TUNNEL AND STATION COST METHODOLOGY

VOLUME II: STATIONS

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FINAL REPORT

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16. Abstract

This report (in two volumes) describes a cost estimating methodology for subway tunnels and stations. This methodology is for the use of planners and designers interested in evaluating a realistic range for the cost of subway tunnels and stations within which the actual bid would fall.

The rationale behind this cost estimating methodology is the effort to parallel the estimating process of contractors. Extensive interviews with reputable subway tunnel and station contractors and designers were conducted to identify the basic framework for estimating costs.

A hierarchical cost estimating technique is developed, whereby project-specific and contractor-specific factors are identified and structured, i.e., typical advance rates are developed for a variety of geological and geometrical conditions; crew sizes (by skill) for varying geological conditions and construction methods; type and size of equipment and their associated write-off values; type of materials; contractor overhead, taxes, interest costs; etc.

Finally, a data base of actual equipment, labor, materials, and lump sum costs is compiled and may be updated as changes occur.

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STATIONS

SYMBOLS AND ABBREVIATIONS

CD	center diameter
CFM	cubic feet/meter
CL	center line
CY	cubic yard
EMT	electric metallic tubing
GAL	gallon
GPM	gallons per minute
ID	inside diameter
L	length of tunnel
LBS	pounds
LF	lineal foot
LHD	load-haul-dump
OD	outside diameter
SF	square foot
TBM	tunnel boring machine
WF	weighting factor

PREFACE

This study has been undertaken to develop a working subway tunnel and station cost estimating methodology. Initially, there was some concern as to the usefulness of such an undertaking, in light of the several previously developed techniques. It was concluded that the best approach for developing a "usable" methodology was to observe the actual subway contractors and try to formalize some of their cost estimating processes in a realistic model.

The information contained in this report will be of use to governmental agencies, planners, engineers, and designers, as well as contractors interested in a "first-pass" estimate.

This study was prepared by M. Ziad Ramadan, Barbara M. Parness, and Youssef E. Nassar; of Multisystems, Inc., for the Office of Technology Development and Deployment, Office of Rail and Construction Technology, Urban Mass Transportation Administration, U.S. Department of Transportation, under contract to the Transportation Systems Center in Cambridge, Massachusetts.

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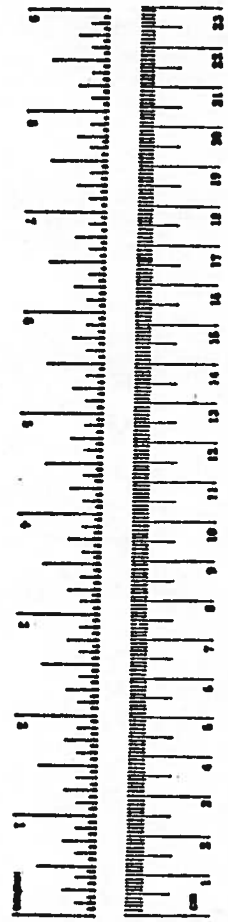
METRIC CONVERSION FACTORS

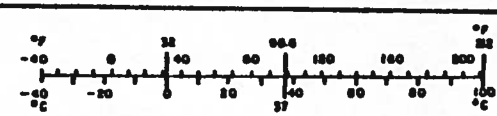
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. INTRODUCTION

The following report constitutes one portion of a study dedicated to the development of a subway tunnel and station cost estimating methodology. This portion deals with cut-and-cover subway stations. The same philosophy underlying the mined tunnel report is adopted in this report, namely, the acquisition of insight into contractors' cost estimating procedures and their replication in a model to be used by designers and planners. Again, it should be emphasized that estimating is a very complex task which is obviously site-specific. Thus, the model produces a cost range within which an actual bid would fall.

Unlike tunnels, stations can vary substantially in architectural features, geometry, and size, thereby making it more difficult to develop an all encompassing model. It was agreed from the outset that cut-and-cover station designs would be investigated, and that the model would utilize them as the basis for estimating costs. The station design is a function of the location of the station (urban density and geotechnical conditions), the level of public usage anticipated, and the type of tunnel construction between stations. The type of station design is input to the model along with all other major features and site conditions. All construction activities plus any miscellaneous and markup factors are then identified and costed.

A large volume of data has been compiled, including data pertaining to the types of equipment used in cut-and-cover station construction, materials, crew compositions, and labor rates. Assumptions have been made concerning construction methods (utilities relocation, ground control, etc.) because they were deemed workable and realistic. These data and assumptions form the foundation on which the model's cost estimate is built.

2. THE MODEL

2.1 INTRODUCTION

This model attempts to replicate the contractor's procedures for bid preparation, using a step-by-step approach to cost estimating. The study is limited to cut-and-cover stations with varying mezzanine and platform configurations. The model estimates quantities and costs given the actual detailed design parameters of the station.

2.2 IDENTIFICATION AND MODELING OF PROJECT CHARACTERISTICS

To obtain a good estimate, one needs to identify all the project characteristics that have an impact on costs. Background information and input data can come from many sources, such as:

- Designer's specifications, cost line items, and estimated quantities
- Designer's description of station type, geology, and special urban conditions
- The Environmental Impact Statement for the project
- The contractor's past experience in subway station construction and his familiarity with the geographical area (or a similar one)
- General economic conditions
- Government regulations

The volume of this data is quite large, so the contractor selects from all of these sources the project characteristics which significantly affect costs. Appendix B contains a listing of the project characteristics which were considered important in terms of their cost impact. They have been grouped under ten categories:

1. General
2. Community constraints
3. Construction site conditions
4. Utilities

5. Building protection
6. Station design
7. Shaft design
8. Station and shaft geology
9. Station and shaft support system
10. Muck hauling from construction site to dump

For each project characteristic, a variable which comprehensively defines it has been established. Each variable has been assigned a name of twelve characters or less, a unit of measure, a description, and a range of possible values. Each variable has also been assigned a data type (i.e., scalar, character, vector, or matrix) and an input status (i.e., required input, non-required input, or optional input). These features are listed for all variables in Appendix B.

2.3 CONTRACTOR DECISIONS

Eleven fundamental cost components have been defined, comprising the construction of a subway station, together with the major options for each one. The components are listed in sequential order below. (A comprehensive flowchart of these components may be found in Appendix C.)

1. Site preparation and mobilization
2. Traffic control
   a. rerouting traffic
   b. maintaining one lane
   c. two-way traffic with decking
3. Utilities
   a. sewer
   b. water
   c. gas (ducts)
   d. electrical and telephone (poles)
4. Underpinning and building protection
   a. underpinning
   b. ground consolidation

5. Groundwater control
   a. trenching and pumping
   b. deep wells
   c. ground improvement
6. Excavation and support
   a. open excavation
   b. ground wall support system
      1. soldier piles and lagging
      2. steel sheet piles
      3. slurry walls
   c. bracing
      1. cross bracings
      2. tiebacks (both rock and soil-grouted)
      3. decking (installation and removal)
   d. muck handling
      1. lifting (both vertical lift and access ramp)
      2. hauling
7. Box structure
   a. invert
   b. walls
      1. reinforced concrete
      2. slurry
   c. slabs
      1. reinforced concrete
      2. composite
   d. roof
      1. girders
      2. top
   e. columns
      1. rectangular
      2. circular
   f. platform
8. Mechanical systems
   a. air handling
      1. fans
      2. hangers

3. ducts and fittings

b. drainage

1. pipes (steel or copper)
2. hangers
3. fittings
4. welding

c. fire protection

1. pipes (steel or copper)
2. hangers
3. fittings
4. welding

d. toilets and waste disposal

1. fixtures
2. pipings and fittings (cast iron or steel)

9. Electrical systems

a. conduits (elbows)
b. junction boxes
c. wiring
d. fixtures
e. switchgear
f. systems (fire, sound, security, emergency)
g. grounding
h. lighting control
i. devices
j. disconnect switches
k. electric manholes

10. Finishings

a. interior masonry
b. metals
c. carpentry
d. moisture protection
e. finishes
f. doors/windows/glass

11. Backfill and restoration

a. backfill

1. with utilities (hand or machine)

2. without utilities (hand or machine)

b. surface restoration

1. landscaping

2. roads

12. Demobilization and site cleanup

2.4 MODEL BREAKDOWN

In an attempt to replicate the contractor's estimating process, the model breaks each of the components listed above into progressively finer levels of detail. The finest level of detail is considered to be the operational level. That is, the model breaks down a component into smaller and smaller subcomponents or activities until it reaches a point at which all of the activities can be defined in terms of a set of standard operations. Appendix J contains a listing of these standard operations. The operations in turn are broken down into the labor, equipment, and materials needed to perform them. By accumulating the labor, equipment, and materials for each operation, the model then determines the labor, equipment, and materials required for the component as a whole.

Those labor, equipment, and materials costs which are directly incurred in the performance of the operations for a component are included in that component's cost. After the cost of each has been determined, the model then calculates the labor, materials, and equipment costs that do not relate to any particular activity but rather to the job as a whole. These costs include overhead, miscellaneous small tools, bonds, property taxes, license permits, dues, contributions, legal work, accounting, entertainment, progress photographs, employee expenses, travel, relocation, and the borrowing of capital invested in the project, etc. In addition, the model calculates a cost markup or profit margin for the contractor. This cost markup is based on the general state of the economy, the cost of the job, and the expected duration of the job. The following sections explain in detail how the model derives the labor, materials, and equipment costs of each component; the labor, materials, and equipment costs of work not related to activities; and the contractor's profit margin for the job. Together these costs comprise the bid estimate.

3. SITE PREPARATION AND MOBILIZATION

3.1 INTRODUCTION

This component comprises all efforts needed to prepare the site so that construction can begin, as well as all expenses of equipment mobilization, freight in and out, and expenses of setting up field offices. Site preparation includes such activities as tree removal, pavement removal, building demolition, fencing of the site, and security measures. Mobilization includes such activities as the setting up of equipment and of field offices. In order to determine the cost of the site preparation and mobilization activity, it must be divided into the following subactivities:

1. Site clearing
2. General site preparation
3. Site fencing
4. Trailer setup
5. Equipment setup
6. Utilities setup
7. Security

The method for calculating the cost of each of these subactivities is described in this chapter.

3.2 SITE CLEARING

This activity includes all work required to clear the site of any existing obstructions, such as trees, pavement, or buildings. It is subdivided into: 1) tree removal, 2) pavement removal, 3) small building demolition, 4) medium building demolition, and 5) large building demolition.

3.2.1 Tree Removal

This activity consists of all foliage and tree removal work on the construction site. The cost of this activity is based on the square footage of the area to be cleared and the extent of tree congestion. The area to be cleared and the congestion of trees (light, moderate, or heavy) are given to the model as input. The model calculates the cost of this activity by extracting from the lump sum costs data file (detailed in Appendix I) the cost per square foot of clearing few trees, some trees, or heavy foliage and trees. That unit cost is then multiplied by the square footage of the area to be cleared to produce the cost of tree removal.

3.2.2 Pavement, Curbing, and Sidewalk Removal

This activity consists of all asphalt or concrete pavement, curbing, and sidewalk removal work to be done on the construction site. The model calculates the cost of this activity by extracting the cost per square foot of pavement, curbing, and sidewalk removal from the lump sum costs data file in Appendix I and then multiplying it by the square footage of pavement, curbing, and sidewalk which has been input to the model.

3.2.3 Small Building Demolition

This activity consists of the demolition of one- or two-story wood-framed buildings on the construction site. The cost of this activity is calculated by extracting the unit cost of small building demolition from the lump sum costs data file in Appendix I and then multiplying it by the number of cubic feet of small buildings to be demolished. The number of cubic feet of small buildings to be demolished is derived from data previously input to the model.

3.2.4 Medium Building Demolition

This activity consists of the demolition of small masonry structures and light commercial buildings on the construction site. Its cost is calculated by extracting the unit cost of medium building demolition from the lump sum costs data file in Appendix I and then multiplying it by the number of cubic feet of medium buildings to be demolished. The number of cubic feet of medium buildings to be demolished is derived from data already supplied to the model.

3.2.5 Large Building Demolition

This activity consists of the demolition of large masonry structures, multi-story buildings, and bridges on the construction site. Its cost is calculated by extracting from the lump sum costs data file in Appendix I the unit cost of large building demolition and then multiplying it by the number of cubic feet of large buildings to be demolished. The number of cubic feet of large buildings to be demolished is derived from data previously input to the model.

3.3 GENERAL SITE PREPARATION

This activity comprises general site work requirements such as snow removal; rodent, insect, and odor control; street cleaning; etc. The cost of this activity is calculated by extracting a unit price from the lump sum costs data file in Appendix I for minimal, moderate, or extensive general site work. The particular unit cost extracted depends on the user's input to the model regarding general site work requirements.

3.4 SITE FENCING

This activity consists of all fencing requirements for the construction site and the area around each access ramp. The model is supplied with the lineal footage of fencing needed for the site and the type of fencing. The model considers three types of fencing: 1) 6-foot high chain link fence, 2) wire mesh on 4-in x 4-in posts 8 feet high, and 3) painted plywood (sound barrier type). If type one fencing is specified to the model, then the costing of this activity is done by extracting from the lump sum costs data file the price per lineal foot of chain link fencing installation and then multiplying that unit price by the fence length. Similarly, if wire mesh or three fencing is specified to the model, then the unit cost of wire mesh or plywood fencing installation is extracted from the lump sum costs data file and used in the calculation of the cost of site fencing.

3.5 TRAILER SETUP

This activity includes the setting up of site offices, change houses, maintenance shops, and sanitary facilities. Because this activity can vary greatly from one job to the next, it is difficult to accurately estimate its cost. For example, in one situation the contractor might desire to lease or purchase an adjacent building, remodel that building, and use it as his office during construction. In another situation, the contractor might install temporary trailers on site which would serve as an office and change house, and provide the necessary sanitary facilities. This model assumes that the contractor would employ the latter option and therefore calculates the cost of this activity by extracting the cost per trailer from the equipment costs data file (Appendix F) and multiplying it by the number of trailers previously input to the model.

3.6 EQUIPMENT SETUP

This activity covers all mobilization, freight handling, and equipment setup costs. The model has already defined the excavation methods via the flow chart in Appendix C, and the support and bracing methods via input variables. These methods in turn are listed in Appendix J along with the major pieces of equipment they require. Therefore, at this point the model knows exactly what equipment is needed on site. In order to estimate the cost of the setup activity, however, the model must know not only the type of equipment but also the distance between the current equipment location and the site. It is difficult to estimate this distance due to variations in vendor locations. Hence, the model, given the type of equipment required, costs this activity by assigning an average lump sum setup cost to those major pieces of equipment requiring a setup effort. Equipment setup costs have been assigned to the various types of equipment in the lump sum cost data file. It should be noted that the model assumes there is no equipment setup costs associated with the muck handling system. The sum of the setup cost for each pertinent piece of equipment represents the total equipment setup cost for the job.

3.7 UTILITIES SETUP

This activity consists of the setting up of all utilities for field offices on the construction site. It includes the installation of electric, telephone, water, and sewage systems. The model calculates the cost of utilities setup by extracting a lump sum cost for this activity from the lump sum costs data file.

3.8 SECURITY

This activity covers all the security and surveillance requirements for the construction site. Its cost is based on the level of surveillance stipulated by the user. The cost of this activity is derived by extracting from the lump sum costs data file a monthly cost for surveillance activities under light, medium, or heavy surveillance requirement conditions. This unit cost is then multiplied by the job duration (in months) to arrive at a total cost for security. The algorithm for computing the job duration is given in Appendix C.

4. TRAFFIC CONTROL

4.1 INTRODUCTION

Among the many activities with which a contractor has to contend, traffic control is the one most often at odds with the local community. More so than noise or dust, traffic disruption is a continual source of complaint. The community's needs for vehicular access can vary widely, depending on the conditions at the construction site. For purposes of estimating the cost of traffic control, the model assumes three alternatives: 1) traffic is completely rerouted, thereby freeing the construction site from any traffic-related problems; 2) one-way traffic is permitted, thereby allowing for excavation on one side of the street; and 3) vehicular access is vital and must be permitted, thereby necessitating a total decking system. The cost of decking per se is not included here; it is accounted for in Section 8.5, Bracing. This section covers only the following traffic control items: the policing of the area and automated traffic guidance systems.

4.2 TRAFFIC GUIDANCE SYSTEMS

In order for the model to determine the cost of traffic guidance, the user must specify the expected number of traffic signals to be removed or installed.

$$\text{Cost of traffic guidance} = X_R\, C_R + X_{I1}\, C_{I1} + X_{I2}\, C_{I2} .$$

where, X_R = the number of signals to be removed

C_R = the cost of removing one traffic signal

X_{I1} = the number of old signals to be installed

C_{I1} = the cost of installing one old traffic signal

X_{I2} = the number of new signals to be installed

C_{I2} = the cost of installing one new traffic signal

(The difference between C_{I1} and C_{I2} represents the cost of equipment.) The user should not forget that relocation of traffic signals occurs twice, once when the traffic flow is altered, and once when it is returned to normal. This affects the values chosen for X_R, X_{I1}, and X_{I2}. The costs of removing and installing traffic signals are treated as lump sums which incorporate the costs of labor, materials, and equipment. These costs are found in the lump sum costs data file (Appendix I).

4.3 POLICING

In order for the model to determine the cost of policing, the user must specify its duration and the number of policemen required. When traffic is completely rerouted, thereby obviating the need for any other traffic control operations, the model assumes that only one traffic officer is on duty for the entire job duration.

$$\text{Cost of policing} = X_L \times C_L \times D$$

where, X_L = the number of traffic officers

C_L = the unit cost of traffic officers per day

D = the duration of policing in days

The cost of traffic officers is found in Appendix I.

The total cost of traffic control is the sum of the cost of traffic guidance and the cost of policing.

5. UTILITIES

5.1 INTRODUCTION

Utilities constitute a significant part of the cost estimate. They are generally site-specific, and are therefore difficult to estimate. This difficulty is compounded by the fact that plans and layouts of existing utilities are not very precise or complete. In any event, the model assumes the availability and accuracy of such data. In order to estimate the cost of handling utilities, a framework has been developed for all types of utilities, namely, water, sewer, gas (ducts), electric (poles), telephone, etc.

The model considers four different procedures for handling each utility located on the station site: 1) maintaining the existing utility in place; 2) removing the utility permanently; 3) replacing the existing utility with a new utility in the same position (not applicable to electric, telephone, or gas utilities); and 4) relocating the existing utility. Each of these procedures can be defined as a sequence of standard operations. A complete listing of standard operations for the cut-and-cover station construction process is found in Appendix J.

5.2 SEQUENCE OF OPERATIONS

The sequence of operations for each of the four utilities-handling procedures is described in the sections below. The user selects one of these procedures and then furnishes certain physical parameters (depths, geological conditions, etc.) of the utility in order to determine a unique set of construction operations (see Appendix J). These operations are standard, but in combination they make for a variety of situations.

5.2.1 Maintenance of Utilities

The following sequence of operations is conducted. The description of each operation is generalized. The model utilizes each description in conjunction with data input by the user in order to select the appropriate specific operation from Appendix J.

1. Open trench with existing utilities, 0-10 feet deep, for a user-specified base width, soil condition, and water condition.

2. If necessary, open trench with existing utilities, 10-20 feet deep, for a user-specified base width, soil condition, and water condition.

3. If necessary, brace trench with existing utilities, 10-20 feet deep, for a user-specified base width, angle of repose, and water condition.

4. Support pipe in place.

5. If necessary, fill trench (by dozer or by hand), and if necessary, backfill.

5.2.2 Removal of Utilities

The following sequence of operations is conducted. The description of each operation is generalized. The model utilizes each description in conjunction with data input by the user in order to select the appropriate specific operation from Appendix J.

1. Open trench with existing utilities, 0-10 feet deep, for a user-specified base width, soil condition, and water condition.

2. If necessary, open trench with existing utilities, 10-20 feet deep, for a user-specified base width, soil condition, and water condition.

3. If necessary, brace trench with existing utilities, 10-20 feet deep, for a user-specified base width, angle of repose, and water condition.

4. Remove pipe from trench.

5.2.3 Replacement of Utilities

1. Same as utilities removal reference.

2. Place new pipe in same trench.

3. Fill trench in which utility has been replaced, given the method (dozer or hand) and whether or not it is compacted.

5.2.4 Relocation of Utilities

The following sequence of operations is conducted. The description of each operation is generalized. The model utilizes each description in conjunction with data input by the user in order to select the appropriate specific operation from Appendix J.

1. Open trench with existing utilities, 0-10 feet deep, for a user-specified base width, soil condition, and water condition.

2. If necessary, open trench with existing utilities, 10-20 feet deep, for a user-specified base width, soil condition, and water condition.

3. If necessary, brace trench with existing utilities, 10-20 feet deep, for a user-specified base width, angle of repose, and water condition.

4. Open trench without utilities, 0-10 feet deep, for a user-specified base width, soil condition, and water condition.

5. If necessary, open trench without utilities, 10-20 feet deep, for a user-specified base width, soil condition, and water condition.

6. If necessary, brace trench without utilities, 10-20 feet deep, for a user-specified base width, angle of repose, and water condition.

7. Remove pipe from trench with existing utilities, given the material from which it is fabricated.

8. Place same pipe or new pipe in trench without utilities.

9. Fill trench in which utility has been relocated, given the method (dozer or hand) and whether or not it is compacted.

5.3 COSTING OF UTILITIES-HANDLING PROCEDURES

The cost of a utilities-handling procedure is determined by summing the costs of its component operations. The cost of each operation in its turn is calculated by summing the costs of the labor, materials, and equipment needed to perform the operation.

The equipment used in each operation is given in Appendix J. The model costs this equipment by extracting the unit price of each type of equipment from the equipment costs data file in Appendix F. This cost is then reduced according to the write-off value for the particular piece of equipment, which is found in Appendix D.

The materials used in utilities-handling operations consist of piping and cross bracings. The quantity and type of piping are provided via the input variables (see Appendix B, Section 4). Similarly, the input variables indicate whether or not each trench is braced, and, if so, the number and size of the cross bracings required. The cost of each of these items is then calculated by extracting its unit price from the material costs data file in Appendix H and multiplying it by the total amount required.

In order to calculate the labor cost of an operation, the model first looks at its advance rate. For each trench excavation, bracing, and refill operation, Appendix J provides an advance rate in terms of cubic yards per day. For each pipe placement, pipe support and pipe removal operation, Appendix J provides an advance rate in terms of lineal feet per day. The model divides the advance rate into the volume of the trench or the length of the pipe, as appropriate, in order to derive the total number of days required for the operation. The model's next step is to obtain the crew configuration for the operation from Appendix J. From this configuration, the model can determine the number of man-hours per day required of each labor type. Then, for each labor type, the model extracts from the labor costs data file in Appendix G the cost per man-hour of wages and the cost per man-hour of fringe benefits for the appropriate city. The model then adds 34.88 percent of the hourly wage rate to the hourly fringe benefits rate figure to account for the government-mandated benefits of social security (6.13 percent), workers' compensation (24.00 percent), and unemployment taxes and insurance (4.75 percent). The sum of the hourly wage rate and the hourly benefit rate (including both union-stipulated and government-stipulated benefits) equals the total cost per man-hour for a specific labor type. The model multiplies this cost by the number of man-hours required per day to produce the daily labor cost for each labor type. Summing the daily cost for each labor type yields the total daily labor cost for the operation. Once the labor cost per day is computed, it is multiplied by the number of days required for the operation in order to arrive at the total labor cost for the operation.

6. BUILDING PROTECTION

6.1 INTRODUCTION

There are three basic types of building protection from which a contractor can choose: underpinning, contingency support, and ground consolidation. Underpinning is the most common type of building protection. It generally consists of a structural element designed to transfer foundation loads below the "zone of influence." Contingency support is used only when the expected soil settlement is minimal and the buildings have a good tolerance for such movements. It is usually a temporary system of a corrective nature (i.e., hydraulic jacking, or column pick-up). Ground consolidation is a technique of limited effectiveness. It consists of stabilizing the soil mass within the "zone of influence," thereby reducing the deformation or settlement of the soil/structure.

6.2 SELECTION OF THE PROTECTION SYSTEM

When confronted with the problem of building protection, the contractor must make a decision concerning which type of protection system to use. To this end, the following categories have been devised for structures. Given the category of each structure, the model can then select an appropriate protection system.

<u>Category A</u>: Structures with a low tolerance for settlement and deformation.

<u>Category B</u>: Structures experiencing little (less than 2 inches) or no settlement.

Underpinning is required for structures in Category A, while the contractor must choose between contingency support and ground consolidation for structures in Category B.

6.3 UNDERPINNING

There are two types of underpinning, pier and pile. The pier type entails excavation by hand to an average depth of 35-40 feet. When excavation to depths greater than 40 feet is required, the pile type is selected by the model.

A typical pit pier is 3 feet by 4 feet in plan. Its depth must be provided by the user, or a default of 40 feet is assumed. Excavation is done by hand using a 3-man crew, one 8-hour shift, and an advance rate of 4 feet per shift. The model uses the dimensions of each pit pier to calculate the total number of cubic yards to be excavated. This number is multiplied by the unit price of pit pier underpinning found in the lump sum costs data file to yield the total cost of underpinning a given structure.

A typical jacked pile consists of a 12-inch diameter pipe in sections from 3 to 5 feet long. The pile is advanced through a jacking and cleaning-out process to a depth of approximately 50 feet. The model uses this figure as the default for the pile length variable in Appendix B, Section 5, if the user fails to provide one. The pile is then filled with concrete. Installation requires 6 8-hour shifts when a 2-man crew is employed. The model costs this activity by multiplying the sum of all pile lengths for a structure by the unit price of jacked pile underpinning in the lump sum costs data file.

6.4 CONTINGENCY SUPPORT

This method of building protection involves supporting the structure independently of its footings. High capacity hydraulic jacks are used to raise column or wall loads off their footings. The installation time for a pick-up is generally 2 to 3 weeks. The model multiplies the number of pick-ups for a structure (from Appendix B, Section 5) by the unit price of contingency support (from Appendix I) to produce the total cost of supporting that structure.

6.5 GROUND CONSOLIDATION

Ground consolidation includes methods such as freezing or grouting (chemical or cement). These methods are used on a limited basis, yet can be quite effective when used properly. For a given structure, the model requires that the user specify the particular ground consolidation method to be used and the volume (in cubic yards) of soil to be treated. The model multiplies this volume by the appropriate unit price in the lump sum costs data file to yield the total cost of ground consolidation.

