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Sanitary Landfill Cost

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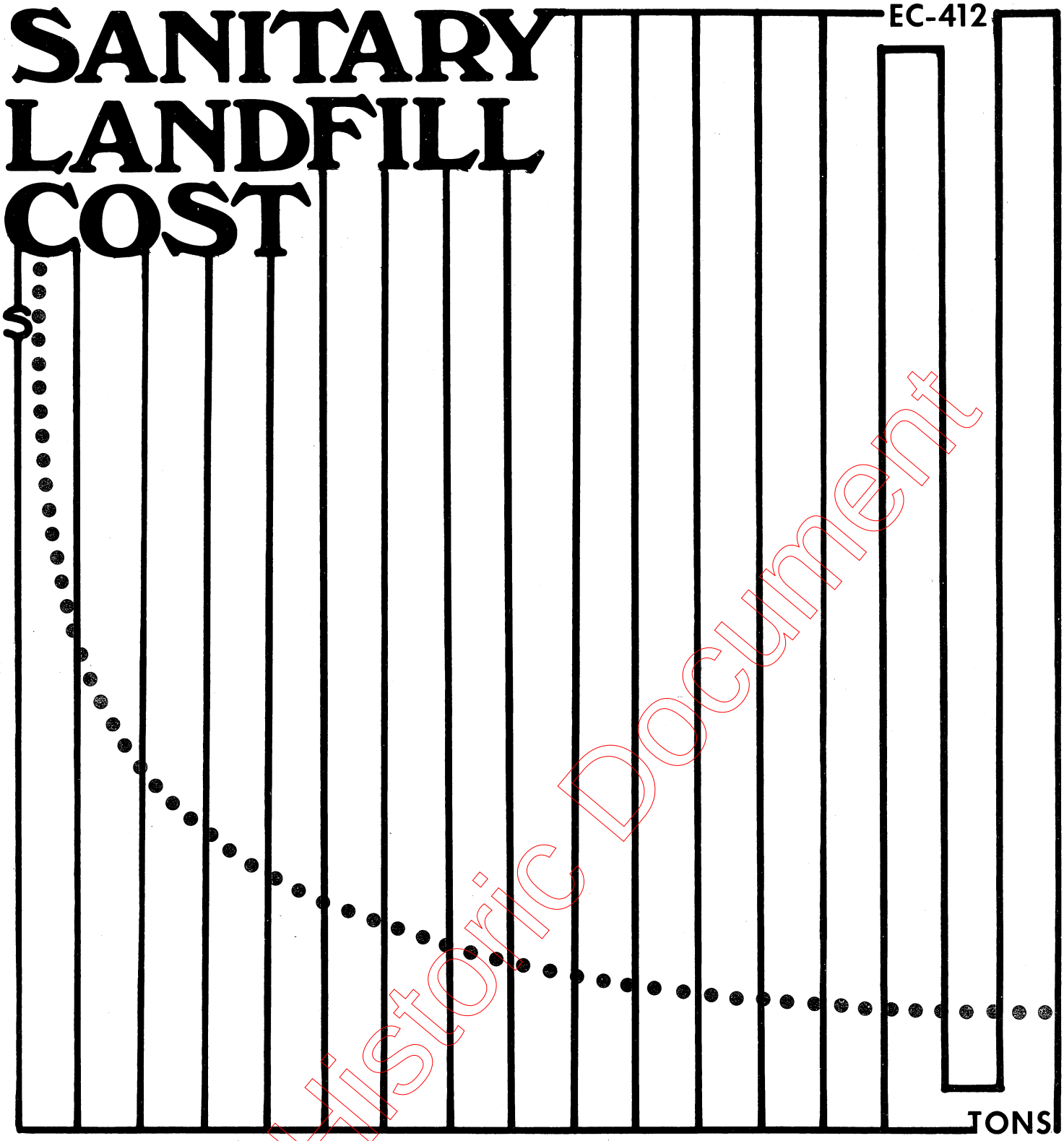
SANITARY LANDFILL COST

EC-412



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SANITARY LANDFILL COST

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In recent years there has been an increasing awareness of the environment. Concern has heightened over the impact that man has had -- and continues to have -- upon his natural surroundings. The creation of solid waste and the methods used to dispose of it have become of particular importance.

