRED TO MAKE IT OPERATIONAL AND OTHER INFORMATION NECESSARY FOR ITS EFFICIENT OPERATION. SINCE THESE PROGRAMS ARE SUBROUTINES, THEY MAY BE LINKED TOGETHER FOR SOLVING EXTREMELY COMPLEX PROBLEMS WHERE A MULTIPLICITY OF OPERATIONS ARE REQUIRED. THE FACTS EXECUTIVE SYSTEM CAN READ AND INTERPRET THE CONTENT OF THE PREAMBLE OF FACTS PROGRAMS AND FROM THIS ANALYSIS, CREATE A COMMANDS PROGRAM CONTAINING THE ELEMENTS THAT ARE NECESSARY FOR MAKING THE FACTS SUBROUTINE FULLY OPERATIONAL.
YOU ARE NOW AT COMMAND LEVEL (PROMPT SYMBOL***).
ENTER NEXT FACTS COMMAND AT ***? PROMPT.

<table>
<thead>
<tr>
<th>VALID COMMANDS</th>
<th>ACCEPTABLE COMMANDS</th>
<th>PROMPT SYMBOL</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABBREVIATE AB</td>
<td>**</td>
<td>PRINT ABBREVIATED PROMPTING</td>
<td></td>
</tr>
<tr>
<td>BRIEF BR</td>
<td>$$$</td>
<td>PRINT BRIEF DESCRIPTION OF PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>CONSTRUCT CO</td>
<td>+++</td>
<td>CONSTRUCT COMMANDS PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>DELETE DE</td>
<td>%%%</td>
<td>DELETE COMMANDS PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>DIRECTORY DI</td>
<td>&amp;&amp;&amp;</td>
<td>LIST OF PROGRAMS IN USER'S DIRECTORY</td>
<td></td>
</tr>
<tr>
<td>FULL FL</td>
<td>***</td>
<td>PRINT FULL PROMPTING</td>
<td></td>
</tr>
<tr>
<td>HELP HE</td>
<td>@@</td>
<td>PRINT FACTS SYSTEM DETAILS</td>
<td></td>
</tr>
<tr>
<td>LIST LI</td>
<td>###</td>
<td>LIST OF FACTS PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>MESSAGE ME</td>
<td>+++</td>
<td>MAKE SYSTEM COMMENTS</td>
<td></td>
</tr>
<tr>
<td>RAMUS RA</td>
<td>&lt;&lt;&lt;</td>
<td>PRINT RAMUS SYSTEM DETAILS</td>
<td></td>
</tr>
<tr>
<td>STOP STOP</td>
<td></td>
<td>RETURNS USER TO RAMUS SYSTEM</td>
<td></td>
</tr>
</tbody>
</table>

In response to the ***? question, please enter RA. This will tell the computer to print the following details on RAMUS.

***? RA

<<<


YOU ARE NOW AT COMMAND LEVEL (PROMPT SYMBOL***).
ENTER NEXT FACTS COMMAND AT ***? PROMPT.

<table>
<thead>
<tr>
<th>VALID COMMANDS</th>
<th>ACCEPTABLE COMMANDS</th>
<th>PROMPT SYMBOL</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABBREVIATE AB</td>
<td>**</td>
<td>PRINT ABBREVIATED PROMPTING</td>
<td></td>
</tr>
<tr>
<td>BRIEF BR</td>
<td>$$$</td>
<td>PRINT BRIEF DESCRIPTION OF PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>CONSTRUCT CO</td>
<td>+++</td>
<td>CONSTRUCT COMMANDS PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>DELETE DE</td>
<td>%%%</td>
<td>DELETE COMMANDS PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>DIRECTORY DI</td>
<td>&amp;&amp;&amp;</td>
<td>LIST OF PROGRAMS IN USER'S DIRECTORY</td>
<td></td>
</tr>
<tr>
<td>FULL FL</td>
<td>***</td>
<td>PRINT FULL PROMPTING</td>
<td></td>
</tr>
<tr>
<td>HELP HE</td>
<td>@@</td>
<td>PRINT FACTS SYSTEM DETAILS</td>
<td></td>
</tr>
<tr>
<td>LIST LI</td>
<td>###</td>
<td>LIST OF FACTS PROGRAMS</td>
<td></td>
</tr>
<tr>
<td>MESSAGE ME</td>
<td>+++</td>
<td>MAKE SYSTEM COMMENTS</td>
<td></td>
</tr>
<tr>
<td>RAMUS RA</td>
<td>&lt;&lt;&lt;</td>
<td>PRINT RAMUS SYSTEM DETAILS</td>
<td></td>
</tr>
<tr>
<td>STOP STOP</td>
<td></td>
<td>RETURNS USER TO RAMUS SYSTEM</td>
<td></td>
</tr>
</tbody>
</table>
In response to ***, please type LI; this will get you to the LIST level of FACTS. When the computer prints ###?, please type *; this will tell the computer to list all the functional codes, the number of programs in each area, and a description of the functional code. Typing LI in response to the first question, and * in response to the second will cause the following output to be printed.

***? LI
YOU ARE NOW AT LIST LEVEL (PROMPT SYMBOL ###).
ENTER ONE FUNCTIONAL AREA CODE (E.G. J) IN RESPONSE TO EACH PROMPT.
ENTER AN * FOR LIST OF CODES. ENTER WORD END TO RETURN TO COMMAND LEVEL.
###?*

<table>
<thead>
<tr>
<th>FUNCTIONAL AREA CODE</th>
<th>PROGRAMS IN AREA</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>1</td>
<td>ELECTRICAL</td>
</tr>
<tr>
<td>H1</td>
<td>8</td>
<td>HYDRAULICS-SPILLWAYS</td>
</tr>
<tr>
<td>H2</td>
<td>11</td>
<td>HYDRAULICS-OUTLET WORKS</td>
</tr>
<tr>
<td>H3</td>
<td>2</td>
<td>HYDRAULICS-GATES &amp; VALUES</td>
</tr>
<tr>
<td>H6</td>
<td>23</td>
<td>HYDRAULICS-OPEN CHANNELS</td>
</tr>
<tr>
<td>H7</td>
<td>5</td>
<td>HYDRAULICS-SPECIAL PROBLEMS</td>
</tr>
<tr>
<td>I</td>
<td>4</td>
<td>SOILS</td>
</tr>
<tr>
<td>J</td>
<td>3</td>
<td>ECONOMICS</td>
</tr>
<tr>
<td>L</td>
<td>2</td>
<td>MECHANICAL</td>
</tr>
<tr>
<td>M</td>
<td>1</td>
<td>MATHEMATICAL</td>
</tr>
<tr>
<td>U</td>
<td>1</td>
<td>GEODESORY &amp; SURVEYING</td>
</tr>
<tr>
<td>X</td>
<td>21</td>
<td>STRUCTURAL</td>
</tr>
<tr>
<td>Z</td>
<td>1</td>
<td>OTHER</td>
</tr>
</tbody>
</table>

After the computer has printed information on the functional codes, it will ask the user if a listing of individual programs is desired. Since the program on deleading costs is stored in the functional area code J, the user should enter J in response to ###. The listing will then identify J0003 as the desired program. (Note, as of the date of the printing of this publication, the computerized cost estimation program had not been placed in the FACTS library. Thus, the listing of all programs in the J, economic, functional area code is necessary to determine if J0003 is the correct FACTS program number.) An output similar to that which follows would then be printed.

The user should then type END and BR in response to the prompting, ***, question from the computer so that a brief of program J0003 can be obtained (see below).
YOU ARE NOW AT BRIEF LEVEL (PROMPT SYMBOL $$\$\$\$\$\$\$). ENTER ONE PROGRAM NAME (E.G. H2010) IN RESPONSE TO EACH PROMPT. TYPE WORK END TO RETURN TO COMMAND LEVEL.

$$\$\$\$\$\$ ? J0003

I. DESCRIPTION

J0003 WILL ANALYZE THE COSTS OF THE ALTERNATIVE METHODS FOR ELIMINATING THE LEAD PAINT HAZARD FROM A DWELLING UNIT. THE PROGRAM PERMITS THE USER TO INPUT SPECIFIC INFORMATION ON ANTICIPATED CONTRACT PACKAGES OF DWELLING UNITS. THE LEAST-COST COMBINATION OF ABATEMENT TECHNIQUES FOR EACH DWELLING UNIT IS IDENTIFIED. DWELLING UNITS ARE GROUPED TOGETHER INTO CONTRACT PACKAGES SO THAT THE SUM OF THE EXPECTED BID PRICES IS MINIMIZED. THE EXPECTED BID PRICE FOR EACH CONTRACT IS GIVEN. EXPECTED CONTRACT COSTS FOR EACH DWELLING UNIT ARE ALSO GIVEN.

II. LIMITATIONS

J0003 WILL HANDLE ANTICIPATED CONTRACT PACKAGES OF UP TO 10 DWELLING UNITS. DATA FOR EACH DWELLING UNIT IS ENTERED IN RESPONSE TO QUESTIONS AT RUN TIME.

