89-106

Analysis of Solid Waste System Costs for the State of Vermont

submitted to:

The Vermont Interregionnal
Solid Waste Management Commitee

Submitted by:
Tellus Institute
89 Broad Street
Boston, MA 02110
(617) 426-5844

John Schall

and

Wehran Engineering
1 Mill Street
Burlington, VT 05401

July 1990

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Decisions about the size of waste collection districts and processing and disposal facilities are an important element in planning efficient, environmentally sound waste management at the least cost. This report provides detailed analyses of the effects of scale on costs for a broad range of waste management options. It also analyses integrated waste management scenarios, to assess the overall cost-effectiveness of waste management districts of different sizes.

Cost Analyses for Collection Systems and Processing and Disposal Facilities

The analysis reviews a wide range of technologies for waste collection and processing and disposal systems, including recycling, composting, waste-to-energy facilities, and landfills. Using demographic data for Vermont and the Tellus Institute WastePlan computer model, the analysis then develops cost estimates for individual collection, processing, and disposal technologies, analyzing costs for systems of different sizes in order to identify economies or diseconomies of scale for each technology.

- As expected, costs per ton for waste collection are lower for more densely populated regions where collection trucks can make more stops per hour. At the same time, collection costs increase as the distance to the processing or disposal site increases.

- Cost analyses for a broad range of processing and disposal facilities show capital and operating costs per ton decreased as facility size and throughput increased, at least through the range of sizes applicable for Vermont. The causes of these economies of scale, however, were often different for different types of solid waste facilities.

- For **recycling** processing facilities, increased size lowers per-ton costs by allowing increased labor efficiencies and more efficient use of even the smallest sized processing equipment. The magnitude of these impacts varies across type of recycling facility. Recycling depots show the largest economies of scale because of the high capital costs for processing equipment.

- In addition, the more efficient use of equipment in larger facilities creates economics of scale for all types of **leaf and yardwaste composting** facilities. For leaf and yardwaste composting facilities, analyses show a clear cost superiority for the low technology system over the intermediate technology system for sizes relevant to Vermont.

- For **solid waste composting** facilities there are two major sources of economies of scale. The first is capital costs for equipment to separate waste into its organic and inorganic fractions. Second is labor costs. A relatively large number of workers is required for any composting facility, with only small increases needed as facility size increases.

• For **waste-to-energy** facilities the dominant factors affecting economies of scale were the capital costs of pollution control technology and the relatively large fixed number of workers required to operate a waste-to-energy plant, independent of size. While capacity increases 16 fold from the smallest to the largest plant analyzed, labor requirements increase only 2 fold.

• For **landfills** the dominant factor affecting the economies of scale is the geometry of the waste pile. As the base area of the landfill gets larger, waste can be piled higher while still maintaining required slopes. As the height of the landfill increases, the amount of garbage that can be placed on one acre of land increases; while the liner, leachate collection system, and other costs are relatively constant per acre.

• For both waste-to-energy facilities and landfills, pollution control systems are a major element in economies of scale. Because many of the earlier facilities of both types did not have these pollution control systems, the capital costs of past facilities will not be a good predictor of future costs.

Effects of Scale on Costs for Integrated Waste Management Systems

Analyses of individual waste management technologies show waste collection costs increase as travel distances increase, but processing and disposal costs decrease as facility size increases, for sizes relevant to Vermont. These opposing effects of scale mean that analysis of integrated waste management systems -- considering collection, processing, and disposal together -- is crucial to understanding costs for waste districts of different sizes.

Three scenarios are defined and analyzed using the WastePlan computer model to investigate the joint effects of scale in integrated waste management systems. Scenario I estimates costs when each Vermont solid waste district develops a single facility for recycling and disposal, Scenario II splits the state into four waste management regions, and Scenario III uses two regions. For each scenario, sensitivity analyses are used to analyze how sensitive cost estimates are to changes in assumptions used to construct the cost models.

• Results show lowest costs for Scenario II, with 4 waste management regions. However, costs for Scenario III, with 2 regions, are only 2 percent higher. One interpretation of these results focuses on Scenario II as a median among alternative plans, suggesting that planners seek an optimal region size between Scenario I, with 11 regions, and Scenario III, with 2 regions. Another interpretation focuses on the small difference in cost between the two regional plans (Scenarios II and III). The similar costs for these two scenarios suggest the possibility that changes in region size within this general range have little cost impact. Based on this interpretation, planners may want to give priority to non-economic factors in deciding the best regional configuration for waste management in Vermont.

- Higher recycling costs are the primary source of higher systems costs for Scenario I, since costs for garbage collection and disposal are similar in all three scenarios.

- Sensitivity analyses show that changes in assumptions about garbage collection and disposal have relatively large effects on cost estimates. Changes in assumptions for recycling and leaf and yardwaste management have relatively little cost impact because these systems are a relatively small portion of waste management costs.

- Because of the very strong economies of scale in landfill costs, shifting from mixed waste composting to landfill-only for residential garbage creates cost savings in Scenarios II and III. However, two additional considerations are important for planners choosing between these techniques. First, the landfill costs modelled here include only engineering costs, not necessarily the "true" costs, including costs of long-term environmental management. Second, mixed waste composting is an important strategy for meeting the state's 40% recycling goal. In addition, mixed waste composting costs could be reduced if regions share facilities for landfill disposal of residues.

- Sensitivity analyses show the use of long-haul transfer facilities increased costs for regional recycling and mixed waste composting for Scenario II.

- Including existing waste incineration increases costs for Scenario III by $11 per ton because of substantially higher costs for incineration than for mixed waste composting.

- The accuracy of system-wide cost estimates depends on a large number of assumptions about the type of technology used, labor efficiency, facility reliability, and specific characteristics of the collection programs and facilities. Although these analyses are useful in comparing costs for different types of systems, they should not be used as a substitute for developing specific cost estimates for a particular region and waste management program.

1. INTRODUCTION

As growing concerns about environmental resources are added to traditional concerns about cost and efficiency, comprehensive planning for solid waste becomes an increasingly complex balancing act. Systems for recycling, composting, and energy generation must be considered along with landfills or other disposal.

In Vermont, planning for large rural areas as well as urban and suburban centers poses additional challenges. Decisions about the size of waste collection districts and processing and disposal facilities are particularly important to efficient waste management. Should smaller towns or groups of towns manage wastes independently, or are larger districts or inter-district systems more cost-effective? Smaller districts mean shorter distances for transporting wastes; but larger units can share larger facilities, which may mean economies of scale.

Part A of this report provides detailed analyses of the effects of scale on costs for a broad range of waste management options. These analyses help planners identify when "big is better" and when smaller-scale operations are more economical.

Part B of this report analyzes the costs of three scenarios for a Vermont integrated waste management system (with differing regional configurations) and provides three sensitivity analyses for each scenario. These scenarios identify approaches consistent with Vermont law, including requirements for source reduction, recycling, and composting. This analysis also examines the sensitivity of cost estimates to changes in assumptions underlying the development of these three scenarios.

Part A: Identification of Waste Management Options

In tailoring this analysis to the needs of Vermont, we first identified technologies most appropriate to conditions in the state. Next we identified three possible waste-district sizes for collection and up to six different scales of operation for processing facilities. Finally, we defined additional assumptions about characteristics of the Vermont waste stream, and costs and operations of waste management systems.

Waste technologies selected for further study were chosen in consultation with Vermont Interregional Solid Waste Management Committee after a comprehensive review of possible techniques. The waste collection systems selected for analysis include both curbside collection and drop-off systems for recyclable, leaf and yardwaste, and refuse. The processing and disposal facilities range from low-technology options such as drop-boxes and recycling depots to more sophisticated systems, including state-of-the-art materials recovery facilities, static pile and in-vessel composting, and waste-to-energy units.

Outline of Part A

Part A contains two sections. Section 1 examines the cost variations within different solid waste management collection systems as and population density changes and as the distance to the end processing/disposal site increases.

Section 1: Solid Waste Management Collection Systems

Chapter 2. Recycling Collection Systems
Chapter 3. Leaf, Yardwaste and Foodwaste Collection Systems
Chapter 4. Refuse Collection Systems

In Section 2, we explore the cost impacts as facility size and throughput increases for each type of solid waste management facility. These economies (or diseconomies) of scale are based on the structure of capital costs, both building and equipment, and on operating costs, both labor and non-labor, as developed in our analysis.

Section 2: Solid Waste Management Processing and Disposal Technologies and their Corresponding Facilities

Chapter 5. Recycling Facilities
Chapter 6. Leaf and Yardwaste Composting Technologies
Chapter 7. Mixed Solid Waste (MSW) Composting Facilities
Chapter 8. Transfer Facilities
Chapter 9. Construction and Demolition (C&D) Waste Recycling Facilities
Chapter 10. Waste-to-Energy Facilities
Chapter 11. Landfills

Part A - Report Structure

The structure of each collection chapter (Chapters 2 - 4) is as follows:

- A descriptive analysis of the collection system including various alternative collection methods, operation practices, existing programs and pro and cons of different alternatives.

- Identification of the collection systems selected for a detailed cost analysis. These systems were selected through interactions with the Vermont Interregional Solid Waste Management Committee.

- The technical and cost assumptions made for each individual collection program are outlined. These assumptions include: type and cost of collection vehicle, crew size and salary structure, collection efficiency, operating cost parameters (miles/gallon, fuel cost per gallon, maintenance cost/mi. etc).

  Common assumptions to the cost analyses of all collection systems are outlined at the beginning of Section 2 of the report. These are primarily the characteristics (population, road miles, people/household, waste generation rate, etc.) of each the three different Vermont demographic regions that are modeled in the collection analysis.

- Results are presented and summarized. For each collection system, the following will be presented:

  - detailed cost tables of both the capital, operating and life cycle costs.
  - cost curves showing life-cycle cost per ton as a function of distance to the solid waste facility for each demographic region and each collection system type.
  - Analysis of the cost changes by demographic region and by distance to the facility site.

The structure of each of the facility chapters (Chapters 5 - 11) is as follows:

- A descriptive analysis of each facility type including operation characteristics, facility description, existing facilities and pro and cons.

- Identification of the facilities selected for detailed cost analysis.

- Technical and cost assumptions used to model the capital and operating costs (including materials or energy revenue assumptions) for each of the facilities analyzed. These assumptions include: the equipment and building components of each type of facility, the operating requirements, labor rates, utility costs, and material mixture in the case of source separated recycling facilities.

- Results of the capital, operating and life-cycle costs of each size of each type of facility are presented. For each facility, the following is presented:

  - Detailed cost tables for the capital, operating and life-cycle costs of each facilities.

  - Cost curves representing the life-cycle cost per ton as a function of facility size.

  - Analysis of the effect of increasing size on both capital, operating and life-cycle costs. Where economies of scale are present, we analyze its source, within both the capital and operating cost structure.

Types of Cost Analysis Performed

Several factors affect the true cost of a facility or collection system. The size and duration of annual financial payments will vary greatly depending upon the capital intensity of the project, the length of financing periods and the terms of the financing. When analyzing these payments, their long run impact, and not simply their costs in the first year, must be considered.

An accurate comparison of the costs produced in this report is vital if the report is to be useful to solid waste planners. We have developed a consistent methodology which is used for all collection systems and facilities, based on explicit financial assumptions and performance of a life-cycle cost analysis. The analysis starts by developing total capital costs and annual operating costs for all collection systems and facilities, and then calculates the annual cost of the system over its lifetime, otherwise known as life-cycle cost analysis. The 1990 net present value of these life-cycle costs is calculated, which measures the cost of each program over its entire lifetime, if paid in 1990. The remainder of this section of the introduction will describe this process in greater detail along with some of the conclusions that can be drawn from the analysis.

Capital and Operating Costs

For each facility and collection system, estimation of the total capital costs and annual operating costs depends upon the characteristics of the system being analyzed. For facilities, capital costs are estimated by constructing and equipping the facility with the technology necessary to perform the type of waste processing or disposal being considered. Similarly, the annual costs of operating the facility are estimated, not including financial costs such as debt payments. For collection programs, the required number of trucks is determined; this is the only major capital cost of a collection program. In addition, annual operating costs, which are primarily labor, are estimated.

Most capital cost estimates assume facility construction commencing in 1990, though some facilities, notably landfills, spread construction throughout their lifetimes. The operating costs are also assumed to be 1990 operating costs, though these as well may change through time.

Life-Cycle Costs

Once total capital costs and annual operating costs have been estimated, the next step is to calculate the annual total costs of the facility or collection program over its lifetime. To estimates costs into the future, the following assumptions have been made about the financial terms of the capital payments and economic conditions:

- Interest rate = 8.5%. Capital costs are paid over the lifetime of the facility, which varies with the type of facility and ranges from 10 to 20 years. Constant annual payments, similar to a mortgage, are assumed across the facility lifetime. However, some facilities may delay parts of construction into the future or have equipment replacement scheduled in the future.

- Inflation rate = 4%.

- Revenue inflation rate = 2%. Revenues from the sale of recycled materials are inflated at a lower rate as a conservative estimate of their future value. However, revenues from the sale of electricity are inflated at the regular inflation rate of 4%.

discount rate 7.5% see p 1-6

In each of the cost analyses presented in this report, the life-cycle per ton costs are presented in nominal dollars, which is the dollars of the year represented. For example, Year 4 (as listed in each of the summary cost tables) is 1994, so the Year 4 cost of a program is presented in 1994 dollars. The per ton costs for almost all systems will increase in nominal dollars each year. However, depending upon the cost structure of the systems being analyzed, costs in future years may increase rapidly or slowly. Systems with high capital costs (relative to operating costs) usually increase slowly because the capital portion of the annual costs do not increase with time. In contrast, systems with high operating costs will increase more quickly, because these costs increase annually due to inflation. Of course, other factors affect this generalization, particularly when capital costs are spread out over time or when operating costs change with time (both of which occur, for example, in landfills).

Net Present Value

In order to rationally use the information contained in a life-cycle cost analysis, we need to know the present value of the costs. The present value of a payment in a future year is less than the nominal cost of that payment. This is because it is advantageous to delay payments into the future so money can be used in other ways today. By reducing these future costs, we can estimate what their present value is today. We have assumed a discount rate of 7.5% and all present value costs are calculated in 1990 dollars. This means that a cost of $100,000 in 1991 has a present value of $92,500 in 1990 dollars.

Comparison of the nominal costs in a life-cycle analysis is difficult because each year's costs are measured in that year's nominal dollars, which have different values in the present. By determining the net present value (NPV) of each year's costs, systems can be compared on an equal basis. Once the NPV costs have been calculated, each years costs can be added together to determine the lifetime cost of the system. This lifetime cost can then be divided by the number of years in the facility's lifetime to determine the present value of the annual costs. This annual cost can be divided by the average annual tonnage to determine the cost per ton.

In the cost table for each facility and collection program, the annual life-cycle per ton costs have been listed for each year of the systems lifetime, along with the 1990 present value of the per ton costs. As mentioned above, the life-cycle costs are listed in nominal dollars (e.g. 1999 costs in 1999 dollars). The 1990 present value of these lifetime per ton costs is calculated on the assumption that all future costs are discounted at 7.5% annually. This means that costs far in the future have much lower value than costs in the near term. For example, a cost of $100,000 in 2005 is worth about $33,800 in 1990 net present value.

Several interesting results arise from analyzing the net present value. Systems with high capital costs (relative to operating costs) have present value costs which are much lower than first year costs. This occurs because capital payments are constant each year and their present value decreases by 7.5% each year. Within 15 years, the capital payments have a present value of only 34% compared to the first year. Systems with high operating costs have slightly lower present value costs than first year costs. Operating costs increase annually by 4% (as a result of inflation) which partially offsets the decreased value of future operating costs resulting from the discount rate.

For a community or region performing long-term planning, the present value of life-cycle costs is an important measure of the long-run financial costs of various waste management options. First year costs are inadequate because they do not consider costs in future years which may differ (such as in landfills) and different proportions of capital and operating costs which will affect the size of future payments. As shown above, two waste management options with the same first year costs but different proportions of capital and operating costs may have significantly different costs over their life-time.

In the analyses of costs for each of the facilities and collection systems, we will focus upon the present value of the lifetime per ton costs as the most important, "bottom line" figure for use in solid waste planning. However, most of the discussion of individual components of capital and operating costs will use first-year costs.

Part B: Identification of Waste Management Sensitivity Analysis

The Vermont Interregional Solid Waste Management Committee selected three scenarios with differing regional makeups for developing solid waste systems comprised of roughly the same technological configuration. In addition, three sensitivity analyses were performed for each scenario.

The selection of the scenarios was influenced greatly by the Part A analysis of the effects of scale on costs for waste collection, processing, and disposal. Part A showed significant *diseconomies* of scale in the collection of recyclable, compost, and garbage. That is, as the size of the collection region increases, collection costs per ton increase due to increased transportation distance. However, larger regions may use larger facilities for processing and disposing of recyclable, compost and garbage; and the larger facilities exhibit significant *economies* of scale. That is, facility costs per ton decrease as capacity increases because larger facilities make more efficient use of machinery, labor, and space.

Because of the diseconomies of scale for collection systems and the economies of scale for processing and disposal facilities found in Part A, increasing levels of regionalization became the key variable to test for the three scenarios. At what level of regionalization do the increasing collection costs outweigh the decreasing facility costs? To test for this effect, Scenario I estimated the costs when each solid waste district develop a single facility for recycling and disposal for all waste generated within the district. Scenario II splits the state into 4 regions and Scenario III splits the state into 2 regions, each with its own recycling and disposal facilities. Each region uses more than one leaf and yard waste composting site in all scenarios, but they too, get larger as the region size increases.

PART A

Cost Analysis of Solid Waste Collection Systems and Facilities

SECTION 1

Solid Waste Management Collection Systems

2. RECYCLING COLLECTION SYSTEMS

General Design of all Analyses

Estimates of the effects of scale on collection costs depend on two types of information: (1) capital and operating costs of different collection methods and (2) demographic characteristics of the region. Demographic factors influence the amount and type of waste to be collected, the number of stops per hour for curbside collection systems, and the hauling distance from the collection area to processing or disposal facilities.

In order to model appropriate options for Vermont, we examined demographic data including population, density, and travel distances. Based on these data, we defined three types of waste collection regions: **Urban Centers** with 29,000 population and 85 miles of road, **Small Urban/Suburban** regions with population of 5,000 and 72 road miles, and **Rural** regions with population of 1,000 and 69 road miles. These definitions produce a population density per road mile representative of Vermont demographic regions. For each of these regions, we modelled three possible hauling distances from the collection region to the processing or disposal facility.

Additional assumptions about the waste stream and about costs of different technologies were based on information from Vermont and other New England states, as well as national data. Assumptions that are unchanged across all of the collection systems analyzed in this report are shown in Table 2-1. Additional assumptions are included in discussions of each technology.

TABLE 2-1

ASSUMPTIONS FOR WASTE COLLECTION SYSTEMS

Labor	$20,000 per year per worker
Waste generation	2.68 pounds per person per day
People per household	2.6
Interest rate	8.5%
Insurance, licenses	$1,600 per truck
Gasoline	$1.00 per gallon
Blue Box	$5.00 per unit; 5 year lifetime

Waste Composition[1]	Percent
newspapers	10.40
mixed office paper	2.20
corrugated containers	5.40
other paper	17.40
glass containers (clear)	8.03
glass containers (green)	2.20
glass containers (amber	1.09
glass, miscellaneous	0.40
non-ferrous metals	0.40
ferrous metals	5.20
plastic containers, HDPE	1.60
plastic containers, PET	0.16
plastic, other	4.30
yard and wood wastes	15.10
foodwaste	8.70
other wastes	13.40
Total	95.98

[1]Waste composition is less than 100 percent because materials recycled through the bottle-bill are factored out of the waste composition.

RESIDENTIAL RECYCLING COLLECTION SYSTEMS

This section describes three different types of curbside recycling collection systems: commingled collection with curbside sort, commingled collection without curbside sort, and multiple separation collection. These systems target residential recyclables, including newspapers, corrugated cardboard, magazines, mixed paper, glass, tin/metal, aluminum, and plastic.

DESCRIPTION

Today, over 1,500 curbside recycling programs are operating in the U.S. The types and sizes of these programs vary from those for large cities (Chicago, Minneapolis, Seattle, and Portland) to those for small towns (Proctor, VT; Hyde Park, VT; and Prairie Du Sac, WI). Table 2-2 lists a few of the curbside collection programs in operation throughout the country.

Although the characteristics of curbside programs are as varied as the communities they serve, each curbside collection program has four primary actors: local residents, the hauler of recyclables, the receiver of recyclables (usually a processing facility), and the community or public agency overseeing the program. Table 2-3 shows the different decisions made by these actors in a curbside collection system. Since the community usually initiates decisions concerning curbside collection of recyclables, most choices (such as container type, frequency and date of collection, etc.) are listed under "community." However, the majority of curbside collection system decisions are made in consultation with both the hauler and receiver of the recyclables. The collection options chosen by the community and hauler affect participation rates (the percent of households that recycle at least some of their wastes) and capture rates (the percent of recyclables actually recycled by participating households). Collection methods also affect collection efficiency, the quality of the recyclables, and the amount of processing necessary to make the recyclables marketable.

Curbside collection programs start with community residents and end with the receiver/processor of the recyclables. In a curbside collection program residents are asked (voluntary) or mandated to set aside recyclables from their garbage. The recyclables are separated by residents into a "commingled" pile (usually newspapers bundled separately and all containers mixed together), or they are separated into distinct categories (multiple separation). If residents place commingled recyclables at the curb, the hauler may separate them at the curb. If not, the recyclables are separated at a processing facility. The processor of the recyclables, through material specifications, often determines how recyclables are collected.

To enhance participation rates, communities or haulers often supply residents with containers for their recyclables. Containers are manufactured in a variety of sizes and shapes, depending on the program. The three primary container types are single containers (often called "blue boxes"), stackable containers (single containers stacked), and wheeled containers (carts). Single containers range in size from 12 to 22 gallon boxes and wheeled containers range in size from 32 to 105 gallons. Another collection "container" being tested in pilot projects is plastic bags, which are used in commingled collection programs.

A number of other factors also influence recycling participation rates: requirements for separating recyclable materials by type, frequency of collection (e.g., weekly, bi-weekly, monthly), timing of collection (e.g., same day as trash collection), type of recycling program (voluntary or mandatory), public education, and garbage rates (variable or per bag). In general, recycling rates are highest for collection programs that include commingled separation, weekly collection, collection on the same day as garbage collection, mandatory recycling, public education, and variable garbage collection fees. Variable garbage collection fees encourage recycling by making residents aware of the costs of garbage disposal.

Once the recyclables are placed at the curb, haulers collect the recyclables in specialized recycling vehicles or other vehicles retrofitted for recycling collection. Some curbside collection systems utilize packer trucks to collect just one recyclable (typically newspapers) which is transported directly to market (no intermediate processing). Specialized recycling vehicles, like curbside containers, are manufactured in an array of types. The four principal vehicle types are trailers, open-top trucks, closed-top manual loading trucks, and closed-top automatic loading trucks. One advantage of specialized recycling trucks is that they are equipped to handle multiple recyclables. Often they have movable dividers. A recent addition to some recycling trucks is equipment for plastic compaction.

Other factors that affect the efficiency of curbside collection (i.e., stops per hour) include housing density, participation and capture rates, crew size, and commingled or separated placement of recyclables at the curb. If haulers separate commingled recyclables at the curb, it slows the collection time per stop from 7 seconds per household to 30 seconds.

COMMINGLED SEPARATION

Pros:

- Quicker to collect (if no curbside sort);
- Generally higher participation rates than multiple separation;

- Easier to optimize truck space with only two dividers (for newspaper and containers);
- Lower costs for container (need only one).

Cons:

- Requires post-collection processing (if no curbside sort);
- Longer collection time (if sorted at curbside);

MULTIPLE SEPARATION

Pros:

- If markets are nearby, can bypass processor and send recyclable(s) directly to user or broker;
- Source separated recyclables require less processing;
- Collectors provide quality control;

Cons:

- Requires multiple containers;
- Lower participation rates than commingled;
- Need trucks or trailers with multiple dividers;
- Less optimal use of truck capacity because individual materials' compartment will fill before others;
- Slows collection time.

BLE 2-2

EXAMPLES OF EXISTING COLLECTION SYSTEMS

Location	Commingled/ Multiple Separation	Container	Vehicle Type	Voluntary/ Mandatory
Bristol, VT	commingled	none	dump truck	voluntary
Burlington, VT (3000 households)	commingled (curbside sort)	14 gallon	converted beverage truck	voluntary
Evesham, NJ	multiple separation	yes	packer w/barrel trailer	mandatory
Hyde Park, VT	commingled (curbside sort)	5 gallon pail	n/a	voluntary
Onondaga Co., NY	multiple separation	10 gallon	n/a	mandatory
Prairie Du Sac, WI (pop. 2289)	commingled	plastic bag	packer truck pick-up truck	voluntary
Rhode Island (pop. served approx. 300,000)	commingled	14 gallon	manual truck automatic truck low-profile manual truck	mandatory
Rutland/Proctor, VT (3700 households)	commingled (curbside sort)	gallon	manual load w/plastic compactor	voluntary
Seattle (pop. 490,000)	multiple separation (3 containers) commingled	3 containers	recycling truck	voluntary
Woodbury, NJ	multiple separation (8 categories)	none (residents provide container)	recycling trailers behind compactor	mandatory

TABLE 2-3

DECISIONS OF KEY ACTORS IN CURBSIDE COLLECTION PROGRAMS

Residents	Hauler	Community	Receiver/Processor
Separate Recyclables	Truck Type	Recyclables Collected	Recyclables Handled
	specialized recycling truck	Mandatory or Voluntary	Level of Processing
	other (flatbed, packer pickup, etc.)	Collection Day	Markets
	Crew Size	Frequency of Collection	
		Container Type	
		one bin	
		multi-bin	
		cart	
		bag	
		household provided	
		Commingled or Source Separated	
		Public Education	

COST ANALYSIS

Collection costs were analyzed for the three primary recycling systems: commingled collection, commingled collection with curbside sort, and residential multiple separation. Each system was analyzed for three types of regions (urban, small urban/suburban, and rural) and for three different hauling distances from collection to processing (7, 22, and 37 miles). For small urban/suburban centers, we also compare the costs associated with one town owning a recycling truck with costs for a truck shared by two or three towns.

Assumptions

Assumptions about the composition of the waste stream and costs that are common to all of the collection system analyses are shown in Table 2-1. In addition, some recycling costs vary by the type of collection region, and assumptions about these costs are shown in Table 2-4. Other costs depend on participation and capture rates, which are higher for commingled collections systems than for systems where residents must separate recyclables before they are collected. Assumptions about these costs associated with the type of collection system are shown in Table 2-5. Finally, this analysis assumes program administration costs of $0.80 per household. The average time required for recycling vehicles to unload at the processing facility is 0.33 hours, and the travel speed is 20 miles per hour for the 7-mile haul and 30 miles per hour for the longer distances.

TABLE 2-4

COST ASSUMPTIONS FOR URBAN, SUBURBAN, AND RURAL WASTE COLLECTION REGIONS

	Urban	Small Urban/ Suburban	Rural
Population	29,000	5,000	1,000
Road Miles	85	72	69
Truck Type	low-body recycling	low-body recycling	pickup w/ recycling trailer
purchase cost	$62,000	$62,000	$30,000
miles per gallon	3	3	15
maintenance ($/mi.)	$0.16	$0.16	$0.07
capacity (cu. yd.)	25	25	15
lifetime (years)	7	7	10
Stops per Hour*			
commingled collection	120	90	50
separated collection	100	80	40
(curbside sort & residential multiple separation)			

* Only time collecting from houses (not time transporting materials to facility) is included in this figure.

TABLE 2-5

PARTICIPATION AND CAPTURE RATES (PERCENTAGES) FOR COMMINGLED AND CURBSIDE RECYCLING COLLECTION

Recyclable	COMMINGLED Participation	COMMINGLED Capture	MULTIPLE SEPARATION Participation	MULTIPLE SEPARATION Capture
newspapers	80	85	70	75
corrugated containers	65	75	55	65
glass containers (clear, green, amber)	65	75	55	65
non-ferrous metals[2]	65	75	55	65
ferrous metals[3]	65	35	55	25
plastic containers (HDPE,PET)	65	75	55	65

Effects of Demographic Region

Because of differences in population density, urban, small urban/suburban, and rural regions differ in the number of collection stops per hour. In urban areas, higher density means more collection stops per hour, resulting in greater collection efficiency and lower costs per ton. Conversely, rural areas where distances between stops are greatest have the highest collection costs per ton. For example, costs for an urban commingled collection program 7 miles from the recycling facility were

[2] The capture rate for non-ferrous metals has been lowered because not all non-ferrous materials are accepted by the collection program. We estimate that aluminum containers make up about 85% of the non-ferrous metals; the remaining 15% is scrap aluminum, copper, brass, and other metals.

[3] The capture rate for ferrous metals has been lowered because only tin and bi-metal cans are accepted by the recycling collection program, yet other materials are included in the ferrous metals category. We estimate that roughly 45% of the ferrous materials are ferrous cans while the remaining 55% is scrap metal, which is not accepted by the program.

estimated at $28 per ton, compared to $45/ton for the same program in a rural area. For commingled collection 37 miles from the recycling facility, the range is from $51/ton for an urban region to $67/ton in a rural area. For less efficient recycling programs, such as curb-separated collection, the urban-rural cost differential is even greater. Figure 2-1, shows these results by region for Commingled Collection. Figures 2-2 and 2-3 illustrate the results for Multiple Separation and Curb Sort Collection respectively. The per ton costs we have used in these figures and will use throughout this section on recycling collection are the present value of the lifetime per ton costs. More detailed costs figures are shown in Table 2-6.

