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Costs of Solid Waste Management in the Knoxville, Tennessee Metropolitan Area

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SUMMARY

THE GENERAL OBJECTIVE of this study was to estimate the direct and indirect costs of solid waste management in the metropolitan area composed of Anderson, Blount, and Knox counties, Tennessee.

Estimates were made of the weights and volumes of solid waste collected and dumped at four facilities operated within the study area during the last 4 months of 1970. Costs associated with handling these amounts of solid waste were estimated on the basis of records provided by government agencies and private individuals and business firms in the study area.

The estimates were made for facilities and services operated by the cities of Knoxville, Alcoa, Maryville, and Oak Ridge, and by Knox and Blount counties.

Lowest total unit costs for collection and disposal were for Knoxville — $9.98 per ton and $3.09 per cubic yard of solid waste. These costs were moderately higher for Oak Ridge — $10.49 per ton and $4.10 per cubic yard. Highest estimated costs were for Knox County — $26.19 per ton and $8.11 per cubic yard. Costs for the three jurisdictions in Blount County (Alcoa, Maryville, and Blount County) averaged $23.89 per ton and $7.29 per cubic yard.

Among the factors that could account for the differences among the cost estimates are: economies of scale (especially in the case of Knoxville); differences in the composition of the refuse delivered to the landfills; and relatively low densities of households in outlying areas of Knox and Blount counties.

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THE SOLID WASTE PROBLEM

"THE AVERAGE CITY DWELLER, directly or indirectly, uses about 150 gallons of water per day, 4 pounds of food, and 19 pounds of fossil fuel. This is converted into roughly 120 gallons of sewage, assuming an 80% recovery of water input; 4.5 pounds of solid refuse , and 1.9 pounds of air pollutants."[1,2]

Solid waste[3] management is concerned with economically efficient collection, movement, and disposal of useless, unused, unwanted, or otherwise discarded materials. As urban activities expand outward from a city's central district, past the rural-urban fringe, sites that would otherwise be used for waste disposal are now used for commercial and/or residential purposes. Therefore, transportation costs associated with collection and disposal are greatly

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[1]Henry Still, **The Dirty Animal** (New York: Hawthorn Books, Inc., 1967), p. 28.

[2]Pollution may be defined as the "undesirable change in the physical, chemical, or biological characteristics of our air, land, and water that may or will harmfully affect human life or that of other desirable species, our industrial processes, living conditions, and cultural assets; or that may or will waste or deteriorate our raw materials." Pollutants are residues. Definition from Committee on Pollution, **Waste Management and Control**, Publication 1400 (Washington: National Academy of Sciences, National Research Council, 1966), p. 3.

[3]**Solid Waste** is defined as useless, unused, unwanted, or discarded materials. **Refuse** is generally used in reference to solid wastes. Defined by American Public Works Association, **Municipal Refuse Disposal** (Chicago: Public Administration Service), p. 11. Hereafter referred to as APWA.

affected by urban and suburban growth and development. That is,

> From 20 to 40% of annual budgets of departments of public works is applied to the tasks of refuse collection and refuse disposal. Of this repetitive expenditure, approximately 80% is consumed in collection, the cost of which has been steadily increasing with no apparent improvement in sanitary quality of service rendered.[4]

To the average citizen, this could mean more taxes to maintain environmental quality at current levels.

Studies conducted by the American Public Works Association and the United States Department of Public Health reported that fewer than 50% of the United States cities with population greater than 2,500 disposed of community refuse by approved sanitary and nuisance-free methods. Approximately 80% of urban and rural towns with populations between 1,000 and 5,000 disposed of refuse in open pits or dumps. This was done without regard to sanitation standards, health hazards, and associated community blight near the dump.[5]

The Tennessee Department of Public Health recognized the potential health problems associated with careless solid waste disposal. The Solid Waste Disposal Act became effective in 1971 (Tennessee Code Annotated, Section 53-4301 to 53-4315).[6] However, liberal waiver provisions were made because local governments claimed that the regulations could impose excessive financial burdens on community resources.

In any case, reliable data on the economics of solid waste management are needed by all agencies and individuals concerned with efficient solution of solid waste problems. This report contains results of a study that was made to generate this kind of information. The results apply to communities in the metropolitan area of Knoxville, Tennessee, and to similar localities elsewhere.

OBJECTIVES AND GENERAL PROCEDURE

The general objective of the study reported here was to estimate the direct and indirect costs of solid waste management in the metropolitan area composed of Anderson, Blount, and Knox counties, Tennessee.

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[4]Marcus M. Truitt, et al, **Mathematical Modeling of Solid Waste Collection Policies**, Public Health Service Publication No. 2030 (Washington: Government Printing Office, 1970), p. 1.

[5]APWA, **Refuse Disposal**, p. v.

[6]Tennessee Code Commission, **Tennessee Code Annotated**, Volume 9A Cumulative Supplement (New York: The Bobbs-Merrill Company, Inc., 1970), pp. 133-141.

Estimates were made of the weights and volumes of solid waste collected and dumped at four facilities operated within the study area during the last 3 months of 1970. Costs associated with handling these amounts of solid waste were estimated on the basis of records provided by government agencies and private individuals and business firms in the study area.

The estimates were made for facilities and services operated by the cities of Knoxville, Alcoa, Maryville, and Oak Ridge, and by Knox and Blount counties. Further, the costs were for operating procedures that conform to solid waste disposal regulations of the State of Tennessee.

DESCRIPTION OF THE STUDY AREA

The area in which the study was made typified in many ways other urban-rural areas in Tennessee and in the South. That is, the central city (Knoxville) served as the commercial, industrial, and cultural center for the population; but in keeping with current social trends, a substantial portion of the population lived in suburbs or rural areas and commuted to the inner city for employment. Also, many "bedroom communities" that surrounded the main city were incorporated jurisdictions that provided municipal services and generated revenues to pay for the services.

The United States Bureau of the Census defined the Anderson, Knox, and Blount counties area as a Standard Metropolitan Statistical Area (SMSA). The 1970 population of the area was estimated at 400,337.[7] The number of persons residing in the same household (2.73) in the study area was close to the state average, 2.8. The median value of homes in both the Knoxville SMSA and the entire state was $12,700.[8] About 13.5% of the population in the Knoxville SMSA in 1970 was nonwhite; for the entire state the percentage was 16.3%[9]

Solid wastes generally were disposed of in the study area by using sanitary landfills. All jurisdictions, except one, provided

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[7]United States Department of Commerce, **1970 Census of Population, Tennessee, Final Population Counts,** PC (VI)-44, Bureau of the Census (Washington: Government Printing Office, December, 1970), p. 3.

[8]United States Department of Commerce, **1970 Census of Population, General Housing Characteristics,** HC (VI)-44, Bureau of the Census (Washington: Government Printing Office, February, 1971), p. 5.

[9]United States Department of Commerce, **1970 Census of Population Advance Report, Tennessee, General Population Characteristics,** PC (V2)-44 Bureau of the Census (Washington: Government Printing Office, February, 1971), p. 4.

collection and disposal services for residents living within their respective boundaries. In the case of the exception, the community contracted with a private corporation to furnish collection and disposal services. The fees for these services were paid from community tax revenues, rather than from direct payments by individual users.

In other rural and suburban areas not served by municipal agencies, householders subscribed individually to refuse collection services, paying $2 to $3 a month for pickups made once or twice a week. Outlying jurisdictions in the study area, as well as the individual counties, maintained centrally-located refuse disposal sites. Households not served by municipal collection and not subscribing to pickup services either hauled their refuse to the county landfill or disposed of it in some other way. Widespread use of the latter method of disposal has caused many roadside and backyard dumps to appear throughout the area. The use of these dumps and other improperly-operated landfills are responsible for increased landscape, water, and air pollution. Efforts have been made at both state and local levels to clean up roadside dumps and to prohibit future appearance of new ones.

ESTIMATES OF SOLID WASTE WEIGHTS AND VOLUMES

Proper data were not available on the quantities of solid waste generated in the area covered by this study. Therefore, a sample survey was made to estimate these values. Since most solid waste was collected in compactor trucks, these trucks were the sampling units. Initially, all other vehicles (private cars, private trucks, and business-owned trucks) bringing refuse to the dumps that were surveyed were to be covered also in gathering data for the estimates.[10] However, cars and private trucks had to be omitted from the data plan because the typical nonprofessional driver of these vehicles was not skillful enough to safely position his vehicle on the portable scales used in the survey. Inclement weather during the period in which the study was made would have compounded the risks. The procedure used to adjust for amounts of refuse delivered by these vehicles will be discussed below.

The sample size (total number of trucks weighed) was constrained by the time and resources available for data gathering.

[10]That is to say, there would be a complete enumeration of amounts of solid waste delivered in these vehicles in addition to the data gathered from the sample of compactor trucks.

However, results of research on solid waste management conducted in other areas of the United States indicated that weekly amounts collected during the autumn season were representative of average weekly quantities generated over the entire year.[11]

Data from published results of prior studies were expressed in pounds per unit. However, a unit of measure having less variability among time periods and among delivery vehicles would be preferable for extrapolative purposes. Volume was considered first as an "ideal" measure. However, volume varies with compression force, moisture content of the refuse compressed, and density of the component materials in the particular heterogeneous mass of refuse being measured. Rather than attempting to reconcile these factors and the relationships between volume and weight, both weights and volumes were used in the analysis. Another reason for retaining both bases of measurement was that costs could be compared on both weight and volume bases for the same waste materials, thus adding more range to the analysis.

