A GUIDEBOOK FOR RURAL

SOLID WASTE MANAGEMENT SERVICES

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INTRODUCTION

Environmental and public health concerns in the U.S. have resulted in Federal and State legislation concerning solid waste. The most recent Federal action by the Environmental Protection Agency was the adoption of Subtitle "D", which will have a major impact on how landfills must be designed, operated, and closed. Also, many states have adopted legislation mandating waste reduction to extend the life of their landfills. Government officials responsible for solid waste collection and disposal, particularly in rural Oklahoma and Mississippi, have limited resources at their disposal to meet these requirements. Consequently, rural government officials and community leaders will benefit from a knowledge of the solid waste collection and disposal alternatives that may be available to them.

It is estimated that an average American disposes of nearly one ton of solid waste a year. Clearly, collecting and disposing of that volume of material is a major problem. This is especially true in rural areas where collection and disposal is most often left up to the individual household. A result is often illegal rural roadside dumps which create environmental and health hazards.

Disposal of solid waste after it is collected is, and will become, an even bigger problem in rural areas. Most small community landfills will not be able to meet stringent Subtitle "D" requirements for new landfills. This will lead to the establishment of large regional landfills. Local decision makers will need to investigate solid waste management alternatives that will be economically feasible given certain local physical and political conditions.

OBJECTIVES AND DATA

The primary objective of this study is to develop information useful to decisionmakers in evaluating the economic feasibility of various alternative solid waste systems in small communities and rural areas in the South. Specific objectives of the study include:

1. develop a procedure to estimate the amount of solid waste generated in a specific area;

2. summarize life cycle costs of a Subtitle "D" landfill;

3. provide data which will enable local decisionmakers to evaluate costs of directly hauling waste to a landfill verses operation of a transfer station;

4. provide data which will enable local decisionmakers to estimate capital and operating costs of community convenience centers;

5. develop a methodology to estimate capital and operating costs of rural collection systems; and

6. summarize community waste stream reduction options which include recycling and yard waste composting.

Data for the guidebook were gathered from national and regional sources as well as specific data for solid waste systems in Oklahoma and Mississippi. The authors have worked with numerous systems within these states to collect solid waste generation data, and capital and operating (cost) data. Included in this guidebook is a procedure to evaluate various solid waste management options which can be used in rural locations throughout the South.

ESTIMATING SOLID WASTE VOLUME

Basic to the evaluation of any solid waste management system is the amount of solid waste that will be generated in the area under consideration. Major factors in the amount of solid waste generated include: population of the area; and the area in which the residents are located.

Most national data suggests that the solid waste produced per capita ranges from 2 to 8 pounds per day (Franklin Associates, 1986). In this guidebook it is assumed that residents of cities and communities produce an average of 5 pounds per day per capita, including solid waste produced from businesses and institutions. Although no comprehensive data exists for rural Oklahoma and Mississippi, data from the Delaware County Oklahoma rural green box systems suggests that each rural resident produces about 3.5 pounds of solid waste per day, (Table 1).

The weekly amount of solid waste collected in an area can be estimated by using the data in Table 1 in the following formula.

VOLW = [5 (cusers) + 3.5 (rusers)] ÷ 2,000 where:

VOLW = total volume (tons) of solid waste collected per day;

CUSERS = users living in communities;

RUSERS = users living in rural areas.

Residents also generate a quantity of bulky items such as furniture, mattresses, home appliances, car tires, and other items not usually picked up with packer trucks. Delaware County, Oklahoma data suggests that each resident will produce about 16 pounds of white goods

TABLE 1

ESTIMATED AMOUNT OF SOLID WASTE PRODUCED PER DAY

Area	Per capita
Solid waste produced per day	Pounds per day
Urban	5.0
Rural	3.5
Bulky waste produced per year	Pounds per year
Urban and rural	
White goods	16
Other bulky items	23

Source: Operations of solid waste systems in Oklahoma and Mississippi (appliances) and 23 pounds of other bulky goods per year. Estimates of the total amount of bulky waste produced in a system per year, can be made using the following formula:

VOLBW = [16 (SUSERS) + 23 (SUSERS)] ÷ 2,000

VOLBW - volume of bulky waste (tons) discarded annually

SUSERS = total number of city and rural residents in the service area

The total waste stream (volume) is crucial for evaluating solid waste management alternatives. If local data are available relative to the waste stream, that data should be used. However, if data are not available,the above estimates will provide a good indication of the solid waste stream for a given service area.

EXAMPLE

To aid decision makers, an example county has been established that contains 10,000 community residents and 5,000 rural residents. This example county will be used in the following sections of the guidebook. Specifics of this example will be explained at the end of each section of text.

To illustrate how to estimate the solid waste stream, Form I has been created. Using the estimates and formulas provided in the text, the county is estimated to generate approximately 12,319 tons of solid waste per year. In addition, 120 tons of white goods, and 173 tons of other bulky waste will be generated each year. It is assumed that 120 tons of white goods will be recycled, so therefore, will not be sent to the landfill.

FORM I ESTIMATING SOLID WASTE STREAM

I. Rural

______	X	______	=	______
number of people		lbs discarded per capita per day		lbs discarded per day
				+

II. Community

______	X	______	=	______
number of people		lbs discarded per capita per day		lbs discarded per day
			=	______
				total lbs discarded per day
			÷	2,000
				lbs per ton
			=	______
				total tons discarded per day
			x	365
				days/year

TOTAL TONS OF SOLID WASTE = ______

III. BULKY ITEMS AND WHITE GOODS

________________	X	______________________________	=	______________________________
number of people		lbs of white goods per person per year		lbs of white goods per year
				÷
				2,000
				lbs per ton
				=

TONS OF WHITE GOODS PER YEAR ______________________________

________________	X	______________________________	=	______________________________
number of people		lbs of bulky items per person per year		lbs of bulky items per year
				÷
				2,000
				lbs per ton
				=

TONS OF BULKY ITEMS PER YEAR ______________________________

IV. ____________________ + __________________________________ = ______________________________

tons of bulky items | tons of community solid waste | tons of solid waste to landfill

X

____

tipping fee per ton

=

TOTAL TIPPING FEES $______________________________

SUBTITLE "D" LANDFILL COSTS

Landfills will be a part of solid waste management in the future. Recycling, composting, and in some cases incineration, have the potential to reduce the solid waste stream, but they do not eliminate the need for landfills. Given that fact, and the new Federal and state regulations designed to make landfills environmentally safe, it is imperative that community leaders responsible for solid waste management become aware of the impact of new landfill requirements on landfill costs.

Landfill costs are very site specific, depending on topography, soil type, geologic and hydrologic features, ground water condition, geographic location, and other factors. Landfill costs also are greatly affected by the daily volume of material they receive, that is, there are significant economies of size associated with landfills. These economies of size will become much more pronounced because Subtitle "D" municipal solid waste (MSW) landfill requirements significantly increase costs--much more expensive construction, and higher operating, closure, and post-closure costs.

Life cycle costs are defined as all costs incurred from the time the landfill is conceived, through the 30 year post-closure period as required by Subtitle "D". These costs include: pre-construction--planning, engineering, legal, licensing, and land acquisition; construction; operating; closure; and post-closure. Life cycle costs are the basis for tipping fees. Profit must also be included for privately operated landfills.

Three factors included in life cycle costs must be noted. First, a large amount of capital is needed to construct and operate a landfill, so the cost of that capital (interest) must be included in life cycle costs. Second, closure and post-closure costs are significant, so some type of fund (and/or financial assurance) must be established to take care of those costs when they come due. And third, inflation over the life of the landfill, including the post-closure period, needs to be a part of life cycle cost estimates. Responsible landfill management will include all of the above when establishing charges for solid waste services and/or tipping fees.

Since there are so many variables that can affect the costs of a specific landfill, the estimates to be discussed should not be considered as "the costs" that any given landfill will incur. Rather, the estimated costs should be thought of as being a guide for decision makers as they begin to think about constructing and operating a Subtitle "D" MSW landfill. Estimates from Oklahoma and Tennessee are presented.

OKLAHOMA ESTIMATES

No comprehensive landfill "life cycle" cost data were available for Oklahoma in relation to the new Subtitle "D" requirements. However, discussions with Oklahoma State Department of Health personnel responsible for solid waste management produced some estimates based on experience, and some estimates based on data they have developed (Table 2). Pre-construction cost is based on experience and includes: engineering and design; geologic and hydrologic studies, legal fees, and licensing. Construction, closure, and post-closure costs are based on a study of a hypothetical 44 acre Subtitle "D" landfill. (Solid Waste Management Services, 1992) These data are only presented to show the magnitude of the investment required for Subtitle "D" MSW landfills. It should be noted that Oklahoma construction cost estimates per acre are consistent with those in Tennessee (Table 3).

TABLE 2

SUBTITLE "D" LANDFILL COST ESTIMATES, OKLAHOMA

Item	Cost
	Dollars
Pre-construction[1]	150 - 200,000
	---cost per acre---
Construction	
Clay liner	24,200 - 42,350
Clay/composite liner	42,269 - 54,369
Other	40,000 - 50,000
Closure[2]	9,475
Post-closure[2]	41,169

Source: Solid Waste management Services, Oklahoma State Department of Health.

[1]Does not include land cost.

[2]Based on a hypothetical 44 acre landfill.

TENNESSEE ESTIMATES[1]

A comprehensive study of Subtitle "D" type landfill life cycle costs was completed in Tennessee for landfills taking in from 25 to 500 tons of solid waste per day (TPD). While these data reflect landfill costs in Tennessee, they should be similar to many southern states and are the best data available.

Assumptions from the Tennessee study used in this presentation are as follows:

1. an interest rate of 7.25 percent for public financing;
2. an average inflation rate of 5 percent for the landfill life cycle;
3. a life cycle of 25 years plus 30 year closure period;
4. an equipment life of 10 years with a 25 percent salvage value;
5. 20 percent of the site will be constructed in the initial phase; and
6. a compaction rate of 800 pounds per square yard for the landfill

The Tennessee study includes data for clay and synthetic liners. Only data for the synthetic liners are included in this presentation. If it is possible to use a clay liner, their data show 20-25 percent lower life cycle costs.

Shown in Table 3 is the estimated costs of establishing Subtitle "D" landfills, and the costs of closure and post-closure. The area covered by the landfills range from 25 acres for the smallest landfill (25 TPD), to 200 acres for the largest landfill (500 TPD). The population served by the smallest landfill is about 10,000 and about 200,000 for the largest landfill. These data are only presented to show the magnitude of the investment required for a Subtitle "D" MSW landfill. No operating costs, capital costs, nor inflation are included in Table 3.

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[1]For complete details of Tennessee cost data, see Dunsmore, 1991.

TABLE 3

COST OF DEVELOPING AND CLOSING A SUBTITLE "D" LANDFILL

Item	Tons per day (acres)				
	25(25)	50(50)	100(65)	200(100)	500(200)
			$1,000 Dollars		
Development[1]	210	315	490	650	1,100
Construction[2]	2,500	5,000	6,500	10,000	20,000
Closure[3]	250	500	650	1,000	2,000
Post-Closure[4]	1,250	2,500	3,250	5,000	10,000
Total	4,210	8,315	10,890	16,650	33,100

Source: Dunsmore, 1991.

[1]Including land costs.

[2]$10,000 per acre - composite liner

[3]$100,000 per acre

[4]$50,000 per acre

Shown in Table 4 are the estimated annual life cycle costs of operating the Tennessee landfills. Operating and capital costs and inflation are included in these estimates. It was assumed that the landfill would operate 286 days per year. The assumed depth of fill is 22 feet for the 25 and 50 TPD landfills and 30 feet for the larger landfills. Note that operating costs are assumed to be the same for the small landfills, and that costs for the very largest landfill are only three times operating costs for the smaller landfill. That is because personnel and equipment are under utilized at the smaller landfills. The smaller landfills must have personnel and a basic compliment of equipment available while the landfill is open, and their solid waste volume just does not keep them fully employed.