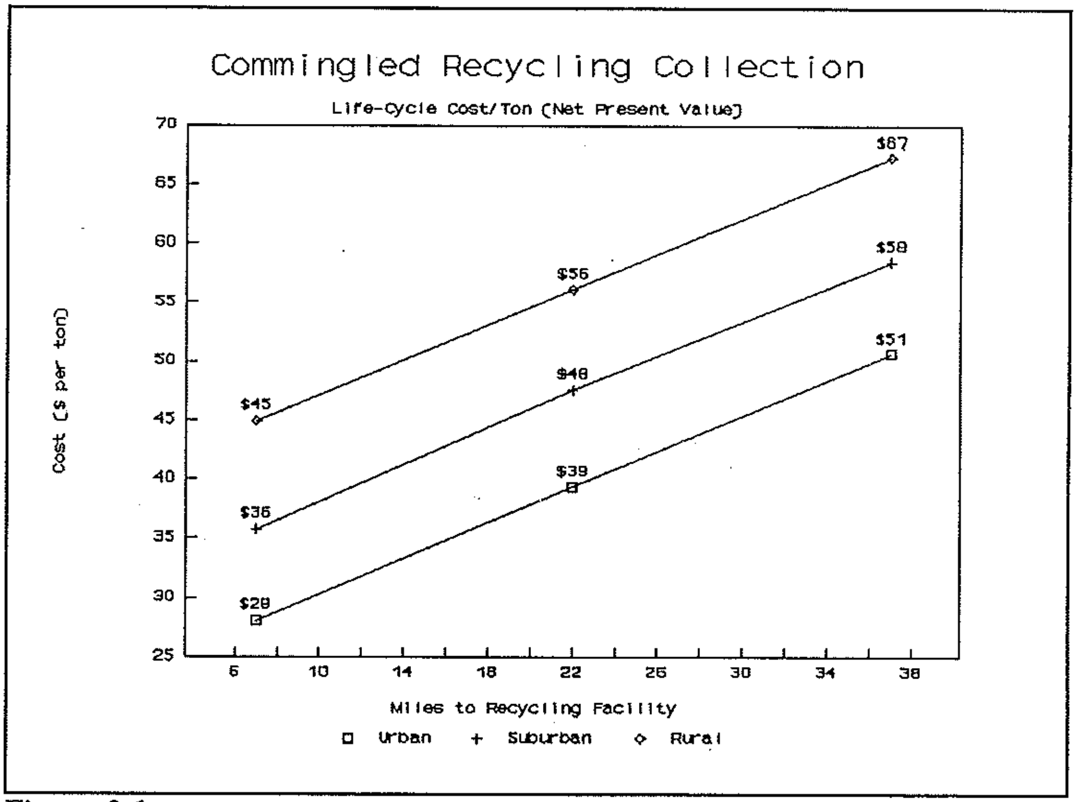


Figure 2-1

There is one additional assumption made in these scenarios that results in cost savings for both the small urban/suburban and rural regions. In neither of these cases is the region able to fully utilize a single truck when collection occurs 5 days per week. When a truck is not fully utilized we have assumed that the region will share a truck, paying only the costs associated with the portion of the truck they use. When this assumption is changed and we assume a full truck will be purchased and used for only a 2-day collection week, the costs of collection increase dramatically, from a low of $49 in the commingled program 7 miles from the facility to a high of $90/ton for the multiple separation program 37 miles from the facility.

Effects of Distance from Recycling Facility

As expected, costs for collection programs of all types and in each region increase with increases in the distance the collection truck must drive to the recycling facility. Greater hauling distances mean collection trucks must spend more time traveling to and from the recycling facility and less time on the actual collection route. In addition, longer distances mean that more trucks are required, thus increasing both capital and operating costs.

The range of costs for the 7 mile haul is from $28/ton in the commingled, urban program to $60/ton for the rural, multiple separation program. The range of costs for the 37 mile haul is $51/ton for the commingled, urban program to $80/ton for the rural, multiple separation program.

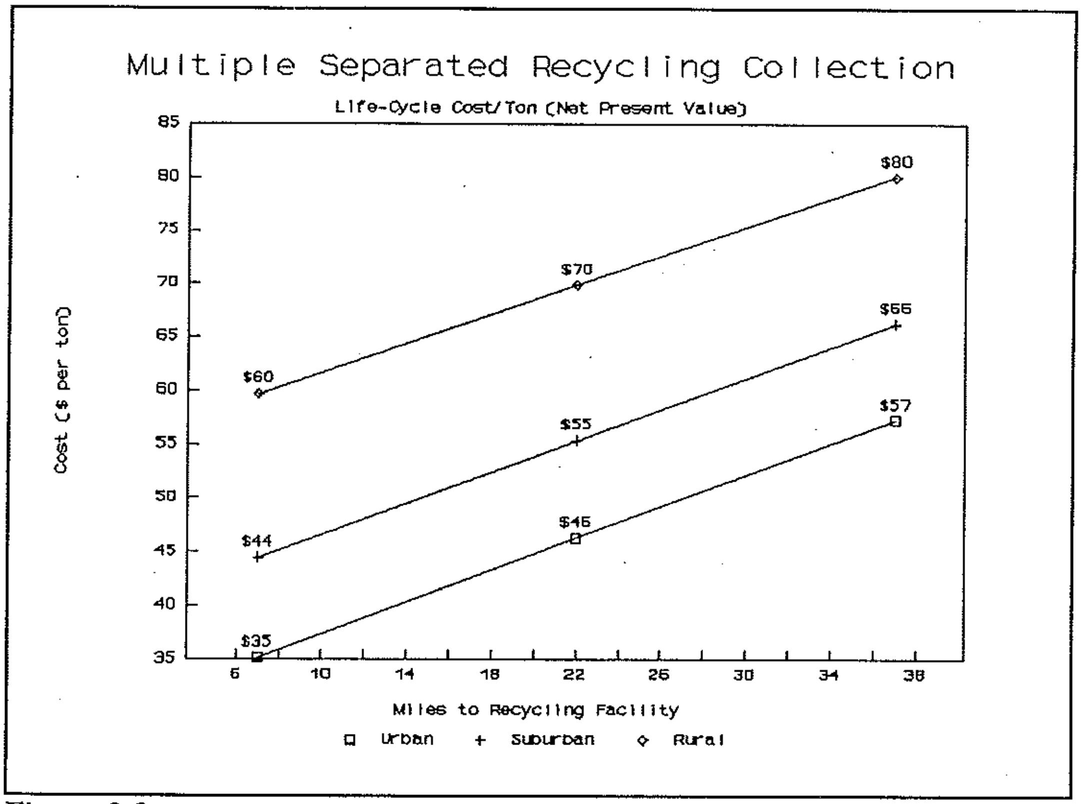


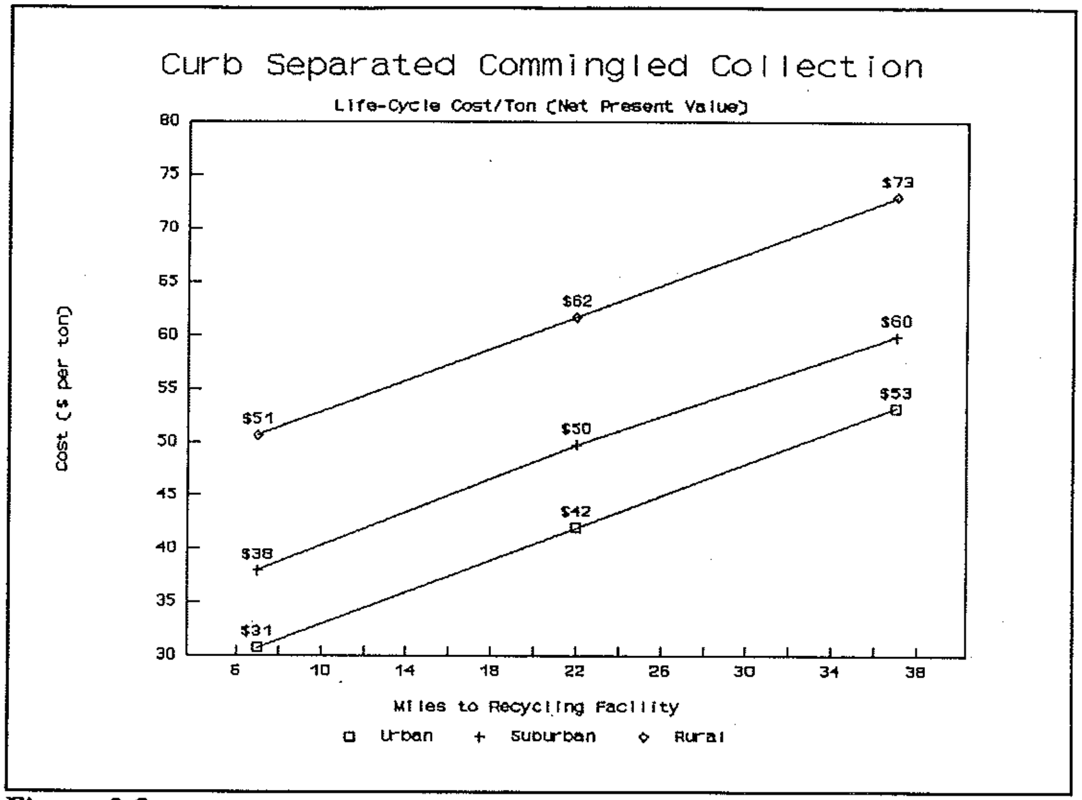
Figure 2-2

While longer transportation distances increase collection costs, these costs may be offset if the recycling facility benefits from economies of scale in serving a larger population area. These economies of scale are discussed in Section 3 of this report. Whether they are sufficient to offset the increased collection costs are examined n Part B of this report.

Effects of Collection Type

Our analysis indicates that commingled collection is consistently more cost effective than either multiple separation or commingled collection with curbside sort for all demographic areas and for all transportation distances. Multiple separations systems, which require residents to separate recyclables, are consistently the least cost-effective. (Compare Figure 2-1 with Figures 2-2 and 2-3.) Costs for commingled collection range from $28 per ton for an urban program 7 miles from the recycling facility to $67 per ton for a rural program 37 miles away. In comparison, costs for multiple separation range from $35 per ton for an urban program with a 7-mile haul to $80 per ton for a rural program 37 miles away.

There are two factors that explain the lower costs for commingled collection. First, higher participation and capture rates are typical in commingled collection because it is easier for households to participate. Thus, commingled collection produces more collected tons than multiple separation, and this larger volume means lower costs per ton. Second, commingled curbside collection is faster than separated collection. Simply throwing the paper from a commingled setout container into one half of the truck and emptying the remaining glass, metal and plastic containers in the other half is faster than either collecting the five or six containers from a multiple separation program or sorting a commingled container at the truck. Faster collection at each stop means more stops per hour.



Curb Separated Commingled Collection
Life-Cycle Cost/Ton (Net Present Value)
Cost ($ per ton)
80
75
70
65
60
55
50
45
40
35
30
$73
$62
$60
$53
$51
$50
$42
$38
$31
6
10
14
18
22
26
30
34
38
Miles to Recycling Facility
Urban
Suburban
Rural

Figure 2-3

TABLE 2-6

COMMINGLED CURBSIDE COLLECTION

CAPITAL and O & M COSTS		Urban 7 miles	Urban 22 miles	Urban 37 miles	Suburban 7 miles	Suburban 22 miles	Suburban 37 miles	Rural 7 miles	Rural 22 miles	Rural 37 miles
Capital Costs (annual)										
Number of Trucks		1.45	1.94	2.43	0.31	0.40	0.48	0.11	0.14	0.17
Cost per Truck		12,735	12,735	12,735	12,735	12,735	12,735	4,882	4,882	4,882
Annual Truck Costs		18,466	24,706	30,946	3,948	5,094	6,113	537	683	830
Annual Container Costs		11,154	11,154	11,154	1,923	1,923	1,923	385	385	385
Annual Capital Costs		29,620	35,860	42,100	5,871	7,017	8,036	922	1,068	1,215
Operating Costs (1990) (annual)										
Operations Costs per Truck										
Fuel & Maintenance		5,738	11,082	14,274	9,337	13,090	15,523	5,328	5,762	6,049
Insurance & License		1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Labor		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
Program Adm.		7,139	7,139	7,139	1,231	1,231	1,231	246	246	246
O & M Costs		47,939	72,094	96,257	11,069	15,427	19,434	3,296	4,189	5,082
1990 Net Annual Costs (Capital + O & M)		77,559	107,954	138,357	16,940	22,444	27,470	4,218	5,257	6,297
1990 Net Annual Costs/Ton		31.37	43.67	55.97	39.77	52.69	64.48	49.05	61.13	73.22
LIFECYCLE COSTS										
Per Ton Cost (nominal $)	Year 1	32.15	44.84	57.53	40.81	54.13	66.31	50.58	63.08	75.59
	2	32.96	46.05	59.15	41.89	55.64	68.21	52.18	65.10	78.05
	3	33.80	47.31	60.83	43.01	57.21	70.18	53.83	67.21	80.60
	4	34.67	48.62	62.58	44.18	58.84	72.23	55.56	69.40	83.26
	5	35.58	49.99	64.41	45.40	60.53	74.37	57.35	71.68	86.03
	6	36.52	51.41	66.30	46.66	62.29	76.59	59.22	74.05	88.90
	7	37.50	52.88	68.27	47.98	64.13	78.90	61.16	76.52	91.89
1990 Present Value of Lifetime Per Ton Costs		28.05	39.32	50.60	35.73	47.58	58.40	44.89	56.07	67.26

TABLE 2-6
(Continued)

COMMINGLED COLLECTION WITH CURBSIDE SORT

CAPITAL and O & M COSTS	Urban 7 miles	Urban 22 miles	Urban 37 miles	Suburban 7 miles	Suburban 22 miles	Suburban 37 miles	Rural 7 miles	Rural 22 miles	Rural 37 miles
Capital Costs (annual)									
Number of Trucks	1.66	2.15	2.64	0.34	0.43	0.48	0.13	0.16	0.19
Cost per Truck	12,735	12,735	12,735	12,735	12,735	12,735	4,882	4,882	4,882
Annual Truck Costs	21,140	27,380	33,620	4,330	5,476	6,113	635	781	928
Annual Container Costs	11,154	11,154	11,154	1,923	1,923	1,923	385	385	385
Annual Capital Costs	32,294	38,534	44,774	6,253	7,399	8,036	1,020	1,166	1,313
Operating Costs (1990) (annual)									
Operations Costs per Truck									
Fuel & Maintenance	5,006	9,989	13,127	8,504	12,153	14,595	4,443	4,972	5,343
Insurance & License	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Labor	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
Program Adm.	7,139	7,139	7,139	1,231	1,231	1,231	246	246	246
O & M Costs	52,633	76,775	100,930	11,738	16,089	18,989	3,736	4,626	5,517
1990 Net Annual Costs (Capital + O & M)	84,927	115,310	145,705	17,991	23,488	27,024	4,755	5,792	6,830
1990 Net Annual Costs/Ton	34.36	46.65	58.94	42.23	55.14	63.44	55.29	67.34	79.42
LIFECYCLE COSTS									
Per Ton Cost (nominal $) Year 1	35.21	47.89	60.58	43.34	56.65	65.22	57.03	69.50	81.98
Year 2	36.09	49.18	62.27	44.48	58.22	67.07	58.84	71.73	84.65
Year 3	37.01	50.52	64.04	45.67	59.85	69.00	60.72	74.06	87.43
Year 4	37.97	51.92	65.88	46.91	61.55	71.01	62.67	76.48	90.31
Year 5	38.97	53.38	67.79	48.20	63.32	73.09	64.70	79.00	93.31
Year 6	40.00	54.89	69.77	49.54	65.16	75.26	66.82	81.61	96.44
Year 7	41.08	56.46	71.84	50.94	67.07	77.52	69.02	84.34	99.68
1990 Present Value of Lifetime Per Ton Costs	30.72	41.99	53.27	37.94	49.77	57.41	50.64	61.79	72.96

TABLE 2-6
(Continued)

MULTIPLE SEPARATION COLLECTION

CAPITAL and O & M COSTS		Urban 7 miles	Urban 22 miles	Urban 37 miles	Suburban 7 miles	Suburban 22 miles	Suburban 37 miles	Rural 7 miles	Rural 22 miles	Rural 37 miles
Capital Costs (annual)										
Number of Trucks		1.40	1.76	2.11	0.29	0.35	0.41	0.11	0.13	0.15
Cost per Truck		12,735	12,735	12,735	12,735	12,735	12,735	4,882	4,882	4,882
Annual Truck Costs		17,829	22,414	26,871	3,693	4,457	5,221	537	635	732
Annual Container Costs		9,760	9,760	9,760	1,683	1,683	1,683	337	337	337
Annual Capital Costs		27,589	32,174	36,631	5,376	6,140	6,904	874	972	1,069
Operating Costs (1990) (annual)										
Operations Costs per Truck										
Fuel & Maintenance		4,760	9,262	12,245	9,054	12,187	14,411	4,990	5,370	5,649
Insurance & License		1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Labor		20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
Program Adm.		6,246	6,246	6,246	1,077	1,077	1,077	216	216	216
O & M Costs		44,270	61,971	79,347	10,199	13,182	16,170	3,229	3,826	4,423
1990 Net Annual Costs (Capital + O & M)		71,859	94,145	115,978	15,575	19,323	23,074	4,103	4,798	5,493
1990 Net Annual Costs/Ton		39.29	51.47	63.41	49.44	61.34	73.25	65.13	76.15	87.18
LIFECYCLE COSTS										
Per Ton Cost (nominal $)	Year 1	40.26	52.83	65.15	50.74	63.02	75.30	67.18	78.58	89.99
	2	41.26	54.24	66.95	52.09	64.76	77.44	69.31	81.11	92.91
	3	42.31	55.70	68.83	53.49	66.57	79.66	71.53	83.74	95.95
	4	43.40	57.23	70.78	54.94	68.45	81.97	73.83	86.47	99.11
	5	44.53	58.81	72.81	56.46	70.41	84.37	76.23	89.31	102.40
	6	45.71	60.46	74.92	58.03	72.45	86.87	78.72	92.27	105.81
	7	46.94	62.18	77.12	59.67	74.56	89.47	81.32	95.34	109.37
1990 Present Value of Lifetime Per Ton Costs		35.11	46.29	57.23	44.44	55.35	66.27	59.65	69.86	80.07

TABLE 2-6
(Continued)

SUBURBAN COLLECTION, TWO DAYS PER WEEK

CAPITAL and O & M COSTS		Commingled			Commingled Curbside Sort			Multiple Separation		
		7 miles	22 miles	37 miles	7 miles	22 miles	37 miles	7 miles	22 miles	37 miles
Number of Trucks		0.78	0.99	1.20	0.85	1.07	1.28	0.72	0.88	1.03
Cost per Truck		12,735	12,735	12,735	12,735	12,735	12,735	12,735	12,735	12,735
Annual Truck Costs		9,933	12,608	15,282	10,825	13,626	16,301	9,169	11,207	13,117
Annual Container Costs		1,923	1,923	1,923	1,923	1,923	1,923	1,683	1,683	1,683
Annual Capital Costs		11,856	14,531	17,205	12,748	15,549	18,224	10,852	12,890	14,800
Operating Costs (1990) (annual)										
Operations Costs per Truck										
Fuel & Maintenance		3,735	5,236	6,209	3,402	4,861	5,838	3,622	4,875	5,754
Insurance & License		1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Labor		8,320	8,320	8,320	8,320	8,320	8,320	8,320	8,320	8,320
Program Adm.		1,231	1,231	1,231	1,231	1,231	1,231	1,077	1,077	1,077
O & M Costs		11,882	16,235	20,586	12,555	17,047	21,401	10,827	14,097	17,221
1990 Net Annual Costs (Capital + O & M)		23,738	30,766	37,791	25,302	32,596	39,625	21,679	26,986	32,021
1990 Net Annual Costs/Ton		55.72	72.22	88.71	59.40	76.52	93.02	68.82	85.67	101.65
LIFECYCLE COSTS										
Per Ton Cost (nominal $) Year	1	56.84	73.75	90.64	60.57	78.12	95.03	70.20	87.46	103.84
	2	58.00	75.33	92.65	61.80	79.78	97.12	71.63	89.32	106.12
	3	59.21	76.98	94.74	63.08	81.51	99.29	73.12	91.26	108.48
	4	60.46	78.69	96.92	64.40	83.31	101.55	74.66	93.27	110.94
	5	61.77	80.48	99.18	65.78	85.19	103.90	76.27	95.37	113.50
	6	63.12	82.33	101.53	67.21	87.13	106.35	77.94	97.54	116.16
	7	64.54	84.26	103.98	68.71	89.16	108.89	79.68	99.81	118.93
1990 Present Value of Lifetime Per Ton Costs		48.96	63.71	78.46	52.15	67.46	82.21	60.46	75.52	89.81

3. LEAF, YARDWASTE, AND FOODWASTE COLLECTION SYSTEMS

This chapter describes four categories of leaf and yardwaste collection systems: three types of bag collection, bin collection, three types of drop-off collection, and several types of bulk collection. Finally, this section describes a collection system for incorporating foodwaste (and potentially other household organic material) into a leaf and yardwaste collection program.

BAG COLLECTION

Bag collection is the most common form of containerized collection of leaf and yard waste. Residents bag their leaves and generally set them at the curb for scheduled collection. Various types of trucks are used for collection. Efficiency of collection is a function of the truck type, the collection crew size, and the amount of material collected per truck stop and per truck load.

Bagged yard waste is generally unprocessed and uncompacted at the time of set-out at the curb. The bulk density of dry, uncompacted leaves ranges from 125 - 250 pounds per cubic yard, whereas grass clippings may be over 500 pounds per cubic yard. Efficiency of collection is increased when these relatively light materials can be compacted thereby increasing truck tonnage. Packer trucks, which compact material to a bulk density of 800 - 1000 pounds per cubic yard and can be the most efficient for collection of bagged yard waste.

Three types of bags are currently available for yard waste collection: standard plastic, bio/photodegradable plastic, and paper. Each have their respective advantages and disadvantages, which are listed in Table 3-1.

TABLE 3-1

Bag Types	Advantages	Disadvantages
Standard Plastic	Widely available, residents can provide their own.	Debagging is labor intensive. Poses litter and disposal problem. Residual plastic from incomplete removal may necessitate post processing such as screening.
Degradable Plastic		
a) Biodegradable	Can order clear bags to check for contamination. Special printing can be used as a good promotional tool for residents.	Distribution of bags must be planned. Degradation rate of bags has not yet been demonstrated. Shredding is required. Degradation products and impact on environment are not yet fully understood. Standards have not been set for degradability.
b) Photodegradable	Special printing can be used as a good promotional tool for residents.	All parts of bag must be exposed to sunlight. All comments with respect to biodegradable plastic also apply.
Paper	Proven biodegradable. Degradation products are environmentally safe. Special printing can be used as a good promotional tool for residents. Bags stand by themselves, are easy to fill and can hold larger quantities of leaves than similar sized plastic bags.	Cost is 1.5 - 2 times that of plastic bags. Heavy and cumbersome to distribute. May require shredding to decompose in a reasonable time frame. Bags do not have a closure, material can come out if bags tip over.

Collection of yard waste bagged in standard plastic bags requires an extra debagging step. Plastic bags must be removed or shredded prior to composting to allow water or oxygen to mix with the composting material. Debagging may be accomplished manually or mechanically, but both methods substantially increase labor costs.

One method of mechanical debagging consists of running windrow turning equipment over bagged yard waste, thereby shredding the material along with the bags. The shredded bags are caught on the windrow turner teeth, and are then removed by hand. This method is slow, as the windrow turner must be stopped every few minutes for cleaning. Plastic removal can also be accomplished by grinding full bags of yard waste in a machine such as a tub mill grinder, and screening out the plastic after composting.

Existing bag collection programs: Islip, NY and Muskegon, MI are two examples of municipalities that collect yard waste in standard plastic bags. Islip is currently grinding leaf bags and screening out the plastic, and Muskegon is using a windrow turner to remove bags prior to composting. Bristol, CT and Urbana, IL are currently working with biodegradable plastic bags. Urbana and Woodbury, MN are also trying out photodegradable bags. Springfield and Lowell, MA, Brattleboro, VT and Waterbury, CT are examples of programs using paper bags for yard waste collection.

Pros: (Bag vs. bulk collection)

- No specialized equipment is needed for collection;
- Material tends to be freer of contamination;
- Roadways remain clear of leaves;
- Collection of bagged yard waste has been shown to be more efficient than most bulk collection methods.

Cons: (Bag vs. bulk collection)

- Debagging is necessary when standard plastic bags are used;
- Bags must be purchased either by residents or the municipality;
- Substantial labor is involved in bagging yard waste;
- May require more public education.

BIN COLLECTION

Bin collection is another form of containerized collection in which material is placed in a reusable container for curbside collection. It is used mainly for the collection of relatively high density material, such as grass. Collection crews empty the bin into a collection vehicle, usually a packer truck, and leave the bin at the curb. Small bins with 20 gallons of capacity are carried to the curb by residents. Larger bins on wheels, with up to 90 gallons of capacity, are rolled to the curb. Specialized collection vehicles can be used to empty these containers.

Existing bin collection programs: Omaha, NE; Barrington, IL; and Huntington Woods, IL

Pros:

- Bins are reusable;
- Material collected does not need debagging;
- Bins are easy to fill and empty.

Cons:

- Can only handle relatively small amounts of material;
- Initial cost of bins is high.

DROP-OFF COLLECTION

An alternative to curbside collection is the establishment of one or more drop-off sites where residents or landscapers can deposit yard waste. An employee can inspect loads for contamination and collect any tipping fees. Drop-off of bagged material may be allowed, or debagging by residents may be required. When enough material is collected, it can then be processed. Drop-off programs are most often used in rural areas where curbside collection is not cost effective.

There are three major types of drop-off programs: centralized, decentralized, and non-dedicated bin programs. In centralized drop-off, the drop-off site is effectively used as a staging area for the compost site. The site may be an open area, such as a field, and is often located at the landfill. The area may be defined by walls such as Jersey barriers. These barriers serve as push walls for front-end loaders. When a sufficient quantity of yard waste is deposited, pre-processing can take place. Once the material is prepared, it is moved to a nearby composting pad.

In decentralized drop-off numerous sites are located in a municipality to limit transportation time for residents. These sites can also be used as staging areas. The site may have pre-processing equipment such as chippers or tub mill grinders, so only prepared material is delivered to the composting site. Finally, there may be non-dedicated drop-off sites that may have bins, such as dumpsters or packer trucks. These can be located in various locations within a municipality. Residents can load their yard waste directly into a dumpster or packer. This method is practical if material is separated or moved a long distance, such as to another municipality.

Existing drop-off programs: Wellesley and Holden, MA have centralized drop-off facilities with adjacent composting facilities; St. Petersburg, FL and the Tidewater Area, VA have a decentralized drop-off system; and Westford, MA has a non-dedicated drop-off system.

Pros:

- Municipal collection costs are minimal;
- No specialized equipment is needed.

Cons:

- Special effort is required by residents;
- Participation is generally low;
- Contamination rate may be higher than other collection methods.

BULK COLLECTION

In bulk collection systems, residents rake leaves to the curb during the leaf collection period. Leaves are collected from the streets by specialized vehicles.
A number of bulk collection methods are described here in more detail, but all of these systems share several advantages and disadvantages.

Pros:

- Minimal work is required of residents.

Cons:

- Greater likelihood of material contamination from street trash and petroleum products than in bagged leaves;

- Leaf piles can blow into streets, causing slippery driving conditions and messy appearance;
- On-street parking where leaves are piled, can cause leaf fires from hot catalytic converters.

Vacuum Collection

Vacuum trucks are widely used for bulk collection of leaves. Vacuum trucks drive up the street and vacuum the leaves. The vacuum equipment is often trailer mounted, attached to the rear of a dump truck fitted with a leaf collection box. There are also one-unit vacuum trucks that often perform other functions such as drain or sewer cleaning. In either case, a vacuum hose or arm extends out to collect leaves at the curb. Crew size can range from 3-4 people: a driver, one person to control the vacuum attachment, and one to two people to rake the leaves toward the hose.

Existing vacuum collection programs: Cuyahoga County, OH; Montgomery County, MD; and Newton, MA have such programs.

Pros:

- Tow-behind vacuums are relatively inexpensive;
- Most vacuum trucks partially shred leaves, which compacts them and serves as a pre-processing step.

Cons:

- Infective on wet or frozen leaves;
- Cannot be used for brush or grass.

Front-end loader collection

Front-end loader collection is another method of collecting leaves piled at the curb by residents. The loader scoops up leaves at the curb and deposits them into dump or packer trucks for delivery to the compost site. At least one raker is needed to aid the loader operator in scooping up the leaves. A collection crew of 3 to 6 workers is typical: 1 loader operator, 1 to 2 rakers and 1 to 3 truck drivers. Packer trucks can handle a much greater quantity of material than dump trucks. The opening on the packer can be fitted with a special chute to catch the leaves as they are transferred from the loader bucket.

Existing front-end loader collection programs: Bridgewater and Newark, NJ; Bristol, CT have such programs.

Pros:

- Equipment is generally owned by municipalities;
- Loaders can collect wet or frozen material, as well as brush and grass.

Cons:

- High labor requirement;
- Streets and front lawns can be damaged by loaders.

"Claw" Collection

The Claw is an attachment to a front-end loader with two opposing "shells." The equipment operates by opening and closing the two shells and lifting the attachment to move and dump material in the same way as a front-end loader. The bottom face of the claw shells can lie flush with the street. As with the other bulk collection methods, residents rake leaves to the curb. A 4 to 6 person crew is required for this collection method: 1 loader operator, 1 to 2 rakers, and 1 to 3 truck drivers. To collect leaves, the claw shells are opened and the loader advances into a pile of leaves. When the opened shell is full of material, the claw is shut, compressing the leaves. The leaves are then deposited into a dump or packer truck.

Existing programs using the Claw: Davis and Sacramento, CA; Columbia, SC have such programs.

Pros:

- Considered the most efficient collection bulk collection method;.
- Can pick up all loose material, including brush and grass, and can even be used for snow removal.

Cons:

- Claw attachment must be purchased and installed on loader.

Leaf Bunchers

A less widely used piece of equipment for bulk leaf collection is the leaf buncher. This is an attachment to a truck with a snow plow hitch. The hydraulic system for raising and lowering the snow plow is necessary for the operation of the leaf buncher. The buncher consists of a curved, framed wire screen (in the shape of a soccer goal) with a circular street sweeper brush. The "buncher truck" drives into the leaf pile, while the brush sweeps leaves into the screen. The leaves become compacted until the screen is totally full. At this point, the buncher is raised depositing a compacted bunch of leaves. This bunch of leaves is then picked up by a front-end loader and transferred into a dump truck for transportation to the compost site. The minimum crew size is 5 people: the buncher truck driver, a raker, a loader operator, and 2 truck drivers. As leaves compact more effectively when damp, a water truck can be used to spray the leaf piles before collection. A packer truck can be used for transportation if a chute is attached to facilitate the transfer of leaves.

Existing leaf buncher collection programs: Minneapolis, MN has such a program.

Pros:

- Does not damage roads;
- Leaf buncher is a very simple piece of equipment.

Cons:

- Requires extra trucks;
- Leaf bunchers are not commercially available and must be custom made.

Modified Packer with Leaf Pusher

Rear-loading packer trucks can be modified with a moveable hopper that serves as a "dustpan." A jeep or tractor, fitted with a curved pushing unit pushes the leaves into the hopper on the packer truck. When the hopper is filled, it is raised and the collected material is dumped into the back of the packer. The pushing unit can be filled with a street sweeping brush to remove material more effectively from the street, although it works less well for wet leaves. A crew of 3 to 4 workers is necessary for this type of collection: a packer truck driver, a leaf pusher driver, and 1 to 2 rakers.

Existing Modified Packer Collection Programs: Traverse City, MI; and Madison, WI have such programs.

Pros:

- Found to be more efficient than vacuum collection;
- Utilizes equipment that has other uses.

Cons:

- Hopper and pusher units have to be custom made.

GREEN BIN COLLECTION SYSTEMS

Food waste and compostable yard waste are the main items targeted in "green bin" collection systems. Often, tissues and soiled paper also are included. Residents are required to separate these materials. A covered pail is often used for kitchen waste, which is set out at the curb on collection day, or emptied into bins on rollers. Special divided bins are available. These have one side to use for compostable waste, and the other side for other waste. In apartment buildings, residents often empty their pail into a large container stored in the garage or garbage area.