The American Public Works Association (APWA)[12] stated that it was relatively easy to determine accurate weights and volumes of solid waste when the material was in the transporting vehicle ready to be discharged. In the area studied, the greatest proportion of solid waste collected and deposited arrived at the landfills in compaction (packer) trucks. Accordingly, the sampling procedure to gather data was as follows:

The purpose of the sample was to estimate the average weight per cubic yard of solid waste delivered in packer trucks at a 95% confidence level. It was assumed that data taken in any 1 week at each of the four landfills surveyed would be representative of the other 51 weeks during the year. A sampling unit was defined as one compacted truckload, and all such loads per day during a 6-day week constituted the population sampled at each of the four landfills.

The specific details of the sample design were these:

Let X = pounds per cubic yard of solid waste on one truck out of the population. The population mean expressed in pounds per cubic yard per load, $\mu = E(X)$, was the sample objective. Records from the respective solid waste agencies indicated that a total of 551 packer vehicles could be expected over a 1-week period at all

[11] American Public Works Association, p. 30.
[12] Ibid., p. 42.

four sites covered by the study. The expected subtotals by landfill sites were: Knoxville, 355; Blount County, 90; Knox County, 40; and Oak Ridge, 66 vehicles per week.

Snedecor and Cochran[13] stated that if homogeneous strata within a heterogeneous population could be delineated, a gain in precision over simple random sampling would result. Stratified sampling required a choice with respect to the size of sample to be taken from any stratum. Therefore, a proportional allocation was used which sampled a given fraction from every stratum.

The sample size was computed from $n = \left[Z \frac{\sigma_x}{L} \right]^2$ where Z was the confidence level desired (or the probability the error in the mean would exceed L); σ_x was the sample variance of the population; and L was the allowable error in the sample mean[14] measured in pounds; and n was the sample size for each site.

A sample of size, n = 10, was drawn from the population to establish a standard deviation for the population.[15] The stratified sample, using a proportional allocation with 5% probability of an error exceeding ± 10 pound per cubic yard, indicated a sample size, n, at Knoxville of 129; Blount County, 33; Knox County, 15; and Oak Ridge, 24.

A random number table was used to select the loaded garbage trucks to be weighed at each landfill site.

All vehicles entering the landfill when surveys were made were stopped and the driver was questioned as to the origin of the solid waste carried; that is, residential, industrial, commercial, or agricultural. The type of material to be discarded was noted, along with vehicle identification and estimated cubic yardage of refuse. Solid waste volume was determined by measuring the inside dimensions of the carrier vehicle's load area. Refuse not lending itself to the simplified code used in the questionnaire was descriptively noted. (See Appendix for sample questionnaire.) The data on the questionnaires were the basis for computing the mean weights per cubic yard of packer truck solid waste. The volume data collected from those vehicles not weighed (private cars and trucks

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[13]G. W. Snedecor and William G. Cochran, **Statistical Methods**, 6th edition (Ames: The Iowa State University Press, 1967), p. 520.

[14]Snedecor and Cochran, p. 521.

[15]Sampling procedure used was discussed with Dr. H. A. Lasater, University of Tennessee Statistics Department, Knoxville, October 30, 1970.

operated by nonprofessional drivers) were transformed into weights using published engineering information.[16] Compaction factors for each waste category were used to derive a standardized solid waste density for vehicles hauling loose waste.[17] A compaction factor of 0.8, for example, meant that the loose solid waste material would decrease to 80% of its original volume when enough compaction force was applied and a specific material density was attained. The standardized density allowed data on solid waste receipts at the landfill sites to be compared and/or aggregated.

The resultant weight and volume output from the computer was expanded to a 52-week basis. Table 1 presents the solid waste quantities estimated for 52-week periods on the basis of the 1-week sample of data taken at each site.

Table 1. Estimated annual weights and volumes of solid waste collected and disposed of for six jurisdictions in the Knoxville SMSA, 1970

Jurisdiction	Weight	Volume[a]
	Tons	Cubic yards
Knoxville	119,467.40	385,231.6
Knox County	6,736.08	20,433.4
Alcoa[b]	5,813.12	19,066.3
Maryville[b]	6,308.15	21,055.9
Blount County[b]	9,110.27	26,233.0
Oak Ridge	22,520.16	57,610.8

[a]Volumes determined by compacted densities of materials collected from each jurisdiction.

[b]Disposed of in landfill operated by City of Alcoa.

COSTS OF SOLID WASTE MANAGEMENT

The costs of municipal solid waste management were analyzed on the basis of a set of stages and activities that conformed to Tennessee Solid Waste Disposal Regulations.[18] Cost data and equipment specifications were obtained from the respective municipalities in the study area and were used to synthesize cost budgets consistent with each size and operating environment. Table 2 shows the operating cost stages financed by public funds for each

[16]United States Department of Health, Education, and Welfare, **Collection and Disposal of Solid Wastes for the Des Moines Metropolitan Area**, pp. 2-30.

[17]**Ibid.**

[18]Tennessee Code Commission, **Tennessee Code Annotated**, pp. 131-141.

Table 2. Cost stages for solid waste services — six jurisdictions in the Knoxville SMSA, 1970

Jurisdiction	Cost stage		
	Administrative and overhead	Collection	Disposal
Knoxville	X	X	X
Knox County	X	[a]	X
Alcoa	X	X	X
Maryville	X	X	[b]
Blount County	[c]	[c]	[c]
Oak Ridge	X	[d]	[d]

[a]Knox County did not operate collection services.

[b]Maryville used landfill operated by City of Alcoa.

[c]Blount County residents were served by private contractors. Refuse was disposed of in landfill operated by City of Alcoa.

[d]City of Oak Ridge contracted with private operators for services. Public Health Department acted as inspector and community relations coordinator.

of the jurisdictions surveyed. Knox and Blount county residents were served by private collection services, while Oak Ridge contracted for solid waste services with a private firm.

OVERHEAD AND COLLECTION COSTS

Overhead and collection costs were grouped into three categories: administrative overhead, garage and maintenance overhead, and collection equipment overhead and operation; and each of the cost categories discussed below were allocated accordingly.

Administrative Overhead

Land and buildings. When more than one agency shared a municipal office building, building costs attributed to solid waste management were estimated by a floor space allocation technique. The actual floor space for specific office areas and total building floor area was obtained from personnel assigned to the solid waste management office and from engineering records. The proportion of the total building unit used for solid waste management services was calculated and the resulting ratio was used also to allocate costs normally assigned by the municipality to the general operating fund, such as telephones and utilities.

The Knox County solid waste building cost allocation presented a unique problem in that the County Clerk, who also administered

the landfill, was housed with most other county agencies in a large, old building. The landfill inspector for Knox County was headquartered in another building. Rather than attempting to cost out these two buildings, it was more realistic to determine the cost of nearby comparable rental office space of equal size, and to use these rental rates as estimates. These rates ranged from $3.96 to $4.56 per square foot without utilities. An average rental price of $4.36 per square foot, based on rates supplied by local building rental agencies, was estimated for Knoxville.

Observation by the researchers indicated that new military administrative buildings built by the Federal Government in recent years differ little architecturally and functionally from civilian counterparts constructed for use by local governments. Therefore, if new building costs could not be obtained from current insurance appraisals or other sources, a construction cost rate from the **National Construction Estimator**[19] for military building costs was selected. The **National Construction Estimator** provided a guide for completed building space including fixtures and equipment normally considered built-in or attached to the structure, for example, window screens, venetian blinds, and drinking water coolers.[20] An administrative building of the type approved for military installations would have cost $26.62 per square foot, adjusted for location factors and size.[21]

Table 3 gives the estimated allocations of land and building spaces for solid waste services in municipal buildings and garages for Knoxville, Knox County, Alcoa, Maryville, Blount County, and Oak Ridge. The size of the publicly-owned land plot surrounding these buildings varied. The table shows that Maryville operated four garages. Three were of low cost pole barn construction, and served mainly as storage facilities. The fourth, a more permanent structure, housed repair shops.

The municipal garage complex in Knoxville was a series of antiquated buildings. To estimate costs of these buildings, a single model structure was designed that combined both garage space and office space on the side. The model garage was patterned after similar maintenance facilities operated by other public agencies.

The cost allowances for building in the Knoxville City Hall were based on the area occupied by the public works department.

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[19]Gary Moselle (ed.), **National Construction Estimator** (18th edition: Los Angeles: Craftsman Book Company, 1970-1971, p. 174.

[20]**Ibid.**, p. 175.

[21]**Ibid.**, pp. 176-177.

Table 3. Buildings and land allocated to solid waste services for six jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction and facility	Land		Buildings	
	Total amount used by facility	Portion allocated to solid waste services	Total cost	Portion allocated to solid waste services
	Acres	Percent	Dollars	Percent
Knoxville — Municipal bldg.	6.00	15.00	54,091.84	15.00
Garage[b]	7.09	70.00	105,925.00	70.00
Knox County — Municipal bldg.	[c]	[c]	1,098.72[c]	6.00
Garage	[c]	[c]	627.84[c]	40.00
Alcoa — Municipal bldg.	2.50	50.00	150 000.00	1.67
Garage		50.00	220,000.00	90.00
Garage	3.00	50.00	4,960.00	100.00
Maryville — Municipal bldg.	3.50	0.63	300,000.00	0.63
Garage		70.00	3,472.00	25.00
Garage	2.00	70.00	6,240.00	70.00
Garage		70.00	2,184.00	75.00
Garage		70.00	2,000.00	33.33
Blount County	[d]	[d]	[d]	[d]
Oak Ridge — Municipal bldg.[e]	6.68	0.69	565,331.72	0.69
Garage	[e]	[e]	[e]	[e]

[a]Costs allocated to solid waste management based on area occupied by public works department and percent of public works staff time spent on management of solid waste services.

[b]Knoxville garage building costs synthesized on basis of single model garage structure.

[c]Knox County basic cost data were not available. Land requirements and building costs based on rents charged for comparable property nearby.

[d]Blount County residents were served by private contractors who collected material and disposed of it in landfill operated by the City of Alcoa. Hence municipal overhead costs for solid waste services were negligible.