6.6 ESTIMATING THE COST OF BUILDING PROTECTION

The user inputs to the model the number of structures in each category (A and B), and for each structure, the depth of soil to be excavated for pit piers, the length of pile for jacked piles, the number of pick-ups or the volume of soil to be consolidated together with the particular ground consolidation technique to be used. Unit costs for each type of building protection are furnished in Appendix I. Total costs are computed by the model as described above. In addition, the user inputs to the model the extent of the monitoring requirements for building settlement, blasting damage, seismic controls, etc. Based on this input, the model selects the appropriate lump sum cost for building protection monitoring from the lump sum costs data file in Appendix I. The sum of all these various costs represents the total cost for the building protection activity.

7. GROUNDWATER CONTROL

7.1 INTRODUCTION

The inflow of water at a construction site can significantly increase the cost of excavation and construction. It is therefore important for the contractor to implement an effective groundwater control program. The contractor indicates to the model the ground control and/or ground solidification techniques to be used via input variables in Appendix B, Section 9.

7.2 TRENCHING AND PUMPING

This method is conventional for draining soil strata with little or moderate groundwater inflow. Trenches are typically 2 feet wide by 3 feet deep, and are excavated with a backhoe loader. Pumping is generally conducted 24 hours a day using a 2-inch pump if the water inflow is slight (less than 200 gallons per minute (gpm)/1000 feet), a 4-inch pump if the water inflow is moderate (200-1000 gpm/1000 feet), or a 6-inch pump if the water inflow is heavy (more than 1000 gpm/1000 feet). (The amount of water inflow is provided in Appendix B, Section 8.) The costs for the backhoe loader and appropriate-size pump are found in Appendix F. The crew configuration for dewatering is included in Appendix E. The model uses the same procedure for calculating labor costs as described for the utilities-handling activity. In doing so, it assumes that the duration of the dewatering activity is equal to the duration of the excavation, support, and structure activities.

7.3 DEEP WELLS

Deep wells are used to lower the water table in the ground. Each well contains a submersible pump whose size is determined as described above. The pump is placed near the bottom of a pipe (6 inches, 10 inches, or 18 inches in diameter, depending on the water inflow). The wells are placed at 100-foot intervals. The cost of dewatering using deep wells therefore depends on the number of wells, their depth, and the water inflow, and is calculated for each geological stratum by means of the following equations:

Cost of pipe = $C_i \times L$

Cost of pump = P_i

Cost of excavation = $W \times L$

where, i = 1, 2, or 3 = slight, moderate, or heavy water inflow

C_i = cost per lineal foot of a 6-inch, 10-inch, or 18-inch diameter pipe (see Appendix H)

L = depth of well in feet within geological stratum (see Appendix B, Section 9)

P_i = cost of a 2-inch, 4-inch, or 6-inch submersible pump (see Appendix F)

W = cost per lineal foot of well excavation (see Appendix I)

The sum of these costs is multiplied by the number of wells. The number of wells is calculated using the equation: $\frac{\text{excavation width}}{100} \times \frac{\text{excavation length}}{100}$.

7.4 GROUND SOLIDIFICATION

This classification covers all techniques used to modify some characteristic of the soil (strength, permeability, etc.). These methods are site-specific, and are used to facilitate the excavation and support process, to minimize the need for underpinning, and to improve water conditions. Three techniques are commonly employed: chemical grouting, cement grouting, and to a limited extent, freezing. Grouting is used when the permeability of the soil is high (thus allowing for heavy water inflow) or when the soil needs to be strengthened. Cement, bentonite, or chemical gel is generally injected into the soil's intergranular voids. The lump sum cost of both types of grouting is expressed per cubic yard of soil mass to be treated (see Appendix I). The volume of soil mass to be treated can be found in Appendix B, Section 9. Freezing of the ground is rarely done because it involves placing a network of pipes and circulating a refrigerant through them. The water in the soil then freezes and the soil becomes a cohesive icy mass. Freezing does not usually work with coarse-grained soils which are below the water table. The cost of freezing the groundwater is determined in the same manner as it is for grouting. Ground improvement was also discussed in Section 6, Building Protection. When estimating total costs, care must be taken not to duplicate the time and expense entailed in this activity.

8. EXCAVATION AND SUPPORT

8.1 INTRODUCTION

This chapter explains the procedure for costing two major components of the construction of any subway station, namely, the excavation and ground support activities. Excavation includes the extraction of the soil, the lifting of the muck to the surface, and the hauling of the muck to the dump. Ground support includes the ground wall support system (e.g., soldier piles and lagging) and the type of bracing.

8.2 EXCAVATION

To estimate the cost of excavation, the user must input values to the model for the following variables:

1. the type of soil to be excavated
2. the extent of water inflow (and its associated dewatering requirements)
3. the depth of the excavation (i.e., top lift or bottom lift)
4. the bracing requirements

There are 28 possible combinations of the various values for these variables (see Appendix C), each of which defines a unique excavation operation with unique requirements for labor and equipment, plus a typical advance rate (daily progress rate). The requirements attending each excavation operation are defined in Appendix J. Using the advance rate and the volume of soil to be excavated, the model computes a duration for the excavation. This duration is used to estimate the cost of labor (same method as described in previous chapters) and the cost of equipment (depreciation rates in Appendix D).

8.3 MUCK HANDLING

There are four parts to the muck handling process: lifting the muck from the bottom of the excavation to the surface, hauling the muck from the construction site to the dump, dumping and reworking muck at the dump site, and the dumping fee.

Lifting can be accomplished by: (1) a direct vertical lift (i.e., either a crane with muck car and excavator, or a clamshell), or (2) an access ramp by which trucks can reach the bottom of the excavation and be loaded there. The contractor indicates his preference by means of an input variable in Appendix B, Section 10. The cost of lifting via an access ramp consists of a one-time cost for construction of the ramp; the cost of removing the muck by truck from the bottom of the excavation is included in the cost of hauling.

The cost per ton of ramp construction is treated as a lump sum figure by the model and can be found in Appendix I. This figure is multiplied by the tonnage of crushed stone required for the ramp (see Appendix B, Section 10) to produce the total cost of muck lifting. The cost of lifting via a crane, muck car, and excavator consists of an equipment component and a labor component. The costs of a 100-ton crane, muck car, and excavator are extracted from Appendix F. The labor cost is derived using the same procedure described in Chapter 5: the crew composition for muck lifting is located in Appendix E and the duration of the muck lifting activity is assumed equal to the duration of the excavation. The cost of lifting via a clamshell also consists of an equipment component and a labor component. The cost of a clamshell is obtained from Appendix F. The procedure for calculating the labor cost is again the same, but in this case there is only one person on the crew, a crane operator.

The cost of hauling muck is the cost per mile of transporting one cubic yard of muck (see Appendix I) multiplied by the effective volume of muck generated, then multipied by the mileage between the dump site and the construction site. The effective volume of muck is 1.5 times the volume of the station (1.8 for rock). The distance between the dump site and the construction site is given in Appendix B, Section 10.

The cost per cubic yard of dumping and reworking muck at the dump site is also found in Appendix I. It is multiplied by the effective volume of muck to produce the total cost of dumping and reworking. The dumping fee, if any, is just a lump sum figure. The user tells the model whether the dumping fee is non-existent, small, medium, or large (see Appendix B, Section 10). The corresponding cost per cubic yard is extracted from the lump sum costs data file and multiplied by the effective volume of muck.

8.4 GROUND WALL SUPPORT SYSTEM

Of all the activities in cut-and-cover construction, the ground wall support system is probably the most critical from a technical and financial point of view. The decision regarding installation of ground wall support is an important one; it should take into account the following considerations: the cost and duration of the installation, the financial impact on other activities (excavation, bracing, underpinning, structure, etc.), the impact on utilities, the compatibility with dewatering requirements, the nature of the soil (e.g., standup time), and so forth. Taking into account all of these factors is clearly a difficult if not infeasible task. Consequently, the model assumes that the type of ground wall support is a parameter provided by the user. That is, the model does not attempt to formulate a decision about the type of ground wall support system based on the factors listed above. However, it does help the user make a good decision concerning the ground wall support system in the following manner: if different types of ground wall support systems are specified by the user, the model computes their respective costs as well as the costs of factors associated with them (e.g., bracing). The user can then use these figures to choose the least costly option. This procedure is generally what occurs. The decision concerning the ground wall support system is left to the contractor. He uses certain design criteria and cost figures, together with his own judgment to come up with the expected least expensive alternative.

To recap, the user specifies the type of ground wall support system: soldier piles and lagging, steel sheet piles, or slurry walls (concrete cast-in-place). He also specifies the geometric features of the ground wall support system (depth, width, length, etc.), the strength of the piling (if steel or concrete), the reinforcing requirements for slurry walls, and the size of wood lagging. In addition, he must specify the type of soil, the water conditions, and whether or not utilities are present.

All of these parameters affect the installation rate of the ground wall support system. Typical advance rates for the three types of ground wall support systems are found in Appendix J. The model utilizes these advance rates and the geometric features of the walls specified by the user to compute a duration for the operation. This duration, together with the crew configurations and lists of equipment also provided in Appendix J, are used in costing the labor and equipment. The labor costing procedure is the same as described previously, and the equipment costing procedure consists of extracting the appropriate unit costs from Appendix F and then applying to them the depreciating rates in Appendix D. Materials costs can also be computed since the types, amounts, and unit costs are readily available in Appendices B, H, and J.

8.5 BRACING

Bracing is effectively a part of the ground wall support system. The bracing system and the ground wall support system should be compatible in all aspects and together should minimize the cost and disruption of the actual construction effort.

The first level of bracing is actually the decking. Only one type of decking is considered by the model, 36-inch steel beams with 12-inch wide wood lagging. The cost of decking installation is computed as follows: the user specifies the length of the decking, the width of the decking, and the number of steel beams (Appendix B, Section 9). This data and the advance rate in Appendix J are used to compute a duration for the operation. This duration determines the cost of labor given the crew configuration in Appendix J and the cost of equipment usage given the type of equipment in Appendix J, according to the same procedures described above. The cost of materials is found by tapping the material costs data file and multiplying the relevant unit costs by the weight of steel beams and square feet of wood lagging. The weight of the beams in pounds is calculated as length of decking x number of beams x 74 lbs/ft of beam. The square feet of wood lagging equals the length of decking x width of decking.

After the decking is installed, bracing may still be required. The user specifies at this stage whether or not bracing is required, and the size, number, and type of bracing (cross bracings or tiebacks). For each type of bracing there is a unique advance rate, crew configuration, and equipment list provided in Appendix J. The model uses the input data and appropriate advance rate to compute the duration of the operation, and then follows the same procedure that was used for decking to estimate the cost of labor and equipment for bracing. The total weight of cross bracings in pounds is equal to 1.7 x length of decking x lbs/ft of cross bracing x number of cross bracings (the last three factors are input variables). The material cost for cross bracings is determined by multiplying their total weight by the unit cost of structural steel from Appendix H. The material cost for tiebacks is computed as length of tieback x number of tiebacks x cost per foot of tiebacks from Appendix H.

9. STRUCTURE

9.1 INTRODUCTION

The cost of a cut-and-cover station structure is computed by the model as a function of its size and design configuration. The model considers three basic design configurations: 1) mezzanine separate from trainroom and at street level, with side platforms; 2) mezzanine separate from trainroom and at platform level, with side platforms; and 3) mezzanine within trainroom and above platform level, with a center platform. Given the design configuration and the appropriate size specifications for the station structure, the model deduces the number and dimensions of its component parts (i.e., intermediate slabs, platforms, base, etc.). Each component part is individually analyzed, and the resultant cost estimate is combined with the cost estimates for all other component parts in order to produce an aggregate cost estimate for the entire station structure.

9.2 COMPONENTS OF THE STATION STRUCTURE

The model breaks down a cut-and-cover station structure into a maximum of nine structural components, depending upon the design configuration and the size specifications which the user provides as input:

1. Base
2. Permanent walls
3. Intermediate slabs
4. Roof girders
5. Roof
6. Rectangular columns
7. Circular columns
8. Platforms
9. Vertical circulation elements

Each component is listed in Appendix J, together with a brief set of "typical" specifications (dimensions, strength of concrete, etc.). Beneath each component is listed the sequence of standard operations comprising it, such as placement of reinforcing steel, placement of formwork, and casting of concrete. For each operation, Appendix J provides the advance rate, as well as the crew configuration and equipment needed to construct the "typical" component. The model assumes that the crew configuration and equipment needed for an operation never vary. Hence, if a user of the model indicates that a particular component is larger or smaller than the typical case, the model assumes that the same crew configurations and equipment are used nonetheless and that, instead, the duration of each operation is increased or decreased as appropriate. Material quantities are computed by means of the size specifications provided by the user in Appendix B.

9.3 COSTING OF THE STATION STRUCTURE

The cost of a station structure is determined by summing the costs of its structural components. The model deduces the type, number, and size of each of the nine structural components based upon the user's input in Appendix B, Section 6. A component consists of a sequence of operations and its cost is calculated by summing the costs of the labor, materials, and equipment needed to perform all of the operations.

The model's first step is to compute the duration of each operation on the basis of the input data in Appendix B and the advance rates in Appendix J. The advance rate for each operation is expressed in terms of a unit of measure per day. The duration of the operation is calculated by dividing the advance rate into the number of pounds of steel, the square footage of formwork, the cubic yards of concrete, or whatever is appropriate to the operation (the paragraph below dealing with materials discusses how this latter figure is computed). The duration is subsequently used in the labor and equipment cost calculations.

The equipment used in each operation is given in Appendix J. The model costs this equipment by extracting the unit price of each type of equipment from the equipment costs data file in Appendix F. This cost is then reduced according to the write-off value for the particular piece of equipment, which is found in Appendix D, Equipment Write-off Values.

The materials used in each operation are derived from the data in Appendix B, Section 6. Most of the materials fall into five basic categories:

- cubic yardage of concrete

- square footage of formwork
- number of pounds of reinforcing steel
- number of pounds (tons) of girders for the roof
- number of elevators, escalators, and stairways

The cubic yardage of concrete for a particular operation is computed by multiplying together the structural component's length, width, and thickness, as input to the model by the user. Similarly, the square footage of formwork is computed by multiplying together the length and the width of the particular structural component. The number of pounds of reinforcing steel per cubic yard of concrete is provided by the user to the model for each structural component. The model multiplies this figure by the component's cubic yardage of concrete, as calculated above, in order to produce the total number of pounds of reinforcing steel required. The user supplies the model with two pieces of information regarding roof girders, the size of the girders (depth and lbs/ft) and the distance between girders. Given this data and the roof's dimensions, the model calculates the total weight of the roof girders. The number of stairways (both normal and emergency), the number of escalators, and the number of elevators are user-inputted variables.

Once the appropriate material quantities for each operation are determined, they are used to compute costs: each material item's unit price is extracted from the material costs data file in Appendix H and multiplied by the quantity required to produce the total cost of that material for the particular operation.

In order to calculate the labor cost of an operation, the model utilizes the same procedure described in Chapter 5.

10. MECHANICAL AND ELECTRICAL SYSTEMS

10.1 MECHANICAL

Contractors engaged in mechanical work for subway stations begin their normal estimating procedure by first taking off the job (evaluating the quantities of each type of labor, equipment, and materials element required to complete the job as specified in the M-series plans). After evaluating the quantities of each work element, unit prices are applied to produce direct costs. These are added to subcontracting costs and indirect costs (burden costs) to yield the total cost of mechanical work.

Typically, estimating the cost of mechanical work proceeds as follows:

Labor is listed by trade. There are three labor trades typically performing mechanical work:

- Sheet metal workers
- Piping workers
- Plumbers

Equipment for mechanical work is broadly assigned to two categories:

- HVAC (Heating, Ventilation, and Air Conditioning)
- Plumbing

Materials costs reflect actual costs plus hauling and taxes.

Subcontracted work includes testing, balancing, automatic control systems, rigging, etc. Burden costs are determined by labor trade category, and they include shop and field labor fringe benefits, project planning and control, and travel expenses.

The model simulates this process by subdividing mechanical work into physical components (e.g., air handling system, drainage system, fire protection system, etc.). See Appendix C for the mechanical work breakdown tree.

Each work component consists of several elements. For example, the air handling system is subdivided into fans, hangers, ductwork, and fittings. Each of these elements is further specified in Appendix B, Section 6 in terms of type and size, when applicable. For example, pipes carrying water (for drainage or fire protection purposes) can be fabricated from either steel or copper, with diameters ranging between ½ in and 8 in.

Finally, for each type and size of element, the model selects the appropriate lump sum cost from the lump sum costs data file (Appendix I). This cost includes labor, materials, and equipment costs. One should note that, in general, mechanical work is subcontracted and thus its total cost reflects the subcontractor's overhead and profit margin. To expedite matters, the model computes only the "true" cost of mechanical work, and assumes that the subcontractor's overhead and profit margin are included in the overall overhead and profit margin component of the job estimate (see Chapter 14).

10.2 ELECTRICAL

The basic goal of the cost estimating methodology is to replicate the contractor's estimating process in order to produce a realistic cost figure. After interviewing several electrical contractors involved in rapid transit work, the following procedure was found to be common to nearly all of them.

The electrical contractor receives a set of E-series plans from the client or the engineer/architect. The contractor's estimating department goes about the task of taking off (measuring) all pertinent information (i.e., length of conduits, number of junction boxes, etc.). After taking off the job, they begin pricing. Here the contractor might use historical cost data compiled in-house, costs quoted by national pricing services (NPS, Blue Book), and/or actual quotes from suppliers and vendors. From this pricing effort, the estimating team derives the total cost of materials and, subsequently, the cost of equipment (generally a minor item).

Concurrent with the pricing effort, labor requirements are computed and the total number of labor hours is determined. This total number of hours and the projected job duration are used in determining crew sizes. Based on the nature of the job and the schedule for electrical work, crew rates are computed. Inflation, escalation, and contingency adjustments are made duing the final stages of bid preparation.

To simulate this estimating process in our methodology, electrical work is subdivided into physical components (e.g., conduits, wiring, fixtures, etc.). See Appendix C for the complete electrical work breakdown.

A few of the components are further subdivided into elements. For example, systems are subdivided into fire, sound, security, and emergency. Furthermore, each component or element is specified in Appendix B, Section 6 in terms of type and size, when applicable.

Finally, for each type and size of component or element, the model selects the appropriate lump sum cost from the lump sum costs data file (Appendix I). This cost includes labor, materials, and equipment costs. One should note that, in general, electrical work is subcontracted and thus its total cost reflects the subcontractor's overhead and profit margin. To expedite matters, the model computes only the "true" cost of electrical work, and assumes that the subcontractor's overhead and profit margin are included in the overall overhead and profit margin component of the job estimate (see Chapter 14).

11. FINISHINGS

Architectural finish work accounts for a significant portion of the cost of a subway station. It is very much a job-specific activity since it depends on the type of structure, the owner's budget, the architect's preferences, etc. Many items can be included in this category, but to make estimating a little easier, we have divided the work into six functional components, namely, masonry, carpentry, metals, doors/windows/glass, moisture protection, and finishes. Each component is further delineated into elements, thereby yielding a better picture of the physical aspects of the work. For example, masonry is subdivided into three types (any of which could occur alone or together with other types): brick, block and tile, and stone work. To estimate the cost of brick work, the user must input to the model the square footage of brick work to be installed (Appendix B, Section 6). The model uses this figure and the lump sum cost per square foot of brick work installation found in Appendix I to come up with an expected cost. The same procedure is followed to cost out all components of the finishings activity. Appendix B, Section 6 Computer Input Terms, contains a list of the required inputs, and Appendix I contains the lump sum unit costs needed to do the costing.

12. BACKFILL AND RESTORATION

12.1 INTRODUCTION

Backfilling, utilities relocation, resurfacing, and landscaping are all part of the final restoration process occurring on the construction site. Utilities relocation is covered in Chapter 5, while resurfacing of streets and landscaping are grouped together as one component, namely, restoration.

12.2 BACKFILLING

Many factors affect backfilling operations, such as the existence of utilities, the removal of decking, the spatial constraints for compacting equipment, and the distance and availability of backfill if the previously excavated material is not up to specifications (the model assumes that the previously excavated material is not the backfill).

The user is required to provide answers to the following questions in Appendix B, Section 3:

- Are there any utilities present, which would slow the rate of production?
- Which method is used (machine or hand)?
- What amounts (cubic yards) of each type of backfill material are used (structural, common, and impervious)?

This information enables the model to select the appropriate backfill operation from Appendix J. Listed in this appendix are the advance rate, the crew configuration, and the type of equipment for the operation.

The model uses the advance rate and the cubic yardage of structural backfill, common backfill, and/or impervious backfill to be placed in order to calculate the duration of the operation. The duration, crew configuration, and labor rates in Appendix G are used to compute the cost of labor. Multiplying the cubic yardage of each type of backfill provided by the user times the corresponding unit cost in Appendix H yields the materials cost. Finally, the model computes the cost of equipment by means of the types of equipment listed for the operation in Appendix J, the unit costs in Appendix F, and the depreciation rates in Appendix D.

12.3 RESTORATION

The restoration component includes the resurfacing of the streets and the landscaping of the site. Resurfacing encompasses four elements: the base course, the pavement, the curbs, and the sidewalks. The base course consists of either crushed stone or bank run gravel. The pavement is either bituminous or concrete paving. Curbs are either asphalt plain berms or concrete berms. Sidewalks are bituminous, brick-on-sand, or cast-in-place concrete. For each of these elements, the user specifies the exact type in Appendix B, Section 3. The user also specifies the size of each element (i.e., volume of base course, length of curbing, and area of pavement and sidewalks). The model multiplies each of these sizes by the corresponding lump sum unit cost listed in Appendix I to produce the cost of resurfacing.

In the same manner, the cost of landscaping is estimated. The user specifies in Appendix B, Section 3 the type of landscaping work to be done, if any: topsoiling and seeding; seeding, some sodding, and shrubs; or extensive landscaping, shrubs, and trees. He also specifies the size of the area to be landscaped. For each type of landscaping work, there is a cost per square yard in the lump sum costs data file. The model selects the appropriate unit cost and multiplies it by the area to be landscaped in order to produce the cost of landscaping.

13. DEMOBILIZATION AND SITE CLEANUP

The cost of site cleanup is estimated via a lump sum figure which can be found in the lump sum costs data file in Appendix I. The model costs the demobilization activity by assuming that its cost is equal to the equipment setup cost (see Section 3.6).

14. MISCELLANEOUS COSTS, OVERHEAD, INTEREST, AND PROFIT MARGIN

14.1 MISCELLANEOUS COSTS

Miscellaneous costs include certain fixed items whose costs the contractor incorporates in his bid. These items, together with their estimated dollar values, are as follows:

Taxes	$100,000
Bonding	0.5 percent of bid
Insurance	2.5 percent of cost
Property Taxes	$100,000
Licenses	$20,000
Dues	$15,000
Contributions	$10,000
Legal	$40,000
Accounting	$40,000
Entertainment	$10,000
Progress Photographs	$10,000
Employee Expenses	$60,000
Travel	$20,000
Employee Relocation	$50,000
Small Tools and Equipment	11 percent of direct labor cost
Maintenance and Repairs	4 percent of direct labor cost
Fuels	6 percent of direct labor cost
Safety, First Aid, and Protective Clothing	1 percent of direct labor cost
Scheduling, Tests, Inspections, Surveys	$150,000

14.2 OVERHEAD

To compute the cost of overhead, the contractor's estimate the total project duration, as well as the crew composition for overhead activities and the associated labor rates (Appendix G), must be determined. The following notations are used:

D = the total project duration in working days, obtained by summing the duration of each of the activities described in the preceding chapters

L_i = daily labor rate, including wages and benefits, for every crew member (i) listed in the crew composition table for overhead in Appendix E

It is understood that the contractor does not maintain a full-size overhead staff at the beginning or the end of a project. Accordingly, the model assumes an effective total duration of overhead activities equal to two months less than the total duration of the project.

$D_O = D - 40$ (1 month = 20 working days)

The total overhead cost is then computed in the following manner:

$$\text{Overhead Cost (OC)} = D_o \times \sum_i L_i$$

In other words, the overhead cost is equal to the effective duration of overhead activities, in days, multiplied by the daily cost of the entire overhead crew.

14.3 INTEREST

Many factors affect the interest expense which the contractor incorporates in his bid. Such factors include the cost of major pieces of equipment, the payment schedule (i.e., the amount of money retained by the owner during the project and the time differential between the contractor's expenses and the associated payment by the owner), the owner's willingness to reimburse the contractor for mobilization expenses and the amount of such expenses, the project duration, and the current prevailing interest rates. The model computes the interest expense as follows:

$$\text{Interest Cost} = \text{total job cost} \times 2 \times \left(\frac{\text{annual prime rate} + 1}{12}\right) \%$$

The annual prime rate is defined by the user in Appendix B, Section 1.

14.4 PROFIT MARGIN

The profit margin incorporated in a bid is a function of the general state of the economy, the anticipated number of bidders on the project, the number of projects expected to arise in the future, the owner's attitude toward contractors (Is he fair? Does he grant change orders when necessary?), and the risk entailed in the project (Is the geology of the area well known? Are union contracts expected to expire soon? Is the design of the station well detailed?). The model calculates the contractor's profit margin according to the following procedure:

Labor Risk = all labor costs (direct labor including fringe benefits, overhead, and miscellaneous costs)

Profit Margin
- = 45 percent x labor risk (if user specifies an optimistic cost estimate in Appendix B, Section 1)
- = 52 percent x labor risk (if user specifies a most likely cost estimate in Appendix B, Section 1)
- = 60 percent x labor risk (if user specifies a pessimistic cost estimate in Appendix B, Section 1)

GLOSSARY OF TERMS

backfill	refilling of a trench, excavation, or space around foundations and walls.
bouldery till	drift deposited by a glacier and consisting of clay, sand, gravel, and boulders.
breasting	mechanism at the front of a tunnel boring machine (TBM) or shield to hold the face of the excavation.
caulking	the process of stopping up and making tight against leakage by forcing in a sealing substance (caulk).
conduit	pipe or tube for receiving and protecting electric wires or cables (telephone, etc.).
cut-and-cover	station or tunnel constructed in a cut or excavation and covered with material (e.g., earth, paving) after completion.
decking	installation, or materials used in installing, a surface to move on, or work under (under-the-roof construction).
drill jumbo	a traveling carriage, rail- or wheel-mounted, for mounting drills for tunnel driving.
faulted rock	rock with faults, or with fractures accompanied by a displacement of one side of the fracture with respect to the other and in a direction parallel to the fracture.
floating crown bars	same as forepoling, but driving sheathing into the ground.
folded rock	rock patterned in folded layers.
forepoling	excavating the ground by driving poles into the ground ahead of the excavation face.
forklift	machine for lifting heavy objects by inserting a row of steel fingers under the load and lifting vertically.
formwork	a set of wooden or metallic forms in place for the reception of concrete.
grouting	the process of applying or using grout, a thin mortar fluid poured or sprayed under pressure. Grout is used mainly to fill in spaces between tunnel lining and the surrounding earth.
heading engineer	an engineer/surveyor directing the tunnel heading direction.

jointed rock	rock with fractures or cracks that are not accompanied by dislocation but are generally arranged in a systematic pattern.
lagging	planking erected to prevent cave-ins in excavations by supporting the soil.
load-haul-dump	truck/loader especially designed for mucking operations.
massive rock	rock having no regular form but not necessarily being without a crystalline structure (e.g., sandstone).
muck	material removed in the process of excavating or mining.
poling hood	mechanism used to support the face/sides of an excavation when digging by sections, and to protect workers.
powderman	one whose work is to set the dynamite (powder) charge and blast.
shotcrete	a mixture of cement, sand, and water applied by pneumatic pressure.
skip-cage	caged car mounted on wheels, rails, or vertical shafts for carrying men or materials.
slurry	a stable suspension of powdered bentonite in water used to keep the excavation stable while concrete is poured in to form the wall.
soil-grouted	grouting in a soil-earth environment.
soldier piles	long slender poles of timber, steel or concrete driven into the ground to resist a lateral force, water and earth pressure, or to carry vertical loads.
steel sheet piles	steel boards driven into the ground to form a wall retaining the side of the excavation.
tiebacks	metallic bars/rods tied to the back of the retaining wall of an excavation, and held at the other end by the pressure of the ground.
track mucker	rail-mounted machine that removes soil from the face of the tunnel and dumps it onto trucks, conveyor belts, etc., for final muck hauling out of the excavation.
trenching	excavating a long narrow cut in the ground.
underpinning	the material and construction used to support properties adjacent to the construction site.

