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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
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U.S. DEPARTMENT OF COMMERCE, Philip M. Klutznick, *Secretary*

Luther H. Hodges, Jr., *Deputy Secretary*
Jordan J. Baruch, *Assistant Secretary for Science and Technology*

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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.

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Most Common SI Units and their
Equivalent Values in
Customary Units

QUANTITY	INTERNAITONAL (SI) UNIT	U.S. CUSTOMARY UNIT	APPROXIMATE CONVERSION
LENGTH	meter (m)	foot (ft)	1 m = 3.2808 ft
	millimeter (mm)	inch (io)	1 mm = 0.0394 in
AREA	square meter (m^2)	square yard (yd^2)	1 m^2 = 1.1960 yd^2
		square foot (ft^2)	1 m^2 = 10.764 ft^2
	square millimeter (mm^2)	square inch (in^2)	1 mm^2 = 1.5500 x 10^{-3} in^2
VOLUME	cubic meter (m^2)	cubic yard (yd^3)	1 m^3 = 1.3080 yd^3
		cubic foot (ft^3)	1 m^3 = 25.315 ft^3
	cubic millimeter (mm^3)	cubic inch (in^3)	1 mm^3 = 61.024 x 10^{-6} in^3
CAPACITY	liter (L)	gallon (gal)	1 L = 0.2642 gal
	milliliter (mL)	fluid ounce (ft oz)	1 mL = 0.0338 fl oz
VELOCITY, SPEED	meter per second (m/s)	foot per second (ft/s or f.p.s.)	1 m/s = 3.2808 ft/s
	kilometer per hour (km/h)	mile per hour (mile/h or m.p.h.)	1 km/h = 0.6214 mile/h
ACCELERATION	meter per secood squared (m/s^2)	foot per second squared (ft/s^2)	1 m/s^2 = 3.2808 ft/s^2
MASS	metric ton (t) [1000 kg]	short ton [2000 lb]	1 t = 1.1023 ton
	kilogram (kg)	pound (lb)	1 kg = 2.2046 lb
	gram (g)	ounce (oz)	1 g = 0.0353 oz
DENSITY	metric ton per cubic meter (t/m^3)	ton per cubic yard (ton/yd^3)	1 t/m^3 = 0.8428 ton/yd^3
	kilogram per cubic meter (kg/m^3)	pound per cubic foot (lb/ft^3)	1 kg/m^3 = 0.0624 lb/ft^3
FORCE	kilonewtoo (kN)	ton-force (tonf)	1 kN = 0.1124 tonf
		kip [1000 lbf]	1 kN = 0.2248 kip
	newton (N)	pound-force (lbf)	1 N = 0.2248 lbf
MOMENT OF FORCE, TORQUE	kilonewtoo meter (kN·m)	ton-force foot (tonf·ft)	1 kN·m = 0.3688 tonf·ft
	newton meter (N·m)	pound-force inch (lbf·in)	1 N·m = 8.8508 lbf·in
PRESSURE, STRESS	megapascal (MPa)	ton-force per square inch ($tonf/in^2$)	1 MPa = 0.0725 $tonf/in^2$
		ton-force per square foot ($tonf/ft^2$)	1 MPa = 10.443 $tonf/ft^2$
	kilopascal (kPa)	pound-force per square inch (lbf/in^2)	1 kPa = 0.1450 lbf/in^2
		pound-force per square foot (lbf/ft^2)	1 kPa = 20.885 blf/ft^2
WORK, ENERGY, QUANTITY OF HEAT	megajoule (MJ)	kilowatthour (kWh)	1 MJ = 0.2778 kWh
	kilojoule (kJ)	British thermal unit (Btu)	1 kJ = 0.9478 Btu
	joule (J)	foot pound-force (ft·lbf)	1 J = 0.7376 ft·lbf
POWER, HEAT FLOW RATE	kilowatt (kW)	horsepower (hp)	1 kW = 1.3410 hp
	watt (W)	British thermal unit per hour (Btu/h)	1 W = 3.4121 Btu/h
		foot pound-force per second (ft·lbf/s)	1 W = 0.7376 ft·lbf/s
COEFFICIENT OF HEAT TRANSFER [U-value]	watt per square meter kelvin ($W/m^2·K$) [$=(W/m^2·°C)$]	Btu per square foot hour degree Fahrenheit ($Btu/ft^2·h·°F$)	1 $W/m^2·K$ = 0.1761 $8tu/ft^2·h·°F$
THERMAL CONDUCTIVITY [k-value]	watt per meter kelvin (W/m·K) [$=(W/m·°C)$]	Btu per square foot degree Fahrenheit ($Btu/ft^2·°F$)	1 W/m·K = 0.5778 $Btu/ft^2·°F$

NOTES: (1) The above conversion factors are showo to three or four places of decimals.

(2) Unprefixed SI units are underlined. (The kilogram, although prefixed, is an SI base unit).

REFERENCES: NBS Guidelines for the Use of the Metric System, LC1056, Revised August 1977;
The Metric System of Measurement, Federal Register Notice of October 26, 1977, LC 1078, Revised November 1977;
NBS Special Publication 330, "The International System of Units (SI)," 1977 Edition;
NBS Technical NOte 938, "Recommended Practice for the use of Metric (SI) Units in Building Design and Construction," Revised edition June 1977;
ASTM Standard E621-78, "Standard Practice for the Use of Metric (SI) Units in Building Design and Construction," (based on NBS TN 938), March 1978;
ANSI Z210 .1-1976, "American National Standard for Metric Practice;" also issued as ASTM E380-76$^{\epsilon}$, or IEEE Std. 268-1976.

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.

---

[1] BASIC is an acronym for Beginner's All-purpose Symbolic Instruction Code. A good introduction to BASIC is given in D. Spencer, A Guide to BASIC Programming: A Time-Sharing Language, Addison-Wesley Publishing Company, Inc., Reading, Mass., 1970.

[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

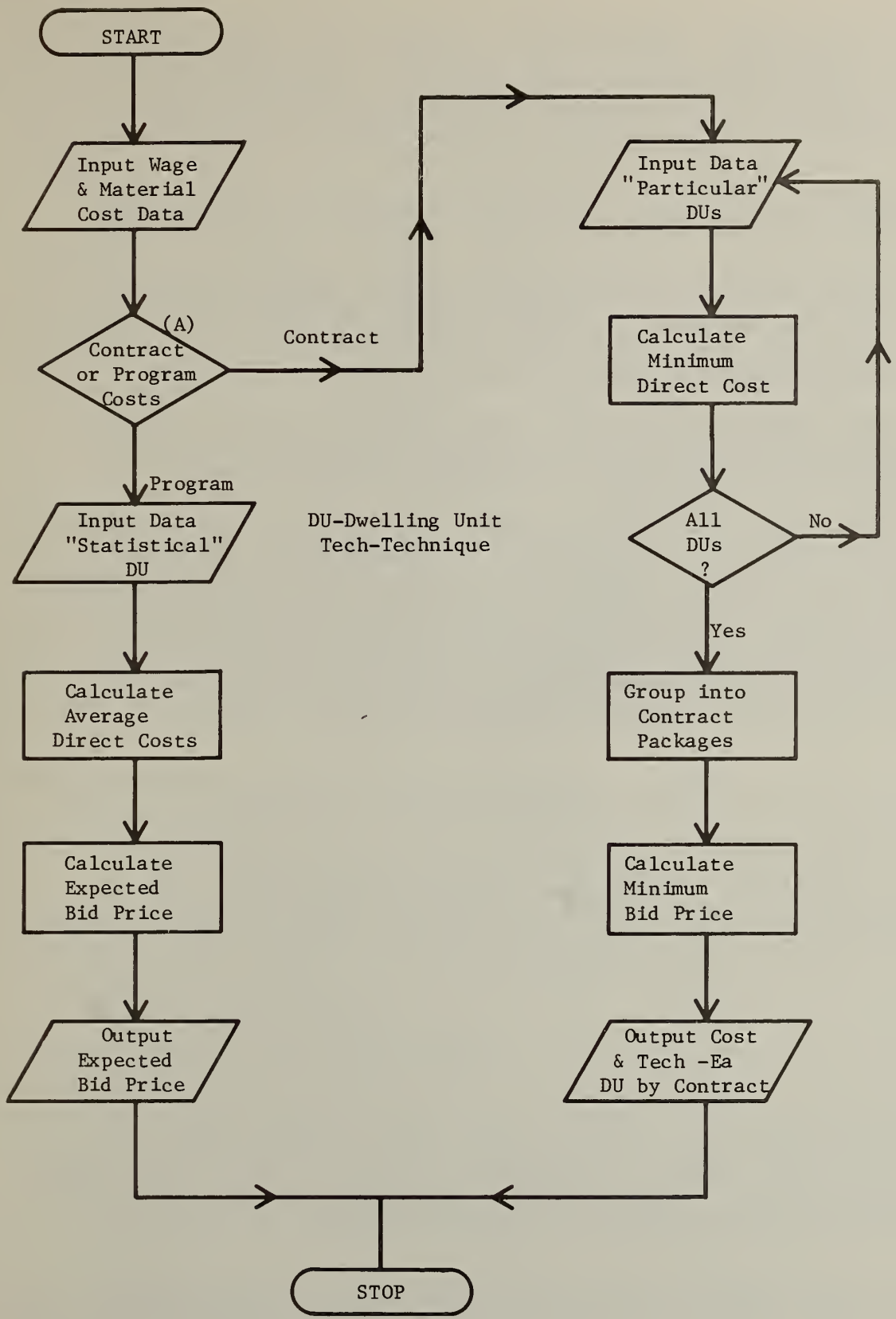

DIAGRAM 2.1

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.[1]) 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.[2]

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

AVERAGE HOURLY
WAGE RATE

CARPENTER	_____
PAINTER	_____
PLASTERER	_____
PAPER HANGER	_____
APPRENTICE CARPENTER	_____
LABORER	_____

MATERIAL PRICES

GYPSUM WALLBOARD - (4' x 8' sheet)	_____
PLYWOOD PANELING - (4' x 8' sheet)	_____
VINYL-COATED FABRIC - (SQUARE YARD)	_____
CEMENT-COATED FIBERGLASS - (SQUARE YARD)	_____
FLAT LATEX WALL PAINT - (GALLON)	_____
SEMI-GLOSS ENAMEL (OIL BASE)(GALLON)	_____

IF NEEDED

UNFINISHED DOOR - (NEW - EACH)	_____
UNFINISHED DOOR FRAME - (NEW - EACH)	_____
UNFINISHED WINDOW AND FRAME - (NEW - EACH)	_____

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,

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[1] A detailed description of the organization and implementation phases of a dwelling unit survey is given in William G. Hall and Lillian T. Slovic, Survey Manual for Estimating the Incidence of Lead Paint in Housing, National Bureau of Standards, Technical Note 921, September 1976.