[e]Oak Ridge contracted with private operators for collection and disposal. Public Health Department acted as inspector and public relations coordinator.

Engineering records were the source of figures on floor space allotted to public works activities. Finally, the average percentage of time spent on solid waste management by the public works office staff was basis for allocating intradepartmental building costs.

Office equipment. Allowances for office equipment were a significant cost element. Equipment inventories used to derive these costs were determined by observation and survey at the

offices covered in this study. Prices of individual items of equipment were obtained from local suppliers.

Appendix Table 1 shows the equipment items for four of the six municipalities studied. The City of Alcoa provided a lump sum estimate of annual office costs associated with solid waste management in lieu of an inventory. The figure given ($916.30) compared closely with those for similar-sized solid waste management offices.

Estimates for Blount County were not made because of the very small amount of municipal office services that was concerned with solid waste management. The county operated neither a collection nor disposal service. Instead, private collection contractors dealt directly with individual residents and businesses for refuse removal services.

Blount County negotiated a contract with the City of Alcoa to operate a joint Blount County, Maryville, and Alcoa landfill, agreeing to pay 40% of the total disposal costs. Under this arrangement, Maryville and Alcoa each paid 30%.

Office equipment depreciation, interest, maintenance, and insurance costs were computed from the information given in Appendix Table 1. Equipment life was estimated at 15 years with zero salvage value. Maintenance costs were estimated at 1.5% per year of purchase cost, and a 6% interest rate was assumed.

Garage and Maintenance Overhead

Knoxville, Maryville, and Alcoa operated municipal equipment repair and storage facilities. Appendix Table 2 lists estimated garage equipment costs for Knoxville, Maryville, and Alcoa. Only the City of Alcoa retained an inventory of spare parts and equipment to meet emergency needs. The average annual cost of this inventory as related to solid waste was estimated at $2,200. The data given in Appendix Table 2 were used to compute annual depreciation (assuming zero salvage value), interest on capital invested (assuming 6% interest), and maintenance costs (assuming 1% per annum of original equipment cost). Insurance costs were computed from rates for garage equipment.

Collection Equipment and Overhead

Collection vehicles. One of the largest cost categories in solid waste management was that concerned with collection vehicles. Solid waste collection services traditionally have been labor intensive. But, efforts have been made to raise collection efficiency

through increased mechanization. The collection equipment is expensive. Also, inspection of municipal collection truck service records in the study area showed that this equipment was costly to maintain. For example, maintenance records for city-owned compactor trucks for the period, 1961-1970, indicated an estimated annual maintenance cost rate of 150% of initial investment and a 7-year useful life. Specific items included in maintenance costs were parts, lubricants, tires, and labor.

Trashmobiles and GRD trucks[22] used in Knoxville had, according to records kept, a 90% annual maintenance cost rate and 4- and 10-year estimated use lives, respectively. Based on published data,[23] automobile and pickup truck maintenance rates were estimated at 50% of purchase cost, with an estimated use life of 10 years. Purchase prices of the various types of vehicles were obtained from published municipal bid price lists.[24] Depreciation, interest, and maintenance costs were computed from the data in Appendix Table 3.

Additional bases for the estimates of vehicle costs were a 10% salvage value on equipment and a 6% interest rate on capital invested. Insurance rates, quoted by a regional insurance firm familiar with municipal vehicle insurance, estimated annual liability insurance costs per automobile at $156; trashmaster sized truck at $568; and larger packer type truck at $912. This was a cost assigned to the average degree of risk the vehicles faced while performing collection services. Some municipalities did not buy commercial insurance, but rather insured the vehicles themselves. If a vehicle was then involved in an accident, the municipality paid any costs for which it was liable from its general fund. The cost of commercial insurance, however, was included as an item in vehicle costs under both situations.

Fuel. Fuel costs are affected by both time and distance of operation. Accurate fuel records generally were maintained for municipally-owned vehicles. These records were the basis of the

[22]Trucks used to lift and empty large solid waste containers into the compaction trailer.

[23]Glenn H. Glover, "Costs of Farm Machinery Used for Cotton Production in Tennessee," **University of Tennessee Experiment Station Bulletin 448,** Knoxville, October, 1968, p. 21

[24]M. U. Snoderly (ed.), "Bid Data on Current Municipal Public Works," **The University of Tennessee Technical Bulletin 60,** MTAS, Knoxville, July, 1969; and Frank E. Kirk (ed.), "Bid Data on Current Municipal Public Works," **The University of Tennessee** (Knoxville) **Technical Bulletin 62,** July, 1970, and **Technical Bulletin 63,** January, 1971.

estimated fuel consumption rates for the localities covered by this study.

Appendix Table 4 shows the bases of the fuel cost estimates made for jurisdictions in the study area. Fuel used by each type of vehicle in Knoxville was estimated from fuel fill-up receipts. Total fuel costs for Maryville and Alcoa were taken from city accounting records and the rates listed in the table were derived from these data. Oak Ridge and Knox County automobile fuel costs were derived from average fuel consumption rates and daily mileages provided by drivers of the vehicles.

Labor. Direct and indirect labor was the largest single cost item in solid waste management.

The wage and salary rates reported by jurisdictions in the study area for employees engaged in waste management administration, collection, and disposal activities are summarized in Appendix Table 5. Also shown are the manpower requirements, estimated fringe benefit rates, and hours of work per week for each job category. The bases for the pay rates — hourly wage or annual salary — reflect the accounting procedures used in each municipality. These pay rate data were used to estimate total labor costs. These costs were: the number of employees in each job category times the respective pay scales (including fringe benefits) times hours worked per week.

Utilities. Utility costs were determined from municipal records and interviews with city officials. When only a total utility cost covering all municipal operations was available, the costs were allocated in the same manner as building depreciation. That is, total costs of telephone, electric, gas, and water services were added for a given operating period and multiplied by a solid waste service allocation factor, computed from floor space allocations in the respective municipal service buildings.

Office supplies. Office supplies included items such as postage, paper, and duplication services. Municipalities bought these supplies in bulk to obtain quantity price discounts, and the individual items were used as needed by the different agencies in the jurisdiction. Since records of use by specific agencies were not kept, office supply costs were estimated by interviewing solid waste office personnel in each jurisdiction in the study area.

Automobile. Allowances for automobile costs were reported by Knox County, Maryville, and Oak Ridge. These figures are in-

cluded in Appendix Table 6. In Knoxville and Alcoa, some vehicles (and costs) were assigned directly to solid waste supervisory personnel or foremen, and the associated vehicular costs for these jurisdictions are included in Appendix Table 8.

The cost data estimated for garage and maintenance overhead for the jurisdictions that provided collection services are given in Appendix Table 7. Labor costs included here were for foremen or other personnel in garage offices whose work related directly to collection services. For Knoxville, these costs also covered staff personnel in the garage offices whose duties were directly related to collection services. On the other hand, charges for maintenance labor and mechanics were not included. Rather, these were incorporated into the maintenance factors added to vehicle costs.

Overhead and operating costs for solid waste collection equipment are shown also in Appendix Table 8 for the jurisdictions that provided these services (Knoxville, Alcoa, and Maryville).

Finally, the cost data shown in Appendix Tables 6, 7, and 8 are given on total annual and per ton and cubic yard bases. The unit costs were obtained by dividing the totals for each item in a jurisdiction by the estimated annual weight and volume of solid waste produced in that municipality (see Table 1).

DISPOSAL COSTS

Assumption of Disposal Analysis

Disposal costs were estimated for the three jurisdictions in the study area — Knoxville, Knox County, and Alcoa — that operated solid waste disposal sites. The estimates were those for operations that conformed to Tennessee Solid Waste Disposal Regulations.

The general assumptions on which the analysis was based were these:

The trench method of disposal recommended by the American Public Works Association was used.[25]

Compaction density, in general, depends on pressure applied in compaction, duration of application of pressure, moisture content, type of material compacted, and amount of initial compaction pressure in the truck. In this study it was assumed that the com-

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[25]American Public Works Association, pp. 19-146.

[26]United States Department of Health, Education and Welfare, **Solid Waste Landfill Stabilization, An Interim Report** (Ralph Stone and Company, Cincinnati: Bureau of Solid Waste Management, 1968), Table 5, pp. 1-4; Table 7, pp. 2-3.

[27]American Public Works Association, p. 100.

paction density to be attained at the landfill sites was 600 pounds, dry weight. Published sources reported densities of from 515 to 613 pounds per cubic yard.[26] Other sources[27] reported higher figures. However, the figure of 600 pounds per cubic yard was deemed to apply to the situation in the study area on the basis of observation and consultation with supervisory personnel at the disposal sites.

Trench Design and Excavation

Table 1 indicated the estimated amounts of refuse to be disposed of per year from each jurisdiction covered by the study. The annual deliveries were converted to daily amounts delivered to each disposal site as follows:

Knoxville — 765,817 pounds and 1,235 cubic yards;
Knox County — 53,888.64 pounds and 81.73 cubic yards;
Alcoa — 136,215 pounds and 212.52 cubic yards.

The required width of the trench used depends on the amount of truck traffic during peak delivery periods. A trench that is too narrow will not allow simultaneous dumping from several trucks, causing costly collection truck delays. On the other hand, too wide a trench creates compaction problems, in that the compactor must spend more time driving about to spread and compact refuse that is discharged over a larger area. The trenches used in the analysis were wide enough to accommodate peak traffic loads at each particular site.

A trench that is too deep can partly fill with water, creating compaction problems. Based on existing soil conditions, the depths of the trenches at Knoxville and Alcoa were set at 18 feet and 9 feet, respectively. Also, on the basis of observation of actual trench-fill operations in the study area, a 30-degree grade or slope was assumed for the trench compaction face.