III. DATA

TWO TYPES OF DATA ARE INPUT, CONTRACT SPECIFIC DATA AND DWELLING UNIT SPECIFIC DATA. INPUT DATA FOR EACH ANTICIPATED CONTRACT CONSIST OF THE FOLLOWING:

A. CONTRACT SPECIFIC DATA

<table>
<thead>
<tr>
<th>WAGE SPECIFIC DATA</th>
<th>AVERAGE HOURLY WAGE RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARPENTER</td>
<td>&quot;</td>
</tr>
<tr>
<td>PAINTER</td>
<td>&quot;</td>
</tr>
<tr>
<td>PLASTERER</td>
<td>&quot;</td>
</tr>
<tr>
<td>PAPER HANGER</td>
<td>&quot;</td>
</tr>
<tr>
<td>APPRENTICE CARPENTER</td>
<td>&quot;</td>
</tr>
<tr>
<td>LABORER</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

MATERIAL

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>PRICE PER 4' x 8' SHEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>GYPSUM WALLBOARD</td>
<td>&quot;</td>
</tr>
<tr>
<td>PLYWOOD PANELING</td>
<td>&quot;</td>
</tr>
<tr>
<td>VINYL-COATED FABRIC</td>
<td>&quot;</td>
</tr>
<tr>
<td>CEMENT-COATED FIBERGLASS</td>
<td>&quot;</td>
</tr>
<tr>
<td>FLAT LATEX WALL PAINT</td>
<td>&quot;</td>
</tr>
<tr>
<td>SEMI-GLOSS ENAMEL (OIL BASE)</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
</tr>
</tbody>
</table>

42
IF NEEDED:

UNFINISHED DOOR PRICE FOR ONE, NEW
UNFINISHED DOOR FRAME "
UNFINISHED WINDOW AND FRAME PRICE FOR BOTH, NEW

B. DWELLING UNIT DATA

GROSS SQ. FT. OF WALL AREA SQUARE FEET
NET SQ. FT. OF WALL AREA "
LINEAR FT. OF DOORS AND FRAME LINEAR FEET
LINEAR FT. OF WINDOWS & FRAMES "
LINEAR FT. OF MISCELLANEOUS TRIM "

OCCUPANCY PERCENT OCCUPIED OR 1 IF OCCUPIED
\[ \text{or} \] \( \emptyset \) IF UNOCCUPIED

WAINSCOTTING PERCENT OF WALL AREA

SUBSTRATE CONDITION PERCENT UNSOUND OR 1 IF POOR
\[ \text{or} \] \( \emptyset \) IF SATISFACTORY OR BETTER

PANTRY WORK PERCENT NEEDING IT OR 1 IF NEEDED
\[ \text{or} \] \( \emptyset \) IF NOT

WALLPAPER ON WALLS PERCENT HAVING > 2 LAYERS 1 IF 3 OR MORE LAYERS
\[ \text{or} \] \( \emptyset \) IF NOT

IF NEEDED:

NUMBER OF DOORS TO REPLACE NUMBER

NUMBER OF DOOR FRAMES TO REPLACE "

NUMBER OF WINDOWS AND FRAMES TO REPLACE "

ADDRESS DU/AGE CATEGORY

XRF READINGS AVERAGE OR SEPARATE OR ADDRESS AS SPECIFIED FOR EACH TRIM TYPE

FINISH

$$$? END

The user has now identified the computerized cost estimation program and is now ready to construct a file to store a "duplicate" of the FACTIS program. To do this, type END in response to $$**, and then CO in response to the prompting, ***, question. Study the following steps carefully. First, when the computer prints +++?, hit the nonprinting carriage return character. Second, type J0003 (if the FACTS program number for the computerized deleading program was different, please enter that number) when the computer prints +++?. Third, type FINIS.
Fourth, enter three letters (for example, your initials). The FACTS executive system then automatically establishes a directory file and assigns you a program name. You should record this information where you can easily refer to it. Fifth, type END. Sixth, type STOP. These six steps should generate an output similar to that which follows.

***? CO

YOU ARE NOW AT CONSTRUCT LEVEL (PROMPT SYMBOLS +++)
ENTER DIRECTORY FILE NAME? IF YOU DON'T HAVE ONE, HIT A CARRIAGE RETURN.
+++ ?

ENTER ONE PROGRAM NAME (E.G. H2010) IN RESPONSE TO EACH PROMPT. AFTER ALL NAMES HAVE BEEN ENTERED, TYPE FINIS AFTER SUBSEQUENT PROMPT.
+++ ? J0003

+++ ? FINIS

ENTER 3 CHARACTERS (E.G. YOUR INITIALS) TO BE USED AS A PREFIX IN NAMING YOUR NEW DIRECTORY FILE.

+++ ? KAH

THE FOLLOWING PROGRAMS ARE ADDED TO YOUR DIRECTORY FILE KAH100 (MON 12/12/78)

COMMANDS PROGRAM NAME FACTS PROGRAM USED RUN OPTION
KAH00 J0003 RUNBIG

THESE PROGRAMS WILL BE SAVED UNTIL YOU DELETE THEM. THEY CAN BE RUN AT RAMUS LEVEL BY ENTERING RUN OPTION: COMMENTS PROGRAM NAME (E.G. RUNBIG: SRH00).

*** ? STOP

The computer has now returned you to RAMUS. You may now run your program by typing OLD: (your program name) and then RUNBIG after the computer prints READY.
APPENDIX C: SAMPLE COMPUTER RUNS

The purpose of this appendix is to provide the reader with detailed examples of actual computer runs. The reader is encouraged to carefully study the computer runs included in this appendix since examples of both contract and program cost estimates are provided. Once the reader has studied the type and nature of the data inputs and outputs, it should be possible for both sections of the computer program to be run and interpreted with little or no difficulty.

C.1 Forecasting Abatement Costs for an Individual Dwelling Unit or Contract

A sample computer run for estimating the cost of deleading 10 dwelling units is provided in this section. This computer run is intended to illustrate 1) the type and nature of data inputs, 2) the way in which the computer output identifies the dwelling units in a contract package and estimates their deleading costs, 3) the way in which the computer output identifies the least cost abatement technique for each dwelling unit, and 4) the way in which the computer output identifies the expected bid price and markup ratio of the contract.

Recall that information on no more than 10 dwelling units can be input into the computer program at any one time. In addition, every effort should be made to group dwelling units so that they are geographically close when establishing the "preliminary" contract package. In the example presented in this section all 10 dwelling units are on the same block. Although this does not imply that only dwelling units which are in the same neighborhood should be grouped together, care should be exercised to insure that contractor transportation costs are held to a minimum.
SAMPLE COMPUTER RUN

OLD: KAHØØ
READY
RUNNH

KAHØØ  10:18  ATL MON  08/14/78

WAGE RATE INFORMATION

INPUT WAGE RATE PER HOUR FOR CARPENTER  
? 9.18
INPUT WAGE RATE PER HOUR FOR PAINTER  
? 9.67
INPUT WAGE RATE PER HOUR FOR PLASTERER  
? 9.12
INPUT WAGE RATE PER HOUR FOR PAPERHANGER  
? 8.50
INPUT WAGE RATE PER HOUR FOR APPRENTICE CARPENTER  
? 5.68
INPUT WAGE RATE PER HOUR FOR LABORER  
? 5.62

MATERIAL PRICE INFORMATION

INPUT PRICE OF 4 FT BY 8 FT SHEET OF GYPSUM WALLBOARD  
? 2.40
INPUT PRICE OF 4 FT BY 8 FT SHEET OF PLYWOOD PANELLING  
? 8.00
INPUT PRICE PER SQUARE YARD OF VINYL-COATED FABRIC  
? 4.75
INPUT PRICE PER SQUARE YARD OF CEMENT-COATED FIBERGLASS  
? 3.00
INPUT PRICE PER GALLON OF LATEX FLAT WALL PAINT  
? 9.00
INPUT PRICE PER GALLON OF SEMI-GLOSS ENAMEL (OIL BASE)  
? 11.00

TYPE 1 IF THERE ARE ANY DOORS, DOOR FRAMES OR WINDOWS AND FRAMES THAT NEED TO BE REPLACED, Ø IF NOT  
? Ø

IF PROGRAM COST ESTIMATES ARE DESIRED, TYPE 1, IF CONTRACT COST ESTIMATES ARE DESIRED, TYPE Ø  
? Ø

INPUT NUMBER OF DWELLING UNITS TO BE DONE (MUST BE < = 10)  
? 10

STOP FOR A MINUTE AND CHECK THE DATA YOU HAVE JUST INPUT IF ANY ERROR WAS MADE IN ENTERING IT, YOU MAY TYPE 1 TO REPEAT INPUT STATEMENTS: IF NOT, TYPE Ø TO CONTINUE  
? Ø
TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? 102 MAIN STREET

INPUT CROSS SQUARE FEET OF WALL AREA
? 450

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 39

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 40

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 66

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED
(TYPE AS A DECIMAL, E.G., 0.25 FOR 25 PERCENT)
? Ø