[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 deleaded. 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]

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[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/cm^2), as measured by a portable x-ray fluorescence analyzer.

[2] For further information on the statistical methods used to arrive at these cost equations, see Robert E. Chapman and Joseph G. Kowalski, Lead Paint Abatement Costs: Some Technical and Theoretical Considerations, National Bureau of Standards, Technical Note 979, February 1978.

TABLE 2.2 INPUT DATA REQUIREMENTS

DATA REQUIREMENT	NATURE OF DATA AS A FUNCTION OF THE TYPE OF COST ESTIMATE DESIRED: PROGRAM	CONTRACT
WAGE	AVERAGE HOURLY WAGE RATE	AVERAGE HOURLY WAGE RATE
CARPENTER	"	"
PAINTER	"	"
PLASTERER	"	"
PAPER HANGER	"	"
APPRENTICE CARPENTER	"	"
LABORER	"	"
MATERIAL		
GYPSUM WALLBOARD	PRICE PER 4' x 8' SHEET	PRICE PER 4' x 8' SHEET
PLYWOOD PANELING	"	"
VINYL-COATED FABRIC	PRICE PER SQUARE YARD	PRICE PER SQUARE YARD
CEMENT-COATED FIBERGLASS	"	"
FLAT LATEX WALL PAINT	PRICE PER GALLON	PRICE PER GALLON
SEMI-GLOSS ENAMEL (Oil Base)	PRICE PER GALLON	PRICE PER GALLON
IF NEEDED:		
UNFINISHED DOOR	PRICE FOR ONE, NEW	PRICE FOR ONE, NEW
UNFINISHED DOOR FRAME	"	"
UNFINISHED WINDOW AND FRAME	PRICE FOR BOTH, NEW	PRICE FOR BOTH, NEW
DWELLING UNIT	BASED ON "STATISTICAL" DWELLING UNIT	OBSERVED VALUE IN THE PARTICULAR DWELLING UNIT
GROSS SQ. FT. OF WALL AREA	SQUARE FEET	SQUARE FEET
LINEAR FT. OF DOORS AND FRAMES	LINEAR FEET	LINEAR FEET
LINEAR FT. OF WINDOWS AND FRAMES	"	"
LINEAR FT. OF MISCELLANEOUS TRIM	"	"
OCCUPANCY	PERCENT OCCUPIED	1 IF OCCUPIED 0 IF UNOCCUPIED
WAINSCOTTING	PERCENT OF WALL AREA	PERCENT OF WALL AREA
SUBSTRATE CONDITION	PERCENT UNSOUND	1 IF POOR 0 IF SATISFACTORY OR BETTER
PANTRY WORK	PERCENT NEEDING IT	1 IF NEEDED 0 IF NOT
WALLPAPER ON WALLS	PERCENT HAVING>2 LAYERS	1 IF 3 OR MORE LAYERS
IF NEEDED:		0 IF 2 OR LESS
NUMBER OF DOORS TO REPLACE	NUMBER	NUMBER
NUMBER OF DOOR FRAMES TO REPLACE	"	"
NUMBER OF WINDOWS AND FRAMES TO REPLACE	AVERAGE OR SEPARATE "	AVERAGE OR SEPARATE "
ADDRESS	DU/AGE CATEGORY	ADDRESS AS SPECIFIED
XRF READING (LEAD CONTENT: mg/cm^2)	FOR EACH TRIM TYPE	FOR EACH TRIM TYPE

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.[1]

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.[2]

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

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[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 multiplication 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 Abatement Costs: Some Technical and Theoretical Consideration, National Bureau of Standards, Technical Note 979, February 1979.

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 contact 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 veiwed 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

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[1] For a thorough discussion see Mary Natrella, Experimental Statistics, National Bureau of Standards, Handbook 91, August 1963.

TABLE 2.3

NUMBER OF DWELLING UNITS BY TYPE/AGE CATEGORY

Dwelling Unit Type	Dwelling Unit Age		
	Pre 1940	1940-1960	Post 1960
Multifamily Low Rise			
Multifamily High Rise			
Single Family Attached			
Single Family Detached One Story			
Single Family Detached Two or More Stories			

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

DU/AGE CATEGORY	PRE 40 SINGLE FAMILY ATTACHED
WALL AREA - (GROSS SQUARE FEET)	
DOORS AND FRAMES - (LINEAR FEET)	
WINDOWS AND FRAMES - (LINEAR FEET)	
MISCELLANEOUS TRIM - (LINEAR FEET)	
OCCUPANCY - (PERCENT OCCUPIED)	
WAINSCOTTING - (PERCENT WALL AREA)	
SUBSTRATE CONDITION - (PERCENT UNSOUND)	
PANTRY WORK - (PERCENT NEEDING IT)	
WALLPAPER REMOVAL - (PERCENT HAVING >2 LAYERS)	
XRF READINGS - (DOORS)[a]	
XRF READINGS - (WINDOWS)[a]	
XRF READINGS - (MISCELLANEOUS)[a]	
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.[1] 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.

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[1] For a detailed description of FACTS, see Users' Manual for the Federal Agencies' Computer Time-Sharing System, National Research Council, Building Research Advisory Board, Federal Construction Council, Technical Report 68, 1976.

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 Teletypewriter, 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.[1] Once the user has signed onto the system, the terminal should respond with an output similar to that printed below.[2]

---

[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.

```
GSA 44Ø TIME-SHARING SYSTEM 1
 ON AT 1Ø:16 PB:Ø4 TTY:6Ø
Ø8/14/78
USER ID--
PASSWORD?__ __ __ __
TYPE OLD OR NEW:  O  L  D
OLD:  K  A  H  Ø  Ø
READY
 R  U  N  B  I  G
```

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, KAHØØ, 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. KAHØØ was the program name selected in this case.

As soon as you enter RUNBIG 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., 8.5Ø and not $8.5Ø).

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	
CARPENTER	9.18
PAINTER	9.67
PLASTERER	9.12
PAPER HANGER	8.50
APPRENTICE CARPENTER	5.68
LABORER	5.62
MATERIAL PRICES	
GYPSUM WALLBOARD - (4' x 8' sheet)	2.40
PLYWOOD PANELING - (4' x 8' sheet)	8.00
VINYL-COATED FABRIC - (SQUARE YARD)	4.75
CEMENT-COATED FIBERGLASS	3.00
LATEX FLAT WALL PAINT - (GALLON)	9.00
SEMI-GLOSS ENAMEL (OIL BASE)-(GALLON)	11.00
IF NEEDED	
UNFINISHED DOOR - (NEW-EACH)	--
UNFINISHED DOOR FRAME - (NEW-EACH)	--
UNFINISHED WINDOW AND FRAME - (NEW-EACH)	--

TABLE 3.2 DWELLING UNIT DATA FORM

ADDRESS	102 Main Street
WALL AREA - (GROSS SQUARE FEET)	450
DOORS AND FRAMES - (LINEAR FEET)	39
WINDOWS AND FRAMES - (LINEAR FEET)	40
MISCELLANEOUS TRIM - (LINEAR FEET)	66
OCCUPANCY	1
WAINSCOTTING - (PERCENT WALL AREA)	0
SUBSTRATE CONDITION	0
PANTRY WORK	0
WALLPAPER REMOVAL	0
XRF READINGS - (DOORS)	3.0
XRF READINGS - (WINDOWS)	3.0
XRF READINGS - (MISCELLANEOUS)	3.0
IF NEEDED	
REPLACEMENT DOORS - (NUMBER)	
REPLACEMENT DOOR FRAMES - (NUMBER)	
REPLACEMENT WINDOWS AND FRAMES - (NUMBER)	

```
RUNBIG

KAHØØ      1Ø:18  ATL MON   Ø8/14/78

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
 ? 8.5Ø
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
 ? 2.4Ø
INPUT PRICE OF 4 FT BY 8 FT SHEET OF PLYWOOD PANELING
 ? 8.ØØ
INPUT PRICE PER SQUARE YARD OF VINYL-COATED FABRIC
 ? 4.75
INPUT PRICE PER SQUARE YARD OF CEMENT-COATED FIBERGLASS
 ? 3.ØØ
INPUT PRICE PER GALLON OF LATEX FLAT WALL PAINT
 ? 9.ØØ
INPUT PRICE PER GALLON OF SEMI-GLOSS ENAMEL (OIL BASE)
 ? 11.ØØ
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 < = 1Ø)
 ? 1Ø

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
 ? 1Ø2 MAIN STREET
INPUT GROSS SQUARE FEET OF WALL AREA
 ? 45Ø
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
 ? 4Ø
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., 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
 ? 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
```