Operating costs are shown in more detail in Table 5. Again, equipment and labor costs per ton of capacity are displayed as being much higher for the smaller landfill. Ground water monitoring costs are shown as part of miscellaneous. A certain number of test wells are required regardless of the size of the landfill. The number of wells goes up in proportion to area, not volume.

Figure 1 presents the data from Table 4 in graphic form. The data clearly show economies of size. It could be argued that labor and equipment costs might be less for the 25 TPD landfill than for the 50 TPD landfill with prudent management of labor and equipment. However, estimated cost per ton for small landfills would still be extremely high compared to larger landfills. The case for regional landfills in sparsely populated rural areas that would serve at least around 50,000 people (125 TPD) appears to be very strong.

A cost that must be considered when discussing regional landfills is the cost of transportation to the regional landfill. Hauling solid waste over long distances is expensive.

TABLE 4

ESTIMATED ANNUAL SUBTITLE "D" LANDFILL COSTS

Item	Tons per day (acres)				
	25(25)	50(50)	100(65)	200(100)	500(200)
			$1,000 Dollars		
Development[1,4,]	18	27	39	58	95
Construction[2,4]	44	87	105	172	336
Ongoing Construction[3,4]	75	150	145	300	500
Operating	339	339	399	622	1,027
Closure[5]	6	12	24	46	115
Post Closure[5]	11	23	46	92	229
Total	493	638	758	1,290	2302
			Dollars		
Cost per ton	69	45	26	23	16

Source: Dunsmore, 1991.

[1]Including land costs.

[2]20% of acres initial construction

[3]Ongoing development and construction of landfill.

[4]Amortized at 7.25%.

[5]A discount rate of 3% is assumed.

TABLE 5

ESTIMATED OPERATING COSTS FOR "D" LANDFILL COSTS

Item	Tons per day (acres)				
	25(25)	50(50)	100(65)	200(100)	500(200)
			1,000 Dollars		
Equipment Costs[1]	171	171	185	313	543
Labor Cost[2]	78	78	116	144	199
Miscellaneous[3]	90	90	98	165	285
Total	339	339	399	622	1,027

Source: Dunsmore, 1991

[1]Including depreciation, maintenance, fuel and oil and servicing.

[2]Including benefits.

[3]Utilities, insurance office expense lechate treatment, ground water monitoring, etc.

FIgure 1

Source: Dunsmore, 1991

The waste can be hauled directly to the landfill with the collection trucks, or a transfer station can be built. These costs must be added to landfill costs (tipping fees) for those communities having to transfer and/or haul their waste to a landfill. They need to weigh that cost against the cost of operating their own landfill.

It has been estimated that transfer station and transportation costs, for a one way distance of 50 miles, range from about $10 per ton for a transfer station serving a population 30,000, to about $15-20 per ton for a population of 5-10,000 (Sloggett, et. al., 1992). Costs would be somewhat less for shorter transfer distances. However, for distances of less than 20-25 miles--depending on volume and collection equipment, it may be cheaper to use the collection vehicles to haul directly to the landfill rather than to utilize a transfer station.

TRANSFER STATION VS. DIRECT HAUL

When a local landfill closes, community leaders are faced with two options. They can directly haul their solid waste to a regional landfill with their collection trucks, or they can construct a transfer station. A transfer station is a place where solid waste picked up by collection trucks is unloaded into larger transfer vehicles for delivery to the disposal site. The choice of whether to direct haul or build a transfer station depends upon such factors as type of collection equipment, distance to the landfill, and the amount of solid waste to be handled.

TRANSFER STATION COSTS

Transfer vehicles have the capacity to hold several loads of solid waste from collection vehicles, thereby saving numerous trips by the collection vehicles to the landfill. This process saves time and reduces operating costs for communities with larger solid waste volumes and/or long hauling distances. The cost of a transfer station may be divided between capital costs and annual costs. Capital cost is the cost of purchasing the items needed to construct and operate a transfer station. Annual costs are the costs that occur each year to insure the continual operation of the transfer station.

TRANSFER STATION CAPITAL COSTS

Many factors influence the capital cost of a transfer station including location, distance from the landfill, equipment used, and the volume and type of material handled. The capital cost estimates discussed in this section are listed in Table 6.

TABLE 6

CAPITAL NEEDS OF A TRANSFER STATION

Item	Cost per unit
	dollars
Site	
Land[1]	*
Ramp and retaining wall	20,000 - 30,000
Building	35 per square foot
Fencing	10 per foot
Crushed rock	6,534 per acre
Equipment	
Without compaction	
Transfer semi-truck	52,000 - 75,000
Transfer trailer	40,000 - 50,000
With compaction I	
Hopper and compactor (5.5 cu. yd.)	28,000 - 40,000
Roll-off containers	4,000 - 5,000
Roll-off truck with hoist	60,000 - 70,000
With compaction II	
Transfer semi-truck	52,000 - 75,000
Self-contained compactor trailer	50,000 - 65,000
Hopper and chute	2,500 - 5,000
Other	
License	10,000 - 20,000
Contingency	10,000 - 20,000

Source: Equipment dealers and operators of Solid Waste Systems in Oklahoma and Mississippi.

[1]locally determined

Site Cost

The location of the site should be such that the distance collection vehicles and transfer vehicles must travel is kept to a minimum. The site should be large enough to include a building for collection vehicles to unload waste into the transfer vehicles and an outside area large enough for trucks to easily maneuver. If white goods and other bulky items are to be accepted at the transfer station, more space should be allotted. A reasonable size location should be between 1-5 acres. An example transfer site layout is presented in Figure 2.

The site must either be located on a sloping tract of land, or a ramp must be built. If a sloping site is used, then a level floor can be built with a drop-off so the waste can be unloaded into the transfer vehicle. If a level site is used, a ramp must be built so the collection vehicle will be above the transfer vehicle to allow the waste to be dumped down into the transfer vehicle.

Cost of the land will vary from region to region. The community or county may own the land, or it may be donated by a private source. However, in most cases the land will cost at least $1,000 per acre to purchase and, in some instances, much more.

A building on the transfer station site will allow the operation to continue despite inclement weather, and will provide a place for offices and vehicle storage. The size of the building will depend on the volume of waste being transferred. The building should at least be large enough to allow the collection vehicle room to dump the waste into a transfer vehicle. Containers for bulky items may also be placed inside, but it is not necessary.

Cost of the building will also vary according to the region where it is built. An estimate of $35 per square foot is used in this example and includes a steel building with a concrete floor,

figure 2

and a retaining wall. This estimate also includes a restroom and office, a roof extending over the transfer vehicle, and a large overhead door.

If white goods and other bulky items are to be accepted, then a concrete ramp and retaining wall will be needed to allow waste to be dumped down into a transfer container. The retaining wall should be high enough to place the transfer container below ramp level. The ramp and retaining wall is estimated to cost approximately $20,000 to $30,000 depending on the size and regional costs.

It is assumed that the entire perimeter of the transfer station site is fenced and has one or more lockable entry gates. The fence will provide security, and keep blowing debris from leaving the site. The fence is estimated to cost $10 per linear foot for an industrial type six foot chain link fence with barbed wire at the top and one large gate. One acre will require 820 feet of fence, two acres - 1230 feet, three acres - 1640 feet, and so on.

Crushed rock will be used for all roadways and parking lots to allow for all-weather use. The cost of crushed rock can vary greatly depending on the region and the distance from the quarry. A reasonable delivery price range to consider is from $3 to $10 per ton. A price of $6 per ton is used for this estimate. There are approximately 1.35 tons in one cubic yard of 3" crushed rock. A roadbed and parking area covered with 6" of crushed rock @ $6 per ton will cost $.15 per square foot. One acre contains 43,560 square feet. It would cost ($.15 x 43.560) $6,534 to cover one acre with 6" of crushed rock at $6 per ton.

<u>Equipment Costs</u>

There are basically two common types of transfer vehicles, open top or compactable trailers, and roll off containers. While both perform the same duties, different equipment is utilized with each system (Table 6).

Open top trailers utilize a tractor truck to transfer solid waste without being compacted. Collection vehicles empty their loads into the open top of the trailer. When the trailer is full, a hydraulic "walking floor" conveys the material to the end of the trailer. This transfer trailer is estimated to cost approximately $40,000-$50,000 each with and additional $52,000-$75,000 for a tractor truck. The trailer may legally hold up to 20 tons of material.

Another type of transfer trailer is the self contained compactor trailer. Collection vehicles dump waste through a hopper into the front of the trailer, and a blade inside the trailer compacts the material. The trailer is emptied by opening the end of the trailer and pushing the material out with the blade. A self contained compactor trailer is estimated to cost $50,000 to $65,000, with a capacity of about 20 tons. A tractor truck must also be purchased for this trailer.

Roll off containers utilize a stationary compactor, and a special truck with a tilting bed to pick up large roll off containers to transfer solid waste. Collection vehicles dump waste through a hopper into the stationary compactor which pushes the material into a roll off container that is clamped to the end of the compactor. When the roll off box is full, the truck bed is tilted to ground level next to the roll off box and the truck uses a hoist to pull the box onto the bed. An empty container is then attached to the compactor. The full box is hauled to the disposal site and is emptied by tilting the bed and dumping the material by gravity. The hopper and compactor cost approximately $28,000 to $40,000, with the roll-off containers costing $4,000 to $5,000 each. A roll-off tandum axle straight truck with a hydraulic bed and hoist cost from $60,000 to $70,000 depending on the size and features. Roll off boxes can legally hold up to 10 tons of material.

Advantages of using transfer trailers include eliminating the need for a stationary compactor and higher payloads resulting in fewer trips. However, the roll off box system requires less of an initial capital investment than do transfer trailer systems.

Other capital costs include fees for licensing and a contingency fee. While there is no cost for the license itself, legal and engineering fees for a transfer station can easily cost from $10,000 to $20,000. A contingency fee of $10,000 to $20,000 is added to cover unforeseen costs and to allow for cost variations from region to region.

TRANSFER STATION ANNUAL COSTS

Annual costs are the costs that occur each year to insure the continual operation of the system. Annual costs can be further divided into annual capital costs and operating costs. Annual capital costs are the yearly depreciation of capital items, and operating costs are the day to day out of pocket costs for such things as labor and fuel.

Annual Capital Cost

It is very important that funds be set aside each year for capital items so that money will be available to replace the item when it is fully depreciated. For this analysis, straight line depreciation will be used.

Annual depreciation for transfer station capital items are shown in Table 7. The transfer building, ramp and retaining wall, and the hopper and chute will be depreciated over a 25 year period. The transfer trailers, fencing, roll off containers, and compactor will be depreciated over 10 years. The crushed rock for roadways will need to be replaced after 5 years.

The amount set aside for the transfer trucks will vary according the level of usage. Most transfer trucks should be good for approximately 200,000 miles. By dividing the annual miles accumulated into 200,000, the useful life of the vehicle will be estimated. The vehicle should be depreciated in a straight line over the useful life.

Annual Operating Costs

Operating costs are yearly expenditures for items such as fuel, labor, maintenance, and fringe benefits needed on a daily basis for the operation of the system. The operating costs for a transfer station are listed in Table 8.

Fuel is estimated to cost $1.00 per gallon for diesel. The tractor truck is estimated to get approximately 6 miles per gallon for a fuel cost of $.167 per mile. The tilt bed truck gets approximately 8 miles per gallon for a fuel cost of $.125 per mile. Maintenance costs include costs for repairs, tires, and routine lubrication and servicing. These costs are estimated to be $.35 per mile for both the tractor and the tilt bed truck. Maintenance for the transfer trailers are estimated to be $.10 per mile.