In many areas the sanitary landfill is still the most relevant alternative for solid waste disposal. Estimates of the costs for various-sized sanitary landfills are thus important when planning for the disposal of solid waste.

The per ton cost for solid waste disposal at a sanitary landfill depends on the size of the operation. As the daily quantity of solid waste is increased, more efficient use is made of men and machinery. In addition, at larger operations, equipment with a greater potential for efficiency can be substituted for equipment with less potential. As an example, the average annual per ton cost of disposal for a daily quantity of 100 tons of solid waste is just over $2.00. The average cost for a quantity of 600 tons per day, by comparison, is less than $1.00 per ton.

An estimate of the per ton sanitary landfill cost for solid waste disposal can be obtained from the expression below. This cost is calculated by putting the appropriate daily volume of solid waste in tons into the expression.

$$AC = \$1.024 + \frac{112.043}{(V)} - 0.0006\,(V) + 0.0000002\,(V^2)$$

where: AC = the average annual per ton cost for solid waste disposal at a sanitary landfill
V = the daily quantity of solid waste in tons

The purpose of this report is to provide some insight into the economics of solid waste disposal.[1] Attention will be focused on the sanitary landfill and its associated costs. The information which follows is not community specific but should prove generally useful to those who must deal with the solid waste problem.

Solid Waste Disposal

Disposal may be defined as the destruction and/or final removal of solid waste, and several disposal alternatives are technically feasible. The relevant methods for Indiana are those which satisfy the standards of the Indiana State Board of Health.

Most frequently used are the sanitary landfill and incineration. "The sanitary landfill is presently the only true disposal method and is basic to any solid wastes program. Incineration is a volume reduction process and produces residues which should be sanitary landfilled."[2] Grinding, composting, pyrolysis, high temperature incineration, and salvaging and recycling techniques are used less often but may find increased application in the future.

The sanitary landfill is generally considered to be the most economical alternative. It provides for the spreading and compaction of solid waste in shallow layers usually not more than two feet in depth. Each of these layers is covered with six to eight inches of soil at the end of a day's operations

1/ A more detailed account of the cost derivation is available in K. C. Clayton and J. M. Huie, Solid Waste Economics -- The Sanitary Landfill, Department of Agricultural Economics, Purdue University.

2/ National Association of Counties Research Foundation, "Design and Operation (#5)," Solid Waste Management, U. S. Department of Health, Education and Welfare, Public Health Service, Consumer Protection and Environmental Health Service, Environmental Control Administration, Bureau of Solid Waste Management, 1969, p. 10.

or more frequently if required. A completed sanitary landfill receives a final two-foot cover of soil.

Of its three variations, the area method is best used when natural depressions exist at the site. The major limitation of this variation is that cover material must be hauled in or obtained from an adjacent area. Use of the trench method eliminates the cover material problem. Solid waste is placed in a trench that has been dug specifically for that purpose and is covered with the soil that was originally excavated. A natural slope or grade at the site is used for the ramp method. Solid waste is dumped on this slope, spread, compacted and covered with soil.

Because the trench method is more generally applicable, its cost is described in this report.[3]

What are the Costs of a Sanitary Landfill?

Every solid waste disposal system is unique, and the various costs for each system reflect this fact. As a result, no two systems have exactly the same cost structure. Such differences in cost can be attributed, in the case of disposal at a sanitary landfill, to soil characteristics, cover material availability, site topography, types of solid waste received, differences in labor cost and other factors. An actual solid waste system, then, must be tailored to fit the existing conditions. A detailed engineering study with specific operational guidelines and cost estimates must be developed for each individual case.

Such detail is not considered in the present analysis. The development of cost functions for general planning purposes requires, moreover, that differences between systems be balanced against each other to provide representative cost estimates. Again, it must be emphasized that the estimates which follow are not community specific.

We have used a five-year basis for estimating sanitary landfill cost. This appears realistic for planning purposes as new technology in alternative disposal methods can be expected in the foreseeable future. Also, changes are likely in institutional requirements which may make other alternatives more relevant.

Creation of any noise, land, air or water pollution at the disposal site is assumed to be minimal. As additional information becomes available on the social cost, however, it should be included in the sanitary landfill cost function.