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.

```
                                                    CONTRACT 1

DWELLING UNIT  8                                 116 MAIN STREET

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

DWELLING UNIT  4                                 1Ø8 MAIN STREET

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


DWELLING UNIT 9                                  118 MAIN STREET

     WALL TECHNIQUE                 GYPSUM WALLBOARD
     TRIM TECHNIQUE                 ELECTRIC HEAT GUN
            DIRECT COST                $ 914.9Ø3

DWELLING UNIT 6                                  112 MAIN STREET

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

                                CONTRACT PRICE        $3123.88
                                MARKUP RATIO           1.16Ø98
```

```
                                                    CONTRACT 2

DWELLING UNIT 7                                     114 MAIN STREET

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

DWELLING UNIT 5                                     11Ø MAIN STREET

     WALL TECHNIQUE                 CEMENTITIOUS COATING
     TRIM TECHNIQUE                 ELECTRIC HEAT GUN
            DIRECT COST               $ 685.Ø26

                                          CONTRACT PRICE      $ 1735.34
                                          MARKUP RATIO          1.36454


                                                    CONTRACT 3

DWELLING UNIT 2                                     1Ø4 MAIN STREET

     WALL TECHNIQUE                 CEMENTITIOUS COATING
     TRIM TECHNIQUE                 ELECTRIC HEAT GUN
            DIRECT COST               $ 783.331

DWELLING UNIT 1                                     1Ø2 MAIN STREET

     WALL TECHNIQUE                 CEMENTITIOUS COATING
     TRIM TECHNIQUE                 ELECTRIC HEAT GUN
            DIRECT COST               $ 696.741

                                          CONTRACT PRICE      $ 2Ø82.18
                                          MARKUP RATIO          1.4Ø681


                                                    CONTRACT 4

DWELLING UNIT 10                                    12Ø MAIN STREET

     WALL TECHNIQUE                 CEMENTITIOUS COATING
     TRIM TECHNIQUE                 ELECTRIC HEAT GUN
            DIRECT COST               $ 754.359

DWELLING UNIT 3                                     1Ø6 MAIN STREET

     WALL TECHNIQUE                 VENEER PLASTER
     TRIM TECHNIQUE                 ELECTRIC HEAT GUN
            DIRECT COST               $ 846.427

                                          CONTRACT PRICE      $ 2351.66
                                          MARKUP RATIO          1.469Ø7

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

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

READY
BYE
OFF AT 11:Ø4
```

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 deleaded 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.

---

[1] Thomas H. Boone, Harvey W. Berger, A. Philip Cramp, Herbert A. Jackson The Demonstration of Experimental Lead Paint Hazard Abatement Methods in Washington, D.C., National Bureau of Standards, NBSIR 75-761, June 1975, and Thomas H. Boone, Harvey W. Berger, A. Philip Cramp, Herbert A. Jackson, The Demonstration of Experimental Lead Paint Hazard Abatement Methods in Atlanta, Georgia, National Bureau of Standards, NBSIR 75-974, December 1975.

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. Preformed 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 sucessfully 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 PAINT REMOVER

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.

VALID COMMANDS	ACCEPTABLE ABBREVIATION	PROMPT SYMBOL	COMMAND ACTION
ABBREVIATE	AB	***	PRINT ABBREVIATED PROMPTING
BRIEF	BR	$$$	PRINT BRIEF DESCRIPTION OF PROGRAMS
CONSTRUCT	CO	+++	CONSTRUCT COMMANDS PROGRAMS
DELETE	DE	%%%	DELETE COMMANDS PROGRAMS
DIRECTORY	DI	&&&	LIST OF PROGRAMS IN USER'S DIRECTORY
FULL	FL	***	PRINT FULL PROMPTING
HELP	HE	@@@	PRINT FACTS SYSTEM DETAILS
LIST	LI	###	LIST OF FACTS PROGRAMS
MESSAGE	ME	↑↑↑	MAKE SYSTEM COMMENTS
RAMUS	RA	<<<	PRINT RAMUS SYSTEM DETAILS
STOP	STOP		RETURNS USER TO RAMUS SYSTEM

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

***? RA

<<<
ALL PROGRAMS, INCLUDING THE FACTS EXECUTIVE SYSTEM, ARE RUN UNDER THE CONTROL OF RAMUS (REMOTE ACCESS MULTI-USER SYSTEM). IN ORDER TO RUN A COMMANDS PROGRAM DEVELOPED WITHIN FACTS, THE USER MUST EXIT TO RAMUS. THIS CAN BE DONE AT ANY TIME BY TYPING AN S AND THEN HITTING A CARRIAGE RETURN OR WHEN AT COMMAND LEVEL THE USER MAY TYPE STOP. AT RAMUS LEVEL THE USER MAY RUN ANY PROGRAM BY TYPING "RUN OPTION: PROGRAM NAME" FOR EXAMPLE, IF THE USER WANTED TO RUN A COMMANDS PROGRAM NAMED RLR01 AND ITS RUN OPTION IS RUN, THE USER WOULD TYPE RUN: RLR01 AND THEN HIT A CARRIAGE RETURN. (FOR GREATER DETAIL OF THE RAMUS SYSTEM AND ITS OPTIONS, THE USER MUST OBTAIN A COPY OF THE OPERATING SYSTEM MANUAL THROUGH GSA).

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

VALID COMMANDS	ACCEPTABLE ABBREVIATION	PROMPT SYMBOL	COMMAND ACTION
ABBREVIATE	AB	***	PRINT ABBREVIATED PROMPTING
BRIEF	BR	≡≡≡	PRINT BRIEF DESCRIPTION OF PROGRAMS
CONSTRUCT	CO	+++	CONSTRUCT COMMANDS PROGRAMS
DELETE	DE	%%%	DELETE COMMANDS PROGRAMS
DIRECTORY	DI	&&&	LIST OF PROGRAMS IN USER'S DIRECTORY
FULL	FL	***	PRINT FULL PROMPTING
HELP	HE	@@@	PRINT FACTS SYSTEM DETAILS
LIST	LI	###	LIST OF FACTS PROGRAMS
MESSAGE	ME	↑↑↑	MAKE SYSTEM COMMENTS
RAMUS	RA	<<<	PRINT RAMUS SYSTEM DETAILS
STOP	STOP		RETURNS USER TO RAMUS SYSTEM

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.
###?*
```

FUNCTIONAL AREA CODE	PROGRAMS IN AREA	DESCRIPTION
E	1	ELECTRICAL
H_1	8	HYDRAULICS-SPILLWAYS
H_2	11	HYDRUALICS-OUTLET WORKS
H_3	2	HYDRAULICS-GATES & VALUES
H_6	23	HYDRAULICS-OPEN CHANNELS
H_7	5	HYDRAULICS-SPECIAL PROBLEMS
I	4	SOILS
J	3	ECONOMICS
L	2	MECHANICAL
M	1	MATHEMATICAL
U	1	GEODESORY & SURVEYING
X	21	STRUCTURAL
Z	1	OTHER

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).

***? BR

YOU ARE NOW AT BRIEF LEVEL (PROMPT SYMBOL $$$).
ENTER ONE PROGRAM NAME (E.G. H2Ø1Ø) IN RESPONSE TO EACH PROMPT.
TYPE WORK END TO RETURN TO COMMAND LEVEL.
$$$? JØØØ3

I. DESCRIPTION

JØØØ3 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

JØØØ3 WILL HANDLE ANTICIPATED CONTRACT PACKAGES OF UP TO 1Ø 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

WAGE	AVERAGE HOURLY WAGE RATE
CARPENTER	"
PAINTER	"
PLASTERER	"
PAPER HANGER	"
APPRENTICE CARPENTER	"
LABORER	"

MATERIAL

GYPSUM WALLBOARD	PRICE PER 4' x 8' SHEET
PLYWOOD PANELING	"
VINYL-COATED FABRIC	PRICE PER SQUARE YARD
CEMENT-COATED FIBERGLASS	PRICE PER SQUARE YARD
FLAT LATEX WALL PAINT	PRICE PER GALLON
SEMI-GLOSS ENAMEL (OIL BASE)	PRICE PER GALLON

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 Ø IF UNOCCUPIED
WAINSCOATING	PERCENT OF WALL AREA		
SUBSTRATE CONDITION	PERCENT UNSOUND	OR	1 IF POOR Ø IF SATISFACTORY OR BETTER
PANTRY WORK	PERCENT NEEDING IT	OR	1 IF NEEDED Ø IF NOT
WALLPAPER ON WALLS	PERCENT HAVING > 2 LAYERS		1 IF 3 OR MORE LAYERS Ø 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 FOR EACH TRIM TYPE	OR	ADDRESS AS SPECIFIED

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 FACTS 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. H2Ø1Ø)  IN RESPONSE TO
EACH PROMPT.  AFTER ALL NAMES HAVE BEEN ENTERED, TYPE FINIS AFTER
SUBSEQUENT PROMPT.
+++  ? JØØØ3

+++  ? FINIS

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

+++  ? KAH

THE FOLLOWING PROGRAMS ARE ADDED TO YOUR DIRECTORY FILE  KAH1ØØ
                    (MON 12/12/78)

COMMANDS PROGRAM NAME FACTS PROGRAM USED RUN OPTION
      KAHØØ          JØØØ3               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:
SRHØØ).

***  ? 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 whch 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       1Ø:18  ATL MON    Ø8/14/78

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
 ? 8.5Ø
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
 ? 2.4Ø
INPUT PRICE OF 4 FT BY 8 FT SHEET OF PLYWOOD PANELLING
 ? 8.ØØ
INPUT PRICE PER SQUARE YARD OF VINYL-COATED FABRIC
 ? 4.75
INPUT PRICE PER SQUARE YARD OF CEMENT-COATED FIBERGLASS
 ? 3.ØØ
INPUT PRICE PER GALLON OF LATEX FLAT WALL PAINT
 ? 9.ØØ
INPUT PRICE PER GALLON OF SEMI-GLOSS ENAMEL (OIL BASE)
 ? 11.ØØ
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 < = 1Ø)
 ? 1Ø

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
 ? 1Ø2 MAIN STREET
INPUT GROSS SQUARE FEET OF WALL AREA
 ? 45Ø
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
 ? 4Ø
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., 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
 ? 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 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
 ? 7ØØ
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 TRM, 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
 ? 6ØØ
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
 ? 6Ø
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
 ? 36Ø
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
 ? Ø
INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING
PAINT REMOVAL
 ? Ø
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.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 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
 ? 56Ø
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.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 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
 ? 5ØØ
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
```

```
                    DWELLING UNIT NUMBER 7

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
 ? CONTRACT 5 - D.U. 7***
INPUT GROSS SQUARE FEET OF WALL AREA
 ? 32Ø
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
```