Each day that the disposal site was operated, a layer of refuse was deposited on the compaction face surface, along with the required amount of covering compaction dirt. On succeeding days of operation, successive layers of refuse and cover dirt would be deposited and compacted on the previous days' compactions. And so, the compaction slope and the area of the compaction face surface were calculated in order to use data on solid waste deliveries to determine the linear footage of trench that would be required each day.

The length of the compaction slope, assuming a 30-degree slope and a given trench depth, was derived with trigonometric formulas. The formula for the tangent of an angle was used to compute the length of the adjacent side (see Figure 1). Then, the hypotenuse

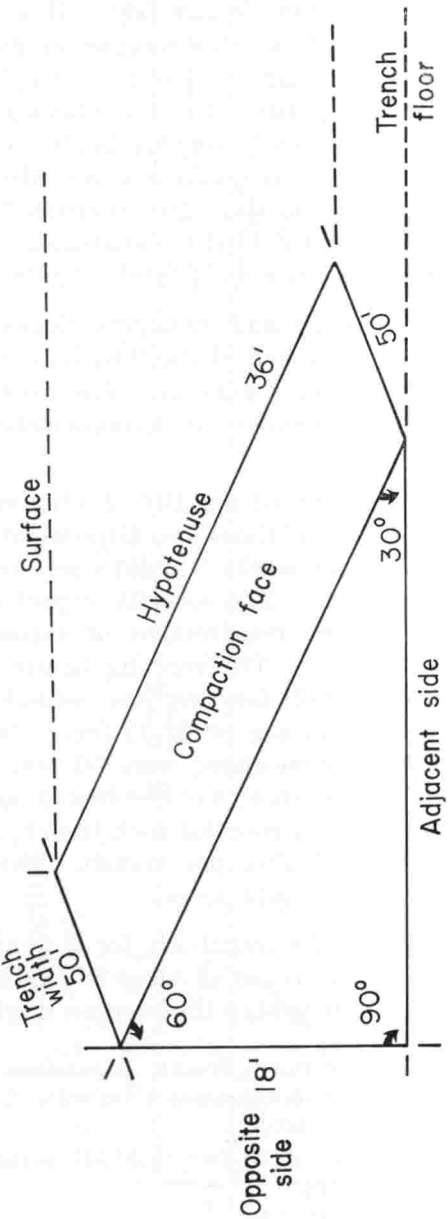

Figure 1. Cross-section of a landfill trench end.

formula $h = \sqrt{a^2 + b^2}$ was used to find the length of the compaction face surface.

Using the Alcoa landfill trench as an example, the compaction face surface was a rectangle with dimensions of 50 feet by 36 feet, with a resulting area of 1,800 square feet. If a 1-foot layer of refuse were spread uniformly on this compaction face surface, the volume of solid waste necessary to cover it completely would be 1,800 cubic feet, or 66.67 yards. To accommodate the estimated volumes of waste delivered daily to this landfill — 212.52 cubic yards — a trench with the dimensions given above would have filled at a rate of 3.188 feet per day. An additional 6-inch layer of compacted dirt to meet state health department requirements[28] would have to be added, giving a daily total fill rate of 3.688 feet.

Both ends of the trench had 30-degree slopes. And so, the triangular space at the distal end of the trench provided additional space for refuse disposal (see Figure 2). The volume of this area was 1,039.13 cubic yards, enough to accommodate deliveries for 4.24 days.

Following the recommended practice of digging two trenches per year, the length of each of these two disposal trenches in Alcoa was computed as follows: 26 weeks × 6 days per week = 156 days of required trench capacity. The end fill capacity of 4.24 days was subtracted, leaving the requirement of capacity for 151.76 days of solid waste disposal. The running length of the trench, then, was 151.76 days × 3.69 feet per day, equalling 559.99 feet plus the length of the distal end or 62.35 feet. The total trench dimensions when viewed from above were 50 feet wide × 622.34 feet long. The land area required for one trench was 0.714 acre.[29] A 16-foot buffer perimeter surrounded each trench, increasing land area requirements to 0.967 acre per trench. The two trenches used the first year required 1.934 acres.

The average distance of a round-trip for a scraper to load and unload while excavating the trench at Alcoa was 1,426.68 feet. This was two times the length, including the overrun length, and 75% or

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[28]Tennessee Department of Public Health, **Regulations Governing Solid Waste Processing and Disposal in Tennessee** (Nashville: Tennessee Department of Public Health, 1971), p. 10.

[29]Computations: 622.34 feet × 50 feet = 31,117 square feet ÷ 43,560 square feet per acre = 0.714 acre.

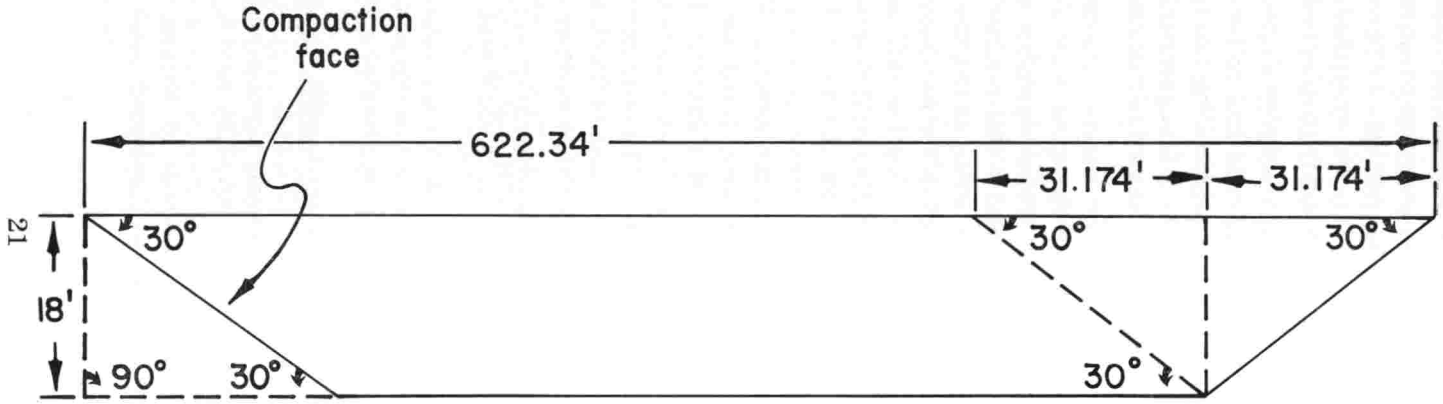

Figure 2. Cross-section of landfill trench with a trapezoidal shape.

twice the trench width.[30] The earth displaced from the trench was piled directly next to the trench so adequate cover material was conveniently available. Because construction of the succeeding trench had to be started before the one in use was filled, location of the displaced earth pile had to be thoroughly preplanned.

An excavation equipment manufacturer suggested that where trenches were large and much material had to be transported distances of 1,000 feet or more, a self-loading scraper was recommended. And so, the Caterpillar Self-Loading Scraper, Model 613, 11 CY capacity was used for the Alcoa landfill operation.[32]

It was assumed for computing scraper operating costs, that half the 7,426.68 foot transport distance was under uphill and loaded conditions, and half was under downhill and empty conditions. Specifications for the Model 613 scraper[33] indicated the following average speeds on each portion of the travel cycle: uphill, 4.5 miles per hour and downhill, 26 miles per hour. The rates of speed were converted to travel time, taking into account acceleration and deceleration times, and loading and dumping times, based on Drevdahl's formulas for scraper travel time.[34] The loaded travel time was 2.25 minutes; the empty travel time was 0.39 minutes; and the load and unload time was 0.39 minutes. Each cycle averages 3.74 minutes. This figure was corrected for efficiency[35] and the final adjusted cycle time was 4.99 minutes. By dividing this 4.99 cycle time into 480 (the minutes in an 8-hour work day) 96.19 trips or loads per day were possible. The operator was assumed to complete the final cycle of each day, accomplishing 97 cycles with 11 CY per load for 1,067 CY of material moved per work day.

An outside factor affecting the excavation rate was precipitation. Wet ground can cause material loading and unloading prob-

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[30]The displaced earth or spoil pile was located adjacent to the trench. The scraper operator minimized the travel or haul distance. Therefore, when he excavated the left side of the trench, he deposited spoil toward the left side of the pile.

[31]Caterpillar Tractor Company, **Sanitary Landfill Machine Selection Guide** (Peoria: Caterpillar Tractor Company, 1970), p. 4.

[32]Caterpillar Tractor Company, **Elevating Scrapers**, Publication No. AEO 20048 (Peoria: Caterpillar Tractor Company, 1970), pp. 4-6.

[33]**Ibid.**

[34]Elmer R. Drevdahl, Jr., **Fundamentals of Excavation Equipment for Engineering and Technology** (Tucson: Roadrunner Technical Publications, 1963), pp. 3-32.

[35]**Ibid.**

lems, plus the possibility of a mired scraper. A precipitation factor was introduced into the computations and was based on information published by the National Climatic Center,[36] using the years 1965 and 1967-1970. The statistical data published indicated precipitation of at least 0.01 inch per day occurred 124.6 days per year for the 5 years observed, or 34.1% of the days.

At the end of the day, the scraper loaded cover material from the pile next to the trench and deposited the material in locations convenient to the compacting operation. The compactor spread the material, covering the compacted solid waste with a 6-inch layer of earth.