A transfer station will need to employ at least one full-time attendant at $5 per hour, or $10,400 per year. A part-time or full-time driver for the transfer vehicles will also be needed at $7 per hour. If needed full-time, the yearly cost is $14,560. Fringe benefits are estimated to be 30% of total labor for workman's comprehensive insurance, FICA, unemployment, and other benefits. A contingency cost of $10,000 is included to cover the cost of utilities and office material as well as other unforeseen costs.

TABLE 7

TRANSFER STATION CAPITAL ITEM USEFUL LIFE

Item	Useful Life in Years
Site	
Building	25
Ramp and retaining wall	25
Fencing	10
Crushed rock	5
Equipment	
Tranfer trailer	10
Stationary compactor	10
Roll off containers	10
Hopper and chute	25
Transfer truck[1]	*

Source: Equipment dealers and operations of solid waste systems in Oklahoma and Mississippi

[1] Will vary according to annual mileage.

TABLE 8

TRANSFER STATION OPERATING COSTS

Item	Cost/Unit
	dollars
Fuel	
Semi	.167/mile
Tilt bed	.125/mile
Maintenance	
Transfer trucks	.35/mile
Trailers	.10/mile
Labor	
Attendant ($5/hr)	10,400/yr
Driver ($7/hr)	12,480/yr
Fringe Benefits	30% of total labor
Contingency	10,000 - 20,000

Source: Sloggett, Doeksen and Fitzgibbon, July 1992.

EXAMPLE

To help estimate the cost of building and operating a transfer station. Forms II and III have been created. Form II estimates the capital requirements of building a transfer station, and Form III estimates the annual cost of operating a transfer station.

The example county will be used for these estimates. It is assumed that only the solid waste collected within the community will be handled by the transfer station, and the landfill is approximately 35 miles from the transfer station. The transfer station will be placed on three acres of land with a 1,200 sq. ft. building. Open top transfer trailers with walking floors and a 20 ton capacity will be used to transfer the solid waste to the landfill.

The number of miles accumulated per year must be estimated to determine annual costs. The 9,125 tons transferred per year (Form I) is divided by the trailer capacity (20 tons) to obtain an estimated 457 trips per year. The 457 trips per year are then multiplied times the round trip distance (70 miles) from the landfill for an estimated 31,990 miles per year. To estimate the annual depreciation of the transfer truck, the 31,990 annual miles are divided by the maximum useable miles of the truck (200,000) to obtain a useful life of 6.25 years.

The example uses data provided in the text to estimate the cost of building and operating a transfer station. If local data are available, it should be used. Using the formulas and estimates, capital costs of this transfer station are estimated to be $246,400, and annual costs before tipping fees are estimated to be $85,634.

FORM II ESTIMATED TRANSFER STATION CAPITAL COSTS

Site and Equipment Capital Cost

Land:	____________ Acres	X	____________ $/acre	=	$____________ total land cost
Ramp and Retaining wall:				=	$____________ total ramp cost
Building:	____________ sq. ft.	X	____________ $/sq.ft.	=	$____________ total building cost
Fencing:	____________ ft. of fence	X	____________ $/ft.	=	$____________ total fence cost
Crushed rock or gravel:	____________ acres to be covered	X	____________ $/acre	=	$____________ total roadway cost
	Total site and development				$____________

Equipment

Without compaction:

Transfer semi-truck	____________ number of trucks	X	$____________ $/truck	=	$____________ total truck cost
Trailer(s)	____________ number of trailers	X	$____________ $/trailer	=	$____________ total trailer cost

With compaction I:

Hopper & compactor (5.5 cu. yd.) $______________________

Roll-off containers	____________ number of containers	X	$ $6,000 $/container	=	$____________ total container cost
Roll-off truck w/hoist	____________ number of trucks	X	$____________ $/truck	=	$____________

or

With compaction II

Transfer semi-truck	____________ number of trucks	X	$____________ $/truck	=	$____________
Self-contained compactor trailer	____________ number of trailers	X	$____________ $/trailers	=	$____________
Hopper and Chute				=	$____________
	Total Equipment			=	$____________

<u>Other</u>

License/permit	=	$____________
Total estimated capital costs	=	$____________

FORM III ANNUAL COSTS OF OPERATING A SOLID WASTE TRANSFER STATION

I. Equipment and Site Annual Capital Costs (Straight line depreciation) From Form II

Site

$ ________	÷	________	=	$ ________
building cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
ramp and wall cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
fencing cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
crushed rock cost		useful life		annual depreciation
				+

Equipment

$ ________	÷	________	=	$ ________
hopper and chute cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
total transfer trailer cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________

total transfer truck cost	useful life (maximum 200,000 miles)	annual depreciation

Total Annual Capital Cost = $ ______________________

II. Transfer Station Annual Operating Costs

Labor

________	X	$ ________	=	$ ________
number of attendants hours per year		hourly wage rate		total attendant labor
________	X	$ ________	=	$ ________
number of driver hours per year		hourly wage rate		total driver labor
________	X	$ .25	=	$ ________
total attendant and driver labor		administration cost		total administration labor

$ ________	+	$ ________	+	$ ________	=	$ ________
total driver labor		total attendant labor		total administration labor		total labor cost

$ ________	X	.30	=	$ ________
total labor cost		fringe benefit rate		total fringe benefit cost

$ ______________________

total labor cost

+

$ ______________________________

fringe benefit cost

Total annual labor cost = ______________________________

Vehicle

______________	X	$ ______________________	=	$ ______________________
total annual transfer miles		transfer truck operating costs per mile (fuel & maint.)		transfer truck operating costs

+

______________	X	$ ______________________	=	$ ______________________
total annual transfer miles		transfer trailer operating costs per mile		transfer trailer operating costs

=

Transfer vehicles operating cost = $ ______________________

Building and site

$ ______________	X	12 months	=	$ ______________________
utilities per month				annual site utilities

Transfer site

$ ________ + $ ________ + $ ________

total annual labor | total vehicle operating costs | annual site cost

Total annual operating cost = $ ________

TOTAL ANNUAL COSTS OF OPERATING A TRANSFER STATION

Total annual capital cost $ ________

+

Total annual operating costs $ ________

=

Total annual costs of a transfer station $ ________

÷

Number of tons transferred(Form I) ________

=

Transfer cost per ton of Solid Waste $ ________

DIRECT HAUL COSTS

Another solid waste disposal option is to use the collection trucks to deliver solid waste directly to a regional landfill. The cost of hauling solid waste directly to a distant landfill depends on the number and size of collection vehicles, the number of workers on each truck, the distance to the landfill, and the volume of waste to be transported.

It is assumed that existing collection trucks are used so no capital cost estimates are made. The annual cost of directly hauling solid waste to a landfill includes: depreciation, fuel, maintenance, labor, and a contingency fee to allow for unforeseen costs.

Annual capital cost (depreciation) for the collection vehicles is included in direct haul cost estimates to allow for the replacement of the vehicles when they are worn out. The replacement cost of each vehicle is divided by the useful life in miles to arrive at a per mile depreciation cost. To determine the annual capital cost of each vehicle, multiply the depreciation cost times the annual number of miles driven to the landfill and back.

The collection vehicle is estimated to get approximately 8 miles per gallon. At a cost of $1.00 per gallon, fuel is estimated to cost $.125 per mile. Maintenance cost for tires, lubricants and minor repairs is estimated at $.375 per mile for a total operating cost of $.50 per mile. Labor is estimated to be $6.00 per hour per driver. Fringe benefits total 30% labor cost for FICA, workmans compensation insurance, unemployment insurance, and other benefits. A contingency fee equal to 10 percent of operating costs should be added to pay for insurance, supervision, and other unforeseen costs.

EXAMPLE

To estimate the cost of directly hauling solid waste to the landfill with collection vehicles, Form IV was created. Only the solid waste collection from the example community will be used to estimate the direct haul costs.

To estimate annual capital costs, the total annual mileage from the community to the landfill must be estimated. If we assume that 20 cubic yard collection vehicles will hold approximately 5 tons per load, it would take about (9,125 tons per year ÷ 5 tons per load) 1,825 trips per year to dispose of the solid waste. The 1,825 trips per year is multiplied times the round trip miles from the landfill (70) to obtain an estimate of 127,750 miles per year. To estimate the annual capital costs, the cost of a 20 cubic yard collection truck (page) is divided by the estimated vehicle life (150,000 miles) to obtain a per mile depreciation. Then, the total annual miles is multiplied times the per mile depreciation to estimate the annual capital costs.

The annual operating costs include vehicle operating costs and labor. Vehicle operating costs are estimated by multiplying the annual mileage times the per mile cost of fuel and maintenance. Labor cost is estimated by figuring the amount of time drivers spend in route and back from the landfill. Dividing the total annual mileage by the average speed of the vehicle gives the total hours spent in route. The direct haul hours are multiplied times the wage rate to estimate the direct haul wages. Fringe benefits are also included to estimate the total direct haul labor cost. A contingency rate of 10% is included to cover unforeseen costs. Using the formulas and estimates provided in the text, the annual cost before tipping fees of directly hauling waste to the landfills is $161,623.

FORM IV ESTIMATING DIRECT HAUL COSTS

I. Annual Capital Costs

$ ____________	÷	____________	=	$ ____________
vehicle cost		useful life in miles		depreciation cost per mile
$ ____________	X	____________		
depreciation cost per mile		total annual mileage		

Annual Capital Cost = $ ____________

II. Annual Operating Costs

____________	X	$ ____________	=	$ ____________
total annual mileage		vehicle operating costs per mile (fuel + maintenance)		vehicle operating costs
____________	÷	____________	=	____________
total annual mileage		average collection vehicle speed		direct haul hours
____________	X	$ ____________	=	$ ____________
direct haul hours		wage rate/hour		direct haul wages
$ ____________	X	____________	=	$ ____________
direct haul wages		fringe benefit rate		total direct haul labor

Annual Operating Costs = $ ____________

				(vehicle operating cost + total labor cost)
$ ______	X	______	=	$ ______
annual operating costs		contingency rate		contingency

Annual Capital Costs	$ ______
	+
Annual Operating Costs	$ ______
	+
Contingency	$ ______
	=
Total Direct Haul Costs	$ ______
	÷
Tons Hauled (Form I)	______
	=
Cost Per Tons	$ ______

TRANSFER STATION VS. DIRECT HAUL

The choice of the two methods of hauling solid waste to the landfill could be made strictly on an economic basis using Forms II-IV. The cost of operating a transfer station for the example community i estimated at $85,634 per year. Directly hauling the solid waste costs approximately $161,623 The cost of building and operating a transfer station verses delivering the solid waste to the landfill with collection vehicles is a key consideration in the analysis. However, other factors and political situations may also influence the final decision.

A transfer station can serve other purposes for the community. In the absence of a local landfill, a transfer station provides a place for residents to dispose of items not picked up by normal collection crews. Large items such as appliances and mattresses may be discarded at a transfer station. Finally, a transfer station provides a facility where a recycling program could be easily implanted.

RURAL COMMUNITY CONVENIENCE CENTERS

As the new Subtitle "D" landfill regulations begin to take effect, many landfills will close, particularly in rural areas. In the absence of a local landfill or transfer station, residents will more likely use illegal roadside dumps to dispose of waste not collected by the current system, unless an alternative disposal site is provided. Illegal dumps are not only an eyesore, but are also a source of groundwater pollution and potential health problems. Convenience centers provide a place for citizens to dispose of items not picked up by normal solid waste collection, and they can provide a space for a recycling program.

A community convenience center is simply a place for residents to bring material that they wish to dispose of, or to recycle. There is a wide spectrum of convenience center designs. Factors such as the type of material accepted, location and topography of the center, and the amount of money to be spent will affect the design of the facility. Minimal requirements for a convenience center include:

1. all weather surfaces on the access road and on the site;

2. easy access by residents to the site and to the solid waste and/or recycling containers on the site;

3. a fence around the perimeter to prevent material from blowing around and for security; and

4. an attendant on duty while the center is open to assist residents, prevent scavenging and vandalism, keep the site neat, and most importantly, to control what is deposited at the site.