DWELLING UNIT NUMBER 8

```
TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
 ? CONTRACT 5 - D.U. 8***
INPUT GROSS SQUARE FEET OF WALL AREA
 ? 52Ø
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
 ? Ø
INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING
PAINT REMOVAL
 ? Ø
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
 ? 1
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.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 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
 ? 65Ø
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 1Ø

TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT
 ? CONTRACT 5 - D.U. 1Ø
INPUT GROSS SQUARE FEET OF WALL AREA
 ? 45Ø
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 AVAILALBE
 ? 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 — 116 MAIN STREET

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

DWELLING UNIT 4 — 1Ø8 MAIN STREET

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

DWELLING UNIT 9 — 118 MAIN STREET

WALL TECHNIQUE	GYPSUM WALLBOARD
TRIM TECHNIQUE	ELECTRIC HEAT GUN
DIRECT COST	$ 914.9Ø3

DWELLING UNIT 6 — 112 MAIN STREET

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

CONTRACT PRICE	$ 3123.88
MARKUP RATIO	1.16Ø98

CONTRACT 2

DWELLING UNIT 7 — 114 MAIN STREET

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

DWELLING UNIT 5 — 11Ø MAIN STREET

WALL TECHNIQUE	CEMENTITIOUS COATING
TRIM TECHNIQUE	ELECTRIC HEAT GUN
DIRECT COST	$ 685.Ø26

CONTRACT PRICE	$ 1735.34
MARKUP RATIO	1.36454

```
                                   CONTRACT  3

DWELLING UNIT  2                   1Ø4 MAIN STREET

     WALL TECHNIQUE           CEMENTITIOUS COATING
     TRIM TECHNIQUE           ELECTRIC HEAT GUN
            DIRECT COST        $ 783.331

DWELLING UNIT  1                   1Ø2 MAIN STREET

     WALL TECHNIQUE           CEMENTITIOUS COATING
     TRIM TECHNIQUE           ELECTRIC HEAT GUN
            DIRECT COST        $ 696.741

                                   CONTRACT PRICE       $2Ø82.18
                                   MARKUP RATIO          1.4Ø681


                                   CONTRACT  4

DWELLING UNIT  1Ø                  12Ø MAIN STREET

     WALL TECHNIQUE           CEMENTITIOUS COATING
     TRIM TECHNIQUE           ELECTRIC HEAT GUN
            DIRECT COST        $ 754.359

DWELLING UNIT  3                   1Ø6 MAIN STREET

     WALL TECHNIQUE           VENEER PLASTER
     TRIM TECHNIQUE           ELECTRIC HEAT GUN
            DIRECT COST        $ 846.427

                                   CONTRACT PRICE       $ 2351.66
                                   MARKUP RATIO           1.469Ø7

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


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

READY
BYE

OFF AT 11:Ø4
```

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        13:5Ø ATL MON      12/12/78
WAGE RATE INFORMATION

INPUT WAGE RATE PER HOUR FOR CARPENTER
 ? 8.2Ø
INPUT WAGE RATE PER HOUR FOR PAINTER
 ? 8.5Ø
INPUT WAGE RATE PER HOUR FOR PLASTERER
 ? 7.7Ø
INPUT WAGE RATE PER HOUR FOR PAPERHANGER
 ? 7.3Ø
INPUT WAGE RATE PER HOUR FOR APPRENTICE CARPENTER
 ? 5.ØØ
INPUT WAGE RATE PER HOUR FOR LABORER
 ? 5.5Ø

MATERIAL PRICE INFORMATION

INPUT PRICE OF 4 FT BY 8 FT SHEET OF GYPSUM WALLBOARD
 ? 2.2Ø
INPUT PRICE OF 4 FT BY 8 FT SHEET OF PLYWOOD PANELLING
 ? 5.9Ø
INPUT PRICE PER SQUARE YARD OF VINYL-COATED FABRIC
 ? 4.1Ø
INPUT PRICE PER SQUARE YARD OF CEMENT-COATED FIBERGLASS
 ? 3.ØØ
INPUT PRICE PER GALLON OF LATEX FLAT WALL PAINT
 ? 6.5Ø
INPUT PRICE PER GALLON OF SEMI-GLOSS ENAMEL (OIL BASE)
 ? 7.7Ø
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
 ? 1
```

```
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 LUNIT IF THERE IS AN ERROR,
TYPE 1 TO REPEAT INPUT STATEMENTS IF NOT, TYPE Ø
 ? Ø
                                        PRE 4Ø SINGLE ATTACHED

WALL COST          TRIM COST          TOTAL COST          MARKUP RATIO
 597.572            2Ø9.972            8Ø7.545               1.31

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.

```
ØØØØ1REMP2ØCHAIN RUNNH:JØØØ3***
ØØØ1ØREMS141. DESCRIPTION
ØØØ12REMSØ1
ØØØ14REMS62   JØØØ3 WILL ANALYZE THE COSTS OF THE ALTERNATIVE METHODS FOR
ØØØ16REMSØ1
ØØØ18REMS62   ELIMINATING THE LEAD PAINT HAZARD FROM A DWELLING UNIT. THE
ØØØ2ØREMSØ1
ØØØ22REMS6Ø   PROGRAM PERMITS THE USER TO INPUT SPECIFIC INFORMATION ON
ØØØ24REMSØ1
ØØØ26REMS62   ANTICIPATED CONTRACT PACKAGES OF DWELLING UNITS.  THE LEAST-
ØØØ28REMSØ1
ØØØ3ØREMS61   COST COMBINATION OF ABATEMENT TECHNIQUES FOR EACH DWELLING
ØØØ32REMSØ1
ØØØ34REMS63   UNIT IS IDENTIFIED. DWELLING UNITS ARE GROUPED TOGETHER INTO
ØØØ36REMSO1
ØØØ38REMS63   CONTRACT PACKAGES SO THAT THE SUM OF THE EXPECTED BID PRICES
ØØØ4ØREMSØ1
ØØØ42REMS6Ø   IS MINIMIZED. THE EXPECTED BID PRICE FOR EACH CONTRACT IS
ØØØ44REMSØ1
ØØØ46REMS6Ø   GIVEN. EXPECTED CONTRACT COSTS FOR EACH DWELLING UNIT ARE
ØØØ48REMSØ1
ØØØ5ØREMS14   ALSO GIVEN.
ØØØ52REMSØ1
ØØØ54REMS142. LIMITATIONS
ØØØ56REMSØ1
ØØØ58REMS62   JØØØ3 WILL HANDLE ANTICIPATED CONTRACT PACKAGES OF UP TO 1Ø
ØØØ6ØREMSØ1
ØØØ62REMS6Ø   DWELLING UNITS. DATA FOR EACH DWELLING UNIT IS ENTERED IN
ØØØ64REMSØ1
ØØØ66REMS37   RESPONSE TO INQUIRIES AT RUN TIME.
ØØØ68REMSO1
ØØØ7ØREMSØ73. DATA
ØØØ72REMSØ1
ØØØ74REMS58   TWO TYPES OF DATA ARE INPUT, CONTRACT SPECIFIC DATA AND
ØØØ76REMSØ1
ØØØ78REMS63   DWELLING UNIT SPECIFIC DATA. INPUT DATA FOR EACH ANTICIPATED
ØØØ8ØREMSØ1
ØØØ82REMS38   CONTRACT CONSISTS OF THE FOLLOWING:
ØØØ84REMSØ1
ØØØ86REMS27  A. CONTRACT SPECIFIC DATA
ØØØ88REMSØ1
ØØØ9ØREMSØ9      WAGE
ØØØ92REMS54                                              AVERAGE HOURLY
ØØØ94REMS51       CARPENTER                                 WAGE RATE
ØØØ96REMSØ1
ØØØ98REMS48       PAINTER                                       "
ØØ1ØØREMSØ1
ØØ1Ø2REMS48       PLASTERER                                     "
ØØ1Ø4REMSØ1
ØØ1Ø6REMS48       PAPER HANGER                                  "
```