An Overview

Costs of a sanitary landfill are of two types. First, there is an initial investment; second, there is a yearly cost of operation that includes a principal and interest charge on the initial investment. An outline of specific sanitary landfill costs will serve to guide the discussion and is presented as follows:

1. Planning and designing costs
2. Initial site development costs
   a. Site preparation
   b. Access roadways within the sanitary landfill
   c. Fencing
   d. Landscaping
   e. Access roadways into the sanitary landfill
   f. Water supply
   g. Equipment shed and personnel facility
   h. Scale and Scalehouse
3. Land Expense
4. Equipment Owning and Operating Expense
5. Personnel Wages and Salaries
   a. Scaleman
   b. Foreman
   c. Laborer
   d. Secretary

3/ For further details on all disposal methods see J. M. Huie, Solid Waste Management - Storage, Collection and Disposal, EC-397, Cooperative Extension Service, Purdue University, West Lafayette, Indiana.

6. Annual Site Maintenance and Development Costs
7. Administration and Overhead Expenses

Once these costs have been calculated they can be combined to provide an estimate of the total annual cost for solid waste disposal at a sanitary landfill.

Planning and Designing

Careful planning and designing are essential if a sanitary landfill is to function successfully when it is placed in operation. Costs must be incurred for legal services, consulting assistance, solid waste surveys, potential site investigations and the determination of site engineering specifications.

The average annual planning and designing expense is calculated as follows:

$$PD = \$12.40\ (V)$$

where: PD = the total annual planning and designing cost of a sanitary landfill
V = the daily volume of solid waste in tons

Initial Site Development

The estimated initial site development costs for a sanitary landfill are summarized in Table 1. The total of these costs, plus interest at the rate of eight percent on the investment, is presented in functional form as follows:

Size of Sanitary Landfill	Annual Initial Site Development Cost
0- 499 tons/day	$ID_1 = \$12,400 + 85.56\ (A)$
500- 999 tons/day	$ID_2 = \$13,640 + 85.56\ (A)$
1000-1700 tons/day	$ID_3 = \$14,880 + 85.56\ (A)$

where: ID = the total annual initial site development cost at a sanitary landfill
A = the number of acres of land required for a given daily volume of solid waste disposal

Land

Land requirements for a sanitary landfill can be met by use of land already owned, by the purchase of land or through a land lease. It is assumed in this report that land will be leased for the five-year planning period.

Total five-year land requirements for the sanitary landfill method of disposal are given by the following expressions according to the anticipated initial volume:

Size of Sanitary Landfill	Land Requirement
0- 199 tons/day	$L_1 = 10 + 0.2828\ (V)$
200-1700 tons/day	$L_2 = 0.3393\ (V)$

where: L = the total number of acres required to operate a sanitary landfill using the trench method for five years
V = the daily volume of solid waste in tons

Given the physical land requirements, we calculate land cost. If the primary land use in a given area is agricultural, the value of farm land can be taken as representative of the cost which must be paid to obtain land for a sanitary landfill. If the average

Table 1. Estimated Initial Site Development Costs for a Sanitary Landfill, Indiana, 1970

Site development items	Costs
Fixed costs	
Access roadway into sanitary landfill	$10,000
Water supply	5,000
Equipment shed and personnel facility	5,000
Scale	10,000
Scalehouse	10,000
Miscellaneous	10,000
TOTAL (less than 500 tons per day)	$50,000
Access roadway into sanitary landfill	$10,000
Water supply	5,000
Equipment shed and personnel facility	10,000
Scale	10,000
Scalehouse	10,000
Miscellaneous	10,000
TOTAL (500 to less than 1000 tons per day)	$55,000
Access roadway into sanitary landfill	$10,000
Water supply	5,000
Equipment shed and personnel facility	15,000
Scale	10,000
Scalehouse	10,000
Miscellaneous	10,000
TOTAL (1000 or more tons per day)	$60,000
Variable costs	
Site preparation	$185/acre
Access roadways within sanitary landfill	70/acre
Fencing	50/acre
Landscaping	40/acre
TOTAL	$345/acre

present value of better farm land is $500 per acre, and there is an annual return of four percent for agricultural use, that return would be $20 per acre.