CONVENIENCE CENTER COSTS

The costs of building and maintaining a rural community convenience center can be divided into capital costs and annual costs. Capital costs are the costs of purchasing the items needed to construct and operate a convenience center. Annual costs include the costs of operating the convenience center.

CAPITAL COSTS

The costs of constructing a convenience center could be as little as a few thousand dollars for a minimal center, or as much as over $100,000 for a full service convenience center that includes recycling. The following discussion of cost estimates for the site and equipment includes a list of many items that could be used for a convenience center (Table 9). However, not all of these items are necessary. A minimal convenience center may only have a few small containers (dumpsters) and one or two large roll off boxes. Community leaders must decide what kind of convenience center services and equipment would best fit the needs of their community.

<u>Site Cost</u>

Location of the convenience center is extremely important. As its' name implies, the center should be located in a high traffic area so it is convenient for citizens to find and use. A site from one to three acres should be sufficient. Cost of the land will vary from region to region. In some instances, land may already be owned by the community, or it may be donated. However, land for a convenience center may cost up to $1,000 per acre or more.

If white goods and other bulky items are to be accepted, then a concrete ramp and retaining

TABLE 9

CAPITAL NEEDS OF A COMMUNITY CONVENIENCE CENTER

Item	Cost per Unit
	Dollars
Site	
Land[1]	*
Ramp and retaining wall	20,000 - 30,000
Building	35 per square foot
Fencing[2]	10 per foot
Crushed rock[2]	6,534 per acre
Equipment	
Green boxes	450 - 600
40 cu. yd. open top roll-off boxes	3,000 - 4,000
40 cu. yd. closed roll-off boxes	4,000 - 5,000
Two cu. yd. stationary compactor	7,500 - 10,000
Roll-off truck with hoist	60,000 - 70,000
Chipper	20,000 - 25,000

Source: Equipment dealers and operators of Solid Waste Systems in Oklahoma and Mississippi.

[1]Determined by local land prices.
[2]Cost may vary from region to region

wall should be constructed to allow citizens to drop heavy items down into large waste containers--trailers or roll off boxes. The ramp and retaining wall will cost approximately $20,000 to $30,000 depending on the local conditions. A small building should also be constructed to house the convenience center attendant. A building containing an office and a restroom is estimated to cost $35 per square foot.

The entire perimeter of the convenience center should be fenced to provide security and prevent blowing material from leaving the site. Fencing is estimated to cost $10 per linear foot for a six foot chain link fence with barbed wire at the top and one large gate.

Crushed rock will be used for the roadways and parking area to allow for all weather usage. Assuming the roadways will be covered with 6" of crushed rock at $6 per ton, it will cost approximately $6,534 per acre for the crushed rock. These prices will vary greatly depending on the distance from the quarry, and the region it is purchased.

Equipment Cost

The type of equipment needed at the convenience center depends on the services provided and the type of material to be handled. More equipment will be required if recycling is provided at the center. Listed in Table 9 are several pieces of equipment that may be used in a rural community convenience center along with cost estimates for each.

Green boxes are simply a dumpster painted green. Green boxes included in this analysis hold from 6 to 8 cubic yards of waste. Each green box is estimated to cost from $450 to $600. Separate containers for glass, paper, and other recyclables can be provided if a recycling operation is desired.

Large roll off containers are also used at convenience centers. There are two types of roll off containers, open top and closed top. Open top roll off containers included in this analysis hold up to 40 cubic yards of material, and are usually used for large items. Residents simply dump their material into the open top of the container. When the container is full, it is removed by a special truck with a tilting bed. Each open top roll off container is estimated to cost $3,000 to $4,000.

A closed top roll off container utilizes a stationary compactor to load solid waste. Residents drop their waste through a hopper into the compactor which pushes the material into the roll off container. When the container is full, it too is removed by a special truck. Each closed top roll off container is estimated to cost from $4,000 to $5,000. A two cubic yard stationary compactor is estimated to cost $7,500 to $10,000.

The special truck to haul roll off boxes tilts its bed down and loads the container onto the bed with a hydraulic hoist. The material is unloaded by tilting the bed down and allowing gravity to pull the solid waste out. A roll off truck is estimated to cost approximately $60,000 to $70,000.

A wood chipper may be provided to allow customers to dispose of tree limbs and brush clippings. The chipper listed in Table 9 is a commercial chipper which can handle limbs up to twelve inches in diameter and costs $20,000 - $25,000. Smaller chippers may be purchased for much less, but will have less capacity and durability.

Community leaders must first decide what type of solid waste will be accepted, then choose the equipment that will best fit their requirements. In some cases, a community may have to purchase very little equipment. Private solid waste companies will often provide the equipment and dispose of the solid waste on a cost per load basis. The availability of such an agreement will depend mostly on the location relative to a private solid waste company. With this arrangement, a community can save a large amount of money that would be spent on equipment. The cost to dispose of waste on a per load basis will depend on the number of loads, tipping fees, and the distance to the landfill. In many areas, charges from $100-250 for a 40 cubic yard load are common. In some cases, the cost may be partially offset by selling recyclable materials.

ANNUAL COSTS

Annual costs are the yearly costs that insure the continual operation of a convenience center. Annual costs can be further divided between annual capital and operating costs. Annual capital costs are the yearly depreciation of capital items, and annual operating costs are the daily out of pocket expenditures for such items as fuel and labor.

Annual Capital Costs

It is important that funds be set aside each year so that money will be available to replace the capital items when they wear out. Straight line depreciation is a simple method of estimating annual capital costs.

The capital items shown in Table 9 are assumed to have the following approximate useful life:

	Years
Ramp and retaining wall	25
Building	25
Fencing	10
Crushed Rock	5
Roll off containers	10
Green Boxes	5
Stationary Compactor	10

Chipper	10

A roll off truck should be depreciated according to its' level of usage. Each truck should be able to accumulate up to 200,000 miles before being replaced. To calculate the useful life of the roll off truck, divide the annual milage into 200,000. Then, depreciate the truck over its useful life to allow for replacement of the vehicle.

By contracting with a private company to provide equipment and remove all of the solid waste, annual capital costs will be avoided. However, community leaders must decide which option best fits their community.

Operating Costs

The operating costs for a rural community convenience center include expenditures for labor, equipment maintenance, fuel, utilities, and tipping fees. (Table 10)

An attendant will be needed for the convenience center. Retired persons or other part-time help may be hired at $5.00 per hour. The attendant would be responsible for helping citizens, keeping the site clean, and, if recycling is implemented, making sure that materials are properly separated. The attendant can also prevent any hazardous material from being deposited at the center. Fringe benefits are estimated to be 30 percent of total labor for items such as unemployment insurance, FICA, and workmans compensation.

Utilities for the convenience center may run from $100 to $200 per month for electricity and phone. If a stationary compactor is used, utilities may be substantially higher.

The roll off truck is estimated to get 8 miles per gallon. With diesel estimated to cost $1.00 per gallon, fuel costs would be approximately $.125 per mile. Maintenance on the roll off truck is estimated to cost approximately $.35 per mile to pay for tires and minor repairs.

Tipping fees for solid waste will vary, but are estimated at approximately $15 per ton. Subtitle "D" regulations could cause tipping fees to increase beyond this estimate.

CONVENIENCE CENTER DESIGN AND OPERATION

The design and operation of a rural community convenience center is restricted only by the imagination of the designer. The design should allow residents to use the center easily and quickly. The biggest factors in determining the layout of the center are the type of material being handled, and the containers used to store the materials.

One example of a minimal community convenience center in rural Oklahoma is located on the edge of town on an unused portion of an old highway. All equipment is provided and emptied by a private company. It uses a compactor and roll off boxes. The center is open from 20-25 hours per week, and accepts most types of municipal solid waste and bulky items. This convenience center was established with very little capital and operating costs are low, while still providing residents with a useful service.

An example of a community convenience center at the other end of the spectrum is also located in rural Oklahoma. This site was designed specifically as a convenience center, and is built on a raised concrete pad with large roll off containers below. Containers for large bulky items are placed on one side of the pad. On the other side, recyclables--glass, metal, paper--are

TABLE 10

OPERATING EXPENSES OF A RURAL COMMUNITY CONVENIENCE CENTER

Item	Costs
	Dollars
Attendant	5 per hour
Fringe Benefits	30% of labor
Utilities	100 per month
Truck (fuel)	.125 per mile
Truck (maintenance)	.35 per mile
Tipping fees	15 per ton
Contract fees	per cubic yard

Source: Operators of solid waste systems in Oklahoma and Mississippi.

placed in the appropriate containers. A composting area that accepts community yard waste (grass clippings) is located at the center, as well as facilities to accept used motor oil, antifreeze, and old batteries.

The full service convenience center is open 50 hours per week and provides excellent incentives for its residents. The center pays a slight fee for recyclable materials, and the composting facility accepts yard waste collected by curbside pickup and yard waste dropped off by residents. The community has banned the disposal of yard waste in normal curbside collection to help promote the composting operation.

The city owns very little of the convenience center equipment. It is owned by private companies that either haul the solid waste or the recyclable materials. The sale of the recyclable material helps pay for operating costs. However, a large investment was required in preparing the location as a convenience center.

EXAMPLE

To help estimate the cost of building and operating a rural community convenience center. Forms V and VI were created. Form V estimates the capital requirements of building a convenience center. Form VI estimates the annual costs of operating a convenience center. The example county community will be used for this analysis. It is assumed that a private solid waste company will provide the equipment. Therefore, the capital and operating costs of the equipment are not included in this example.

The capital cost include the cost of purchasing land, a building, and site improvements of fencing and crushed rock for roadways. Using Form V, the estimated capital costs of building a convenience center for the example community is $51,300.

For VI estimates the annual costs of operating the convenience center. Annual capital costs are the depreciation of capital items. The total cost of the capital item is divided by the useful life in years to obtain an annual capital cost. Operating costs include labor, utilities, and disposal fees. It is assumed the center is open 48 hours per week, or 2,496 hours per year. An attendant is paid $5.00 per hour. Utilities are estimated to cost $100 per month. Disposal fees will be on a per ton or cubic yard basis. For this example, the contract disposal fees are estimated to be $20 per ton, and will cover the cost of equipment and disposal.

Using the formulas and estimates provided in the text, the example rural community convenience center is estimated to cost $203,674 per year. If local estimates are available, they should be used.

FORM V. ESTIMATED CAPITAL COSTS FOR A COMMUNITY CONVENIENCE CENTER

Site:

Land

________	X	$________	=	$________
number of acres		$/acres		total land cost
				+
Ramp and retaining wall			=	$________

Building(s)

				+
________	X	$________	=	$________
# sq. ft.		$/sq. ft.		total building cost
				+

Fencing

________	X	$________	=	$________
# ft. of fence		$/ft.		total fence cost
				+

Crushed rock

________	X	$________	=	$________
# of acres		$/acres		total roading cost
				=

Total estimated site costs $________

Equipment:

Roll-off box (40 open cu. yd.)

______________ X $__________________________ = $________________________
number of boxes $/box total container cost

+

Roll-off box (40 closed cu. yd.)