```
ØØ1Ø8REMSØ1
ØØ11ØREMS48       APPRENTICE CARPENTER                          "
ØØ112REMSØ1
ØØ114REMS48       LABORER                                       "
ØØ116REMSØ1
ØØ118REMS13      MATERIAL
ØØ12ØREMSØ1
ØØ122REMS63       GYPSUM WALLBOARD                  PRICE PER 4' x 8' SHEET
ØØ124REMSØ1
ØØ126REMS54       PLYWOOD PANELING                              "
ØØ128REMSØ1
ØØ13ØREMS61       VINYL-COATED FABRIC               PRICE PER SQUARE YARD
ØØ132REMSØ1
ØØ134REMS56       LATEX FLAT WALL PAINT             PRICE PER GALLON
ØØ136REMSØ1
ØØ138REMS48       SEMI-GLOSS ENAMEL                             "
ØØ14ØREMS18         (OIL BASE)
ØØ142REMSØ1
ØØ144REMS15      IF NEEDED:
ØØ146REMSØ1
ØØ148REMS58       UNFINISHED DOOR                   PRICE FOR ONE, NEW
ØØ15ØREMSØ1
ØØ152REMS51       UNFINISHED DOOR FRAME                         "
ØØ154REMSØ1
ØØ156REMS59       UNFINISHED WINDOW AND FRAME       PRICE FOR BOTH, NEW
ØØ158REMSØ1
ØØ16ØREMS23   B. DWELLING UNIT DATA
ØØ162REMSØ1
ØØ164REMS51       GROSS SQ. FT. OF WALL AREA        SQUARE FEET
ØØ166REMSØ1
ØØ168REMS51       LINEAR FT. OF DOORS AND FRAMES    LINEAR FEET
ØØ17ØREMSØ1
ØØ172REMS46       LINEAR FT. OF WINDOWS & FRAMES                "
ØØ174REMSØ1
ØØ176REMS46       LINEAR FT. OF MISCELLANEOUS TRIM              "
ØØ178REMSØ1
ØØ18ØREMS61        OCCUPANCY            PERCENT OCCUPIED OR 1 IF OCCUPIED
ØØ182REMS63                                                Ø IF UNOCCUPIED
ØØ184REMS48       WAINSCOTTING         PERCENT OF WALL AREA
ØØ186REMSØ1
ØØ188REMS43       SUBSTRATE CONDITION  PERCENT UNSOUND OR 1 IF POOR
ØØ19ØREMSØ1                                               Ø IF NOT
ØØ192REMS61       PANTRY WORK          PERCENT NEEDING IT OR 1 IF NEEDED
ØØ194REMS58                                                Ø IF NOT
ØØ196REMS63       WALLPAPER ON WALLS   PERCENT HAVING >2 LAYERS, 1 IF 3 OR
ØØ198REMS6Ø                                          MORE LAYERS Ø IF
ØØ2ØØREMS48       IF NEEDED:                          NONE
```

```
ØØ2Ø2REMSØ1
ØØ2Ø4REMS36       NUMBER OF DOORS TO BE REPLACED
ØØ2Ø6REMSØ1
ØØ2Ø8REMS38        NUMBER OF DOOR FRAMES TO REPLACE
ØØ21ØREMSØ1
ØØ212REMS34       NUMBER OF WINDOWS AND FRAMES
ØØ214REMS17        TO REPLACE
ØØ216REMSØ1
ØØ218REMS6Ø       ADDRESS       DU/AGE CATEGORY         ADDRESS AS SPECIFIED
ØØ22ØREMSØ1
ØØ222REMS42       XRF READINGS  AVERAGE OR SEPARATE OR
ØØ224REMS38                     FOR EACH TRIM TYPE
1ØØØØ FILES WAGE;MATL;AWR
1ØØØ5 DIM D(1Ø,1Ø),F(1Ø,1Ø),L(1Ø,1Ø),P(1Ø,1Ø)
1ØØ1Ø DIM W(1Ø,1Ø),Y(1Ø,1Ø),Z(5,1Ø),X(45,3)
1ØØ15 DIM Z$(1Ø),P$(1Ø),Y$(1Ø),Q$(1Ø)
1ØØ2Ø REM READ NAMES OF WALL TECHNIQUES INTO VARIABLES
1ØØ25 READ A$,B$,C$,D$,E$,F$
1ØØ3Ø DATA GYPSUM WALLBOARD,PLYWOOD PANELING,CEMENTITIOUS COATING
1ØØ35 DATA VENEER PLASTER    ,VINYL-COATED FABRIC,CEMENT-COATED FIBERGLASS
1ØØ4Ø REM READ NAMES OF TRIM TECHNIQUES INTO VARIABLES
1ØØ45 READ G$,H$,I$,J$
1ØØ5Ø DATA INFRA-RED DEVICE,SOLVENT STRIP     ,ELECTRIC HEAT GUN
1ØØ55 DATA HAND SCRAPING    ,
1ØØ6Ø MAT READ F(7,6)
1ØØ65 DATA Ø.6,Ø,Ø,Ø,Ø.4,Ø,Ø.82,Ø,Ø,Ø,Ø.18,Ø,Ø.24,Ø.6,Ø,Ø,Ø.16,Ø
1ØØ7Ø DATA Ø.2Ø,Ø.39,Ø.29,Ø,Ø,Ø.12,Ø.26,Ø.26,Ø,Ø.48,Ø,Ø
1ØØ75 DATA Ø.5Ø,Ø.14,Ø,Ø.36,Ø,Ø,Ø,Ø,Ø,Ø,Ø.5,Ø.5
1ØØ8Ø READ K$,L$
1ØØ85 DATA NONE             ,COMPONENT REPLACEMENT ONLY
1ØØ9Ø REM WAGE RATES STORED AS W(I,1) FOR MATRIX MULTIPLICATION
1ØØ95 PRINT "WAGE RATE INFORMATION"
1Ø1ØØ PRINT
1Ø1Ø5 MAT W=ZER(6,1)
1Ø11Ø PRINT "INPUT WAGE RATE PER HOUR FOR CARPENTER"
1Ø115 INPUT W(1,1)
1Ø12Ø PRINT "INPUT WAGE RATE PER HOUR FOR PAINTER"
1Ø125 INPUT W(2,1)
1Ø13Ø PRINT "INPUT WAGE RATE PER HOUR FOR PLASTERER"
1Ø135 INPUT W(3,1)
1Ø14Ø PRINT "INPUT WAGE RATE PER HOUR FOR PAPERHANGER"
1Ø145 INPUT W(4,1)
1Ø15Ø PRINT "INPUT WAGE RATE PER HOUR FOR APPRENTICE CARPENTER"
1Ø155 INPUT W(5,1)
1Ø16Ø PRINT "INPUT WAGE RATE PER HOUR FOR LABORER"
1Ø165 INPUT W(6,1)
1Ø17Ø MAT L=ZER(7,1)
1Ø175 MAT L=F*W
1Ø18Ø SCRATCH #1
1Ø185 SCRATCH #3
1Ø19Ø MAT WRITE #1,W
```

```
1Ø195 MAT WRITE #3,L
1Ø2ØØ REM MATERIAL PRICES STORED AS M(I)
1Ø2Ø5 PRINT
1Ø21Ø PRINT
1Ø215 PRINT "MATERIAL PRICE INFORMATION"
1Ø22Ø PRINT
1Ø225 SCRATCH #2
1Ø23Ø PRINT "INPUT PRICE OF 4 FT BY 8 FT SHEET OF GYPSUM WALLBOARD"
1Ø235 INPUT M(1)
1Ø24Ø PRINT "INPUT PRICE OF 4 FT BY 8 FT SHEET OF PLYWOOD PANELING"
1Ø245 INPUT M(2)
1Ø25Ø PRINT "INPUT PRICE PER SQUARE YARD OF VINYL-COATED FABRIC"
1Ø255 INPUT M(3)
1Ø26Ø PRINT "INPUT PRICE PER GALLON OF LATEX FLAT WALL PAINT"
1Ø265 INPUT M(4)
1Ø27Ø PRINT "INPUT PRICE PER GALLON OF SEMI-GLOSS ENAMEL (OIL BASE)"
1Ø275 INPUT M(5)
1Ø28Ø FOR L=1 TO 5
1Ø285 WRITE #2,M(L)
1Ø29Ø NEXT L
1Ø295 PRINT "TYPE 1 IF THERE ARE ANY DOORS, DOOR FRAMES OR WINDOWS"
1Ø3ØØ PRINT "AND FRAMES THAT NEED TO BE REPLACED, Ø IF NOT"
1Ø3Ø5 INPUT Q
1Ø31Ø IF Q=Ø THEN 1Ø345
1Ø315 PRINT "INPUT PRICE OF NEW, UNFINISHED DOOR"
1Ø32Ø INPUT M(6)
1Ø325 PRINT "INPUT PRICE OF NEW, UNFINISHED DOOR FRAME"
1Ø33Ø INPUT M(7)
1Ø335 PRINT "INPUT PRICE OF NEW, UNFINISHED WINDOW AND FRAME"
1Ø34Ø INPUT M(8)
1Ø345 PRINT
1Ø35Ø REM COMPUTE AVERAGE WAGE RATES FOR EACH WALL TECHNIQUE AND FOR TRIM
1Ø355 PRINT "IF PROGRAM COST ESTIMATES ARE DESIRED, TYPE 1, IF"
1Ø36Ø PRINT "CONTRACT COST ESTIMATES ARE DESIRED, TYPE Ø"
1Ø365 INPUT P
1Ø37Ø IF P=1 THEN 1Ø395
1Ø375 PRINT "INPUT NUMBER OF DWELLING UNITS TO BE DONE (MUST BE <= 1Ø)"
1Ø38Ø INPUT N
1Ø385 LET N9=N
1Ø39Ø GO TO 1Ø4ØØ
1Ø395 LET N=1
1Ø4ØØ PRINT
1Ø4Ø5 PRINT "STOP FOR A MINUTE AND CHECK THE DATA YOU HAVE JUST INPUT"
1Ø41Ø 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"
1Ø42Ø INPUT Z
1Ø425 IF Q7<>1 THEN 1Ø435
1Ø43Ø IF Z=1 THEN 1Ø295
1Ø435 IF Z=1 THEN 1ØØ95
1Ø44Ø REM N2 IS NUMBER OF CONTRACTS, N3 IS NUMBER OF PAIRS
1Ø445 IF INT(N/2)=N/2 THEN 1Ø465
```