APPENDIX A

GEOLOGICAL CLASSIFICATIONS

A station site can be broken down into one, two, or three strata to denote its macro-geology:

1 = Rock
2 = Soft Ground
3 = Mixed Ground

If a station were constructed entirely in rock, then there would be only one stratum (rock). Similarly, if the general geology of the site were either all soft ground or all mixed ground, then there would also exist only one stratum. If the geology of the site were to evolve from soft ground to mixed ground, then there would be two strata (soft ground, mixed ground), and so on. Each stratum is defined in terms of the detailed geological classifications into which it falls. The possible detailed geological classifications within each type of stratum are as follows:

	<u>Rock</u>
Rock strength	1 = decomposed 2 = soft 3 = medium 4 = hard
Geological structure	1 = massive 2 = slightly faulted or folded 3 = moderately faulted or folded 4 = intensely faulted or folded
Joint pattern	1 = very closely jointed 2 = closely jointed 3 = moderately jointed 4 = moderate to blocky 5 = blocky to massive 6 = massive
Joint condition	1 = tight or cemented 2 = slightly weathered or altered 3 = severely weathered, altered, or open
Abrasiveness	1 = low 2 = medium 3 = high

Soft Ground

1 = Uniformly soft and compact ground

2 = Soft clay

3 = Firm clay

4 = Stiff, cohesive clay

5 = Running sand, silt, and gravel

6 = Cohesive sand, silt, and gravel

7 = Cemented sand, silt, and gravel

8 = Uncemented sand, silt, and gravel below water

9 = Bouldery till

Mixed Ground

Vector containing 2 elements (x, y),

where x = soft ground classification (1-9)
and y = rock strength classification (1-4)

Several items of data are delineated on a stratum-by-stratum basis. These items include groundwater inflow and methane gas problems. The model evaluates the user input data and determines appropriate construction procedures for each geological stratum.

APPENDIX B

COMPUTER INPUT TERMS

This glossary contains those terms which are required of the user or computed by the model in its evaluation of cut-and-cover station operations. It covers the spectrum of what we believe to be the important factors affecting costs. Refer to Section 2 for a full explanation of this appendix.

COMPUTER INPUT TERMS

1. General

Field Name (12-Char.)	Unit of Measure	Description
LOCATION	city (1-22) SR	A number representing a city: 1 = Atlanta, 2 = Baltimore, 3 = Boston, 4 = Chicago, 5 = Cleveland, 6 = Denver, 7 = Detroit, 8 = Houston, 9 = Los Angeles, 10 = Miami, 11 = Milwaukee, 12 = Minneapolis, 13 = New Orleans, 14 = New York, 15 = Oakland, 16 = Philadelphia, 17 = Pittsburgh, 18 = Portland, 19 = San Francisco, 20 = Seattle, 21 = St. Louis, 22 = Washington, D.C.
STARTDATE	Julian date CR	Start date of construction
DURATION	days SR	Duration of contract
COSTBIAS	1-3 SR	Bias of cost estimate: 1 = pessimistic, 2 = optimistic, 3 = most likely
ATTITUDE	1-3 SR	Owner attitude toward change orders: 1 = fair (owner grants justifiable change orders), 2 = unpredictable (owner vacillates between being fair and being unfair), 3 = unfair (owner refuses to grant justifiable change orders, thereby forcing contractor to resort to filing a claim in court)
LIABILITY	1-3 SR	Amount of legal liability placed on contractor through designer's specifications and changed conditions clauses: 1 = low (contract stipulates that owner will pay additional expenses arising from unexpected geological conditions or other unforeseen circumstances), 2 = medium (contract stipulates that owner will pay some of the additional expenses arising from unforeseen circumstances), 3 = high (contract places the financial responsibility for unforeseen circumstances upon the contractor)

COMPUTER INPUT TERMS

1. General (continued)

Field Name (12-Char.)	Unit of Measure	Description
REIMBURSE	1-3 SR	Owner willingness to reimburse contractor for partial completion of work: 1 = low (owner is unwilling to pay contractor anything for work activities until they have been completed), 2 = medium (owner is sometimes willing to make partial payments to contractor for work activities that are partially complete), 3 = high (owner is willing to make partial payments to contractor for work activities that are partially complete, recognizing the fact that the contractor incurs expenses at the outset of an activity for which he deserves to be reimbursed at that point in time)
INFLATION	%/year SR	Inflation rate
INTEREST	%/year SR	Interest rate on construction loans (national prime rate)
ECONOMY	1-3 SR	Economic climate within subway station construction industry: 1 = poor (there are few current or anticipated subway station jobs in the U.S.), 2 = fair (there are some current and/or anticipated subway station jobs in the U.S.), 3 = good (there is a good number of current and anticipated subway station jobs in the U.S.)
BIDDERS	bid SR	Anticipated number of bidders
RENEGOTIATE	% of contract complete SR	Expected timing of union contract re-negotiations as a percentage of contract completion
SHIFTNUMBER	1-4 SR	Number of work shifts per day: 1 = one 8-hour shift 2 = two 8-hour shifts 3 = two 10-hour shifts 4 = three 8-hour shifts

Note:
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COMPUTER INPUT TERMS

2. Community Constraints

Field Name (12-Char.)	Unit of Measure	Description
INSULATE	y or n CR	Contractor must insulate surface equipment for noise (yes or no)
CLOSERAMPS	y or n CR	Access ramps must be closed when not in use (yes or no)
OPERATIONHRS	1-3 SR	Hours of operation: 1 = always prohibit operation between 10 p.m. and 7 a.m., 2 = prohibit operation between 10 p.m. and 7 a.m. when drilling-and-blasting, 3 = allow operation between 10 p.m. and 7 a.m. without restriction
DRILLNBLAST	1-5 SR	Limitations on drill-and-blast: 1 = drill-and-blast not allowed, 2 = drill-and-blast allowed daytimes only, and limited to 4-foot cycles, 3 = drill-and-blast allowed daytimes only, and limited to 10-foot cycles, 4 = drill-and-blast allowed day and night, and limited to 4-foot cycles, 5 = drill-and-blast allowed day and night, and limited to 10-foot cycles
STOCKPILE	y or n CR	Contractor allowed to stockpile dynamite (yes or no)

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COMPUTER INPUT TERMS

3. Construction Site Conditions

Field Name (12-Char.)	Unit of Measure	Description
GENSITEWORK	1-3 SR	General requirements for snow removal; rodent, insect, and odor control; street cleaning; etc.: 1 = minimal, 2 = moderate, 3 = extensive
CONGESTION	1-6 SR	Congestion surrounding construction site: 1 = open spaces and industrial neighborhoods, 2 = recreational locations, 3 = residential areas, 4 = institutional developments, 5 = outlying business areas, 6 = central business districts
STORAGEPLACE	miles SR	Distance from materials storage location provided by the owner to contractor work area and to each access ramp (0, if there is sufficient room onsite to store materials)
SURVEILLANCE	1-3 SR	Level of surveillance/security: 1 = light, 2 = medium, 3 = heavy
WORKAREA	sq ft SR	Dimensions of surface area provided by the owner for contractor work area and around each access ramp
SITECLEAR	1-3 SR	Extent of site clearing required: 1 = grass, topsoil, few trees, 2 = some trees, 3 = heavy foliage and trees
SITEAREA	sq ft SR	Square footage of area to be cleared of foliage
PAVEREMOVAL	sq ft SR	Asphalt or concrete pavement, curbing, and sidewalk to be removed
SMALLDEMO	cu ft SR	Volume of 1- or 2-story wood frame buildings to be demolished and removed from site, in cubic feet
MEDIUMDEMO	cu ft SR	Volume of small masonry structures and light commercial buildings to be demolished and removed from site, in cubic feet
LARGEDEMO	buildings SR	Volume of large masonry structures, multi-story buildings, and bridges to be demolished and removed from site, in cubic feet
FENCELENGTH	lineal ft SR	Lineal footage of fencing required

COMPUTER INPUT TERMS

3. Construction Site Conditions (continued)

Field Name (12-Char.)	Unit of Measure	Description
FENCETYPE	1-3 SR	Type of fencing: 1 = 6-foot-high chain link fence, 2 = wire mesh on 4 inch (in) by 4-in posts 8 feet high, 3 = painted plywood (sound barrier type), 4- by 4-in frame 8 feet high
BASETYPE	1-2 SR	Type of resurfacing base course to be installed: 1 = crushed stone, 2 = bank run gravel
PAVEMENTTYPE	1-2 SR	Type of pavement to be installed: 1 = bituminous, 2 = concrete
CURBINGTYPE	1-2 SR	Type of curbing to be installed: 1 = asphalt plain berms, 2 = concrete berms
SIDEWALKTYPE	1-3 SR	Type of sidewalks to be installed: 1 = bituminous, 2 = brick-on-sand, 3 = cast-in-place concrete
BASEAREA	cu yd SR	Volume of resurfacing base course to be installed
PAVEMENTAREA	ft SR	Length of pavement to be installed
CURBINGAREA	ft SR	Length of curbing to be installed
SIDEWALKAREA	sq yd SR	Area of sidewalks to be installed
LANDSCAPTYPE	1-4 SR	Type of landscaping work: 1 = none, 2 = topsoiling/seeding, 3 = seeding, some sodding, and shrubs, 4 = extensive landscaping, shrubs, and trees
LANDSCAPAREA	sq yd SR	Area to be landscaped
BACKFILL	cu yd VR	Amount of structural fill, common fill, and impervious fill used as backfill
FILLMETHOD	1-2 SR	Method of backfilling: 1 = machine, 2 = hand
BACKFILLUTIL	y or n CR	Utilities are in the way of the backfill operation (yes or no)

3. Construction Site Conditions (continued)

Field Name (12-Char.)	Unit of Measure	Description
TRAILERNUM	trailers SO	Number of trailers to be established on construction site
EMPRELOCNUM	employees SO	Number of employees to be relocated to construction site
STATIONSITE	1-4 SR	Location of station: 1 = directly underneath public roadway, 2 = underneath and to one side of public roadway, 3 = under private, purchasable property, 4 = under public but uncongested property
ROADWIDTH	ft SR	If station is located under public roadway, width of road plus adjacent sidewalks
SIDEWALK	ft SR	Minimum sidewalk distance to be maintained for public use during construction (0, if not applicable)
SIGNALREM	signals SR	Number of traffic signals to be removed
OLDSIGNALINS	signals SR	Number of old traffic signals to be installed
NEWSIGNALINS	signals SR	Number of new traffic signals to be installed
TRAFFICOFFCR	officers SO	Number of traffic officers required
TRAFFICTIME	days SO	Duration for which traffic officers are required
TRAFPROBLEM	1-3 SO	Traffic problems due to commercial activity in area, traffic volume, down holes in street, utilities, alignment, concreting, needs of flagmen, detours, and truck access to area: 1 = minimal, 2 = moderate, 3 = extensive

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COMPUTER INPUT TERMS

4. Utilities

Field Name (12-Char.)	Unit of Measure	Description
UTILRELOC	1-4 SR	Extent of utilities relocation: 1 = none, 2 = little, 3 = moderate, 4 = extensive
UTILDISTANCE	ft SR	Minimum allowable distance from buildings along main roadway at which utilities can be placed
SEWAGETYPE	1-2 SR	Type of sewage lines: 1 = gravity dependent lines, 2 = pressurized lines
UTILDIRECT	1-2 SR	Direction in which utility lines run: 1 = parallel to station length, 2 = perpendicular to station length
UTILCROSS	1-3 SR	If utilities run in a parallel direction, are there also cross-utilities extending perpendicularly from the main utilities to connect to buildings bordering station: 1 = none, 2 = cross-utilities connect to buildings on one side of station, 3 = cross-utilities connect to buildings on both sides of station
UTILSTATUS	1-2 VR	For each utility pipe, status of utility: 1 = existing, 2 = new
UTILTYPE	1-5 VR	For each utility pipe, type of utility: 1 = water, 2 = sewage, 3 = gas, 4 = electric, 5 = telephone
UTILDIAMETER	in VR	For each utility pipe, diameter of pipe
UTILMATERIAL	1-5 VR	For each utility pipe, material from which pipe is fabricated: 1 = VCP, 2 = RCP, 3 = CMP, 4 = DIP, 5 = PVC
UTILLENALL	ft VR	For each utility pipe, length of pipe in its entirety
UTILLENSECT	ft VR	For each utility pipe, length of sectional pieces of pipe
UTILHANDLE	1-4 VR	For each utility pipe, procedure for handling pipe: 1 = maintain, 2 = remove, 3 = replace, 4 = relocate
UTILSUPPORT	y or n VR	For each utility pipe, pipe is supported (yes or no)

4. Utilities (continued)

Field Name (12-Char.)	Unit of Measure	Description
UTILDIM	ft MR	For each utility pipe, length, width, and depth of trench
UTILOPENCUT	y or n VR	For each utility pipe, trench is open cut (yes or no)
UTILFILL	1-2 VR	For each utility pipe, trench is filled: 1 = machine, 2 = hand
UTILCOMPACT	y or n VR	For each utility pipe, trench is compacted (yes or no)
UTILBRACE	y or n VR	For each utility pipe, trench is braced (yes or no)
UTILANGLE	degrees VR	For each utility pipe, the angle of repose of the trench
UTILLOC	1-3 SR	Quality of utilities surveys showing locations: 1 = poor, 2 = fair, 3 = good
UTILBRACENUM	bracings VR	If cross bracings used for bracing a trench, number of cross bracings
UTILBRACESIZ	lbs/ft VR	If cross bracings used for bracing a trench; size of cross bracings

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COMPUTER INPUT TERMS

5. Building Protection

Field Name (12-Char.)	Unit of Measure	Description
MONITOR	1-3 SR	Monitoring of settlement, blasting damage, seismic controls, etc.: 1 = minimal, 2 = moderate, 3 = extensive
HISETTLE	structures SR	Number of structures having little tolerance for settlement and deformation
LOSETTLE	structures SR	Number of structures experiencing little (less than 2 in) or no settlement
SOILEXCAV	ft MO	For each pit pier underneath a given structure, the depth of soil to be excavated (if any)
PILELENGTH	ft MO	For each jacked pile underneath a given structure, the length of piling to be installed (if any)
PICKUP	pick-ups VR	The number of pick-ups or other contingency supports (if any) underneath a given structure
GROUTORFREEZ	1-4 VR	The ground consolidation method to be used for each structure: 1 = none, 2 = freezing the soil, 3 = cement grouting, 4 = chemical grouting
SOILCONSOL	cu yd VR	The volume of soil underneath a given structure to be consolidated via grouting or freezing (if any)
BUILDINSURE	1-4 SR	Amount of special insurance for building protection: 1 = none, 2 = small, 3 = medium, 4 = large

Note:

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M = Matrix

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N = Not required of user
O = Optional

COMPUTER INPUT TERMS

6. Station Design

Field Name (12-Char.)	Unit of Measure	Description
STRATNUMBER	strata SR	Number of geological strata (1, 2, or 3)
STRATDEPTH	ft VR	Depth of each geological stratum
STATIONDEPTH	ft SR	Depth from ground surface to top of station
BOXWIDTH	ft SO	Outside width of cut-and-cover box (including vertical circulation areas)
BOXLENGTH	ft SR	Outside length of cut-and-cover box (including vertical circulation areas)
BOXDEPTH	ft SR	Outside depth of cut-and-cover box
BASETHICK	ft SO	Thickness of base of cut-and-cover box
BASESTRENGTH	lbs/ sq in SR	Strength of concrete used for base of cut-and-cover box in pounds per square inch (psi)
BASEREBARNUM	bar no. SR	Rebar number of reinforcing steel used for base of cut-and-cover box
BASEREBARWGT	lbs/ cu yd SR	Weight of reinforcing steel used for base of cut-and-cover box per unit volume of concrete
WALLTHICK	ft SO	Thickness of walls of cut-and-cover box
WALLSTRENGTH	lbs/ sq in SR	Strength of concrete used for walls of cut-and-cover box in psi
WALLREBARNUM	bar no. SR	Rebar number of reinforcing steel used for walls of cut-and-cover box
WALLREBARWGT	lbs/ cu yd SR	Weight of reinforcing steel used for walls of cut-and-cover box per unit volume of concrete

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
ROOFSUPPORT	1-3 SR	Primary means of support for roof of cut-and-cover box: 1 = poured reinforced concrete, 2 = steel girders with poured reinforced concrete, 3 = steel girders with precast reinforced concrete
ROOFTHICK	ft SO	Thickness of roof of cut-and-cover box
ROOFSTRENGTH	lbs/ sq in SR	Strength of concrete used for roof of cut-and-cover box in psi
ROOFREBARNUM	bar no. SR	Rebar number of reinforcing steel used for roof of cut-and-cover box
ROOFREBARWGT	lbs/ cu yd SR	Weight of reinforcing steel used for roof of cut-and-cover box per unit volume of concrete
GIRDERSIZE	depth x lbs/ft VR	If steel girders are used, size of girders
GIRDERDIST	ft SR	If steel girders are used, distance between girders
SLABWIDTH	ft SO	If intermediate slabs are used, width of slabs
SLABTHICK	ft SO	If intermediate slabs are used, thickness of slabs
SLABSTRENGTH	lbs/ sq in SR	If intermediate slabs are used, strength of slabs in psi
SLABREBARNUM	bar no. SR	If intermediate slabs are used, rebar number of reinforcing steel
SLABREBARWGT	lbs/ cu yd SR	If intermediate slabs are used, weight of reinforcing steel per unit volume of concrete
COLUMNS	1-3 SR	Columns erected in middle of cut-and-cover box: 1 = none, 2 = rectangular columns, 3 = circular columns

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
COLUMNDIM1	ft VO	If columns are rectangular, length and width of base of columns
COLUMNDIM2	ft SO	If columns are circular, diameter of base of columns
COLUMNDIST	ft SO	Distance between columns
COLSTRENGTH	lbs/ sq in SR	Strength of concrete used for columns in psi
COLREBARNUM	bar no. SR	Rebar number of reinforcing steel used for columns
COLREBARWGT	lbs/ cu yd SR	Weight of reinforcing steel used for columns per unit volume of concrete
STATIONTYPE	1-3 SR	Type of station: 1 = mezzanine separate from trainroom and at street level, and side platforms, 2 = mezzanine separate from trainroom and at platform level, and side platforms, 3 = mezzanine within trainroom and above platform level, and center platform
PLATWIDTH	ft SO	Width of platform
PLATTHICK	ft SO	Thickness of platform
PLATSTRENGTH	lbs/ sq in SR	Strength of concrete used for platform in psi
PLATREBARNUM	bar no. SR	Rebar number of reinforcing steel used for platform
PLATREBARWGT	lbs/ cu yd SR	Weight of reinforcing steel used for platform per unit volume of concrete
LIGHTINGTYPE	1-3 SR	Type of lighting in station: 1 = incandescent, 2 = mercury, 3 = fluorescent

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
INTENSITY	footcandles SR	Intensity of lighting in station
LIGHTINGDIST	ft SR	Distance between lights in station
NORMSTAIRNUM	stairways SR	Number of stairways for normal use
EMERSTAIRNUM	stairways SR	Number of stairways for emergency use
STAIRLENGTH	ft SR	Length of stairways
STAIRWIDTH	ft SR	Width of stairways
ESCALNUM	escalators SR	Number of escalators
ESCALLENGTH	ft SR	Length of escalators
ESCALWIDTH	ft SR	Width of escalators
ELEVNUM	elevators SR	Number of elevators
REFRIGERATE	y or n SR	Is refrigeration needed as part of the ventilation system (yes or no)?
REFRIGLOAD	tons SR	Capacity (load) of the refrigeration machine
PIPINGTYPE	1-9 SR	Type of piping for refrigeration: 1 = bituminous fiber, 2 = non-reinforced concrete, 3 = reinforced concrete, 4 = corrugated metal, 5 = porous wall concrete, 6 = polyvinyl chloride, 7 = ductile iron, 8 = vitrified clay, 9 = plastic solid wall
PIPINGDIAM	in SR	Diameter of piping for refrigeration
PIPINGLEN	ft SR	Length of piping for refrigeration

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
DRNMATERIAL	cu yd SR	Amount of sub-base drainage material
SMOKEDETECT	detectors SR	Number of smoke detectors
FIREALARM	alarms SR	Number of fire alarms
PIPETYPE	1-5 VR	Type of piping: 1 = brass, 2 = cast iron, 3 = copper, 4 = PVC, 5 = stainless steel
PIPESIZE	in MR	For each type of pipe, diameter in inches
PIPELENGTH	ft MR	For each type of pipe, length in feet
FOUNTAIN	fountains SR	Number of drinking fountains
LAVATORY	lavatories SR	Number of lavatories, wall hung and stainless steel
PUMPTYPE	1-8 VR	Type of pump: 1 = general utility, 15-horse power (HP) four stage; 2 = general utility, 15-HP single stage; 3 = general utility, 15-HP double stage; 4 = fire pump, 500 gallons/minute (GPM); 5 = fire pump, 1000 GPM; 6 = fire pump, 2000 GPM; 7 = fire pump, 3000 GPM; 8 = fire pump, 4500 GPM
PUMPNUMB	pumps MR	For each pump type, the number of pumps
SPRINKLETYP	1-2 SR	Type of sprinkler system: 1 = wet; 2 = dry, exposed piping
SPRINKLERNUM	sprinklers SR	Number of sprinkler heads in system
BOILERTYPE	1-4 VR	Type of boiler, not including flue piping, electrical wiring, gas or oil piping, or base pad: 1 = electric, 2 = gas fired, 3 = oil fired, 4 = gas/oil
BOILERMBH	MBH MR	For each boiler type, the rating in 1000-BTU's per hour (MBH)

COMPUTER INPUT TERMS

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
BOILERNUMB	boilers MR	For each boiler type, the number of boilers
HVUNIT	1-3 VR	Heating and ventilating units: 1 = 750 cubic feet/minute (CFM), 2 = 1250 CFM, 3 = 1500 CFM
HVUNITNUMB	HV units MR	Number of heating and ventilating units of each type
HEATRECOV	1-4 VR	Heat recovery, air-to-air exchanges: 1 = 1000 - 10,000 cubic feet/minute (CFM), 2 = 10,000 - 20,000 CFM, 3 = 20,000 - 30,000 CFM, 4 = above 30,000 CFM
HEATRECOVNUM	exchangers MR	Number of exchangers, for each type
CONDUITTYPE	1-5 VR --	Type of conduit: 1 = aluminium, 2 = rigid galvanized steel, 3 = steel intermediate conduit (IMC), 4 = electric metallic tubing (EMT), 5 = unicouple (EMT)
CONDUITDIAM	in MR	For each type of conduit, diameter in inches
CONDUITLEN	ft MR	For each type of conduit, length in feet
ELBOWTYPE	1-3 VR	Type of elbow: 1 = horizontal, 2 = vertical, 3 = cross
ELBOWWIDTH	in MR	For each type of elbow, width in inches
ELBOWNUMBER	elbows MR	For each type of elbow, number of elbows
CLOSUREWIDTH	in VR	Width of end closures
CLOSURENUM	closures MR	Number of end closures for each width
TEEWIDTH	in VR	Width of tees
TEENUMBER	tees MR	Number of tees for each width

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
RISERWIDTH	in VR	Width of risers
RISERNUMBER	risers MR	Number of risers for each width
FLOORDUCTYPE	1-3 VR	Type of under floor duct: 1 = single, 2 = double, 3 = triple
DUCTSIZE	in MR	For each type of duct, size in inches
JUNCTIONBOX	boxes MR	For each type of duct, number of junction boxes
WIRETYPE	1-3 VR	Type of wire: 1 = copper insulated strand wire, 2 = aluminum insulated strand wire, 3 = copper nylon jacketed wire
WIRESIZE	number MR	For each type of wire, size specification
WIRELENGTH	ft MR	For each type of wire, length of wire in feet
CABLEVOLTAGE	volts VR	Voltage of cables
CABLESIZE	number MR	For each cable voltage, size specification
CABLELENGTH	ft MR	For each cable voltage, length of cable in feet
GROUNDRODTYP	1-3 VR	Type of ground rod: 1 = copper clad, 2 = bare copper wire, 3 = brazed connections
GROUNDRODSIZ	number MR	For each type of ground rod, size specification
GROUNDRODLEN	ft MR	For each type of ground rod, length of ground rod in feet
BREAKERAMP	amps VR	Amperage of circuit breakers
BREAKERNUM	breakers MR	Number of circuit breakers for each amperage rating