In order for sanitary landfilling to draw land away from agriculture, an annual return in excess of $20 per acre will be required. It is therefore assumed that the necessary land can be obtained for a five-year period at $25 per acre per year. The costs associated with various levels of operations are computed according to:

Size of Sanitary Landfill	Land Expense
0- 199 tons/day	L = $250 + 7.0695 (V)
200-1700 tons/day	L = $8.4835 (V)

where: L = total annual cost for land for a sanitary landfill
V = the daily volume of solid waste in tons

Equipment

The expense for sanitary landfill equipment is generally recognized to have a considerable impact upon the total cost of disposal. The appropriate piece or pieces of equipment for each given size of sanitary landfill must be determined on the basis of estimated machine capacity as per manufacturer's specifications and also according to estimated owning and operating costs. A summary of machine class requirements is in Table 2. Representative equipment included in each of the machine classes is in Table 3.

To calculate the cost of a given piece of sanitary landfill equipment, we first make an "hourly owning and operating cost estimate." Such an estimate can be developed with the aid of handbooks available from equipment manufacturers. Typical costs to be considered are those included in Table 4. In making the estimate of fixed and variable equipment costs, it has been assumed that depreciation is straight-line on the basis of hours of operation. An average depreciation period is 10,000 hours. Interest, insurance and taxes are set at twelve percent of the delivered price.

The expense of the machinery operator is considered as one of the several input costs too, and is included in the equipment expense. An hourly wage rate of $5.00, including fringe benefits, is assumed for all machine classes except 8 and 10 (see Table 3). For these latter two classes, $5.30 per hour is assumed. It is further assumed that an equipment operator must be paid for a minimum of eight hours per day and that overtime is at a rate of 1 1/2 times the normal hourly wage.[4]

Table 2. Equipment Requirements and Purchase Price of Equipment by Size of Sanitary Landfill, Indiana, 1970

Volume in tons per day	Machine class	Purchase price*
0 - 49	4	$ 35,438
50 - 149	5	44,006
150 - 249	6	56,625
250 - 499	9	77,000
500 - 1199	9 & 10	122,100
1200 - 1224	6 & 9	133,625
1225 - 1624	7 & 9	158,293
1625 - 1700	8 & 9	191,966

* Purchase price information provided by Whayne Supply Company (Caterpillar equipment dealer), Louisville, Kentucky.

Table 3. Sanitary Landfill Machinery Classes, Indiana, 1970.

Class	Caterpillar	International Harvester	Allis-Chalmers
1	951	150	6G
2	955	175	7G
3	977	250	12G
4	D5	TD- 9	HD-6
5	D6	TD-15	HD-11
6	D7	TD-20	HD-16
7	D8	TD-25C	HD-21
8	D9		
9	825 (compactor)		
10	---------- Dragline ----------		

Sources: Caterpillar Purchasing Guide, Caterpillar Tractor Company, 1971; Sanitary Landfill Methods and Benefits, Allis-Chalmers, Construction Machinery Division, Springfield, Illinois; and discussions with equipment dealer representatives.

4/ An equipment operator is assumed to be paid for 260 days per year. Ten of these days will include paid holidays and inclement weather so that there will be 250 operating days per year.

Table 4. Sanitary Landfill Equipment Owning and Operating Cost Estimate, Indiana, 1970

1.	Delivered Price	_____
2.	Less: Resale or Salvage Value	_____
3.	Net Depreciation Value (Item 1 - Item 2)	_____
	FIXED COST	
4.	Hourly Depreciation: Net Depreciation Value (Item 3) / Depreciation Period in Hours	_____
5.	Hourly Interest, Insurance, Taxes: Annual Interest, Insurance, Taxes / Estimated Annual Use in Hours	_____
6.	Total Hourly Fixed Cost (Item 4 + Item 5)	_____
	VARIABLE COST	
7.	Hourly Fuel: Unit Price x Hourly Consumption	_____
8.	Hourly Lubricants, Filters, Grease: Annual Lubricants, Filters, Grease Cost / Estimated Annual Use in Hours	_____
9.	Hourly Repairs: Annual Repair Cost / Estimated Annual Use in Hours	_____
10.	Total Hourly Variable Cost (Item 7 + Item 8 + Item 9)	_____
11.	OPERATOR'S HOURLY WAGE	_____
12.	TOTAL HOURLY FIXED AND VARIABLE COSTS (Item 6 + Item 10 + Item 11)	_____