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? Ø

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, Ø IF NOT
? Ø

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? Ø

INPUT AVERAGE XRF READING
? 3.0

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT
IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS
IF NOT, TYPE Ø
? Ø
DWELLING UNIT NUMBER 2

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT

? CONTRACT 5 - D.U. 2

INPUT GROSS SQUARE FEET OF WALL AREA

? 700

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL

$ 75

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL

? 52

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL

? 74

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT

? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED (TYPE AS A DECIMAL, E.G., Ø .25 FOR 25 PERCENT)

? .25

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT

? Ø

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT

? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, Ø IF NOT

? Ø

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE

? Ø

INPUT AVERAGE XRF READING

? 5. Ø

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS IF NOT, TYPE Ø

? Ø
DWELLING UNIT NUMBER 3

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? CONTRACT 5 - D.U. 3

INPUT GROSS SQUARE FEET OF WALL AREA
? 600

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 99

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 60

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 86

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED
(TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)
? Ø

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? Ø

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, Ø IF NOT
? 1

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? Ø

INPUT AVERAGE XRF READING
? 3.Ø

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT
IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS
IF NOT, TYPE Ø
? Ø
DWELLING UNIT NUMBER 4

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? CONTRACT 5 - D.U. 4***

INPUT GROSS SQUARE FEET OF WALL AREA
? 360

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 18

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 0

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 0

TYPE 1 IF UNIT IS OCCUPIED, 0 IF NOT
? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED (TYPE AS A DECIMAL, E.G., 0.25 FOR 25 PERCENT)
? 0

TYPE 1 IF SUBSTRATE CONDITION IS POOR, 0 IF NOT
? 0

TYPE 1 IF PANTRY WORK IS NECESSARY, 0 IF NOT
? 0

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, 0 IF NOT
? 0

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, 0 IF ONLY AN AVERAGE IS AVAILABLE
? 0

INPUT AVERAGE XRF READING
? 1.0

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT
IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS
IF NOT, TYPE 0
? 0
DWELLING UNIT NUMBER 5

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? CONTRACT 5 - D.U. 5***

INPUT GROSS SQUARE FEET OF WALL AREA
? 560

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 32

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 34

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 52

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED (TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)
? Ø

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? Ø

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, Ø IF NOT
? Ø

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? Ø

INPUT AVERAGE XRF READING
? 1.0

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS IF NOT, TYPE Ø
? Ø
DWELLING UNIT NUMBER 6

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
 ? CONTRACT 5 - D.U. 6

INPUT GROSS SQUARE FEET OF WALL AREA
 ? 5♡♡♡♡♡

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR
FRAMES REQUIRING PAINT REMOVAL
 ? 75

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF
WINDOW FRAMES REQUIRING PAINT REMOVAL
 ? 52

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING
PAINT REMOVAL
 ? 74

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
 ? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED
(TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)
 ? Ø

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
 ? 1

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
 ? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS,
Ø IF NOT
 ? Ø

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS,
WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE
IS AVAILABLE
 ? Ø

INPUT AVERAGE XRF READING
 ? 9.Ø

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT
IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS
IF NOT, TYPE Ø
 ? Ø

52
DWELLING UNIT NUMBER 7

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? CONTRACT 5 - D.U. 7***

INPUT CROSS SQUARE FEET OF WALL AREA
? 320

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 32

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 34

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 52

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? 1

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED (TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)
? Ø

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? Ø

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, Ø IF NOT
? Ø

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? Ø

INPUT AVERAGE XRF READING
? 5.Ø

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT
IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS IF NOT, TYPE Ø
? Ø
TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? CONTRACT 5 - D.U. 8***
INPUT GROSS SQUARE FEET OF WALL AREA
? 520
INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 42
INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 0
INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 0
TYPE 1 IF UNIT IS OCCUPIED, 0 IF NOT
? 1
INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED (TYPE AS A DECIMAL, E.G., 0.25 FOR 25 PERCENT)
? 0
TYPE 1 IF SUBSTRATE CONDITION IS POOR, 0 IF NOT
? 0
TYPE 1 IF PANTRY WORK IS NECESSARY, 0 IF NOT
? 1
TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, 0 IF NOT
? 0
TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, 0 IF ONLY AN AVERAGE IS AVAILABLE
? 0
INPUT AVERAGE XRF READING
? 1.0
STOP AND CHECK THE DATA FOR THIS DWELLING UNIT IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS IF NOT, TYPE 0
? 0
DWELLING UNIT NUMBER 9

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? CONTRACT 5 - D.U.9***

INPUT GROSS SQUARE FEET OF WALL AREA
? 650

INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 57

INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 48

INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 74

TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? Ø

INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED (TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)
? Ø

TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? 1

TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? Ø

TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, Ø IF NOT
? Ø

TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? 3.Ø

INPUT AVERAGE XRF READING
? 3.Ø

STOP AND CHECK THE DATA FOR THIS DWELLING UNIT
IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS
IF NOT, TYPE Ø
? Ø
DWELLING UNIT NUMBER 10

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? CONTRACT 5 - D.U. 10
INPUT CROSS SQUARE FEET OF WALL AREA
? 450
INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 81
INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 52
INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 78
TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? 1
INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED (TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)
? .25
TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? Ø
TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? Ø
TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS, Ø IF NOT
? Ø
TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? Ø
INPUT AVERAGE XRF READING
? 3.Ø
STOP AND CHECK THE DATA FOR THIS DWELLING UNIT
IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS
IF NOT, TYPE Ø
? Ø
CONTRACT 1

DWELLING UNIT 8

WALL TECHNIQUE CEMENTITIOUS COATING
TRIM TECHNIQUE ELECTRIC HEAT GUN
DIRECT COST $ 477.892

DWELLING UNIT 4

WALL TECHNIQUE CEMENTITIOUS COATING
TRIM TECHNIQUE ELECTRIC HEAT GUN
DIRECT COST $ 355.398

DWELLING UNIT 9

WALL TECHNIQUE GYPSUM WALLBOARD
TRIM TECHNIQUE ELECTRIC HEAT GUN
DIRECT COST $ 914.903

DWELLING UNIT 6

WALL TECHNIQUE GYPSUM WALLBOARD
TRIM TECHNIQUE ELECTRIC HEAT GUN
DIRECT COST $ 942.53

CONTRACT PRICE $ 3123.88
MARKUP RATIO 1.16098

CONTRACT 2

DWELLING UNIT 7

WALL TECHNIQUE CEMENTITIOUS COATING
TRIM TECHNIQUE ELECTRIC HEAT GUN
DIRECT COST $ 586.713

DWELLING UNIT 5

WALL TECHNIQUE CEMENTITIOUS COATING
TRIM TECHNIQUE ELECTRIC HEAT GUN
DIRECT COST $ 685.026

CONTRACT PRICE $ 1735.34
MARKUP RATIO 1.36454
### CONTRACT 3

<table>
<thead>
<tr>
<th>DWELLING UNIT 2</th>
<th>104 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>CELMENTITIOUS COATING</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$783.331</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DWELLING UNIT 1</th>
<th>102 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>CELMENTITIOUS COATING</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$696.741</td>
</tr>
</tbody>
</table>

| CONTRACT PRICE  | $2082.18 |
| MARKUP RATIO    | 1.40681 |

### CONTRACT 4

<table>
<thead>
<tr>
<th>DWELLING UNIT 10</th>
<th>120 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>CELMENTITIOUS COATING</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$754.359</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DWELLING UNIT 3</th>
<th>106 MAIN STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TECHNIQUE</td>
<td>VENEER PLASTER</td>
</tr>
<tr>
<td>TRIM TECHNIQUE</td>
<td>ELECTRIC HEAT GUN</td>
</tr>
<tr>
<td>DIRECT COST</td>
<td>$846.427</td>
</tr>
</tbody>
</table>

| CONTRACT PRICE  | $2351.66 |
| MARKUP RATIO    | 1.46907 |

If you wish to do more cost estimates type 1, if not type 0?

Running Time: 38.8 secs  I/O Time: 261.3 secs

Ready
Bye

Off at 11:04
C.2 Forecasting Abatement Costs for a Major Program

The purpose of this section is twofold. First, it is intended that this section illustrate the type and nature of data inputs and outputs associated with the use of the computer program for policy analysis. Second, a framework for estimating baseline program costs based on the results of the dwelling unit survey is established.