Collection systems have to be tailored to the source separation program. A dedicated packer truck can be used for the collection of waste set out in pails. Automated collection is often used for the larger bins on wheels. Many trucks have two loading mechanisms that operate independently. Specialized collection vehicles with internal compartments have been designed for use with divided bins. Such trucks have two discrete compartments, each with its own compaction unit. One side is used for compostable waste and the other is used for the disposal fraction.

Existing Green Bin Systems: Amsterdam, AVRI, and Ede, Netherlands have such programs.

Pros:

- High quality compost can be produced from source separated waste;
- Mechanized separation equipment is not needed.

Cons:

- Residents must separate their waste;
- Additional or specialized collection vehicles are needed.

COST ANALYSIS FOR LEAF AND YARDWASTE COLLECTION SYSTEMS

Collection costs were analyzed for three typical leaf and yardwaste collection systems: bagged collection and bulk collection using a claw or leaf pusher. Each method was analyzed separately for urban, small urban/suburban, and rural regions and for three different distances from collection to processing (5, 10, and 20 miles).

Assumptions

Based on the assumption that 15 percent of the waste stream is yard waste, this analysis assumes 10 percent of the waste stream is leaf waste. Resident participation is set at 80 percent for bagged leaf collection and 85 percent for the two bulk collection systems. Costs for program administration and public education are estimated at $0.40 per household.

Additional assumptions specify costs associated with the different vehicles and equipment needed for each yardwaste collection system. We assume that trucks are owned by the city and will be used during hours when they are not needed by the city for other purposes. We also assume 30 collection days for leaf collection and 260 collection days for trash, so truck costs associated with leaf collection will be 30/290 or 10 percent of the total cost of the truck. The cost of a 20 C.Y. rear packer for the program is therefore $10,000, plus insurance and licence at $160/year.

The packer/claw cost is accounted for by charging 10 percent of the packer cost and 30 percent of the costs of the front end loader and Claw. These costs are estimated as $10,000 + $36,000 = $46,000. The packer/pusher cost for leaf collection is 10 percent of the full packer cost and 30 percent of the cost of the snow plow trucks. These costs are estimated as $10,000 + $12,000 = $22,000. License and insurance for both the packer/claw and the packer/pusher is $640/year.

Bagged leaf collection requires two workers per crew, collecting wastes from 45 households per hour in the urban region, 35 per hour in the small urban/suburban region, and 30 per hour in the rural region. These collection rates are measured only for times when the truck is collecting from households, and to the compost site. Bulk collection requires a crew of four (2 drivers and 2 laborers), collecting 70 households per hour in the urban region, 55 per hour in the small urban/suburban region, and 40 per hour in the rural region.

Effects of Demographic Region

As expected, greater population density, which means more households collected per hour, is associated with lower unit costs for all methods of leaf collection. Thus, leaf collection costs are lowest for the urban region and highest for the rural region for both bagged and bulk collection at all three distances from the compost site. Costs range from $25 per ton for an urban bagged collection system located 5 miles from the compost site to $89 per ton for rural bulk collection (with claw) 20 miles from the compost site. However, it is important to remember that costs of bags are not included in this analysis. Resident purchase of bags could cause participation to drop, whereas distribution of bags by local waste districts would increase public costs. Bag costs could add approximated $30 per ton to collection costs. Cost analyses are shown in more detail in Figures 3-1 to 3-3 and in Table 3-2. The costs represented in these figures and used throughout the leaf and yard waste collecting section are the present value of life-cycle costs, which are explained in the introduction.

Results of this analysis support the common sense view that bulk leaf collection in sparsely populated rural regions is not likely to be cost effective unless leaves and yardwaste are collected and disposed in the regular solid waste disposal system at a relatively high cost per ton. Part B scenario analysis identifies the level of tipping fees at which rural leaf collection would be cost effective.

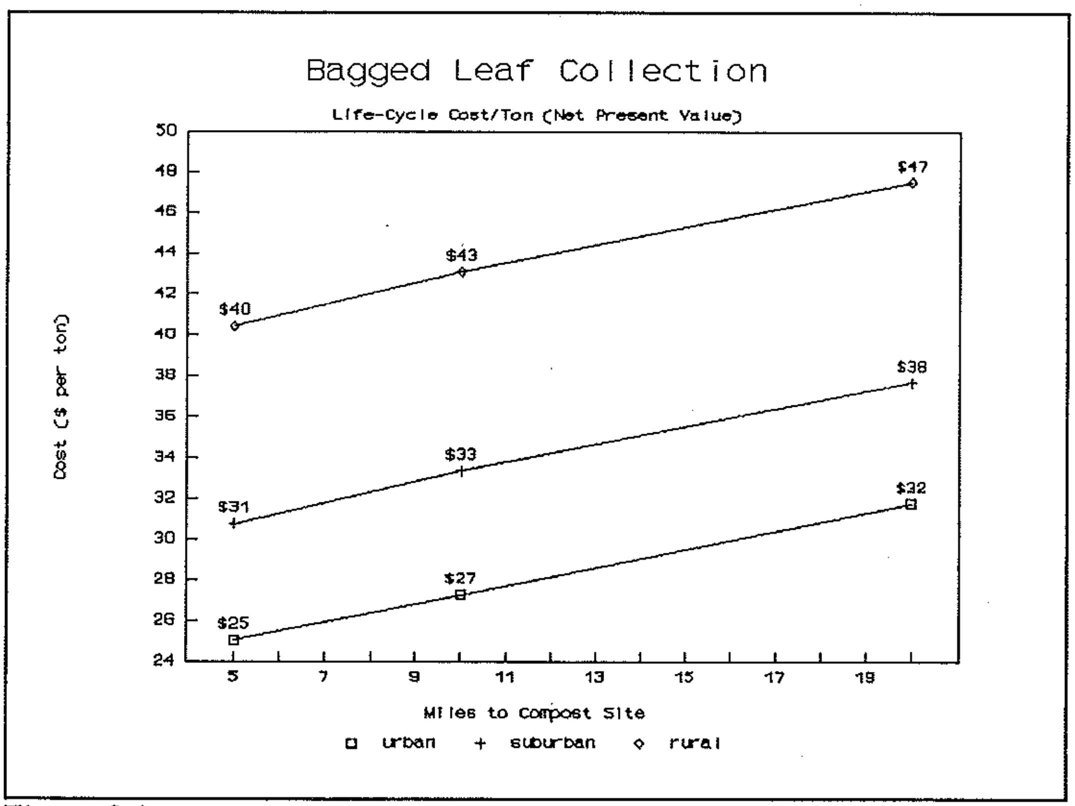


Figure 3-1

Effects of Distance from the Compost Facility

The farther the collection vehicle must travel to the compost site, the more expensive the collection system per ton. With greater hauling distances, trucks spend a larger percentage of their time driving to and from the compost site, so more trucks are required to collect the same tonnage of material. Longer hauling distances mean higher unit costs for collection for all demographic regions and all collection systems.

While increased distance to the compost site is consistently associated with higher unit costs for collection, these costs may be offset by lower processing costs if the longer haul allows use of a larger windrow compost facility. The effect of these offsetting factors are explored in Part B.

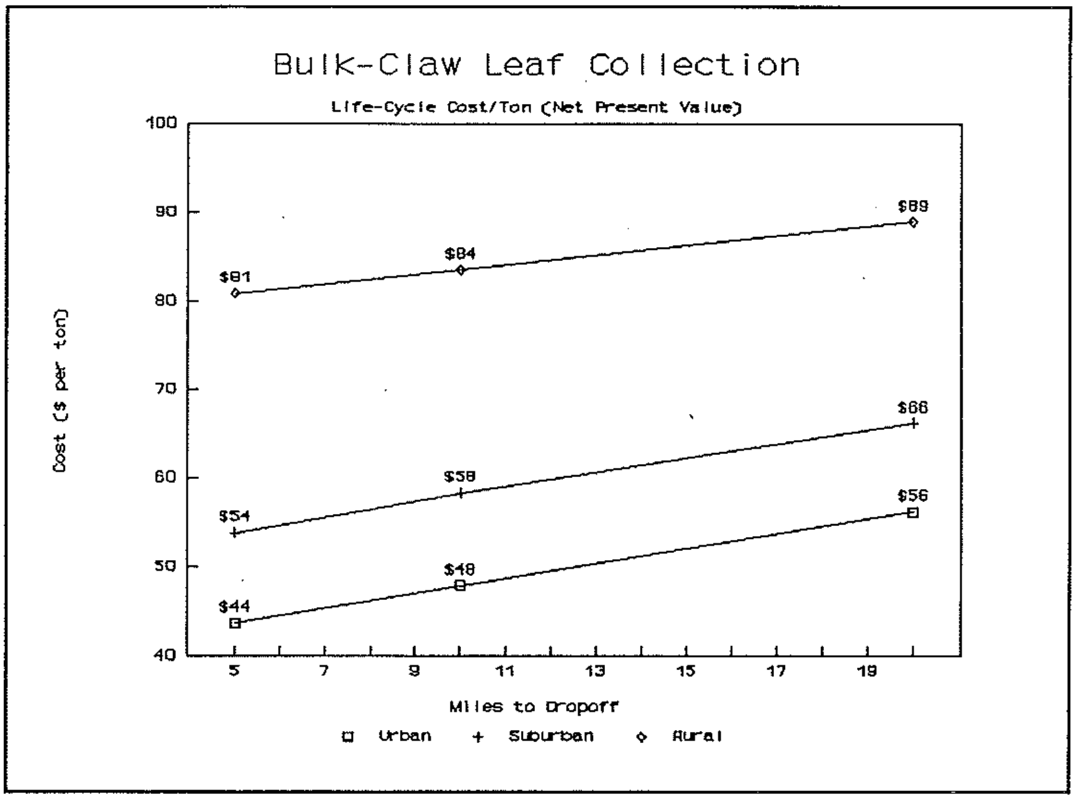


Figure 3-2

Effects of Collection Method

Of the three collection methods analyzed in this report, bagged collection results in the lowest cost per ton, across all demographic regions and distances to the compost site. Cost differences range from $10 per ton to $42 per ton less for bagged collection than for bulk systems. This outcome is a result of differences in capital and labor costs.

Capital costs are lowest for bagged collection because it requires only one piece of equipment, the 20 yd packer truck. (Costs for the bags are not included in the analysis because these cost are typically paid by households.) Bulk collection with the claw or leaf pusher requires additional capital equipment (a front end loader and claw or a snow plow truck and leaf pusher).

Labor costs also are lower for bagged collection. We have assumed two workers per crew are required for bagged collection. For both of the bulk collection systems, four workers are required, one for each vehicle and two rakers. Costs of additional workers required to operate the bulk collection equipment are partly offset because bulk systems collect more leaves per hour. However, this difference is not large enough to fully offset the greater labor requirements for bulk collection.

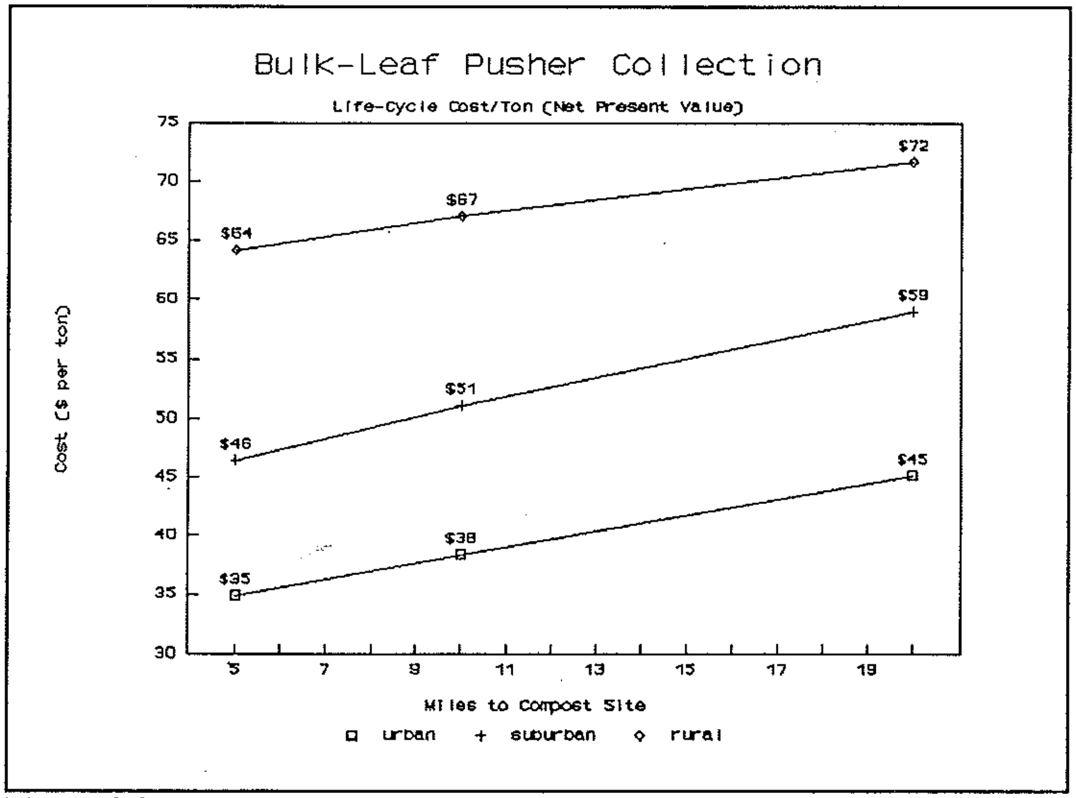


Figure 3-3

TABLE 3-2

VERMONT BAGGED LEAF COLLECTION - 20 CY PACKER

CAPITAL AND O&M COSTS		URBAN 5 miles	URBAN 10 miles	URBAN 20 miles	SUBURBAN 5 miles	SUBURBAN 10 miles	SUBURBAN 20 miles	RURAL 5 miles	RURAL 10 miles	RURAL 20 miles
Capital Costs (annual)										
Number of trucks		3.16	3.34	3.71	0.68	0.72	0.78	0.16	0.17	0.18
Annualized cost per truck		2,054	2,054	2,054	2,054	2,054	2,054	2,054	2,054	2,054
Total truck cost		6,491	6,860	7,620	1,397	1,479	1,602	329	349	370
O&M Costs (1990, annual)										
O&M per Truck										
Fuel & Maintenance		465	799	1,368	428	642	1,053	259	289	386
Insurance & Licence		160	160	160	160	160	160	160	160	160
Labor		4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800
Program Administration		4,462	4,462	4,462	769	769	769	164	164	164
Total O&M Costs		21,605	23,697	27,939	4,570	4,982	5,691	1,217	1,296	1,443
1990 Total annual costs		28,096	30,557	35,559	5,967	6,461	7,293	1,545	1,645	1,813
1990 Total costs/ton		30.94	33.65	39.16	38.00	41.15	46.45	51.51	54.85	60.42
LIFECYCLE COSTS										
Per Ton Cost (nominal $) Year	1	28.25	30.74	35.78	34.74	37.63	42.49	45.54	48.49	53.44
	2	29.13	31.70	36.92	35.82	38.80	43.83	46.99	50.03	55.15
	3	30.04	32.70	38.10	36.93	40.02	45.22	48.49	51.64	56.93
	4	30.99	33.74	39.32	38.09	41.28	46.66	50.05	53.30	58.79
	5	31.98	34.82	40.60	39.30	42.60	48.17	51.68	55.03	60.72
	6	33.00	35.95	41.92	40.56	43.97	49.73	53.37	56.84	62.72
	7	34.07	37.12	43.30	41.87	45.40	51.36	55.13	58.71	64.81
1990 Present Value of Lifetime Per Ton Costs		25.04	27.26	31.77	30.78	33.36	37.71	40.44	43.07	47.50

TABLE 3-2
(Continued)

BULK LEAF COLLECTION - 20 C.Y. PACKER WITH CLAW

		URBAN			SUBURBAN			RURAL		
CAPITAL AND O&M COSTS		5 miles	10 miles	20 miles	5 miles	10 miles	20 miles	5 miles	10 miles	20 miles
Capital Costs (annual)										
Number of trucks		2.21	2.37	2.68	0.47	0.50	0.55	0.13	0.135	0.14
Annualized cost per truck		9,449	9,449	9,449	9,449	9,449	9,449	9,449	9,449	9,449
Total truck cost		20,882	22,394	25,323	4,441	4,725	5,197	1,228	1,276	1,323
O&M Costs (1990, annual)										
O&M per Truck										
Fuel & Maintenance		936	1,569	2,612	641	928	1,485	445	452	562
Insurance & Licence		640	640	640	640	640	640	640	640	640
Labor		9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Program Administration		4,740	4,740	4,740	817	817	817	164	164	164
1990 Total O&M Costs		29,439	32,727	39,183	6,271	6,865	7,934	1,940	1,998	2,160
1990 Total annual costs		50,321	55,121	64,507	10,712	11,590	13,131	3,169	3,274	3,482
1990 Total costs/ton		49.09	53.78	62.93	60.52	65.48	74.19	90.53	93.54	99.50
LIFECYCLE COSTS										
Per Ton Cost (nominal $)	1	50.24	55.05	64.46	61.94	67.03	75.98	92.75	95.83	101.97
	2	51.44	56.38	66.05	63.41	68.64	77.84	95.05	98.20	104.53
	3	52.68	57.76	67.71	64.94	70.32	79.78	97.45	100.67	107.20
	4	53.97	59.20	69.43	66.54	72.07	81.80	99.95	103.24	109.98
	5	55.32	60.69	71.22	68.19	73.88	83.90	102.54	105.91	112.87
	6	56.71	62.25	73.08	69.92	75.77	86.08	105.24	108.69	115.87
	7	58.17	63.86	75.01	71.71	77.73	88.35	108.04	111.58	118.99
1990 Present Value of Lifetime Per Ton Costs		43.68	47.90	56.17	53.84	58.32	66.19	80.86	83.53	88.98

TABLE 3-2
(Continued)

BULK LEAF COLLECTION - 20 CY PACKER WITH LEAF PUSHER

CAPITAL AND O&M COSTS		URBAN			SUBURBAN			RURAL		
		5 miles	10 miles	20 miles	5 miles	10 miles	20 miles	5 miles	10 miles	20 miles
Capital Costs (annual)										
Number of trucks		2.21	2.37	2.68	0.47	0.50	0.55	0.13	0.135	0.14
Annualized cost per truck		4,519	4,519	4,519	4,519	4,519	4,519	4,519	4,519	4,519
Total truck cost		9,987	10,710	12,111	2,124	2,260	2,485	587	610	633
O&M Costs (1990, annual)										
O&M per Truck										
Fuel & Maintenance		857	1,437	2,392	1,249	1,701	2,474	379	414	514
Insurance & Licence		640	640	640	640	640	640	640	640	640
Labor		9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Program Administration		4,740	4,740	4,740	817	817	817	164	164	164
1990 Total O&M Costs		29,264	32,414	38,594	6,879	7,638	8,923	1,874	1,960	2,112
1990 Total annual costs		39,251	43,125	50,705	9,003	9,898	11,408	2,462	2,570	2,744
1990 Total costs/ton		38.29	42.07	49.47	50.86	55.92	64.45	70.33	73.44	78.41
LIFECYCLE COSTS										
Per Ton Cost (nominal $)	1	39.44	43.34	50.97	52.42	57.64	66.47	72.48	75.68	80.82
	2	40.62	44.65	52.54	54.03	59.44	68.57	74.70	78.01	83.33
	3	41.86	46.02	54.17	55.72	61.31	70.75	77.02	80.44	85.94
	4	43.14	47.44	55.86	57.46	63.25	73.02	79.43	82.96	88.66
	5	44.48	48.92	57.63	59.28	65.27	75.38	81.93	85.58	91.48
	6	45.87	50.46	59.46	61.17	67.37	77.83	84.54	88.30	94.41
	7	47.31	52.06	61.36	63.14	69.55	80.38	87.25	91.14	97.47
1990 Present Value of Lifetime Per Ton Costs		34.87	38.34	45.15	46.44	51.11	59.00	64.19	67.04	71.64

4. REFUSE COLLECTION SYSTEMS

Introduction

In order to determine the most appropriate refuse collection systems reflective of the housing densities found in Vermont, a density profile was developed for each municipality in the State. Information collected for each municipality included the area, population, highway miles (exclusive of Class 4 highways), permanent dwellings and vacation dwellings.

This data was analyzed to determine the number of dwellings per road mile for each of the 251 gores, organized towns and cities in the State. This value is the most significant variable in a cost analysis of refuse collection systems.

A density profile was also developed for each of the 11 solid waste districts in the State. Each town was assigned to a solid waste district, as a member or non-member town. Towns which are not currently members of a solid waste district were assigned to a district on the basis of geographical location by county and/or by giving consideration to current membership in an existing Regional Planning Commission.

Based upon the housing densities in each municipality and solid waste district, a cost analysis was developed for each of four refuse collection systems described as:

- Small community citizen's drop-off facility;
- Curbside collection, rural area;
- Curbside collection, small urban center with outlying bedroom community;
- Curbside collection, large urban center.

Small Community Citizens' Drop-off

There are 152 municipalities and 4 solid waste districts with housing densities of between 0 to 13 dwellings per highway mile. This represents 29 percent of the Vermont population. The majority of these rural communities have in place citizen's drop-off facilities which serve as refuse collection points for further processing, transfer and/or disposal. Municipal curbside refuse collection is rarely provided in rural areas due to a perception that it is costly, and because it shows up in municipal budgets and tax bills. Even though curbside collection is more convenient, it will not likely replace self delivery to a drop-off facility in rural areas. The relatively high cost and the unsightly conditions caused by refuse cans at the curb are the primary reasons that curbside collection is not more popular. Also there is a certain social benefit that taking refuse to a drop-off facility provides; a Saturday morning out, a chance to visit friends and politicians or to concurrently run errands. In most rural areas, refuse pickup can be contracted with private waste haulers for those needing or desiring the convenience.

The cost analysis of these sites is presented in Section 8: Transfer Facilities.

Pros:

- Provides a public disposal system for all residents without the cost of collection;
- In many communities, facilities are in place and operating;
- Transport costs are borne by individuals and businesses;
- User costs are proportioned equally;
- Promotes onsite disposal of yard wastes and composting;
- Increases participation in drop-off recycling program.

Cons:

- Public service is not readily available to those who do not have use of an automobile;
- Inconvenience to some leads to illegal dumping or disposal;
- Increased automobile emissions.

Curbside Collection

Curbside collection can be provided by the municipality through a publicly-operated program or a contract with a private hauler. In areas where collection is not offered by the municipality, residents often individually contract with private haulers for collection of materials. Because municipal populations are small in Vermont, private haulers perform the majority of collection in the state, usually servicing a multiple number of towns and residents in a region.

Pros:

- Reduces traffic and auto emissions;
- Increased resident convenience;
- Services all residents;
- Opportunity to charge variable can or bag disposal rates.

Cons:

- Reduces incentives for backyard composting;
- Reduces participation in recycling if only a drop-off program is offered.

The efficiency of organized waste collection depends upon route selection designed to maximize the number of pickup points per hour and minimize the hauling time to the drop-off point. Routes may be computer derived, set up by management, or chosen by the route driver. The latter is often the best in terms of ultimately finding the most efficient route. Some companies and larger municipalities have route auditors who ride each collection route on a regular basis and make recommendations designed to increase efficiency.

The number of pickup points per day for residential and commercial collection, excluding weather considerations, depends upon the distance between stops, the nature of the roads and terrain, the capacity of the packer body, the ability of the driver to "pack" the truck, the hauling time, and dumping time spent at the drop-off point.

Rear loaders come into most people's minds when one says "garbage truck". They load from the rear as the name implies. They are versatile in that they can be used for both residential and container pickup (through use of a hook and winch mounted on top of the packer body). Waste is emptied into the rear of the truck and compacted by a packer blade operated manually by the operator. A separate curved blade at the front of the packer body is used, at the drop-off point, to push the waste out of the truck once the tailgate has been raised.

Rear loaders are typically operated by one to three people (usually one person in rural areas). They range in capacity from 5 to 35 cubic yards (C.Y.) and are the packer truck most often used by the waste haulers in Vermont.

When the number of establishments requiring containerized pickup increases, it is more efficient to devote a specialized vehicle or vehicles to commercial, industrial and multi-family pickups.

Front loading packers are almost always used for collection of business wastes from containers called "dumpsters" or "cans". Hydraulically operated forks on the front of the truck which fit into slots on the can lift the container over the cab so that the contents empty into a door in the top of the packer body which opens automatically as the forks are raised. Front loaders are generally large (25-50 C.Y.) and are only used in areas with high densities of business accounts. They are seldom, if ever used for curbside residential collection.

Another type of specialized collection vehicle frequently seen in Vermont is the "roll-off" truck. This type of truck has a tilt body in the back with a winch to "roll off" closed or open-topped containers once the tilt body is raised. The roll-off container is left at the user's site until it is full; the truck then winches the container onto the tilt body and carts it to the drop-off point where it is emptied by opening a door in the rear of the container and tilting the body. Containers are often "shuttled" so that a container just emptied is used to replace a full one at the next pick up point.

Roll-off trucks are used to service mini-transfer stations, large commercial customers such as department stores and supermarkets, and building demolition and construction sites. Roll-off trucks require a single operator. The containers range in size from 10 C.Y. (with open tops) to 50 C.Y. or larger closed containers.

COST ANALYSIS OF SOLID WASTE COLLECTION SYSTEM

The cost analysis of solid waste collection systems uses the same three demographic regions, Urban (29,000 people on 85 route miles), Suburban/Small Urban (5,000 people on 72 route miles) and Rural (1,000 people on 69 route miles) and the same distances, 7, 22, and 37 miles, as was used in the previous analysis of recycling collection programs.

Cost and Technical Assumptions:

The following assumptions will be common to all of the garbage collection scenarios:

- Packer trucks will have a capacity of 31 C.Y. and have a compaction ratio of 3:1 (i.e. three times the original garbage density). For Vermont, this is roughly 800 lb. per C.Y. (PCY).
- Distances to the disposal site will be 7, 22, and 37 miles, with an average speed of 30 miles per hour. The dump time at the disposal site will be 15 minutes.
- Program administration costs are $.80 per household.
- No source reduction or recycling program is assumed.
- Cost per truck is $110,000, annualized over 7 years at 10% interest. Annual insurance and licensing costs are $1,600 per year.
- Collection of refuse in roll-off containers and dumpsters will be contracted individually to private haulers.
- Collection vehicles are to be parked at a landfill or transfer station when not in use. Scheduled maintenance will be provided at the office and maintenance facility at the landfill or transfer station.

In addition, the following assumptions change between population regions:

	Urban	Suburban	Rural	Rural Drop-off
Population	29,000	5,000	1,000	
Annual Refuse Collection	13,614	2,347	469	
Stops per hour	100	70	50	
Crew Size	3	2	2	
Population Density Range (HH/road mile)	27.25-92	17.25-27.25	13-17.25	0-13

The population density ranges are used here only as rough classifications for Vermont municipalities. In Part B, these figures will be used to determine the portion of Vermont solid waste districts which have rural, suburban and urban characteristics.

By Demographic Region

It is by now, not surprising that solid waste collection programs, like recycling and compost collection, increase in cost per ton as population density decreases. This result is tempered in the solid waste collection system, going from urban to suburban, because the crew size decreases from 3 to 2 laborers. The familiar explanation holds in solid waste collection as in previously described collection programs: in more densely populated areas, collection crews collect more households per hour and thus more tonnage per hour. Since the capital cost and the majority of the operating cost (i.e. labor) is independent of how many households are collected in an hour, the more households collected, the lower the cost will be per ton. Based on the assumptions described above, the cost of curbside collection ranges from $24/ton in urban areas located 7 miles from the dump site to $52/ton in rural areas located 37 miles from the disposal site. As in previous analyses, we have assumed that "truck sharing" occurs when a demographic region requires less than one truck. When this assumption is changed and a 2-day collection week is used as described in the last set of columns in Table 4-1, the cost/ton increases about 55%, from $40, $45, and $52/ton to $63, $72 and $80/ton respectively in rural areas for the 7, 22 and 37 mile delivery to the disposal site. The costs used in Figure 4-1 are the net present value of the lifetime per ton costs, which are explained in the introduction to this report.

The cost differences for solid waste collection in different demographic regions are significantly smaller than the differences across demographic areas for recycling and composting. This is because the garbage collection system collects more material per stop than recycling or composting, so fewer households are required to fill a vehicle. Thus, even though the number of households collected per hour decreases as density decreases, fewer of these households are contributing to every collected ton, so the effect of density-related inefficiency is less pronounced.

By Distance from Disposal Site

As distance from the disposal site increases, solid waste collection follows the familiar pattern of increased cost/ton. As in other collection systems, this is because more of the collection day is spent driving to and from the disposal site, and thus more trucks are required to collect a given waste stream. Since truck costs (both capital and most of operating) are fixed, the more trucks required to collect a given tonnage of waste, the higher the cost/ton. Based on the assumptions described above, the range of collection cost for urban programs increases from $24/ton when the disposal site is located 7 miles away to $38/ton when the disposal site is located 37 miles away. For small urban/suburban regions, this range is from $26/ton to $38/ton. For rural regions, this range is from $40/ton to $52/ton.