The total equipment cost at a given level of operation is computed, using the "hourly owning and operating cost estimate" as described above and the number of hours required for a particular machine to handle a given volume of solid waste. This time requirement is determined on the basis of the capacity estimates contained in Table 5. The procedure for calculating the time requirement is to estimate the time needed to perform each of the three operations -- excavation, spreading and compacting -- involved in the trench method of sanitary landfilling. These time estimates are calculated as follows:

Excavation:

$$\text{Required excavation} = \frac{\text{solid waste volume}}{\text{assumed in place density of earth}}$$

$$\text{Hours for excavation} = \frac{\text{required excavation}}{\text{machine excavation rate}}$$

Spreading:

Given: Solid waste averages 400 lb./cu. yd. off the packer truck when emptied at the sanitary landfill

$$\text{Volume of solid waste to be spread} = \frac{\text{solid waste volume}}{400 \text{ lb./cu. yd.}}$$

$$\text{Hours for spreading} = \frac{\text{volume of solid waste to be spread}}{\text{machine spreading rate}}$$

Compacting:

$$\text{Volume of solid waste to be spread} = \text{volume of solid waste to be compacted}$$

$$\text{Hours for compacting} = \frac{\text{volume of solid waste to be compacted}}{\text{machine compacting rate}}$$

It has been assumed that imperfect operating conditions and operator inefficiencies cause machinery to function at fifty percent of the capacity estimates given in Table 5.

Given the time requirements and the hourly owning and operating cost estimate, the daily or annual (250 operating days per year) cost of operating each piece of equipment at various disposal volumes can be calculated. The proper machine or combination of machines for each volume of solid waste is then selected on a least-cost basis. The disposal system's equipment expense is thus the minimum result when costs for several machines and combinations of machines are compared.

In general form this total annual equipment expense appears as follows:

$$E = FC + F(V)$$

where: E = the total annual cost of equipment at a sanitary landfill
FC = the total annual fixed cost of equipment at a sanitary landfill
F(V) = the total annual variable cost of equipment at a sanitary landfill
V = the daily volume of solid waste in tons

The exact numerical form will vary according to the machine or combination of machines that is used.

Specific least-cost expressions of total annual equipment expense are not presented.[5] A summary of the total annual cost and average annual cost per ton of solid waste disposal is included in Table 6.

Personnel

Wages and salaries of the personnel required at a sanitary landfill contribute significantly to the total cost of such an operation. The cost of equipment operators is included in the equipment owning and operating cost estimates and as a result will be excluded from the general cost of personnel.

A scaleman is employed to provide for the operation of the scale at the sanitary landfill. In addition, the collection of any user-fees can also be performed by the scaleman. The wage rate for this position is assumed to be $4 per hour, including fringe benefits.

A foreman is required to coordinate and oversee the operation of a sanitary landfill. In the case of smaller operations, those with volumes of less than 250 tons per day, the equipment operator can serve as foreman in addition to the operation of his machine. (At a volume of 225 tons per day, for example,

5/ These expressions are provided in K. C. Clayton and J. M. Huie, Solid Waste Economics... The Sanitary Landfill.

Table 5. Physical Capacity Estimates for Sanitary Landfill Equipment, Indiana, 1970[a]

Machine class[e]	Assumed density	Excavation capacity[b]	Spreading capacity[c]	Compacting capacity[c]
	(lb./cu. yd.)	(bcy./hr.)[d]	(lcy./hr.)[d]	(lcy./hr.)[d]
1	1000	56	1200	855
2	1000	76	1200	855
3	950	110	1200	1275
4	800	210	1128	775
5	1000	260	2300	885
6	1000	400	2430	1290
7	1000	560	3000	1440
8	1100	650	4200	1600
9	1300	260	2760	2916
10	--	300	--	--

a/ All capacity estimates are given at 100% of efficiency (estimates used in the calculation of equipment expense are 50% of true efficiency).

b/ Excavation capacities assume a 100-foot one-way push as would be the case when the trench method of sanitary landfilling is used.

c/ Spreading and compacting capacities assume a 100-foot one-way push with four passes required.

d/ Notation: bcy. = banked cubic yard; lcy. = loose cubic yard.

e/ Examples of the machines included in the respective classes are presented in Table 3.