Part 1: Computer Run

OLD: KAHØØ
READY
RUNNH

KAHØØ 13:50 ATL MON 12/12/78

WAGE RATE INFORMATION

<table>
<thead>
<tr>
<th>Input Wage Rate Per Hour For</th>
<th>?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpenter</td>
<td>8.20</td>
</tr>
<tr>
<td>Painter</td>
<td>8.50</td>
</tr>
<tr>
<td>Plasterer</td>
<td>7.70</td>
</tr>
<tr>
<td>Paperhanger</td>
<td>7.30</td>
</tr>
<tr>
<td>Apprentice Carpenter</td>
<td>5.00</td>
</tr>
<tr>
<td>Laborer</td>
<td>5.50</td>
</tr>
</tbody>
</table>

MATERIAL PRICE INFORMATION

<table>
<thead>
<tr>
<th>Input Price Of 4 Ft By 8 Ft Sheet Of</th>
<th>?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum Wallboard</td>
<td>2.20</td>
</tr>
<tr>
<td>Plywood Panelling</td>
<td>5.90</td>
</tr>
<tr>
<td>Vinyl-Coated Fabric</td>
<td>4.10</td>
</tr>
<tr>
<td>Cement-Coated Fiberglass</td>
<td>3.00</td>
</tr>
<tr>
<td>Latex Flat Wall Paint</td>
<td>6.50</td>
</tr>
<tr>
<td>Semi-Gloss Enamel (Oil Base)</td>
<td>7.70</td>
</tr>
</tbody>
</table>

Type 1 if there are any doors, door frames or windows and frames that need to be replaced, Ø if not

If program cost estimates are desired, type 1, if contract cost estimates are desired, type Ø

? 1

59
STOP FOR A MINUTE AND CHECK THE DATA YOU HAVE JUST INPUT IF ANY ERROR
WAS MADE IN ENTERING IT, YOU MAY TYPE 1 TO REPEAT INPUT STATEMENTS:
IF NOT, TYPE Ø TO CONTINUE

? Ø

DWELLING UNIT INFORMATION

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
? PRE 4Ø SINGLE ATTACHED
FOR POLICY ESTIMATES INPUT AVERAGES FOR SQUARE FEET, LINEAR FEET, XRF, ETC.; AND PERCENTAGE OF SAMPLE NEEDED FOR THOSE VARIABLES REQUIRING
A 1 OR Ø
INPUT GROSS SQUARE FEET OF WALL AREA
? 45Ø
INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR FRAMES REQUIRING PAINT REMOVAL
? 33
INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF WINDOW FRAMES REQUIRING PAINT REMOVAL
? 3Ø
INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING PAINT REMOVAL
? 11Ø
TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT
? .975
INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED
(TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)
? Ø
TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT
? .25
TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT
? .1Ø
TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS,
Ø IF NOT
? .Ø5
TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS, WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE IS AVAILABLE
? Ø
INPUT AVERAGE XRF READING
? 3.47
STOP AND CHECK THE DATA FOR THIS DWELLING UNIT IF THERE IS AN ERROR,
TYPE 1 TO REPEAT INPUT STATEMENTS IF NOT, TYPE Ø
? Ø

PRE 4Ø SINGLE ATTACHED

<table>
<thead>
<tr>
<th>WALL COST</th>
<th>TRIM COST</th>
<th>TOTAL COST</th>
<th>MARKUP RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>597.572</td>
<td>209.972</td>
<td>807.545</td>
<td>1.31</td>
</tr>
</tbody>
</table>

IF YOU WISH TO DO MORE COST ESTIMATES TYPE 1, IF NOT TYPE Ø
? Ø

RUNNING TIME: 13.7 SECS I/O TIME: 5Ø.3 SECS

READY
BYE
OFF AT 14:2Ø
Part 2: Baseline Program Cost Estimate

In Section 2.4 a framework for determining baseline program cost estimates based on the results of the dwelling unit survey was developed. Based on the results of the computer run presented in Part 1, we can conclude that the costs of deleading the "statistical" Pre 40 Single Family Attached dwelling unit is approximately $810. Now since the dwelling unit survey revealed that there were 750 dwelling units in this category (see Section 2.4), a baseline program cost estimate of approximately $610,000 is indicated. Once the different types and ages of dwelling units in the region under study have been identified and the number of dwelling units in each category counted, a table similar to Table 2.3 can be constructed. Unlike Table 2.3 this table would include the baseline program cost estimate rather than the number of dwelling units in each category. Strategies for dealing with particular type/age categories based on program costs could then be developed.
APPENDIX D: LISTING OF COMPUTER PROGRAM

0001REMP2OCHAIN RUNNH:J0003***
0001REMS141. DESCRIPTION
0001REMS01
0001REMS62 J0003 WILL ANALYZE THE COSTS OF THE ALTERNATIVE METHODS FOR
0001REMS62 ELIMINATING THE LEAD PAINT HAZARD FROM A DWELLING UNIT. THE
0002REMS01 PROGRAM PERMITS THE USER TO INPUT SPECIFIC INFORMATION ON
0002REMS60 ANTIQUE CONTRACT PACKAGES OF DWELLING UNITS. THE LEAST-
0002REMS62 COST COMBINATION OF ABATEMENT TECHNIQUES FOR EACH DWELLING
0002REMS61 UNIT IS IDENTIFIED. DWELLING UNITS ARE GROUPED TOGETHER INTO
0003REMS63 CONTRACT PACKAGES SO THAT THE SUM OF THE EXPECTED BID PRICES
0003REMS01 IS MINIMIZED. THE EXPECTED BID PRICE FOR EACH CONTRACT IS
0003REMS60 GIVEN. EXPECTED CONTRACT COSTS FOR EACH DWELLING UNIT ARE
0003REMS61 ALSO GIVEN.
0004REMS01
0004REMS142. LIMITATIONS
0005REMS62 J0003 WILL HANDLE ANTIQUE CONTRACT PACKAGES OF UP TO 10
0006REMS62 DWELLING UNITS. DATA FOR EACH DWELLING UNIT IS ENTERED IN
0006REMS61 RESPONSE TO INQUIRIES AT RUN TIME.
0007REMS01
0007REMS73. DATA
0008REMS61 TWO TYPES OF DATA ARE INPUT, CONTRACT SPECIFIC DATA AND
0008REMS63 DWELLING UNIT SPECIFIC DATA. INPUT DATA FOR EACH ANTIQUE
0008REMS01 CONTRACT CONSISTS OF THE FOLLOWING:
0008REMS27 A. CONTRACT SPECIFIC DATA
0009REMS01
0009REMS09 WAGE
0009REMS54 WAGE
0009REMS51 CARPENTER
0009REMS01 PAINTER
0009REMS48 PLASTERER
0009REMS48 PAPER HANGER
0009REMS48

62
<table>
<thead>
<tr>
<th>Laborer</th>
<th>Apprentice Carpenter</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum Wallboard</td>
<td></td>
<td>Price per 4' x 8' Sheet</td>
</tr>
<tr>
<td>Plywood Paneling</td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>Vinyl-Coated Fabric</td>
<td></td>
<td>Price per Square Yard</td>
</tr>
<tr>
<td>Latex Flat Wall Paint</td>
<td></td>
<td>Price per Gallon</td>
</tr>
<tr>
<td>Semi-Gloss Enamel (Oil Base)</td>
<td></td>
<td>&quot;</td>
</tr>
</tbody>
</table>

- **If Needed:**
- Unfinished Door
- Unfinished Door Frame
- Unfinished Window and Frame

**B. Dwelling Unit Data**

<table>
<thead>
<tr>
<th>Gross Sq. Ft. of Wall Area</th>
<th>Linear Ft. of Doors and Frames</th>
<th>Linear Ft. of Windows &amp; Frames</th>
<th>Linear Ft. of Miscellaneous Trim</th>
<th>Occupancy</th>
<th>Wainscoting</th>
<th>Substrate Condition</th>
<th>Pantry Work</th>
<th>Wallpaper on Walls</th>
<th>If Needed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square Feet</td>
<td>Linear Feet</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Percent Occupied or 1 if Occupied</td>
<td>Percent of Wall Area</td>
<td>Percent Unsound or 1 if Poor</td>
<td>Percent Needing It or 1 if Needed</td>
<td>Percent Having &gt;2 Layers, 1 if 3 or More Layers</td>
<td>None</td>
</tr>
</tbody>
</table>