The amount of time necessary for the scraper to transport cover material was deducted from time for constructing the trench. The cover material transportation cycle from a loading point at the spoil pile to the compaction face, and return, was estimated at 260 feet. Using the same procedure used to calculate the time per cycle as in the case of digging the trench, an average speed of 5.4 miles per hour was converted to a cycle time of 1.65 minutes. After adjustment was made for an operating efficiency factor,[37] the cycle time was 2.20 minutes.[38]

The quantity of compacted cover material was 3.33 cubic yards. One factor that must be taken into account in excavating earth is its compaction characteristics. In earthmoving operations, it is not uncommon for the material that has been moved to be compacted more densely than it was in its original state.[39] In any case, compaction coefficients have been published for a variety of materials encountered in excavating work. The compacted volume of "common earth" is 80% of its original volume; a characteristic referred to as "shrink."[40] When earth in its natural state (bank earth) is loaded into a scraper, it becomes less dense. This feature is known as "swell," and for wet or dry earth the amount of swell is estimated at 25% greater than the original bank measure.[41]

These concepts of shrink and swell were used to determine the

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[36]National Climatic Center, **Local Climatological Data, Knoxville, Tennessee** (Washington: Government Printing Office, 1965; 1967-1970), p. 1.

[37]This efficiency factor accounted for driver rest stops, machine breakdown, and the like. See Caterpillar Tractor Company, **Fundamentals of Earthmoving** (Peoria: Caterpillar Tractor Company, April, 1968), p. 24.

[38]Drevdahl, pp. 3-32.

[39]Caterpillar Tractor Company, **Fundamentals of Earthmoving**, p. 6.

[40]Drevdahl, pp. 3-6.

[41]**Ibid.**, pp. 2-3.

number of loads required to provide adequate quantities of cover material. The 33.3 cubic yards compacted cover, when adjusted, equalled 49.95 cubic yards of loose material. At 11 cubic yards per load, 4 cycles, taking 8.8 minutes plus travel time between work areas, were required. Total intrasite travel time per cycle was estimated at 11 minutes. The additional 4.4 cubic yards of cover material required was easily pushed into place by the compactor. In terms of effort lost excavating the trench, the time required to provide cover material was equivalent to four excavation loads, leaving a daily maximum of 1,023 cubic yards of trench materials excavated per day. At the rate of 1,023 cubic yards per day, 19.26 days were required for trench excavation without precipitation. Assuming that precipitation occurred 34.1% of the days, the excavation period was extended to 25.83 work days, or 5.2 five-day weeks.

Before establishing the total number of hours the scraper operated per year, another assumption was required; namely, that the scraper was used to provide cover material during days of no precipitation. Given machine warm-up time and travel time, the machine operated an average of one-half hour per day including Saturdays, hauling cover material. The scraper was assumed to operate 92.41 hours when not doing excavation, plus 231.12 hours while excavating or a total of 323.53 hours per year.

Disposal Equipment — Scrapers

Scrapers. The basic unit was an 11 CY self-elevating scraper, powered by a 150 flywheel horsepower diesel engine, and with a list price of $42,976 with standard equipment.[42] Annual depreciation costs were estimated assuming 10% salvage value and a 15-year life. The estimated maximum useful life of a scraper under average conditions is normally 10,000 hours.[43] However, the scrapers used in some situations would be used for a smaller total number of hours under the conditions assumed. The 15-year useful life was used in this analysis to take account of obsolescence and deterioration over time. The interest cost of capital invested in scrapers was estimated using a 6% rate. Maintenance and repairs costs were computed from coefficients established from past equipment maintenance records and included an allowance for parts and

[42]Grant Whitmore, Sales Representative, Stowers Machinery Corporation, Knoxville, Tennessee, personal interview, May 4, 1971.

[43]Caterpillar Tractor Company, **Fundamentals of Earthmoving**, p. 50.

repair labor for different levels of operating conditions.[44]. A repairs factor of 0.8 of annual depreciation charges was used also.[45]

Fuel. Annual fuel costs were computed from a formula based on engine horsepower, cost per gallon of fuel, and machine operating time. Costs of lubricating and hydraulic oils were estimated using average consumption rates based on a 0.15 gallon per hour rate of lubricant consumption, prices per gallon of lubricant, and total hours of operating time.[46] A factor of 50% was added to the charges for lubricating oil to take account of costs of lubricants, oils, and grease.[47]

Tires. Charges for tires were a relatively significant variable cost item, and were considered separately from the other scraper costs. Using a previously-published guide,[48] tire life for scrapers was estimated for the assumed operating conditions. Prices of tires of the required size and type were obtained from a local tire dealer.[49] Tire depreciation costs were based on estimated life and a zero salvage value; maintenance and repairs were estimated at 15% of this depreciation.[50] Finally, charges for invested capital were based on a 6% interest rate.

Labor. Scraper operators were joint employees of two or more public service departments. And so, their wages and fringe benefits were allocated to disposal functions on the basis of the proportion of time spent on trench excavating duties.

Disposal Equipment — Compactors

Compactors. The basic unit was a Caterpillar Model 815 with blade and 170 flywheel horsepower rating.[51] The compactor was assumed to have operated 6-day weeks, or 312 days per year (less legal holidays). The compactor price was $44,926, including a blade.[52] The operating life of the equipment was estimated at

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[44]**Ibid.**, p. 53.

[45]Drevdahl, pp. 2-8.

[46]**Ibid.**, pp. 2-9.

[47]**Ibid.**, pp. 2-20, pp. 6-37.

[48]**Ibid.**, pp. 2-13.

[49]Goodyear Tire Sales Representative, Knoxville, Tennessee, personal interview, June 3, 1971.

[50]Drevdahl, pp. 2-12.

[51]Caterpillar Tractor Company, **Self-Propelled Compactors**, Publication No. AEO 20098 (Peoria: Caterpillar Tractor Company, 1969).

[52]Grant Whitmore, Sales Representative, Stowers Machinery, Inc., Knoxville, Tennessee, personal interview, May 4, 1971.

13,000 hours, based on estimated operating life of similar machinery.[53] The compactor was assumed to operate 5 hours per day for 312 days per year, giving an estimated life of 8.3 years. A daily operating time was assumed, based on observations at the landfill sites. Annual depreciation charges were made, assuming a 10% salvage value. The interest cost for capital invested in scrapers was based on a 6% annual rate. A factor of 0.7 times depreciation cost was used to estimate maintenance and repair costs.[54]

Fuel. Fuel costs were computed in the same manner as for scrapers. Estimated costs of lubricating oils and grease also included an additional 50% for other lubricants.[55]

Labor. Charges for labor were based on wage and fringe benefit rates shown in Appendix Table 5, as well as estimated time spent on disposal functions. On the basis of observations at the landfill sites, it was assumed that the compactor operators were trained also to operate scrapers. This enabled them to haul cover dirt during times when trench excavating was not needed.

Land. Estimated charges for land use were based on a plot of land that met State of Tennessee requirements for landfill operations. Several important factors will affect the suitability of a particular parcel of land as a disposal site.[56] They include: 1) the degree of comprehensive land use planning; 2) the thoroughness of geologic survey to predict underground and surface water pollution, and to determine the depth of soil available for trenching and cover material; 3) the effective zoning regulations; and 4) the likelihood of public acceptance of the site.

Landfill planning also must include consideration of future solid waste disposal needs as affected by population growth, per capita solid waste generating rates, and the development of alternative — perhaps more efficient — disposal methods. In this analysis, a 5-year planning horizon was used. Land requirements were estimated on the basis of population projections prepared by the East Tennessee Development District.[57] These projections

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[53]Caterpillar Tractor Company, **Fundamentals of Earthmoving**, p. 50.

[54]Drevdahl, pp. 2-8.

[55]**Ibid.**, pp. 6-37.

[56]American Public Works Association, p. 93.

[57]East Tennessee Development District, "Blount, Anderson, Knox County Population Projects" (Knoxville: East Tennessee Development District, 1971).

indicated an average annual population increase for 1970-75 of 1.83%. A constant rate of per capita solid waste generation was assumed for the 5-year period. Land costs per acre were obtained from tax appraisers' offices and interest costs were based on 6% annual rate.

Other Costs

Scales. The cost of a 50,000 pound capacity pit scale with weight printer and simple enclosure averaged $11,750 installed.[58] The scale suppliers suggested an expected scale life of 20 years and a 1% of initial cost annual maintenance factor. Scale depreciation charges assumed a 10% salvage value. Interest costs were based on a 6% annual rate.

Fences. Tennessee Solid Waste Disposal Regulations specify fence requirements[59] for a landfill area. Costs of these requirements were estimated on the basis of square plots of land with 6-foot fences with barbed wire tops and three 12-foot gates. The cost rates used were $2.90 per linear foot for fencing and $125.00 each for the gates, installed.[60] A 15-year fence life, 10% salvage value, zero maintenance costs, and 6% interest on investment, were also used.

Road materials. Inclement weather can make access to the landfill dumping area impossible if an all-weather road is not maintained. Crushed aggregate (stone) was used to build the access road and the stone was estimated to cost $3.15 per ton delivered.[61]

Insurance. Liability insurance cost rates for a fenced landfill were obtained from local insurance agences.[62]

Joint Costs

As indicated earlier, the landfill operated by the city of Alcoa served Alcoa, Maryville, and Blount County. Total costs of operating and maintaining the landfill were shared, by joint agreement, at the rates of 30, 30, and 40%, respectively. These allocations are reflected in Table 12, which shows estimated costs of disposal services for each jurisdiction in the study area.

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[58]Tennessee Scale and Supply Company and Cole Scale Supply Company, Knoxville, Tennessee, personal interviews, April 6, 1971.

[59]Tennessee Solid Waste Disposal Regulation, p. 8.

[60]Moselle, p. 149.

[61]**Ibid.**, p. 26.

[62]Powell Insurors, personal interview.

Contract Services

In two jurisdictions — Knox County and Blount County — solid waste collection services were provided by private contractors dealing with individual homeowners. In Oak Ridge, both collection and disposal services were provided by the private contractor. In this case, the contract was between the service agency and the municipal government, and the solid waste services were available to all citizens in the jurisdiction.