Source: The estimated capacities have been provided by Whayne Supply Company, Louisville, Kentucky.

the class 6 machinery operator needs only 4.9 hours to fulfill his machine-hour duties and thus has 3.1 hours of an eight-hour work day to provide for the management function.) As volumes increase beyond 250 tons per day, however, it becomes increasingly unreasonable to expect the machinery operator to effectively manage the sanitary landfill. At these levels of operation, a foreman is employed specifically to perform the management function. His salary, including fringe benefits, is assumed to be $12,500 per year.

In most cases, a sanitary landfill will also require the services of at least one laborer. This employee is needed to remove blown papers from fences, refuel machinery, provide landscape maintenance and perform other general maintenance functions. It is assumed, however, that such a position is necessary only at medium to larger-sized sanitary landfills. One laborer will thus be employed when volumes of disposal range from 250 to 499 tons per day. When volumes exceed 500 tons per day, it is assumed that two laborers are required. The wage rate for each laborer is $2.50 per hour including fringe benefits.

As in most businesses, it is essential that proper records of the sanitary landfill operation be kept. This is especially true in the case of multi-government disposal operations because the collection and dissemination of information is basic to the success of the cooperative effort. A secretary is thus required when volumes reach and exceed 250 tons per day. The wage rate for a secretary is taken as $2.75 per hour, including fringe benefits.

It is assumed that a sanitary landfill is open to the public from 8:00 A.M. to 6:00 P.M., five days per week. Total annual wages of hourly personnel are based on such a ten-hour day (with the exception of an eight-hour day for the secretarial position). Sanitary landfill personnel requirements (excluding machinery operators) and the resulting total annual cost are presented in Table 7.

Annual Site Maintenance and Development

Periodic maintenance must be performed in order for a sanitary landfill to function

Table 6. Estimated Annual Equipment Owning and Operating Expense, Indiana, 1970[a]

Volume in tons per day	Machine class required[b]	Total annual cost	Annual cost per ton	Volume in tons per day	Machine class required[b]	Total annual cost	Annual cost per ton
25	4	$15068	$2.411	875	9 & 10	$ 57758	$0.264
50	5	16325	1.306	900	9 & 10	59147	0.263
75	5	18815	1.003	925	9 & 10	60488	0.262
100	5	20173	0.807	950	9 & 10	61504	0.259
125	5	21488	0.688	975	9 & 10	62839	0.258
150	5	23109	0.616	1000	9 & 10	64217	0.257
175	6	24479	0.560	1025	9 & 10	65381	0.255
200	6	26340	0.527	1050	9 & 10	66573	0.254
225	6	27860	0.495	1075	9 & 10	67766	0.252
250	9	29388	0.470	1100	9 & 10	69084	0.251
275	9	30668	0.446	1125	9 & 10	70421	0.250
300	9	32233	0.430	1150	9 & 10	71771	0.2496
325	9	33556	0.413	1175	9 & 10	73356	0.2497
350	9	34918	0.399	1200	6 & 9	82967	0.2770
375	9	36294	0.387	1225	7 & 9	83930	0.2741
400	9	37540	0.375	1250	7 & 9	85644	0.2740
425	9	39022	0.367	1275	7 & 9	87254	0.2737
450	9	41495	0.369	1300	7 & 9	88825	0.2733
475	9	43916	0.370	1325	7 & 9	90258	0.2725
500	9 & 10	45299	0.362	1350	7 & 9	91694	0.2717
525	9 & 10	45705	0.348	1375	7 & 9	93081	0.2708
550	9 & 10	46312	0.337	1400	7 & 9	94500	0.2699
575	9 & 10	46868	0.326	1425	7 & 9	95625	0.2684
600	9 & 10	47674	0.318	1450	7 & 9	97066	0.2678
625	9 & 10	48455	0.310	1475	7 & 9	98611	0.2674
650	9 & 10	49374	0.304	1500	7 & 9	100263	0.2673
675	9 & 10	50280	0.298	1525	7 & 9	101832	0.2671
700	9 & 10	50824	0.290	1550	7 & 9	103624	0.2674
725	9 & 10	51330	0.283	1575	7 & 9	105340	0.2675
750	9 & 10	52174	0.278	1600	7 & 9	107130	0.2678
775	9 & 10	53005	0.274	1625	8 & 9	116096	0.2858
800	9 & 10	54022	0.270	1650	8 & 9	117556	0.2850
825	9 & 10	55337	0.268	1675	8 & 9	118804	0.2837
850	9 & 10	56641	0.267	1700	8 & 9	120490	0.2835

a/ The machine class for each volume has been selected on the basis of lowest cost. This cost is inclusive of the operator in each case.

b/ Examples of the machines included in the respective classes are presented in Table 3.