COMPUTER INPUT TERMS

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
CIRCUITNUM	circuits VR	Circuit rating (number of circuits) in fuse cabinets
CABINETNUM	cabinets MR	Number of fuse cabinets for each circuit rating
SWTBOARDAMP	amps VR	Amperage of switchboards
SWTBOARDNUM	switchboards MR	Number of switchboards for each amperage rating
SWITCHAMP	amps VR	Amperage of safety switches
SWITCHNUMBER	switches MR	Number of safety switches for each amperage rating
CAPACVOLTAGE	volts VR	Voltage of capacitors
CAPACREACT kilovars	kvar MR	For each capacitor voltage, the reactance in
CAPACNUMBER	capacitors MR	For each capacitor voltage, the number of capacitors
FIXTURETYPE	1-7 VR	Type of lighting fixtures: 1 = recessed fluorescent, 2 = fluorescent industrial, 3 = mercury vapor, 4 = incandescent, 5 = mercury vapor floodlights, 6 = metal halide floodlights, 7 = high pressure sodium floodlights
BULBNUMBER	bulbs MR	For each type of lighting fixture, number of bulbs per fixture
BULBWATTAGE	watts MR	For each type of lighting fixture, wattage of bulbs
FIXTURENUM fixtures	fixtures MR	For each type of lighting fixture, number of
MANHOLEDIM	ft MR	Dimensions of manholes (length, width, depth)
MANHOLENUM	manholes MR	For each set of dimensions, number of manholes

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
FIRESYSZONE	zones VR	Zone rating of fire systems
FIRESYSNUM	systems MR	Number of fire systems for each zone rating
SOUNDSYSTYPE	1-2 VR	Type of sound systems: 1 = intercom with 25 station capacity, 2 = industrial public address system
HANDSETNUM	handsets VR	For each type 1 sound system, the number of handsets
SOUNDSYS1NUM	systems SR	Number of type 1 sound systems
SPEAKERNUM	speakers VR	For each type 2 sound system, the number of speakers
SOUNDSYS2NUM	systems SR	Number of type 2 sound systems
SECURESYSNUM	systems SR	Number of security systems
CONTROLROOM	y or n CR	Existence of a controller room in station (yes or no)
MEZZANINE	sq ft SR	Square footage of mezzanine
TURNSTILENUM	turnstiles SR	Number of turnstiles
TURNSTILETP	1-2 SR	Type of turnstile: 1 = electronic, 2 = mechanical
CHANGEMAKER	1-2 SR	Change-making facility: 1 = machine, 2 = attendant in a booth
TVSYSTEM	TV systems SR	Number of TV monitoring systems for security/surveillance
SECURITYSYS	security systems SR	Number of security alarm and lock systems
PABXPHONE	phone sets SR	Number of telephone sets (PABX) to be installed in station

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
EMERGPHONE	phone sets SR	Number of telephone sets (line-emergency) to be installed in station
SWINGGATE	swing gates SR	Number of swing gates
RAMP	ramps SR	Number of ramps
WATERPROOF	1-3 SR	Type of waterproofing: 1 = concrete, 2 = membrane, 3 = elastomeric
INTMASONRY	1-7 SR	Type of interior masonry: 1 = concrete blocks, 2 = granite blocks, 3 = marble, 4 = limestone, 5 = slate, 6 = acoustical blocks, 7 = brick
FINISHING	1-7 SR	Type of finishing: 1 = dry wall, 2 = acoustical tiles, 3 = painting, 4 = ceramic tiles, 5 = quarry tiles, 6 = metal tiles, 7 = terra cotta
FLOORING	1-4 SR	Type of flooring: 1 = cast-in-place terrazzo flooring, 2 = brick flooring, 3 = resilient flooring, 4 = granite flooring
HEADHOUSE	1-3 SR	Headhouses: 1 = simple, 2 = moderate, 3 = elaborate
SIGNNUMBER	signs SR	Number of signs in station
UPEDUCTLEN	ft SR	Length of exhaust ducts beneath platform
UPEDUCTDIAM	in SR	Diameter of exhaust ducts beneath platform
UPEDUCTTYPE	1-6 SR	Type of exhaust ducts beneath platform: 1 = aluminum alloy, 2 = galvanized steel, 3 = flexible, 4 = stainless steel, 5 = fiberglass, 6 = plastic

COMPUTER INPUT TERMS

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
UPEFANTYPE	1-4 SR	Type of exhaust fans beneath platform: 1 = conventional axial, 2 = in-line centrifugal, 3 = vane-axial, 4 = centrifugal
UPEFANCAP	cu ft/ min SR	Capacity of exhaust fans beneath platform
UPEFANNUM	fans SR	Number of exhaust fans beneath platform
OTEDUCTLEN	ft SR	Length of exhaust ducts above the tracks
OTEDUCTDIAM	in SR	Diameter of exhaust ducts above the tracks
OTEDUCTTYPE	1-6 SR	Type of exhaust ducts above the tracks: 1 = aluminum alloy, 2 = galvanized steel, 3 = flexible, 4 = stainless steel, 5 = fiberglass, 6 = plastic
OTEFANTYPE	1-4 SR	Type of exhaust fans above the tracks: 1 = conventional axial, 2 = in-line centrifugal, 3 = vane-axial, 4 = centrifugal
OTEFANCAP	cu ft/ min SR	Capacity of exhaust fans above the tracks
OTEFANNUM	fans SR	Number of exhaust fans above the tracks
CURDUCTLEN	ft SR	Length of duct-plenum for air curtains
CURDUCTDIAM	in SR	Diameter of duct-plenum for air curtains
CURDUCTTYPE	1-6 SR	Type of duct-plenum for air curtains: 1 = aluminum alloy, 2 = galvanized steel, 3 = flexible, 4 = stainless steel, 5 = fiberglass, 6 = plastic
CURFANTYPE	1-4 SR	Type of fans for air curtains: 1 = conventional axial, 2 = in-line centrifugal, 3 = vane-axial, 4 = centrifugal

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
CURFANCAP	cu ft/ min SR	Capacity of fans for air curtains
CURFANNUM	fans SR	Number of fans for air curtains
IMPFANTYPE	1-4 SR	Type of fans for impulse fan system: 1 = conventional axial, 2 = in-line centrifugal, 3 = vane-axial, 4 = centrifugal
IMPFANCAP	cu ft/ min SR	Capacity of fans for impulse fan system
IMPFANNUM	fans SR	Number of fans for impulse fan system
NOZZLENUM	nozzles SR	Number of discharge nozzles for impulse fan system
DAMPERNUM	dampers SR	Number of dampers for impulse fan system
MASONRY	sq ft VR	Square footage of brick work, block and tile, and stone work to be installed
RIGIDWALL	sq ft SR	Square footage of rigid walls to be installed.
STRUCTMETAL	lbs VR	Weight of structural metals and metal joists
DECKMETAL	sq ft SR	Square footage of metal decking
ORNAMETAL	ft SR	Lineal footage of miscellaneous and ornamental metals
CARPENTRY	board ft SR	Board footage of carpentry work
MOISTPROTECT	sq ft VR	Square footage of waterproofing, insulation, and roofing/siding to be installed
DOORWINDOW	each VR	Number of metal doors and gates, and metal windows

COMPUTER INPUT TERMS

6. Station Design (continued)

Field Name (12-Char.)	Unit of Measure	Description
GLASSGLAZE	sq ft SR	Square footage of glass and glazing
TILETERRAZZO	sq ft VR	Square footage of tile, terrazzo
ACOUSTICAL	sq ft SR	Square footage of acoustically treated areas
FLOORAREA	sq ft SR	Square footage of flooring
INTPAINT	sq ft SR	Square footage of interior areas to be painted
EXTPAINT	sq ft SR	Square footage of exterior areas to be painted
FIREPROOF	sq ft SR	Square footage of areas to be fireproofed

Note: S = Scalar
C = Character string
V = Vector
M = Matrix

R = Required of user
N = Not required of user
O = Optional

COMPUTER INPUT TERMS

7. Shaft Design

Field Name (12-Char.)	Unit of Measure	Description
STATSHAFTNUM	shafts SR	Number of shafts associated with station (0, 1, or 2)
SHAFTDEPTH	ft VR	Depth of each shaft
SHAFTLENGTH	ft VR	Length of each shaft opening
SHAFTWIDTH	ft VR	Width of each shaft opening
SHAFTPURPOSE	1-4 VR	Purpose of each shaft: 1 = access, 2 = fan, 3 = vent, 4 = access and vent
FANNUMBER	fans VR	Number of fans in each fan shaft
FANTYPE	1-4 VR	Type of fans: 1 = conventional axial, 2 = in-line centrifugal, 3 = vane-axial, 4 = centrifugal
FANCAPACITY	cu ft/ min VR	Capacity of fans
AIRFILTER	1-9 VR	Type of air filter: 1 = activated charcoal, 2 = by-pass, 3 = electronic air cleaner, 4 = high efficiency, 5 = medium efficiency, 6 = permanent washable, 7 = renewable disposable, 8 = throwaway glass, 9 = paper media
AIRDUCTLEN	ft VR	Length of air ducts
AIRDUCTDIAM	in VR	Diameter of air ducts
AIRDUCTTYPE	1-6 VR	Type of air ducts: 1 = aluminum alloy, 2 = galvanized steel, 3 = flexible, 4 = stainless steel, 5 = fiberglass, 6 = plastic
AIRDIFFUSER	diffusers VR	Number of air diffusers

Note:
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C = Character string
V = Vector
M = Matrix

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O = Optional

COMPUTER INPUT TERMS

8. Station and Shaft Geology

Field Name (12-Char.)	Unit of Measure	Description
STRATCLASS	1-3 VR	Classification of each geological stratum: 1 = rock, 2 = soft ground, 3 = mixed
SOILCLASS	1-9 MR	Soil classification of soft ground strata: 1 = uniformly soft and compact ground, 2 = soft clay, 3 = firm clay, 4 = stiff, cohesive clay, 5 = running sand, silt, and gravel, 6 = cohesive sand, silt, and gravel, 7 = cemented sand, silt, and gravel, 8 = uncemented sand, silt, and gravel below water, 9 = bouldery till
ROCKSTRENGTH	1-4 MR	Strength of rock strata: 1 = decomposed, 2 = soft, 3 = medium, 4 = hard
ROCKFAULTS	1-4 MR	Geological structure of rock strata: 1 = massive, 2 = slightly faulted or folded, 3 = moderately faulted or folded, 4 = intensely faulted or folded
JOINTPATTERN	1-6 MR	Joint pattern in rock strata: 1 = very closely jointed, 2 = closely jointed, 3 = moderately jointed, 4 = moderate to blocky, 5 = blocky to massive, 6 = massive
JOINTWEAR	1-3 MR	Joint condition of rock strata: 1 = tight or cemented, 2 = slightly weathered or altered, 3 = severely weathered, altered, or open
ABRASIVENESS	1-3 MR	Abrasiveness of rock strata: 1 = low, 2 = medium, 3 = high
MIXEDCLASS	(1-9, 1-4) MR	Classification of mixed ground strata: A 2-element vector (x,y), where x = soil classification of soft ground portion and y = strength classification of rock portion
GROUNDWATER	1-4 MR	Anticipated water inflow within each stratum: 1 = none, 2 = slight (< 200 gallons per minute (gpm)/1000 ft), 3 = moderate (200-1000 gpm/1000 ft), 4 = heavy (> 1000 gpm/1000 ft)
METHANEGAS	1-4 MR	Methane gas problems anticipated within each stratum: 1 = none, 2 = minimal, 3 = moderate, 4 = extensive

Note:
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V = Vector
M = Matrix

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N = Not required of user
O = Optional

COMPUTER INPUT TERMS

9. Station and Shaft Support System

Field Name (12-Char.)	Unit of Measure	Description
GROUNDCNTRL	1-4 MR	Ground control method used below ground level within each stratum: 1 = none, 2 = trenching and pumping, 3 = compressed air, 4 = deep wells
DEEPWELLDPTH	ft MR	If deep wells used for ground control, depth of wells within each stratum
GRNDSOLIDIFY	1-4 SR	Ground solidification technique used at surface: 1 = none, 2 = freezing the groundwater, 3 = cement grouting, 4 = chemical grouting
SOILSOLIDIFY	cu yd SR	The volume of soil to be solidified via grouting or freezing (if any)
SUPPORTLEN1	ft VR	For one of the sides along the station length, the portion supported via slurry walls, the portion supported via soldier piles and lagging, and the portion supported via steel sheet piling
SUPPORTLEN2	ft VR	For the other side along the station length, the portion supported via slurry walls, the portion supported via soldier piles and lagging, and the portion supported via steel sheet piling
BRACETYPE	1-3 SO	Type of bracing: 1 = tiebacks, 2 = cross bracings, 3 = none
PILESIZE	lbs/ft SR	If soldier piles and lagging used for support, size of piles
PILEDISTANCE	ft SR	If soldier piles and lagging used for support, distance between piles
PILENUM	piles SO	If soldier piles and lagging used for support, number of piles
PILEDEPTH	ft SO	If soldier piles and lagging used for support, depth of piles
WOODLAGAREA	sq ft SN	If soldier piles and lagging used for support, area covered by wood lagging
WOODLAGDEPTH	ft SO	If soldier piles and lagging used for support, depth of wood lagging
METALAREA	sq ft SN	If steel sheet piling used for support, area covered by sheet piling

COMPUTER INPUT TERMS

9. Station and Shaft Support System

Field Name (12-Char.)	Unit of Measure	Description
METALDEPTH	ft SO	If steel sheet piling used for support, depth of sheet piling
METALTHICK	in SR	If steel sheet piling used for support, thickness of sheet piling
TIEBACKNUM	tiebacks SO	If tiebacks used for bracing the support, number of tiebacks
TIEBACKPULL	ft SR	If tiebacks used for bracing the support, length of tiebacks
BRACENUM	bracings SR	If cross bracings used for bracing the support, number of cross bracings
BRACESIZE	lbs/ft SR	If cross bracings used for bracing the support, size of cross bracings
SLWALLPERM	y or n CN	If slurry walls used for support, they are incorporated in the permanent structure of the station (yes or no)
SLWALLTHICK	ft SN	If slurry walls used for support, thickness of each section
SLWALLENGTH	ft SO	If slurry walls used for support, horizontal length of each section
SLWALLDEPTH	ft SN	If slurry walls used for support, depth of each section
SLWALLDIST	ft SR	If slurry walls used for support, distance between sections
SLWALLREINF	lbs/ cu yd SR	If slurry walls used for support, weight of reinforcing steel per cubic yard of concrete
DECKBEAMS	beams SR	Number of 36-in steel beams for decking
DECKLENGTH	ft SR	Length of the decking
DECKWIDTH	ft SR	Width of the decking

Note: S = Scalar
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M = Matrix

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N = Not required of user
O = Optional

COMPUTER INPUT TERMS

10. Muck Hauling from Construction Site to Dump

Field Name (12-Char.)	Unit of Measure	Description
HAULVEHICLE	1-3 SR	Muck hauling vehicle: 1 = rubber tire, 2 = diesel-powered rail, 3 = battery-powered rail
PUBLICRAIL	y or n CR	If diesel-powered rail or battery-powered rail, rail is publicly owned (yes or no)
RAILPROTECT	1-3 SR	If publicly owned rail, amount of railroad protection required: 1 = low, 2 = medium, 3 = heavy
DUMPSITEPREP	1-4 SR	Preparation of dump site required: 1 = none, 2 = minimal, 3 = moderate, 4 = extensive
DUMPDISTANCE	miles SR	Distance from dump site to construction site
DUMPFEE	1-4 SR	Size of dump fee: 1 = none, 2 = small, 3 = medium, 4 = large
MUCKLIFTING	1-3 SR	Muck lifting method: 1 = crane with muck car and excavator, 2 = clamshell, 3 = access ramp
RAMPWEIGHT	tons SR	If access ramp used for muck lifting, amount of crushed stone required to build ramp

Note:

S = Scalar
C = Character string
V = Vector
M = Matrix

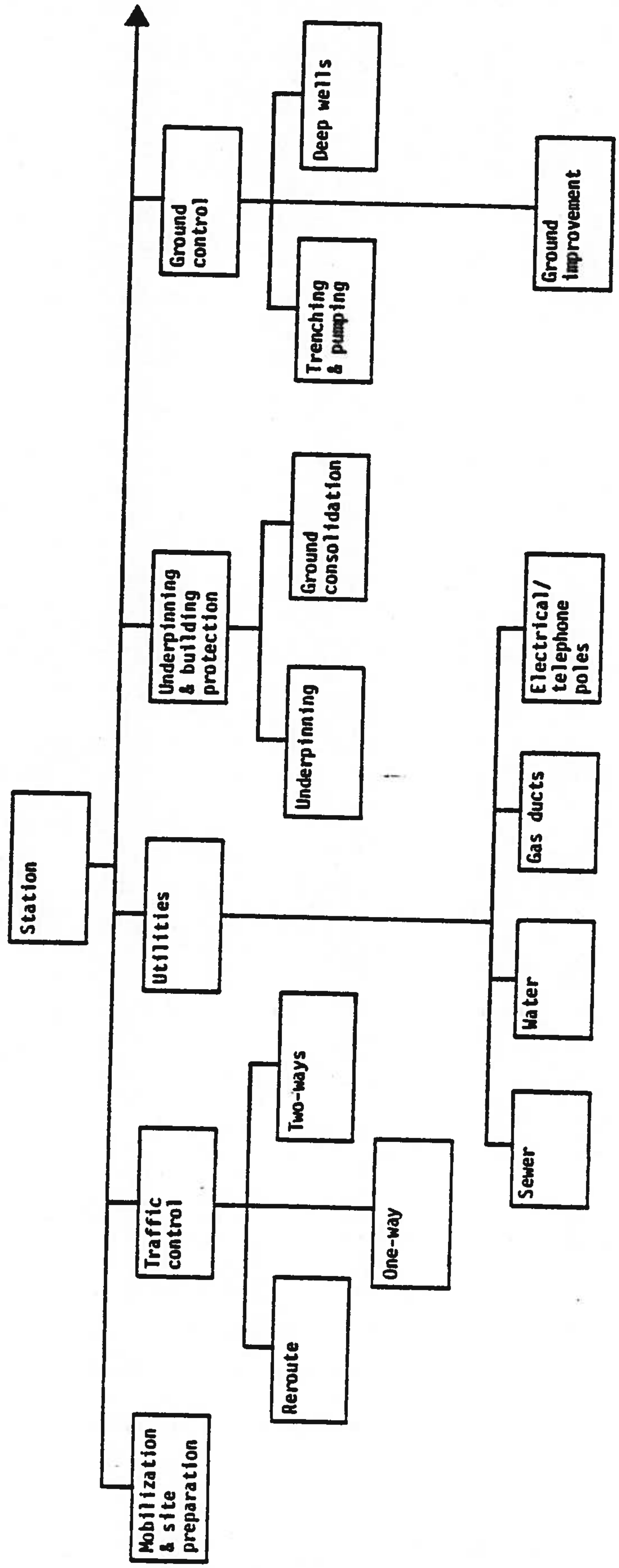
R = Required of user
N = Not required of user
O = Optional

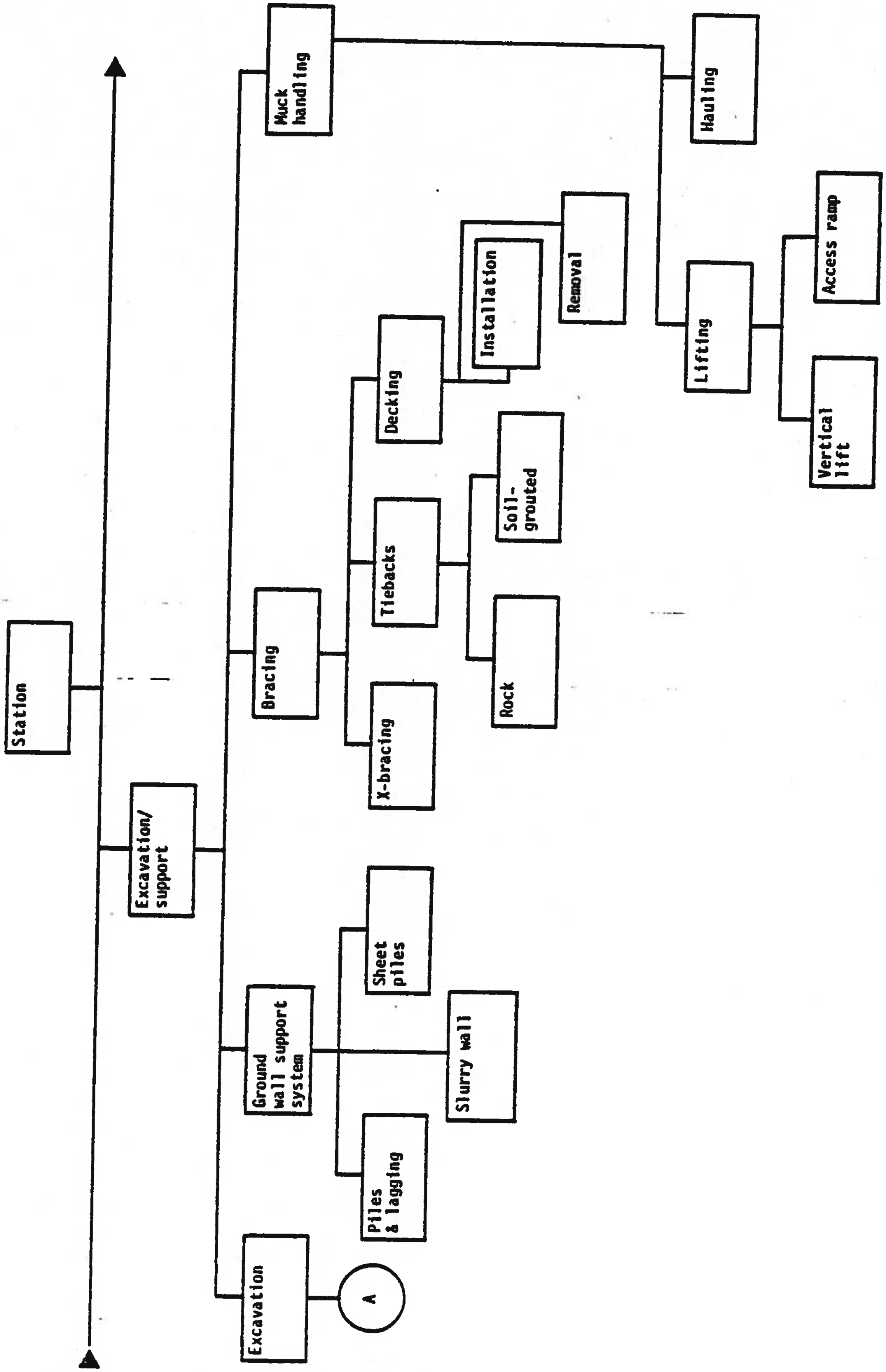
APPENDIX C

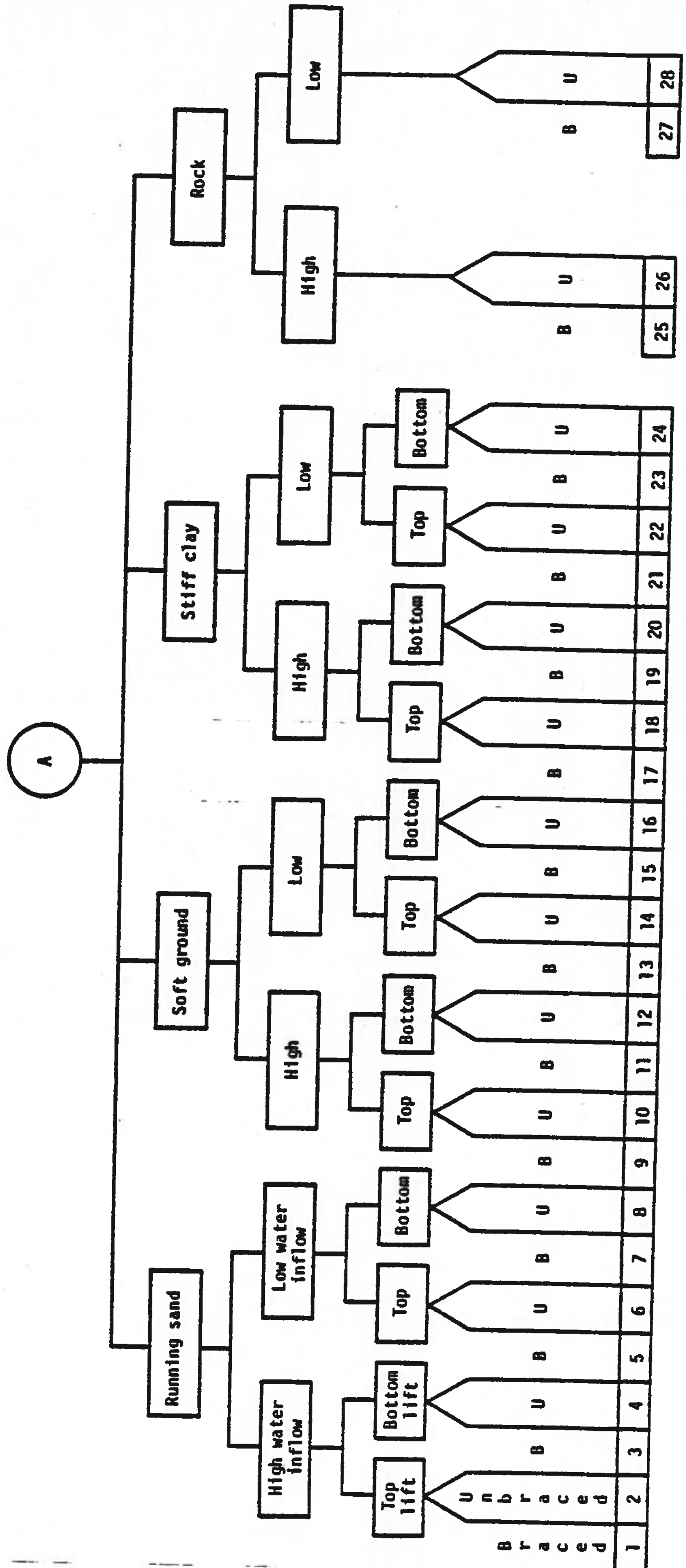
WORK BREAKDOWN TREES

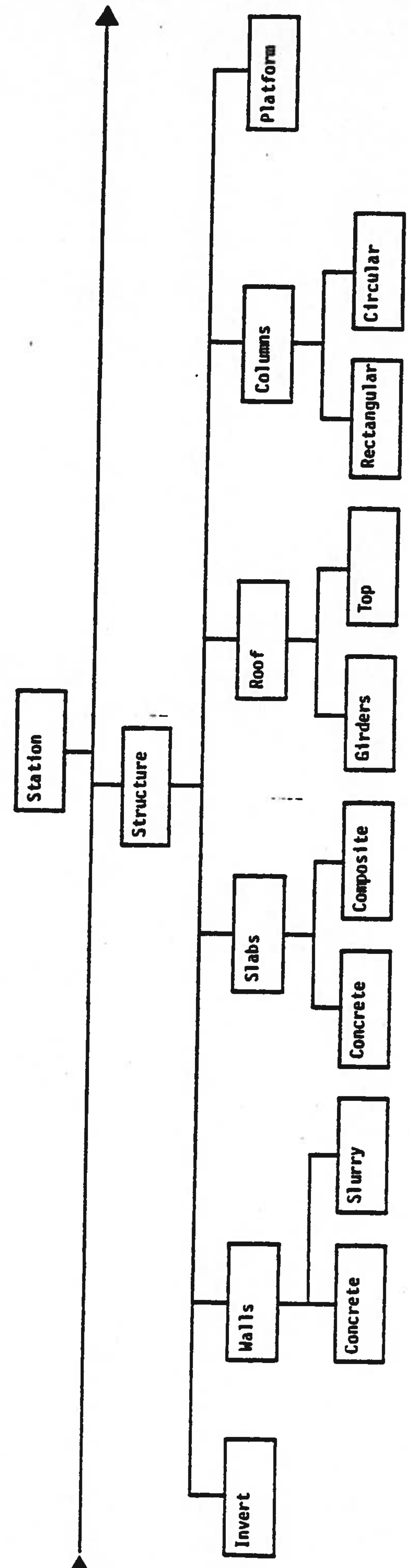
This appendix contains comprehensive flowcharts for all eleven cost components comprising the construction of a subway station.