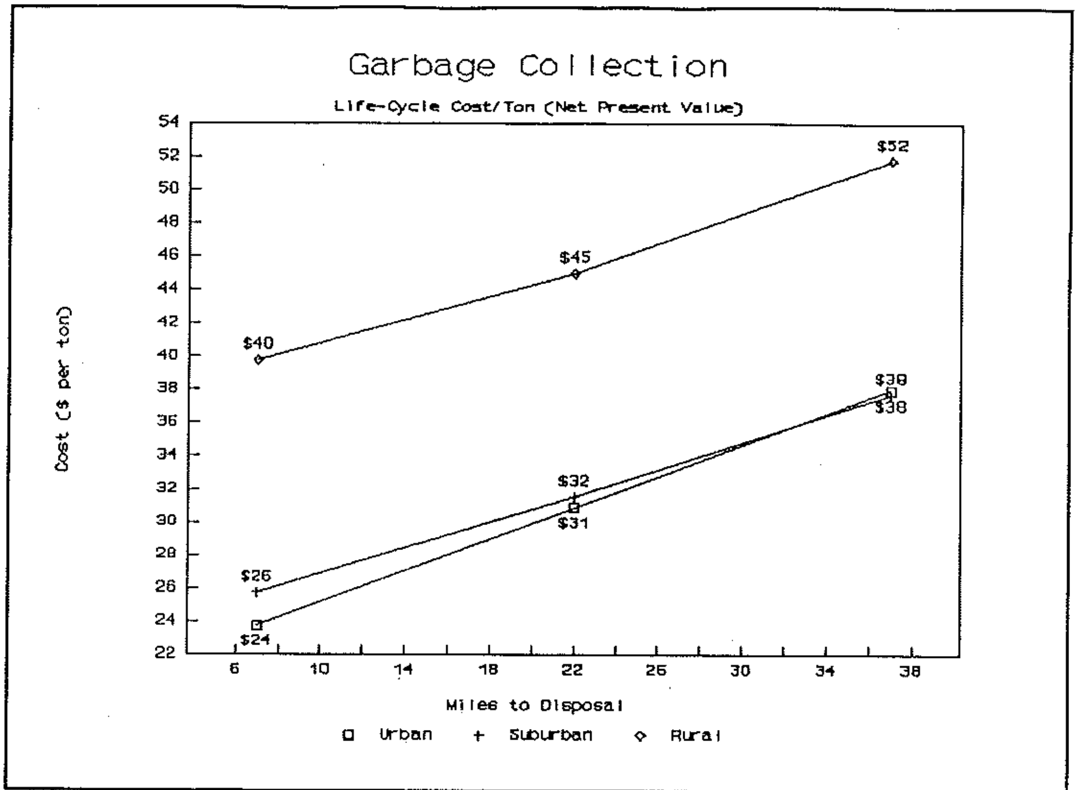


Figure 4-1

13000
17000

TABLE 4-1

GARBAGE COLLECTION COSTS

CAPITAL and O & M COSTS	Urban			Suburban			Rural		
	7 miles	22 miles	37 miles	7 miles	22 miles	37 miles	7 miles	22 miles	37 miles
Capital Costs (annual)									
Number of Trucks	3.71	4.45	5.18	0.88	1.00	1.13	0.24	0.26	0.29
Cost per Truck	22,595	22,595	22,595	22,595	22,595	22,595	22,595	22,595	22,595
Annual Truck Costs	83,827	100,548	117,042	19,884	22,595	25,532	5,423	5,875	6,553
Annual Capital Costs	83,827	100,548	117,042	19,884	22,595	25,532	5,423	5,875	6,553
O & M Costs (1990) (annual)									
Operations Costs per Truck									
Fuel & Maintenance	6,438	14,691	20,605	8,226	14,314	19,037	18,368	22,026	25,042
Insurance & License	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Labor	62,400	62,400	62,400	41,600	41,600	41,600	41,600	41,600	41,600
Program Adm.	8,923	8,923	8,923	1,538	1,538	1,538	308	308	308
O & M Costs	270,248	359,098	447,177	46,793	59,052	71,866	15,084	17,267	20,098
1990 Net Annual Costs (Capital + O & M)	354,075	459,646	564,219	66,676	81,647	97,398	20,507	23,141	26,651
1990 Net Annual Cost/ton	26.01	33.76	41.44	28.41	34.79	41.50	43.73	49.34	56.82
Annual Tons	13,614	13,614	13,614	2,347	2,347	2,347	469	469	469
LIFECYCLE COSTS									
Per Ton Costs (nominal $) Year	26.80	34.82	42.76	29.21	35.79	42.72	45.01	50.81	58.54
	27.63	35.92	44.12	30.04	36.84	44.00	46.35	52.35	60.32
	28.49	37.06	45.55	30.90	37.93	45.32	47.74	53.94	62.18
	29.38	38.24	47.02	31.80	39.06	46.70	49.19	55.60	64.10
	30.31	39.48	48.56	32.73	40.24	48.13	50.69	57.32	66.11
	31.27	40.76	50.16	33.70	41.46	49.62	52.26	59.11	68.19
	32.28	42.10	51.82	34.71	42.74	51.17	53.89	60.97	70.36
1990 Present Value of Lifetime Per Ton Costs	23.74	30.90	37.99	25.71	31.58	37.75	39.76	44.93	51.81

TABLE -4-1
(Continued)

RURAL SOLID WASTE COLLECTION - COMPARISON OF TRUCK SHARING VS. SOLE OWNERSHIP

CAPITAL and O & M COSTS	Rural - Sharing Truck			Rural - 1.5 Days per Week		
	7 miles	22 miles	37 miles	7 miles	22 miles	37 miles
Capital Costs (annual)						
Number of Trucks	0.24	0.26	0.29	0.79	0.88	0.96
Cost per Truck	22,595	22,595	22,595	22,595	22,595	22,595
Annual Truck Costs	5,423	5,875	6,553	17,850	19,884	21,691
Annual Capital Costs	5,423	5,875	6,553	17,850	19,884	21,691
O & M Costs (1990) (annual)						
Operations Costs per Truck						
Fuel & Maintenance	18,368	22,026	25,042	5,510	6,608	7,512
Insurance & License	1,600	1,600	1,600	1,600	1,600	1,600
Labor	41,600	41,600	41,600	12,480	12,480	12,480
Program Adm.	308	308	308	308	308	308
O & M Costs	15,084	17,267	20,098	15,784	18,513	21,036
1990 Net Annual Costs (Capital + O & M)	20,507	23,141	26,651	33,634	38,397	42,728
1990 Net Annual Cost/ton	43.73	49.34	56.82	71.71	81.87	91.10
Annual Tons	469	469	469	469	469	469
LIFECYCLE COSTS						
Per Ton Costs (nominal $) Year	45.01	50.81	58.54	73.06	83.45	92.90
	46.35	52.35	60.32	74.46	85.09	94.76
	47.74	53.94	62.18	75.92	86.80	96.70
	49.19	55.60	64.10	77.43	88.58	98.72
	50.69	57.32	66.11	79.01	90.42	100.82
	52.26	59.11	68.19	80.64	92.34	103.00
	53.89	60.97	70.36	82.35	94.34	105.27
1990 Present Value of Lifetime Per Ton Costs	39.76	44.93	51.81	62.72	71.74	79.95

5. RECYCLING FACILITIES

Chapter 5 describes three broad categories of recycling facilities: drop-off facilities, recycling depots, and materials recovery facilities. Each subsection describes our working definition for each of these facilities and presents the variations commonly found for each facility type. Capital and operating costs are analyzed for the major recycling facility components.

DROP-OFF FACILITY

A drop-off facility is a low-cost, flexible approach to recycling. Residents bring their recyclables to the collection site, depositing separated materials into containers provided by the facility. Individual programs collect different materials, depending on the characteristics of the site, the availability of local markets, and the equipment available to process the materials after collection. Wastes typically targeted for drop-off recycling include newspapers, white/office paper, colored paper, corrugated cardboard, magazines, glass containers, aluminum containers, copper, lead (batteries), metal cans, plastic containers (HDPE and PET), and used motor oil.

Many drop-off facilities operate in connection with a processing facility, or provide a minimum level of processing on-site for some of the materials collected. Drop-off programs often have at least one attendant on-site who will aid those bringing materials to recycle, monitor the quality of materials brought, and perform minimum processing of materials. On-site processing may include crushing of glass, baling or granulating of plastics, and baling of paper, and a small amount of quality control (contaminant removal).

The major advantage of a drop-off facility is its low cost of operation. Collection containers, labor and transportation to a processing facility or end-user are often the only significant operating costs for the facility.

The major disadvantage is inconvenience. Residents must bring their recyclables to the site, which tends to discourage high levels of participation. In addition, it may be difficult to maintain quality control at unattended facilities.

The flexibility inherent in a drop-off operation allows for many permutations of this collection system. Most of these variations are designed to either bring the collection containers closer to the residents to encourage participation. For example, buy-back programs may increase participation, particularly in economically depressed areas. In a buy-back program, residents are paid, usually on a per pound basis, for most or all materials they bring to recycle. Prices are determined by the operator based on prevailing market conditions.

Low participation rates in drop-off programs contribute to disadvantages in processing and marketing recyclables. Because of the nature of the equipment required to process recyclables, it is often not economically feasible for a drop-off program to process the small volume of materials it collects. Without processing drop-off facilities often suffer from poor quality control, so they must settle for the lowest market prices for collected materials. The small quantity of materials generated by drop-offs also contributes to low market prices, since low volume limits the marketing options available to the facility.

These problems of processing and marketing may be alleviated by new initiatives in cooperative marketing by drop-off centers on a regional basis and by mobile processors who travel from site to site, processing materials for a fee. These innovations create a larger quantity of material for potential buyers, which increases market prices. Such a system should be considered as part of the logistics of the operations of the various drop-off collection programs.

Despite their limitations, drop-off centers are well suited to rural areas where curbside collections may not be economically feasible. Several types of drop-off facilities are described and analyzed in greater detail later in this chapter. They require enough space for parking, drop-off bins, processing and storage of materials, and an office (for attended programs). Small centers that handle up to 20 tons per month require 3,000-5,000 square feet. Larger centers, that recover up to 50 tons per month, require 8,000 to 15,000 square feet of space. The level of participation at drop-off centers depends on the convenience of location and the promotion the program receives. Participation rates vary from ten to 95 percent. Diversion rates vary similarly, from between 2 and 50 percent of the residential waste stream.

Permanently-Sited Drop-Off Facility

A permanently-sited drop-off center may operate on various schedules, but always at the same site. It can be sited at a solid waste processing facility, such as at a landfill or transfer station, or it can be sited independently. Those sited in conjunction with a solid waste facility, to which residents must already go to dispose of their waste, usually have higher participation and diversion rates than facilities that require an extra trip by residents who wish to recycle.

Participation in recycling programs at combined recycling/trash disposal facilities can be as high as 100 percent of residents who use the facility, particularly if recycling is mandatory for use of the facility. This level of participation may represent from 30 to 80 percent of the local population.

Drop-off facilities can achieve diversion rates as high as 50 percent of the residential solid waste stream by emphasizing education and by assuring that a wide range of materials are included in the program. However, most programs do not achieve such high diversion levels. A more common range for diversion from the waste stream is 5 to 15 percent.

Independently sited drop-off collection programs attract a lower rate of participation and lower rates of diversion from the waste stream. The fraction removed from the waste stream from an independently-sited drop-off generally ranges from 1 to 10 percent.

Larger facilities may include bays for roll-off containers into which residents deposit their recyclables. Such collection facilities are appropriate in areas of higher population density, or where residential traffic is high.

Drop-off collection programs exist throughout the United States and Europe.

Pros: (Permanently-sited drop-off relative to other drop-offs)

- Added storage capacity (materials do not have to be transported every day), which creates
  - The opportunity to collect more materials;
  - Lower transportation and labor costs; and
  - Easier operations characteristics.
- High participation when sited in conjunction with drop-off waste.

Cons:

- Travel distances may discourage some residents;
- Unattended sites often have contamination problems.

Central Drop-Off With Satellite Collection

These programs use a central, permanently-sited drop-off facility, usually with the capacity to process collected materials. The central collection site is no different from the permanently-sited facility described above. Differences arise in the nature of the satellites, which can include mobile satellites, semi-permanent satellite locations, or "igloos." These programs are suited to rural areas that include a center of relatively high population. The central facility is located at the population center; the satellites are set up to serve residents who are unlikely to come to the population center on a regular basis. Satellite collections are also useful when the centralized drop-off is not located at a site to which residents must commonly go.

Igloo Drop-off Collection

So called because of its shape, the igloo system was designed to make drop-off collection as accessible as possible. This system employs small covered containers ranging in size from 1.1-4.0 C.Y.. There are other containers designed for unattended satellite collection that are rectangular and not igloo-shaped. There are also compartmentalized containers designed to hold two or three different materials. All of these containers operate on the same principle. They are meant for places where people commonly go, such as supermarket or mall parking lots, and they can be emptied on-site. For ease of reference, all will be referred to as igloos.

Igloos have an individual, clearly marked entry chute for each type of material, and are sized so as to discourage contamination by other materials. Despite this, the quality of materials collected will be lower than for an attended drop-off. A common contaminant of igloos accepting glass are lids and neck rings. Igloos designed for newspapers may receive a wide range of paper products.

The small size of the igloo collection containers allows easy and relatively unobtrusive placement in shopping areas, parks, and other locations commonly frequented by residents. An array of igloos can be placed close to one another with each intended to collect only one material--commonly newspaper, glass containers, and metal containers. Residents bring their recyclables to the nearest igloo array and deposit the recyclable material in the designated container. The containers are designed to prevent anybody other than the operator from retrieving the deposited materials. The igloos are emptied, usually once a week, by an operator using a specially-designed truck with crane. The crane picks the containers up, empties them into the truck's divided compartments, and then replaces the igloos.

The rate of diversion by igloo systems is difficult to determine. In West Germany, where they originated, and in Pennsylvania, where they are successfully used, a single igloo designed for glass collection will collect 25 tons in a year, though this figure will vary from region to region. Participation rates are also difficult to come by, and are dependent on the amount of education and public support the igloo programs receive. Successful programs permit recycling by residents who live far from the drop-off location, so they increase the participation rate of a centrally located drop-off program.

Pros: (igloo system relative to other drop-off programs)

- Accessibility of the igloos to residents;
- High visibility of the odd-looking containers;
- Low labor costs.

Cons:

- Lack of quality control at the collection site;
- Opportunities for vandalism of the igloos;
- One-by-one deposit of materials in the containers (for igloos with small chute openings).

Existing programs: Begun in West Germany, igloo collection programs have spread to the State of California, Snohomish County, Washington, Waukesha County, Wisconsin, Delaware County, Pennsylvania, Dallas, Texas, New Haven, Connecticut, and Windham Solid Waste Management District, Vermont.

Mobile Drop-Off Collection

This system brings collection containers to areas of relatively high population density, reducing the distance that residents have to travel. Thus, it is suited to rural areas where population centers are dispersed. The collection schedule depends on the population served, materials collected, and distances traveled.

Mobile systems may use a van-type truck that can pull a trailer for additional collection volume, or they may use roll-off containers if a large volume of materials are to be collected. They can be sited on either public or private lots, such as shopping centers, where residential traffic will be high. A mobile system can rotate among a group of sites to provide broader coverage at reduced expense.

Compared to an igloo system, participation rates tend to be lower for mobile systems because the drop-off site is not always available. There is usually only one day per week when collection occurs at any one site. The quality of materials collected by these programs tends to be good if the sites are attended.

Pros: (mobile drop-off collection relative to other drop-off collection)

- Added convenience for residents, since can be sited in a nearby, highly frequented location;
- Mobile unit can be shared by a number of small regions.

Cons:

- Higher transportation, labor, and capital costs for attendants and drivers;
- Drop-off not available to residents every day.

Existing programs: Programs exist in Adams, Brown, and Clermont Counties in rural Southwestern Ohio; Waukesha County, Wisconsin; South Windsor Solid Waste Management District, Vermont; and at other locations throughout the U.S.

Drop-Box Drop-Off Collections

These collection systems are similar to the igloo drop-offs in that permanently-sited satellite collections are placed in highly visible locations. Drop boxes can consist of a small shed or series of sheds that house collection containers, which can be as simple as clearly marked 55-gallon drums or custom-made plywood boxes; or they can be roll-off containers that are compartmentalized and/or covered.

At unattended sites the level of quality control, relative to igloos, suffers if there is no discriminating chute into which materials are placed. At attended sites quality control can be quite good. An advantage of these systems over igloo programs is their lower capital costs; the type of specialized and expensive equipment required of igloo programs is not necessary for drop-boxes.

Existing programs: Such programs exist throughout the country; examples include Morrison County, MN; Kent, OH; and St. Petersburg, FL.

COST ANALYSIS OF DROP-OFF COLLECTION

The costs of two types of drop-off systems have been analyzed: permanently sited drop-offs and igloo drop-offs. Though we have assumed that the permanently sited facility will share the same site with a transfer station, this type of facility could easily be sited on its own in an urban or suburban center. The igloo system is more appropriate for a rural area, where service must be provided over a larger area.

Assumptions for Permanently Sited Drop-off Collection

Facilities with daily capacities of 11.5, 5.8, and 2.9 tons per day are considered. The three facilities, which operate in conjunction with a transfer station, are designed to handle the following materials: newspaper, glass, ferrous metals (split into three categories: cast and heavy steel, light steel, and white goods), non-ferrous metals, batteries, waste oil reusables (such as mattresses, lawn mowers, etc.) steel cans, and HDPE. Additional assumptions for this analysis are as follows:

- newspaper is compacted.

- any residue, such as from unclaimed reusables, can be sent to the proximate transfer station.
- HDPE will be ground to be economically transported.
- steel cans are flattened for easy transport.
- a new site does not have to be purchased because the transfer station site already exists and is sufficient.
- there is plenty of space at the site because the site is a former landfill.

Equipment needs for the **11.5 ton per day operation** were developed as follows:

Newspaper will be compacted into an 80 cubic yard trailer using a standard trash compactor. An additional 3-C.Y. container will handle any overflow when the trailer is being transported. Glass requires 1 40-C.Y. container for clear, 1 divided 30-C.Y. container for amber and green, and 3-C.Y. containers to collect glass when both of the above containers are full. The three types of collected metals are deposited into 3 20-C.Y. containers after the quality of separation is assured by the staff.

Non-ferrous metals, including lead, copper, brass, aluminum, and stainless will be set aside in 55-gallon barrels and delivered to market by pick-up truck. Alternatively, because aluminum can be bulky (venting systems, house siding, windows, sliding doors, etc), it may be necessary to store that metal on the ground and then load it into an available 20-C.Y. container to deliver it to market.

Batteries will be stored and tied on pallets, and delivered to market by the pallet load. Waste oil, dropped off by residents, will be stored in a tank.

Residents will be offered the opportunity to leave household items they no longer want or need but which may have some value to other residents in a specially designated area. Large amounts of staff time may be required to closely monitor the quality of materials being dropped off.

Steel cans will be deposited on a picking tray where the staff can periodically look them over and process them with a flattener. They will be stored in a concrete bunker until a 20-ton load is generated.

HDPE will be collected in gaylord boxes that are housed in a small shed or possibly in the processing building. Because of its bulk, HDPE will have to be processed on-site. Though a small granulator has sufficient capacity to handle the daily throughput, a larger granulator is assumed to reduce the staff time needed for feeding the granulator. The HDPE will be stored for shipment in gaylord boxes.

The equipment needs for the **5.8 ton per day facility** are almost the same as for the 11.5 ton per day operation. The only differences are that a smaller granulator can be purchased to handle the 100 pounds-per-day collection rate, one fewer employee will be needed, and fewer containers are required.

For the **2.9 ton per day facility**, one fewer laborer is required, glass is crushed manually rather than with a mechanical crusher, and fewer containers are required.

Analysis of Permanently Sited Drop-off Facility Costs

Drop-off facilities are the most basic recycling facilities, requiring only minimal storage and processing equipment and a simple structure. They have relatively simple operations needs and few employees. Net capital costs of the facilities considered here range from about $83,000 for a 2.9 TPD facility to roughly $128,000 for an 11.5 TPD facility. Annual operating costs range from $37,000 for the smaller facility to $102,000 for the larger facility. Capital costs and annual operating costs of the 11.5, 5.8, and 2.9 TPD facilities are presented in Table 5-1. The net annual cost per ton is shown in Table 5-1 on the assumption of 8.5% interest over a 10-year payment period.

Several conclusions can be drawn from these facility costs. First, unit costs for both capital and operations increase as capacity decreases, showing a clear economy of scale. For the largest facility, capital costs per ton of capacity are roughly $13,000, rising to about $18,000 for the mid-size facility and $28,400 for the smallest facility. Annualized per ton capital and operating costs for 1990 range from about $42 for the 11.5 TPD facility to $68 for the 2.9 TPD facility. The present value of the lifetime per ton costs is lower, ranging from $21 for the 11.5 TPD facility and $41 for the 2.9 TPD facility.

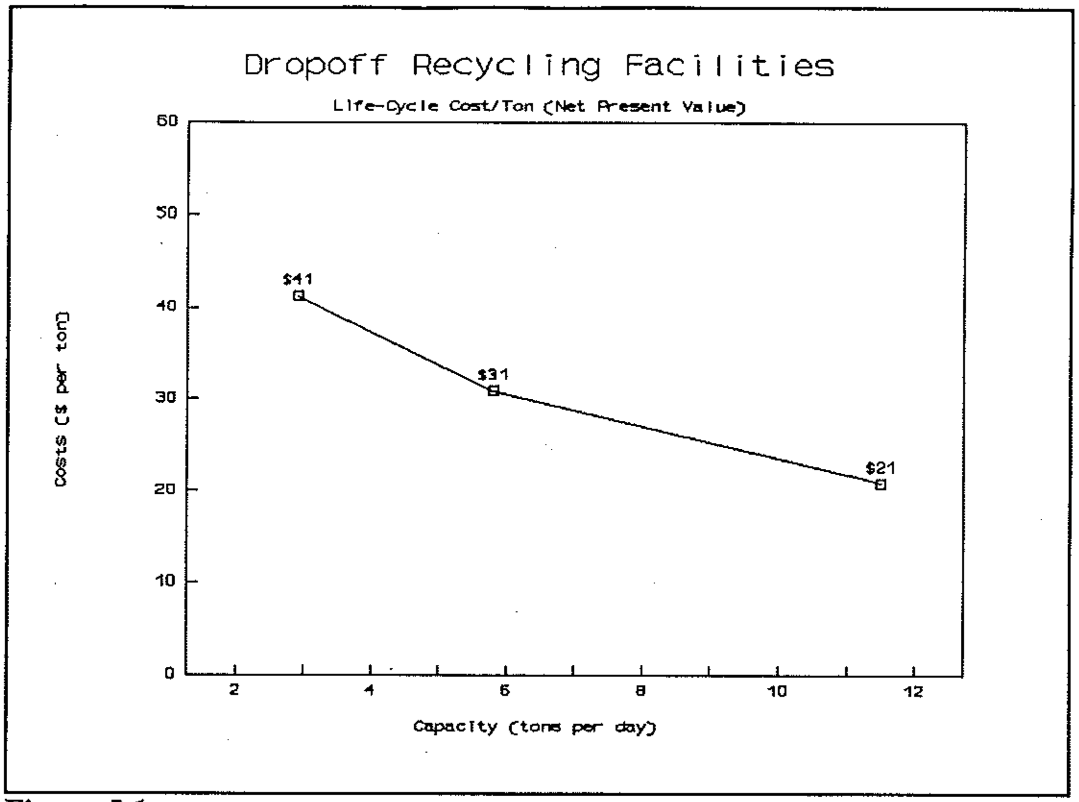


Figure 5-1

Drop-off Facility Capital Costs

The building and equipment used by the three facilities analyzed is essentially the same, with a few minor exceptions. Facility square footage changes slightly to reflect a need to store additional materials. Equipment varies only slightly because the smallest commercially available equipment is being used in most cases. As a result, the difference in annual capital cost between the largest and smallest facilities is only about 60% (roughly $22,000 per year for the 11.5 TPD facility versus about $13,000 per year for the 2.9 TPD facility) though the capacity increases 400%. In fact equipment in the smaller facilities is underutilized, making the capital cost per ton very high. Basic building requirements, such as office and processing equipment area, are relatively constant at this scale of materials flow, so use of this space will be much more efficient and more economical with higher flows of material.

Drop-off Facility Operating Costs

Drop-off facilities are clearly very labor and operations intensive, as shown by the size of operations costs in comparison to annualized capital costs. For the 11.5 TPD facility operations costs are more than four times higher than annual capital costs ($34 per ton to $8.50 per ton). They are almost three times greater for the 2.9 TPD facility ($49 per ton to $18 per ton). The labor intensiveness of the drop-off operation is shown by the large proportion of operating costs accounted for by labor. In the 11.5 TPD facility, labor costs are $20 per ton, or almost 50% of total costs, while at the 2.9 TPD facility, labor costs are $26.50 per ton, or 40% of total costs. Much of this labor intensiveness results from utilizing equipment with low capacities and from simple maintenance and supervision activities.

Labor costs are one of the major sources of economies of scale in operations. Only one additional person is required to double capacity. Other operations costs such as insurance and utilities have large economies of scale as well. Basic utility requirements do not significantly increase with increased size. Insurance costs are proportional to capital costs, which also show significant economies of scale.

Because of strong economies of scale, the unit costs of a drop-off facility are quite dependent upon the amount of material received. In smaller facilities, much of the physical plant is underutilized, so the major change needed to handle an increased flow of recyclables is an increase in labor. And, as we have noted, labor requirements increase less than proportionately with capacity.

Efforts to increase cost-efficiency for drop-off recycling should emphasize measures designed to increase participation, since drop-off programs receive their materials from a relatively fixed area of population. Other recycling facilities, such as depots and materials recovery facilities (MRFs), have greater flexibility to solicit materials from a wider range of communities and programs, and therefore are less dependent upon maximizing participation in the local community.

TABLE 5-1

DROP-OFF FACILITY COST ESTIMATE

CAPACITY (TPD)	11.5	5.8	2.9
BUILDING			
Building - Total Cost ($)	80,000	70,000	65,000
Building Size (sq. ft.)	3,200	2,800	2,600
Cost/sq. ft. - Basic Structure	25	25	25
TOTAL SITE COSTS:	$80,000	$70,000	$65,000
EQUIPMENT			
Materials Handling	$27,630	$19,660	$6,500
Containers	$25,630	$18,160	$5,000
Waste Oil Tank	$2,000	$1,500	$1,500
Materials Processing	$40,200	$14,200	$11,100
Paper Compacter	$20,000		
Glass Crusher	$3,100	$3,100	
Plastics Granulator	$10,000	$4,000	$4,000
Can Crusher	$7,100	$7,100	$7,100
TOTAL EQUIPMENT COSTS:	$67,830	$33,860	$17,600
TOTAL	$147,830	$103,860	$82,600
$/TPD Capacity	$12,855	$17,907	$28,483
1990 OPERATING COSTS			
Labor	$60,000	$40,000	$20,000
Utilities	$5,500	$3,000	$2,000
Insurance	$6,000	$4,000	$3,000
Maintenance	$7,000	$5,000	$3,000
Supplies	$8,000	$5,000	$3,500
Equipment/Transportation Rental	$15,000	$7,500	$5,500
1990 TOTAL OPERATING COSTS	$101,500	$64,500	$37,000
$/ton/year	$33.95	$42.77	$49.07

ANNUAL PER TON CAPITAL AND OPERATING COSTS - DROPOFF FACILITY

1990 Capital Costs Payments	$8.51	$11.46	$17.70
Site	$4.08	$7.07	$13.14
Handling Equipment	$1.81	$2.55	$1.68
Processing Equipment	$2.63	$1.84	$2.88
1990 O & M Costs	$33.95	$42.77	$49.07
Labor	$20.07	$26.53	$26.53
Utility	$1.84	$1.99	$2.65
Insurance	$2.01	$2.65	$3.98
Maintenance	$2.34	$3.32	$3.98
Supplies	$2.68	$3.32	$4.64
Equipment/Transportation Rental	$5.02	$4.97	$7.29
1990 Total Annual Cost	$42.46	$54.23	$66.77

TABLE 5-2

DROP-OFF ANNUALIZED COSTS

Capacity		11.5	5.8	2.9
Capital Costs		$147,830	$103,860	$82,600
1990 Capital Payment		$25,445	$17,284	$13,345
1990 Operating Costs		$101,500	$64,500	$37,000
1990 Total Costs		$126,945	$81,784	$50,345
1990 Total Cost per Ton		$42.46	$54.23	$66.77
1990 Revenues			Annual Tonnage	
Newspaper		1196.0	603.2	301.6
Corrugated Cardboard		239.2	120.6	60.3
Glass		478.4	241.3	120.6
Ferrous		598.0	301.6	150.8
Non-Ferrous		15.0	7.5	3.8
Batteries		6.0	3.0	1.5
Waste Oil		12.0	6.0	3.0
Reusables		119.6	60.3	30.2
Tin Cans		179.4	90.5	45.2
Plastic		146.5	73.9	36.9
Total		2990.0	1508.0	754.0
	Revenues per ton ($)		Annual Revenues	
Newspaper	0	$0	$0	$0
Cardboard	30	$7,176	$3,619	$1,810
Glass	40	$19,136	$9,651	$4,826
Ferrous	15	$8,970	$4,524	$2,262
Non-Ferro	700	$10,465	$5,278	$2,639
Batteries	0	$0	$0	$0
Waste Oil	-250	($2,990)	($1,508)	($754)
Reusables	0	$0	$0	$0
Tin Cans	30	$5,382	$2,714	$1,357
Plastic	80	$11,721	$5,911	$2,956
1990 Total Revenues		$59,860	$30,190	$15,095
1990 Net Cost		$67,085	$51,594	$35,250
1990 Cost per ton		$22.44	$34.21	$46.75
LIFECYCLE COSTS				
Per Ton Cost (nominal dollars)	Year 1	23.39	35.52	48.31
	2	24.40	36.89	49.95
	3	25.45	38.33	51.65
	4	26.55	39.83	53.44
	5	27.71	41.40	55.30
	6	28.92	43.04	57.24
	7	30.18	44.75	59.28
	8	33.14	48.16	63.08
	9	34.53	50.03	65.30
	10	35.99	51.99	67.61
1990 Present Value of Lifetime per Ton Costs		20.80	30.92	41.21

Assumptions for the Igloo Recycling Collection Program

Analysis of the costs of operating an igloo recycling collection program will vary greatly depending on the specific collection characteristics of the program, including the demographic profile of the region served, distribution of igloo complexes, number and type of igloos used and frequency of collection. The assumptions used in making our cost analysis are as follows:

- Urban areas have three sites (each serving 9,667 people) and are collected once per week; there is one suburban site collected once per week; there is one rural site collected once every two weeks.

- The number and size of containers used at each site are chosen to optimally handle the estimated material flow.

- One roll-off truck with 40 C.Y., 4-compartment container and specially equipped winch will service the sites. The truck will have enough sites to service to require a full, 5-day collection week.

Collection costs were calculated by estimating the hourly cost of operating the collection vehicle and then determining the time required to service urban, suburban, and rural sites. We have assumed that on average rural and suburban sites will require 42 minutes per igloo to service and urban sites will require 54 minutes. The time to collect urban sites is higher because the truck is only able to service one site before taking the load to market. In suburban areas, the truck can be dumped after two sites have been serviced; and there are two fewer igloos per site, so less time is required per site. Many rural sites can be serviced in one collection; but the drive distance between sites is much larger, thereby accounting for the same site service time as suburban sites.

Education and promotion costs have been set at $.70 per household.

Analysis of Igloo Recycling Collection Program

The present value of the lifetime costs per ton of igloo programs in urban and suburban areas are roughly the same, $26 and $30 per ton respectively, while rural programs are significantly more expensive, $52 per ton. (These costs are shown in Tables 5-3 and 5-4.) The primary reason for increased cost effectiveness in the urban and suburban regions is that greater population density means one site can generate a larger amount of recyclables. Each urban site serves 9,000 people, whole suburban sites service 5,000, and rural sites only 1,000. Since the cost to collect each site is relatively fixed, the cost per ton goes down as the amount of materials collected at each site increases.

In addition, there are economies of scale in the capital costs of the individual igloos. For example, a 4 cubic yard igloo costs less than twice as much as a 1.1 cubic yard igloo even though it has four times the capacity. This economy helps justify the use of larger igloo containers.