Table 7. Personnel Requirements and Annual Cost for a Sanitary Landfill, Indiana, 1970[a]

Volume in tons per day	Total	Foreman	Laborer	Scaleman	Secretary
0 - 249	$10,400			$10,400	
250 - 499	35,120	$12,500	$ 6,500	10,400	$5,720
500 - 1700	41,620	12,500	13,000	10,400	5,720

a/ Personnel requirements exclude machinery operators.

properly over its five-year anticipated life. Repairs and preventive maintenance are necessary to insure the continued usefulness of the scale, scalehouse, equipment shed and other facilities. In addition to specific site preparation requirements, this expense also provides for the application of the final two-foot cover of earth on completed trenches. Previous studies indicate that this cost is approximately equal to ten percent of the initial site development expense.

Administration and Overhead

Expenditures must be made for utility services, heating oil, office supplies, and other such administrative and overhead requirements. Contingency funds to meet unexpected expenses are also included in this category. A representative annual cost of $10 per ton of initial daily capacity is assumed.

Total Cost

The total annual cost of operating a sanitary landfill includes those expenses just considered: (1) planning and designing costs, (2) initial site development costs, (3) land expense, (4) the owning and operating expense of equipment, (5) wages and salaries of personnel, (6) annual site maintenance and development costs, and (7) an administration and overhead expense. These cost components can be combined to provide an expression of total annual cost that assumes the general form:

$$TC = PD + ID + L + E + P + M + AO$$

where: TC = the total annual cost of disposal at a sanitary landfill
PD = the total annual planning and designing cost
ID = total annual initial site development cost
L = total annual land expense
E = total annual equipment expense
P = total annual wages and salaries of personnel
M = total annual site maintenance and development cost
AO = total annual administration and overhead cost

If the costs in the preceding expression are separated into their fixed and variable components, a reduced form for the total annual cost at a sanitary landfill is obtained:

$$TC = FC + VC\ (V)$$

where: TC = the total annual cost of disposal at a sanitary landfill
FC = the total annual fixed cost
VC(V) = the total annual variable cost
V = the daily volume of solid waste in tons

In its empirical form, this expression is found to appear as:

$$TC = \$28010.87 + 255.920\ (V) - 0.148\ (V^2) + 0.00005\ (V^3)$$

where: TC = the total annual cost of disposal at a sanitary landfill
V = the daily volume of solid waste in tons

The preceding expression of total annual cost can be converted to yield average annual cost per ton. The average annual cost expression for a sanitary landfill is of the form:

$$AC = \$1.024 + \frac{112.043}{(V)} - 0.0006\ (V) + 0.0000002\ (V^2)$$

where: AC = the average annual per ton cost of disposal at a sanitary landfill in the long-run
V = the daily volume of solid waste in tons