63
NUMBER OF DOORS TO BE REPLACED
NUMBER OF DOOR FRAMES TO REPLACE
NUMBER OF WINDOWS AND FRAMES TO REPLACE
ADDRESS
DU/AGE CATEGORY
ADDRESS AS SPECIFIED
XRF READINGS
AVERAGE OR SEPARATE OR FOR EACH TRIM TYPE
FILES WAGE; MATL; AWR
DIM D(10,10), F(10,10), L(10,10), P(10,10)
DIM W(10,10), Y(10,10), Z(5,10), X(45,3)
DIM Z$(10), P$(10), Y$(10), Q$(10)
REM READ NAMES OF WALL TECHNIQUES INTO VARIABLES
READ A$, B$, C$, D$, E$, F$
DATA GYPSUM WALLBOARD, PLYWOOD PANELING, CEMENTITIOUS COATING
DATA VENEER PLASTER, VINYL-COATED FABRIC, CEMENT-COATED FIBERGLASS
REM READ NAMES OF TRIM TECHNIQUES INTO VARIABLES
READ G$, H$, I$, J$
DATA INFRA-RED DEVICE, SOLVENT STRIP, ELECTRIC HEAT GUN
DATA HAND SCRAPING
MAT READ F(7,6)
DATA 0.6, 0, 0, 0, 0.4, 0, 0.82, 0, 0, 0.18, 0, 0.24, 0.6, 0, 0.16, 0
DATA 0.20, 0.39, 0.29, 0, 0.12, 0.26, 0, 0.26, 0, 0.48, 0, 0
DATA 0.50, 0.14, 0, 0.36, 0, 0, 0, 0, 0, 0, 0, 0.5, 0, 0.5
READ K$, L$
DATA NONE, COMPONENT REPLACEMENT ONLY
REM WAGE RATES STORED AS W(I,1) FOR MATRIX MULTIPLICATION
PRINT "WAGE RATE INFORMATION"
MAT W=ZER(6,1)
PRINT "INPUT WAGE RATE PER HOUR FOR CARPENTER"
INPUT W(1,1)
PRINT "INPUT WAGE RATE PER HOUR FOR PAINTER"
INPUT W(2,1)
PRINT "INPUT WAGE RATE PER HOUR FOR PLASTERER"
INPUT W(3,1)
PRINT "INPUT WAGE RATE PER HOUR FOR PAPERHANGER"
INPUT W(4,1)
PRINT "INPUT WAGE RATE PER HOUR FOR APPRENTICE CARPENTER"
INPUT W(5,1)
PRINT "INPUT WAGE RATE PER HOUR FOR LABORER"
INPUT W(6,1)
MAT L=ZER(7,1)
MAT L=F*W
SCRATCH #1
SCRATCH #3
MAT WRITE #1, W
64
10195 MAT WRITE #3,L
10200 REM MATERIAL PRICES STORED AS M(I)
10205 PRINT
10210 PRINT
10215 PRINT "MATERIAL PRICE INFORMATION"
10220 PRINT
10225 SCRATCH #2
10230 PRINT "INPUT PRICE OF 4 FT BY 8 FT SHEET OF GYPSUM WALLBOARD"
10235 INPUT M(1)
10240 PRINT "INPUT PRICE OF 4 FT BY 8 FT SHEET OF PLYWOOD PANELING"
10245 INPUT M(2)
10250 PRINT "INPUT PRICE PER SQUARE YARD OF VINYL-COATED FABRIC"
10255 INPUT M(3)
10260 PRINT "INPUT PRICE PER GALLON OF LATEX FLAT WALL PAINT"
10265 INPUT M(4)
10270 PRINT "INPUT PRICE PER GALLON OF SEMI-GLOSS ENAMEL (OIL BASE)"
10275 INPUT M(5)
10280 FOR L=1 TO 5
10285 WRITE #2,M(L)
10290 NEXT L
10295 PRINT "TYPE 1 IF THERE ARE ANY DOORS, DOOR FRAMES OR WINDOWS"
10300 PRINT "AND FRAMES THAT NEED TO BE REPLACED, Ø IF NOT"
10305 INPUT Q
10310 IF Q=Ø THEN 10345
10315 PRINT "INPUT PRICE OF NEW, UNFINISHED DOOR"
10320 INPUT M(6)
10325 PRINT "INPUT PRICE OF NEW, UNFINISHED DOOR FRAME"
10330 INPUT M(7)
10335 PRINT "INPUT PRICE OF NEW, UNFINISHED WINDOW AND FRAME"
10340 INPUT M(8)
10345 PRINT
10350 REM COMPUTE AVERAGE WAGE RATES FOR EACH WALL TECHNIQUE AND FOR TRIM
10355 PRINT "IF PROGRAM COST ESTIMATES ARE DESIRED, TYPE 1, IF"
10360 PRINT "CONTRACT COST ESTIMATES ARE DESIRED, TYPE Ø"
10365 INPUT P
10370 IF P=1 THEN 10395
10375 PRINT "INPUT NUMBER OF DWELLING UNITS TO BE DONE (MUST BE <= 10)"
10380 INPUT N
10385 LET N9=N
10390 LET N=1
10395 GO TO 10400
10400 PRINT
10405 PRINT "STOP FOR A MINUTE AND CHECK THE DATA YOU HAVE JUST INPUT"
10410 PRINT "IF ANY ERROR WAS MADE IN ENTERING IT, YOU MAY TYPE 1"
10415 PRINT "TO REPEAT INPUT STATEMENTS; IF NOT, TYPE Ø TO CONTINUE"
10420 INPUT Z
10425 IF Q<1 THEN 10435
10430 IF Z=1 THEN 10295
10435 IF Z=1 THEN 10095
10440 REM N2 IS NUMBER OF CONTRACTS, N3 IS NUMBER OF PAIRS
10445 IF INT(N/2)=N/2 THEN 10465
10450 LET N2=(N+1)/2
10455 LET N3=N2-1
10460 GO TO 10475
10465 LET N2=N/2
10470 LET N3=N2
10475 MAT F=ZER(N,10)

REM INPUT DU INFORMATION THAT MUST BE STORED FOR COMPUTING
10480 REM MARKUP AND BID PRICE
10490 FOR J=1 TO N
10495 IF P=0 THEN 10510
10500 PRINT "DWELLING UNIT INFORMATION"
10505 GO TO 10525
10510 PRINT 10515 PRINT 10520 PRINT "DWELLING UNIT NUMBER" J
10525 PRINT 10530 PRINT "TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT"
10535 INPUT Q$(J)
10540 IF P=0 THEN 10560
10545 PRINT "FOR POLICY ESTIMATES INPUT AVERAGES FOR SQUARE FEET, LINEAR F"
10550 PRINT "XRF, ETC.; AND PERCENTAGE OF SAMPLE NEEDED FOR THOSE VARIABL"
10555 PRINT "REQUIRING A 1 OR Ø"
10560 PRINT "INPUT GROSS SQUARE FEET OF WALL AREA"
10565 INPUT D(1,J)
10570 REM D(2,J) IS NET SQUARE FEET OF WALL AREA
10575 IF D(1,J)<400 THEN 10590
10580 LET D(2,J)=77+0.64*D(1,J)
10585 GO TO 10595
10590 LET D(2,J)=0.83*D(1,J)
10595 PRINT "INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR"
10600 PRINT "FRAMES REQUIRING PAINT REMOVAL"
10605 INPUT D(3,J)
10610 REM D8 IS NUMBER OF DOORS AND FRAMES TO BE DELEADED
10615 LET D8=D(3,J)/8
10620 PRINT "INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF"
10625 PRINT "WINDOW FRAMES REQUIRING PAINT REMOVAL"
10630 INPUT D(4,J)
10635 REM D7 IS NUMBER OF WINDOWS AND FRAMES TO BE DELEADED
10640 LET D7=D(4,J)/7
10645 PRINT "INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING"
10650 PRINT "PAINT REMOVAL"
10655 INPUT D(5,J)
10660 LET D(7,J)=D(3,J)+D(4,J)+D(5,J)
10665 PRINT "TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT"
10670 INPUT D(6,J)
10675 REM INPUT OTHER DU RELATED DATA NECESSARY FOR CALCULATIONS
10680 IF D(1,J)=Ø THEN 10735
10685 PRINT "INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED"
10690 PRINT "(TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)"
10695 INPUT E(3)
10700 PRINT "TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT"
10705 INPUT E(4)
10710 PRINT "TYPE 1 IF PANTRY WORK IS NECESSARY, 0 IF NOT"
10715 INPUT E(5)
10720 PRINT "TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS,"
10725 PRINT "0 IF NOT"
10730 INPUT E(6)
10735 IF Q=0 THEN 10770
10740 PRINT "INPUT NUMBER OF DOORS TO BE REPLACED"
10745 INPUT E(7)
10750 PRINT "INPUT NUMBER OF DOOR FRAMES TO BE REPLACED"
10755 INPUT E(8)
10760 PRINT "INPUT NUMBER OF WINDOWS & FRAMES TO BE REPLACED"
10765 INPUT E(9)
10770 IF D(1,J)<>0 THEN 10810
10775 LET Z1=0
10780 LET C8=0
10785 LET C9=0
10790 LET B8=0
10795 LET B9=0
10800 LET B(1)=0
10805 GO TO 10815
10810 IF Z1=9 THEN 10815
10815 IF D(7,J)=0 THEN 10905
10820 PRINT "TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS,"
10825 PRINT "WINDOWS AND MISCELLANEOUS TRIM, 0 IF ONLY AN AVERAGE"
10830 PRINT "IS AVAILABLE"
10835 INPUT Y
10840 IF Y=1 THEN 10875
10845 PRINT "INPUT AVERAGE XRF READING"
10850 INPUT X
10855 LET X1=X
10860 LET X2=X
10865 LET X3=X
10870 GO TO 10905
10875 PRINT "INPUT XRF READING FOR DOORS AND DOOR FRAMES"
10880 INPUT X1
10885 PRINT "INPUT XRF READING FOR WINDOWS AND FRAMES"
10890 INPUT X2
10895 PRINT "INPUT XRF READING FOR MISCELLANEOUS TRIM"
10900 INPUT X3
10905 PRINT "STOP AND CHECK THE DATA FOR THIS DWELLING UNIT"
10910 PRINT "IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS"
10915 PRINT "IF NOT, TYPE 0"
10920 INPUT Z
10925 IF Z=1 THEN 10520
10930 REM COMPUTE PAINTING COST FOR WALLS AND CEILINGS
10935 IF Z1=0 THEN 11025
10940 LET C8=1.35*(D(1,J)/39.95)+2
10945 LET C9=D(1,J)+C8 +2
10950 REM B8 IS PAINTING COST FOR ALL TECHNIQUES BUT GYP AND VENEER PLASTER
10955 LET B8=0.860296*C8+0.0106*M(2,1)+0.0257*M(4)+0.1736*D(2,J)/D(1,J)