______________ X $__________________________ = $________________________
number of boxes $/box total container cost

+

Stationary compactor (2 cu. yd.) = $____

+

$______________ + $__________________________ = $________________________
total site cost total equipment cost total capital cost

+

Wood chipper = $________________________

+

Roll-off truck w/hoist

______________ X $__________________________ = $________________________
# of trucks $/truck

=

Total estimated equipment costs = $________________________

Total estimated capital costs $________________________

FORM VI ESTIMATING ANNUAL CAPITAL AND OPERATING COSTS FOR CONVENIENCE CENTER

Annual capital costs (from Form V)

$ ______	÷	______	=	$ ______
total ramp and retaining wall cost		useful life		annual depreciation
				+
$ ______	÷	______	=	$ ______
total building cost		useful life		annual depreciation
				+
$ ______	÷	______	=	$ ______
total fencing cost		useful life		annual depreciation
				+
$ ______	÷	______	=	$ ______
total crushed rock		useful life		annual depreciation
				+
______	÷	______	=	$ ______
total cost of open roll-off boxes		useful life		annual depreciation
				+
$ ______	÷	______	=	$ ______
total cost of closed top roll-off boxes		useful life		annual depreciation
				+
$ ______	÷	______	=	$ ______
total cost		useful life		annual depreciation

of stationary compactor

+

$ ______ ÷ ______ = $ ______

total roll-off truck cost ÷ useful life (maximum 200,000 miles) = annual depreciation

Total annual capital costs = $ ______ summation of annual depreciation

Annual Operating Costs

Labor

______ X $ ______ = $ ______

number of annual attendant hours X hourly wage rate = annual attendant wages

+

______ X $ ______ = $ ______

number of annual driver hours X hourly wage rate = annual driver wages

=

$ ______

annual wages

$ ______ X ______ = $ ______

annual wages	Fringe benefits	total annual labor cost

Utilities

$ ______	X	12	=	______
average utility cost per month		month per year		annual utility costs

Tipping Fees[1]

______	X	$ ______	=	$ ______
number of tons or cu. yds. produced annually		cost per ton or cu. yd.		annual tipping fees

Contract Disposal Fees[2]

______	X	$ ______	=	$ ______
number of units		cost per unit		annual contract disposal fees

Total Annual Operating Costs = $ ______
summation of annual operating costs

Total Annual Capital Costs $ ______

+

Total Annual Operating Costs $ ______

=

Total Annual Costs $_________________________

[1]may be zero if private contractor is hired to handle roll-off boxes.
[2]will be zero if hauling your own boxes and paying tipping fees.

RURAL SOLID WASTE COLLECTION ALTERNATIVES

In many rural areas outside of organized communities, rural residents do not have access to solid waste collection services. With no convenient place to dispose of their waste, some residents rely on illegal roadside dumps. Illegal dumps are not only an eyesore, but also pose a serious health and groundwater pollution problem. Roadside dumps have been a problem in the past, and are likely to increase in the future if action is not taken. Establishing a rural collection system will decrease the incidence of illegal dumps.

There are three alternatives for rural solid waste collection: green box systems; convenience centers; and door-to-door service. These three alternatives may be used exclusively or in combination. Local community decision makers must choose which system or combination of systems best fit their requirements.

GREEN BOX SYSTEM

A "green box" is a dumpster painted green. A rural green box collection system entails placing green boxes (eight cubic yard boxes are common) along heavily used rural roads. Rural residents are encouraged, by easy access, to deposit waste in the green boxes as they pass. The waste is collected once or twice a week and hauled either to a landfill or transfer station. The number of green boxes at each rural location depends on the number of persons in the immediate vicinity--generally a three to five mile radius.

A green box system is attractive to local decisionmakers because the resident bears part of the responsibility (i.e. costs) of waste collection. Residents must expend time and energy to carry their solid waste to container sites.

However, a green box system affords local decisionmakers with the least control of material thrown into the containers. Legal responsibility for illegal or hazardous material placed in containers is often a concern of local decision makers. Persons other than residents of the collection area may use the containers, resulting in excessive volumes. Additionally, container sites are often difficult to obtain. Residents want the container convenient to their travel pattern and location, but not in their back yard (NIMBY)

Once rural leaders have a basic understanding of a green box collection system, the following guidelines should be considered in setting up a collection system. First, there are at least four possible location criteria to consider. Containers should be located:

1. Near concentrations of residents.
2. Along frequently traveled roads.
3. Where most residents do not have to travel more than 3 to 5 miles to dispose of their waste.
4. In sufficient numbers at each location to handle estimated volume.

Second, estimate the number of containers required for the collection system. The number of containers depends on factors such as population, waste generation rates, container capacity, seasonability, and frequency of collection. A typical container system will use 8-cubic yard containers. One cubic yard of uncompacted garbage weighs about 175 lbs. Thus, the total number of containers required for once a week pickup can be derived from the following equation:

TC = (((SUSER x WG) x 7 days) / 175 lbs.) / CC

Where

TC = Total number of containers needed

SUSERS = Number of residents in system

WG = Waste generated per person per day

CC = Container capacity

Third, develop a map showing collection routes or areas and roads with containers. State Highway Departments usually have maps which show roads and number and location of houses in the county. These are very helpful in keeping track of container locations, routes, and service areas (Myles, Schmidt, and Murray, 1991).

GREEN BOX CAPITAL COSTS

The capital items associated with a green box system are listed in Table 11. A green box system includes a packer truck, collection bins, and site development costs. Included in the cost of site development is land, fence, and crushed rock for all-weather use.

Front loading packer trucks are used for large bulk waste collection. One or two man crews collect waste by using hydraulic arms located on the front of the truck to pick up large containers and dump the waste into the top of the packer body. These collection vehicles are restricted to use in high density areas such as apartment complexes, and business districts, or collection systems where a single drop-off location is maintained for a large area, such as county-wide green box systems.

The advantages of a green box system include:

1. Cost--is the least expensive rural collection alternative to
   implement and maintain.
2. Convenience--residents are not required to travel far to dispose of their waste.
3. Public Health--controlling illegal dumping helps eliminate pollution problems and rodents.

TABLE 11

CAPITAL ITEMS ASSOCIATED WITH A GREEN BOX SYSTEM

Item	Cost per unit
	Dollars
Green boxes (8 cubic yard)	450 - 600
Packer truck (35 cubic yard)	111,000 - 120,301
Site development[1]	2,775 - 3,500

Source: Equipment dealers and operators of green box systems in Oklahoma and Mississippi.

[1]Includes cost of land, which will vary from region to region.

RURAL CONVENIENCE CENTERS

Convenience centers are strategically placed solid waste collection sites, attended during open hours, and designed to handle the solid waste from a more densely populated rural area. Convenience centers may include:

1. 18-20 or more green boxes.
2. Containers for recycling paper, metal, plastic, or glass.
3. Open top 40 cubic yard containers for bulky items.
4. Equipment to compact solid waste with a stationary compactor.
5. Any combination of the above four items.

The centers should be well landscaped, and easily accessible along well-traveled routes to attract residents living near-by.

The advantages of convenience centers include:

1. Convenience centers require less travel for the packer trucks than a green box system.
2. Unloading partially filled green boxes along green box routes is eliminated because a packer truck is dispatched to a convenience center only after the attendant calls for a full load to be removed.
3. Waste separation and compaction are often performed at convenience centers.
4. Convenience centers are generally easier to keep clean because they are attended.
5. The attendant can assist persons who need help and make sure that waste material is placed in the right container.
6. Most important of all, the attendant can control deposits.

CONVENIENCE CENTER CAPITAL COST

The estimated costs of three types of convenience centers are presented:

1. standard green box convenience center;
2. combination convenience center; and
3. compactor convenience center.

Standard Green Box Convenience Center

The example standard convenience center consists of a number of green boxes on a one acre site, conveniently located for easy access (Figure 3). As households deliver waste, a certain amount of waste separation can occur. Separate containers for paper, glass, plastics, and metals may be provided. An attendant is available to help users with separation.

The estimated costs for items associated with a standard convenience center are green boxes, and site preparation (Table 12) and a front loading packer truck. The Tennessee Valley Authority (TVA) [O'Conner] has indicated that the cost of developing a one acre site as pictured in Figure 3 is about $10,000 to $12,000 excluding land costs.

Combination Convenience Center

In this example, a combination convenience center is a standard convenience center that includes a large open-top roll off container to accept bulky household items (Figure 4), and a truck to haul the container. The estimated costs of the roll off boxes are $3,000 to $4,000. It may be possible to contract for the truck to haul the boxes. If not a truck will cost approximately $60,000 to $70,000. A front loading packer truck will again be needed to empty the green boxes. A ramp is built on the site and bulky household items are dumped from the ramp into the roll off box. The estimated cost for items associated with combination convenience centers are presented in Table 13.

figure 3

TABLE 12

ESTIMATED COST OF SELECTED STANDARD CONVENIENCE CENTER ITEMS

Item Price per Unit	
	Dollars
Front loading packer truck (35 cu. yd.)	111,000 - 120,301
Green box (eight cubic-yard dumpsters)	450 - 600
Site preparation[1]	10,000 - 12,000
One acre land	*

Source: Equipment dealers and operators of Solid Waste Systems in Oklahoma and Mississippi.

*Determined by local land prices.
[1]Greenbox convenience center

figure 4

TABLE 13

ESTIMATED COST OF SELECTED COMBINATION CONVENIENCE CENTER ITEMS

Item	Price per Unit
	Dollars
Green box (eight cubic-yard dumpsters)	450 - 600
40 cu. yd. open top roll-off boxes	3,000 - 4,000
Roll-off truck with hoist	60,000 - 70,000
Front loading packer truck (35 cu. yd.)	111,000 - 120,301
Site preparation	20,000
One acre land	*

Source: Equipment dealers and operators of Solid Waste Systems in Oklahoma and Mississippi.
*Determined by local land prices.

Compactor Convenience Center

The example compactor convenience center uses a two-cubic yard stationary compactor together with a 42 cubic-yard closed container in place of green boxes. Waste is deposited into the compactor by the user and then compacted into a closed container by the center attendant. The two cubic yard compactor has an estimated cost of $7,500 to $10,000. Two open-top roll-off units are also used in this example (Figure 5). A roll off truck will be required to dispose of the roll off boxes. A roll off truck will be required to dispose of the roll off boxes. The estimated cost for items associated with this type of convenience center are presented in Table 14.

In some cases, convenience center equipment may be operated on a rental basis. Private solid waste management companies will often provide containers and dispose of the waste for a fee. The only capital cost for the system would be providing the site for the center. Depending on the type of material being dumped, the cost of disposing of each load will range from $100 to $300 per load. One major factor affecting the availability of rental equipment is the distance that a community is from a private solid waste management company.

Convenience centers have several advantages over green box collection systems (O'Connor) including:

1. Cleanliness--attendants keep the area clean and help residents in unloading trash.
2. Efficiency--attendants call for trucks only when full-loads are available.
3. Cost--after initial start-up costs, they are less expensive to operate due to transportation, routing, site cleaning, and labor savings.
4. Convenience--operating hours are adjustable to user schedules, and centers are located near populated areas along major roads.
5. Security--attendants maintain security and help eliminate scavenging, vandalism, stray

dogs, and illegal dumping by residential and commercial waste generators.

6. Public Health--controlling illegal dumping helps eliminate pollution problems and rodents.

figure 5

TABLE 14

ESTIMATED COST OF SELECTED COMPACTOR CONVENIENCE CENTER ITEMS

Item	Price per Unit
	Dollars
40 cu. yd. open top roll-off boxes	3,000 - 4,000
42 cu. yd. closed roll-off boxes	4,000 - 5,000
Two cu. yd. stationary compactor	7,500 - 10,000
Roll-off truck with hoist	60,000 - 70,000
Site preparation	20,000
One acre land	*

Source: Equipment dealers and operators of Solid Waste Systems in Oklahoma and Mississippi.
*Determined by local land prices.

DOOR TO DOOR

The most expensive of the three rural collection systems to operate is the door-to-door, or mailbox-to-mailbox collection system. As with community solid waste collection, residents simply place their waste material on the road near their mailbox, and collection vehicles stop at every residence to collect the waste. The collection routes should be laid out to minimize the total mileage for the collection vehicles. The types of roads is also important since inclement weather could slow or halt collection. However, since most mail routes are all-weather, collection vehicles should be able to travel these roads. If once per week collection is considered then each truck and crew should be scheduled for only four days per week. This leaves a day per week to allow for holidays and mechanical break downs.