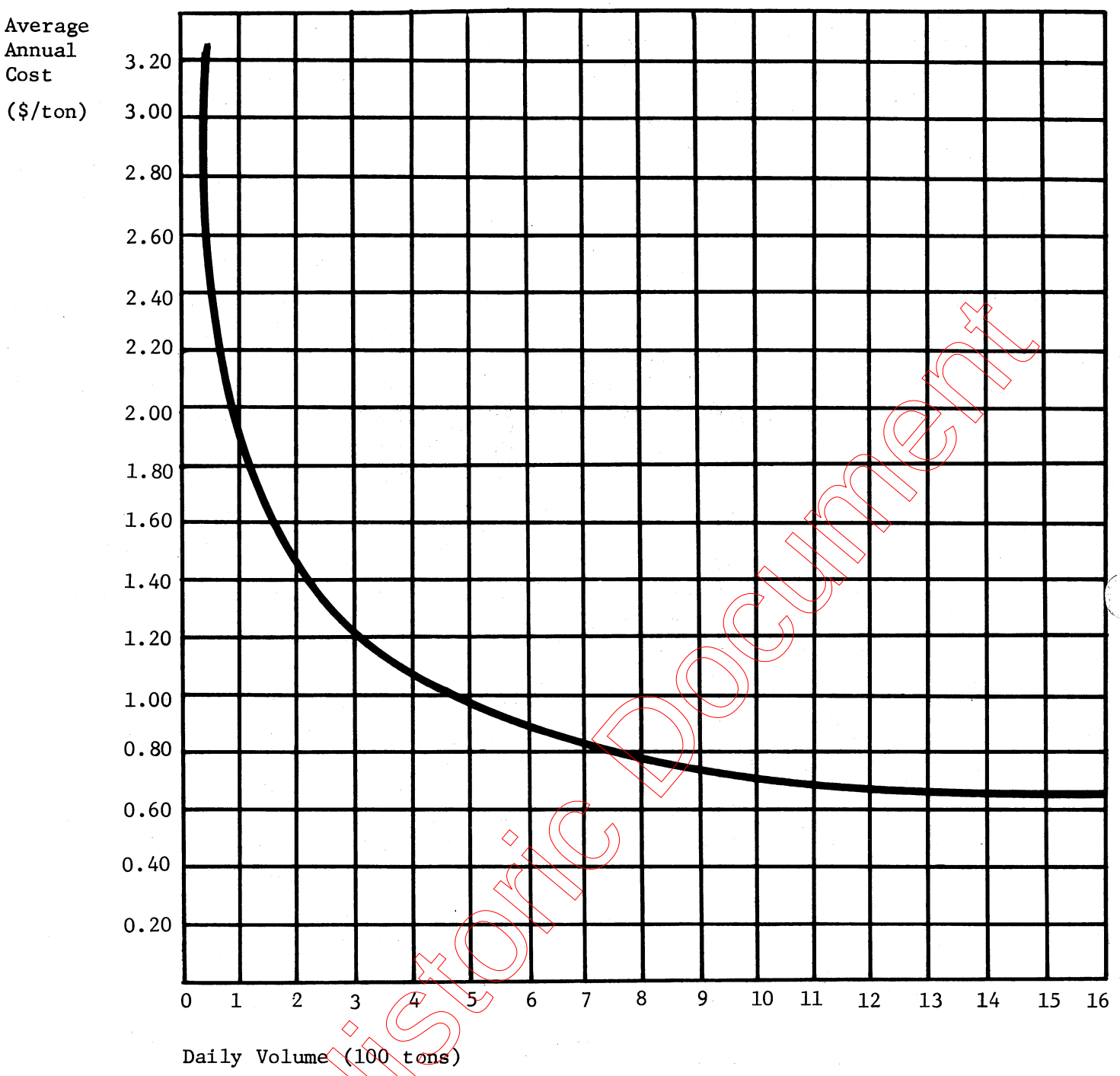
The "planning curve" which results from this expression is depicted in Figure 1. As indicated, increases in volume give rise to decreases in the average annual per ton cost of disposal. Significant per ton cost savings can thus be realized as the size of a sanitary landfill is increased. This is especially true for volumes up to 1000 tons per day.

The following are related publications in addition to those cited in footnotes 1, 2 and 3:

Clean and Green (Chilton Co., Ala.) -- A Solid Waste Disposal Demonstration Proj. Bureau of Solid Waste Mgt., Public Health Serv., Dept. of HEW.

Henningson, Durham, Richardson, Inc., Collection and Disposal of Solid Waste for Des Moines Metro. Area. Solid Waste Prog., Env. Cont. Admin., Public Health Serv., Dept. of HEW, Cincinnati, 1968.

Figure 1. Estimated Average Annual Solid Waste Disposal Cost at a Sanitary Landfill, Indiana, 1970.



Cooperative Extension Work in Agriculture and Home Economics, State of Indiana, Purdue University and U. S. Department of Agriculture Cooperating. H. G. Diesslin, Director, West Lafayette, Ind. Issued in furtherance of the Acts of May 8 and June 30, 1914.