The two private contractors who served Knox County residents reported serving a total of 3,280 customers at an annual cost of $30.00 per home.[63] In Blount County, nine contractors reported serving 3,259 households, also at a cost of $30.00 per home per year.[64]

Data collected at the Knox County landfill indicated that, on an annual basis, an estimated 4,645.16 tons of refuse, with a volume of 15,253.16 cubic yards, were collected and delivered by the private contractors. Similarly, data collected at the Alcoa landfill indicated that the private contractors collected and delivered an estimated 4,338.72 tons of refuse, with a volume of 14,097.2 cubic yards.

The total receipts from contract fees reported for each site were divided by the respective estimated annual weights and volumes of refuse collected by the contractors. The resulting costs were $21.18 per ton and $6.45 per cubic yard for Knoxville, and $22.53 per ton and $6.94 per cubic yard for Blount County.

In the case of Oak Ridge, the jurisdiction incurred some overhead and operating expenses for the landfill operations. However, the remainder of all other services, including collection and disposal, were provided for all residents by the single private contractor. The figures shown in Appendix Table 9 for Oak Ridge reflect these arrangements.

TOTAL COSTS OF SOLID WASTE SERVICES

Table 4 summarizes the cost data presented in Appendix Tables 2-9 for each jurisdiction in the study area. The lowest total unit costs for collection and disposal were for Knoxville — $9.98 per ton and $3.09 per cubic yard. All services in the city were provided by a municipal agency.

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[63]Interviews with the owners of Firms A and B providing garbage pick-up service in Knox County, November 11, 1970.

[64]Interviews with the owners of the nine firms providing garbage pick-up service in Blount County, October 19-21, 1970.

Table 4. Total annual cost and total cost per ton and cubic yard for solid waste services in jurisdiction in the Knoxville SMSA, 1970

Jurisdiction and cost basis	Administrative overhead	Garage and maintenance overhead	Collection overhead and operation	Disposal overhead and operation	Contract services for collection	Contract services for collection and disposal	Total costs of all services
	Dollars						
Knoxville							
Total annual	24,838.56	7,365.34	914,251.32	165,356.77	[a]	[a]	1,191,811.99
Per ton	0.21	0.73	7.65	1.38	[a]	[a]	9.98
Per cubic yard	0.06	0.23	2.37	0.43	[a]	[a]	3.09
Knox County							
Total annual	3,645.57	[b]	[b]	30,102.81	98,400.00	[a]	132,148.38
Per ton	0.54	[b]	[b]	4.47	21.83	[a]	26.19
Per cubic yard	0.18	[b]	[b]	1.47	6.45	[a]	8.10
Alcoa							
Total annual	8,780.93	21,415.18	102,908.74	11,079.25[c]	[a]	[a]	144,184.10
Per ton	1.51	3.68	17.70	1.91	[a]	[a]	24.80
Per cubic yard	0.46	1.12	5.40	0.58	[a]	[a]	7.56
Maryville							
Total annual	5,250.78	1,578.98	125,337.14	11,079.25[c]	[a]	[a]	143,246.15
Per ton	0.83	0.25	19.87	1.76	[a]	[a]	27.71
Per cubic yard	0.25	0.08	5.97	0.58	[a]	[a]	6.82

Table 4. (Continued)

Jurisdiction and cost basis	Administrative overhead	Garage and maintenance overhead	Collection overhead and operation	Disposal overhead and operation	Contract services for collection	Contract services for collection and disposal	Total costs of all services
	Dollars						
Blount County							
Total annual	[d]	[e]	[e]	14,772.30[c]	97,770.00	[a]	112,542.30
Per ton	[d]	[e]	[e]	1.62	22.53	[a]	24.16
Per cubic yard	[d]	[e]	[e]	0.56	6.94	[a]	7.50
Oak Ridge							
Total annual	12,005.71	[f]	[f]	9,550.74	[a]	214 609.00	236,165.45
Per ton	0.53	[f]	[f]	.42	[a]	9.53	10.49
Per cubic yard	0.21	[f]	[f]	.17	[a]	3.73	4.10

[a]Not applicable.

[b]Knox County did not operate collection services.

[c]Alcoa landfill served Alcoa, Maryville, and Blount County. Total costs of operating and maintaining the landfill were shared—by joint agreement—at the rates of 30, 30, and 40% for Alcoa, Maryville, and Blount County, respectively.

[d]Blount County residents obtained collection services from private contractors. Disposal services were provided by Alcoa under joint cost-sharing agreement. Therefore, municipal overhead costs for solid waste services were reported as negligible.

[e]Collection services provided by private contractors.

[f]Oak Ridge residents were served by private contractors who provided collection and disposal services.

Total unit costs for Oak Ridge were moderately higher — $10.49 per ton and $4.10 per cubic yard. Four percent of these costs went to cover charges for services provided by a municipal agency. The remaining 96% was for contract collection and disposal services.

Costs of services in the three jurisdictions that used Alcoa landfill were substantially higher than those for Knoxville and Oak Ridge. On a per ton basis, they ranged from $22.71 (Maryville) to $24.80 (Alcoa). On a cubic yard basis, they ranged from $6.82 (Maryville) to $7.56 (Alcoa). Costs estimated for Blount County services were intermediate — $24.16 per ton and $7.50 per cubic yard.

The highest estimated costs were for Knox County — $26.19 per ton and $8.10 per cubic yard.

Care must be taken in drawing conclusions from these cost estimates. Various factors could have accounted for the differences among them. For example, economies of scale may explain the lower costs for Knoxville. Also, differences in the composition of the refuse collected may also influence costs. The relatively low density of households in Knox and Blount Counties was probably associated with the substantially higher collection costs in these jurisdictions. In any event, the differences that did appear suggest that further detailed study of these operations could point out areas in which operating efficiencies might be improved to reduce costs.

APPENDIX

SAMPLE QUESTIONNAIRE

DAILY CARRIER WEIGHT RECORD

Site_____ Date_____, 197____

Carrier ident.***		
Time		
Waste category*		
Source**		
Weight in		
Total		
Weight out		
Amt. delivered		
Estimated C.Y.		

*Waste category: H = household, D = demolition/construction, T = tires, B = bulky-waste (furniture, appliances, etc.)

**Source: R = residential, I = industrial, C = commercial, A = agric., etc.

***Carrier ident.: M = municipal, C = contractor, Car = private car, Pvt. = private truck

SPECIAL NOTES:

Appendix Table 1. Inventory of office equipment used for administration of solid waste services in jurisdictions in the Knoxville SMSA, 1970[a]

Item	Purchase cost[b]	Knoxville[c]	Knox County	Maryville	Oak Ridge
	Dollars	Quantity in units			
Secretary desk	250	2	1	1	1
Secretary chair	70	2	0	1	1
Side chair	60	17	4	8	2
Vertical file	75	20	3	4	1
Executive desk	225	11	2	1	0
Executive chair	90	9	2	1	0
Typewriter	400	7	1	2	1
Electronic calculator	800	4	1	2	0
Work table	130	0	0	2	0
2-way radio	2,350	1	0	1	0
Floor mat	10	0	1	2	1
Bookshelf	23	0	1	1	2
Adding machine	550	5	0	1	0
Letter file	2	5	1	2	1
Wastebasket	5	10	1	3	1

[a]Explanations for jurisdictions not listed:

Alcoa — Municipal officials provided only a total value for the office equipment inventory. On basis of this figure and percent of public works staff time spent on management of solid waste services, amount of $916.30 was allocated to cover these items in estimating administrative costs.

Blount County — Residents were serviced by private contractors; municipal overhead costs for solid waste services were reported as negligible.

[b]Average life of equipment was estimated at 15 years; maintenance rate assumed at 1.5% of original cost per year. Also assumed were a 6% annual interest rate and a zero salvage value.

[c]Includes both municipal building and garage office equipment.

Appendix Table 2. Garage equipment and parts inventories used for solid waste services in jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction	Cost item	Initial cost	Maintenance factor	Estimated life
		Dollars	Percent	Years
Knoxville	Garage equipment	4,815.00[b]	1	15
Alcoa	Garage equipment	1,255.00	1	10
	Spare parts inventory	2,200.00	[c]	[c]
Maryville	Garage equipment	2,800.00	1	15

[a]Accounting systems of jurisdictions not shown did not report these cost items separately.

[b]Equipment allocated at 70% of initial cost to solid waste services.

[c]Not applicable to inventory items.

Appendix Table 3. Collection vehicle inventories and cost for solid waste services in jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction and type of vehicle	Number of units	Cost[b]	Life	Maintenance factor
		Dollars	Years	Percent
Knoxville				
Packer truck, rear load, 20 CY[c]	26	339,612	7	150
Packer truck, front load, 25 CY	7	148,204	7	150
GRD truck, hoist	1	19,000	10	90
Tractor and trailer, 42 CY	1	37,000	7	150
Trashmobile, Datsun size	29	85,550	4	90
Automobile, sedan	3	6,990	10	50
Pickup truck	1	1,961	10	50
Knox County				
Automobile, sedan	0.4[d]	2,330	10	50
Maryville				
Packer truck, front load, 25 CY	1	21,172	7	150
Packer truck, rear load, 20 CY	1	13,062	7	150
Packer truck, rear load, 16 CY	2	22,384	7	150
Packer truck, rear load, 13 CY	1	9,602	7	150
Automobile, station wagon	0.1[d]	2,400	10	50
Alcoa				
Truck, Dempster Dinosaur, 47 CY	1	33,000	7	150
Packer truck, front load, 25CY	1	21,172	7	150
Packer truck, rear load, 18 CY	1	9,880	7	150
Packer truck, rear load, 13CY	1	9,602	7	150
Pickup truck	0.7[d]	1,961	10	50
Oak Ridge				
Automobile, sedan	1	2,330	10	50

[a]Knox County and Oak Ridge do not operate collection services. Blount County residents served by private contractors.