```
1Ø45Ø LET N2=(N+1)/2
1Ø455 LET N3=N2-1
1Ø46Ø GO TO 1Ø475
1Ø465 LET N2=N/2
1Ø47Ø LET N3=N2
1Ø475 MAT F=ZER(N,1Ø)
1Ø48Ø REM INPUT DU INFORMATION THAT MUST BE STORED FOR COMPUTING
1Ø485 REM MARKUP AND BID PRICE
1Ø49Ø FOR J=1 TO N
1Ø495 IF P=Ø THEN 1Ø51Ø
1Ø5ØØ PRINT "            DWELLING UNIT INFORMATION"
1Ø5Ø5 GO TO 1Ø525
1Ø51Ø PRINT
1Ø515 PRINT
1Ø52Ø PRINT "            DWELLING UNIT NUMBER"J
1Ø525 PRINT
1Ø53Ø PRINT "TYPE IN AN IDENTIFYING ADDRESS OR DU TYPE FOR THIS DWELLING UNIT"
1Ø535 INPUT Q$(J)
1Ø54Ø IF P=Ø THEN 1Ø56Ø
1Ø545 PRINT "FOR POLICY ESTIMATES INPUT AVERAGES FOR SQUARE FEET, LINEAR F
1Ø55Ø PRINT "XRF, ETC.; AND PERCENTAGE OF SAMPLE NEEDED FOR THOSE VARIABL
1Ø555 PRINT "REQUIRING A 1 OR Ø"
1Ø56Ø PRINT "INPUT GROSS SQUARE FEET OF WALL AREA"
1Ø565 INPUT D(1,J)
1Ø57Ø REM D(2,J) IS NET SQUARE FEET OF WALL AREA
1Ø575 IF D(1,J)<4ØØ THEN 1Ø59Ø
1Ø58Ø LET D(2,J)=77+Ø.64*D(1,J)
1Ø585 GO TO 1Ø595
1Ø59Ø LET D(2,J)=Ø.83*D(1,J)
1Ø595 PRINT "INPUT LINEAR FEET OF DOORS PLUS LINEAR FEET OF DOOR"
1Ø6ØØ PRINT "FRAMES REQUIRING PAINT REMOVAL"
1Ø6Ø5 INPUT D(3,J)
1Ø61Ø REM D8 IS NUMBER OF DOORS AND FRAMES TO BE DELEADED
1Ø615 LET D8=D(3,J)/8
1Ø62Ø PRINT "INPUT LINEAR FEET OF WINDOWS PLUS LINEAR FEET OF"
1Ø625 PRINT "WINDOW FRAMES REQUIRING PAINT REMOVAL"
1Ø63Ø INPUT D(4,J)
1Ø635 REM D7 IS NUMBER OF WINDOWS AND FRAMES TO BE DELEADED
1Ø64Ø LET D7=D(4,J)/7
1Ø645 PRINT "INPUT LINEAR FEET OF MISCELLANEOUS TRIM REQUIRING'
1Ø65Ø PRINT "PAINT REMOVAL"
1Ø655 INPUT D(5,J)
1Ø66Ø LET D(7,J)=D(3,J)+D(4,J)+D(5,J)
1Ø665 PRINT "TYPE 1 IF UNIT IS OCCUPIED, Ø IF NOT"
1Ø67Ø INPUT D(6,J)
1Ø675 REM INPUT OTHER DU RELATED DATA NECESSARY FOR CALCULATIONS
1Ø68Ø IF D(1,J)=Ø THEN 1Ø735
1Ø685 PRINT "INPUT PERCENT OF WALL AREA THAT IS WAINSCOTTED"
1Ø69Ø PRINT "(TYPE AS A DECIMAL, E.G., Ø.25 FOR 25 PERCENT)"
1Ø695 INPUT E(3)
1Ø7ØØ PRINT "TYPE 1 IF SUBSTRATE CONDITION IS POOR, Ø IF NOT"
```

```
1Ø7Ø5 INPUT E(4)
1Ø71Ø PRINT "TYPE 1 IF PANTRY WORK IS NECESSARY, Ø IF NOT"
1Ø715 INPUT E(5)
1Ø72Ø PRINT "TYPE 1 IF 3 OR MORE LAYERS OF WALLPAPER ARE ON WALLS,"
1Ø725 PRINT "Ø IF NOT"
1Ø73Ø INPUT E(6)
1Ø735 IF Q=Ø THEN 1Ø77Ø
1Ø74Ø PRINT "INPUT NUMBER OF DOORS TO BE REPLACED"
1Ø745 INPUT E(7)
1Ø75Ø PRINT "INPUT NUMBER OF DOOR FRAMES TO BE REPLACED"
1Ø755 INPUT E(8)
1Ø76Ø PRINT "INPUT NUMBER OF WINDOWS & FRAMES TO BE REPLACED"
1Ø765 INPUT E(9)
1Ø77Ø IF D(1,J)<>Ø THEN 1Ø81Ø
1Ø775 LET Z1=Ø
1Ø78Ø LET C8=Ø
1Ø785 LET C9=Ø
1Ø79Ø LET B8=Ø
1Ø795 LET B9=Ø
1Ø8ØØ LET B(1)=Ø
1Ø8Ø5 GO TO 1Ø815
1Ø81Ø LET Z1=9
1Ø815 IF D(7,J)=Ø THEN 1Ø9Ø5
1Ø82Ø PRINT "TYPE 1 IF SEPARATE XRF READINGS ARE AVAILABLE FOR DOORS,"
1Ø825 PRINT "WINDOWS AND MISCELLANEOUS TRIM, Ø IF ONLY AN AVERAGE"
1Ø83Ø PRINT "IS AVAILABLE"
1Ø835 INPUT Y
1Ø84Ø IF Y=1 THEN 1Ø875
1Ø845 PRINT "INPUT AVERAGE XRF READING"
1Ø85Ø INPUT X
1Ø855 LET X1=X
1Ø86Ø LET X2=X
1Ø865 LET X3=X
1Ø87Ø GO TO 1Ø9Ø5
1Ø875 PRINT "INPUT XRF READING FOR DOORS AND DOOR FRAMES"
1Ø88Ø INPUT X1
1Ø885 PRINT "INPUT XRF READING FOR WINDOWS AND FRAMES"
1Ø89Ø INPUT X2
1Ø895 PRINT "INPUT XRF READING FOR MISCELLANEOUS TRIM"
1Ø9ØØ INPUT X3
1Ø9Ø5 PRINT "STOP AND CHECK THE DATA FOR THIS DWELLING UNIT"
1Ø91Ø PRINT "IF THERE IS AN ERROR, TYPE 1 TO REPEAT INPUT STATEMENTS"
1Ø915 PRINT "IF NOT, TYPE Ø"
1Ø92Ø INPUT Z
1Ø925 IF Z=1 THEN 1Ø52Ø
1Ø93Ø REM COMPUTE PAINTING COST FOR WALLS AND CEILINGS
1Ø935 IF Z1=Ø THEN 11Ø25
1Ø94Ø LET C8=1.35*(D(1,J)/39.95)↑2
1Ø945 LET C9=D(1,J)+C8
1Ø95Ø REM B8 IS PAINTING COST FOR ALL TECHNIQUES BUT GYP AND VENEER PLASTER
1Ø955 LET B8=-Ø.ØØØ296*C8+Ø.Ø1Ø6*W(2,1)+Ø.Ø257*M(4)+Ø.1736*D(2,J)/D(1,J)
```

```
1Ø96Ø IF B8>=Ø.Ø8 THEN 1Ø97Ø
1Ø965 LET B8=Ø.Ø8
1Ø97Ø REM B9 IS PAINTING COST FOR GYP AND VENEER PLASTER
1Ø975 LET B9=-Ø.ØØØ296*C9+Ø.Ø1Ø6*W(2,1)+Ø.Ø257*M(4)+Ø.1736*D(2,J)/D(1,J)
1Ø98Ø IF B9>=Ø.Ø8 THEN 1Ø99Ø
1Ø985 LET B9=Ø.Ø8
1Ø99Ø LET B(1)=-1.77ØØ+3Ø6.5874/D(2,J)+Ø.Ø62Ø*L(1,1)
1Ø995 LET B=Ø.5ØØ9*M(1)+Ø.274Ø*E(5)
11ØØØ REM GYPSUM WALLBOARD
11ØØ5 LET B(1)=B(1)+B
11Ø1Ø IF B(1)>=Ø.25 THEN 11Ø2Ø
11Ø15 LET B(1)=Ø.25
11Ø2Ø LET B(1)=B(1)*D(1,J)+B9*C9
11Ø25 LET C(J)=B(1)
11Ø3Ø LET G(J)=B(1)
11Ø35 LET Z$(J)=A$
11Ø4Ø LET P$(J)=A$
11Ø45 IF Z1<>Ø THEN 11Ø8Ø
11Ø5Ø LET Z$(J)=K$
11Ø55 FOR K=2 TO 6
11Ø6Ø LET B(K)=Ø
11Ø65 NEXT K
11Ø7Ø GO TO 1134Ø
11Ø75 REM PLYWOOD PANELING
11Ø8Ø LET A(2)=Ø.Ø7995*M(2)-Ø.Ø231*L(2,1)+Ø.Ø829*E(4)
11Ø85 LET B(2)=-Ø.3245+Ø.ØØØ54*D(2,J)+Ø.Ø748*L(2,1)+1.26Ø2*A(2)
11Ø9Ø IF B(2)>=Ø.77 THEN 111ØØ
11Ø95 LET B(2)=Ø.77
111ØØ LET B(2)=B(2)*D(1,J)+B8*C8
111Ø5 IF C(J)<=B(2) THEN 1113Ø
1111Ø LET C(J)=B(2)
11115 LET G(J)=B(2)
1112Ø LET Z$(J)=B$
11125 LET P$(J)=B$
1113Ø REM CEMENTITIOUS COATING
11135 LET A(3)=-Ø.5ØØ2+Ø.6872*D(2,J)/D(1,J)+Ø.1Ø37+Ø.1741*E(4)
1114Ø LET B(3)=-Ø.8817-Ø.ØØØ4*D(1,J)+Ø.1154*L(3,1)+3.8636*A(3)+Ø.1416*E(6)
11145 IF B(3)>=Ø.22 THEN 11155
1115Ø LET B(3)=Ø.22
11155 LET B(3)=B(3)*D(1,J)+B8*C8
1116Ø IF C(J)<=B(3) THEN 11175
11165 LET C(J)=B(3)
1117Ø LET Z$(J)=C$
11175 REM VENEER PLASTER
1118Ø LET A(4)=A(3)-Ø.Ø847
11185 LET B(4)=Ø.8817-Ø.ØØØ4*D(1,J)+Ø.1154*L(4,1)+3.8636*A(4)+Ø.1416*E(6)+Ø.2Ø6
1119Ø IF B(4)>=Ø.35 THEN 112ØØ
11195 LET B(4)=Ø.35
112ØØ LET B(4)=B(4)*D(1,J)+B9*C9
112Ø5 IF C(J)<=B(4) THEN 1122Ø
1121Ø LET C(J)=B(4)
```