67
10960 IF B8>=0.08 THEN 10970
10965 LET B8=0.08
10970 REM B9 IS PAINTING COST FOR GYP AND VENEER PLASTER
10975 LET B9=0.0009*W(2,1)+0.0257*M(4)+0.1736*D(2,J)/D(1,J)
10980 IF B9>=0.08 THEN 10990
10985 LET B9=0.08
10990 LET B(1)=-1.7706+0.65874/D(2,J)+0.0620*L(1,1)
10995 LET B=0.5009*M(1)+0.2740*E(5)
11000 REM GYPSUM WALLBOARD
11005 LET B(1)=B(1)+B
11010 IF B(1)>=0.25 THEN 11020
11015 LET B(1)=0.25
11020 LET B(1)=B(1)*D(1,J)+B9*C9
11025 LET C(J)=B(1)
11030 LET G(J)=B(1)
11035 LET Z$(J)=A$
11040 LET P$(J)=A$
11045 IF Z1<>0 THEN 11080
11050 LET Z$(J)=K$
11055 FOR K=2 TO 6
11060 LET B(K)=0
11065 NEXT K
11070 GO TO 11340
11075 REM PLYWOOD PANELING
11080 LET A(2)=0.07995*M(2)-0.0231*L(2,1)+0.0829*E(4)
11085 LET B(2)=-0.3245+0.0054*D(2,J)+0.0748*L(2,1)+1.2602*A(2)
11090 IF B(2)>=0.77 THEN 11100
11095 LET B(2)=0.77
11100 LET B(2)=B(2)*D(1,J)+B8*C8
11105 IF C(J)<=B(2) THEN 11130
11110 LET C(J)=B(2)
11115 LET G(J)=B(2)
11120 LET Z$(J)=B$
11125 LET P$(J)=B$
11130 REM CEMENTITIOUS COATING
11135 LET A(3)=-0.5002+0.6872*D(2,J)/D(1,J)+0.1037+0.1741*E(4)
11140 LET B(3)=-0.8817-0.004*D(1,J)+0.1154*L(3,1)+3.8636*A(3)+0.1416*E(6)
11145 IF B(3)>=0.22 THEN 11155
11150 LET B(3)=0.22
11155 LET B(3)=B(3)*D(1,J)+B8*C8
11160 IF C(J)<=B(3) THEN 11175
11165 LET C(J)=B(3)
11170 LET Z$(J)=C$
11175 REM VENEER PLASTER
11180 LET A(4)=A(3)-0.0847
11185 LET B(4)=-0.8817-0.004*D(1,J)+0.1154*L(4,1)+3.8636*A(4)+0.1416*E(6)+0.206
11190 IF B(4)>=0.35 THEN 11200
11195 LET B(4)=0.35
11200 LET B(4)=B(4)*D(1,J)+B9*C9
11205 IF C(J)<=B(4) THEN 11220
11210 LET C(J)=B(4)
11215 LET Z$(J)=D$
11220 REM VINYL-COATED FABRIC
11225 LET R(5)=-25.2456+0.0276*D(2,J)+22.0745*D(2,J)/D(1,J)
11230 LET R=1.2933*L(5,1)-24.8364*E(3)
11235 LET R(5)=R(5)+R
11240 LET A(5)=0.0958*M(2)+0.5447*E(3)
11245 LET B(5)=L(5,1)/R(5)+A(5)
11250 IF B(5)>=0.84 THEN 11260
11255 LET B(5)=0.84
11260 LET B(5)=B(5)*D(1,J)+B8*C8
11265 IF C(J)<=B(5) THEN 11280
11270 LET C(J)=B(5)
11275 LET Z$(J)=E$
11280 REM CEMENT-COATED FIBERGLASS
11285 LET R(6)=43.5809-33.6107*D(2,J)/D(1,J)-45.5105*E(3)
11290 LET R=-3.4202*E(4)+8.1578
11295 LET R(6)=R(6)+R
11300 LET A(6)=0.5600*D(2,J)/D(1,J)+1.0900*L(6,1)/R(6)
11305 LET B(6)=L(6,1)/R(6)+A(6)
11310 IF B(6)>=0.66 THEN 11320
11315 LET B(6)=0.66
11320 LET B(6)=B(6)*D(1,J)+B8*C8
11325 IF C(J)<=B(6) THEN 11340
11330 LET C(J)=B(6)
11335 LET Z$(J)=F$
11340 REM FIND XRF TIMES LINEAR FEET FOR TRIM
11345 LET Y1=X1*D(3,J)
11350 LET Y2=X2*D(4,J)
11355 LET Y3=X3*D(5,J)
11360 REM FIND MINIMUM DIRECT COST TECHNIQUE FOR TRIM
11365 REM S(I)=DOORS T(I)=WINDOWS U(I)=TRIM V(I)=TOTAL
11370 REM INFRA-RED HEATING DEVICE
11375 IF D(6,J)=1 THEN 11445
11380 LET S(1)=(-0.2903*L(7,l)-0.0007*Y1)/0.92
11385 IF S(1)>=1.05 THEN 11395
11390 LET S(1)=1.05
11395 LET T(1)=(-0.2903*L(7,l)-0.0007*Y2)/0.89
11400 IF T(1)>=1.05 THEN 11410
11405 LET T(1)=1.05
11410 LET U(1)=(-0.1354*L(7,l)-0.4913)/0.88
11415 IF U(1)>=0.29 THEN 11425
11420 LET U(1)=0.29
11425 LET V(1)=S(1)*D(3,J)+T(1)*D(4,J)+U(1)*D(5,J)
11430 LET H(J)=V(1)
11435 LET Y$(J)=G$
11440 GO TO 11455
11445 LET H(J)=100000
11450 LET V(1)=0
11455 REM SOLVENT-BASED PAINT REMOVER
11460 LET S(2)=(-1.3499+0.5727*L(7,l)-0.0013*Y1)/0.88
11465 IF S(2)>=1.25 THEN 11475