TABLE 5-3

IGLOO ESTIMATE

	Rural	Suburban	Urban
CAPITAL COSTS			
Igloos - Total Cost per Region	$2,650	$4,075	$17,175
Igloo Size: 1.1 cu.yd.			
Total No. per Site	3	2	0
Cost per Igloo	$375	$375	$375
Igloo Size: 2.7 cu.yd.			
Total No. per Site	2	2	3
Cost per Igloo	$450	$450	$450
Igloo Size: 3.3 cu.yd.			
Total No. per Site	0	1	0
Cost per Igloo	$550	$550	$550
Igloo Size: 4.0 cu.yd.			
Total No. per Site	1	3	7
Cost per Igloo	$625	$625	$625
No. of Sites	1	1	3
Total No. of Igloos	6	7	30
Interest Rate	8.5%	8.5%	8.5%
Payment Term (years)	5	5	5
Annualized Igloo Cost per Region	$672.48	$1,034.10	$4,358.43
Truck and Crane	$100,000	$100,000	$100,000
Interest Rate	8.5%	8.5%	8.5%
Payment Term (years)	10	10	10
Annualized Truck Cost	$15,240.77	$15,240.77	$15,240.77
Annualized Truck Cost per Working Hour	$8.37	$8.37	$8.37
1990 TRUCK OPERATING COSTS			
Total Labor Costs	$23,000	$23,000	$23,000
Number of full-time employees	1	1	1
Annual Salary	$23,000	$23,000	$23,000
Vehicle Fuel and Maintenance	$10,000.00	$10,000.00	$10,000.00
Annual Vehicle Miles	25,000	25,000	25,000
Fuel and Maintenance per mile	$0.40	$0.40	$0.40
1990 Operating Costs	$33,000	$33,000	$33,000
1990 Operating Costs per Hour	$15.87	$15.87	$15.87
1990 Total Hourly Costs	$24.24	$24.24	$24.24

TABLE 5-4

ANNUAL PER SITE COSTS		Rural	Suburban	Urban
		Weekly Volume of Materials per Site (cu. yds.)		
News		0.87	4.36	8.42
Glass		0.67	3.36	6.49
Steel Cans		0.53	2.65	5.11
Plastic		1.74	8.71	16.83
TOTAL CUBIC YDS/SITE PER WEEK:			19.07	36.86
TOTAL CUBIC YDS/SITE PER 2-WEEKS:		7.63		
		Weekly Tonnage of Materials per Site (tons)		
News		0.24	1.20	2.32
Glass		0.20	1.01	1.95
Steel Cans		0.04	0.21	0.41
Plastic		0.03	0.15	0.29
TOTAL TONS/SITE PER WEEK:			2.57	4.97
TOTAL TONS/SITE PER 2-WEEKS:		1.03		
Time Required to Service Each Site (hrs)		0.70	0.75	0.90
Annual Time to Service Each Site (hrs)		18.2	39.0	46.8
Hourly Costs Per Ton		$16.51	$7.07	$4.39
Hourly Costs per Cubic Yard		$2.22	$0.95	$0.59
1990 IGLOO COSTS PER SITE				
Annual Site Servicing Costs		$441.16	$945.34	$1,134.41
Annualized Igloo Cost		$672.48	$1,034.10	$1,452.81
Education and Advertising		$700.00	$3,500.00	$6,766.90
Cost per Household		$0.70	$0.70	$0.70
Households per Site		1,000	5,000	9,667
1990 Total Costs per Site		$1,813.64	$5,479.43	$9,354.11
1990 Total Program Costs		$1,813.64	$5,479.43	$28,062.34
1990 REVENUES		Annual Tonnage		
Newspaper		12.5	62.3	361.4
Glass		10.5	52.4	303.8
Steel Cans		2.2	11.0	63.8
Plastic		1.6	7.9	46.0
TOTALS:		26.7	133.6	775.0
	Revenues per ton	Annual Revenue		
Newspaper	0	$0.00	$0.00	$0.00
Glass	25	$261.91	$1,309.57	$7,595.48
Steel Cans	5	$11.00	$55.02	$319.14
Plastic	25	$39.62	$198.09	$1,148.90
TOTALS:		$312.53	$1,562.67	$9,063.51
1990 Total Net Program Costs		$1,501.10	$3,916.76	$18,998.83
1990 Total Program Costs per Ton		$56.17	$29.31	$24.51

TABLE 5-4 (Con't)

LIFECYCLE COSTS			Rural	Suburban	Urban
Per Ton Cost (nominal dollars)	Year	1	57.41	30.31	25.44
		2	61.81	31.59	26.85
		3	63.53	39.32	35.27
		4	55.52	31.02	26.90
		5	70.44	45.67	41.47
		6	58.50	33.44	29.15
		7	84.53	49.49	43.39
1990 Present Value of Lifetime per Ton Costs			51.83	29.75	26.01

RECYCLING DEPOT

A recycling depot is intermediate in size; it is larger than a drop-off center and smaller than a MRF. It receives and processes source-separated materials from drop-off and curbside programs. Recycling depots do not have the automated separation technology found in an MRF, relying instead on manual picking from conveyors or the floor for any required separation of materials. Facilities in this category will also remove contaminants as needed by handpicking. The tonnages processed range from 10 tons per week to 50 tons per day, considerably less than the volume processed by a MRF.

Depots typically handle separated paper, including newspaper, white/office paper, corrugated cardboard, magazines, and mixed paper/junk mail. They also target aluminum cans and packaging, glass containers, tin cans, bi-metal cans and plastic containers (HDPE, PET).

A depot is essentially a processing center; it processes materials in a labor-intensive manner using the most basic processing equipment. Such equipment commonly includes glass crushers, plastic granulators, balers (either auto-fed by conveyor or not, and either horizontal or vertical pit). Depots also require large depository bins to accept delivered materials (concrete bunkers will suffice), conveyor systems to move materials from depository bins to processors, storage and shipping containers, and moving equipment (forklift or pallet trucks). Depending on their size, depots may also own semi- or roll-off trailers to transport processed materials to market. In depots where PET is being baled, a perforator may also be needed.

At a large depot servicing mostly drop-off programs, source-separated glass is typically deposited into bunkers and conveyor-fed to a glass crusher. Newspaper is received from roll-off containers, deposited either into bunkers or onto a conveyor-fed tip floor, and then fed into a baler. Source-separated tin and bi-metal cans, and aluminum cans are transferred from their separate or divided collection containers into unique processing streams in the depot. A facility that bales a number of materials, such as newspaper, HDPE and PET, aluminum, tin, and bi-metal cans, will often feed these different streams separately into the same baler.

There is some blurring of the line between recycling depots, and dump and sort facilities. Recycling depots, handling post-consumer, residential recyclables, have often developed out of, and under the same roof as, commercial dump and sort facilities. This combined effort gives dump and sort operations the opportunity to investigate the processing techniques and economic feasibility of dealing with residential materials.

Most recycling depots are run by organizations that also provide hauling services for drop-off programs and/or collection services for curbside programs. Revenues from these services, in addition to the revenues provided by the commercial dump and sort operations housed under the same roof, provide financial support for processing functions performed by the depot.

The recycling depot is one type of hybrid among the many recycling facility designs, other facilities might have manual separation of commingled recyclables, manual separation with limited automated separation, no materials processing, among other separation and processing options. The type of facility appropriate for a given region will depend upon local conditions and the scope of this study is unable to address the large number of hybrid types of facilities and their costs.

Existing Facilities: Many existing processing facilities nationwide fit the description of a recycling depot. In Vermont, Casella Waste Management in Rutland processes materials from many drop-off programs and several curbside programs. Hardwick Recycling Salvage in Morrisville is servicing one curbside collection program. Other nationally prominent facilities exist in Ann Arbor, MI, Seattle, WA, and in Marin County, CA.

Pros:

- Less residue generated than processing systems that receive commingled recyclables;
- Achieves marketing economies of scale and quality of product so as to achieve high marketability;
- Flexible enough to handle curbside, drop-off, and commercial collections.

Cons:

- If associated with curb-side collection, requires source-separation at the curb.

COST ANALYSIS OF RECYCLING DEPOT

Assumptions

The cost analysis includes depots of four sizes: 2 TPD, 10 TPD, 25 TPD, 50 TPD. All four recycling depots will handle only materials that have been source separated or require minimal separation (such as tin and aluminum cans, and HDPE and PET plastic). Each depot contains separate processing areas: one for newspaper only, one for glass, one for mixed plastics, and one for mixed metal cans. The depots are designed to process newspaper, glass, plastic, aluminum, and tin cans. A payment term of 15 years is used.

Processing Streams

After being dumped on the tipping floor, newspaper is either pushed into the baler with a front-end loader, or automatically fed into the baler by a conveyor. The 50 and 25 TPD facilities both require large horizontal balers, the 10 TPD facility requires a smaller horizontal baler, and the 2 TPD facility can adequately process paper using a much smaller and more labor-intensive vertical baler.

Glass is delivered color-separated into three concrete bunkers in the processing building. The glass processing line consists of a feed hopper and a conveyor leading to a crusher. In the 50 and 25 TPD facilities, crushed glass is moved via a conveyor to roll-off containers, while in the smaller facilities, glass drops directly into a small container (3-5 cubic yards) beneath the crusher. All four facilities make use of the same small glass crusher.

Plastics (either HDPE or both HDPE and PET) are delivered in either Gaylord boxes or similar containers. These containers are dumped onto a conveyor that feeds a granulator. If the plastic does not arrive source-separated, the feed line is also a picking line, with employees separating different plastic resins, as well as different colors of the same resin.

In the two larger facilities that use larger granulators, the ground plastic is blown directly into Gaylord containers, while in the smaller facilities, the ground plastic is transferred by hand into Gaylord containers. The 2 TPD facility uses the smallest commercially available granulator, which processes approximately 100 pounds of HDPE per hour, which is more than adequate for the annual tonnage generated at this small depot.

The fourth processing stream is for metal cans. The analysis assumes that cans arrive at the facility as a commingled stream of aluminum and tin, and are separated by a conveyor that moves them along a magnetic separator. The separated steel cans are then shifted onto a conveyor that feeds a can flattener. The aluminum is pushed by the front-end loader into a vertical baler. All four facilities make use of the same magnetic separator and conveyance system. The smallest facility uses the vertical baler for both aluminum and newspaper.

Containers/Shipping

The 50 ton per day (TPD) depot requires:

- 5 van trailers (3 newspaper, 1 plastic, 1 aluminum);
- 1 open top trailer (metal cans);
- 4 roll-off containers (2 flint glass, 1 amber glass, 1 green glass).

The 25 TPD facility requires:

- 4 van trailers (2 newspaper, 1 plastic, 1 aluminum);
- 4 roll-off containers (2 flint glass, 1 amber glass, 1 green glass).

The 10 TPD facility requires:

- 3 van trailers (1 newspaper, 1 plastic, 1 aluminum);
- 2 roll-off containers (1 flint glass, 1 amber and green glass).

The 2 TPD facility requires:

- 2 van trailers (1 newspaper, 1 plastic and aluminum);
- 2 roll-off containers (1 flint glass, 1 amber and green glass).

Some of the costs of renting these containers are included in the annual shipping costs.

Labor Requirements

The 50 TPD facility requires 13 full-time employees. Three people operate each of the front-end loaders used to handle the newspaper, glass, and metal. In addition, these operators will run the forklifts for moving processed materials. Six equipment operators will run the newspaper, plastic, metal, and glass processing lines, with an additional line worker, largely to separate plastics. One full-time driver is also required to transport the more than 12 truckloads of processed materials per week to market. Finally, two administrative employees manage the facility, market the materials, and maintain the accounting system.

The 25 TPD facility will operate with two less employees. The reduced volume of materials allows for one less mobile equipment operator and one less equipment operator.

The 10 TPD facility requires only 5 full-time employees. One employee can process the approximately 8 tons of newspaper that enters the facility daily and one employee can handle both the glass and plastic streams. One employee is needed to process the metals, drive materials to market, and perform general maintenance and assist with processing; and one is needed as an administrator.

Finally, at the 2 TPD facility, one employee can perform essentially all the processing, as well as the delivery of materials to market. One half-time employee will be required to administer the facility, perform accounting chores, and assist in operations.

Analysis of Recycling Depot Costs

The recycling depot represents the intermediate level of technology among the three recycling facilities analyzed. Depots have significantly more processing capacity than drop-off facilities, but without the materials separation technology of the materials recovery facility. The four sizes of depots (50, 25, 10 and 2 TPD) have basically the same type of materials processing technology, though the actual capacities of individual pieces of equipment varies with facility size. Building size also varies, with the largest facility (50 TPD) occupying 20,000 square feet and the smallest (2 TPD) occupying 4,000 square feet, as do labor and other operations costs. The capital and operations costs of the four facilities analyzed are presented in Tables 5-5 and 5-6.

Our analysis shows that there are clear economies in scale for both the capital cost and operating expenses for recycling depots. There are also economies of scale for net costs considering revenues from the sale of materials, averaging $38.80 per ton. The net present value of the lifetime costs range from a low of $14 per ton for the 50 TPD facility to $69 per ton for the 10 TPD facility. The 2 TPD facility has even higher costs at $162 per ton. The present value of the lifetime costs does not differ greatly with the first-year cost because of the declining value of the revenue stream, which increases at only 2% per year, relative to inflating operating costs. The present value would be even lower if the revenues were assumed to increase at 4% per year, the same as inflation.

Sources of the economies of scale are spread fairly evenly across most specific cost items (see Table 5-6). However, capital costs escalate at a faster rate than operating costs as facility size decreases. The capital cost per ton decreases threefold as facility capacity increases from 10 to 50 TPD while operating costs decrease only twofold.

One clear conclusion is that a 2 TPD recycling facility that does any processing is simply not cost effective. Even the 10 TPD facility is overly burdened by the fixed equipment and building costs.

Recycling Depot Capital Costs

Capital costs can be divided into building and equipment costs. Both equipment costs and building costs contribute to economies of scale in capital costs. Building costs have economies of scale because there are large space requirements for the processing area, office, and tipping floor, and these requirements increase less than proportionally as capacity increases. Equipment economies exist because even the smallest available sizes are used to their full capacity only in the larger facilities. There are also additional economies of scale as equipment size increases.

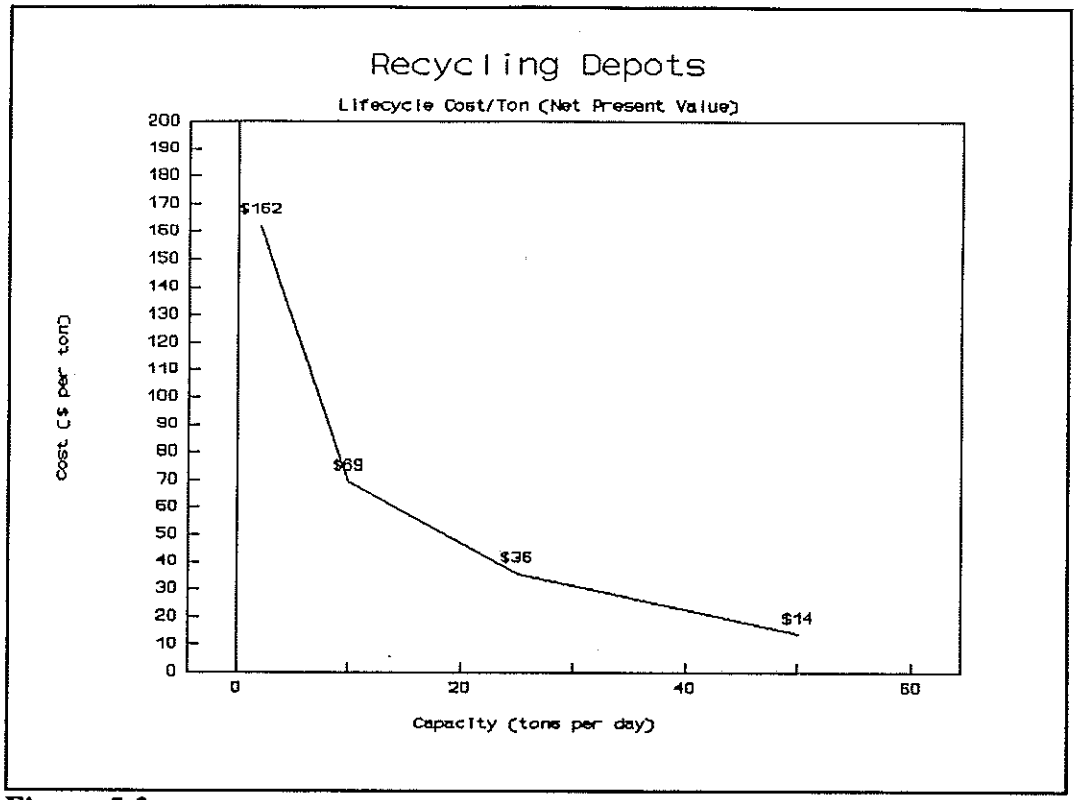


Figure 5-2

Recycling Depot Operations Costs

In 1990, operations costs account for roughly 65% of total annual costs, with labor alone accounting for 35% to 40%. This proportion will increase with time because operations costs increase and capital payments stay fixed. Two of the major operating costs -- labor and supplies -- exhibit significant economies of scale. Labor costs range from $87 per ton for the 2 TPD facility to $22 per ton for the 50 TPD facility. When capacity goes from 10 TPD to 50 TPD, both labor and supply costs per ton are cut in half. Smaller cost items such as utilities, insurance and maintenance decrease by 60% to 70%. The only operating cost item that does not have a large economy of scale is shipping. The cost to ship a load of materials is relatively constant; so as facility size increases, the only change is the number of loads.

TABLE 5-5

DEPOT ESTIMATE

CAPACITY (TPD)	50	25	10	2
BUILDING/SITE				
Building - Total Cost ($)	1,000,000	800,000	650,000	160,000
Building Size (sq. ft.)	20,000	16,000	13,000	4,000
Land Costs ($)	20,000	17,500	15,000	12,500
Needed Acreage	4.0	3.5	3.0	2.5
Costs/sq.ft. - Basic Structure	50	50	50	40
TOTAL SITE COSTS:	$1,020,000	$ 817,500	$665,000	$172,500
EQUIPMENT				
Materials Handling	$ 142,400	$ 92,400	$ 81,400	$ 49,400
Front-end Loader	$ 72,000	$ 36,000	$ 36,000	$ 18,000
Forklift	$ 50,000	$ 36,000	$ 32,000	$ 18,000
Containers	$ 20,400	$ 20,400	$ 13,400	$ 13,400
Materials Processing	$ 138,000	$ 123,600	$ 94,700	$ 29,200
Vertical Baler	$ 15,000	$ 7,500	$ 7,500	$ 15,000
Horizontal Baler	$ 80,000	$ 80,000	$ 65,000	
Glass Crusher	$ 10,000	$ 7,000	$ 3,100	$ 3,100
Plastics Granulator	$ 20,000	$ 20,000	$ 12,000	$ 4,000
Can Crusher	$ 13,000	$ 9,100	$ 7,100	$ 7,100
Materials Separation	$ 254,000	$ 217,000	$152,000	$ 40,000
Magnetic Separator	$ 4,000	$ 2,000	$ 2,000	
Conveyors	$ 250,000	$ 215,000	$150,000	$ 40,000
TOTAL EQUIPMENT COSTS	$ 534,400	$ 433,000	$328,100	$118,600
TOTAL CAPITAL COSTS	$1,554,400	$1,250,500	$993,100	$291,100
$/TPD Capacity	$ 31,088	$ 50,020	$ 99,310	$145,550
1990 OPERATING COSTS				
Labor	$ 280,000	$ 220,000	$110,000	$ 45,000
Utilities	$ 20,000	$ 16,500	$ 12,000	$ 7,000
Insurance	$ 22,000	$ 17,000	$ 14,000	$ 10,000
Maintenance	$ 30,000	$ 23,000	$ 15,000	$ 7,000
Supplies	$ 45,000	$ 32,500	$ 18,000	$ 7,000
Shipping	$ 70,000	$ 40,000	$ 18,000	$ 6,500
TOTAL	$ 467,000	$ 349,000	$187,000	$ 82,500
$/ton/year	$ 35.92	$ 53.69	$ 71.92	$ 158.65

TABLE 5-6

RECYCLING DEPOT ANNUALIZED COSTS

Capacity	50	25	10	2
Capital Costs	$1,554,400	$1,250,500	$993,100	$291,100
1990 Capital Payment	$227,234	$183,039	$144,180	$43,943
1990 Operating Costs	$467,000	$349,000	$187,000	$82,500
1990 Total Costs	$694,234	$532,039	$331,180	$126,443
1990 Total Cost/Ton	52.25	80.00	123.60	238.27

1990 Revenues	Annual Tonnage			
Newspaper	6,409	3,205	1,282	256
Glass	5,005	2,503	1,001	200
Tin Cans	754	377	151	30
Plastic	728	364	146	29
Aluminum	104	52	21	4
Total	13000	6500	2600	520

	Revenues per ton($)	Annual Revenues			
Newspaper	5	32,045	16,023	6,409	1,282
Glass	50	250,250	125,125	50,050	10,010
Tin Cans	60	45,240	22,620	9,048	1,810
Plastic	100	72,800	36,400	14,560	2,912
Aluminum	1000	104,000	52,000	20,800	4,160
Total Revenues		504,335	252,168	100,867	20,173
1990 Net Cost		$189,899	$279,871	$230,313	$106,270
Net Cost per ton		$14.61	$43.06	$88.58	$204.37

ANNUAL PER TON CAPITAL AND OPERATING COSTS

Annualized Capital Costs	$16.32	$26.30	$51.68	$79.61
Site	$8.29	$13.29	$27.03	$35.05
Handling Equip	$2.14	$2.78	$6.12	$18.56
Processing Equip	$2.07	$3.72	$7.12	$10.97
Separation Equip	$3.82	$6.52	$11.42	$15.03
1990 O & M Costs	$35.92	$53.69	$71.92	$158.65
Labor	$21.54	$33.85	$42.31	$86.54
Utility	$1.54	$2.54	$4.62	$13.46
Insurance	$1.69	$2.62	$5.38	$19.23
Maintenance	$2.31	$3.54	$5.77	$13.46
Supplies	$3.46	$5.00	$6.92	$13.46
Shipping	$5.38	$6.15	$6.92	$12.50
1990 Annual Costs	$52.25	$80.00	$123.60	$238.27

TABLE 5-6
(continued)

		50	25	10	2
LIFECYCLE COSTS					
Per Ton Cost (nominal dollars) Year	1	15.27	44.43	90.68	209.94
	2	15.97	45.87	92.88	215.74
	3	16.72	47.39	95.19	221.80
	4	17.51	48.98	97.60	228.12
	5	18.35	50.65	100.13	234.70
	6	19.24	52.41	102.77	241.56
	7	20.19	54.25	105.54	248.72
	8	24.15	60.98	117.52	272.60
	9	25.21	63.01	120.55	280.38
	10	26.32	65.14	123.71	288.49
	11	27.50	67.38	127.03	296.93
	12	28.75	69.72	130.49	305.74
	13	30.07	72.17	134.11	314.91
	14	31.46	74.75	137.90	324.48
	15	36.39	83.07	152.52	353.71
1990 Present Value of Lifetime per Ton Costs		13.72	35.80	69.47	162.19

MATERIALS RECOVERY FACILITY (MRF)

A materials recovery facility separates and processes commingled recyclables collected through a curbside collection or drop-off program. Commingled papers include newspaper, white/office paper, corrugated cardboard, magazines, and mixed paper/junk mail. Commingled containers include aluminum cans and packaging, glass containers, tin cans, bi-metal cans, and plastic containers (HDPE, PET). Paper products and containers must be separated by the collection program. (This poses few operational difficulties.) The individual processing lines at the MRF separate the components of each of the two recyclables streams, removing contaminants and processing the materials (crushing, baling, etc.) into a form that can be sent to markets.

Slight variations may exist among the systems offered by the many vendors currently marketing MRF technology. Typically, the paper line moves material along a conveyor belt past picking stations where different grades of paper (office paper, magazines,...) and contaminants can be removed. The remaining material, usually newspaper or corrugated cardboard, is sent to a baler. When sufficient volumes of other grades of paper are accumulated, they too are sent to the baler.

The mixed containers are sent through a processing system that mechanically and manually separates the materials into separate material streams. Magnets separate tin/ferrous cans from other metals. Air classifiers or similar machines separates light materials (plastic, aluminum) from heavy materials (glass); and eddy currents or manual labor separate plastic from aluminum. Manual labor separates glass into each of its colors.

Separated materials are then processed into a marketable form by glass crushers, tin can slitters and crushers, aluminum flatteners and blowers, and plastics balers or granulators. Some of these processing systems have the capability to remove contaminants (paper and plastic labels, metal caps), which reduce the materials' market value.

Site requirements are roughly 2 to 4 acres, depending upon the capacity of the facility. Building sizes range from 20,000 to 40,000 square feet. Existing structures can be used, though the space constraints of the processing systems usually make it difficult to find an appropriate fit.

Various vendors have developed proprietary systems, including separating and processing equipment. Though the actual equipment may differ, the processing steps involved are essentially the same. The MRF systems we analyze are state-of-the-art systems offered by vendors with the capability to separate and process the full range of mixed recyclables. An alternate approach, which we will not investigate, separates the commingled materials but does no subsequent material processing. These systems produce materials with lower marketability and increased transportation costs, due to lower material density.

Existing Facilities: No facilities currently exist in Vermont. Facilities in New England include Johnston, RI; Groton, CT; and Springfield, MA.

Pros:

- Materials have highest market value because of large, reliable quantity and high quality;
- Materials separation is not required during collection;
- Materials can be accepted from curbside programs, satellite drop boxes, drop-off facilities and transfer points;
- Full range of recyclable materials can be sorted and processed;
- Optimal for regional programs receiving materials from many towns or even multiple districts;
- Can be designed to accept both mixed residential and commercial loads;
- Paper processing lines can be designed to sort different materials in different orders depending upon the type of loads being sorted.

Cons:

- Large equipment requirements make small facilities infeasible;
- Changes to the processing line must be made if new recyclable containers are to be processed;
- Relatively large initial capital costs;
- Relatively long lead time for vendor procurement and facility construction.

COST ANALYSIS

Assumptions

The cost analysis includes Materials Recovery Facilities of three sizes: 60 TPD, 120 TPD, 180 TPD. The 180 TPD facility will handle approximately all the recyclables from the entire state of Vermont. The 60 TPD facility represents the smallest technically feasible size for a facility that performs the separation and processing operations assumed in our analysis. Facilities with smaller capacity will have the same pieces of separation and processing equipment as the 60 TPD facility, though possibly with a smaller tipping floor and storage area. It is not necessary to analyze smaller facilities, because cost differences will be small in comparison to the 60 TPD facility, and the economics will be worse.

The analysis assumes that the Materials Recovery Facilities will receive materials both directly from commingled curbside collection programs and from drop-off centers where materials are deposited in separate paper and mixed material containers. The commingled recyclables stream is composed of the following elements: newspaper, corrugated cardboard, mixed paper, glass containers, aluminum cans, tin and bi-metal cans, and PET and HDPE plastic containers. Materials are delivered to the facility in two separate streams, one for paper and one for all containers and cans.

Site and Building

The materials recovery facility building must house the tipping area, paper and mixed container processing lines, and indoor storage of processed paper, plastics, and tin cans. Glass will be stored in outside bunkers and aluminum will be stored in a van trailer. The building housing the facility will be of higher quality than those housing the depot or drop-off facilities because of increased engineering requirements placed on the structural and electrical characteristics of the building. The cost per square foot is $75, rather than $50 as used for the depot.

Materials Separation and Processing

Two separate processing lines will be utilized: one for paper and one for mixed containers. The paper line starts with a feed hopper, which flows into a conveyor system where different grades of paper or residue can be pulled off and deposited in bunkers below the conveyor line. Paper is fed into a large, horizontal baler with a capacity selected to fit the throughput of the facility.

On the mixed containers processing line, the following pieces of equipment are used to separate and densify the different materials:

- Magnetic separator (removes bi-metal and tin cans)
- Air knife or classifier (separates light and heavy materials)
- Tin flattener and shredder
- Glass crushers
- Aluminum flattener and blower
- Plastic granulator.

Glass will be sorted manually by color. Aluminum cans will also be separated manually from plastic containers. Plastic will be further sorted by type, with HDPE and PET being granulated separately.

Residues generated by the facility will include bottle caps, unacceptable plastics, soda bottle O-rings, and trash discarded in containers. We assume that 10% of the material entering the facility will not be processed, and so will require disposal at a tipping fee of $30 per ton.

Labor requirements are outlined in Table 5-7. The majority of employees either manually sort paper, glass, plastics, or residues; or they operate processing equipment, such as balers, granulators, or tin can flattener and shredder. Additional help is needed to operate the mobile equipment that initially feeds the two processing lines and then moves final processed bales or containers into the storage area in the facility.

Analysis of Materials Recovery Facility Costs

The materials recovery facility (MRF) is the most technically advanced form of recycling facility analyzed. Automated equipment is required to perform most of the materials separation and all of the materials processing; and a high quality building with substantial electrical and structural infrastructure is required. The result is that the materials recovery facility is relatively capital intensive compared to other recycling facilities. Capital costs for the three MRF sizes studies here are roughly one-third of the total annual costs, a figure that is much higher than for drop-offs and depots, with the exception of the smallest recycling depots, which are clearly not cost-effective. However, materials recovery facilities are still much less capital intensive than disposal facilities such as landfills and waste-to-energy plants.

Economies of scale are found in both the capital and operating costs of the MRF, as shown by the net present value of the lifetime per ton cost and the per ton capital and operating costs presented in Table 5-7. The net cost per ton is roughly $6 for the 180 TPD facility. It rises to $27 per ton for the 60 TPD facility. The net cost per ton includes an average 1990 materials revenue of $34.30 per ton and net operating expenses ranging from $40 per ton for the largest facility (180 TPD) to $71 per ton for the smallest (60 TPD). The net present value of the lifetime costs does not differ greatly with the first-year cost because of the declining value of the revenue stream, which increases at only 2% per year, relative to inflating operating costs. The present value would be even lower if the revenues were assumed to increase at 4% per year, the same as inflation.