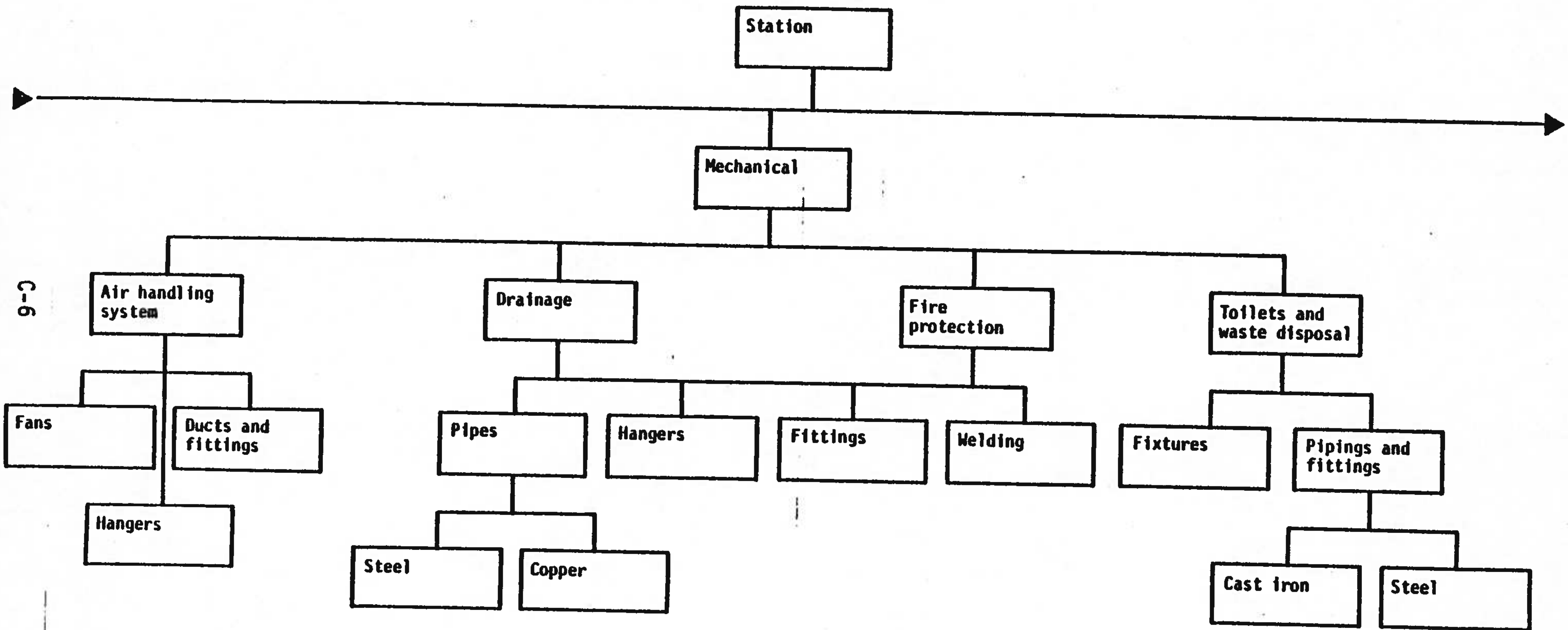
These flowcharts are used in conjunction with the input variables provided in Appendix B to determine the station design and construction methods in detail. These methods translate into a set of operations, which are listed in Appendix J. The model selects the appropriate operations from Appendix J, and uses the accompanying advance rates together with the input variables to calculate the duration of these operations. The total job duration is the sum of the duration of each operation.

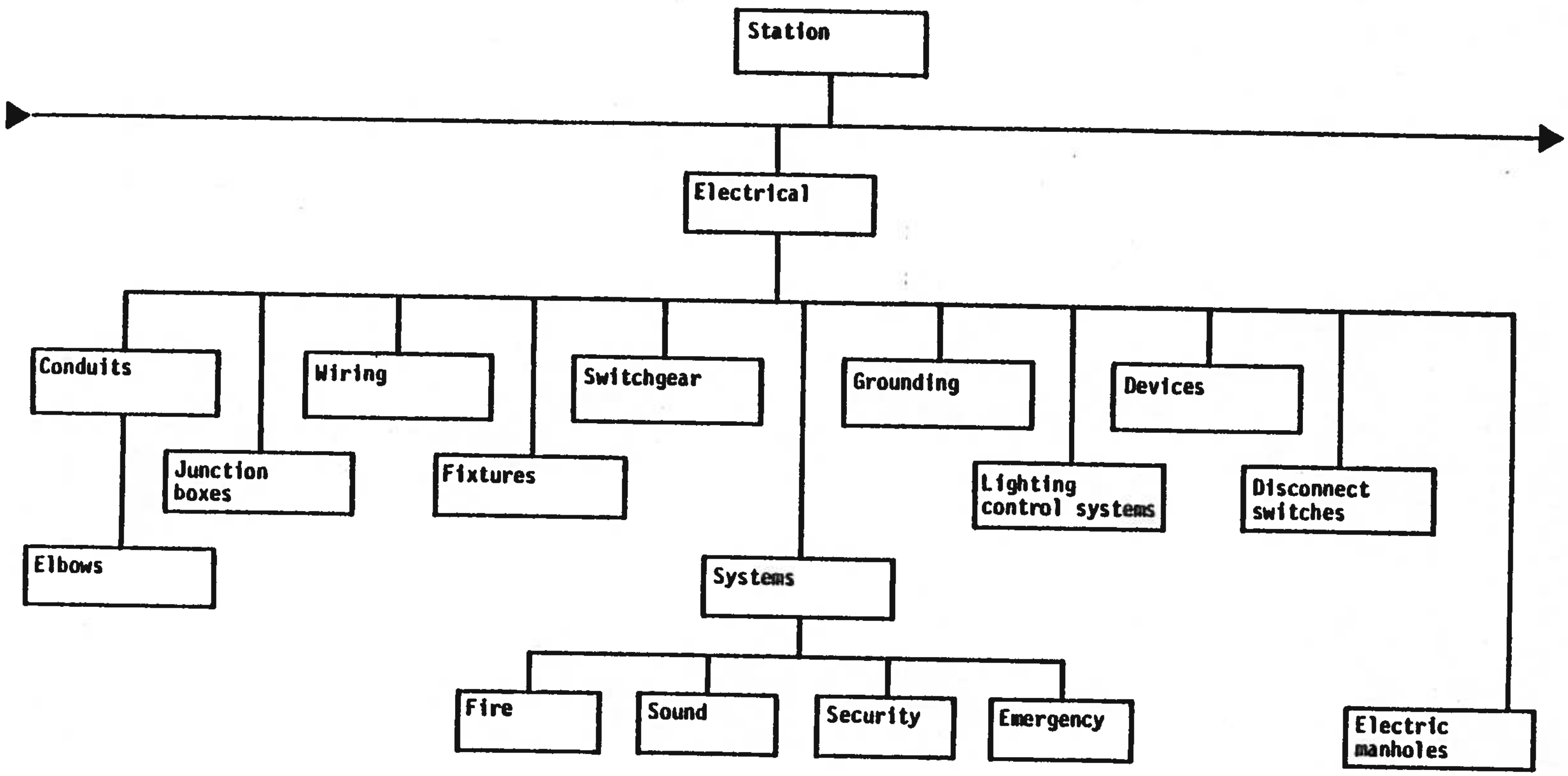

Station
Mobilization & site preparation
Traffic control
Reroute
One-way
Two-ways
Utilities
Sewer
Water
Gas ducts
Electrical/ telephone poles
Underpinning & building protection
Underpinning
Ground consolidation
Ground control
Trenching & pumping
Deep wells
Ground improvement

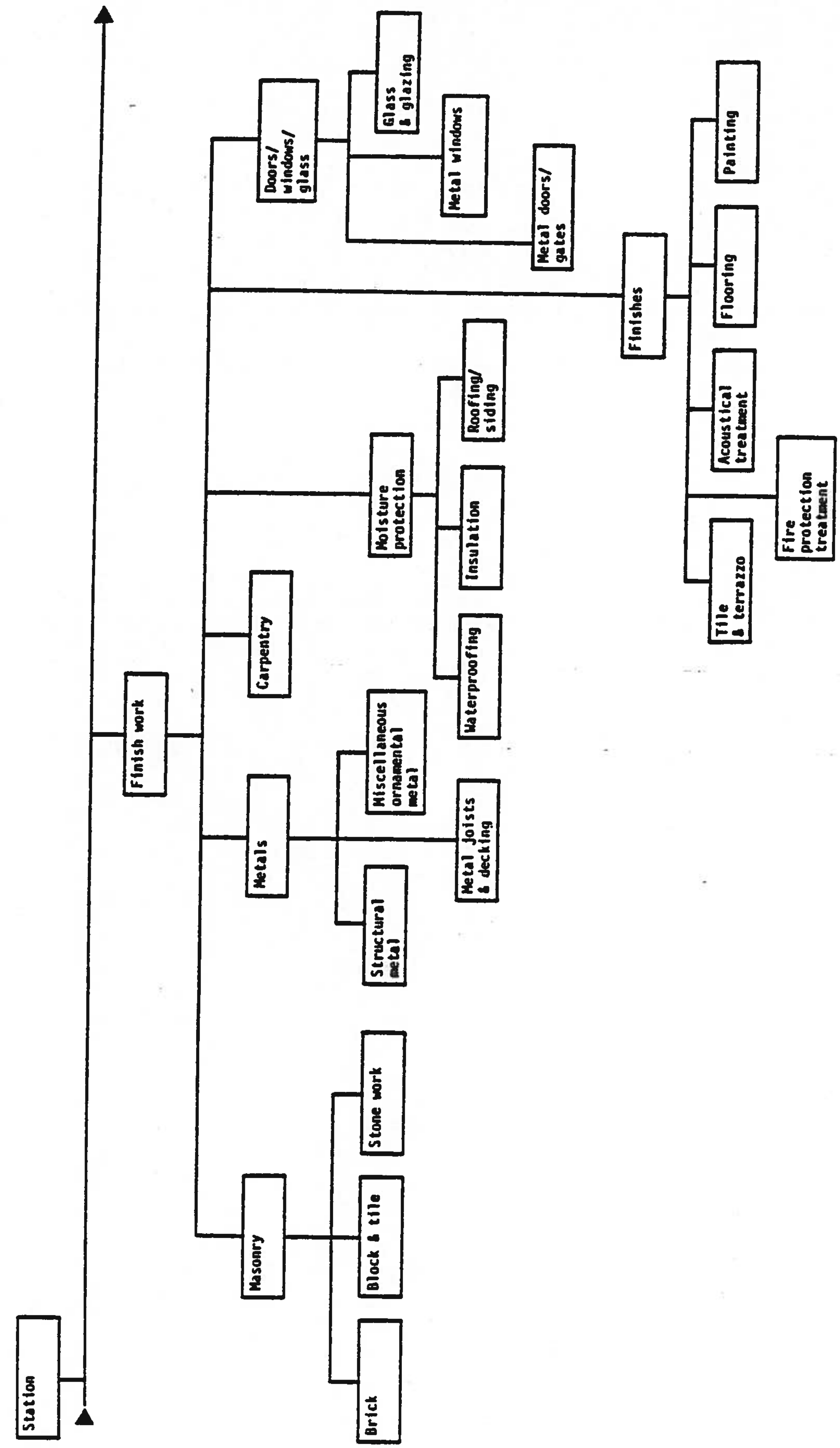

Station
Excavation/
support
Excavation
A
Ground
wall support
system
Piles
& lagging
Slurry wall
Sheet
piles
Bracing
X-bracing
Tiebacks
Rock
Soil-
grouted
Decking
Installation
Removal
Muck
handling
Hauling
Lifting
Vertical
lift
Access ramp

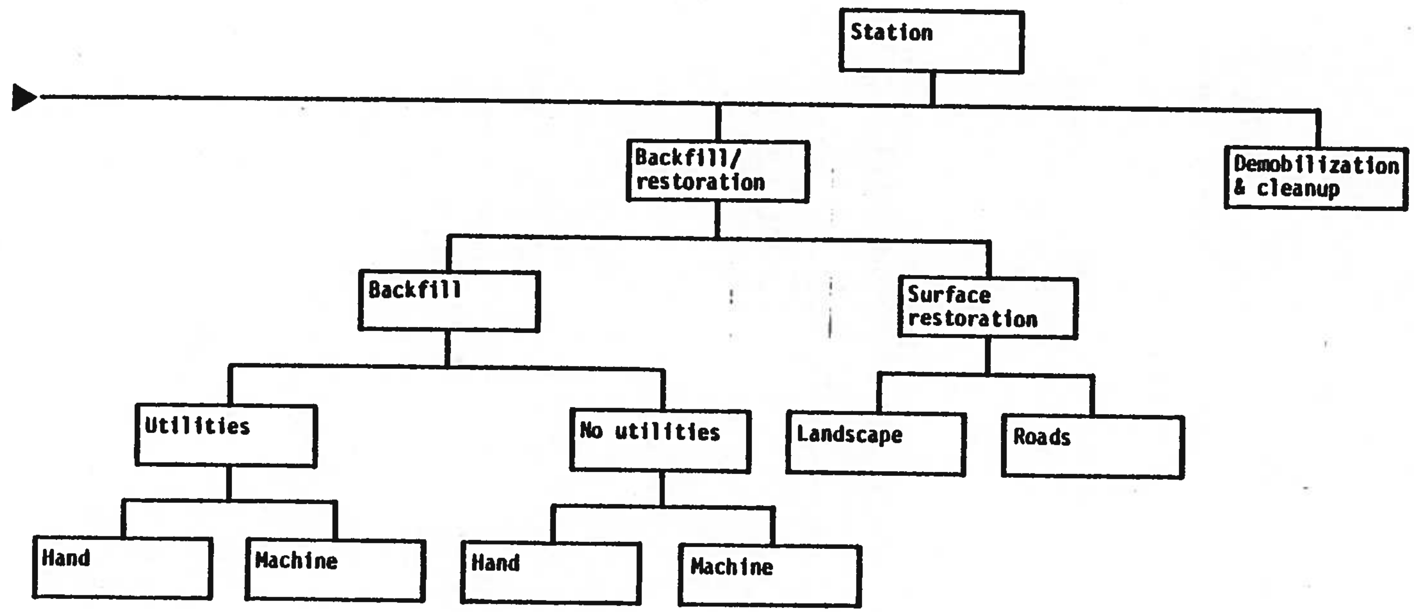

A
Running sand
Soft ground
Stiff clay
Rock
High water inflow
Low water inflow
High
Low
High
Low
High
Low
Top lift
Bottom lift
Top
Bottom
Top
Bottom
Top
Bottom
Top
Bottom
Top
Bottom
Braced
Unbraced
B
U
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28


Station
Structure
Invert
Walls
Concrete
Slurry
Slabs
Concrete
Composite
Roof
Girders
Top
Columns
Rectangular
Circular
Platform


Station
Mechanical
Air handling system
Drainage
Fire protection
Toilets and waste disposal
Fans
Ducts and fittings
Hangers
Pipes
Hangers
Fittings
Welding
Fixtures
Pipings and fittings
Steel
Copper
Cast iron
Steel


Station
Electrical
Conduits
Elbows
Junction boxes
Wiring
Fixtures
Switchgear
Systems
Fire
Sound
Security
Emergency
Grounding
Lighting control systems
Devices
Disconnect switches
Electric manholes


Station
Finish work
Masonry
Brick
Block & tile
Stone work
Metals
Structural metal
Metal joists & decking
Miscellaneous ornamental metal
Carpentry
Moisture protection
Waterproofing
Insulation
Roofing/ siding
Doors/ windows/ glass
Metal doors/ gates
Metal windows
Glass & glazing
Finishes
Tile & terrazzo
Fire protection treatment
Acoustical treatment
Flooring
Painting


Station
Backfill/
restoration
Demobilization
& cleanup
Backfill
Surface
restoration
Utilities
No utilities
Landscape
Roads
Hand
Machine
Hand
Machine

APPENDIX D

EQUIPMENT WRITE-OFF VALUES

Type of Equipment	Write-Off Value (percent)
Rail Muck Cars	50 percent
Rubber Muck Cars	75 percent
Rail	40 percent
Ties	100 percent
Main Cables	60 percent
Telephone Lines	100 percent
Pipes, Copper	70 percent
Ventilation Lines, Hydraulic Lines	100 percent
Man Cars	100 percent
Steel Installer	100 percent
Precast Concrete Installer	100 percent
Drill	80 percent
Locomotive & Support	3 percent per month
Load-Haul-Dump	3 percent per month
Loader	3 percent per month
Tractor	3 percent per month
Forklift	3 percent per month
Compressor	3 percent per month
Headframe	3 percent per month
Hoist	3 percent per month
Skip-Cage System	100 percent
Crane	3 percent per month
Trucks & Autos	3 percent per month
Forming Equipment	100 percent
Vibrator	100 percent
Agitator Car	6 percent per month
Pile Driver	6 percent per month
Clam Bucket	6 percent per month
Backhoe	3 percent per month
Shotcrete Pump	100 percent
Grout Batcher	100 percent
Grout Pump	100 percent
Grout Bin	100 percent
Water Pump	100 percent
Concrete Pump	100 percent
Concrete Batch Plant	3 percent per month
Pneumatic Breaker	100 percent
Signaling Equipment	100 percent
Fan	3 percent per month
Stairs & Ladders	100 percent
Radio Equipment	100 percent
Surface Generator	3 percent per month
Trailer	3 percent per month
Change House	3 percent per month
Repair Shop	3 percent per month
Toilet	3 percent per month

APPENDIX E

CREW COMPOSITIONS

The types and numbers of laborers required for cut-and-cover station operations are detailed in Appendix J, Standard Operations. However, there are certain general activities which are not defined in terms of operations yet which require labor crews. These activities include overhead, above ground support, muck lifting, and dewatering. Their crew compositions are delineated in this appendix.

Table E-1. CREW COMPOSITION FOR OVERHEAD

<u>Day Shift Only</u>	
project manager	1
project engineer	1
field engineer	1
office engineer	1
junior engineer	1
party chief	1
general superintendent	1
surveyor	2
office manager	1
purchasing agent	1
Equal Employment Opportunity (EEO) officer	1
safety engineer	1
secretary	2
first aid	3

Table E-2. CREW COMPOSITION FOR ABOVE GROUND SUPPORT

Number of Shifts	1	2	3
oiler	2	2	2
fork lift operator	1	1	1
miscellaneous laborer	2	2	2
signal man	1	1	1
shop mechanic	1	1	1
shift superintendent	1	1	1
master mechanic	1	1	1
electrician	2	1	1
compressor operator	1	1	1
change house attendant	1	1	1
dewatering laborer	1	1	1

Table E-3. CREW COMPOSITION FOR MUCK LIFTING SYSTEM

Number of Shifts	1	2	3
crane operator	1	1	1
spotter	2	2	2
laborer	1	1	1

Table E-4. CREW COMPOSITION FOR DEWATERING OPERATIONS

Number of Shifts	1	2	3
pump operator	1	1	1
mechanic	1	1	0

APPENDIX F

EQUIPMENT COSTS DATA FILE

Equipment Costs Data File

Field Name (12-char.)	Description	Unit of Measure (UM)	Date of Cost	Cost/UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
INCLINOMETER	Fixed position inclinometer in rock.	FT	6/29/80	$150		Contractors		
PIEZOMETER1	Piezometer for water level measurements.	FT	6/29/80	$40		Contractors		
STRAINGAUGE	Strain gauge on steel ribs.	EA	6/29/80	$2,000		Contractors		
EXTENSOMETER	Borehole extensometer.	FT	6/29/80	$42		Contractors		
ROLLCOMPACT	Roller compactor, 2 drum, 2000 pounds (lbs.)	EA	6/1/80	$20,000		Contractors		
RAMCOMPACT	Rammer compactor, gas, 1000-lb. blow.	EA	6/1/80	$8,700		Contractors		
VIBCOMPACT	Vibratory plate compactor, gas, 13 inch (in.) plate, 1000-lb. blow.	EA	6/1/80	$8,500		Contractors		
WELDER	300-amp welder	EA	6/1/80	$5,300		Contractors		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
TRANSFORMER	Transformer, 600 kilovolt amperes (KVA).	EA	1/1/80	$14,000		Means®		
CIRCUITPANEL	Distribution and branch circuit panel board.	EA	7/1/80	$5,000		Contractors		
FIREALARM	Fire alarm and smoke detection system.	LS	7/1/80	$15,000		Contractors		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
VERTIJUMBO	Vertical jumbo, 4 drills.	LS	7/20/80	$500,000		Atlas Copco (201)696-0554		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
HYDRODRILL	Hydraulic rock drill, 3000-5000 pounds per square inch gravity (PSIG), 1-5/8" diam., 10 ft. round, includes arm, feed unit, power, controls, ...	EA	5/14/80	$150,000		Atlas Copco (201) 696-0554		
PNEUDRILL	Pneumatic drill, 1 5/8" diam., 500 cubic feet/meter (CFM), 100 PSIG, 10 ft. round, includes seat, boom, drill, mounting.	EA	5/12/80	$35,000		Gardner/ Denver (203) 243-0311		
AIRTRACKDRL	Air track drill (Gardner Denver 123).	EA	4/1/80	$1,500		Contractors		
BLASTEQMT	Miscellaneous blasting equipment, magazines, warning system, gas detector, etc.	LS	4/1/80	$4,500		Contractors		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
HEADFRAME	Headframe used in hauling system.	EA	5/13/80	$130,000		Card Corp. (303)922-7511		
MUCKCAR	Muck car, 4 cu yd.	EA	5/13/80	$12,000		Card Corp. (303)922-7511		
HOIST	Hydrostatic drive, 200-horsepower (HP) hoist.	EA	5/13/80	$90,000		Card Corp. (303)922-7511		
SKIPCAGE	Skip & cage system for men & materials, 4.5 by 5 ft., Kimberley type.	EA	5/13/80	$35,000		Card Corp. (303)922-7511		
CRANE25W	25-ton crane on wheels.	EA	5/13/80	$180,000		Grove (617)969-7050		
CRANE50W	50-ton crane on wheels (116-ft. boom).	EA	5/13/80	$245,000		Grove (617)969-7050		
CRANE70C	70-ton hydraulic crawler crane.	EA	4/1/80	$297,000		Contractors		
CRANE80C	80-ton hydraulic crawler crane.	EA	4/1/80	$323,000		Contractors		
CRANE100C	100-ton hydraulic crawler crane.	EA	3/18/80	$375,000		Manitowoc (414)684-6621		
CRANE160W	160-ton crane on wheels.	EA	3/18/80	$550,000		Manitowoc (414)684-6621		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
SHOTPUMP	Shotcrete pump with 50-HP electric motor, accelerator, on a trailer, covered.	EA	5/15/80	$31,000		QUIPCO (617)926-4500		
GROUTBATCHER	Grout batch plant.	LS	5/15/80	$25,000		Contractors		
GROUTPUMP	Grout pump.	EA	5/15/80	$2,500		Contractors		
GROUTBIN	Grout cars.	EA	5/15/80	$2,000		Contractors		
PUMPW2	2" submersible water pump.	EA	3/17/80	$1,000		Flygt Corp. (617)935-6515		
PUMPW4	4" submersible water pump.	EA	3/17/80	$3,126		Flygt Corp. (617)935-6515		
PUMPW6	6" submersible water pump.	EA	3/17/80	$20,000		Flygt Corp. (617)935-6515		
CONCPUMP1	Concrete pump, portable.	EA	3/17/80	$3,000		Logan Equipment (617)567-8700		
CONCPUMP2	Truck-mounted concrete pump.	EA	7/1/80	$120,000		P.J. Equipment (617)387-9545		
CONCPUMP3	Trailer-mounted concrete pump.	EA	7/1/80	$60,000		P.J. Equipment (617)387-9545		
CONCPLANT	Concrete batch plant.	LS	7/1/80	$30,000		P.J. Equipment (617)387-9545		
PAVEBREAKER	65-lb. pneumatic breaker, 60 cubic feet/minute (CFM), 87 pounds/square inch (PSI).	EA	4/2/80	$1,200		Atlas Copco (201)696-0554		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
COMPRESSOR1	800 cubic feet/minute (CFM) portable compressor.	EA	5/13/80	$58,793		Joy Mnftg. Co. (617)536-9207		
COMPRESSOR2	900 CFM portable compressor.	EA	5/13/80	$61,993		Joy Mnftg. Co. (617)536-9207		
COMPRESSOR3	1100 CFM portable compressor.	EA	5/13/80	$68,293		Joy Mnftg. Co. (617)536-9207		
COMPRESSOR4	1600 CFM portable compressor.	EA	5/13/80	$87,493		Joy Mnftg. Co. (617)536-9207		
COMPRESSOR5	1540 CFM stationary compressor.	EA	5/13/80	$50,000		Joy Mnftg. Co. (617)536-9207		
LOADERCAT950	130 horsepower(HP), 2.5 cu. yd., caterpillar wheel loader.	EA	5/14/80	$101,360		Caterpillar (617)435-6320 (Witt Eqmt. Co.)		
LOADERCAT955	130 HP, 2.25 cu. yd., track-type cat loader.	EA	5/14/80	$94,670		Caterpillar (617)435-6320 (Witt Eqmt. Co.)		
LOADERCAT977	190 HP, 3.25 cu. yd., track-type cat loader.	EA	5/14/80	$151,055		Caterpillar (617)435-6320 (Witt Eqmt. Co.)		
TRACTORCAT6	140 HP, track-type cat tractor.	EA	5/14/80	$113,580		Caterpillar (617)435-6320 (Witt Eqmt. Co.)		
TRACTORCAT8	300 HP, track-type cat tractor.	EA	5/14/80	$218,760		Caterpillar (617)435-6320 (Witt Eqmt. Co.)		
FORKLIFT25	25000 lbs. forklift.	EA	6/9/80	$65,000		Clark (617)933-6200		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
FAN24	24" ventilation fan system.	LS	5/13/80	$12,000		Joy Mnftg. Co. (216)339-1111		
FAN36	36" ventilation fan system.	LS	5/13/80	$20,000		Joy Mnftg. Co. (216)339-1111		
FAN48	48" ventilation fan system.	LS	5/13/80	$25,000		Joy Mnftg. Co. (216)339-1111		
AIRCONTAINER	Oxygen container for rescue purposes.	EA	4/1/80	$2,400		Contractors		
STAIRS	Stairs & ladders for exit.	LS	7/1/80	$4,000		Contractors		
RADIO	Radio communication equipment.	LS	4/1/80	$25,000		Contractors		
ELECTRIC1	Surface generator, 10 kilowatts (kw).	EA	1/1/80	$22,500		Means®		
ELECTRIC2	Surface generator, 25 kw.	EA	1/1/80	$35,000		Means		
TRAILER	Trailer equipment & temporary offices (12' x 60').	EA	3/14/80	$11,000		Carpenter Northeastern (315)656-7205		
REPAIRSHOP	Repair shop.	LS	7/1/80	$10,000		Contractors		
TOILET	Toilet facility.	EA	7/1/80	$1,000		Contractors		
GRADALL800	G-800 Gradall.	EA	7/1/80	$92,500		Contractors		
GRADALL1000	G-1000 Gradall.	EA	7/1/80	$154,000		Contractors		
DYNAHOE190	190 Dynahoe.	EA	7/1/80	$35,000		Contractors		