The major capital requirement for a door-to-door system is the collection vehicle. The type of truck required depends on the conditions of the system. Rear loading packer trucks are a common type of collection vehicle. They generally are operated with a two or three man crew. The rear loading set up allows collection on both sides of the street with one pass. These trucks are best suited for small residential trash bins, small brush, and other loose waste.

Side loading packer trucks are designed for residential solid waste collection for a one man crew. The waste is collected by hydraulic arms that pick up uniform size trash containers placed on the curb. The smaller crew requirements decrease operating expenses. However, a side loader may only pick up waste on one side of a street. Road and bridge conditions often force the utilization of smaller trucks. Containers may be provided for residents at a cost of $50 to $100 each. Listed in Table 15 is the estimated cost of two sizes of compactor trucks.

TABLE 15

COLLECTION VEHICLE COST ESTIMATES FOR A DOOR-TO-DOOR SYSTEM

Collection Vehicle	Price per Unit
	Dollars
Packer Size	
10 cu. yd.	40,000 - 50,00
20.0 cu. yd.	60,000 - 70,000
Containers	50 - 100

Source: Equipment dealers

The advantages of a door to door collection system include:

1. Convenience--most convenient collection system for residents

2. Comprehensive--allows for collection from all residents

3. Public Health--controlling legal dumping helps eliminate pollution problems and rodents.

ANNUAL COSTS

ANNUAL CAPITAL COSTS

Annual capital costs are the depreciation of the item used in the collection system. Including depreciation in the annual cost of a collection system allows decision makers to replace capital items when they have reached the end of their useful life.

Annual capital costs depend directly on the number and type of equipment chosen. In this analysis, packer trucks are depreciated by the same amount each year over the life of the vehicle. System operators report that the maximum lifetime of a collection vehicle ranges from 100,000 to 200,000 miles. Green box and convenience center sites are depreciated over 10 years because fencing and crushed rock must be replaced after extended use. Solid waste collection containers are depreciated over five years. The large roll off boxes and stationary compactors are estimated to have a useful life of 10 years. The roll off truck is estimated to last approximately 150,000 miles.

ANNUAL OPERATING COSTS

Operating costs are the costs associated with maintaining day-to-day operations of the system. These costs include expenditures on tires, fuel, maintenance, labor, and other various items. Costs listed in Table 16 will provide estimates for the cost of operating a collection system. While each system will have costs unique to itself, the estimates will provide a good indication of the total cost that decision makers can expect.

Collection vehicles are expected to get approximately 8 miles per gallon. If diesel fuel costs $1.00 per gallon, fuel is estimated to cost $.125 per mile. Maintenance covers things such as tiers, repairs, and oil changes and is estimated to cost $.375 per mile. Therefore, fuel and maintenance will cost approximately $.50 per mile.

Labor costs include drivers, attendants, and administration. Drivers are normally paid approximately $7 per hour, and attendants are paid $4.35 per hour. Administration of the system is estimated to cost 25% of the total labor costs. In some cases, the system may be large enough to warrant a full-time administrator. The annual cost of a full-time administrator is estimated to be $17,500 to $25,000. However, some rural systems will not be large enough to justify this expense. Fringe benefits must also be included to cover insurance, workmans compensation, and retirement. Fringe benefits are estimated to be 30% of total labor.

Utilities for a collection system can cost up to $2,000 per year. Office costs for supplies and phone are estimated at $2,500 per year. Maintenance on green boxes are included for minor repairs and paint for the boxes, and are estimated at $6.00 per box per year. Tipping fees are estimated to cost $15 per ton. Contingency fees are included to cover things such as insurance, and other unforeseen costs.

TABLE 16

OPERATING COSTS FOR SOLID WASTE COLLECTION SYSTEMS, NOVEMBER 1992

Item	Cost/Unit
	Dollars
Vehicles	
Fuel	.125/mile
Maintenance	.375/mile
Depreciation[1]	*
Labor	
Administration	25% of labor
Driver	7 /hr.
Attendants	4.35/hr.
Fringe Benefits	30% of total labor
Other	
Utilities	2,000/year
Office supplies	2,500/year
Maintenance on containers	6/container
Contingency	10,000/year
Tipping fees	15/ton

Source: Operation of Solid Waste Systems

[1] depends on cost, type, and level of use for each item

EXAMPLE

To estimate the cost of rural solid waste collection system, Forms VII and VIII were developed. Form VII estimates the capital cost of a rural collection system, and Form VIII estimates the annual costs of a rural collection system.

Because door to door system are more complex, forms to estimate cost of establishing a door to door collection system are not included. The 5,000 rural residents of the example county will be used for this example. Disposal of the solid waste is assumed to be at the county transfer station. For this example, we assume that the example county selects a standard convenience center collection system with four sites located throughout the county.

Form VII shows the capital costs of building and equipping four convenience center sites. Each site is assumed to be approximately two acres for a total of eight acres of land. Site development is estimated to cost $12,000 per location. Using the formula provided earlier in the text, it is estimated that 88 green boxes would be needed for once a week pick up. Half as many green boxes would be needed for twice a week pick up. One 35 cubic yard packer truck would handle the collection.

Form VIII is used to estimate the annual costs of operating a rural collection system. Annual cost include annual capital costs and annual operating costs. To estimate the useful life of the collection vehicle, the maximum miles the vehicle is capable of accumulating (200,000 miles) is divided by the estimated annual miles. Because the location of the convenience centers are not known, it is assumed that the collection truck will accumulate 40,000 miles per year. Therefore, the collection truck will have a useful life of five years. To estimate the annual cost of a standard convenience center, the total equipment costs and the total site costs are divided by the useful life.

Annual operating costs include expenditures on labor, vehicle operating expenses, and other out of pocket expenses. Labor includes expenditures on a collection crew and attendants for each convenience center. One crew of two drivers is assumed to work 40 hours per week for a total of 4,160 hours per year. Four attendants will work 40 hours per week for a total of 8,320 hours per year. Administration is estimated to cost 25 percent of labor. Fringe benefits are included to cover social security, insurance, and workmans compensation.

Vehicle expenses include fuel and maintenance. To estimate vehicle operating costs, the estimated annual mileage (40,000) is multiplied times the per mile cost for fuel plus maintenance. Other operating expenses include utilities and tipping fees. However, in this example, tipping fees are not included since disposal is at the county transfer station.

Using the formulas and estimates provided in the text, it is estimated the capital cost of building a standard convenience center collection system is $210,120, and the annual costs total $167,356. If local data is available, it should be used.

FORM VII ESTIMATED CAPITAL COSTS OF ALTERNATIVE COLLECTION SYSTEMS

I. Green Box System

________	X	$ ________	=	$ ________
number of boxes		cost per box		total cost of collection boxes
				+
________	X	$ ________	=	$ ________
number of collection trucks		cost per truck		total cost of collection trucks
				+
________	X	$ ________	=	$ ________
number of sites		cost per site		total site development cost
				=

Total Capital Costs of Rural Green Box Collection System $ ________
summation of total site and equipment costs

II. Rural Convenience Center

Site and Preparation

________	X	$ ________	=	$ ________
number of acres		cost per acre		total land cost

+

________	X	$________	=	$________
number of sites		cost per site		total site cost development

Total site cost = $________

Equipment

________	X	$________	=	$________
number of collection boxes		cost per box		total collection box cost
________	X	$________	=	$________
number of collection trucks		cost per truck		total collection truck cost
________	X	$________	=	$________
number of roll-off containers		cost per container		total cost of roll-off containers
				+
________	X	$________	=	$________
number of roll-off trucks		cost per truck		total cost of roll-off trucks
				+
________	X	$________	=	$________
number of stationary compactors		cost per compactor		total cost of a stationary compactors
				=

Total Equipment Cost		$____________________
Total Site Cost	=	$____________________
		+
Total Equipment Cost	=	$____________________
		=
Total Capital Cost of a Convenience Center Collection System		____________________

FORM VIII ANNUAL CAPITAL AND OPERATING EXPENSES FOR RURAL COLLECTION SYSTEMS

I. Annual Capital Cost (from Form VII)

$ ______ total site cost	÷	______ useful life	=	$ ______ annual site depreciation
$ ______ total collection truck cost	÷	______ useful life (maximum 200,000 miles)	=	$ ______ annual collection truck depreciation
				+
$ ______ total collection box cost	÷	______ useful life	=	$ ______ annual collection depreciation
				+
$ ______ total roll-off truck cost	÷	______ useful life (estimated 150,000 miles)	=	$ ______ annual roll-off truck depreciation
				=
		Total Annual Capital Cost		$ ______

II. Annual Operating Cost

______ number of driver hours per year	X	$ ______ hourly wage rate	=	$ ______ total driver labor
				+
______ number of attendant hours per year	X	$ ______ hourly wage rate	=	$ ______ total attendant labor

Administration

$ ______	X	______	=	$ ______
total of above labor		administration cost rate		total administration labor
				or
			=	$ ______
				annual administrator salary
				+
$ ______	X	______	=	$ ______
total labor cost		fringe benefit rate		fringe benefits
				=
		Total Labor Expense	=	$ ______
				summation of labor and benefit costs

III. Vehicle Expense

______	X	$ ______	=	$ ______
total annual packer truck collection mileage		operating cost per mile		total annual collection truck operating costs
				+
______	X	$ ______	=	$ ______
total annual roll-off truck mileage		operating cost per mile		total annual roll-off truck operating costs

=

Total Annual Vehicle Operating Expense $ ____________________

IV. Other

$ ________	X	12	=	$ ________
average utilities per month		months per year		total utilities cost per year

+

________	X	$ ________	=	$ ________
number of tons predicted annually		tipping fees per ton		tipping fees per year

or

________	X	$ ________	=	$ ________
number of cu. yds.		tipping fees per c.y.		tipping fees per year

Total Cost of Tipping Fees and Utilities $ ____________________

Total Annual Capital and Operating Expenses = $ ____________________

÷

Tons Collected (Form I) ____________________

=

Cost Per Ton ____________________

WASTE STREAM REDUCTION

Community leaders wishing to reduce the cost of solid waste management may reduce the amount of material handled by the system. Two options to reduce the amount of waste in their collection systems are recycling centers and yard waste composting systems. Both options can save collection and disposal cost as well as extend the life of current landfills.

SOLID WASTE RECYCLING

More stringent landfill regulations imposed by the EPA coupled with an increasing public concern for the environmental policies have forced communities to re-evaluate the options available for solid waste disposal. Recycling is an alternative waste management system being considered by many local governments. Recycling decreases the volume of material deposited in landfills and provides an additional benefit by lowering the depletion rate of certain natural resources. In addition, in some areas disposal fees at landfills (tipping fees) have increased dramatically in a relatively short time (Brown, 1989). Although recycling will not eliminate the need for landfills, a waste management system that includes recycling will certainly extend the life of existing landfills and decrease the total amount paid in tipping fees.

RECYCLABLE MATERIALS

Materials which are commonly recycled include steel, aluminum, glass, paper, plastic, and various other metals. The average distribution of materials present in municipal solid waste is shown in Figure 6. Only those recyclable materials that can be collected steadily and in a large enough volume will be in demand by secondary markets. Planners should secure markets

figure 6

for recyclable materials before a recycling program is implemented to avoid storage and handling problems.

Buyers will not be interested in an erratic supplier. The quality and quantity of recyclable materials that can be supplied will be major determinants for finding and securing secondary markets. Buyers of recyclable materials often ask for contracts specifying volume and quality requirements.

Aluminum is by far the most popular material to be recycled today because it is easy to collect, sort, and prepare for secondary sale. The largest source of recyclable aluminum comes from beverage cans. The recycled aluminum goes into making more beverage containers at a much lower cost than cans produced from virgin metal. Many markets exist for consumers to sell aluminum for recycling. Even with stiff competition from private collectors, aluminum remains the most profitable material for a community recycling operation. In some cases, aluminum sales offset losses incurred in the collection of other materials.