[b]Ten percent salvage value assumed.

[c]CY = payload capacity in cubic yards.

[d]Decimal fraction indicates estimated allocation of vehicle's use in solid waste service functions.

Appendix Table 4. Fuel costs for collection vehicles used for solid waste services in jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction and type vehicle	Number of vehicles	Gallons per day per vehicle	Total cost per gallons	Number of days operated during year
			Cents	
Knoxville				
Trashmaster	29	9	18.00	260
Automobiles	3	4	18.00	260
Pickup truck	1	4	18.00	260
Rear packer	27	24	18.00	260
Front loader	8	35	18.00	286
Tractor-trailer	1	50	18.00	286
GRD truck	1	30	18.00	286
Knox County				
Automobile	0.4[b]	1.6667	18.00	260
Maryville				
Rear packer	3	12.4285	15.25	292.5
Front loader	1	12.8821	15.00	292.5
Oak Ridge				
Automobile[c]	1	1.1835	21.00	260

[a]Explanations for jurisdictions not listed:

Alcoa — Municipal officials provided lump sum annual fuel cost of $2,621.63.

Blount County — Residents were served by private contractors; jurisdiction operated no vehicles for collection service functions.

[b]Decimal fraction indicates estimated allocation of vehicle's use in solid waste service functions.

[c]Additional charge of $16.00 per year was made to cover motor oil and tires.

Appendix Table 5. Wage, salary, and fringe benefit rates for solid waste services personnel in jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction and job description	Number of men	Salary or wage rate	Fringe benefits	Hours per week
		Dollars	Percent	
Knoxville				
Rear loader truck drivers	27	2.30[b]	10	40
Front loader truck drivers	8	2.45[b]	10	45
Front loader truck helper	8	1.85[b]	10	45
GRD truck driver	2	2.45[b]	10	45
Tractor-trailer drivers	4	2.45[b]	10	45
Trashmaster drivers	29	2.30[b]	10	40
Trashmaster helpers	29	2.15[b]	10	40
Foremen	2	5,832.00[c]	10	[d]
Scraper operator[e]	1	3,312.71[c]	11.5	[d]
Caterpillar operator	1	5,512.00[c]	11.5	[d]
Compactor operator	1	5,512.00[c]	11.5	[d]
Watchman and scalemaster	3	1.65[b]	10	40
Gas pump operators	1	1.65[b]	10	48
City hall personnel	[f]	23,905.00[c,f]	[f]	[d]
Knox County				
Caterpillar operator	1	5,355.00[c]	11.5	[d]
Watchman and scalemaster	2	4,762.90[c]	[g]	[d]
County court personnel	[g]	2,878.20[c,f]	[f]	[d]
Alcoa				
Packer drivers and helpers	12	2.098[b,h]	31.68	40
Caterpillar operators	1.2[i]	7,878.00[c]	[j]	[d]
Scraper operator	0.14[i]	909.59[c]	[j]	[d]
Weighmaster and watchman	1	3,432.00[c]	19.4638	[d]
Foreman	0.7[i]	7,308.00[c]	25.6	[d]
Engineer and staff	8	8,139.59[c]		[d]
Maryville				
Packer drivers and helpers	15	2.351[b,h]	13.11	45
Engineer and staff	[f]	4,540.02[c,f]	[f]	[d]
Oak Ridge				
Public Health department Staff	[f]	9,943.25[c]	[f]	[d]

[a]Explanation for jurisdiction not listed: Blount County residents were served by private contractors who performed all services associated with solid waste collection and disposal.

[b]Rate per hour.

[c]Annual salary rate.

[d]Not applicable.

[e]Allocation of 60.1% was made to solid waste services.

[f]Municipal office building personnel salaries allocated to solid waste services was estimated as a lump sum and included allowance for fringe benefits.

[g]No fringe benefits paid. Instead, employees were given sole scavenger rights at the landfill site.

[h]Imputed from municipal records.

[i]Decimal fractions indicate estimated allocations of personnel efforts to performance of duties associated with solid waste services.

[j]Salaries given as lump sum, and include allowances for fringe benefits.

Appendix Table 6. Total annual cost and cost per ton and cubic yard for administrative overhead for solid waste services in jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Knoxville			
Building depreciation	162.27	0.0014	0.0004
Building maintenance	81.14	0.0007	0.0002
Building interest	243.42	0.0020	0.0006
Building insurance	16.23	0.0001	0.0000
Land interest	6.21	0.0001	0.0000
Office equipment depreciation	29.25	0.0002	0.0001
Office equipment maintenance	6.57	0.0001	0.0000
Office equipment interest	13.17	0.0001	0.0000
Office equipment insurance	1.10	0.0000	0.0000
Staff labor[b]	23,905.00	0.2001	0.0621
Utilities	28.00	0.0002	0.0001
Supplies[c]	346.20	0.0029	0.0009
Total	24,838.56	0.2079	0.0644
Knox County			
Building rent[d]	317.06	0.0471	0.0155
Office equipment depreciation	14.64	0.0022	0.0007
Office equipment maintenance	4.88	0.0007	0.0002
Office equipment interest	8.05	0.0012	0.0004
Office equipment insurance	0.61	0.0001	0.0000
Staff labor[b]	2,878.20	0.4273	0.1409
Utilities	138.29	0.0205	0.0068
Supplies[c]	31.00	0.0046	0.0015
Automobile	252.84	0.0375	0.0124
Total	3,645.57	0.5412	0.1784
Alcoa			
Building depreciation	49.98	0.0086	0.0026
Building maintenance	25.00	0.0043	0.0013
Building interest	74.97	0.0129	0.0039
Building insurance	5.58	0.0010	0.0003
Land interest	96.80	0.0166	0.0051
Office equipment depreciation	61.09	0.0105	0.0032
Office equipment maintenance	9.16	0.0016	0.0005
Office equipment interest	27.49	0.0047	0.0014
Office equipment insurance	2.29	0.0004	0.0001
Staff labor[b]	8,139.59	1.3959	0.4269
Utilities	112.98	0.0194	0.0059
Supplies[c]	176.00	0.0302	0.0092
Total	8,780.93	1.5061	0.4604

Appendix Table 6 (Continued)

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Maryville			
Building depreciation	37.98	0.0060	0.0018
Building maintenance	18.99	0.0030	0.0009
Building interest	56.97	0.0090	0.0027
Building insurance	5.68	0.0009	0.0003
Land interest	162.86	0.0258	0.0078
Office equipment depreciation	117.28	0.0186	0.0056
Office equipment maintenance	14.07	0.0022	0.0007
Office equipment interest	42.22	0.0067	0.0020
Office equipment insurance	3.52	0.0006	0.0002
Staff labor[b]	4,540.02	0.7197	0.2161
Utilities	114.07	0.0181	0.0054
Supplies[c]	50.00	0.0079	0.0024
Automobile	87.12	0.0138	0.0041
Total	5,250.78	0.8323	0.2500
Oak Ridge			
Building depreciation	78.47	0.0035	0.0014
Building maintenance	39.23	0.0017	0.0007
Building interest	117.70	0.0052	0.0020
Building insurance	10.17	0.0005	0.0002
Land interest	57.06	0.0025	0.0010
Office equipment depreciation	58.68	0.0026	0.0010
Office equipment maintenance	19.56	0.0009	0.0003
Office equipment interest	32.27	0.0014	0.0006
Office equipment insurance	2.45	0.0001	0.0000
Public refuse containers[e]	300.30	0.0133	0.0052
Staff labor[b]	9,943.25	0.4415	0.1726
Utilities	81.80	0.0036	0.0014
Supplies[c]	625.00	0.0290	0.0113
Automobile	639.77	0.0284	0.0111
Total	12,005.71	0.5342	0.2088

[a]Explanation for jurisdiction not listed: Blount County residents were served by private contractors who performed all services associated with solid waste collection and disposal.

[b]Excludes mayor's and city council's salaries.

[c]Items such as pencils, stationery, postage, duplication, and the like.

[d]Allotted to solid waste services on basis of floor space used.

[e]Sidewalk containers furnished by the city.

Appendix Table 7. Total annual cost and cost per ton and cubic yard for garage and maintenance overhead for solid waste services in jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Knoxville			
Building depreciation[b]	1,483.00	0.0124	0.0038
Building maintenance	741.48	0.0062	0.0019
Building interest	2,224.42	0.0186	0.0058
Building insurance	192.05	0.0016	0.0005
Land interest	19,456.95	0.1629	0.0505
Shop equipment depreciation	773.26	0.0065	0.0020
Shop equipment maintenance	210.04	0.0018	0.0005
Shop equipment interest	347.95	0.0029	0.0009
Shop equipment insurance	20.57	0.0002	0.0001
Labor	60,305.62	0.5048	0.1565
Utilities	1,110.00	0.0093	0.0029
Supplies	500.00	0.0042	0.0013
Total	87,365.34	0.7314	0.2267
Alcoa			
Building depreciation	4,229.97	0.7277	0.2219
Building maintenance	2,879.00	0.4953	0.1510
Building interest	6,279.00	1.0801	0.3293
Building insurance	535.76	0.0922	0.0281
Land interest	180.00	0.0310	0.0095
Shop equipment depreciation	100.00	0.0172	0.0052
Shop equipment maintenance	12.55	0.0022	0.0007
Shop equipment interest	37.66	0.0065	0.0020
Shop equipment insurance	59.39	0.0102	0.0031
Labor	6,537.30	1.12	0.3429
Utilities	73.44	0.0126	0.0038
Supplies	60.43	0.0104	0.0032
Inventory interest	66.00	0.0114	0.0035
Vehicle	364.68	0.0627	0.0191
Total	21,415.18	3.6839	1.1233
Maryville			
Building depreciation	226.45	0.0359	0.0108
Building maintenance	75.41	0.0120	0.0036
Building interest	226.22	0.0359	0.0108
Building insurance	62.21	0.0099	0.0030

Appendix Table 7 (Continued)

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Land interest	168.00	0.0266	0.0080
Shop equipment depreciation	130.67	0.0207	0.0062
Shop equipment maintenance	19.60	0.0031	0.0009
Shop equipment interest	58.80	0.0093	0.0028
Shop equipment insurance	0.52	0.0001	0.0000
Labor	[c]	[c]	[c]
Utilities	561.10	0.0889	0.0267
Supplies	50.00	0.0079	0.0024
Total	1,578.98	0.2503	0.0752

[a]Explanation for jurisdictions not listed: Knox County did not operate collection services. Blount County and Oak Ridge residents were served by private contractors.