Equipment Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Operating Cost/Hr.	Inflation Index
MISCTOOLS	Miscellaneous surface tools (pneumatic, electric, hydraulic, ...).	LS	7/1/80	$10,000	—	Contractors		
TRUCKSAUTOS	Trucks & autos for surface services.	LS	5/15/80	$50,000		Contractors		
FORMEQUIP	Forming equipment (hydraulic traveler).	LS	4/30/80	$25,000		Contractors		
METALFORM	Metal forms.	SQFT	11/1/80	$8		Contractors		
VIBRATOR	Concrete vibrators.	EA	7/1/80	$1,200		P.J. Equipment (617)387-9545		
AGITATORCAR	Agitator car for concrete applications.	EA	7/1/80	$25,000		P.J. Equipment (617)387-9545		
CLAMSHELL	Clam shell bucket.	LS	7/1/80	$55,000		Contractors		
BACKHOE1	Back hoe, small.	EA	7/1/80	$35,000		Allis Chalmers (913)354-8401		
BACKHOE2	Back hoe, large.	EA	7/1/80	$100,000		Allis Chalmers (913)354-8401		
BACKHOCAT235	Cat backhoe.	EA	10/29/81	$300,000		Witt Equipment Co. (617)435-6321		
EXCAVCAT931	Cat excavator.	EA	10/29/81	$50,000		Witt Equipment Co. (617)435-6321		
DOZERCATD4	Cat bulldozer.	EA	10/29/81	$77,000		Witt Equipment Co. (617)435-6321		
VIBPILEDRIVE	Vibratory pile driver.	EA	7/1/80	$140,000		Delmay-Pileco (713)691-3638		
DBPILEHAMMER	Double-acting 1033 pile hammer.	EA	7/1/80	$120,000		Delmay-Pileco (713)691-3638		
TRANSFRM600	.6 KVA isolating transformer.	EA	1/1/80	$58		Means®		
TRANSFRM5000	5 KVA isolating transformer.	EA	1/1/80	$235		Means		

APPENDIX G

LABOR COSTS DATA FILE

In gathering labor data, the intent was to compile information for those cities most likely to build a new subway system or extend an existing subway system. Accordingly, the first determination was cities in the United States which had transit systems of greater than 500 vehicles. For each of these cities the local agreements of the Laborers' International Union of North America and the International Union of Operating Engineers were obtained.

In each agreement the following items of information were reviewed:

1. Union (laborers or operating engineers)
2. Location (city)
3. Effective date of agreement
4. Regulations concerning overtime
5. Regulations concerning the number of hours per shift to be worked in order to earn 8 hours of pay
6. Hourly fringe benefit rate
7. Description of each job classification
8. Hourly wage rate for each job classification

The variance in wage rates between those workers earning the highest wage and those earning the lowest in each local union was minimal. This variance does not impact cost estimates enough to warrant consideration of each individual type of laborer and operating engineer. The following global classifications of union workers were developed:

Laborers

above ground
in cut-and-cover box

Operating Engineers

mechanics-welders
oilers
all other operating engineers

For the cost estimating methodology, an average wage rate for each of these classifications within each city was used. Tables of detailed labor data for the cities of Chicago and Denver are included here. These cities seem to be typical of the cities, reviewed concerning their narrow range of wage rates. Also included in this appendix is a table of labor data for workers such as project engineers and secretaries who are not members of either the laborers' or operating engineers' unions.

TABLE G - 1. DATA BASE OF LABOR RATES

Field Name	Description	Location	Date	Hourly Wage Rate	Hourly Fringe Benefit Rate	Notes
MAINTTECH	maintenance technicians	Chicago	6/1/79	12.23	included in hourly wage rate; increase by 22% to account for Federal Insurance Contributions Act (FICA), worker's compensation, and unemployment	<u>Overtime:</u> 1½ x 0 to 2½ hours in excess of 8 hours per day 2 x more than 2½ hours in excess of 8 hours per day 1½ x 0 to 8 hours on Saturday 2 x more than 8 hours on Saturday 1½ x more than 40 hours per week 2 x Sunday and holidays <u>Hours actually worked for 8 hours of pay:</u> day shift 7½ hours swing shift 7½ hours grave shift 7½ hours
AIRTRACDRILL	air trac drillers			12.23		
MINER	miners			12.23		
BRICKTENDER	bricklayer tenders			12.23		
CNCRTBLOWER	concrete blowers			12.23		
DRILLER	drillers			12.23		
DYNAMITER	dynamiters			12.23		
ERECTOR	erectors			12.23		
FORMMAN	form men			12.23		
JACKHAMMER	jackhammermen			12.23		
MINEMACHINE	mining machines			12.23		
MUCKMACHINE	mucking machines			12.23		
POWERKNIFE	power knifes			12.23		
WELDERBURNER	welders-burners			12.23		
PIPEJACKING	pipe jacking machines			12.23		
SKINNER	skinners			12.23		
CNCRTREPAIR	concrete repairmen			12.23		
MOTORMAN	motor men			12.105		
MUCKER	muckers			12.105		
GROUTMACHINE	grout machines			12.105		
TRACKLAYER	track layers			12.105		
AIRHOIST	air hoists			12.105		
KEYBOARD	key boards			12.005		
CARPUSHER	car pushers			12.005		
CNCRTLABORER	concrete laborers			12.005		
GROUTLABORER	grout laborers			12.005		
STEELSETTER	steel setters			12.005		
TUGGER	tuggers			12.005		
SWITCHMAN	switchmen			12.005		
CAGETENDER	cage tenders			12.005		
DUMPMAN	dumpmen			11.88		
FLAGMAN	flagmen			11.88		
SIGNALMAN	signalmen			11.88		
TOPLABORER	top laborers			11.88		
RODMAN	rodmen			11.88		
LABORFOREMAN	labor foremen			11.88		
LABORSUBFORE	labor sub-foremen			12.88		
				12.38		

TABLE G - 1. DATA BASE OF LABOR RATES (continued)

Field Name	Description	Location	Date	Hourly Wage Rate	Hourly Fringe Benefit Rate	Notes
MAINTTECH	maintenance technicians	Denver	6/1/79	10.92	included in hourly wage rate; increase by 22% to account for FICA, worker's compensation, and unemployment	**Overtime:** 1½ x 0 to 2½ hours in excess of 8 hours per day 2 x more than 2½ hours in excess of 8 hours per day 1½ x 0 to 8 hours on Saturday 2 x more than 8 hours on Saturday 1½ x more than 40 hours per week 2 x Sunday and holidays **Hours actually worked for 8 hours of pay:** day shift 7½ hours swing shift 7½ hours grave shift 7½ hours
AIRTRACDRILL	air trac drillers			10.92		
MINER	miners			10.92		
BRICKTENDER	bricklayer tenders			10.92		
CNCRTBLOWER	concrete blowers			10.92		
DRILLER	drillers			10.92		
DYNAMITER	dynamiters			10.92		
ERECTOR	erectors			10.92		
FORMMAN	form men			10.92		
JACKHAMMER	jackhammermen			10.92		
MINEMACHINE	mining machines			10.92		
MUCKMACHINE	mucking machines			10.92		
POWERKNIFE	power knifes			10.92		
WELDERBURNER	welders-burners			10.92		
PIPEJACKING	pipe jacking machines			10.92		
SKINNER	skinners			10.92		
CNCRTREPAIR	concrete repairmen			10.92		
MOTORMAN	motor men			10.795		
MUCKER	muckers			10.795		
GROUTMACHINE	grout machines			10.795		
TRACKLAYER	track layers			10.795		
AIRHOIST	air hoists			10.795		
KEYBOARD	key boards			10.695		
CARPUSHER	car pushers			10.695		
CNCRTLABORER	concrete laborers			10.695		
GROUTLABORER	grout laborers			10.695		
STEELSETTER	steel setters			10.695		
TUGGER	tuggers			10.695		
SWITCHMAN	switchmen			10.695		
CAGETENDER	cage tenders			10.695		
DUMPMAN	dumpmen			10.57		
FLAGMAN	flagmen			10.57		
SIGNALMAN	signalmen			10.57		
TOPLABORER	top laborers			10.57		
RODMAN	rodmen			10.57		
LABORFOREMAN	labor foremen			10.57		
LABORSUBFORE	labor sub-foremen			11.57		
				11.07		

TABLE G - 1. DATA BASE OF LABOR RATES (continued)

Field Name	Description	Location	Date	Hourly Wage Rate	Hourly Fringe Benefit Rate	Notes
AIRTRACTOR	air tractors	Chicago	7/1/80	13.60	3.15; increase by 22% to account for FICA, worker's compensation, and unemployment	**Overtime:** 1½ x more than 8 hours per day 1½ x more than 40 hours per week 1½ x Saturday 2 x Sunday and holidays **Hours actually worked for 8 hours of pay:** day shift 7½ hours swing shift 7½ hours grave shift 7½ hours
BRAKEMAN	brakemen			13.60		
COMPRESSOR	compressors			11.20		
CONCRETEPUMP	concrete placement pumps			13.60		
GROUTMACHINE	grout machines			12.30		
GUNITEMACH	gunite machines			13.60		
MECHANIC	mechanics			13.60		
MECHWELDER	mechanics-welders			13.60		
MINEHOIST	mine hoist operators			12.30		
MOTORMAN	motormen			13.60		
MUCKMACHINE	mucking machines			13.60		
FRONTENDLOAD	front end loaders			13.05		
SLUSHER	slushers			13.05		
WELDER	welders			11.20		

TABLE G - 1. DATA BASE OF LABOR RATES (continued)

Field Name	Description	Location	Date	Hourly Wage Rate	Hourly Fringe Benefit Rate	Notes
AIRTRACTOR	air tractors	Denver	5/1/80	10.60	2.70; increase by 22% to account for FICA, worker's compensation, and unemployment	<u>Overtime:</u> 1½ x more than 8 hours per day 1½ x Saturday, Sunday 2 x holidays <u>Hours actually worked for 8 hours of pay:</u> day shift 8 hours swing shift 7½ hours grave shift 7 hours
BRAKEMAN	brakemen			9.90		
COMPRESSOR	compressors			10.35		
CONCRETEPUMP	concrete placement pumps			10.75		
GROUTMACHINE	grout machines			10.60		
GUNITEMACH	gunite machines			10.60		
MECHANIC	mechanics			10.75		
MECHWELDER	mechanics-welders			10.90		
MINEHOIST	mine hoist operators			10.75		
MOTORMAN	motormen			10.25		
MUCKMACHINE	mucking machines			10.75		
FRONTENDLOAD	front end loaders			10.75		
SLUSHER	slushers			10.75		
WELDER	welders			10.75		

TABLE G - 1. DATA BASE OF LABOR RATES (continued)

Field Name	Description	Location	Date	Hourly Wage Rate	Hourly Fringe Benefit Rate	Notes
GENSUPER	general superintendents	all	3/17/80	21.25	30% of	permanent
SHIFTSUPER	shift superintendents			18.75	hourly wage	employees of
PROJENGINEER	project engineers			18.75	rate;	the contractor
PROJMANAGER	project managers			30.00	increase by	
OFFMANAGER	office managers			12.50	22% to	
SAFENGINEER	safety engineers			13.75	account for	
SECRETARY	secretaries			5.00	FICA,	
JRENGINEER	junior engineers			10.00	worker's	
FLDENGINEER	field engineers			13.75	compensation,	
OFFENGINEER	office engineers			11.00	and	
PARTYCHIEF	party chiefs			13.50	unemployment	
SURVEYOR	surveyors			10.00		
PURCHAGENT	purchasing agents			11.75		
EEOOFFICER	EEO officers			8.50		

APPENDIX H

MATERIAL COSTS DATA FILE

Material Costs Data File

Field Name (12-char.)	Description	Unit of Measure (UM)	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Inflation Index
ROCKANCHOR	Rock anchor for support.	FT	7/20/80	$20		Contractors	
DRAINAGEMAT	Drainage material.	CUY	7/20/80	$15		Contractors	
STRUCTFILL	Structural backfill, placed.	CUY	7/20/80	$22		Contractors	
COMMONFILL	Common backfill, placed.	CUY	7/20/80	$15		Contractors	
IMPERVFILL	Impervious backfill, placed.	CUY	7/20/80	$18		Contractors	
BITUME1	Bituminous concrete pavement, binder course or top course.	TON	7/20/80	$35		Contractors	
BITUME2	Bituminous concrete for patching.	TON	7/20/80	$35		Contractors	
PIPERAIL1	Iron pipe railing.	FT	6/1/80	$20		Contractors	
PIPERAIL2	Stainless steel pipe railing.	FT	6/1/80	$40		Contractors	

Material Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Inflation Index
CONCMASONRY	Concrete unit masonry.	SQFT	1/1/80	$2.00		Means®	
GRANITEPAVER	Granite block paver, 12" x 12" x 4".	SQFT	7/20/80	$22.00		Contractors	
ELASTOROOF	Elastomeric membrane roofing.	SQFT	1/1/80	$1.00		Means	
METALOUVER	Metal louver.	EA	1/1/80	$12.00		Means	
METALGRATE	Metal grating.	SQFT	1/1/80	$15.00		Means	
HOLLOWDOOR	Hollow metal door and frame.	EA	1/1/80	$450.00		Means	
ALUMDOOR	Aluminum door and frame.	EA	1/1/80	$600.00		Means	
STEELWINDOW	Steel window and frame.	EA	1/1/80	$65.00		Means	
ALUMWINDOW	Aluminum window and frame.	EA	1/1/80	$50.00		Means	
GLASS1	3/8" thick plate glass.	SQFT	1/1/80	$2.10		Means	
GLASS2	1" thick plate glass.	SQFT	1/1/80	$9.25		Means	
SKYLIGHT	Skylight.	SQFT	1/1/80	$15.00		Means	
CANOPY	Canopy.	EA	1/1/80	$2,000.00		Means	

Material Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Inflation Index
DRILLBIT	2" drill bits, 1500 ft. life.	EA	5/15/80	$55.00		Joy Mnftg. Co. (617)536-9207	
DRILLSTEEL	1¼" diam., 12 ft. long, drill steel.	EA	5/15/80	$155.00		Joy Mnftg. Co. (617)536-9207	
GROUT	Grout used for ground control.	CUFT	4/15/80	$4.50		Means®	
CONCRETE	Ready mix concrete, 4000 pound/square inch (PSI).	CUFT	1/1/80	$50.00		Contractors	
SHOTCRETE	Shotcrete/gunite for tunnel support.	SQFT	1/1/80	$2.35		Means	
CURING	Curing compound, 55 gal. lots.	GAL	1/1/80	$3.40		Means	
FORMLUMBER	Lumber used for concrete formwork.	BF	8/25/80	$0.50		Contractors	
RESTEEL	Reinforcing steel, fabricated.	LBS	4/17/80	$0.25		ENR	
STRUCTSTEEL	Structural steel.	LBS		$0.50			
FORMSTEEL	Steel formwork for concrete pouring in tunnel.	SQFT	7/1/80	$18.00		Contractors	
SAND	Sand.	CUY	8/25/80	$5.00		Contractors	

Material Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Inflation Index
PIPE4	4" porous wall concrete pipe.	FT	1/1/80	$1.00		Means®	
PIPE6	6" porous wall concrete pipe.	FT	1/1/80	$1.05		Means	
PIPE8	8" porous wall concrete pipe.	FT	1/1/80	$1.70		Means	
PIPE10	10" porous wall concrete pipe.	FT	1/1/80	$2.90		Means	
PIPE15	15" porous wall concrete pipe.	FT	1/1/80	$3.80		Means	
PIPE18	18" porous wall concrete pipe.	FT	1/1/80	$5.65		Means	
PIPEFITTING	Pipe fittings, threaded.	EA	1/1/80	$500.00		Means	
VENTLINE24	24" ventilation line, aluminum 18 gauge.	FT	1/1/80	$5.15		Means	
VENTLINE36	36" ventilation line, aluminum 18 gauge.	FT	1/1/80	$7.70		Means	
VENTLINE48	48" ventilation line, aluminum 18 gauge.	FT	1/1/80	$10.30		Means	
COMPAIRLINE2	2" compressed air line, 50 ft. long.	EA	5/15/80	$300.00		Joy Mnftg. Co. (617)536-9207	
COMPAIRLINE4	4" compressed air line, 50 ft. long.	EA	5/15/80	$400.00		Joy Mnftg. Co. (617)536-9207	
COMPAIRLINE8	8" compressed air line, 50 ft. long.	EA	5/15/80	$600.00		Joy Mnftg. Co. (617)536-9207	
WATERLINE2	2" water line.	FT	7/1/80	$2.00		Contractors	
WATERLINE4	4" water line.	FT	7/1/80	$3.00		Contractors	
WATERLINE6	6" water line.	FT	7/1/80	$4.00		Contractors	

Material Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Inflation Index
ELECTRIC600	600 volt copper armored cable, #8, 3 wire.	FT	1/1/80	$0.79		Means®	
ELECTRIC5000	5000 volt copper armored cable, #8, 3 wire.	FT	1/1/80	$10.00		Means	
LIGHTING	200 watt bulb/socket, wire (every 40 ft.).	FT	1/1/80	$2.00		Means	
COMMUNICATE	Antenna and telephone lines, underground.	FT	1/1/80	$20.00		Means	
ELECENERGY	Electric energy consumption.	KWH	6/2/80	$0.10		Boston Edison (617)424-2271	

Material Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost of Shipping/Mile	Cost Source	Inflation Index
PILE10	H10 pile, 42 lbs/ft.	FT	3/24/80	$8.50		Bethlehem Steel (617)267-2111	
PILE12	H12 pile, 53 lbs/ft.	FT	3/24/80	$10.80		Bethlehem Steel (617)267-2111	
PILE14	H14 pile, 74 lbs/ft.	FT	3/24/80	$15.00		Bethlehem Steel (617)267-2111	
WOODLAGGING	Wood lagging.	BF	8/25/80	$0.50		Contractors	
WOODDECKING	Wood lagging for decking.	SQFT	1/1/80	$3.50		Means®	
TIEBACK	Tieback.	FT	8/25/80	$1.50		Contractors	
SHEETMETAL	Sheet metal plates (assuming reuse).	LBS	4/17/80	$0.25		ENR	
STEELBEAM	Steel beams.	LBS	8/25/80	$0.30		Commercial Shearing (216)746-8011	
JOIST1	40-foot span joist.	LBS	7/1/80	$0.50		Contractors	
JOIST2	Greater than 40-foot span joist.	LBS	7/1/80	$0.60		Contractors	
SHEETPILE	Steel sheet piles (assuming salvage).	SQFT	1/1/80	$4.00		Means	

Material Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/ UM	Cost of Shipping/Mile	Cost Source	Inflation Index
ROCKBOLT	Rock bolt (10-15 ft).	FT	5/15/80	$2.00		Bethlehem Steel (617)267-2111	
CAPSWIRE	Caps & wire for blasting, per hole.	LS	4/15/80	$2.75		Hercules, Inc. (302)575-5000	
DYNAMITE	Dynamite.	LBS	4/15/80	$0.65		Hercules, Inc. (302)575-5000	