```
11215 LET Z$(J)=D$
1122Ø REM VINYL-COATED FABRIC
11225 LET R(5)=-25.2456+Ø.Ø276*D(2,J)+22.Ø745*D(2,J)/D(1,J)
1123Ø LET R=1.2933*L(5,1)-24.8364*E(3)
11235 LET R(5)=R(5)+R
1124Ø LET A(5)=Ø.Ø958*M(2)+Ø.5447*E(3)
11245 LET B(5)=L(5,1)/R(5)+A(5)
1125Ø IF B(5)>=Ø.84 THEN 1126Ø
11255 LET B(5)=Ø.84
1126Ø LET B(5)=B(5)*D(1,J)+B8*C8
11265 IF C(J)<=B(5) THEN 1128Ø
1127Ø LET C(J)=B(5)
11275 LET Z$(J)=E$
1128Ø REM CEMENT-COATED FIBERGLASS
11285 LET R(6)=43.58Ø9-33.61Ø7*D(2,J)/D(1,J)-45.51Ø5*E(3)
1129Ø LET R=-3.42Ø2*E(4)+8.1578
11295 LET R(6)=R(6)+R
113ØØ LET A(6)=Ø.56ØØ*D(2,J)/D(1,J)+1.Ø9ØØ*L(6,1)/R(6)
113Ø5 LET B(6)=L(6,1)/R(6)+A(6)
1131Ø IF B(6)>=Ø.66 THEN 1132Ø
11315 LET B(6)=Ø.66
1132Ø LET B(6)=B(6)*D(1,J)+B8*C8
11325 IF C(J)<=B(6) THEN 1134Ø
1133Ø LET C(J)=B(6)
11335 LET Z$(J)=F$
1134Ø REM FIND XRF TIMES LINEAR FEET FOR TRIM
11345 LET Y1=X1*D(3,J)
1135Ø LET Y2=X2*D(4,J)
11355 LET Y3=X3*D(5,J)
1136Ø REM FIND MINIMUM DIRECT COST TECHNIQUE FOR TRIM
11365 REM S(I)=DOORS T(I)=WINDOWS U(I)=TRIM V(I)=TOTAL
1137Ø REM INFRA-RED HEATING DEVICE
11375 IF D(6,J)=1 THEN 11445
1138Ø LET S(1)=(Ø.29Ø3*L(7,1)-Ø.ØØØ7*Y1)/Ø.92
11385 IF S(1)>=1.Ø5 THEN 11395
1139Ø LET S(1)=1.Ø5
11395 LET T(1)=(Ø.29Ø3*L(7,1)-Ø.ØØØ7*Y2)/Ø.89
114ØØ IF T(1)>=1.Ø5 THEN 1141Ø
114Ø5 LET T(1)=1.Ø5
1141Ø LET U(1)=(Ø.1354*L(7,1)-Ø.4913)/Ø.8Ø
11415 IF U(1)>=Ø.29 THEN 11425
1142Ø LET U(1)=Ø.29
11425 LET V(1)=S(1)*D(3,J)+T(1)*D(4,J)+U(1)*D(5,J)
1143Ø LET H(J)=V(1)
11435 LET Y$(J)=G$
1144Ø GO TO 11455
11445 LET H(J)=1ØØØØØ
1145Ø LET V(1)=Ø
11455 REM SOLVENT-BASED PAINT REMOVER
1146Ø LET S(2)=(-1.3499+Ø.5727*L(7,1)-Ø.ØØ13*Y1)/Ø.88
11465 IF S(2)>=1.25 THEN 11475
```

```
11147Ø LET S(2)=1.25
11475 LET T(2)=(-1.3499+Ø.5727*L(7,1)-Ø.ØØ13*Y2)/Ø.88
11148Ø IF T(2)>=1.25 THEN 1149Ø
11485 LET T(2)=1.25
1149Ø LET U(2)=Ø.1354*L(7,1)/Ø.82
11495 IF U(2)>=Ø.51 THEN 115Ø5
115ØØ LET U(2)=Ø.51
115Ø5 LET V(2)=S(2)*D(3,J)+T(2)*D(4,J)+U(2)*D(5,J)
11515Ø IF H(J)<=V(2) THEN 11525
11515 LET H(J)=V(2)
1152Ø LET Y$(J)=H$
11525 REM ELECTRIC HEAT GUN
1153Ø LET S(3)=Ø.2775*L(7,1)-Ø.ØØ861*D(3,J)+Ø.1769
11535 IF S(3)>=Ø.58 THEN 11545
1154Ø LET S(3)=Ø.58
11545 LET T(3)=Ø.2775*L(7,1)-Ø.ØØ861*D(4,J)+Ø.4735
1155Ø IF T(3)>=Ø.58 THEN 1156Ø
11555 LET T(3)=Ø.58
1156Ø LET U(3)=Ø.1372*L(7,1)-Ø.ØØ73*D(5,J)+Ø.14Ø6
11565 IF U(3)>=Ø.17 THEN 11575
1157Ø LET U(3)=Ø.17
11575 LET V(3)=S(3)*D(3,J)+T(3)*D(4,J)+U(3)*D(5,J)
1158Ø IF H(J)<=V(3) THEN 11595
11585 LET H(J)=V(3)
1159Ø LET Y$(J)=I$
11595 REM HAND SCRAPING
116ØØ LET S(4)=Ø.9468-Ø.Ø213*D(3,J)+Ø.3262*L(7,1)
116Ø5 IF S(4)>=1.16 THEN 11615
1161Ø LET S(4)=1.16
11615 LET T(4)=Ø.9468-Ø.Ø213*D(4,J)+Ø.3262*L(7,1)
1162Ø IF T(4)>=1.16 THEN 1163Ø
11625 LET T(4)=1.16
1163Ø LET U(4)=Ø.1146*L(7,1)
11635 IF U(4)>=Ø.45 THEN 11645
1164Ø LET U(4)=Ø.45
11645 LET V(4)=S(4)*D(3,J)+T(4)*D(4,J)+U(4)*D(5,J)
1165Ø IF H(J)<=V(4) THEN 11665
11655 LET H(J)=V(4)
1166Ø LET Y$(J)=V$
11665 REM PAINTING COSTS FOR TRIM
1167Ø LET S(9)=(Ø.7517*W(2,1)+Ø.9343*M(5)-Ø.8776*D8)*D8
11675 LET T(9)=(2.5942*W(2,1)+1.5865*M(5)-3.8199*D7)*D7
1168Ø LET U(9)=(Ø.Ø388*W(2,1)*D(5,J)
11685 LET V(9)=S(9)+T(9)+U(9)
1169Ø REM V(9) IS TOTAL COST FOR PAINTING TRIM-ALL TECHNIQUES
11695 IF V(9)>=Ø.Ø9*D(7,J) THEN 117Ø5
117ØØ LET V(9)=Ø.Ø9*D(7,J)
117Ø5 REM COMPONENT REPLACEMENT COST
1171Ø LET S(8)=(Ø.7517*W(2,1)+Ø.9343*M(5)-Ø.8776*E(7))*E(7)*Ø.7
11715 LET T(8)=(Ø.7517*W(2,1)+Ø.9343*M(5)-Ø.8776*E(8))*E(8)*Ø.7
1172Ø 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)*(95.2023-4.5476*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$(1)
11885:'CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
11890 PRINT
11895 PRINT "WALL COST","TRIM COST","TOTAL COST","MARKUP RATIO"
11900 PRINT P3,P4,P5,P2
11905 PRINT
11910 PRINT
11915 PRINT "IF YOU WISH TO DO MORE COST ESTIMATES TYPE 1, IF NOT TYPE 0"
11920 INPUT P6
11925 IF P6=1 THEN 10355
11930 GO TO 13300
11935 REM F IS BASIC DATA MATRIX
11940 LET F(J,1)=C(J)+H(J)
11945 LET F(J,2)=D(2,J)
11950 LET F(J,3)=D(7,J)
11955 IF Z$(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)
```

```
11198Ø LET F(J,6)=G(J)
11985 LET F(J,7)=G(J)-C(J)
11999 NEXT J
11995 LET F1=Ø
12ØØØ AT Y=ZER(N,1Ø)
12ØØ5 MAT Y=F
12Ø1Ø IF N<>1 THEN 12Ø25
12Ø15 LET Y(1,8)=1
12Ø2Ø GO TO 1249Ø
12Ø25 REM PAIR DWELLING UNITS
12Ø3Ø REM L IS DIFFERENTIAL MARKUP MATRIX
12Ø35 MAT L=ZER(N,N)
12Ø4Ø FOR I=1 TO N
12Ø45 FOR K=1 TO N
12Ø5Ø IF Y(I,2)<>Ø THEN 12Ø7Ø
12Ø55 IF Y(K,2)<>Ø THEN 12Ø7Ø
12Ø6Ø LET L(I,K)=1Ø
12Ø65 GO TO 12Ø75
12Ø7Ø LET L(I,K)=-Ø.ØØØØ79*Y(I,2)+Ø.ØØØ52*Y(I,3)-Ø.2144*(Y(I,4)/(Y(I,2)+Y(K,2)))
12Ø75 NEXT K
12Ø8Ø NEXT I
12Ø85 FOR I=1 TO N
12Ø9Ø LET L(I,I)=9
12Ø95 NEXT I
121ØØ REM P IS DIRECT COST MATRIX
121Ø5 MAT P=ZER(N,N)
1211Ø FOR J=1 TO N
12115 LET P(J,J)=Y(J,1)
1212Ø NEXT J
12125 REM D IS TEST MATRIX
1213Ø MAT D=ZER(N,N)
12135 MAT D=L*P
1214Ø REM W IS TRIANGULAR TEST MATRIX
12145 MAT W=ZER(N,N)
1215Ø FOR K=1 TO N-1
12155 LET I=K+1
1216Ø LET W(I,K)=D(I,K)+D(K,I)
12165 LET I=I+1
1217Ø IF I<N THEN 1216Ø
12175 NEXT K
1218Ø LET N1=N*(N-1)/2
12185 MAT X=ZER(N1,3)
1219Ø LET J=1
12195 FOR K=1 TO N-1
122ØØ LET I=K+1
122Ø5 LET X(J,1)=W(I,K)
1221Ø LET X(J,2)=I
12215 LET X(J,3)=K
1222Ø IF J>=N1 THEN 1225Ø
12225 LET I=I+1
1223Ø LET J=J+1
```