[b]Building life was estimated at 50 years for Knoxville and Alcoa; for Maryville at 33.3 years.

[c]No administrative or supervisory labor worked in this garage.

Appendix Table 8. Total annual cost and cost per ton and cubic yard for overhead and operation of solid waste collection equipment in jurisdictions in the Knoxville SMSA, 1970[a]

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Knoxville			
Collection vehicle depreciation	89,180.78	0.7465	0.2314
Collection vehicle maintenance	133,838.00	1.1203	0.3473
Collection vehicle interest	21,064.54	0.1763	0.0547
Collection vehicle insurance	49,428.00	0.4137	0.1283
Collection vehicle fuel costs	61,123.80	0.5116	0.1586
Labor	559,616.20	4.6843	1.4522
Total	914,251.32	7.6527	2.3725
Alcoa			
Collection vehicle depreciation	9,469.86	1.6290	0.4967
Collection vehicle maintenance	15,783.00	2.7151	0.8278
Collection vehicle interest	2,430.60	0.4181	0.1275
Collection vehicle insurance	3,648.00	0.6275	0.1913
Collection vehicle fuel costs	2,621.63	0.4510	0.1375
Labor	68,955.65	11.8621	3.6166
Total	102,908.74	17.7028	5.3974
Maryville			
Collection vehicle depreciation	8,514.14	1.3497	0.4053
Collection vehicle maintenance	14,189.00	2.2493	0.6755
Collection vehicle interest	2,185.32	0.3464	0.1040
Collection vehicle insurance	4,560.00	0.7229	0.2171
Collection vehicle fuel costs	2,228.37	0.3533	0.1061
Labor	93,660.31	14.8475	4.4588
Total	125,337.14	19.8691	5.9668

[a]Explanation for jurisdictions not listed: Knox County did not operate collection services. Blount County and Oak Ridge residents were served by private contractors.

Appendix Table 9. Total annual cost and cost per ton and cubic yard for overhead and operation of solid waste disposal services in the Knoxville SMSA, 1970

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Knoxville			
Scraper depreciation	5,830.63	0.0488	0.0151
Scraper interest	2,800.64	0.0234	0.0073
Scraper maintenance	4,664.50	0.0390	0.0121
Scraper fuel	1,316.75	0.0110	0.0034
Scraper lub oils	427.43	0.0036	0.0011
Tires depreciation	6,472.44	0.0542	0.0168
Tires interest	310.68	0.0026	0.0008
Tires maintenance	970.87	0.0081	0.0025
Labor	3,693.67	0.0309	0.0096
Bulldozer depreciation	8,772.53	0.0734	0.0228
Bulldozer interest	2,573.27	0.0215	0.0067
Bulldozer maintenance	7,895.27	0.0661	0.0205
Bulldozer fuel	2,223.77	0.0186	0.0058
Bulldozer lub oils	606.53	0.0051	0.0016
Labor	6,145.88	0.0514	0.0159
Compactor depreciation	8,671.79	0.0726	0.0225
Compactor interest	2,639.11	0.0221	0.0069
Compactor maintenance	6,070.24	0.0508	0.0157
Compactor fuel	2,681.23	0.0224	0.0069
Compactor lub oils	870.48	0.0073	0.0023
Labor	6,145.88	0.0514	0.0159
Roadway crushed stone	1,260.00	0.0105	0.0033
Watchmen salaries	11,325.60	0.0948	0.0294
Land interest	35,093.22	0.2937	0.0911
Fence costs	5,470.46	0.0458	0.0142
Scale costs	1,034.00	0.0087	0.0027
Liability insurance	29,244.35	0.2448	0.0759
Utilities	145.55	0.0012	0.0004
Total	165,356.77	1.3838	0.4292
Knox County			
Compactor depreciation	3,825.00	0.5678	0.1872
Compactor interest	1,122.00	0.1666	0.0549
Compactor maintenance	3,633.75	0.5394	0.1778
Compactor fuel	1,767.00	0.2623	0.0865

Appendix Table 9 (Continued)

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Compactor lub oils	382.50	0.0568	0.0187
Labor	5,970.83	0.8864	0.2922
Roadway crushed stone	250.00	0.0371	0.0122
Watchmen salaries	4,762.90	0.7071	0.2331
Land interest	383.40	0.0569	0.0188
Trench excavation cost	5,974.80	0.8870	0.2924
Interest on trenches	44.81	0.0067	0.0022
Fence cost	504.03	0.0748	0.0247
Scale costs	1,034.00	0.1535	0.0506
Liability insurance	319.50	0.0474	0.0156
Utilities	128.29	0.0190	0.0063
Total	30,102.81	4.4688	1.4732
Alcoa			
Scraper depreciation	773.57	0.1331	0.0406
Scraper interest	425.46	0.0732	0.0223
Scraper maintenance	618.86	0.1065	0.0325
Scraper fuel	94.19	0.0162	0.0049
Scraper lub oils	26.24	0.0045	0.0014
Tire depreciation	290.96	0.0501	0.0153
Tire interest	33.17	0.0057	0.0017
Tire maintenance	43.64	0.0075	0.0023
Labor	275.73	0.0474	0.0145
Compactor depreciation	1,461.45	0.2514	0.0766
Compactor interest	444.77	0.0765	0.0233
Compactor maintenance	1,023.01	0.1760	0.0537
Compactor fuel	516.59	0.0889	0.0271
Compactor lub oils	126.36	0.0217	0.0066
Labor	2,363.40	0.4066	0.1240
Roadway crushed stone	264.60	0.0455	0.0139
Weighmaster-watchman salary	1,230.00	0.2116	0.0645
Land interest	354.56	0.0610	0.0186
Fence cost	221.15	0.0380	0.0116
Scale cost	310.20	0.0534	0.0163
Utilities	33.60	0.0058	0.0018
Liability insurance	147.74	0.0254	0.0077
Total	11,079.25	1.9060	0.5811

Appendix Table 9 (Continued)

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Maryville			
Scraper depreciation	773.57	0.1226	0.0368
Scraper interest	425.46	0.0674	0.0202
Scraper maintenance	618.86	0.0981	0.0295
Scraper fuel	94.19	0.0149	0.0045
Scraper lub oils	26.24	0.0042	0.0013
Tire depreciation	290.96	0.0461	0.0138
Tire interest	33.17	0.0053	0.0016
Tire maintenance	43.64	0.0069	0.0021
Labor	275.73	0.0437	0.0131
Compactor depreciation	1,461.45	0.2317	0.0696
Compactor interest	444.71	0.0705	0.0212
Compactor maintenance	1,023.01	0.1622	0.0487
Compactor fuel	516.59	0.0819	0.0246
Compactor lub oils	126.36	0.0200	0.0060
Labor	2,363.40	0.3747	0.1125
Roadway crushed stone	264.60	0.0419	0.0126
Weighmaster-watchman salary	1,230.00	0.1950	0.0586
Land interest	354.56	0.0562	0.0169
Fence cost	221.15	0.0351	0.0105
Scale cost	310.20	0.0492	0.0148
Utilities	33.60	0.0053	0.0016
Liability insurance	147.74	0.0234	0.0070
Total	11,079.25	1.7563	0.5275

Appendix Table 9 (Continued)

Jurisdiction and cost item	Total cost per year	Cost per ton	Cost per cubic yard
		Dollars	
Blount County			
Scraper depreciation	1,031.42	0.1132	0.0393
Scraper interest	567.28	0.0623	0.0216
Scraper maintenance	825.14	0.0906	0.0314
Scraper fuel	125.58	0.0138	0.0048
Scraper lub oils	34.99	0.0038	0.0013
Tire depreciation	387.94	0.0426	0.0148
Tire interest	44.22	0.0049	0.0017
Tire maintenance	58.19	0.0064	0.0022
Labor	367.64	0.0404	0.0140
Compactor depreciation	1,948.60	0.2139	0.0743
Compactor interest	593.02	0.0651	0.0226
Compactor maintenance	1,364.02	0.1497	0.0520
Compactor fuel	688.78	0.0756	0.0263
Compactor lub oils	168.48	0.0185	0.0064
Labor	3,151.20	0.3459	0.1201
Roadway crushed stone	352.80	0.0387	0.0134
Weighmaster-watchman salary	1,640.00	0.1800	0.0625
Land interest	472.75	0.0519	0.0180
Fence cost	294.87	0.0324	0.0113
Scale cost	413.60	0.0454	0.0158
Utilities	44.80	0.0049	0.0017
Liability insurance	196.98	0.0216	0.0075
Total	14,772.30	1.6215	0.5630
Oak Ridge			
Collection-disposal contract	214,609.00	9.5296	3.7252
Land interest	360.00	0.0160	0.0063
Land improvements	124.20	0.0055	0.0021
Scale expenses	1,034.00	0.0459	0.0179
Fence expenses	1,082.54	0.0481	0.0188
Landfill insurance	2,500.00	0.1110	0.0434
Utilities	50.00	0.0022	0.0009
Watchman salary	4,400.00	0.1954	0.0764
Total	224,159.74	9.9537	3.8910