APPENDIX I

LUMP SUM COSTS DATA FILE

Lump Sum Costs Data File

Field Name (12-char.)	Description	Unit of Measure (UM)	Date of Cost	Cost/UM	Cost Source	Inflation Index
PILELOADING	Pile loading test.	EA	7/20/80	$8,000	Contractors	
GRANITECURB1	Granite curb, straight.	FT	7/20/80	$28	Contractors	
GRANITECURB2	Granite curb, curved.	FT	7/20/80	$42	Contractors	
CURBMOVE	Curbing removal and resetting.	FT	7/20/80	$12	Contractors	
IRRIGATION	Irrigation system.	LS	7/20/80	$10,000	Contractors	
CARPENTRY	Miscellaneous carpentry.	LS	7/20/80	$20,000	Contractors	
INSULATE1	Vermiculite or perlite pouring insulation for masonry.	SQFT	1/1/80	$0.45	Means®	
INSULATE2	Fiberglass insulation for rigid walls.	SQFT	1/1/80	$0.50	Means	
INTPAINT	Interior painting.	SQFT	1/1/80	$0.25	Means	
EXTPAINT	Exterior painting.	SQFT	1/1/80	$0.90	Means	
SIGNS	Signs and displays.	LS	7/20/80	$10,000	Contractors	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
FLASHING	Metal flashing.	FT	1/1/80	$1.20	Means®	
WATERPROOF1	Sheet-applied water-proofing membrane.	SQFT	1/1/80	$6.50	Means	
WATERPROOF2	Bituminous water-proofing.	SQFT	1/1/80	$0.35	Means	
WATERPROOF3	Capillary waterproofing sheets.	SQFT	1/1/80	$0.60	Means	
FIREPROOF	Sprayed-on mastic fireproofing.	SQFT	1/1/80	$6.00	Means	
SEALANT	Sealant.	FT	1/1/80	$1.00	Means	
GLAZING	Glass glazing.	SQFT	1/1/80	$2.35	Means	
PORCELAIN	Porcelain enamel work.	SQFT	1/1/80	$3.75	Means	
ACOUSTILE	Acoustical tile.	SQFT	1/1/80	$3.95	Means	
CERAMIC	Ceramic tile.	SQFT	1/1/80	$2.50	Means	
GYPSUM	Gypsum drywall.	SQFT	1/1/80	$0.20	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
TERRACOTTA	Terra cotta.	SQFT	1/1/80	$1.25	Means®	
GRANITE	Granite block masonry.	SQFT	1/1/80	$5.00	Means	
LIMESTONE	Limestone masonry.	SQFT	1/1/80	$6.50	Means	
CONCBLOCK	Concrete block masonry.	SQFT	1/1/80	$2.10	Means	
ACOUSTBLOCK	Acoustical block masonry.	SQFT	1/1/80	$4.50	Means	
BRICK1	Brick masonry for walls.	SQFT	1/1/80	$7.00	Means	
BRICK2	Brick masonry for columns.	VLF	1/1/80	$11.00	Means	
BRICK3	Brick pavement.	SQFT	1/1/80	$4.50	Means	
TERRAZFLOOR	Cast-in-place terrazzo flooring.	SQFT	1/1/80	$3.20	Means	
BRICKFLOOR	Brick flooring.	SQFT	1/1/80	$4.00	Means	
RESILFLOOR	Resilient flooring.	SQFT	1/1/80	$0.75	Means	
GRANITEFLOOR	Granite flooring.	SQFT	1/1/80	$4.50	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
MINGENSITE	Minimal general sitework preparation (snow removal, insect & odor control, street cleaning,...).	LS	8/25/80	$10,000.00	Contractors	
MODGENSITE	Moderate general sitework preparation.	LS	8/25/80	$20,000.00	Contractors	
EXTGENSITE	Extensive general sitework preparation.	LS	8/25/80	$50,000.00	Contractors	
CHAINLINK	Installation of 6 ft high chain link fence, 6 gauge.	FT	1/1/80	$9.35	Means®	
WIREMESH	Installation of wire mesh fence on 4 in by 4 in posts, 8 ft high.	FT	1/1/80	$7.47	Means	
PLYWOOD	Installation of painted plywood fence (sound barrier type), 4 in by 4 in frame, 8 ft high.	FT	1/1/80	$7.91	Means	
LGTSURVEIL	Light surveillance for construction site (one guard).	MN	3/17/80	$1000.00	Contractors	
MEDSURVEIL	Medium surveillance (three-guard crew).	MN	3/17/80	$3000.00	Contractors	
HVYSURVEIL	Heavy surveillance (two crews, closed-circuit system with 3 cameras, monitor).	MN	3/17/80	$6400.00	Contractors	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
TRAFFIC	A police officer controlling traffic.	DAY	7/1/80	$80	Contractors	
REMOVESIGNAL	Removal of traffic signal.	EA	7/1/80	$300	Contractors	
INSOLDSIGNAL	Installation of old traffic signal.	EA	7/1/80	$500	Contractors	
INSNEWSIGNAL	Installation of new traffic signal.	EA	7/1/80	$1,500	Contractors	
TRAFFICSIGN	Traffic control signal, 2 directions.	EA	1/1/80	$15,000	Means®	
TURNSTILE	Mechanical, one-coin operation turnstile, 30-35 persons/minute.	EA	7/1/80	$2,000	Perey Turnstile (212) 599-0077	
ELEVATOR	Electric elevator, installed.	EA	1/1/80	$22,000	Means	
ESCALATOR	48", 8000 person/hour, 20 ft rise escalator with metal balustrade.	EA	1/1/80	$70,000	Means	
STEELSTAIRS	Steel stairs, installed.	RISER	7/1/80	$100	Contractors	
OFFICEUTIL	Utilities setup for field offices (electric, phone, water, sewage).	LS	1/1/80	$3,000	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
LGTTREE	Light congestion of trees in area to be cleared (cutting & stump removal).	SQFT	1/1/80	$0.04	Means®	
MEDTREE	Medium congestion of trees in area to be cleared.	SQFT	1/1/80	$0.05	Means	
HVYTREE	Heavy congestion of trees in area to be cleared.	SQFT	1/1/80	$0.06	Means	
PAVEREM	Pavement (asphalt, or bituminous or plain concrete), curbing, and sidewalk removal using power equipment.	SQFT	1/1/80	$1.50	Means	
SMLDEMO	Small building demolition (one or two-story wood-framed buildings).	CUFT	1/1/80	$0.10	Means	
MEDDEMO	Medium building demolition (small masonry structures, light commercial, ...).	CUFT	1/1/80	$0.12	Means	
LGEDEMO	Large building demolition (large masonry structures, multi-story, bridges, ...).	CUFT	1/1/80	$0.14	Means	
MUCKTRANS	Transportation of one cubic yard of muck.	MI	8/25/80	$0.15	Contractors	
MUCKDUMP	Dumping and reworking muck at the dump site.	CUY	8/25/80	$1.00	Contractors	
SMLDUMPFEE	Small dumping/disposal fee.	CUY	1/1/80	$3.50	Means	
MEDDUMPFEE	Medium dumping/disposal fee.	CUY	1/1/80	$4.00	Means	
LGEDUMPFEE	Large dumping/disposal fee.	CUY	1/1/80	$6.00	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
CONCPLACE	Placing concrete & finishing.	FT	4/15/80	$45.00	Contractors	
RESTEELPLACE	Placing reinforcing steel.	LBS	8/25/80	$0.25	Contractors	
WOODFINISH	Wood float finish for concrete.	SQFT	8/25/80	$0.40	Contractors	
BROOMFINISH	Broom finish for concrete.	SQFT	1/1/80	$0.20	Means®	
STONEBASE	Placing crushed stone resurfacing base course.	CUY	1/1/80	$7.00	Means	
GRAVELBASE	Placing bank run gravel resurfacing base course.	CUY	1/1/80	$3.75	Means	
BITUMEPAVE	Placing bituminous pavement.	SQY	1/1/80	$2.00	Means	
CONCRETEPAVE	Placing concrete pavement.	SQY	1/1/80	$12.00	Means	
ASPHALTBERM	Placing asphalt plain berms.	LF	1/1/80	$1.80	Means	
CONCRETEBERM	Placing concrete berms.	LF	1/1/80	$5.00	Means	
BITUMEWALK	Placing bituminous sidewalks.	SQY	1/1/80	$2.60	Means	
BRKSANDWALK	Placing brick-on-sand sidewalks.	SQY	1/1/80	$3.10	Means	
CONCRETEWALK	Placing cast-in-place concrete sidewalks.	SQY	1/1/80	$10.80	Means	
TOPSOILSEED	Topsoiling and seeding.	SQY	1/1/80	$0.25	Means	
SEEDSODSHRUB	Seeding, some sodding, and shrubs.	SQY	1/1/80	$0.35	Means	
EXTLANDSCAPE	Extensive landscaping, shrubs, and trees.	SQY	1/1/80	$0.90	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
TOUCHUP	Touch-ups and repairs.	FT	4/15/80	$5.00	Contractors	
FUEL	Fuel costs as a percentage of labor costs.	PCNT	4/15/80	6%	Contractors	
SITECLEANUP	Cleanup of construction site.	LS	8/25/80	$30,000.00	Contractors	
CHEMGROUTING	Chemical grouting per cubic yard of soil mass.	CUY	1/1/80	$175.00	Means®	
CEMGROUTING	Cement grouting per cubic yard of soil mass.	CUY	1/1/80	$200.00	Means	
SOILFREEZING	Freezing soil for ground control.	CUY	3/17/80	$575.00	Contractors	
WELLEXCAV	Well excavation.	FT	8/25/80	$15.00	Contractors	
SHAFTFIT	Shaft fittings.	FT	4/15/80	$300.00	Contractors	
MINMONITOR	Minimal building protection monitoring requirements.	LS	8/25/80	$10,000	Contractors	
MODMONITOR	Moderate building protection monitoring requirements.	LS	8/25/80	$50,000	Contractors	
EXTMONITOR	Extensive building protection monitoring requirements.	LS	8/25/80	$100,000	Contractors	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
SLURRYWALL	Excavation of slurry trench, slurry pumping, resteel installation, and 3000 pounds/square inch (PSI) concrete backfilling.	CUY	1/1/80	$310	Means®	
PITPIER	Pit pier underpinning.	CUY	4/15/80	$300	Contractors	
JACKEDPILE	Jacked pile underpinning.	FT	4/15/80	$230	Contractors	
PICKUP	Pick-up for contingency support.	EA	4/15/80	$9500	Contractors	
ACCESSRAMP	Construction of crushed stone access ramp for lifting muck.	TON	1/1/80	$5.50	Means	
					Means	
SETUP1A	Setup of crane, 70-ton.	LS	1/1/80	$5500	Means	
SETUP1B	Setup of crane, 80-ton.	LS	1/1/80	$6000	Means	
SETUP1C	Setup of crane, 100-ton.	LS	1/1/80	$7000	Means	
SETUP2	Setup of air compressor 900 cubic feet/minute (CFM).	LS	1/1/80	$ 100	Means	
SETUP3	Setup of air track.	LS	1/1/80	$1,200	Means	
SETUP4	Setup of vertical jumbo.	LS	1/1/80	$12,000	Means	
SETUP5	Setup of hydrostatic joist.	LS	1/1/80	$10,000	Means	
SETUP6	Setup of 300-amp welder.	LS	1/1/80	$300	Means	
SETUP7	Setup of 1033 hammer.	LS	1/1/80	$5000	Means	

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Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
BPIPE1	Brass pipe, 1/8" diam., includes fittings 10' off center, on hangers.	FT	1/1/80	$ 4.10	Means®	
BPIPE2	Brass pipe, 1/4" diam., includes fittings 10' off center, on hangers.	FT	1/1/80	$ 4.67	Means	
BPIPE3	Brass pipe, 1/2" diam., includes fittings 10' off center, on hangers.	FT	1/1/80	$ 6.30	Means	
BPIPE4	Brass pipe, 1" diam., includes fittings 10' off center, on hangers.	FT	1/1/80	$ 9.10	Means	
BPIPE5	Brass pipe, 2" diam., includes fittings 10' off center, on hangers.	FT	1/1/80	$17.45	Means	
BPIPE6	Brass pipe, 4" diam., includes fittings 10' off center, on hangers.	FT	1/1/80	$51.00	Means	
BPIPE7	Brass pipe, 6" diam., includes fittings 10' off center, on hangers.	FT	1/1/80	$89.00	Means	
CIPIPE1	Cast iron pipe, 2" diam.	FT	1/1/80	$ 8.10	Means	
CIPIPE2	Cast iron pipe, 3" diam.	FT	1/1/80	$ 8.90	Means	
CIPIPE3	Cast iron pipe, 4" diam.	FT	1/1/80	$10.40	Means	
CIPIPE4	Cast iron pipe, 6" diam.	FT	1/1/80	$10.70	Means	
CIPIPE5	Cast iron pipe, 8" diam.	FT	1/1/80	$17.85	Means	
CIPIPE6	Cast iron pipe, 12" diam.	FT	1/1/80	$30.55	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
CPIPE1	Copper pipe, type K, fittings 10' off center, on hangers, 1/4" diam.	FT	1/1/80	$ 3.43	Means®	
CPIPE2	Copper pipe, type K, fittings 10' off center, on hangers, 1" diam.	FT	1/1/80	$ 6.85	Means	
CPIPE3	Copper pipe, type K, fittings 10' off center, on hangers, 2" diam.	FT	1/1/80	$12.25	Means	
CPIPE4	Copper pipe, type L, fittings 10' off center, on hangers, 1/4" diam.	FT	1/1/80	$ 3.23	Means	
CPIPE5	Copper pipe, type L, fittings 10' off center, on hangers, 1" diam.	FT	1/1/80	$ 6.20	Means	
CPIPE6	Copper pipe, type L, fittings 10' off center, on hangers, 2" diam.	FT	1/1/80	$11.25	Means	
CPIPE7	Copper pipe, type L, fittings 10' off center, on hangers, 4" diam.	FT	1/1/80	$26.00	Means	
CPIPE8	Copper pipe, type L, fittings 10' off center, on hangers, 6" diam.	FT	1/1/80	$60.00	Means	
PPIPE1	Polyvinyl chloride pipe, (PVC) couplings 10'off center, on hangers, 1/4" diam.	FT	1/1/80	$ 4.16	Means	
PPIPE2	PVC pipe, couplings 10' off center, on hangers, 1/2" diam.	FT	1/1/80	$ 4.40	Means	
PPIPE3	PVC pipe, couplings 10' off center, on hangers, 1" diam.	FT	1/1/80	$ 6.15	Means	
PPIPE4	PVC pipe, couplings 10' off center, on hangers, 2" diam.	FT	1/1/80	$ 8.60	Means	
PPIPE5	PVC pipe, couplings 10' off center, on hangers, 4" diam.	FT	1/1/80	$14.35	Means	
PPIPE6	PVC pipe, couplings 10' off center, on hangers, 6" diam.	FT	1/1/80	$22.00	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
SPIPE1	Stainless steel pipe, threaded, couplings, on hangers, 1/4" diam.	FT	1/1/80	$ 3.93	Means®	
SPIPE2	Stainless steel pipe, threaded, couplings, on hangers, 1/2" diam.	FT	1/1/80	$ 5.10	Means	
SPIPE3	Stainless steel pipe, threaded, couplings, on hangers, 1" diam.	FT	1/1/80	$ 7.40	Means	
SPIPE4	Stainless steel pipe, threaded, couplings, on hangers, 2" diam.	FT	1/1/80	$ 13.80	Means	
SPIPE5	Stainless steel pipe, threaded, couplings, on hangers, 4" diam.	FT	1/1/80	$ 39.00	Means	
SPIPE6	Stainless steel pipe, threaded, couplings, on hangers, 6" diam.	FT	1/1/80	$ 73.00	Means	
FOUNTAIN	Stainless steel drinking fountain.	EA	1/1/80	$ 300.00	Means	
LAVATORY	Stainless steel, wall-hung lavatory.	EA	1/1/80	$ 145.00	Means	
PUMP1	General utility pump, four stage, 15-horse-power (HP)	EA	1/1/80	$18,400.00	Means	
PUMP2	General utility pump, single stage, 15-HP.	EA	1/1/80	$ 3,300.00	Means	
PUMP3	General utility pump, double stage, 15-HP.	EA	1/1/80	$ 4,425.00	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
FPUMP1	Diesel fire pump, 500 gallons/minute (GPM).	EA	1/1/80	$10,800	Means®	
FPUMP2	Diesel fire pump, 1000 GPM.	EA	1/1/80	$17,600	Means	
FPUMP3	Diesel fire pump, 2000 GPM.	EA	1/1/80	$31,300	Means	
FPUMP4	Diesel fire pump, 3000 GPM.	EA	1/1/80	$58,000	Means	
FPUMP5	Diesel fire pump, 4500 GPM.	EA	1/1/80	$72,500	Means	
SPRINKLER1	Wet sprinkler system.	HEAD	1/1/80	$ 60	Means	
SPRINKLER2	Dry sprinkler system, exposed piping.	HEAD	1/1/80	$ 65	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
BOILER11	Electric boiler, American Society of Mechanical Engineers (ASME), steam, 120 kilowatts (KW), 409 1000-BTU's/hour (MBH).	EA	1/1/80	$ 8,250	Means®	
BOILER12	Electric boiler, ASME, steam, 1080 KW, 3685 MBH.	EA	1/1/80	$26,500	Means	
BOILER13	Electric boiler, ASME, steam, 2340 KW, 7984 MBH.	EA	1/1/80	$54,000	Means	
BOILER14	Electric boiler, ASME, hot water, 240 KW, 820 MBH.	EA	1/1/80	$ 7,550	Means	
BOILER15	Electric boiler, ASME, hot water, 1200 KW, 4095 MBH.	EA	1/1/80	$21,200	Means	
BOILER16	Electric boiler, ASME, hot water, 2400 KW, 8191 MBH.	EA	1/1/80	$35,600	Means	
BOILER17	Electric boiler, ASME, hot water, 3600 KW, 12283 MBH.	EA	1/1/80	$47,300	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
BOILER21	Gas fired boiler, natural or propane steam, 3000 1000-BTU's/hour (MBH).	EA	1/1/80	$16,700	Means®	
BOILER22	Gas fired boiler, natural or propane steam, 6970 MBH.	EA	1/1/80	$35,500	Means	
BOILER31	Oil fired boiler, cast iron, steam, 2920 MBH.	EA	1/1/80	$13,400	Means	
BOILER32	Oil fired boiler, cast iron, steam, 6970 MBH.	EA	1/1/80	$35,500	Means	
BOILER33	Oil fired boiler, steel, steam, 2400 MBH.	EA	1/1/80	$10,100	Means	
BOILER41	Gas/oil boiler, cast iron, steam, 6970 MBH.	EA	1/1/80	$43,600	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
HVUNIT1	Heating and ventilating unit, filter, heating/ cooling coils, 750 cubic feet/minute (CFM).	EA	1/1/80	$1,400.00	Means®	
HVUNIT2	Heating and ventilating unit, filter, heating/ cooling coils, 1250 CFM.	EA	1/1/80	$1,825.00	Means	
HVUNIT3	Heating and ventilating unit, filter, heating/ cooling coils, 1500 CFM.	EA	1/1/80	$2,200.00	Means	
HEATRECOV1	Air-to-air exchanger, 1000-10000 CFM.	EA	1/1/80	$ 2.42	Means	
HEATRECOV2	Air-to-air exchanger, 10000-20000 CFM.	EA	1/1/80	$ 1.98	Means	
HEATRECOV3	Air-to-air exchanger, 20000-30000 CFM.	EA	1/1/80	$ 1.60	Means	
HEATRECOV4	Air-to-air exchanger, above 30000 CFM.	EA	1/1/80	$ 1.21	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
CONDUIT11	Aluminum conduit, 1/2" diam.	FT	1/1/80	$ 1.70	Means®	
CONDUIT12	Aluminum conduit, 1" diam.	FT	1/1/80	$ 2.40	Means	
CONDUIT13	Aluminum conduit, 1 1/2" diam.	FT	1/1/80	$ 3.30	Means	
CONDUIT14	Aluminum conduit, 2" diam.	FT	1/1/80	$ 4.00	Means	
CONDUIT15	Aluminum conduit, 3" diam.	FT	1/1/80	$ 6.70	Means	
CONDUIT16	Aluminum conduit, 4" diam.	FT	1/1/80	$ 9.35	Means	
CONDUIT21	Rigid galvanized steel conduit, 1/2" diam.	FT	1/1/80	$ 1.80	Means	
CONDUIT22	Rigid galvanized steel conduit, 1" diam.	FT	1/1/80	$ 2.65	Means	
CONDUIT23	Rigid galvanized steel conduit, 1 1/2" diam.	FT	1/1/80	$ 3.40	Means	
CONDUIT24	Rigid galvanized steel conduit, 2" diam.	FT	1/1/80	$ 4.35	Means	
CONDUIT25	Rigid galvanized steel conduit, 3" diam.	FT	1/1/80	$ 8.25	Means	
CONDUIT26	Rigid galvanized steel conduit, 4" diam.	FT	1/1/80	$11.20	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
CONDUIT31	Steel, intermediate metal conduit (IMC), 1/2" diam.	FT	1/1/80	$1.60	Means®	
CONDUIT32	Steel, IMC, 1" diam.	FT	1/1/80	$2.40	Means	
CONDUIT33	Steel, IMC, 1 1/2" diam.	FT	1/1/80	$3.05	Means	
CONDUIT34	Steel, IMC, 2" diam.	FT	1/1/80	$3.80	Means	
CONDUIT35	Steel, IMC, 3" diam.	FT	1/1/80	$6.85	Means	
CONDUIT36	Steel, IMC, 4" diam.	FT	1/1/80	$9.15	Means	
CONDUIT41	Electric metallic tubing (EMT), 1/2" diam.	FT	1/1/80	$0.90	Means	
CONDUIT42	EMT, 1" diam.	FT	1/1/80	$1.50	Means	
CONDUIT43	EMT, 1 1/2" diam.	FT	1/1/80	$2.15	Means	
CONDUIT44	EMT, 2" diam.	FT	1/1/80	$2.55	Means	
CONDUIT45	EMT, 3" diam.	FT	1/1/80	$5.40	Means	
CONDUIT46	EMT, 4" diam.	FT	1/1/80	$7.40	Means	
CONDUIT51	Unicouple EMT 2 1/2" diam.	FT	1/1/80	$3.90	Means	
CONDUIT52	Unicouple 3" diam.	FT	1/1/80	$4.75	Means	
CONDUIT53	Unicouple 3 1/2" diam.	FT	1/1/80	$5.95	Means	
CONDUIT54	Unicouple 4" diam.	FT	1/1/80	$6.85	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
ELBOW11	Horizontal elbow, 9" wide.	EA	1/1/80	$139	Means®	
ELBOW12	Horizontal elbow, 12" wide.	EA	1/1/80	$162	Means	
ELBOW13	Horizontal elbow, 18" wide.	EA	1/1/80	$199	Means	
ELBOW14	Horizontal elbow, 24" wide.	EA	1/1/80	$269	Means	
ELBOW15	Horizontal elbow, 30" wide.	EA	1/1/80	$351	Means	
ELBOW16	Horizontal elbow, 36" wide.	EA	1/1/80	$439	Means	
ELBOW21	Vertical elbow, 9" wide.	EA	1/1/80	$ 76	Means	
ELBOW22	Vertical elbow, 12" wide.	EA	1/1/80	$ 87	Means	
ELBOW23	Vertical elbow, 18" wide.	EA	1/1/80	$100	Means	
ELBOW24	Vertical elbow, 24" wide.	EA	1/1/80	$122	Means	
ELBOW25	Vertical elbow, 30" wide.	EA	1/1/80	$144	Means	
ELBOW26	Vertical elbow, 36" wide.	EA	1/1/80	$158	Means	
ELBOW31	Cross elbow, 9" wide.	EA	1/1/80	$209	Means	
ELBOW32	Cross elbow, 12" wide.	EA	1/1/80	$234	Means	
ELBOW33	Cross elbow, 18" wide.	EA	1/1/80	$286	Means	
ELBOW34	Cross elbow, 24" wide.	EA	1/1/80	$355	Means	
ELBOW35	Cross elbow, 30" wide.	EA	1/1/80	$445	Means	
ELBOW36	Cross elbow, 36" wide.	EA	1/1/80	$535	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
ENDFLB1	End closure, 9" wide.	EA	1/1/80	$ 26	Means®	
ENDFLB2	End closure, 12" wide.	EA	1/1/80	$ 30	Means	
ENDFLB3	End closure, 18" wide.	EA	1/1/80	$ 41	Means	
ENDFLB4	End closure, 24" wide.	EA	1/1/80	$ 52	Means	
ENDFLB5	End closure, 30" wide.	EA	1/1/80	$ 63	Means	
ENDFLB6	End closure, 36" wide.	EA	1/1/80	$ 74	Means	
TEEI	Tees, 9" wide.	EA	1/1/80	$154	Means	
TEE2	Tees, 12" wide.	EA	1/1/80	$176	Means	
TEE3	Tees, 18" wide.	EA	1/1/80	$214	Means	
TEE4	Tees, 24" wide.	EA	1/1/80	$274	Means	
TEE5	Tees, 30" wide.	EA	1/1/80	$351	Means	
TEE6	Tees, 36" wide.	EA	1/1/80	$460	Means	
RISER1	Riser and cabinet connector, 9" wide.	EA	1/1/80	$ 85	Means	
RISER2	Riser and cabinet connector, 12" wide.	EA	1/1/80	$ 99	Means	
RISER3	Riser and cabinet connector, 18" wide.	EA	1/1/80	$117	Means	
RISER4	Riser and cabinet connector, 24" wide.	EA	1/1/80	$144	Means	
RISER5	Riser and cabinet connector, 30" wide.	EA	1/1/80	$171	Means	
RISER6	Riser and cabinet connector, 36" wide.	EA	1/1/80	$210	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
BOX1	Junction box, cast, single duct, 3 1/8".	EA	1/1/80	$ 74	Means®	
BOX2	Junction box, cast, single duct, 7 1/4".	EA	1/1/80	$112	Means	
BOX3	Junction box, cast, double duct, 3 1/8".	EA	1/1/80	$105	Means	
BOX4	Junction box, cast, double duct, 7 1/4".	EA	1/1/80	$242	Means	
BOX5	Junction box, cast, triple duct.	EA	1/1/80	$182	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
WIRE11	Stranded wire, 600 volt, type insulated strand wire (THW), copper, #14.	100 FT	1/1/80	$ 12.45	Means®	
WIRE12	Stranded wire, 600 volt, type THW, copper, #10.	100 FT	1/1/80	$ 19.10	Means	
WIRE13	Stranded wire, 600 volt, type THW, copper, #6.	100 FT	1/1/80	$ 33.30	Means	
WIRE14	Stranded wire, 600 volt, type THW, copper, #2.	100 FT	1/1/80	$ 60.00	Means	
WIRE15	Stranded wire, 600 volt, type THW, copper, 1/0.	100 FT	1/1/80	$ 94.00	Means	
WIRE16	Stranded wire, 600 volt, type THW, copper, 3/0.	100 FT	1/1/80	$136.00	Means	
WIRE17	Stranded wire, 600 volt, type THW, copper, 250 1000-circular mils (MCM).	100 FT	1/1/80	$185.00	Means	
WIRE18	Stranded wire, 600 volt, type THW, copper, 350 MCM.	100 FT	1/1/80	$236.00	Means	
WIRE19	Stranded wire, 600 volt, type THW, copper, 500 MCM.	100 FT	1/1/80	$319.00	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
WIRE21	Stranded wire, 600 volt, type insulated strand wire (THW), aluminum, #8.	100 FT	1/1/80	$ 19.20	Means®	
WIRE22	Stranded wire, 600 volt, type THW, aluminum, #6.	100 FT	1/1/80	$ 21.85	Means	
WIRE23	Stranded wire, 600 volt, type THW, aluminum, #2.	100 FT	1/1/80	$ 35.00	Means	
WIRE24	Stranded wire, 600 volt, type THW, aluminum, 1/0.	100 FT	1/1/80	$ 42.00	Means	
WIRE25	Stranded wire, 600 volt, type THW, aluminum, 3/0.	100 FT	1/1/80	$ 67.00	Means	
WIRE26	Stranded wire, 600 volt, type THW, aluminum, 250 1000-circular mils (MCM).	100 FT	1/1/80	$ 84.00	Means	
WIRE27	Stranded wire, 600 volt, type THW, aluminum, 350 MCM.	100 FT	1/1/80	$109.00	Means	
WIRE28	Stranded wire, 600 volt, type THW, aluminum, 500 MCM.	100 FT	1/1/80	$138.00	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
WIRE31	Stranded wire, 600 volt, type nylon jacketed wire (THWN), copper, #14.	100 FT	1/1/80	$ 12.30	Means®	
WIRE32	Stranded wire, 600 volt, type THWN, copper, #10.	100 FT	1/1/80	$ 18.70	Means	
WIRE33	Stranded wire, 600 volt, type THWN, copper, #6.	100 FT	1/1/80	$ 37.30	Means	
WIRE34	Stranded wire, 600 volt, type THWN, copper, #2.	100 FT	1/1/80	$ 84.00	Means	
WIRE35	Stranded wire, 600 volt, type THWN, copper, 1/0.	100 FT	1/1/80	$125.00	Means	
WIRE36	Stranded wire, 600 volt, type THWN, copper, 3/0.	100 FT	1/1/80	$163.00	Means	
WIRE37	Stranded wire, 600 volt, type THWN, copper, 250 1000-circular mils (MCM).	100 FT	1/1/80	$235.00	Means	
WIRE38	Stranded wire, 600 volt, type THWN, copper, 350 MCM.	100 FT	1/1/80	$296.00	Means	
WIRE39	Stranded wire, 600 volt, type THWN, copper, 500 MCM.	100 FT	1/1/80	$389.00	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
CABLE11	Armored cable (BX), 600 volt, copper, #14, 2 wire.	100 FT	1/1/80	$ 71.00	Means®	
CABLE12	BX, 600 volt, copper, #14, 3 wire.	100 FT	1/1/80	$ 80.00	Means	
CABLE13	BX, 600 volt, copper, #10, 2 wire.	100 FT	1/1/80	$ 99.00	Means	
CABLE14	BX, 600 volt, copper, #10, 3 wire.	100 FT	1/1/80	$126.00	Means	
CABLE21	BX, 15 kilovolts, copper, 3 conductor with polyvinyl chloride jacket, grounded neutral, in cable tray, #1.	FT	1/1/80	$ 8.95	Means	
CABLE22	BX, 15 kilovolts, copper, 3 conductor with polyvinyl chloride jacket, grounded neutral, in cable tray, 1/0.	FT	1/1/80	$ 10.51	Means	
CABLE23	BX, 15 kilovolts, copper, 3 conductor with polyvinyl chloride jacket, grounded neutral, in cable tray, 3/0.	FT	1/1/80	$ 13.19	Means	
CABLE24	BX, 15 kilovolts, copper, 3 conductor with polyvinyl chloride jacket, grounded neutral, in cable tray, 250 1000-circular mils (MCM).	FT	1/1/80	$ 17.32	Means	
CABLE25	BX, 15 kilovolts, copper, 3 conductor with polyvinyl chloride jacket, grounded neutral, in cable tray, 500 MCM.	FT	1/1/80	$ 26.70	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
GROUND11	Ground rods, copper clad, 3/4" diam.	100 FT	1/1/80	$470.00	Means®	
GROUND12	Ground rods, bare copper wire, #6.	100 FT	1/1/80	$ 29.90	Means	
GROUND13	Ground rods, bare copper wire, #2.	100 FT	1/1/80	$ 67.00	Means	
GROUND14	Ground rods, bare copper wire, 3/0.	100 FT	1/1/80	$128.00	Means	
GROUND15	Ground rods, bare copper wire, 4/0.	100 FT	1/1/80	$157.00	Means	
GROUND16	Ground rods, bare copper wire, 250 1000-circular mils (MCM).	100 FT	1/1/80	$180.00	Means	
GROUND21	Ground rods, brazed connections, #6.	100 FT	1/1/80	$ 12.20	Means	
GROUND22	Ground rods, brazed connections, #2.	100 FT	1/1/80	$ 14.20	Means	
GROUND23	Ground rods, brazed connections, 3/0.	100 FT	1/1/80	$ 17.15	Means	
GROUND24	Ground rods, brazed connections, 4/0.	100 FT	1/1/80	$ 19.25	Means	
GROUND25	Ground rods, brazed connections, 250 1000-circular mils (MCM).	100 FT	1/1/80	$ 26.30	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
BREAKER1	Circuit breakers, enclosed, National Electric Manufacturers Association (NEMA) type 1, 600 volt, 3 pole, 30 amp.	EA	1/1/80	$ 131	Means®	
BREAKER2	Circuit breakers, enclosed, NEMA type 1, 600 volt, 3 pole, 100 amp.	EA	1/1/80	$ 162	Means	
BREAKER3	Circuit breakers, enclosed, NEMA type 1, 600 volt, 3 pole, 400 amp.	EA	1/1/80	$ 575	Means	
BREAKER4	Circuit breakers, enclosed, NEMA type 1, 600 volt, 3 pole, 800 amp.	EA	1/1/80	$1,165	Means	
FUSE1	Fuse cabinet, 120/240 volts, 3 wire, 30 amp. branches, 4 circuits.	EA	1/1/80	$ 40	Means	
FUSE2	Fuse cabinet, 120/240 volts, 3 wire, 30 amp. branches, 6 circuits.	EA	1/1/80	$ 55	Means	
FUSE3	Fuse cabinet, 120/240 volts, 3 wire, 30 amp. branches, 8 circuits.	EA	1/1/80	$ 72	Means	
FUSE4	Fuse cabinet, 120/240 volts, 3 wire, 30 amp. branches, 12 circuits.	EA	1/1/80	$ 112	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
SWTBOARD1	Switchboard, aluminum bus bars, no main disconnect-current transformer compartment, 120/208 volt, 6 wire, 600 amp.	EA	1/1/80	$1,170	Means®	
SWTBOARD2	Switchboard, aluminum bus bars, no main disconnect-current transformer compartment, 120/208 volt, 6 wire, 1000 amp.	EA	1/1/80	$1,450	Means	
SWTBOARD3	Switchboard, aluminum bus bars, no main disconnect-current transformer compartment, 120/208 volt, 6 wire, 2000 amp.	EA	1/1/80	$1,885	Means	
SWTBOARD4	Switchboard, aluminum bus bars, no main disconnect-current transformer compartment, 120/208 volt, 6 wire, 3000 amp.	EA	1/1/80	$2,375	Means	
SAFTSW1	Safety switch, fused, heavy duty, 240 volt, 3 pole, 30 amp.	EA	1/1/80	$ 67	Means	
SAFTSW2	Safety switch, fused, heavy duty, 240 volt, 3 pole, 100 amp.	EA	1/1/80	$ 142	Means	
SAFTSW3	Safety switch, fused, heavy duty, 240 volt, 3 pole, 400 amp.	EA	1/1/80	$ 445	Means	
SAFTSW4	Safety switch, fused, heavy duty, 240 volt, 3 pole, 800 amp.	EA	1/1/80	$ 765	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
CAPACITOR11	Capacitor, indoor, dust-proof, 240 volt, 1 kilovar (KVAR).	EA	1/1/80	$109	Means®	
CAPACITOR12	Capacitor, indoor, dust-proof, 240 volt, 5 KVAR.	EA	1/1/80	$301	Means	
CAPACITOR13	Capacitor, indoor, dust-proof, 240 volt, 10 KVAR.	EA	1/1/80	$379	Means	
CAPACITOR14	Capacitor, indoor, dust-proof, 240 volt, 25 KVAR.	EA	1/1/80	$680	Means	
CAPACITOR21	Capacitor, indoor, dust-proof, 480 volt, 1 KVAR.	EA	1/1/80	$ 89	Means	
CAPACITOR22	Capacitor, indoor, dust-proof, 480 volt, 5 KVAR.	EA	1/1/80	$239	Means	
CAPACITOR23	Capacitor, indoor, dust-proof, 480 volt, 10 KVAR.	EA	1/1/80	$269	Means	
CAPACITOR24	Capacitor, indoor, dust-proof, 480 volt, 30 KVAR.	EA	1/1/80	$334	Means	
CAPACITOR25	Capacitor, indoor, dust-proof, 480 volt, 50 KVAR.	EA	1/1/80	$560	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
FIXTURE11	Interior lighting fixture, recessed fluorescent, 2'x4' with 3-40 watt (W), rapid start (R.S.).	EA	1/1/80	$ 61	Means®	
FIXTURE12	Interior lighting fixture, recessed fluorescent, 4'x4' with 4-40W, R.S.	EA	1/1/80	$162	Means	
FIXTURE13	Interior lighting fixture, recessed fluorescent, 4'x4' with 8-40W, R.S.	EA	1/1/80	$191	Means	
FIXTURE21	Interior lighting fixture, fluorescent industrial, 4' with 2-60 W, high output.	EA	1/1/80	$ 84	Means	
FIXTURE22	Interior lighting fixture, fluorescent industrial, 8' with 2-75W, high output.	EA	1/1/80	$ 87	Means	
FIXTURE23	Interior lighting fixture, fluorescent industrial, 8' with 2-110W, slimline.	EA	1/1/80	$105	Means	
FIXTURE31	Interior lighting fixture, mercury vapor, prismatic glass lens, 2'x2' with 250 W deluxe white (DX) lamp.	EA	1/1/80	$242	Means	
FIXTURE32	Interior lighting fixture, mercury vapor, prismatic glass lens, 2'x2' with 400W DX lamp.	EA	1/1/80	$276	Means	
FIXTURE33	Interior lighting fixture, mercury vapor, prismatic glass lens, single unit with 1000W DX lamp, aluminum reflector.	EA	1/1/80	$244	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
FIXTURE41	Interior lighting fixture, incandescent, prewired, 100 watt (W).	EA	1/1/80	$ 39.85	Means®	
FIXTURE42	Interior lighting fixture, incandescent, prewired, 150 W.	EA	1/1/80	$ 42.85	Means	
FIXTURE43	Interior lighting fixture, incandescent, prewired, 300 W.	EA	1/1/80	$ 51.75	Means	
FIXTURE51	Exterior fixture, flood-lights with ballast and lamp, mercury vapor, 1000 watt (W).	EA	1/1/80	$ 329.00	Means	
FIXTURE52	Exterior fixture, flood-lights with ballast and lamp, metal halide, 1000W.	EA	1/1/80	$ 384.00	Means	
FIXTURE53	Exterior fixture, flood-lights with ballast and lamp, high pressure sodium, 1000W.	EA	1/1/80	$ 459.00	Means	
MANHOLE1	Manhole, precast, with iron racks, frame and cover, 4'x6'x7' deep.	EA	1/1/80	$ 645.00	Means	
MANHOLE2	Manhole, precast, with iron racks, frame and cover, 6'x8'x7' deep.	EA	1/1/80	$ 890.00	Means	
MANHOLE3	Manhole, precast, with iron racks, frame and cover, 6'x10'x7' deep.	EA	1/1/80	$1,045.00	Means	