69
LET S(2)=1.25
LET T(2)=(-1.3499+0.5727*L(7,1)-0.0013*Y2)/0.88
IF T(2)>1.25 THEN 11490
LET T(2)=1.25
LET U(2)=0.51
LET V(2)=S(2)*D(3,J)+T(2)*D(4,J)+U(2)*D(5,J)
IF H(J)<=V(2) THEN 11525
LET H(J)=V(2)
LET Y$(J)=H$
REM ELECTRIC HEAT GUN
LET S(3)=0.2775*L(7,1)-0.00861*D(3,J)+0.1769
IF S(3)>=0.58 THEN 11545
LET S(3)=0.58
LET T(3)=0.2775*L(7,1)-0.00861*D(4,J)+0.4735
IF T(3)>=0.58 THEN 11560
LET T(3)=0.58
LET U(3)=0.1372*L(7,1)-0.0073*D(5,J)+0.1406
IF U(3)>=0.17 THEN 11575
LET U(3)=0.17
LET V(3)=S(3)*D(3,J)+T(3)*D(4,J)+U(3)*D(5,J)
IF H(J)<=V(3) THEN 11595
LET H(J)=V(3)
LET Y$(J)=I$
REM HANDSCRAPING
LET S(4)=0.9468-0.0213*D(3,J)+0.3262*L(7,1)
IF S(4)>=1.16 THEN 11615
LET S(4)=1.16
LET T(4)=0.9468-0.0213*D(4,J)+0.3262*L(7,1)
IF T(4)>=1.16 THEN 11630
LET T(4)=1.16
LET U(4)=0.1146*L(7,1)
IF U(4)>=0.45 THEN 11645
LET U(4)=0.45
LET V(4)=S(4)*D(3,J)+T(4)*D(4,J)+U(4)*D(5,J)
IF H(J)<=V(4) THEN 11665
LET H(J)=V(4)
LET Y$(J)=V$
REM PAINTING COSTS FOR TRIM
LET S(9)=(0.7517*W(2,1)+0.9343*M(5)-0.8776*D8)*D8
LET T(9)=(2.5942*W(2,1)+1.5865*M(5)-3.8199*D7)*D7
LET U(9)=(0.0388*W(2,1)*D(5,J)
LET V(9)=S(9)+T(9)+U(9)
REM V(9) IS TOTAL COST FOR PAINTING TRIM-ALL TECHNIQUES
IF V(9)>=0.09*D(7,J) THEN 11705
LET V(9)=0.09*D(7,J)
REM COMPONENT REPLACEMENT COST
LET S(8)=(0.7517*W(2,1)+0.9343*M(5)-0.8776*E(7))*E(7)*0.7
LET T(8)=(0.7517*W(2,1)+1.5865*M(5)-3.8199*E(9))*E(9)
LET U(8)=(2.5942*W(2,1)+1.5865*M(5)-3.8199*E(9))*E(9)
11725 LET V(8)=S(8)+T(8)+U(8)
11730 LET V(5)=E(7)*(95.2923-4.5476*L(1,1)+0.7604*M(6))
11735 LET V(5)=V(5)+E(8)*(5.702*L(1,1)+1.699*M(7))
11740 LET V(5)=V(5)+E(9)*(6.740*L(1,1)+1.1016*M(8)+25.213)
11745 LET V(5)=Q*(V(5)+V(8))
11750 LET H(J)=H(J)+V(9)+V(5)
11755 FOR M=1 TO 4
11760 LET V(M)=V(M)+V(9)
11765 NEXT M
11770 IF H(J)=0 THEN 11790
11775 IF D(7,J)<>0 THEN 11795
11780 LET Y$(J)=L$
11785 GO TO 11795
11790 LET Y$(J)=K$
11795 IF P<>1 THEN 11935
11800 LET B(7)=(B(1)+B(2)+B(3)+B(4)+B(5)+B(6))/6
11805 IF V(1)=0 THEN 11820
11810 LET V(6)=(V(1)+V(2)+V(2)+V(3)+V(4))/4+V(5)
11815 GO TO 11825
11820 LET V(6)=(V(2)+V(3)+V(4))/3+V(5)
11825 LET P2=1.16-0.0003*D(2,J)+0.0015*D(7,J)
11830 IF P2<1.1 THEN 11850
11835 IF P2<1.5 THEN 11855
11840 LET P2=1.5
11845 GO TO 11855
11850 LET P2=1.1
11855 LET P3=P2*B(7)
11860 LET P4=P2*V(6)
11865 PRINT
11870 LET P5=P3+P4
11875 PRINT
11880 PRINT USING 11885,Q$(1)
11885: 'CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
11890 PRINT
11895 PRINT "WALL COST","TRIM COST","TOTAL COST","MARKUP RATIO"
11900 PRINT P3,P4,P5,P2
11905 PRINT
11910 PRINT
11915 PRINT "IF YOU WISH TO DO MORE COST ESTIMATES TYPE 1, IF NOT TYPE 0"
11920 INPUT P6
11925 IF P6=1 THEN 10355
11930 GO TO 13300
11935 REM F IS BASIC DATA MATRIX
11940 LET F(J,1)=C(J)+H(J)
11945 LET F(J,2)=D(2,J)
11950 LET F(J,3)=D(7,J)
11955 IF Z$(J)=P$(J) THEN 11970
11960 LET F(J,4)=0
11965 GO TO 11975
11970 LET F(J,4)=D(2,J)
11975 LET F(J,5)=C(J)
11980 LET F(J,6)=G(J)
11985 LET F(J,7)=G(J)-C(J)
11990 NEXT J
11995 LET Fl=∅
12000 AT Y=ZER(N,10)
12005 MAT Y=F
12010 IF N<>1 THEN 12025
12015 LET Y(1,8)=1
12020 GO TO 12490
12025 REM PAIR DWELLING UNITS
12030 REM L IS DIFFERENTIAL MARKUP MATRIX
12035 MAT L=ZER(N,N)
12040 FOR I=1 TO N
12045 FOR K=1 TO N
12050 IF Y(I,2)<>0 THEN 12070
12055 IF Y(K,2)<>0 THEN 12070
12060 LET L(I,K)=10
12065 GO TO 12075
12070 LET L(I,K)=-0.000079*Y(I,2)+0.00052*Y(I,3)-0.2144*(Y(I,4)/(Y(I,2)+Y(K,2)))
12075 NEXT K
12080 NEXT I
12085 FOR I=1 TO N
12090 LET L(I,I)=9
12095 NEXT I
12100 REM P IS DIRECT COST MATRIX
12105 MAT P=ZER(N,N)
12110 FOR J=1 TO N
12115 LET P(J,J)=Y(J,1)
12120 NEXT J
12125 REM D IS TEST MATRIX
12130 MAT D=ZER(N,N)
12135 MAT D=L*P
12140 REM W IS TRIANGULAR TEST MATRIX
12145 MAT W=ZER(N,N)
12150 FOR K=1 TO N-1
12155 LET I=K+1
12160 LET W(I,K)=D(I,K)+D(K,I)
12165 LET I=I+1
12170 IF I<N THEN 12160
12175 NEXT K
12180 LET N1=N*(N-1)/2
12185 MAT X=ZER(N1,3)
12190 LET J=1
12195 FOR K=1 TO N-1
12200 LET I=K+1
12205 LET X(J,1)=W(I,K)
12210 LET X(J,2)=I
12215 LET X(J,3)=K
12220 IF J>=N1 THEN 12250
12225 LET I=I+1
12230 LET J=J+1

72
IF I>N THEN 12245
GO TO 12205
NEXT K
REM SORT X MATRIX
FOR L=1 TO N-1
FOR M=1 TO N-1
LET Q1=X(M,1)
LET Q2=X(M+1,1)
LET R1=X(M,2)
LET R2=X(M+1,2)
LET S1=X(M,3)
LET S2=X(M+1,3)
IF Q1<=Q2 THEN 12330
LET X(M,1)=Q2
LET X(M+1,1)=Q1
LET X(M,2)=R2
LET X(M+1,2)=R1
LET X(M,3)=S2
LET X(M+1,3)=S1
NEXT M
NEXT L
IF F1=1 THEN 12545
REM Y IS PRELIMINARY CONTRACT PACKAGE MATRIX
LET J=1
LET K=1
LET B2=X(J,2)
LET B3=X(J,3)
IF F(B2,10)=1 THEN 12430
IF F(B3,10)=1 THEN 12430
FOR M=1 TO 7
LET Y(K,M)=F(B2,M)+F(B3,M)
NEXT M
LET Y(K,8)=B2
LET Y(K,9)=B3
LET F(B2,10)=1
LET F(B3,10)=1
IF K=N2 THEN 12490
IF K=N3 THEN 12440
LET K=K+1
NEXT M
GO TO 12360
NEXT I
NEXT K
FOR I=1 TO N
IF F(I,10)=0 THEN 12460
NEXT I
LET B2=I
FOR M=1 TO 7
LET Y(K,M)=F(B2,M)
NEXT M
LET Y(K,8)=B2
LET Y(K,9)=0
12490 IF N>2 THEN 12530
12495 LET N6=1
12500 FOR M=1 TO 7
12505 LET Z(1,M)=Y(1,M)
12510 NEXT M
12515 LET Z(1,8)=1
12520 LET Z(1,9)=0
12525 GO TO 12935
12530 LET Fl=1
12535 LET N=K
12540 GO TO 12025
12545 REM Z IS FINAL CONTRACT PACKAGE MATRIX
12550 LET J=1
12555 LET K=1
12560 IF INT(N/2)=N/2 THEN 12580
12565 LET N4=(N+1)/2
12570 LET N5=N4-1
12575 GO TO 12590
12580 LET N4=N/2
12585 LET N5=N4
12590 FOR J=1 TO (N-1)*N/2
12595 IF X(J,1)>0 THEN 12685
12600 LET B2=X(J,2)
12605 LET B3=X(J,3)
12610 IF Y(B2,10)=1 THEN 12670
12615 IF Y(B3,10)=1 THEN 12670
12620 FOR M=1 TO 7
12625 LET Z(K,M)=Y(B2,M)+Y(B3,M)
12630 NEXT M
12635 LET Z(K,8)=B2
12640 LET Z(K,9)=B3
12645 LET Y(B2,10)=1
12650 LET Y(B3,10)=1
12655 IF K=N4 THEN 12930
12660 IF K=N5 THEN 12680
12665 LET K=K+1
12670 NEXT J
12675 GO TO 12685
12680 LET K=K+1
12685 IF N2=N3 THEN 12805
12690 FOR I=1 TO N
12695 IF Y(I,9)=0 THEN 12705
12700 NEXT I
12705 IF Y(I,10)=1 THEN 12790
12710 LET B2=I
12715 LET N1=N*(N-1)/2
12720 FOR I=1 TO N1
12725 IF X(I,2)=B2 THEN 12740
12730 IF X(I,3)=B2 THEN 12750
12735 NEXT I
12740 LET B3=X(I,3)
12745 GO TO 12755
12750 LET B3=X(I,2)
12755 IF Y(B3,10)=1 THEN 12880
12760 FOR M=1 TO 7
12765 LET Z(K,M)=Y(B2,M)+Y(B3,M)
12770 NEXT M
12775 LET Z(K,8)=B3
12780 LET Z(K,9)=B2
12785 LET Y(B2,10)=1
12790 LET Y(B3,10)=1
12795 IF K=N4 THEN 12805
12800 LET K=K+1
12805 FOR I=1 TO N
12810 IF Y(I,10)=1 THEN 12815
12815 FOR M=1 TO 7
12820 LET Z(K,M)=Y(I,M)
12825 NEXT M
12830 LET Z(K,8)=I
12835 LET Z(K,9)=0
12840 LET Y(I,10)=1
12845 FOR L=1 TO N
12850 IF Y(L,10)=0 THEN 12855
12855 GO TO 12875
12860 GO TO 12860
12865 LET K=K+1
12870 NEXT I
12875 GO TO 12930
12880 FOR I=1 TO N
12885 IF Z(I,8)=B3 THEN 12900
12890 IF Z(I,9)=B3 THEN 12900
12895 NEXT I
12900 LET Z(I,10)=B2
12905 FOR M=1 TO 7
12910 LET Z(K,M)=Z(K,M)+Y(B2,M)
12915 NEXT M
12920 LET Y(B2,10)=1
12925 GO TO 12805
12930 LET N6=K
12935 MAT W=ZER(N6,5)
12940 FOR K=1 TO N6
12945 LET Z8=Z(K,8)
12950 LET W(K,1)=Y(Z8,8)
12955 LET W(K,2)=Y(Z8,9)
12960 IF Z(K,9)=0 THEN 12995
12965 LET Z9=Z(K,9)
12970 LET W(K,3)=Y(Z9,8)
12975 LET W(K,4)=Y(Z9,9)
12980 LET Z9=Z(K,10)
12985 IF Z9=0 THEN 12995
12990 LET W(K,5)=Y(Z9,8)
12995 NEXT K