Materials Recovery Facility Capital Costs

The capital costs of three facilities have been estimated and are presented in Table 5-7. Building costs alone are nearly $2 million for the 180 TPD facility and $1.4 million for the smaller 60 TPD facility. Equipment costs are substantial as well. The 180 TPD has nearly $2 million in equipment costs while the 60 TPD facility has $1.2 million. A large portion of these equipment costs are simply for the physical conveying system and infrastructure to move materials through the series of manual and automated separation

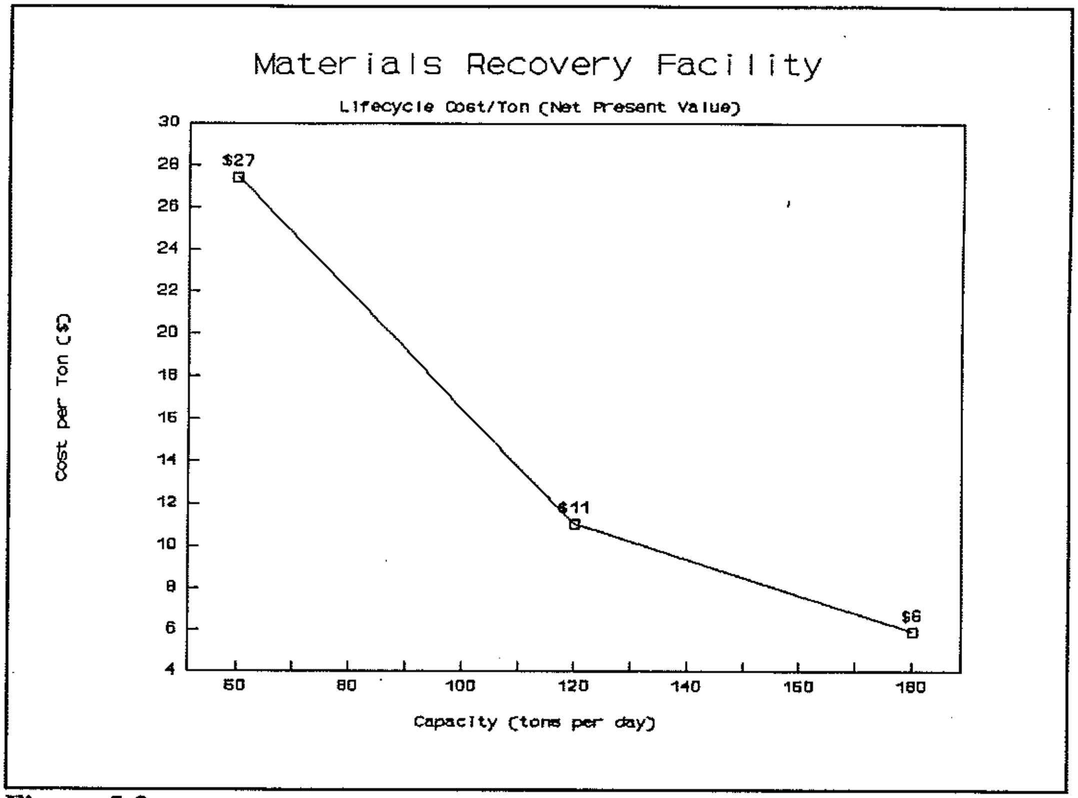


Figure 5-3

stations and finally to the processing equipment. In the 180 TPD facility, this system costs over $650,000 (a portion of the pick-line conveyors should realistically be credited to the overall conveyance system as well) and over $410,000 in the 60 TPD facility. This accounts for one-third of equipment costs in all three facilities analyzed. The large economy of scale in conveyor costs reflects the large amount of the system which is required in each facility regardless of its size. What costs do change results from small increases in conveyor width along with minor changes to the infeed hoppers and supporting physical structure.

Equipment costs show economies of scale resulting from full use of equipment capacities as facility size increases, as well as economies of scale within the specific pieces of processing and separation equipment. For example, the aluminum flattener and blower, plastics baler and magnetic separator used in all three facilities is exactly the same, despite the increase in material flow.

Materials Recovery Facility Operations Costs

Operations costs are also presented in Table 5-7. As for smaller recycling depots and drop-offs, labor is still the dominant cost item, totaling nearly $800,000 per year in the 180 TPD facility and $470,000 per year in the 60 TPD facility. Labor costs show strong economies of scale because only one person is usually needed to operate a piece of equipment, regardless of the flow of material. This means some laborers in the 60 TPD facility could potentially be processing up to three times as much material.

In addition to labor several other operating expenses are significant. Supply and maintenance costs show economies of scale because both of these costs are related to equipment costs, which have large economies of scale, as described above. In addition, the costs of disposing of residues is a cost unique to the MRF because it is the only facility that sorts trash and contaminants from delivered materials. At $3 per ton delivered ($30 per ton to dispose of 10% residues), annual costs of the biggest facility are $140,000 per year. This cost, however, has no effect on economies of scale.

TABLE 5-7

MATERIALS RECOVERY FACILITY ESTIMATE

CAPACITY (TPD)	180	120	60
DESIGN/ENGINEERING	300,000	250,000	200,000
BUILDING/SITE	2,290,000	1,921,250	1,622,500
Land	30,000	26,250	22,500
Acres	4.0	3.5	3.0
Cost per Acre	7,500	7,500	7,500
Site Preparation	300,000	250,000	200,000
Building - Total Cost ($)	1,960,000	1,645,000	1,400,000
Building Size (sq. ft.)	28,000	23,500	20,000
Process Equip Size (s.f.)	13,000	11,000	9,500
Admin/Lockers/Misc Size (s.f.)	3,000	2,500	2,000
Tip Area Size (s.f.)	7,000	6,000	5,000
Storage Area Size (sq. ft.)	5,000	4,000	3,500
Cost/sq.ft. - Basic Structure	70	70	70
EQUIPMENT	1,965,000	1,525,000	1,230,000
Materials Handling	395,000	260,000	155,000
Front-end Loader	275,000	150,000	100,000
Forklift	90,000	90,000	45,000
Containers	30,000	20,000	10,000
Materials Separation	745,000	625,000	515,000
In-feed Conveyor	40,000	30,000	20,000
Magnetic Separator	25,000	25,000	25,000
Pick-line Conveyors	450,000	375,000	300,000
Light/Heavy Separator	30,000	20,000	20,000
Paper Line/Conveyor	200,000	175,000	150,000
Materials Processing	825,000	640,000	560,000
Tin/ferrous Shredder	120,000	85,000	85,000
Glass Crushers	130,000	100,000	100,000
Aluminum Blower/Flattener	30,000	30,000	30,000
Plastics Granulator	30,000	20,000	20,000
Plastics Baler	15,000	15,000	15,000
Misc Conveyors	200,000	140,000	110,000
Paper Baler	300,000	250,000	200,000
GENERAL/ACCEPTANCE COSTS	80,000	60,000	45,000
TOTAL	4,635,000	3,756,250	3,097,500
$/TPD Capacity	25,750	31,302	51,625

1990 OPERATING COSTS

Labor (plus 30% workman's comp and fringe)	784,160	635,440	473,200
Utilities	31,000	26,000	20,000
Insurance	30,000	25,000	20,000
Maintenance	80,000	58,000	40,000
Supplies	100,000	75,000	50,000
Residue Disposal (10% residue, $30 per ton)	140,400	93,600	46,800
TOTAL	1,165,560	913,040	650,000
$/ton	$24.91	$29.26	$41.67

Employees	salary ($/yr)	Employees <-------	--------	------->
Paper Sorters	$20,800	3	2	2
Sorters/Processing Operators	$20,800	13	11	7
Loader Operators	$20,800	3	3	2
Supervisors	$31,200	3	2	2
Maintenance	$20,800	3	2	1
Administration	$52,000	1	1	1
Subtotal		26	21	15

TABLE 5-7
(Continued)

MATERIALS RECOVERY FACILITY ANNUALIZED COSTS

Capacity		180	120	60
Capital Costs		$4,635,000.00	$3,756,250.00	$3,097,500.00
1990 ANNUAL COSTS				
Capital Payment		700,127	561,523	459,621
Operating Costs		1,165,560	913,040	650,000
Total Costs		1,865,687	1,474,563	1,109,621
Total Costs/Ton		39.87	47.26	71.13
Revenues		Annual Tonnage		
Newspaper		16,500	11,000	5,500
Corrugated Cardboard		6,172	4,115	2,057
Mixed Paper		6,172	4,115	2,057
Glass		13,578	9,052	4,526
Tin Cans		2,057	1,372	686
PET Plastic		181	121	60
HDPE Plastic		1,852	1,234	617
Aluminum		288	192	96
Total		46,800	31,200	15,600
	Revenues per Ton($)	Annual Revenues		
Newspaper	5	82,499	54,999	27,500
Corrugated Cardboard	30	185,159	123,439	61,720
Mixed Paper	0	0	0	0
Glass	50	678,917	452,611	226,306
Tin Cans	60	123,439	82,293	41,146
PET Plastic	140	25,346	16,897	8,449
HDPE Plastic	120	222,191	148,127	74,064
Aluminum	1,000	288,025	192,017	96,008
Total Revenues		1,605,577	1,070,384	535,192
Net Annual Cost		260,111	404,178	574,429
Cost per Ton		5.56	12.95	36.82

ANNUAL PER TON CAPITAL AND OPERATING COSTS - MRF

Capacity	180	120	60
Annualized Capital Costs	$14.96	$18.00	$29.46
Design/Engineering	$1.25	$1.57	$2.50
Site	$5.17	$6.51	$10.99
Handling	$1.65	$1.63	$1.94
Separation	$3.11	$3.91	$6.45
Processing	$3.44	$4.01	$7.01
General/Acceptance Test	$0.33	$0.38	$0.56
Annual O & M	$24.91	$29.26	$41.67
Labor	$16.76	$20.37	$30.33
Utilities	$0.66	$0.83	$1.28
Insurance	$0.64	$0.80	$1.28
Maintenance	$1.71	$1.86	$2.56
Supplies	$2.14	$2.40	$3.21
Residue Disposal	$3.00	$3.00	$3.00
Total Annual Costs	$39.87	$47.26	$71.13

TABLE 5-7
(Continued)

LIFECYCLE COSTS

Per Ton Cost (nominal dollars)	Year	5.87	13.44	37.80
		6.20	13.96	38.84
		6.57	14.51	39.93
		6.96	15.10	41.07
		7.38	15.72	42.28
		7.84	16.39	43.55
		8.33	17.10	44.89
		10.29	19.43	48.90
		10.84	20.23	50.38
		11.44	21.07	51.93
		12.08	21.97	53.56
		12.76	22.92	55.27
		13.49	23.92	57.07
		14.26	24.98	58.96
		18.62	30.23	67.60
		19.49	31.42	69.68
		20.42	32.67	71.86
		21.40	33.99	74.14
		22.44	35.38	76.54
		23.54	36.85	79.05
1990 Present Value of Lifetime per Ton Costs		5.92	11.05	27.43

Summary Analysis of Recycling Facilities Costs

Three different types of recycling facilities were analyzed. Representing a range of technical sophistication from the simplest drop-off facility to the most complex materials recovery facility. These facilities have a range a daily capacities from facilities capable of servicing one small community to those sized for a large proportion the state's population.

Several clear conclusions can be drawn from our analysis. First, clear economies of scale were found for all types of facilities. This result should not be surprising, as fixed equipment and facility infrastructure costs, combined with more efficient use of labor result in lower costs as capacity increases.

In addition, there was a clear "economy of scale" across the three types of facilities, with the larger materials recovery facility (180 TPD) being more cost effective than the largest recycling depot (50 TPD), and the largest recycling depot being more cost effective than the largest drop-off facility (11.5 TPD).

One of the major sources of cost-efficiency in larger, more technically advanced facilities is the lower cost per ton for labor. This trend of decreasing labor costs coupled with increasing capacity is found for all facility types, reflecting the greater automation of processing and separation systems in larger facilities. Economies of scale are found because equipment is more fully utilized as capacity increases. Economies of scale are also found for capital costs of the individual pieces of equipment.

Caution should be exercised in directly comparing the costs of different types of recycling facilities. The three types of facilities do not process the same materials. Therefore waste stream reduction potential will differ among the three facilities. For instance, an MRF handles more grades of paper (with a lower average revenue than the other materials) than does the depot; the depot requires larger capital and operations expenditures than simpler facilities, but also offers a larger material diversion potential. These comparisons across facility types can only be performed accurately in the context of an integrated system analysis, which will be the focus of the Part B of this report.

6. LEAF AND YARDWASTE COMPOSTING TECHNOLOGIES

Chapter 6 describes four different technologies for composting leaves and yardwaste. We will refer to them as minimal, low, intermediate, and high level technology systems.

MINIMAL TECHNOLOGY

Minimal level technology composting is the simplest method of composting yard waste. However, it requires the longest composting period and the most land area. It requires the least amount of labor and equipment among the available options. Material is piled into large windrows up to 12 feet tall and 25 feet wide at the base, and is turned with a front-end loader approximately once a year. The material can be watered prior to formation of the windrows, although this is usually not necessary. Approximately 3 years are required to complete the process of composting using this method. For this process the area required is calculated based on an estimate by Strom and Finstein of Rutgers University of 4000 cubic yards of material per acre.

Minimal level technology composting does not involve frequent aeration of the composting material. A large portion of the windrow will remain anaerobic between yearly turnings. Offensive odors are generated throughout the year, but are especially apparent during the pile turnings. The composting area should be located as far as possible from residences to avoid complaints. A buffer zone of at least one quarter mile is recommended.

Existing Minimal Technology Composting Sites: Weston, and Wellesley, MA

Pros:

- Requires minimal labor hours;
- Requires minimal equipment time;
- A large quantity of leaves per acre can be composted;
- A compost pad need not be constructed.

Cons:

- Stabilization of compost product requires 3 years;
- The composting area must be able to accommodate at least 3 years of material;

- Leachate can be a problem if soil type has low percolation rate;
- Large buffer zones are necessary.

LOW TECHNOLOGY COMPOSTING

Low technology composting is the most common method of yard waste composting practiced in the United States. This method optimizes parameters for the composting process for faster production of stabilized compost without the purchase of specialized equipment. A front-end loader is the only piece of equipment required. Land area of one acre for every 4000 to 6000 cubic yards of material is needed, with the allowance of a buffer zone. The site requires a soil pad to support heavy machinery and provide good drainage. Stabilization is achieved in 12 to 18 months, depending on the material and composting conditions. Post processing, such as screening or shredding, may occur if necessary.

Material to be composted is watered, if necessary, to a moisture content of 50 percent before formation into windrows. Windrows 6 to 10 feet high and 15 to 20 feet wide at the base are formed with a front-end loader, allowing adequate spacing between windrows for loader access. After a month, windrows decrease substantially in size due to settling of material and rapid decomposition. At this point, two windrows can be combined to form one the original size. This conserves space and helps the windrows retain heat during the winter months.

Turning windrows mixes and aerates the material. Turning schedules are based on temperature and moisture content monitoring. When the windrow temperature drops below 100 degrees F, or if the moisture content is significantly different from 50 percent, the windrows are turned and water added if necessary. However, it is important to avoid excess turning during cold winter months, because the heat loss due to turning can slow the composting process. More frequent turning in the warmer months ensures adequate mixing and minimal odor generation. A distance of approximately 200 feet between the composting area and residences is required for noise as well as odor buffering.

Existing Low Technology Composting Sites: Newton, MA and Paramus, NJ

Pros:

- No specialized equipment is needed;
- Labor requirements are moderate and can be somewhat flexible.

Cons:

- Stabilization of compost product requires 12-18 months;
- Site must accommodate more than one years' material;
- Post processing may be necessary to produce a high quality compost.

INTERMEDIATE TECHNOLOGY COMPOSTING

Where land area limitations are important, intermediate level technology may be the most appropriate composting method. This method calls for the utilization of specialized windrow turning equipment to size reduce and aerate material for accelerated decomposition. Turning frequency is on the order of once a week. Stabilized compost can be produced in 4 to 8 months, depending on the material and the frequency of turning. For a fixed volume of input material, land area requirements for this composting method are higher than for low level technology because windrow height is limited by the constraints of the windrow turner. Approximately 3000 cubic yards per acre can be composted, and a buffer zone of approximately 200 feet should be allowed. In addition, this method requires a composting pad that can withstand the frequent use of heavy equipment without forming ruts. A reinforced concrete pad is ideal.

An alternative approach involves reducing the initial volume of material without windrow turning equipment. A tub mill grinder or similar equipment may be used. Material is ground and adjusted to the proper moisture level prior to the formation of windrows. Then windrows can be turned using a front-end loader, avoiding the height constraints mentioned above. Up to 8000 to 9000 cubic yards per acre can be composted. The turning schedule described above should be followed. Post processing may also be desirable to improve the texture of the final product.

Capital costs for both windrow turning and size reducing equipment are high, and the equipment is often not in constant use. This makes sharing arrangements with nearby municipalities possible. Time sharing arrangements have been made with as many as four communities for the use of a tubmill grinder. Capital costs can be shared in this way, although transportation and maintenance issues can be problematic under such arrangements.

Existing Intermediate Technology Composting Sites: Springfield, MA, Islip, NY, and Bristol, CT.

Pros:

- Finished compost product can be removed from the site in less than 1 year;
- Composting area need only accommodate 1 years' material.

Cons:

- Capital cost of specialized equipment is high;
- A concrete pad must be constructed or a soil pad may require high maintenance;
- Labor requirements are higher than other composting methods.

HIGH TECHNOLOGY COMPOSTING

High technology composting involves the utilization of static pile or in-vessel systems developed initially for the composting of sludge. These systems are used for the co-composting of sludge or food waste and yard waste. Yard waste serves as an amendment or bulking agent for the other waste material. These combinations of materials require more rigorous process control than is possible by the previously described technologies. Odor can be controlled more effectively with static pile or in-vessel composting. The cost of these technologies is high, and the decision to employ them will be based on the need to manage a waste stream consisting of more than yard waste.

Static pile composting is accomplished by using a forced aeration system located under the pile of composting material. A temperature feedback system is preset to turn on blowers when the pile reaches a certain temperature. The forced air removes excess heat and aerates the pile. Under the optimized conditions produced by this method, the active composting process is completed in 3 to 5 weeks. The material is then moved to a curing pad where additional decomposition and drying will take place. The curing period generally lasts from 4 to 8 weeks.

In-vessel systems include a number of technologies for aerating and mixing composting material within an enclosed vessel. Many of these technologies require the material to meet specific requirements in moisture content and particle size. Some of the technologies can be adapted for the co-composting of ground yard waste with sludge or solid waste, provided all the parameter specifications are met. Some of these systems do not complete the stabilization of the compost in the enclosed structure, so they require further composting using windrow or static pile systems.

Existing High Technology Composting Sites: Fairfield and Greenwich, CT

Pros:

- Two waste streams can be handled at the same time in a complementary fashion;
- Nutrient content of compost may be enhanced through the combination of materials.

Cons:

- A composting building including concrete pad must be constructed;
- Labor requirement is higher to oversee process;.
- Waste streams other than yard waste can contribute significantly to odor problems.

COST ANALYSIS OF LEAF AND YARDWASTE COMPOSTING FACILITIES

Cost analyses are presented for the low and intermediate technology systems. Three different sizes are considered for each technology: 5000 C.Y, 10,000 C.Y., and 20,000 C.Y. These analyses are discussed below and summarized in Figures 6-1 and 6-2. The details appear in Table 6-1.

LOW TECHNOLOGY WINDROW COMPOSTING FACILITY

Assumptions

An acre of land is needed for each 5000 C.Y. of leaves. Volume reduction due to settling and decomposition of leaves is assumed to be 50 percent during the first year. Therefore, for an 18 month composting period, 1.5 acres are needed for a 5000 C.Y. facility (the first year's leaves will have decreased in volume to 2500 C.Y., requiring one half acre, and the second year's leaves will require a full acre). A 10,000 C.Y. facility will require 3 acres and a 20,000 C.Y. facility will require 6 acres. The cost of site preparation assumed in our analysis takes into account the full acreage necessary for these sites, although the cost of windrow formation and turning only accounts for one year's leaves. Our specific assumptions are as follows:

- Clearing and grading costs are $1,500/acre plus $400 for equipment delivery;
- Gate costs are $500 for materials and installation;
- Windrow height is 8 ft, windrow width is 20 ft.;
- For windrow formation, a 4 C.Y. bucket can turn 480 C.Y. of leaves per hour, assuming 5000 C.Y. per acre and 10.4 hours per acre;
- Windrows will be turned only 6 times over the 18 month period, but the average volume being turned will be half of the incoming volume;
- In calculating cost per ton, average bulk density of leaves is 300 lbs/C.Y.
- Front-end loader use and costs are defined below:

	5000 CY	10000 CY	20000 CY
Estimated days of loader time (windrow formation + turning)	2 + 6	3 + 12	6 + 18
Add 50% safety factor (days)	12	22	36
Percentage of total 390 days (18 months of working days)	3%	6%	9%
Capital costs allocated to program (for 18 months) based on loader cost of $100,000 amortized at 10% over 10 years	732	1465	2197

Capital and Operating Costs

The only significant capital cost is the compost site (land and side preparation) and a front-end loader for forming and turning the windrows. These annuals costs range from $3.75 per ton for the 15 acre site holding 5,000 cubic yards to $3.33 per ton for the 6 acre site holding 20,000 cubic yards.

Equipment use is proportional to the amount of material on the site, so the costs of the facility show little economies of scale. The small economies of scale that exist result primarily from the front-end loader costs, which the larger site is able to use slightly more efficiently. The time required to transport the loader to the site each time the windrows are turned is necessary regardless of the site size.

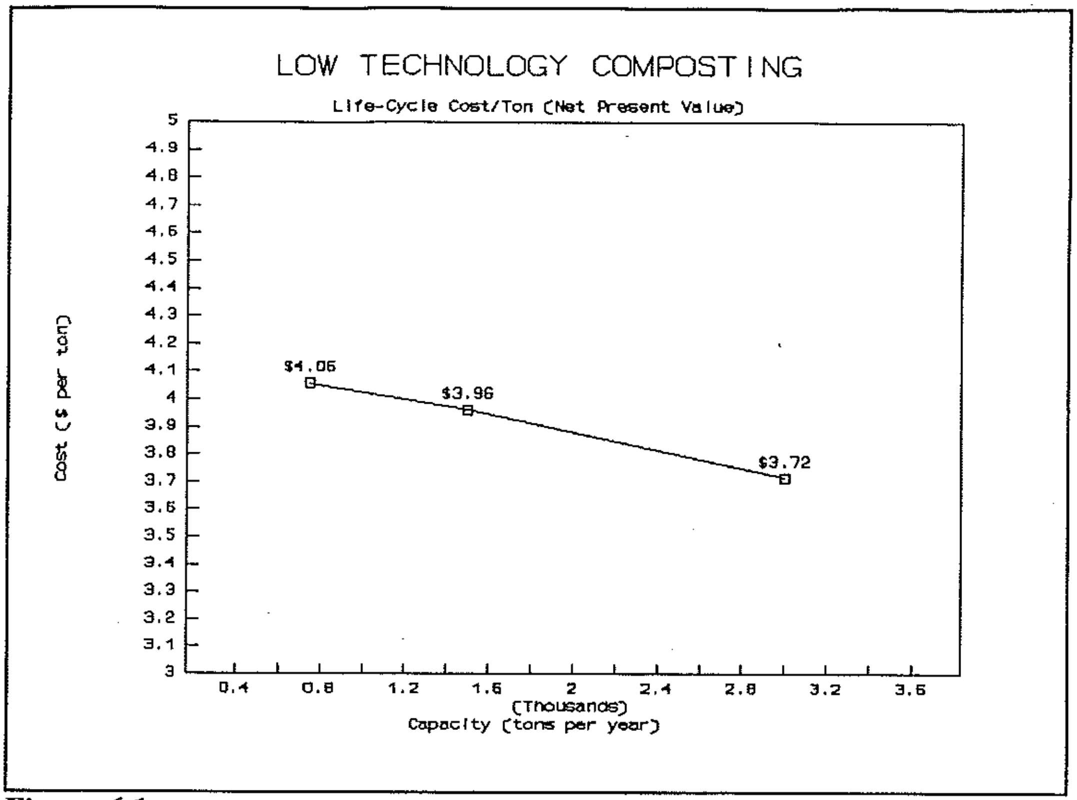


Figure 6-1

INTERMEDIATE TECHNOLOGY COMPOSTING FACILITY
(USING A WILDCAT WINDROW TURNER)

Assumptions

- Most of the assumptions for the intermediate process are similar to the low Technology assumptions. The following describes assumprions that differ:
- Gravel pad - A 6 inch pad is assumed, or 800 C.Y./acre.
- Windrow turner use and costs are defined below:

Wildcat Model	C700	CX700	CX750
Capacity/hr	700 C.Y./hr	1400 C.Y./hr	2000 C.Y./hr
Maximum windrow height	4 ft	5 ft	5 ft
Windrow width	8 ft	10 ft	10 ft
Wildcat windrow turner costs	$17,500	$30,000	$70,000
Cost of front end loader	$42,000	$100,000	$100,000
Windrow layout at each site	2500 C.Y./acre	3000 C.Y./acre	3000 C.Y./acre

Materials handling assumptions - Leaves delivered to the site will be handled 3 times with a loader. The three "handlings" are initial windrow layout, pile combination for the winter and windrow re-layout in spring. Each handling requires 6.3 hrs/acre based on the 480 C.Y. of leaves/hr assumption above. The Wildcat will turn the leaves 2 - 4 times in the fall, and every week for 6 months in the spring and summer, or 30 times total. Operational costs for the loader are estimated at $8/hr and $2/hr for the Wildcat. The average volume of leaves turned by the Wildcat will be decreased to half the original volume in the spring. The time needed to turn the compost is calculated by dividing the volume (half the original cubic yards) by the capacity of the turner.

Capital Cost Analysis

The variation in the cost structure of the Intermediate Technology Composting Facility is relatively small and is driven once again, in large measure by the capital and operating costs of the front-end loader. Because the front-end loader is not kept on site, the time spent bringing the loader to the site for each windrow turning is constant, regardless of the amount of leaves turned. This results in relatively large economies of scale for the turnings, since for this volume of leaves, the time required to actually turn the leaves is small.

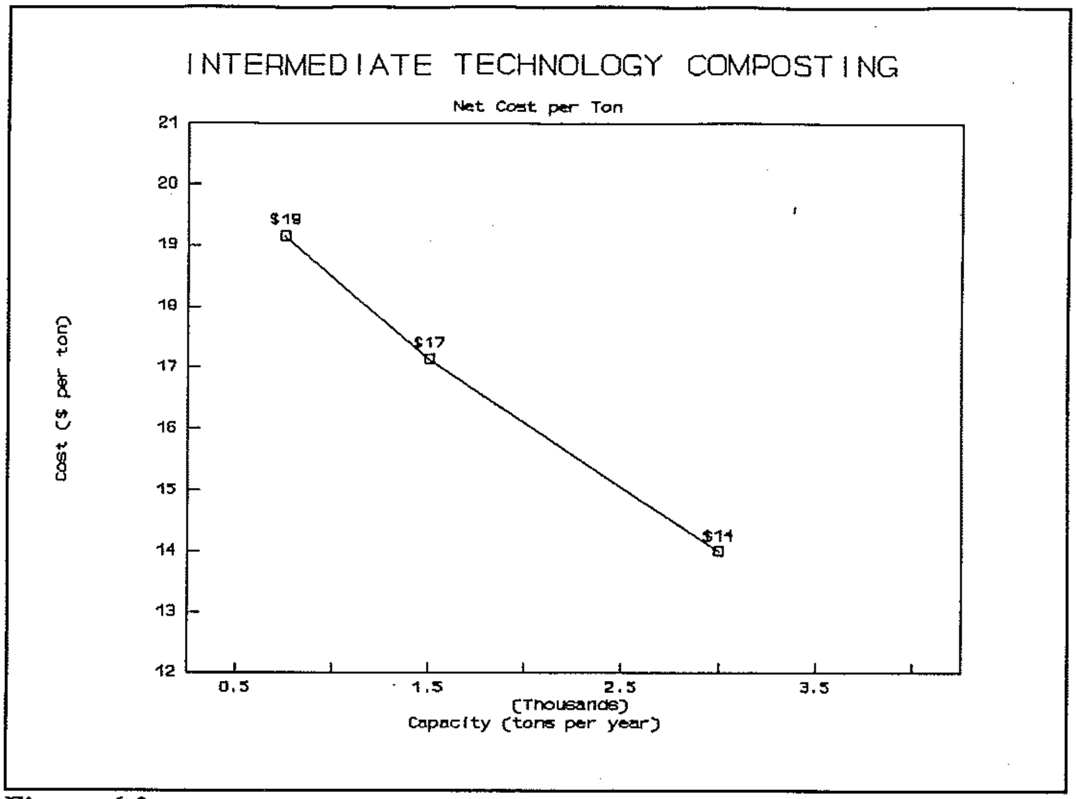


Figure 6-2

Operating Cost Analysis

In the case of the windrow turning system, the time spent turning the windrows on the 2 acre site is identical to the time spent turning the windrows on the 3.5 acre site, even though the volume (and tonnage) is twice as large. This is because the capacity of the windrow turner on the larger site is twice as great as the capacity of the windrow turner used on the smaller site. Thus, the total operations cost of each site is the same, but the larger site handles twice the volume (and tonnage) of material, thus producing the observed economies of scale.

Comparison of the Cost Structure of the Low Technology Composting System vs the Intermediate Technology Composting System

The most striking result of this analysis is not the economies of scale within each of the composting systems, but rather the much lower cost of the Low Technology System versus the Intermediate Technology System (Compare Figure 6-1 with 6-2). There are several reasons for this result.

The first reason is in the difference between the pad required for operation of a dedicated windrow turning machine (intermediate technology) and the pad required for a front end loader (low technology). The thickness of the pad in the first case is 6 inches while no special pad was constructed in the second case. This makes pad construction much more expensive when using a dedicated windrow turner.

The second reason for increased costs in the Intermediate Technology case stems from the restrictions placed on the windrow dimensions by use of a windrow turner compared to a front end loader, and the corresponding increase in acreage required. As the assumptions indicate, the maximum dimensions when using a front end loader are 8 ft. high and 20 ft. wide. The maximum dimensions when using the larger windrow turner used in this analysis are 5 ft high and 10 ft. wide. Although the decomposition rate is increased by the windrow turner, this change does not offset the impact of lower initial volume per acre.

The final reason for the dramatically increased cost of the Intermediate System over the Low Technology System is found in capital cost of the windrow turning equipment. The Intermediate System requires both a dedicated windrow turner and half time use of a front end loader, while the Low Technology System requires only 10% time use of a front end loader because fewer turnings are required.

It is possible that, under certain conditions, Low Technology Systems become more expensive and Intermediate Technology Systems become less expensive. This occurs only for facilities larger than any feasible size of leave and yardwaste facility in the state of Vermont.

TABLE 6-1

VERMONT LEAF AND YARD WASTE COMPOSTING FACILITY

LOW TECHNOLOGY COMPOSTING FACILITY		Assuming 5000 CY/acre - 18 months		
FACILITY SIZE		5000 CY	10,000 CY	20,000 CY
SITE WORK		1.5 AC SITE	3 AC SITE	6 AC SITE
Land		7,500	15,000	30,000
Clearing/grading		2,650	4,900	9,400
Gate		500	500	500
Subtotal		10,650	20,400	39,900
Annualized debt payment 8.5% over 7 years		2,081	3,986	7,795
CAPITAL COSTS				
Front end loader -- $100,000 cost; annual payment of $16,275. Cost allocated according to time used.		732	1,465	2,197
1990 OPERATIONAL COSTS				
Windrow formation Labor cost per acre ($12/hr x 10.4 hrs/acre) Loader op. costs ($8/hr x 10.4 hrs/acre)		208	416	832
Windrow turning 6 times over 18 months assume volume reduction of 50%		624	1,248	2,496
1990 TOTAL OPERATIONAL COSTS		832	1,664	3,328
1990 TOTAL PRODUCTION COSTS		3,645	7,115	13,320
COST/TON assume 300 lb/CY		4.86	4.74	4.44
LIFECYCLE COSTS				
Per Ton Cost (nominal $) Year	1	4.86	4.74	4.44
	2	4.90	4.79	4.48
	3	4.95	4.83	4.53
	4	5.00	4.88	4.58
	5	5.05	4.93	4.63
	6	5.10	4.98	4.68
	7	5.15	5.04	4.73
1990 Present Value of Lifetime per Ton Costs		4.06	3.96	3.72

7. MIXED SOLID WASTE (MSW) COMPOSTING FACILITIES

This chapter describes systems for composting mixed municipal solid waste. In general all of the methods involve some type of preprocessing before the material is composted. The composting process can take place using one of three systems: a windrow system, a static pile system, or an in-vessel system.