Lump Sum Costs Data File

Field Name (12-char.)	Description	UM	Date of Cost	Cost/UM	Cost Source	Inflation Index
SYSTEM11	Fire system, sprinkler and standpipe alarm, control panel, 4 zone.	EA	1/1/80	$ 559	Means®	
SYSTEM12	Fire system, sprinkler and standpipe alarm, control panel, 8 zone.	EA	1/1/80	$ 920	Means	
SYSTEM13	Fire system, sprinkler and standpipe alarm, control panel, 12 zone.	EA	1/1/80	$1,280	Means	
SYSTEM21	Sound system, intercom, 25 station capacity.	EA	1/1/80	$ 720 + $110 per handset	Means	
SYSTEM22	Public address system, industrial.	SPEAKER	1/1/80	$ 214	Means	
SYSTEM31	Security system, burglar alarm, indicating panel with 40 channels.	EA	1/1/80	$2,410	Means	

APPENDIX J

STANDARD OPERATIONS

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN EXCAVATION			
Running Sand, low water inflow, top lift, braced	yd^3/day: 400	A: 1 labor foreman, 1 bottom man, 1 top man, 1 engineer, 1 oiler	80-ton crane or CAT 235™
Running Sand, low water inflow, top lift, unbraced	yd^3/day: 450	A	80-ton crane or CAT 235
Running Sand, low water inflow, bottom lift, braced	yd^3/day: 230	A +2 laborers	80-ton crane + CAT 931™
Running Sand, low water inflow, bottom lift, unbraced	yd^3/day: 280	A +2 laborers	80-ton crane + CAT 931
Running Sand, high water inflow, top lift, braced	yd^3/day: 380	A	80-ton crane or CAT 235
Running Sand, high water inflow, top lift, unbraced	yd^3/day: 430	A	80-ton crane or CAT 235
Running Sand, high water inflow, bottom lift, braced	yd^3/day: 210	A +2 laborers	80-ton crane + CAT 931
Running Sand, high water inflow, bottom lift, unbraced	yd^3/day: 260	A +2 laborers	80-ton crane + CAT 931

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN EXCAVATION			
Soft Ground, low water inflow, top lift, braced	yd^3/day:	A: 1 labor foreman 1 bottom man 1 top man 1 engineer 1 oiler	80-ton crane or CAT 235™
Soft Ground, low water inflow, top lift, unbraced	yd^3/day:	A	80-ton crane or CAT 235
Soft Ground, low water inflow, bottom lift, braced	yd^3/day:	A +2 laborers	80-ton crane + CAT 931™
Soft Ground, low water inflow, bottom lift, unbraced	yd^3/day:	A +2 laborers	80-ton crane + CAT 931
Soft Ground, high water inflow, top lift, braced	yd^3/day:	A	80-ton crane or CAT 235
Soft Ground, high water inflow, top lift, unbraced	yd^3/day:	A	80-ton crane or CAT 235
Soft Ground, high water inflow, bottom lift, braced	yd^3/day:	A +2 laborers	80-ton crane + CAT 931
Soft Ground, high water inflow, bottom lift, unbraced	yd^3/day:	A +2 laborers	80-ton crane + CAT 931

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN EXCAVATION			
Stiff Clay, low water inflow, top lift, braced	yd^3/day: 320	A: 1 labor foreman, 1 bottom man, 1 top man, 1 engineer, 1 oiler	80-ton crane or CAT 235™
Stiff Clay, low water inflow, top lift, unbraced	yd^3/day: 360	A	80-ton crane or CAT 235
Stiff Clay, low water inflow, bottom lift, braced	yd^3/day: 184	A +2 laborers	80-ton crane + CAT 931™
Stiff Clay, low water inflow, bottom lift, unbraced	yd^3/day: 224	A +2 laborers	80-ton crane + CAT 931
Stiff Clay, high water inflow, top lift, braced	yd^3/day: 304	A	80-ton crane or CAT 235
Stiff Clay, high water inflow, top lift, unbraced	yd^3/day: 344	A	80-ton crane or CAT 235
Stiff Clay, high water inflow, bottom lift, braced	yd^3/day: 168	A +2 laborers	80-ton crane + CAT 931
Stiff Clay, high water inflow, bottom lift, unbraced	yd^3/day: 208	A +2 laborers	80-ton crane + CAT 931

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN EXCAVATION			
Rock, low water inflow, braced	yd^3/day: 50	1 labor foreman 1 bottom man 1 top man 1 engineer 1 oiler 2 drillers 1 driller helper 1 blaster 1 powderman	80-ton crane Airtrack (Gardner Denver 123)(TM) Compressor (900 CFM) Muck car (4 cu yd)
Rock, low water inflow, unbraced	yd^3/day: 70		
Rock, high water inflow, braced	yd^3/day: 40		
Rock, high water inflow, unbraced	yd^3/day: 60		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
BACKFILL			
Utilities in the Way, by hand	yd^3/day: 15	4 laborers	-
No Utilities, by hand	yd^3/day: 30	4 laborers	-
No Utilities, by machine	yd^3/day: 60	1 operator	CAT D-4™
Utilities in the Way, by machine	This combination of parameters rarely occurs in reality and is not permitted in the model.		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
BASE			
2 ft thick 600 ft long 60 ft wide 4500 psi			
Reinforcing Steel	lbs/day: 8000	A: 1 labor foreman 4 rodmen 1 engineer 1 oiler 2 laborers	crane service
Poured Concrete	yd^3/day: 150	B: 1 labor foreman 6 laborers 2 finishers 1 engineer 1 oiler	
PERMANENT WALLS			
1 ft thick 600 ft long 8 ft deep-mezzanine 10 ft deep-trainroom 4500 psi			
Reinforcing Steel	lbs/day: 4000	A	
Formwork	ft^2/day: 150	C: 1 labor foreman 4 carpenters 1 laborer	
Poured Concrete	yd^3/day: 100	B	
INTERMEDIATE SLABS			
6 in thick 600 ft long 60 ft wide 4500 psi			
Reinforcing Steel	lbs/day: 6000	A	

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
INTERMEDIATE SLABS (continued)			
Formwork	ft^2/day: 75	C	
Poured Concrete	yd^3/day: 80	B	
ROOF GIRDERS			
A36 steel 2 in thick-flange 3/8 in thick-web 16 in wide-flange 4 ft deep-web 60 ft long	#/day: 2	ironworker foreman 4 ironworkers ironworker helper	100-ton crane (full truck)
ROOF			
2 ft thick 600 ft long 60 ft wide 4500 psi			
Reinforcing Steel	lbs/day: 8000	A	
Formwork	ft^2/day: 80	C	
Poured Concrete	yd^3/day: 90	B	

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
RECTANGULAR COLUMNS			
4 ft long 1 ft wide 4500 psi			
Reinforcing Steel	lbs/day: 2000	A	crane service
Formwork	ft^2/day: 100	C	
Poured Concrete	yd^3/day: 40	B	
CIRCULAR COLUMNS			
24 in diameter 4500 psi			
Reinforcing Steel	lbs/day: 2000	A	
Formwork	ft^2/day: 100	C	
Poured Concrete	yd^3/day: 40	B	
PLATFORM			
6 in thick 600 ft long 10 ft wide 4500 psi			
Reinforcing Steel	lbs/day: 1600	A	

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
PLATFORM (continued)			
Formwork	ft^2/day: 60	C	crane service
Poured Concrete	yd^3/day: 40	B	
VERTICAL CIRCULATION			
48 in wide escalator 20 ft high escalator 6 ft wide stairway 34 risers, each 7 in high stairway 1 intermediate landing stairway	#/month		
2500 lbs capacity elevator	1/month	5 ironworkers 1 ironworker foreman	
SLURRY WALL SUPPORT			
3 ft thick 4500 psi			
Excavation, Slurry Placement, 0-40 ft deep and concrete	yd^3/day: 60	1 foreman 4 laborers 1 operator 1 oiler 1 slurry plant operator 1 pump operator	100-ton crane 4 in pump
Excavation, Slurry Placement, 40-60 ft deep and concrete	yd^3/day: 50		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
SLURRY WALL SUPPORT (continued)			
Excavation and Slurry Placement, greater than 60 ft deep	yd^3/day: 40		
Reinforcing Steel (fabrication and setting)	lbs/day: 1500	1 ironworker foreman 4 ironworkers	crane service
STEEL SHEET PILING			
Placing Sheet Piling, 0-30 ft deep, 36,000 psi	ft^2/day: 500	D 1 dock builder foreman 4 dock builders 1 engineer 1 oiler	70-ton crane 300-amp welder 1033 hammer 900 compressor
Placing Sheet Piling, greater than 30 ft deep, 36,000 psi	ft^2/day: 450	D	
SOLDIER PILES AND LAGGING			
H 14 piles 6 in. x 4 in lagging cross-section			
Placing Piles, 0-40 ft deep	#/day: 8	1 dock builder foreman 4 dock builders 1 engineer 1 oiler	70-ton crane 300-amp welder 1033 hammer 900 compressor
Placing Piles, 40-60 40-60 ft deep	#/day: 7	D	
Placing Piles, 60 ft deep	#/day: 7	D	

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
SOLDIER PILES AND LAGGING (continued)			
Placing Lagging, less than 6 ft long, bottom 5 ft strip	ft^2/day: 200	D	none
Placing Lagging, greater than 6 ft long, above 5 ft strip	ft^2/day: 300	D	
Placing Lagging, less than 6 ft long, above 5 ft strip	ft^2/day: 250	1 dock builder foreman 4 dock builders 1 engineer 1 oiler	70-ton crane 300-amp welder 1033 hammer 900 compressor
Placing Lagging, greater than 6 ft long, bottom 5 ft strip	ft^2/day: 250	D	
CROSS BRACING			
60 ft long	lbs of cross bracings/day: 10000	1 dock builder foreman 4 dock builders 1 engineer 1 oiler	70-ton crane 300-amp welder
TIEBACKS			
5/8 in diameter 25 ft long	# of tiebacks/day: 2	2 blowers 1 dock builder 1 foreman	Airtrack
DECKING			
36 in steel beams 12 in wood decking	ft^2/day: 400	1 dock builder foreman 4 dockbuilders 1 oiler 1 operator	80-ton crane

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH			
0-10 ft deep, 0-4 ft base width, soft soil, high water inflow.	yd^3/day: 120	1 labor foreman 3 laborers 1 engineer 1 oiler	G-800 Gradall(TM)
0-10 ft deep, 0-4 ft base width, soft soil, low water inflow.	yd^3/day: 150		
0-10 ft deep, 0-4 ft base width, medium soil, high water inflow.	yd^3/day: 110		
0-10 ft deep, 0-4 ft base width, medium soil, low water inflow.	yd^3/day: 140		
0-10 ft deep, 0-4 ft base width, stiff soil, high water inflow.	yd^3/day: 90		
0-10 ft deep, 0-4 ft base width, stiff soil, low water inflow.	yd^3/day: 120		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH			
0-10 ft deep, 4-10 ft base width, soft soil, high water inflow.	yd^3/day: 175	1 labor foreman 4 laborers 1 engineer 1 oiler	G-1000 Gradall(TM)
0-10 ft deep, 4-10 ft base width, soft soil, low water inflow.	yd^3/day: 210		
0-10 ft deep, 4-10 ft base width, medium soil, high water inflow.	yd^3/day: 160		
0-10 ft deep, 4-10 ft base width, medium soil, low water inflow.	yd^3/day: 195		
0-10 ft deep, 4-10 ft base width, stiff soil, high water inflow.	yd^3/day: 140		
0-10 ft deep, 4-10 ft base width, stiff soil, low water inflow.	yd^3/day: 175		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH			
10-20 ft deep, 0-4 ft base width, soft soil, high water inflow.	yd^3/day: 200	1 labor foreman 5 laborers 1 engineer 1 oiler	CAT 235(TM) Backhoe
10-20 ft deep, 0-4 ft base width, soft soil, low water inflow.	yd^3/day: 280		
10-20 ft deep, 0-4 ft base width, medium soil, high water inflow.	yd^3/day: 185		
10-20 ft deep, 0-4 ft base width, medium soil, low water inflow.	yd^3/day: 225		
10-20 ft deep, 0-4 ft base width, stiff soil, high water inflow.	yd^3/day: 160		
10-20 ft deep, 0-4 ft base width, stiff soil, low water inflow.	yd^3/day: 200		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH			
10-20 ft deep, 4-10 ft base width, soft soil, high water inflow.	yd^3/day: 200	1 labor foreman 5 laborers 1 engineer 1 oiler	CAT 235(TM) Backhoe
10-20 ft deep, 4-10 ft base width, soft soil, low water inflow.	yd^3/day: 280		
10-20 ft deep, 4-10 ft base width, medium soil, high water inflow.	yd^3/day: 185		
10-20 ft deep, 4-10 ft base width, medium soil, low water inflow.	yd^3/day: 225		
10-20 ft deep, 4-10 ft base width, stiff soil, high water inflow.	yd^3/day: 160		
10-20 ft deep, 4-10 ft base width, stiff soil, low water inflow.	yd^3/day: 200		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
BRACED TRENCH			
10-20 ft deep, 0-4 ft base width, 30° repose angle, high water inflow.	yd^3/day: 60	1 labor foreman 4 laborers 1 engineer 1 oiler	G-1000 Gradall(TM)
10-20 ft deep, 0-4 ft base width, 30° repose angle, low water inflow.	yd^3/day: 85		
10-20 ft deep, 0-4 ft base width, 45° repose angle, high water inflow.	yd^3/day: 45		
10-20 ft. deep, 0-4 ft base width, 45° repose angle, low water inflow.	yd^3/day: 70		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
BRACED TRENCH			
10-20 ft deep, 4-10 ft base width, 30° repose angle, high water inflow.	yd^3/day: 60	1 labor foreman 4 laborers 1 engineer 1 oiler	G-1000 Gradall(TM)
10-20 ft deep, 4-10 ft base width, 30° repose angle, low water inflow.	yd^3/day: 84		
10-20 ft deep, 4-10 ft base width, 45° repose angle, high water inflow.	yd^3/day: 45		
10-20 ft deep, 4-10 ft base width, 45° repose angle, low water inflow.	yd^3/day: 70		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH WITH EXISTING UTILITIES			
0-10 ft deep, 0-4 ft base width, soft soil, high water inflow.	yd^3/day: 70	1 labor foreman 4 laborers 1 engineer 1 oiler	G-800 Gradall(TM)
0-10 ft deep, 0-4 ft base width, soft soil, low water inflow.	yd^3/day: 84		
0-10 ft deep, 0-4 ft base width, medium soil, high water inflow.	yd^3/day: 65		
0-10 ft deep, 0-4 ft base width, medium soil, low water inflow.	yd^3/day: 75		
0-10 ft deep, 0-4 ft base width, stiff soil, high water inflow.	yd^3/day: 55		
0-10 ft deep, 0-4 ft base width, stiff soil, low water inflow.	yd^3/day: 70		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH WITH EXISTING UTILITIES			
0-10 ft deep, 4-10 ft base width, soft soil, high water inflow.	yd^3/day: 84	1 labor foreman 4 laborers 1 engineer 1 oiler	G-1000 Gradall(TM)
0-10 ft deep, 4-10 ft base width, soft soil, low water inflow.	yd^3/day: 105		
0-10 ft deep, 4-10 ft base width, medium soil, high water inflow.	yd^3/day: 75		
0-10 ft deep, 4-10 ft base width, medium soil, low water inflow.	yd^3/day: 100		
0-10 ft deep, 4-10 ft base width, stiff soil, high water inflow.	yd^3/day: 70		
0-10 ft deep, 4-10 ft base width, stiff soil, low water inflow.	yd^3/day: 85		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH WITH EXISTING UTILITIES			
10-20 ft deep, 0-4 ft base width, soft soil, high water inflow.	yd^3/day: 95	1 labor foreman 5 laborers 1 engineer 1 oiler	CAT 235(TM) Backhoe
10-20 ft deep, 0-4 ft base width, soft soil, low water inflow.	yd^3/day: 135		
10-20 ft deep, 0-4 ft base width, medium soil, high water inflow.	yd^3/day: 90		
10-20 ft deep, 0-4 ft base width, medium soil, low water inflow.	yd^3/day: 110		
10-20 ft deep, 0-4 ft base width, stiff soil, high water inflow.	yd^3/day: 80		
10-20 ft deep, 0-4 ft base width, stiff soil, low water inflow.	yd^3/day: 95		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
OPEN TRENCH WITH EXISTING UTILITIES			
10-20 ft deep, 4-10 ft base width, soft soil, high water inflow.	yd^3/day: 95	1 labor foreman 5 laborers 1 engineer 1 oiler	CAT 235(TM) Backhoe
10-20 ft deep, 4-10 ft base width, soft soil, low water inflow.	yd^3/day: 135		
10-20 ft deep, 4-10 ft base width, medium soil, high water inflow.	yd^3/day: 90		
10-20 ft deep, 4-10 ft base width, medium soil, low water inflow.	yd^3/day: 110		
10-20 ft deep, 4-10 ft base width, stiff soil, high water inflow.	yd^3/day: 80		
10-20 ft deep, 4-10 ft base width, stiff soil, low water inflow.	yd^3/day: 95		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
BRACED TRENCH WITH EXISTING UTILITIES			
10-20 ft deep, 0-4 ft base width, 30° repose angle, high water inflow.	yd^3/day: 55	1 labor foreman 5 laborers 1 engineer 1 oiler	G-1000 Gradall™
10-20 ft deep, 0-4 ft base width, 30° repose angle, low water inflow.	yd^3/day: 90		
10-20 ft deep, 0-4 ft base width, 45° repose angle, high water inflow.	yd^3/day: 40		
10-20 ft deep, 0-4 ft base width, 45° repose angle, low water inflow.	yd^3/day: 70		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
BRACED TRENCH WITH EXISTING UTILITIES			
10-20 ft deep, 4-10 ft base width, 30° repose angle, high water inflow.	yd^3/day: 55	1 labor foreman 5 laborers 1 engineer 1 oiler	G-1000 Gradall(TM)
10-20 ft deep, 4-10 ft base width, 30° repose angle, low water inflow.	yd^3/day: 90		
10-20 ft deep, 4-10 ft base width, 45° repose angle, high water inflow.	yd^3/day: 40		
10-20 ft deep, 4-10 ft base width, 45° repose angle, low water inflow.	yd^3/day: 70		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
PLACE PIPE			
VCP	ft/day: 250	1 labor foreman 3 laborers 1 engineer 1 oiler	G-800 Gradall(TM)
RCP	ft/day: 300		
CMP	ft/day: 400		
DIP	ft/day: 200		
PVC	ft/day: 400		
SUPPORT PIPE			
VCP	ft/day: 50		
RCP	ft/day: 40		
CMP	ft/day: 120		
DIP	ft/day: 100		
PVC	ft/day: 120		

STANDARD OPERATIONS

Description	Advance Rate	Crew Configuration	Equipment
FILL TRENCH BY HAND			
Compacted	yd^3/day: 50	1 labor foreman 3 laborers 1 engineer	190 Dynahoe™
Not Compacted	yd^3/day: 100	1 labor foreman 3 laborers 1 engineer	190 Dynahoe

APPENDIX K

REPORT OF NEW TECHNOLOGY

This project was a study of the cost estimating process in subway tunnel and station construction and no patents or inventions resulted from this work. However, this report presents an original prescriptive framework for estimating costs that should help planners and designers in making key managerial decisions as to the feasibility of a subway project.