75
13000 FOR K=1 TO N6
13005 PRINT
13010 PRINT "CONTRACT "K
13015 PRINT
13020 PRINT
13025 LET I=1
13030 LET M(K)=-0.000079*Z(K,2)+0.00052*Z(K,3)-0.2144*(Z(K,4)/Z(K,2))
13035 LET M(K)=M(K)+1.2972
13040 REM W5 IS DWELLING UNIT NUMBER
13045 LET W5=W(K,I)
13050 IF W5<>0 THEN 13075
13055 LET I=I+1
13060 IF I>5 THEN 13165
13065 IF W(K,I)=0 THEN 13165
13070 LET W5=W(K,I)
13075 IF F(W5,2)=0 THEN 13120
13080 LET M9=-0.2144*(F(W5,4))/Z(K,2)
13085 LET M8=M9*Z(K,1)+M(K)*F(W5,7)
13090 IF M8>0 THEN 13120
13095 LET M(K)=M(K)+M9
13100 LET ZS(W5)=PS(W5)
13105 LET F(W5,1)=F(W5,1)+F(W5,7)
13110 LET Z(K,1)=Z(K,1)+F(W5,7)
13115 LET Z(K,4)=Z(K,4)+F(W5,4)
13120 PRINT "DWELLING UNIT "W5,Q$(W5)
13125 PRINT
13130 PRINT "WALL TECHNIQUE "ZS(W5)
13135 PRINT "TRIM TECHNIQUE "Y$(W5)
13140 PRINT "DIRECT COST "$F(W5,1)
13145 PRINT
13150 IF W5=0 THEN 13165
13155 LET I=I+1
13160 IF I<=5 THEN 13045
13165 IF M(K)<1.1 THEN 13185
13170 IF M(K)<=1.5 THEN 13190
13175 LET M(K)=1.5
13180 GO TO 13190
13185 LET M(K)=1.1
13190 LET Z(K,1)=M(K)*Z(K,1)
13195 PRINT "CONTRACT PRICE "$Z(K,1)
13200 PRINT "MARKUP RATIO "M(K)
13205 PRINT
13210 IF Q=0 THEN 13205
13215 PRINT "THIS INCLUDES THE COMPONENT REPLACEMENT YOU REQUESTED"
13220 NEXT K
13225 PRINT "IF YOU WISH TO DO MORE COST ESTIMATES TYPE 1, IF NOT TYPE 0"
13230 INPUT Q7
13235 IF Q7=0 THEN 13300
13240 RESTORE #1
13245 RESTORE #2
13250 RESTORE #3
13255 MAT W=ZER(6,1)
13260 MAT L=ZER(7,1)
13265 MAT READ #1,W
13270 MAT READ #3,L
13275 FOR L=1 TO 5
13280 READ #2,M(L)
13285 NEXT L
13290 MAT D=ZER(10,10)
13295 GO TO 10295
13300 END
REFERENCES


**FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY**

<table>
<thead>
<tr>
<th>01. Summary date</th>
<th>02. Summary prepared by (Name and Phone)</th>
<th>03. Summary action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yr. Mo. Day</td>
<td>Robert Chapman x2278</td>
<td>New   Replacement Deletion</td>
</tr>
<tr>
<td>8 0 0 2 3 4</td>
<td></td>
<td>☒     ☐    ☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>04. Software date</th>
<th>05. Software title</th>
<th>06. Short title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yr. Mo. Day</td>
<td>Lead Based Paint Hazard Abatement Cost Estimation Procedure</td>
<td>J0003</td>
</tr>
<tr>
<td>7 8 0 5 2 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>07. Internal Software ID</th>
<th>08. Software type</th>
<th>09. Processing mode</th>
<th>10. General Application area</th>
<th>11. Submitting organization and address</th>
<th>12. Technical contact(s) and phone</th>
</tr>
</thead>
</table>

13. Narrative

Program will analyze the costs of the alternative methods for eliminating the lead paint hazard from a dwelling unit. It permits the user to input specific information on anticipated contract packages of dwelling units. The least-cost combination of abatement techniques for each dwelling unit is identified. Dwelling units are grouped together into contract packages so that the sum of the expected bid prices is minimized. The expected bid price for each contract and expected contract costs for each dwelling unit are given.

14. Keywords

15. Computer manuf' and model

<table>
<thead>
<tr>
<th>Computer Devices</th>
<th>16. Computer operating system</th>
<th>17. Programing language(s)</th>
<th>18. Number of source program statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teleterm 1030</td>
<td>GSA Timesharing (RAMUS)</td>
<td>Extended BASIC</td>
<td></td>
</tr>
</tbody>
</table>

19. Computer memory requirements

<table>
<thead>
<tr>
<th>Tape drives</th>
<th>Disk/Drum units</th>
<th>Terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>1 (Line Speed = 30)</td>
</tr>
</tbody>
</table>

20. Other operational requirements

None

21. Software availability

<table>
<thead>
<tr>
<th>Available</th>
<th>Limited</th>
<th>In-house only</th>
</tr>
</thead>
<tbody>
<tr>
<td>☒</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Documentation availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available</td>
</tr>
<tr>
<td>☒</td>
</tr>
</tbody>
</table>

22. Documentation availability

<table>
<thead>
<tr>
<th>Available</th>
<th>Inadequate</th>
<th>In-house only</th>
</tr>
</thead>
<tbody>
<tr>
<td>☒</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>


25. Documentation availability


26. FOR SUBMITTING ORGANIZATION USE

185-101
### 1. Publication or Report No.

**NBSIR 80-1977**

### 4. Title and Subtitle

**Forecasting Lead Paint Abatement Costs: A Computerized Approach**

### 7. Author(s)

Robert E. Chapman and Kimberly A. Barnes

### 9. Performing Organization Name and Address

**National Bureau of Standards**  
Department of Commerce  
Washington, DC 20234

### 12. Sponsoring Organization Name and Complete Address (Street, City, State, ZIP)

Office of Policy Development and Research  
Department of Housing and Urban Development  
Washington, D.C. 20410

### 15. Supplementary Notes

[X] Document describes a computer program; SF-185, FIPS Software Summary, is attached.

### 16. Abstract (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This report describes a computerized procedure for estimating the cost of eliminating the lead-based paint hazard from buildings. This procedure is based on the results of an extensive field test program in which lead-based paint hazard abatement activities were carried out in approximately 200 dwelling units. The computerized cost estimation procedure which emerged is particularly useful because it takes into consideration both variations in the conditions of the dwelling unit as well as in the prices for labor and materials. As a result, it permits the least costly abatement technique to be identified under a wide variety of circumstances. In addition, when contract cost estimates are desired, the computer program groups dwelling units together into contracts in such a way that the sum of the expected bid prices is minimized.

This report is intended to serve as a user's manual for staff members concerned with the problem of estimating lead-based paint abatement costs. Specific cases with respect to the preparation of cost estimates for individual dwelling units or of budget estimates for program managers, policy makers, or other decision makers, are treated.

### 17. Key Words (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name, separated by semicolons)

Applied economics; building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning.

### 18. Availability

[X] Unlimited

- Order From Sup. of Doc., U.S. Government Printing Office, Washington, DC 20402, SD Stack No. SN003-003-
- Order From National Technical Information Service (NTIS), Springfield, VA, 22161

### 19. Security Class (This Report)

UNCLASSIFIED

### 20. Security Class (This Page)

UNCLASSIFIED

### 21. No. of Printed Pages

86

### 22. Price

$8.00