```
12235 IF I>N THEN 12245
1224Ø GO TO 122Ø5
12245 NEXT K
1225Ø REM SORT X MATRIX
12255 FOR L=1 TO N1-1
1226Ø FOR M=1 TO N1-1
12265 LET Q1=X(M,1)
1227Ø LET Q2=X(M+1,1)
12275 LET R1=X(M,2)
1228Ø LET R2=X(M+1,2)
12285 LET S1=X(M,3)
1229Ø LET S2=X(M+1,3)
12295 IF Q1<=Q2 THEN 1233Ø
123ØØ LET X(M,1)=Q2
123Ø5 LET X(M+1,1)=Q1
1231Ø LET X(M,2)=R2
12315 LET X(M+1,2)=R1
1232Ø LET X(M,3)=S2
12325 LET X(M+1,3)=S1
1233Ø NEXT M
12335 NEXT L
1234Ø IF F1=1 THEN 12545
12345 REM Y IS PRELIMINARY CONTRACT PACKAGE MATRIX
1235Ø LET J=1
12355 LET K=1
1236Ø LET B2=X(J,2)
12365 LET B3=X(J,3)
1237Ø IF F(B2,1Ø)=1 THEN 1243Ø
12375 IF F(B3,1Ø)=1 THEN 1243Ø
1238Ø FOR M=1 TO 7
12385 LET Y(K,M)=F(B2,M)+F(B3,M)
1239Ø NEXT M
12395 LET Y(K,8)=B2
124ØØ LET Y(K,9)=B3
124Ø5 LET F(B2,1Ø)=1
1241Ø LET F(B3,1Ø)=1
12415 IF K=N2 THEN 1249Ø
1242Ø IF K=N3 THEN 1244Ø
12425 LET K=K+1
1243Ø LET J=J+1
12435 GO TO 1236Ø
1244Ø LET K=K+1
12445 FOR I=1 TO N
1245Ø IF F(I,1Ø)=Ø THEN 1246Ø
12455 NEXT I
1246Ø LET B2=I
12465 FOR M=1 TO 7
1247Ø LET Y(K,M)=F(B2,M)
12475 NEXT M
1248Ø LET Y(K,8)=B2
12485 LET Y(K,9)=Ø
```

```
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 F1=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
1275Ø LET B3=X(I,2)
12755 IF Y (B3,1Ø)=1 THEN 1288Ø
1276Ø FOR M=1 TO 7
12765 LET Z(K,M)=Y(B2,M)+Y(B3,M)
1277Ø NEXT M
12775 LET Z(K,8)=B3
1278Ø LET Z(K,9)=B2
12785 LET Y(B2,1Ø)=1
1279Ø LET Y(B3,1Ø)=1
12795 IF K=N4 THEN 128Ø5
128ØØ LET K=K+1
128Ø5 FOR I=1 TO N
1281Ø IF Y(I,1Ø)=1 THEN 1287Ø
12815 FOR M=1 TO 7
1282Ø LET Z(K,M)=Y(I,M)
12825 NEXT M
1283Ø LET Z(K,8)=I
12835 LET Z(K,9)=Ø
1284Ø LET Y(I,1Ø)=1
12845 FOR L=1 TO N
1285Ø IF Y(L,1Ø)=Ø THEN 12865
12855 NEXT L
1286Ø GO TO 12875
12865 LET K=K+1
1287Ø NEXT I
12875 GO TO 1293Ø
1288Ø FOR I=1 TO N
12885 IF Z(I,8)=B3 THEN 129ØØ
1289Ø IF Z(I,9)=B3 THEN 129ØØ
12895 NEXT I
129ØØ LET Z(I,1Ø)=B2
129Ø5 FOR M=1 TO 7
1291Ø LET Z(I,M)=Z(I,M)+Y(B2,M)
12915 NEXT M
1292Ø LET Y(B2,1Ø)=1
12925 GO TO 128Ø5
1293Ø LET N6=K
12935 MAT W=ZER(N6,5)
1294Ø FOR K=1 TO N6
12945 LET Z8=Z(K,8)
1295Ø LET W(K,1)=Y(Z8,8)
12955 LET W(K,2)=Y(Z8,9)
1296Ø IF Z(K,9)=Ø THEN 12995
12965 LET Z9=Z(K,9)
1297Ø LET W(K,3)=Y(Z9,8)
12975 LET W(K,4)=Y(Z9,9)
1298Ø LET Z9=Z(K,1Ø)
12985 IF Z9=Ø THEN 12995
1299Ø LET W(K,5)=Y(Z9,8)
12995 NEXT K
```

```
13ØØØ FOR K=1 TO N6
13ØØ5 PRINT
13Ø1Ø PRINT
13Ø15 PRINT "                                        CONTRACT "K
13Ø2Ø PRINT
13Ø25 LET I=1
13Ø3Ø LET M(K)=-Ø.ØØØØ79*Z(K,2)+Ø.ØØØ52*Z(K,3)-Ø.2144*(Z(K,4)/Z(K,2))
13Ø35 LET M(K)=M(K)+1.2972
13Ø4Ø REM W5 IS DWELLING UNIT NUMBER
13Ø45 LET W5=W(K,I)
13Ø5Ø IF W5<>Ø THEN 13Ø75
13Ø55 LET I=I+1
13Ø6Ø IF I>5 THEN 13165
13Ø65 IF W(K,I)=Ø THEN 13165
13Ø7Ø LET W5=W(K,I)
13Ø75 IF F(W5,2)=Ø THEN 1312Ø
13Ø8Ø LET M9=-Ø.2144*(F(W5,4))/Z(K,2)
13Ø85 LET M8=M9*Z(K,1)+M(K)*F(W5,7)
13Ø9Ø IF M8>=Ø THEN 1312Ø
13Ø95 LET M(K)=M(K)+M9
131ØØ LET Z$(W5)=P$(W5)
131Ø5 LET F(W5,1)=F(W5,1)+F(W5,7)
1311Ø LET Z(K,1)=Z(K,1)+F(W5,7)
13115 LET Z(K,4)=Z(K,4)+F(W5,4)
1312Ø PRINT " DWELLING UNIT  "W5,Q$(W5)
13125 PRINT
1313Ø PRINT "       WALL TECHNIQUE     "Z$(W5)
13135 PRINT "      TRIM TECHNIQUE     "Y$(W5)
1314Ø PRINT "               DIRECT COST  $"F(W5,1)
13145 PRINT
1315Ø IF W5=Ø THEN 13165
13155 LET I=I+1
1316Ø IF I<=5 THEN 13Ø45
13165 IF M(K)<1.1 THEN 13185
1317Ø IF M(K)<=1.5 THEN 1319Ø
13175 LET M(K)=1.5
1318Ø GO TO 1319Ø
13185 LET M(K)=1.1
1319Ø LET Z(K,1)=M(K)*Z(K,1)
13195 PRINT "                                  CONTRACT PRICE    $"Z(K,1)
132ØØ PRINT "                                    MARKUP RATIO       "M(K)
132Ø5 PRINT
1321Ø IF Q=Ø THEN 132Ø5
13215 PRINT "THIS INCLUDES THE COMPONENT REPLACEMENT YOU REQUESTED"
1322Ø NEXT K
13225 PRINT "IF YOU WISH TO DO MORE COST ESTIMATES TYPE 1, IF NOT TYPE Ø"
1323Ø INPUT Q7
13235 IF Q7=Ø THEN 133ØØ
1324Ø RESTORE #1
13245 RESTORE #2
1325Ø RESTORE #3
```

```
13255 MAT W=ZER(6,1)
1326Ø MAT L=ZER(7,1)
13265 MAT READ #1,W
1327Ø MAT READ #3,L
13275 FOR L=1 TO 5
1328Ø READ #2,M(L)
13285 NEXT L
1329Ø MAT D=ZER(1Ø,1Ø)
13295 GO TO 1Ø295
133ØØ END
```

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FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY

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05. Software title: Lead Based Paint Hazard Abatement Cost Estimation Procedure

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- ☐ Subroutine/Module

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- ☒ Interactive
- ☐ Batch
- ☐ Combination

10. Application area

General
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- ☐ Bibliographic/Textual
- ☐ Management/Business
- ☐ Process Control
- ☒ Other

Specific: Housing renovation cost allocation

11. Submitting organization and address
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Building Technology and Regulatory Technology Div.
CBT, NEL
National Bureau of Standards
Washington, D.C. 20234

12. Technical contact(s) and phone
Robert Chapman, x2278
Kimberly A. Barnes, X2026

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'r and model	16. Computer operating system	17. Programing language(s)	18. Number of source program statements
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19. Computer memory requirements	**20. Tape drives**	**21. Disk/Drum units**	**22. Terminals**
	None	None	1 (Line Speed = 30)

23. Other operational requirements
None

24. Software availability
Available ☒ Limited ☐ In-house only ☐

Applied Economics Group
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Washington, D.C. 20234

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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.

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