The amount of plastic in everyday waste has increased over the last few years as its popularity as container material has increased. The most commonly collected types of plastics are large, clear soft drink containers that are made of polyethylene terephthalate (PET), and gallon and half-gallon milk and juice containers made from high density polyethylene (HDPE). Most plastic containers may be separated using the symbol printed on the bottom of the container. Plastics must be carefully separated and cleaned of contaminants before resale. The market for plastics is small but expanding. Plastics are recycled for use in insulation, floor tiles and automobile bumpers etc. (Brown, 1989). Elimination of these plastics from the waste stream is especially important because of the large landfill volume they require relative to their weight.

Crushed glass is called cullet in the glass industry. Cullet must be separated by color into: 1) clear; 2) brown (amber); and 3) green. Clear cullet is the material most frequently used in the container industry. The secondary markets for glass fluctuate greatly, and the ability to sell cullet depends on the location of a community relative to a glass factory due to high transportation costs. Collection of glass must be closely monitored to completely remove contaminants (bottle caps, stones, metal) before resale, because secondary purchasers are strict about the amount of contaminants present in the cullet. A major attribute of cullet is that there is no noticeable difference between the quality of glass made with or without recycled glass.

Paper comprises the largest single volume of waste sent to landfills. Various types of waste paper include computer paper, old newspaper (ONP), and corrugated cardboard. Newspapers and magazines comprise over 27% of the total supply of waste paper and corrugated papers make up 30% (Franklin, 1986). The paper recycling market is the largest and most price volatile secondary market. As with glass, the collection of waste paper must also be monitored closely to reduce the amount of contaminants found in the paper. Recycled paper has many uses including paper towels, tissue, newsprint and packaging.

Approximately two-thirds of the steel manufactured in the United States is made from scrap metal. Common sources of scrap metal include; washers, dryers, refrigerators, steel cans, and automobiles. Other materials such as used oil, car tires, and batteries may also be recycled. The availability of markets for these goods depends on the location of the community relative to manufacturers which can utilize them.

COLLECTION SYSTEM ALTERNATIVES

After it is determined which materials will be recycled, a collection system must be chosen.

The method by which recyclables are collected may be the most important decision to make to insure a successful operation. A collection system must be chosen to fit the community's desired level of investment to make the program work most efficiently. Obtaining the maximum quantity of recyclable materials should be a goal regardless of which collection system is chosen. Ideally, the collection system will be tailored to utilize existing collection routes and equipment. The three methods of collection outlined in this paper are:

1. drop-off centers;
2. buy-back systems
3. curbside collection.

<u>Drop-Off Systems</u>

Drop-off systems offer the most cost-effective recycling option for a community. The system consists of a number of containers placed around the community where residents can "drop-off" their recyclable materials. Drop-off systems are often implemented by a community as a stepping stone towards a more comprehensive recycling system.

The key for a successful drop-off system is accessibility for the community residents. Drop-off sites that are inconvenient or confusing will have a low participation rate. The sites should be located where residents frequently visit, such as a shopping mall, city parks, or schools. Reducing the distance people must travel to utilize the facilities will also have a positive effect on the success of the system. The drop-off location should be clean and well-lit with clear instructions that are easily followed.

Although drop-off centers are inexpensive and convenient they are not without disadvantages. One major drawback to this system is that non-recyclables are often mixed with the recyclable material. Sorting the materials may be necessary by either collection workers or at a Materials Recovery Facility (MRF) to up-grade the quality of the final products. Another major disadvantage of the drop-off system is the low participation rate. Making the collection sites convenient and educating the community may increase usage, but the drop-off system has the lowest participation rate among the three collection alternatives.

Buy-Back System

A buy-back system also requires that residents deliver their recyclables. The difference is that buy back locations have an attendant, and residents are paid by weight the current market price for their recyclables. Being compensated for recycling creates an excellent incentive for residents to utilize the center. The participation rates for buy-back systems are higher than for drop-off systems and are comparable to curbside recycling rates. However, the investment required to implement a buy-back system is significantly greater than for a drop-off system.

Convenience is again important in the selection of a site for the recycling center. The location should be easily accessible, and contain a large enough area to hold several types of collection containers, including large roll-off type containers. A separate container is needed for each material being purchased. After weighing and checking for contaminants, each material is placed in its respective container.

There are many advantages to a buy-back system. Since the materials are separated and inspected before being purchased, the quality of the recyclables is generally very good. The participation rates are high, and the center provides the community an excellent alternative for various fund-raising events.

The availability and distance to secondary markets will determine which materials can be purchased by the center for resale, and sometimes, in larger cities, there is competition from private industry for the purchase of recyclables such as aluminum. Community leaders must take these variables into account before choosing a buy-back system.

Curbside Collection Systems

In this collection system, citizens place their recyclable materials at the curb. Curbside collection requires a large investment of capital and labor. A pilot program that includes only a small portion of the community is often a good way to begin a curbside recycling program. Once the program begins operating efficiently, it can be expanded to include the entire community. There are many different variations of the system, but residential point collection is utilized in all varieties. Alternative curbside system include:

1. Residents separating recyclable materials into two or more categories before placing the recyclables at the curb.
2. Assorted materials are separated by the collection crew at the curb and placed into different compartments for each material.
3. Co-mingled materials are collected and sent to a Materials Recovery Facility (MRF) for separation.

Once a system has been chosen, a community must choose how often the recyclables will be collected. A special day may be set aside weekly or bi-weekly of recyclable collection, or recyclable collection may replace one day normally reserved for garbage collection. How often to collect is also debated, but storage time for residents should be kept to a minimum. Whatever system is chosen, education and convenience should be stressed to insure that residents utilize the service. Participation rates will be directly related to the simplicity of the program.

A curbside recycling system is an option for only those communities willing to make a large investment. Although it is the most expensive collection system, it generates high participation rates and is the most convenient for residents.

Plan of Action. The implementation of a community recycling program must be done effectively to guarantee the success of the program. The keys to success include planning, educating the public, dedication, and marketing.

A successful recycling program requires that a community have concrete objectives to overcome any obstacles that may arise. Although the program should be run like a business, it will not likely return profits like a business. The three systems outlined in this paper will not generate revenues, but could provide savings through reduced tipping fees at the landfill. A well planned and efficiently operated recycling program will minimize costs and play a part in conserving scarce natural resources.

YARD WASTE COMPOSTING

Municipal composting of yard wastes is receiving attention nation-wide as an alternative solid waste disposal technique. Composting provides a method to decrease the total amount of waste that is currently being placed in landfills and in some cases, produces a product that can be marketed.

Municipal composting probably will not be profitable based on the market value of the end product, but it may be feasible based on the reduction of material going to the landfill. Over 24 million tons of yard waste are discarded annually in the municipal waste stream in the United States, and the vast majority of this total is sent to landfills (Franklin Associates, 1986). This represents nearly eighteen percent of solid waste deposited in landfills.

Composting is a natural form of recycling where organic materials are broken down by micro-organisms. Oxygen reacts with the micro-organisms to decay the material until it produces humus, a soil-like substance. The process can take from three months to three years, depending on the type of material, and the composting technique used. Although nearly any organic material may be composted, leaves, grass clippings, and small brush are excellent composting materials because of their ease of collection and handling. Brush and small branches should be shredded to speed the process.

Although composting yard waste appears to be relatively simple, a successful program requires intensive management, significant capital investment, a solid plan of action, and community dedication. A community may choose from a number of different composting alternatives.

COMPOSTING ALTERNATIVES

The different methods of composting available to community planners should meet the needs of nearly any community. The various composting options rely on different levels of capital and labor and are referred to as: minimum technology; low technology; intermediate level technology; and high level technology.

Minimum Level Technology

Minimum level technology uses leaves as its only composting material. The leaves are collected and piled into large windrows, 12 feet high and 24 feet wide (Strom and Finstein, 1986). The windrows are turned only once per year, and it takes approximately three years to complete the process. This operation typically uses only a front loader to make and turn the windrows. A new front loader of 140 horsepower can be purchased for approximately $70,000. Rent for the composting site and vehicles for employees will vary, and they are properly included in the cost of the operation.

Because of minimal equipment and labor needs, this process is the lowest cost alternative for any community. However, the three year time requirement makes this option unattractive for most cities.

Low Level Technology

Low level technology includes leaves, grass clippings, and brush to make compost. The material is shredded, wetted, and piled into windrows approximately 6 feet high and 12 to 14 feet wide (Strom and Finstein, 1986). Enough water is added to maintain a moisture content near 50 percent. After the pile has stood for a week, temperatures within the windrow should reach 140 to 160 degrees F (Frigden and Rahman, 1990). The windrow is then turned once every three to four months, with a completion time of nine to twelve months, depending on the number of times it is turned.

Equipment needs for this process include a front loader to make and turn windrows, and a grinder, which is used to grind brush and limbs into a uniform size and consistency, and a thermometer with a long probe. The cost of a new grinder ranges from $20,000 to $100,000, depending on the size and features of the grinder. Planners should be sure to purchase a commercial quality grinder with enough capacity to handle future volume increases.

This level of composting technology is the most common in the U.S. today, and produces a quality compost, while maintaining a relatively low cost. Its only major disadvantage is the length of time it takes to complete the compost.

Intermediate Level Technology

The same composting materials and processes are used in this intermediate level technology as are used in low level composting. The basic difference between intermediate and low level technology is the introduction of a machine that turns the windrows weekly. The machine straddles the windrow while turning and mixing the material. This allows more oxygen to infiltrate the windrow which speeds the composting process.

The completion time with this process is between four to six months and could be a good alternative for communities with a high volume of yard waste. The disadvantage is the cost of the turning machine which can cost up to $300,000 depending on the size of the machine (Simpson, 1989).

High Level Technology

The high level process uses leaves, grass clippings, brush and sewage sludge to produce a high quality compost. The material is put into containers with an in-vessel system, or it is piled inside a building with air and water continually forced through the mixture with a static pile system to produce a compost very quickly. The completion time for this process is normally under four months. The equipment needed for a static pile includes a building, air pipe grid, and a fan. The equipment needed for an in-vessel system includes a rotating drum or a tank with a mixing system included.

This type of technology is suitable only for those communities that wish to mix sewage sludge with their compost. The cost of this type of operation is beyond the scope of most rural communities.

COMPOSTING SITE

The space needed for composting depends on the amount and type of material to be composted, and the type of composting operation chosen. From two to ten acres should be sufficient.

In general, the space should be relatively flat with a slope of 2-4%, and have a hard surface with structures to control run-off. Monitor wells may be required to check for ground contamination. The site should be placed near the source of the materials to reduce transportation costs. It should be carefully placed so that potential odor and day-to-day operations do not interfere with residents of the community. Finally, community leaders should check with the appropriate agency to determine whether their state requires a license/permit.