MSW composting is the process of decomposing the organic fraction of the waste stream into a useable end product under controlled conditions. This waste management practice is becoming more prevalent in the United States. It has been utilized for many years in Europe and Japan. In this process food waste, yard waste, paper, and miscellaneous organics, the sum of which comprises a large portion of the waste stream, are composted in a system designed to handle such materials.

MSW composting systems involve 3 basic steps:

- Pre-processing
- Composting
- Post-processing.

PRE-PROCESSING SYSTEMS

Pre-processing is necessary to sort and prepare the material for composting. Effective pre-processing is particularly important for material that is not source separated. Three steps are involved in pre-processing: removal of over-sized items and marketable materials, particle size reduction, and classification.

Over-sized items, such as furniture and white goods, must be removed prior to all other activities. The remaining material is then hand sorted to remove recyclable materials, or size reduced "as is". Various types of shredders or grinding equipment can be used for size reduction. The more the material is size reduced, the more rapid the composting process will be. This is true because composting is a surface area phenomenon, so the efficiency increases as the average particle size is decreases.

In pre-processing, classification equipment separates the material into its component parts. Magnetic separators remove ferrous metals, screens -- such as rotary trommel screens -- separate material based on particle size, and air classifiers and ballistic separators sort material based on physical characteristics, such as weight or shape.

TABLE 6-1
(Continued)

VERMONT LEAF AND YARD WASTE COMPOSTING FACILITY

INTERMEDIATE LEVEL WITH WILDCAT	12 month composting period		
FACILITY SIZE	5000 CY	10,000 CY	20,000 CY
SITE WORK	2 ACRES	3.5 ACRES	7 ACRES
Land	10,000	17,500	35,000
Clearing/grading	3,400	5,650	10,900
Gravel:			
800 CY/AC @ $6.50/CY	10,400	18,200	36,400
Gate	500	500	500
TOTAL SITE COSTS	24,300	41,850	82,800
Annualized debt payment			
8.5% over 10 years	3,704	6,378	12,619
CAPITAL COSTS			
Cost of approp.model Wildcat	17,500	30,000	70,000
Annualized debt payment			
8.5% over 7 years	3,419	5,861	13,676
Loader/tractor			
50% of cost, 8.5% over 7 years	4,103	9,768	9,768
TOTAL ANNUALIZED CAPITAL COSTS	7,522	15,630	23,444
OPERATIONAL COSTS			
Windrow formation	252	441	882
3000 cy/ac, 6.3 hrs.handling			
Windrow combining/layout	504	882	1,764
30 Wildcat turnings			
operation @ $10/hr	1,080	1,080	1,500
labor @ $12/hr	1,300	1,300	1,800
TOTAL OPERATIONAL	3,136	3,703	5,946
TOTAL COST	14,361	25,711	42,010
COST PER TON	19.15	17.14	14.00
LIFECYCLE COSTS Lifetime Costs (1990 $)	83,835	148,831	243,111
Per Ton Cost (nominal dollars) Year 1	19.15	17.14	14.00
2	19.32	17.24	14.08
3	19.49	17.34	14.16
4	19.67	17.45	14.25
5	19.86	17.56	14.34
6	20.05	17.68	14.43
7	20.26	17.80	14.53
1990 Present Value of Lifetime per Ton Costs	15.97	14.17	11.58

in height. The pile is covered with finished compost for insulation. Positive or negative aeration is used to provide oxygen to the decomposing material and cool the pile when the temperature exceeds a preset level. The active composting period ranges from three to five weeks, after which time the material is moved to a curing area. Stabilization requires an additional six to nine weeks. Most static pile systems are covered by a roof, although this is not necessary.

Existing static pile facilities: Such facilities exist in Tolmezzo and Ceresara, Italy

Pros:

- System is mechanically simple;
- Requires less land area than windrow composting;
- Low capital cost of equipment;
- Better odor control than windrow composting;
- No mechanical mixing of material is necessary.

Cons:

- Land area requirement is higher than for in-vessel systems;
- Heterogeneous material mixtures may lead to "short circuiting" in aeration, so pockets of unstabilized material may result.

In-vessel Composting Systems

In-vessel composting systems carry out the composting process in an enclosed system. These systems are usually mechanized to decrease the labor requirements. Many systems do not complete the composting process, and so rely on post-vessel windrow or static pile composting for stabilization. In-vessel systems can be broken into four main categories: drum composter, circular agitated bed, silo - vertical plug flow, agitated bin.

The drum composter is a long, horizontal cylinder which rotates slowly. Material is introduced in one end and tumbled down the length of the cylinder. Decomposition occurring in the cylinder increases the temperature. The tumbling action reduces the particle size and promotes further decomposition. The material remains in the cylinder from three to six days. After this time it is discharged for further composting or curing.

The circular agitated bed is a large diameter digester with a series of augers mounted on a rotating bridge. Material to be composted is introduced into the digester. The bridge rotates clockwise while the augers turn to mix and aerate the material. Composted material is moved toward a central discharge port after 10 days. The material is then moved to a curing area for further stabilization.

COMPOSTING PROCESS

Once the material is prepared, a number of different composting methods can be used. These methods can be broken into three general categories: windrow composting, static pile composting, and in-vessel composting. Combinations of these three methods are often used to complete the composting process.

Windrow Composting

Windrow composting involves forming wastes into elongated piles 4 to 6 feet high and 12 to 18 feet wide at the base. The material is aerated by turning it periodically with a front-end loader or, more effectively, with a windrow turning machine. The active composting period will range from four to eight weeks, depending on particle size and frequency of turning. After this period, the material is moved to curing piles, where it remains for six to nine weeks to complete its stabilization.

Windrow composting must be carried out on a concrete pad, both to support the heavy equipment needed for pile turning, and to protect the environment from leachate contamination. A roofed structure is necessary to protect the compost from the elements. An enclosed building is desirable to control odor emissions.

Existing windrow composting facilities: Barcelona, Spain, and Falkenberg, Sweden

Pros:

- The system is mechanically simple;
- Capital costs for equipment are low;
- Ease in handling a large quantity of material, and in facility expansion.

Cons:

- Land area requirements are high;
- Capital costs for the structure can be high;.
- Incomplete mixing may result in pathogen survival and unstabilized material;
- Odors cannot be easily controlled.

Static Pile Composting

Static pile composting makes use of an aeration system located underneath the composting material. Perforated pipes are connected to blowers which force or draw air though material. The waste mixture is deposited on top of the pipes in piles up to 6 feet

The vertical plug flow system is a concrete tower which is open on the top. Material is fed into the top, and an extractor screw unit discharges material from the bottom. Material is aerated on its trip down the tower by air jets on the side or bottom. Material remains in this system for 25 to 35 days.

The agitated bin system consists of horizontal concrete channels equipped with one of a variety of mechanical mixing devices. Material is introduced into one end of the channel and is advanced and aerated by the mixers until it is discharged at the other end. Aeration jets may also be included. Material remains in the bins from 15 to 20 days.

Existing In-vessel Composting Systems: Such systems are in use in Duisburg, Germany and Big Sandy, TX (drum composter), Wilmington, DE (circular agitated bed), Brazilia, Brazil (vertical plug flow), Lebanon, CT (agitated bin).

Pros:

- Low land area requirements;
- Overhead air volume is minimized, which reduces the cost of odor control equipment;
- Leachate is easily contained;
- Labor costs should be minimized;
- Agitated systems produce homogeneous product.

Cons:

- Capital costs are high;
- Most operating systems accommodate smaller volumes than windrow or static pile systems;
- Systems that do not provide for mixing may have pockets of unstabilized material;
- Mechanical break-downs can cause delays and high maintenance costs;
- Systems with short residence time in the reactor rely on windrow or static pile composting to complete the composting process.

COST ANALYSIS FOR SOLID WASTE COMPOSTING FACILITIES

Assumptions:

- Receiving area - Space for 2 day storage
  Convert TPD to C.Y. using bulk density of 500 lb/C.Y. Assume MSW piled 10 ft high as a basis to calculate floor space needed.

- Composting area - Assume 20% of incoming material is rejected, remainder gets shredded and densified (new bulk density is approx 750 lbs/C.Y.) Floor space needed for composting is 250 - 300 sf/C.Y. A forced air system is employed to speed the composting process.

- Receiving and processing building costs - $50/sf

- Composting building costs - $25/sf

- Curing area costs - $1.5/sf

- Land cost - $5000/acre

- Equipment sizing: Shear shredders can handle up to 50 tons per hour (daily throughput divided by 7 hours working time. Above that volume, hammermills are necessary. Two trommels are needed for the medium and the large facility. Medium throughput trommels, up to 25 TPH, cost approx $150,000. Large throughput trommels (50 TPH) cost $250,000 each.

- Annualized capital cost - Amortize all capital costs at 10% over 20 years.

- Personnel requirements - Salaries: supervisor - $35,000, Equipment operators - $25,000, mechanic and electrician - $30,000, Laborers and scale operators - $20,000.

- Electricity costs - $0.08/kwh

- Maintenance and supplies - Moving equipment and shredder maintenance is 0.075 of cost, structures and other processing equipment is 0.025 of cost.

- Landfill cost - Assume 20% material rejected, multiply tonnage by $25/ton.

Cost Analysis of Solid Waste Composting Facilities

The results of the cost analysis of the solid waste composting facilities shown in Table 7-1 exhibit definite economies of scale. The source of these economies of scale can be broken down into three categories: buildings effects, equipment effects, and operating costs effects. Their aggregate effect is shown in Figure 7-1 below.

Buildings

Building costs show relatively little economies of scale because growth in building cost is similar to growth in facility throughput. The size of the composting and curing areas are directly proportional to amount of material being processed, because windrow sizes are constant regardless of the size of the facility. Since these costs are the majority of building costs, total building costs per ton of capacity are relatively fixed.

The result of this effect, is that the building cost per ton of daily throughput decreases from $33,000 to $28,100 to $24,600 as the size of the facility increases from 80 to 150 to 400 tons per day.

Equipment

Costs of equipment per ton of daily throughput for the 80, 150, and 400 TPD facilities are $14,900, $12,800 and $8,200 respectively. Several factors produce this result.

The most important factor is that equipment costs are not linearly related to throughput. Several pieces of equipment in a solid waste composting facility, such as the shredders, magnetic separators, mixers, and rolling stock related equipment such as scales, roll off containers, bobcats, front end loaders and windrow turners, are required for even the smallest size facility. However, once they are purchased they can process a relatively wide range of throughput. There isn't one size magnetic separator for 80 TPD and another for 150. Once you've got a machine that will meet the requirements of separating the ferrous metal from 80 TPD, it will also handle 150.

The effect of both building and equipment cost economies of scale is to produce a per ton annualized capital cost of $27 for the 80 TPD facility, $25 for the 150, and $20 for the 400 TPD facility.

Operating Costs:

There are also marked, though less dramatic, economies of scale in operating costs for facilities in the 80 to 400 TPD range. The major source of these economies is labor costs. This finding is directly related to equipment costs discussed above. For the most part, laborers are attending to equipment that can process a range of tonnages in the same period of time. Thus, as throughput increases, labor costs do not increase proportionately. Rather the existing labor can process more material with the same labor inputs. Additional workers are added as new pieces of equipment are added (for example, use of a second front end loader) and as increased residue hauling and disposal are required. The labor cost per ton of throughput decreases from $7.75/ton in the 80 TPD plant to $2.95/ton in the 400 TPD plant. This produces almost 75% of the total operating cost decrease from $23/ton in the 80 TPD plant to $16 in the 400 TPD plant. Most of the remaining effect is associated with less than proportional increases in maintenance and supplies.

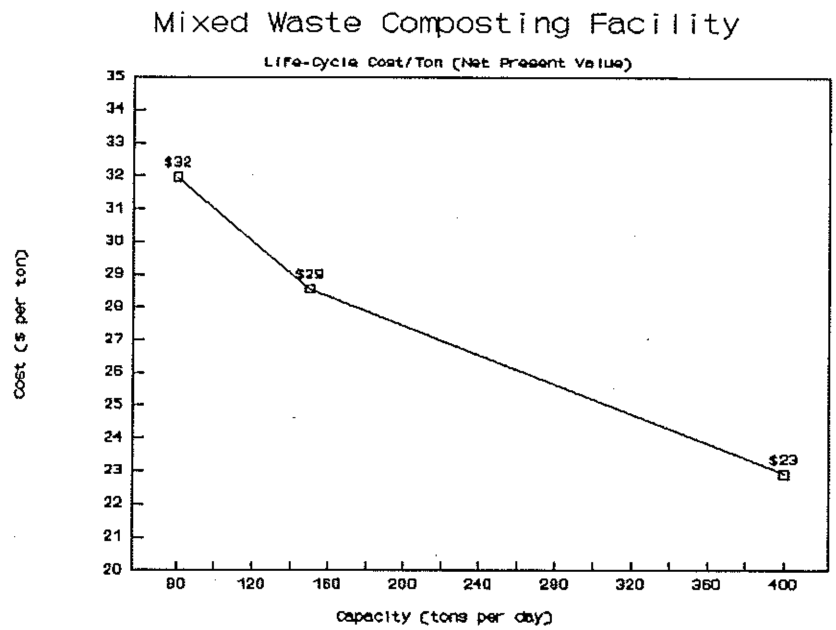


Figure 7-1

Summary of Cost Analysis

The net result of these building, equipment, and operating cost effects is to produce a net present value of the lifetime cost per ton for the 80 TPD plant of $32/ton, $29/ton for the 150 TPD plant, and $23 for the 400 TPD plant. We should note that this analysis makes the conservative assumption that the compost produced by this process is removed at $0 revenue. The inclusion of non-zero revenues would lower the cost for all of the facilities, proportionately to their throughput.

TABLE 7-1

VERMONT SOLID WASTE COMPOSTING FACILITIES

Capacity (TPD)		80		150		400
BUILDINGS	AREA REQ. (x1000 sf)	THOUSAND $	AREA REQ. (x1000 sf)	THOUSAND $	AREA REQ. (x1000 sf)	THOUSAND $
Receiving area	3.3	165.0	4.8	240.0	9.0	450.0
Processing area	6.7	335.0	9.6	480.0	32.0	1600.0
Composting area	71.0	1775.0	133.0	3325.0	354.0	8850.0
Curing area	47.0	70.5	87.0	130.5	233.0	349.5
TOTAL BUILDING COST		2345.5		4175.5		11249.5
$/TPD - BUILDINGS		29.3		27.8		28.1
LAND REQ. (acres)	2.9	14.7	5.4	26.9	14.4	72.2
EQUIPMENT						
Shredder		120.0		250.0		250.0
Mag.separator		90.0		90.0		100.0
Mixer		25.0		25.0		30.0
Conveyors		120.0		380.0		1000.0
Trommels		100.0		300.0		500.0
Windrow aeration system		40.0		75.0		400.0
Compost screen		90.0		90.0		180.0
Truck scale		85.0		85.0		85.0
Roll off containers	3.0	12.0	3.0	12.0	6.0	24.0
Front end loaders	2.0	200.0	3.0	300.0	3.0	300.0
Windrow machine		180.0		180.0		180.0
Roll off truck		115.0		115.0		230.0
Bobcat		15.0		15.0		15.0
TOTAL EQUIP. COSTS		1192.0		1917.0		3294.0
$/TPD - Capital Costs		14.9		12.8		8.2
30% eng./fees		357.6		575.1		988.2
TOTAL COSTS		3909.8		6694.5		15603.9
$/TPD - Capital Costs		48.9		44.6		39.0
ANNUALIZED PAYMENT		553.5		933.4		2039.5
$/Ton - Annualized Payment		27.67		24.89		20.39

TABLE 7-1
(continued)

		80		150		400
ANNUAL OPERATIONS AND MAINTENANCE						
LABOR	WORKERS	SALARY	WORKERS	SALARY	WORKERS	SALARY
Supervisor	1.0	35.0	1.0	35.0	1.0	35.0
Equip.operators	2.0	50.0	3.0	75.0	4.0	100.0
Mechanic/electrician	1.0	30.0	2.0	60.0	2.0	60.0
Laborer/scale operator	2.0	40.0	3.0	60.0	5.0	100.0
TOTAL LABOR		155.0		230.0		295.0
$/TON - Labor		7.75		6.13		2.95
OTHER O&M COSTS	(x 1000)	DOLLARS	(x 1000)	DOLLARS	(x 1000)	DOLLARS
Fuel (gal)	25.0	25.0	34.0	34.0	125.0	125.0
Elec.(kwh)	650.0	52.0	1350.0	108.0	3300.0	264.0
Maint./supplies		119.9		195.3		412.3
Landfill/rejects	4.0	100.0	7.5	187.5	20.0	500.0
Subtotal		296.9		524.8		1301.3
TOTAL O&M		451.9		754.8		1596.3
$/TON - O&M		22.6		20.1		16.0
TOTAL COSTS		1005.4		1688.2		3635.8
$/TON - Capital and O&M		50.27		45.02		36.36
LIFECYCLE COSTS						
Per Ton Costs	Year					
(nominal dollars)	1	49.07		43.93		35.44
	2	49.97		44.73		36.08
	3	50.91		45.57		36.74
	4	51.89		46.44		37.43
	5	52.91		47.34		38.15
	6	53.96		48.29		38.90
	7	55.06		49.27		39.67
	8	56.97		50.94		40.91
	9	58.16		52.00		41.75
	10	59.40		53.11		42.62
	11	60.69		54.25		43.53
	12	62.03		55.44		44.47
	13	63.42		56.68		45.46
	14	64.86		57.97		46.48
	15	71.21		63.46		50.22
	16	72.78		64.86		51.32
	17	74.40		66.31		52.47
	18	76.10		67.82		53.67
	19	77.86		69.38		54.91
	20	79.69		71.02		56.21
1990 Present Value of Lifetime per Ton Costs		31.95		28.56		22.90

8. TRANSFER FACILITIES

Transfer stations for solid waste seve a number of functions: providing self-haul disposal for residents, and giving haulers access to short and long distance disposal facilities. Four types of transfer stations will be analyzed corresponding to these different uses.

- Rural area citizen drop-off;
- Small urban center, suburban drop-off;
- Medium scale tipping floor;
- Long haul transfer facility.

Transfer stations are central collection points where relatively small amounts of waste are collected and consolidated into larger containers. These containers are then used to haul the solid waste to the disposal sites.

The transfer of materials varies primarily with vehicle type, material type, and transfer distance. The transfer weight limit for transporting over highway is 45,000 pounds. For the economic analysis of MSW and recyclable materials, costs vary with compaction rates (lbs. per C.Y.), truck capacity, and travel distances.

COST ANALYSIS OF TRANSFER STATION OPTIONS

Unlike other facilities analyzed in this report, the analysis of the transfer stations is not simply a comparison of different sizes of the same type of facility, but rather different types of facilities. Although they are all solid waste transfer stations, each has a different physical structure and therefore a different capital and operating cost structure as well. Table 8-1 summarizes the results of the cost analysis of the four transfer stations described above. For the rural and small urban center drop-offs, capital, operating, and transportation costs are included. For the medium scale and long-haul facilities, transportation costs are not included, but will be discussed at the end of the section.

Rural Area Citizen Drop-off Facility

Rural area drop-off facilities can serve small communities of up to 5000 people. They are usually open one or two days on a weekend and dedicated for household use. Private waste haulers with vehicles that service bulk containers are required to haul the refuse directly to the disposal site or a larger transfer facility. For the purpose of an economic analysis of a rural area citizen drop-off facility, the following assumptions are made:

- The compactor will have a 1½ cubic yard hopper;
- A 50 cubic yard, open top, roll-off container will be provided for overflow;
- An attendant's shed will be provided;
- Maximum collection capacity: 15 tons/day;
- Facility will be open two days per week.

Cost Analysis of the Rural Drop-off Facility

The rural drop-off transfer station is simply a compactor with a backup roll-off container, a small attendant's shed, and ¼ of a roll off truck (that must be shared with other users). However, because it is handling such a small amount of material (20 tons/week open 2 days per/wk, or the solid waste from approximately 3,000 people) the present value of the lifetime cost per ton is very high, approximately $63/ton. The above capital cost items produce a first year annualized capital cost (including capital reserve) of $20/ton (see Appendix to this section).

The labor component of operations for the rural drop-off facility includes one full time operator, a part time driver, and a part time supervisor. With benefits and overtime provisions the associated costs amount to $30,450/year, which produces a cost of $23/ton just for the labor portion of the 1990 operating cost. With additional operating expenses such as maintenance, utilities, fuel, and minor contracted services, the total 1990 operating cost per ton is $48.

This cost could be reduced by increasing the amount of solid waste handled by this type of transfer station. It is designed to handled 15 tons/day but is only handling 10 tons. Increasing the population base serviced by this transfer station to 4,500 and thus increasing by 50% the amount of material handled would lower the per ton cost from $72/ton to $42/ton. Because of the large operating costs, the net present value of the lifetime costs (about $39 per ton) is lower than the 1990 costs.

Small Urban Center Drop-off Facility

This type of drop-off facility can remain open for up to six days per week (allowing one day per week for maintenance). These facilities have capacities of up to 100 tons per day, requiring a compactor/trailer arrangement for large tonnage and/or long-haul operations. The larger drop-off facilities are designed to allow direct dumping into the compactor.

For a transfer trailer drop-off facility, the following assumptions are made for cost estimating purposes:

- The transfer trailer will have a capacity of 80 C.Y. and will be attached to a 5 C.Y. dual cylinder hopper;
- Two 50 C.Y. roll-off containers will be provided for overflow and bulky wastes;
- The facility will include a tractor for continual removal and replacement of containers during operation;
- Maximum collection capacity: 40 tons/day;
- The facility will be open 6 days per week.

Cost Analysis of the Small Urban Center Drop-off Facility

The physical structure of the small urban drop-off transfer facility is similar to that of the Rural Drop-off Facility. The major difference is a larger compactor and an additional roll-off container. However, because it is open six days per week and handles approximately 25 ton/day, 7,800 tons per year or the solid waste from approximately 22,000 people, it has much lower total annual per ton costs than the rural facility. Total capital costs have only increased slightly due to the larger compactor and additional roll-off. But because of the much larger throughput, annualized capital cost per ton is just $3.50/ton in 1990.

The unit operating costs also show a dramatic decline. The total number of workers goes from 1.5 in the Rural facility to 2.75 in the 25 ton/day small urban facility. There is also a 2-3 fold increase in the utilities and fuel, equipment operation and maintenance and contracted services. However, the 7-fold increase in throughput lowers 1990 per ton operating costs to approximately $13/ton for a net total cost of $16.50/ton. The present value of the lifetime cost is roughly $10 per ton.

Medium Scale Tipping Floor

A tipping floor transfer station consists of a transfer trailer and a concrete tipping floor on which packer vehicles and autos dump their refuse. The transfer trailer is located in a trench which is deeper than the trailer height. Front end loaders are used to move the refuse from the tipping floor to the transfer trailer. Packer vehicles can back into position and unload their refuse directly into the transfer trailer where the waste is distributed and compacted by a crane. Scales are provided to measure the incoming and/or outgoing waste.

For a medium scale tipping floor, the following assumptions are made for cost estimating purposes:

- The transfer station is of the tipping floor type, with waste pushed into trailers in a lower pit. A knuckle-boom crane provides compaction of the waste in the trailers. A three-sided building with a roof is constructed over the tipping floor and pit.

- A separate double bay garage with an attached office is provided. If publicly funded collection is planned, the garage serves as a maintenance facility for the collection vehicles as well.

- Three 106 C.Y. live-floor open top trailers and two tractors haul the waste from the transfer station to the disposal site.

- Maximum collection capacity is 100 tons/day.

Cost Analysis of the Medium Scale, Tipping Floor Transfer Station

As the assumptions list makes clear, this transfer station is a different type of facility than the two previously discussed. It has a more elaborate building structure and more processing equipment. This more elaborate capital structure allows for a larger throughput. Table 8-1 assumes that the facility will process an average of 54 tons/day, 6 days a week for a total annual throughput of 16,900 tons. This is the solid waste generated by approximately 50,000 people. The total capital cost is approximately $1.85 million while the annualized capital cost per ton is $10. This is a significantly higher unit cost than the previous two facilities.

In our analysis we assume that six full time employees and one occasional laborer work in this facility, for a total of $131,950 in labor costs. Remaining operating costs, such as fuel and maintenance on the transfer trailers, bring total operating costs to $221,979 for a total operating cost per ton of $13. Combined with the annualized per ton capital cost this produces a total cost per ton of $23. When the present value of the lifetime cost is estimated, it is lower at about $13 per ton. This cost is more than the cost for the small urban drop-off transfer station described above. However, this waste is able to be hauled a long distance at an economical price, whereas waste from the small urban transfer will be more costly to transfer. This facility is also able to handle large volumes of compactor trucks which the small urban facility could not.

Long Haul Transfer Facility

Long Haul transfer facilities utilize balers typically arranged with a tipping floor and a conveyor system. The waste is dumped onto a tipping floor where a loader separates it and puts it on a conveyor system. The conveyor carries it to a chute which discharges it into a baler. The baler uses rams to compress the waste in a chamber. After the waste is compressed, it is ejected from the chamber and tied with strapping.

The baler produces solid waste bales which weigh from 2,000 to 2,500 pounds, and are approximately 50 cubic feet in volume. A forklift, skidsteer loader or wheeled loader is used to load the bales into the transfer vehicle. The transfer vehicles can be any type of trailer; however, flatbed trailers are usually used to lower the weight of the vehicle and allow the maximum load per vehicle to be accommodated.

For a long haul transfer facility, the following assumptions are made for cost estimating purposes:

- The transfer facility is in an enclosed building with an attached office and four bay garage.
- Eight flatbed trailers and four tractors haul the waste. These costs are not included in facility costs).
- The facility will have a tipping floor, conveyor, and baler.
- A front end loader will be provided.
- Maximum collection capacity is 160 tons/day.

Cost Analysis of Long Haul Transfer Facilities

The difference between this facility and the medium scale tipping floor facility is that the long haul facility bales the solid waste before loading it onto a transfer trailer. Thus, the additional equipment cost and building cost is for the baling equipment, conveyors, and floor space that is required by this facility. However, in this case increased capital costs are almost exactly offset by the increased throughput, producing a total annualized per ton capital cost of $7.

The operating cost decreases slightly in proportion to throughput, producing a small drop in operating cost per ton from the medium scale tipping floor facility of about $2.50, resulting in a total operating cost of $11 per ton. The net result is that total capital and operating cost per ton are $18.

Transfer Costs

The costs of transporting garbage long distances from a transfer facility to disposal site will vary with the type of compaction, form of material (baled, loose), type of vehicle and containers used (roll-off truck, compactor vans and a flat-bed truck with bales are standard options), and distance. The cost components of operations are relatively basic: capital costs include trucks and containers and operating costs include labor, fuel, maintenance and licensing and insurance. A transfer facility may operate all of the components, may lease containers or trucks while supplying drivers, or simply contract with someone to perform all components of the transfer.

The cost depends highly upon the type of densification system used. Denser waste allows more to be transferred each trip (assuming road weight limits are not exceeded), and consequently cost will be lower. For the most efficient baling systems or high compaction systems, per-ton transfer costs will range from $.05 to $.08 per ton-mile. For systems using smaller, less efficient compaction units, costs will range from $.08 to $.12 per ton-mile.

Dump and Sort/Recycling Transfer Facilities

Dump and sort transfer stations target corrugated cardboard, white and mixed office paper, newspaper, wood, ferrous and non-ferrous metals, glass, and plastics. Mixed waste is received at a dump and sort facility where recoverable materials are sorted by manual picking, mechanical processing, or some combination of the two. This type of facility is designed primarily for commercial loads that have a high percentage of recoverable materials, particularly corrugated cardboard. These loads also have less contamination from food and other wastes than residential loads. Residential loads can be processed as well, though the recovery rates are much lower.

In transfer stations where loads of all types are received, loads with a high concentration of recoverable materials are selected for sorting either by targeting particular haulers or routes, or by inspecting loads as they come in. Other facilities accept only loads with high concentrations of recyclables, and some even charge differential tipping fees depending upon the concentration of recoverable material. Charging differential fees provides haulers with the incentive to design routes to collect from businesses with large amounts of recyclables in their waste streams, a process called high-grading.

All dump and sort facilities have a tipping floor where material is dumped by incoming haulers. Transfer stations, where only a portion of the loads are sorted, will reserve an area of the tipping floor for picking. Separation of loads occurs either through directing desirable loads to the reserved area or moving high quality loads with a front-end loader or bobcat after they have been dumped.

Sorting can occur through one of two methods: manual picking or mechanical processing lines. Manual picking involves dumping high quality loads in a separate tipping area and manually picking through the pile to find recoverable material. Recovery of large materials such as cardboard, wood waste, ferrous scrap and even office paper can be done relatively effectively with this method. Recoverable materials are deposited in mobile bins that can be dumped into larger roll-off containers or baled for easier transfer and marketing.

Mechanical sorting systems move waste over conveyors through a series of mechanical separation equipment or manual picking stations where different materials are separated. Using a front-end loader, waste is pushed into a feed hopper for the conveyor where it starts up to the picking lines and processing equipment, which are usually above ground. Separation of non-recoverable materials often occurs first to increase efficiency further down the line. This can occur through manual picking, through trommel screens, or through the use of other separation equipment. Trommel screens are large cylinders up to ten feet in diameter and 16 feet long, with holes of variable size allowing small, heavy material, generally not the recoverable portion of the waste, to fall through.

Material separation occurs mainly through hand picking from a conveyor. Picked materials are deposited into containers or dropped onto another conveyor which in turn drops them into a baler or roll-off container. Some facilities have installed hanging pneumatic tubes which suck light materials such as plastics or office paper into a storage container. Once materials are separated, they usually undergo some sort of processing before shipment, such as the baling of corrugated cardboard, paper, and plastics, and wood chipping.

A dump and sort facility appropriate for Vermont would require an enclosed facility with large bay doors permitting trucks to enter and exit. This type of operation is most appropriate in conjunction with a transfer station, since incorporating dump and sort operations requires minimal improvements and equipment. A facility dedicated to high grade commercial loads is possible. However, the cost effectiveness of this approach is questionable given the lack of large, dense commercial areas in Vermont and the long distance to markets.

While facilities are often operated independently of collection, some haulers are beginning to develop separation capability as a way of cutting their disposal costs. Haulers can then present businesses with a range of services, from simply collecting mixed waste and separating out recoverable material to providing multiple containers for either mixed recyclables or individual materials.

Existing Facilities: A number of transfer stations in Vermont perform some separation. One example of a hauler who targets particular loads is Hardwick Recycling & Salvage, Inc. in Morrisville, which operates a two-container system for a number of its customers and separates mixed loads from commercial customers. In the two-container system, one container is reserved for recyclables such as corrugated cardboard, paper, wood and metals, while the other is dedicated to remaining waste. At Hardwick's facility, both mixed waste and recoverable material are sorted using manual picking. This facility has a baler, glass crusher, and metal shredder for use in processing the materials.

Another example is the Casella Waste Management facility in Rutland. Casella receives source separated office paper and corrugated cardboard, as well as mixed commercial wastes. These materials are sorted on the tip floor, with corrugated cardboard and other recyclables being recovered.