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FORM I ESTIMATING SOLID WASTE STREAM

I. Rural

______	X	______	=	______
number of people		lbs discarded per capita per day		lbs discarded per day
				+

II. Community

______	X	______	=	______
number of people		lbs discarded per capita per day		lbs discarded per day
			=	______
				total lbs discarded per day
			÷	2,000
				lbs per ton
			=	______
				total tons discarded per day
			x	365
				days/year

TOTAL TONS OF SOLID WASTE = ______

III. BULKY ITEMS AND WHITE GOODS

________________ X ______________________________ = ____________________________

number of people | lbs of white goods per person per year | lbs of white goods per year

÷

2,000
lbs per ton

=

TONS OF WHITE GOODS PER YEAR ____________________________

________________ X ______________________________ = ____________________________

number of people | lbs of bulky items per person per year | lbs of bulky items per year

÷

2,000
lbs per ton

=

TONS OF BULKY ITEMS PER YEAR ____________________________

IV. ______________ + ______________________ = ______________________

tons of bulky items | tons of community solid waste | tons of solid waste to landfill

X

____

tipping fee per ton

=

TOTAL TIPPING FEES $______________________

FORM II ESTIMATED TRANSFER STATION CAPITAL COSTS

I. Site and Equipment Capital Cost

Site

Land:	____________ Acres	X	____________ $/acre	=	$____________ total land cost
Ramp and Retaining wall:				=	$____________ total ramp cost
Building:	____________ sq. ft.	X	____________ $/sq.ft.	=	$____________ total building cost
Fencing:	____________ ft. of fence	X	____________ $/ft.	=	$____________ total fence cost
Crushed rock or gravel:	____________ acres to be covered	X	____________ $/acre	=	$____________ total roadway cost
	Total site and development				$____________

Equipment

Without compaction:

Transfer semi-truck	____________ number of trucks	X	$____________ $/truck	=	$____________ total truck cost
Trailer(s)	____________ number of trailers	X	$____________ $/trailer	=	$____________ total trailer cost

With compaction I:

Hopper & compactor (5.5 cu. yd.) $______________________

Roll-off containers	____________ number of containers	X	$ $6,000 $/container	=	$____________ total container cost
Roll-off truck w/hoist	____________ number of trucks	X	$____________ $/truck	=	$____________

or

With compaction II

Transfer semi-truck	____________ number of trucks	X	$____________ $/truck	=	$____________
Self-contained compactor trailer	____________ number of trailers	X	$____________ $/trailers	=	$____________
Hopper and Chute				=	$____________
Total Equipment				=	$____________

Other

License/permit	=	$____________
Total estimated capital costs	=	$____________

FORM III ANNUAL COSTS OF OPERATING A SOLID WASTE TRANSFER STATION

I. Equipment and Site Annual Capital Costs (Straight line depreciation) From Form II

Site

$________	÷	________	=	$________
building cost		useful life		annual depreciation
				+
$________	÷	________	=	$________
ramp and wall cost		useful life		annual depreciation
				+
$________	÷	________	=	$________
fencing cost		useful life		annual depreciation
				+
$________	÷	________	=	$________
crushed rock cost		useful life		annual depreciation
				+

Equipment

$________	÷	________	=	$________
hopper and chute cost		useful life		annual depreciation
				+
$________	÷	________	=	$________
total transfer trailer cost		useful life		annual depreciation
				+
$________	÷	________	=	$________
total transfer truck cost		useful life (maximum 200,000 miles)		annual depreciation

Total Annual Capital Cost = $ ____________

III. Transfer Station Annual Operating Costs

Labor

________	X	$ ________	=	$ ________
number of attendants hours per year		hourly wage rate		total attendant labor
________	X	$ ________	=	$ ________
number of driver hours per year		hourly wage rate		total driver labor
________	X	$ .25	=	$ ________
total attendant and driver labor		administration cost		total administration labor

$ ________	+	$ ________	+	$ ________	=	$ ________
total driver labor		total attendant labor		total administration labor		total labor cost

$ ________	X	.30	=	$ ________
total labor cost		fringe benefit rate		total fringe benefit cost

$ ____________

total labor cost
+

$ ______________________________

fringe benefit cost

Total annual labor cost = ______________________________

Vehicle

______________ X $ ______________________________ = $ ______________________________

total annual transfer miles | transfer truck operating costs per mile (fuel & maint.) | transfer truck operating costs

+

______________ X $ ______________________________ = $ ______________________________

total annual transfer miles | transfer trailer operating costs per mile | transfer trailer operating costs

=

Transfer vehicles operating cost = $ ______________________________

Building and site

$ ______________ X ________ 12 months ________ = $ ______________________________

utilities per month | | annual site utilities

Transfer site

$ ______________ + $ ______________ + $ ______________

total annual labor | total vehicle operating costs | annual site cost

Total annual operating cost = $ ______________________

TOTAL ANNUAL COSTS OF OPERATING A TRANSFER STATION

Total annual capital cost	$____________
	+
Total annual operating costs	$____________
	=
Total annual costs of a transfer station	$____________
	÷
Number of tons transferred(Form I)	$____________
	=
Cost per ton of Solid Waste	$____________

FORM IV ESTIMATING DIRECT HAUL COSTS

I. Annual Capital Costs

$ ________	÷	________	=	$ ________
vehicle cost		useful life in miles		depreciation cost per mile
$ ________	X	________		
depreciation cost per mile		total annual mileage		

Annual Capital Cost = $ ________

II. Annual Operating Costs

________	X	$ ________	=	$ ________
total annual mileage		vehicle operating costs per mile (fuel + maintenance)		vehicle operating costs
________	÷	________	=	________
total annual mileage		average collection vehicle speed		direct haul hours
________	X	$ ________	=	$ ________
direct haul hours		wage rate/hour		direct haul wages
$ ________	X	________	=	$ ________
direct haul wages		fringe benefit rate		total direct haul labor

Annual Operating Costs = $ ________
(vehicle operating cost + total labor cost)

$ ______________________ X ______________________ = $ ______________________

annual operating costs   contingency rate   contingency

Annual Capital Costs $ ______________________

+

Annual Operating Costs $ ______________________

+

Contingency $ ______________________

=

Total Direct Haul Costs $ ______________________

÷

Tons Hauled (Form I) ______________________

=

Cost Per Tons $ ______________________

FORM V. ESTIMATED CAPITAL COSTS FOR A COMMUNITY CONVENIENCE CENTER

<u>Site:</u>

Land

________________ X $______________________________ = $___________________________
number of acres | $/acres | total land cost

+

Ramp and retaining wall = $___________________________

Building(s)

+

________________ X $______________________________ = $___________________________
sq. ft. | $/sq. ft. | total building cost

+

Fencing

________________ X $______________________________ = $___________________________
ft. of fence | $/ft. | total fence cost

+

Crushed rock

________________ X $______________________________ = $___________________________
# of acres | $/acres | total roading cost

=

Total estimated site costs $___________________________

<u>Equipment:</u>

Roll-off box (40 open cu. yd.)

________________ X $______________________________ = $___________________________

number of boxes $/box total container cost

+

Roll-off box (40 closed cu. yd.)

________ X $________ = $________

number of boxes $/box total container cost

+

Stationary compactor (2 cu. yd.) = $____

+

$________ + $________ = $________

total site cost total equipment cost total capital cost

+

Wood chipper = $________

+

Roll-off truck w/hoist

________ X $________ = $________

# of trucks $/truck

=

Total estimated equipment costs = $________

Total estimated capital costs $________

FORM VI ESTIMATING ANNUAL CAPITAL AND OPERATING COSTS FOR CONVENIENCE CENTER

Annual capital costs (from Form V)

$ ________	÷	________	=	$ ________
total ramp and retaining wall cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
total building cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
total fencing cost		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
total crushed rock		useful life		annual depreciation
				+
________	÷	________	=	$ ________
total cost of open roll-off boxes		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
total cost of closed top roll-off boxes		useful life		annual depreciation
				+
$ ________	÷	________	=	$ ________
total cost of stationary compactor		useful life		annual depreciation

+

$ ________	÷	________	=	$ ________
total roll-off truck cost		useful life (maximum 200,000 miles)		annual depreciation

Total annual capital costs	=	$ ________
		summation of annual depreciation

Annual Operating Costs

Labor

________	X	$ ________	=	$ ________
number of annual attendant hours		hourly wage rate		annual attendant wages
				+
________	X	$ ________	=	$ ________
number of annual driver hours		hourly wage rate		annual driver wages
				=
				$ ________
				annual wages
$ ________	X	________	=	$ ________
annual wages		Fringe benefits		total annual labor cost

Utilities

$________	X	12	=	________
average utility cost per month		month per year		annual utility costs

Tipping Fees[1]

________	X	$________	=	$________
number of tons or cu. yds. produced annually		cost per ton or cu. yd.		annual tipping fees

Contract Disposal Fees[2]

________	X	$________	=	$________
number of units		cost per unit		annual contract disposal fees

Total Annual Operating Costs = $________
summation of annual operating costs

Total Capital Costs $________

+

Total Annual Operating Costs $________

=

Total Annual Costs $________

[1]may be zero if private contractor is hired to handle roll-off boxes.
[2]will be zero if hauling your own boxes and paying tipping fees.

FORM VII ESTIMATED CAPITAL COSTS
OF ALTERNATIVE COLLECTION SYSTEMS

I. Green Box System

_______________ X $_______________ = $_______________
number of boxes — cost per box — total cost of collection boxes

+

_______________ X $_______________ = $_______________
number of collection trucks — cost per truck — total cost of collection trucks

+

_______________ X $_______________ = $_______________
number of sites — cost per site — total site development cost

=

Total Capital Costs of Rural Green Box Collection System $_______________
summation of total site and equipment costs

II. Rural Convenience Center

Site and Preparation

_______________ X $_______________ = $_______________
number of acres — cost per acre — total land cost

+

________________	X	$ ________________	=	$ ________________
number of sites		cost per site		total site cost development
		Total site cost	=	$ ________________

Equipment

________________	X	$ ________________	=	$ ________________
number of collection boxes		cost per box		total collection box cost
________________	X	$ ________________	=	$ ________________
number of collection trucks		cost per truck		total collection truck cost
________________	X	$ ________________	=	$ ________________
number of roll-off containers		cost per container		total cost of roll-off containers
				+
________________	X	$ ________________	=	$ ________________
number of roll-off trucks		cost per truck		total cost of roll-off trucks
				+
________________	X	$ ________________	=	$ ________________
number of stationary compactors		cost per compactor		total cost of a staionary compactors
				=
		Total Equipment Cost		$ ________________

Total Site Cost	=	$ ____________________
		+
Total Equipment Cost	=	$ ____________________
		=

Total Capital Cost of a
Convenience Center Collection System ____________________

FORM VIII ANNUAL CAPITAL AND OPERATING EXPENSES
FOR RURAL COLLECTION SYSTEMS

I. Annual Capital Cost (from Form VII)

$ ____________	÷	____________	=	$ ____________
total site cost		useful life		annual site depreciation
$ ____________	÷	____________	=	$ ____________
total collection truck cost		useful life (maximum 200,000 miles)		annual collection truck depreciation
				+
$ ____________	÷	____________	=	$ ____________
total collection box cost		useful life		annual collection depreciation
				+
$ ____________	÷	____________	=	$ ____________
total roll-off truck cost		useful life (estimated 150,000 miles)		annual roll-off truck depreciation
				=
		Total Annual Capital Cost		$ ____________

II. Annual Operating Cost

____________	X	$ ____________	=	$ ____________
number of driver hours per year		hourly wage rate		total driver labor
				+
____________	X	$ ____________	=	$ ____________
number of attendant hours per year		hourly wage rate		total attendant labor

Administration

$ ______	X	______	=	$ ______
total of above labor		administration cost rate		total administration labor
				or
			=	$ ______
				annual administrator salary
				+
$ ______	X	______	=	$ ______
total labor cost		fringe benefit rate		fringe benefits
				=
		Total Labor Expense	=	$ ______
				summation of labor and benefit costs

III. Vehicle Expense

______	X	$ ______	=	$ ______
total annual packer truck collection mileage		operating cost per mile		total annual collection truck operating costs
				+
______	X	$ ______	=	$ ______
total annual roll-off truck mileage		operating cost per mile		total annual roll-off truck operating costs
				=

Total Annual Vehicle Operating Expense $______________

IV. Other

$______	X	12	=	$______
average utilities per month		months per year		total utilities cost per year
				+
______	X	$______	=	$______
number of tons predicted annually		tipping fees per ton		tipping fees per year
		or		
______	X	$______	=	$______
number of cu. yds.		tipping fees per c.y.		tipping fees per year

Total Cost of Tipping Fees and Utilities $______________

Total Annual Capital and Operating Expenses = $______________

÷

Tons Collected (Form I) ______________

=

Cost Per Ton ______________