Outside Vermont, facilities that accept only commercial loads with high levels of recyclables include Wastech Inc. Facilities in Portland, OR, and Vancouver, BC; the Rabanco facility in Seattle, WA; and Oakland County Recycling Services in Oakland, CA. Large dump and sort facilities that accept all types of loads exist in Queens and Long Island, NY; Grand Rapids, MI; and Chicago, IL. Many smaller facilities existing throughout the New England area.

Pros:

- Can be easily retrofitted or integrated into existing collection programs and facilities;
- Targets materials not collected in source separation programs;
- Can increase waste diversion beyond source separation programs;
- Targets commercial generators who may not have space or interest in recycling.

Cons:

- High cost of sorting material from mixed wastes because of high labor requirements;
- Markets for non-standard recyclables, e.g. wood, must be developed if they are to be recovered;
- May reduce public interest, both residential and commercial, in participating in source separation programs;
- Effective worker safety programs must be developed.

SECTION 2

Solid Waste Management Processing and Disposal Technologies and Facilities

TABLE 8-1

SOLID WASTE TRANSFER STATION FACILITY COSTS

	Rural Dropoff	Small Urban Dropoff 6 days	Medium Scale	Long Haul
Annual Tonnage	1,040	7,800	16,900	27,300
Daily Tonnage	4	25	54	88
Capital Costs				
Site Prep	23,100	23,100	93,100	95,600
Infrastructure	31,700	34,825	963,500	1,012,000
Equipment	65,500	94,875	193,000	287,000
Professional Services	10,750	10,750	157,000	163,000
Contingency (15%)	19,658	24,533	203,090	233,640
Total Capital Cost	150,708	188,083	1,609,690	1,791,240
Annualized Capital Cost	15,925	19,875	164,856	189,282
Capital Cost/TPD	$37,677	$7,523	$29,717	$20,471
$/Ton Annualize Capital Cost	$15.31	$2.55	$9.75	$6.93
Operating Costs				
Wages & Salaries	23,925	44,950	131,950	175,450
Utilities, Taxes, Insur.	4,800	13,800	15,600	24,000
Equip. Oper. & Maintenance	10,275	18,744	21,150	28,350
Contracted Services	4,000	11,200	24,325	28,650
Contingencies (15%)	6,450	13,304	28,954	38,468
Total Annual Operating Costs	$49,450	$101,998	$221,979	$294,918
$/Ton Operating Cost	$47.55	$13.08	$13.13	$10.80
Total Annualized Capital and Operating Costs	$65,375	$121,873	$386,835	$484,200
$/Ton Total Cost	$62.86	$15.62	$22.89	$17.74

TABLE 8-1
(continued)

		Rural Dropoff	Small Urban Dropoff 6 days	Medium Scale	Long Haul
Annual Tonnage		1,040	7,800	16,900	27,300
Daily Tonnage		4	25	54	88
Total Capital Cost		$150,708	$188,083	$1,609,690	$1,791,240
1990 Capital Payment		$21,338	$27,716	$176,674	$213,000
Capital Cost per Ton		$20.52	$3.55	$10.45	$7.80
1990 Total Operating Costs		$49,450	$101,998	$221,979	$294,918
Operating Cost per Ton		$47.55	$13.08	$13.13	$10.80
1990 Net Cost		$70,788	$129,714	$398,653	$507,918
Net Cost per Ton		$68.07	$16.63	$23.59	$18.61
LIFECYCLE COSTS					
Per Ton Costs (nominal $)	Year 1	68.07	16.63	23.59	18.61
	2	68.60	16.82	23.64	18.66
	3	69.15	17.01	23.70	18.73
	4	69.73	17.21	23.77	18.80
	5	70.34	17.42	23.85	18.88
	6	70.98	17.63	23.94	18.97
	7	71.64	17.85	24.04	19.07
	8	72.33	18.07	24.15	19.17
	9	73.05	18.31	24.26	19.28
	10	73.80	18.55	24.39	19.39
	11	70.30	17.97	23.95	18.81
	12	71.19	18.24	24.11	18.95
	13	72.10	18.52	24.27	19.10
	14	73.04	18.80	24.45	19.26
	15	74.01	19.09	24.63	19.43
	16	75.00	19.39	24.82	19.61
	17	76.03	19.70	25.03	19.79
	18	77.08	20.01	25.24	19.98
	19	78.16	20.33	25.46	20.18
	20	79.28	20.66	25.69	20.38
1990 Present Value of Lifetime per Ton Costs		39.22	9.85	13.22	10.46

APPENDIX TO CHAPTER 8

RURAL AREA CITIZEN DROP-OFF
FACILITY CAPITAL COSTS

ITEM	UNIT COST ($)	UNIT	TOTAL COST PER ITEM ($)
Site Preparation			
1. Clear and Grub	2,500.00	1 acre	2,500
2. Grading and Drainage	10,000.00	1 ls	10,000
3. Access and Misc.	5,000.00	1 ls	5,000
4. Power	14.00	400 ft	5,600
		Subtotal:	23,100
Infrastructure			
1. Attendant's Bldg.	50.00	144 sf	7,200
2. Retaining wall and Conc. pad	125.00	100 ft	12,500
3. Waste oil tank	1,500.00	1 ls	1,500
4. Monitoring Wells	3,500.00	3 ls	10,500
		Subtotal:	31,700
Equipment			
1. Roll-off Containers	5,500.00	1 ea	5,500
2. Roll-off Truck	92,000.00	0.25 ea	23,000
3. Compactor/Hopper	34,000.00	1 ea	34,000
4. Open-top roll-off Container for overflow	3,000.00	1 ea	3,000
		Subtotal:	65,500
Professional Services			
1. Bid Documents & Review	25,000.00	0.25 ls	6,250
2. Survey Control	1,500.00	1 ls	1,500
3. Construction Insp.	3,000.00	1 ls	3,000
		Subtotal:	10,750
	TOTAL CAPITAL COST		131,050
	CONTINGENCY (15%)		19,658
	TOTAL CAPITAL COSTS:		$150,708

RURAL AREA CITIZEN DROP-OFF FACILITY OPERATING COSTS

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries				
1. Foreman	24,000.00	0.25	ea yr	6,000
2. Operator	8,500.00	1	ea yr	8,500
3. Occasional Laborer	2,000.00	1	ea yr	2,000
	Subtotal without benefits:			16,500
	Fringe Benefits	30%		4,950
	Overtime Allowance	15%		2,475
	Subtotal with benefits:			23,925
Utilities, Taxes, and Insurance				
1. Utilities	100.00	12	mon/yr	1,200
2. Insurance	300.00	12	mon/yr	3,600
		Subtotal:		4,800
Equip Op & Maint				
1. Maintenance	5.00% of capital costs			3,275
2. Licenses, tax, and ins.	7,000.00	1	ea	7,000
		Subtotal:		10,275
Contracted Services				
1. Monitoring Well Analysis	450.00	6		2,700
2. Waste Oil Disposal	1.25	1,040		1,300
		Subtotal:		4,000
	TOTAL O & M COSTS:			43,000
	CONTINGENCY (15%)			6,450
	TOTAL ANNUAL OPERATING COSTS			$49,450

COST ASSUMPTIONS

1. For estimating purposes, the foreman and roll-off truck are assumed to operate between four transfer stations.
2. It is assumed that the transfer station will be constructed on publically owned land, therefore the cost of the land and the land improvements will be minimal.
3. Equipment is traded in at the end of every 10 years with a resale value of 20%.
4. Four of these rural area citizen drop-off facilities would be built at various sites throughout a region.
5. Annual tonage is assumed to increase at a rate of 2% per year.
6. Costs do not include household hazardous waste disposal.

CAPITAL COST SUMMARY AND AMORTIZATION/CAPITAL RESERVE SCHEDULE
RURAL AREA CITIZEN DROP-OFF FACILITY

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	23,100	0	0	0	0
Infrastructure	31,700	0	0	0	0
Equipment	65,500	0	79,691	0	0
Professional Services	10,750	0	0	0	0
Revenues (equipment trade-in)	0	0	(13,100)	0	(15,938)
TOTALS	131,050	0	66,591	0	(15,938)
CONTINGENCY (15%)	19,658	0	9,989	0	0
GRAND TOTAL	150,708	0	76,579	0	(15,938)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010				
Annual Bond Payment @ 8.5%	15,925				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5% to Capital Reserve fund		5,413	5,413	0	0

LIFE CYCLE COSTS: 1990-2010
Rural Area Citizen Drop-Off Facility

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS)
1990	15,925	5,413	49,450	0	70,788	1,040	68.07	68.07
1995	15,925	5,413	60,163	0	81,502	1,148	70.98	58.34
2000	15,925	0	73,198	0	89,123	1,268	70.30	47.49
2005	15,925	0	89,057	0	104,982	1,400	75.00	41.65
2010	15,925	0	108,351	(15,938)	108,338	1,545	70.10	31.99

SMALL URBAN CENTER DROP-OFF FACILITY CAPITAL COSTS
(Open 6 days per week)

ITEM	UNIT COST ($)	UNIT	TOTAL COST PER ITEM ($)
Site Preparation			
1. Clear and Grub	2,500.00	1 acre	2,500
2. Drainage	10,000.00	1 ls	10,000
3. Access and Misc.	5,000.00	1 ls	5,000
4. Power	14.00	400 ft	5,600
		Subtotal:	23,100
Infrastructure			
1. Attendant's Bldg.	50.00	144 sf	7,200
2. Retaining wall and Conc. pad	125.00	125 ft	15,625
3. Waste oil tank	1,500.00	1 ls	1,500
4. Monitoring Wells	3,500.00	3 ls	10,500
		Subtotal:	34,825
Equipment			
1. Roll-off Containers	5,500.00	1.25 ea	6,875
2. Roll-off Truck	92,000.00	0.50 ea	46,000
3. Compactor/Hopper	36,000.00	1 ea	36,000
4. Open-top roll-off Container for overflow	3,000.00	2 ea	6,000
		Subtotal:	94,875
Professional Services			
1. Bid Documents & Review	25,000.00	0.25 ls	6,250
2. Survey Control	1,500.00	1 ls	1,500
3. Construction Insp.	3,000.00	1 ls	3,000
		Subtotal:	10,750
	TOTAL CAPITAL COST		163,550
	CONTINGENCY (15%)		24,533
	GRAND TOTAL CAPITAL COSTS:		$188,083

SMALL URBAN CENTER DROP-OFF FACILITY OPERATING COSTS
(Open 6 days per week)

ITEM	UNIT COST ($)	QUANTITY UNIT		TOTAL COST PER ITEM ($)
Wages and Salaries				
1. Foreman	28,000.00	0.25 ea yr		7,000
2. Drivers	18,000.00	0.5 ea yr		9,000
3. Laborer	15,000.00	1 ea yr		15,000
	Subtotal without benefits:			31,000
	Fringe Benefits		30%	9,300
	Overtime Allowance		15%	4,650
	Subtotal with benefits:			44,950
Utilities, Taxes, and Insurance				
1. Utilities	800.00	12 mon/yr		9,600
2. Insurance	350.00	12 mon/yr		4,200
		Subtotal:		13,800
Equip Op & Maint				
1. Maintenance	5.00% of capital costs			4,744
2. Licenses, tax, and ins.	14,000.00	1 ea		14,000
		Subtotal:		18,744
Contracted Services				
1. Monitoring Well Analysis	450.00	6 per/yr		2,700
2. Waste Oil Disposal	1.25	6,800 gal/yr		8,500
		Subtotal:		11,200
	TOTAL O & M COSTS:			88,694
	CONTINGENCY (15%)			13,304
	GRAND TOTAL OPERATING COSTS			$101,998

CAPITAL COST SUMMARY AND AMORTIZATION/CAPITAL RESERVE SCHEDULE
(Open 6 days per week)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	23,100	0	0	0	0
Infrastructure	34,825	0	0	0	0
Equipment	94,875	0	115,430	0	0
Professional Services	10,750	0	0	0	0
Revenues (equipment trade-in)	0	0	(18,975)	0	(23,086)
TOTALS	163,550	0	96,455	0	(23,086)
CONTINGENCY (15%)	24,533	0	14,468	0	0
GRAND TOTAL	188,083	0	110,923	0	(23,086)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010				
Annual Bond Payment @ 8.5%	19,875				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5% to Capital Reserve fund		7,841	7,841	0	0

LIFE CYCLE COSTS: 1990-2010
SMALL URBAN CENTER DROP-OFF FACILITY
(Open 6 days per week)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS)
1990	19,875	7,841	101,998	0	129,713	7,800	16.63	16.63
1995	19,875	7,841	124,096	0	151,812	8,612	17.63	14.49
2000	19,875	0	150,982	0	170,857	9,508	17.97	12.14
2005	19,875	0	183,692	0	203,567	10,498	19.39	10.77
2010	19,875	0	223,490	(23,086)	220,279	11,590	19.01	8.67

MEDIUM SCALE TIPPING FLOOR TRANSFER FACILITY CAPITAL COSTS
(Open 5 days per week)

ITEM	UNIT COST ($)	UNIT	TOTAL COST PER ITEM ($)
Site Preparation			
1. Clear and Grub	2,500.00	5 acre	12,500
2. Drainage	25,000.00	1 ls	25,000
3. Access and Misc.	50,000.00	1 ls	50,000
4. Power	14.00	400 ft	5,600
		Subtotal:	93,100
Infrastructure			
1. Office/Maintenance Bldg.	110.00	2,500 sf	275,000
2. Scale	60,000.00	1 ea	60,000
3. Monitoring Wells	3,500.00	3 ls	10,500
4. Tipping Floor Facility	50.00	10,000 sf	500,000
5. Leachate Collection System	10,000.00	1 ea	10,000
6. Knuckle-Boom Crane	100,000.00	1 ea	100,000
7. Roll-Off Pad	2,500.00	1 ls	2,500
8. Brush/Tire Area	3,000.00	1 ls	3,000
9. Waste Oil Tank	2,500.00	1 ea	2,500
		Subtotal:	963,500
Equipment			
1. Loader	117,000.00	1 ea	117,000
2. Pickup Truck	17,000.00	1 ea	17,000
3. Roll-Off (Open Top)	3,000.00	3 ea	9,000
		Subtotal:	143,000
Professional Services			
1. Design	75,000.00	1 ls	75,000
2. Bid Documents & Review	40,000.00	1 ls	40,000
3. Survey Control	7,000.00	1 ls	7,000
4. Construction Insp.	35,000.00	1 ls	35,000
		Subtotal:	157,000
	TOTAL CAPITAL COST		1,356,600
	CONTINGENCY (15%)		203,490
	TOTAL CAPITAL COSTS:		$1,560,090

MEDIUM SCALE TIPPING FLOOR TRANSFER
FACILITY OPERATING COSTS
(Open 5 days per week)

ITEM	UNIT COST ($)	QUANTITY UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries			
1. Foreman/Scale Operator	35,000.00	1 ea yr	35,000
2. Loader Operator	16,000.00	1 ea yr	16,000
3. Laborer	15,000.00	1 ea yr	15,000
4. Occasional Laborer	5,000.00	1 ea yr	5,000
5. Mechanic	20,000.00	1 ea yr	20,000
	Subtotal without benefits:		91,000
	Fringe Benefits	30%	27,300
	Overtime Allowance	15%	13,650
	Subtotal with benefits:		131,950
Utilities, Taxes, and Insurance			
1. Utilities	800.00	12 mon/yr	9,600
2. Insurance	500.00	12 mon/yr	6,000
		Subtotal:	15,600
Equip Oper & Maint			
1. Maintenance	5.00% of capital costs		7,150
2. Licenses, tax, and ins.	14,000.00	1 ea	14,000
		Subtotal:	21,150
Contracted Services			
1. Pumping Leachate Holding Tank	500.00	12 yr	6,000
2. Haul C&D Roll-Off	125.00	125 yr	15,625
3. Monitoring Well Analysis	450.00	6 yr	2,700
		Subtotal:	24,325
	TOTAL O & M COSTS:		193,025
	CONTINGENCY (15%)		28,954
	TOTAL OPERATING COSTS		$221,979

CAPITAL COST SUMMARY AND AMORTIZATION/CAPITAL RESERVE SCHEDULE
MEDIUM SCALE TIPPING FLOOR TRANSFER FACILITY
(Open 5 days per week)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	93,100	0	0	0	0
Infrastructure	963,500	0	0	0	0
Equipment	143,000	0	173,981	0	0
Professional Services	157,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(28,600)	0	(34,796)
TOTALS	1,356,600	0	145,381	0	(34,796)
CONTINGENCY (15%)	203,490	0	21,807	0	0
GRAND TOTAL	1,560,090	0	167,189	0	(34,796)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010				
Annual Bond Payment @ 8.5%	164,856				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5% to Capital Reserve fund		11,818	11,818	0	0

LIFE CYCLE COSTS: 1990-2010
MEDIUM SCALE TIPPING FLOOR TRANSFER FACILITY
(Open 5 days per week)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE 1990 DOLLARS
1990	164,856	11,818	221,979	0	398,653	16,900	23.59	23.59
1995	164,856	11,818	270,071	0	446,745	18,659	23.94	19.68
2000	164,856	0	328,583	0	493,439	20,601	23.95	16.18
2005	164,856	0	399,771	0	564,627	22,745	24.82	13.78
2010	164,856	0	486,383	(34,796)	616,443	25,113	24.55	11.20

LONG HAUL TRANSFER FACILITY
CAPITAL COSTS
(Open 5 days per week)

ITEM	UNIT COST ($)	UNIT	TOTAL COST PER ITEM ($)
Site Preparation			
1. Clear and Grub	2,500.00	6 acre	15,000
2. Drainage	25,000.00	1 ls	25,000
3. Access and Misc.	50,000.00	1 ls	50,000
4. Power	14.00	400 ft	5,600
		Subtotal:	95,600
Infrastructure			
1. Office/Maintenance Bldg.	80.00	4,000 sf	320,000
2. Scale	60,000.00	1 ea	60,000
3. Monitoring Wells	3,500.00	4 ls	14,000
4. Tipping Floor Facility	50.00	12,000 sf	600,000
5. Leachate Collection System	10,000.00	1 ea	10,000
6. Roll-Off Pad	2,500.00	1 ls	2,500
7. Brush/Tire Area	3,000.00	1 ls	3,000
8. Waste Oil Tank	2,500.00	1 ea	2,500
		Subtotal:	1,012,000
Equipment			
1. Loader	117,000.00	1 ea	117,000
2. Fork Lift	30,000.00	1 ea	30,000
3. Pickup Truck	17,000.00	1 ea	17,000
6. Roll-Off (Open Top)	3,000.00	1 ea	3,000
7. Baler and Conveyor	120,000.00	1 ea	120,000
		Subtotal:	287,000
Professional Services			
1. Design	80,000.00	1 ls	80,000
2. Bid Documents & Review	40,000.00	1 ls	40,000
3. Survey Control	8,000.00	1 ls	8,000
4. Construction Insp.	35,000.00	1 ls	35,000
		Subtotal:	163,000
	TOTAL CAPITAL COST		1,557,600
	CONTINGENCY (15%)		233,640
	TOTAL CAPITAL COSTS:		$1,791,240

95,600

$406,500 + tip Brush Oil

167,000 + baler

% increase total

LONG HAUL TRANSFER FACILITY
OPERATING COSTS
(Open 5 days per week)

ITEM	UNIT COST ($)	QUANTITY UNIT	TOTAL COST PER ITEM ($)	
Wages and Salaries				
1. Foreman	35,000.00	1 ea yr	35,000	
2. Scale Operator	15,000.00	1 ea yr	15,000	
3. Loader Operator	16,000.00	1 ea yr	16,000	
4. Laborer	15,000.00	2 ea yr	30,000	
5. Occasional Laborer	5,000.00	1 ea yr	5,000	
6. Mechanic	20,000.00	1 ea yr	20,000	
	Subtotal without benefits:		121,000	
	Fringe Benefits	30%	36,300	
	Overtime Allowance	15%	18,150	
	Subtotal with benefits:		175,450	multiplier
Utilities, Taxes, and Insurance				
1. Utilities	1,000.00	12 mon/yr	12,000	
2. Insurance	1,000.00	12 mon/yr	12,000	% total
	Subtotal:		24,000	
Equip Op & Maint				
1. Maintenance	5.00% of capital costs		14,350	% increase 14000 + Main.
2. Licenses, tax, and ins.	14,000.00	1 ea	14,000	
	Subtotal:		28,350	
Contracted Services				
1. Pumping Leachate Holding Tank	500.00	12 yr	6,000	% increase
2. Haul C&D Roll-Off	125.00	150 yr	18,750	22,650 + leachate
3. Backup Hauling	400.00	3 yr	1,200	
4. Monitoring Well Analysis	450.00	6 yr	2,700	
	Subtotal:		28,650	
	TOTAL O & M COSTS:		256,450	
	CONTINGENCY (15%)		38,468	15% new total
	TOTAL OPERATING COSTS		$294,918	

CAPITAL COST SUMMARY AND AMORTIZATION/CAPITAL RESERVE SCHEDULE
LONG HAUL TRANSFER FACILITY
(Open 5 days per week)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	95,600	0	0	0	0
Infrastructure	1,012,000	0	0	0	0
Equipment	287,000	0	349,179	0	0
Professional Services	163,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(57,400)	0	(69,836)
TOTALS	1,557,600	0	291,779	0	(69,836)
CONTINGENCY (15%)	233,640	0	43,767	0	0
GRAND TOTAL	1,791,240	0	335,546	0	(69,836)
Method of Payment	Bond	Rerserve Fund	Rerserve Fund	Rerserve Fund	Rerserve Fund
Amortization period	1990-2010				
Annual Bond Payment @ 8.5%	189,282				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5% to Capital Reserve fund		23,718	23,718	0	0

LIFE CYCLE COSTS: 1990-2010
LONG HAUL TRANSFER FACILITY
(Open 5 days per week)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS)
1990	189,282	23,718	294,918	0	507,918	27,300	18.61	18.61
1995	189,282	23,718	358,812	0	571,813	30,141	18.97	15.59
2000	189,282	0	436,550	0	625,832	33,279	18.81	12.70
2005	189,282	0	531,130	0	720,412	36,742	19.61	10.89
2010	189,282	0	646,201	(69,836)	765,647	40,566	18.87	8.61

9. CONSTRUCTION AND DEMOLITION WASTE RECYCLING FACILITIES

This chapter describes two different types of construction and demolition (C&D) waste processing and recycling facilities. The first broad category includes facilities that handle mixed construction and demolition waste. The second type of facility analyzed only accepts source separated C&D waste, such as wood waste, concrete, sheet rock, etc.

C&D waste recycling facilities employ an array of sorting and processing steps to convert construction, demolition, and land-clearing debris into usable products. Typically, this type of waste consists of wood, stumps, rock, soil, brick, concrete, glass, asphalt, metals, plastic, and paper. Recovered materials may include wood for compost, wood for fuel, doors, windows for road base or fill, non-ferrous metals, ferrous metals, soil, and rock. There are many possible C&D recycling system designs, ranging from complex systems with four or five sorting, washing, and processing stages that are fed mixed C&D waste, to relatively simple systems that recover one type of material and employ only one piece of processing equipment.

Mixed C&D Waste Recycling Facilities

A multi-stage recycling system can accept mixed loads of construction, demolition, and land clearing debris. C&D waste is brought to the facility by truck and is inspected, weighed, and dumped onto a tipping floor. A front-end loader moves the waste from the floor onto an elevating feeder which meters the flow of material to a scalping disk screen. The scalping disk screen vibrates off dirt and small material and allows large materials such as concrete, asphalt, and logs to pass onto a conveyor towards the impact crusher. The small material (6" or less in size) drops onto an under-belt which transfers the material to a rotating trommel screen. The large material continues off the end of the disc screen.

The trommel screen is a rotating, cylindrical cage covered in a screen material. As the small fraction from the scalping disk passes through its length, dirt and soil are sifted out. The material that passes through the trommel continues on, via conveyor belt to the wood/bark/rock washing and recovery tank. At the wash tank stage, the remaining material is washed. The rocks and aggregate are then removed by a rock removal belt, the bark and wood are removed on another belt, and soil is removed by a drag chain. The wood and bark are separated on a double deck screen and may be processed further or sold "as is".

The large material which continues off the end of the disc screen is routed to the impact crusher. Paper, plastic, and non-ferrous materials are picked out by hand from the large material stream (6" plus) as it moves along the picking belt. The remaining material (asphalt, concrete, and wood) passes into the impact crusher, which reduces the size of the material and removes ferrous metals (rebar and nails) under a magnetic separator. Non-ferrous material is fed back into the system at a point between the scalping disk and trommel.

While the equipment components described here are fairly standard in the mixed C&D waste recycling industry, system design and size should be selected with an understanding of C&D waste composition, generation rate, and available markets for end products. Land requirements vary widely with the size of the processing system, the area needed to store incoming waste, and end products.

Existing Facilities: Such facilities are found in Bridgeport, CT; Milton, CT; Newcastle, Delaware; Bothell, WA, Epping, NH (Open Fall of 1990), Gorham, ME (planning stage).

Pros:

- Diverts bulky, hard to handle material from landfills;
- Accepts mixed construction/demolition and land clearing waste, so complex source separation is not needed;
- Material sorting, size reduction, and washing processes produce products that are useful and have high market value (but not as high as hand- or source-separated materials);
- Production of large, reliable quantities of product enhances marketability.

Cons:

- Requires large initial capital investments;
- Utility costs are high;
- Mixed loads of construction and demolition waste may contain hazardous materials. If not detected during load inspection, the hazardous material may cause harm to facility employees or the environment;
- Facilities may cause noise and dust pollution;
- A high fraction of bulk residuals must be landfilled;
- Wash water must be treated and disposed of.

SOURCE SEPARATED RECYCLING FACILITIES

Wood Waste Recycling Facilities

There are many C&D waste recycling facilities that handle source separated materials. They may employ only one or a few processing systems. For example, there are facilities that process only construction wood, logs, pallets, and other wood waste. A facility of this type would consist of an unloading pad, a front-end loader or other heavy conveyance vehicle, screening devices, and a processor such as a tub grinder or hammermill that reduces the wood into small fragments. The output material can be sold directly as a wood fuel or as a bulking agent for leaf or sewage sludge composting. Alternatively, the material can be composted for a period of a year or two and then sold as landscaping mulch.

In some cases the screening and processing equipment is housed in a building while in other cases the whole facility is set up outdoors. The building requirement for an enclosed 350 ton per day facility is approximately 9,000 square feet. Buildings can be insulated to reduce noise pollution. Land requirements for this type of wood waste recycling facility range from five to seven acres for a facility processing 100 tons per day. While space requirements for the equipment are minimal, a few acres are needed for waste and product storage and composting.

Existing Facilities: Such facilities exist in Woburn, MA; Salem, NH, and Lewiston, ME

Pros:

- Diverts bulky, hard to handle material from landfills;
- Initial capital costs are low relative to mixed waste systems;
- Products can be made for several uses, depending on market demand;
- Product quality may be higher for some materials.

Cons:

- Facilities may cause noise and dust pollution;
- Producer commitment to labor intensive source separation is required;
- Land requirements for mulch production are high.

Concrete, Asphalt, and Rubble Recycling Facilities

Concrete, asphalt, and rubble recycling facilities process these materials into an aggregate that can be used for road base and fill. Typically, such facilities consist of a scale for weighing vehicles and products, an unloading pad, a front-end loader for moving materials, a crushing system, a screening system, and a magnetic separation system for rebar (steel reinforcements found in waste concrete). Conveyors can be used to transport the materials from one step to another. Impact crushers or a combination of jaw crusher and cone crusher are used to break up the material. A screening process removes fine materials and sorts the resulting aggregate into sizes usable for road base and fill.

Processing rates for "state-of-the-art" equipment ranges from 100 to 300 tons per hour. One acre of land is sufficient for equipment placement and a small amount of storage space. Two to three people are required to run the crushing/screening equipment and drive the trucks.

Mobile processing units that are transported directly to a site are often more convenient, especially when fill material is needed on the site. These units have separate crushing and conveying systems which can be moved separately. This approach greatly reduces transport costs for sites with large amounts of material and a nearby end use.
Existing Facilities: Such facilities are located in Ipswich, MA, and Bridgeport, CT

Pros:

- Diverts bulky, hard to handle material from landfills;
- Initial capital costs are low relative to mixed waste systems;
- Products can be made for several uses, depending on market demand;
- Existing rock crushing operations may be employed.

Cons:

- Facilities may cause noise and dust pollution;
- Product may be of inconsistent quality;
- Construction specifications tend to discriminate against recycled aggregate.

COST ANALYSIS OF CONSTRUCTION AND DEMOLITION FACILITIES

The costs analysis of construction and demolition recycling facilities reflects the different technology options that are available. The mixed construction and demolition facility, or high technology option, has a high level of automated sorting and processing, and is able to receive a broad range of materials and material mixtures. The source separated C&D facility, a low technology option, has very little automation and can receive only a limited range of materials, and all materials must be source separated. The construction and demolition facilities analyzed include a 500 ton/day, high technology facility, and a 250 ton per day, low technology facility. Results of the cost analysis of these two facilities are summarized in Tables 9-1 and 9-2.

The net present value of the lifetime costs per ton of the two facilities is relatively close -- $9 and $14 per ton for the high and low technologies respectively -- and relatively low compared to the other solid waste options presented here. Because the operating costs of the facility are proportionally much larger than capital cost, the present value of the life-cycle cost is not significantly lower than the first year cost.

In comparing the capital costs of the two facilities, we note that site costs are the same, despite the higher capacity of the high technology facility. The major cost difference is for recycling equipment. The low-technology facility requires a relatively small investment: about $400,000 or 25% of costs. The high technology option requires a more substantial investment: about $1.7 million or 55% of costs.

The labor costs for the two facilities are similar. However, there are large differences in costs for equipment operation, maintenance, utilities, taxes, and insurance. These differences reflect the high costs of operating the automated processing system with its high energy and maintenance requirements.

The sale of materials for use in local construction or other public works projects, such as road construction, could offset some of the operating and capital costs of the facility. Such potential revenues are not reflected in our analysis.

TABLE 9-1

CONSTRUCTION & DEMOLITION DEBRIS FACILITY CAPITAL AND OPERATING COSTS

		High Technology	Low Technology
Capacity		500	250
Annual Tonnage		130,000	65,000
Capital Costs		3,115,005	1,510,180
1990 Annualized Capital Cost		329,166	159,582
1990 Capital Reserve Fund		197,634	68,520
1990 Operating Cost		1,272,803	1,315,352
1990 Net Annual Cost		1,799,603	1,543,454
Cost per Ton		13.84	23.75
LIFECYCLE COSTS			
Per Ton Cost (nominal $)	Year 1	13.84	20.24
	2	14.23	20.91
	3	14.64	21.60
	4	15.07	22.32
	5	15.51	23.08
	6	15.96	23.86
	7	16.44	24.67
	8	16.94	25.52
	9	17.45	26.40
	10	17.99	27.32
	11	17.02	27.22
	12	17.60	28.21
	13	18.21	29.24
	14	18.83	30.31
	15	19.49	31.42
	16	20.16	32.58
	17	20.87	33.78
	18	21.60	35.04
	19	22.37	36.34
	20	23.16	37.70
1990 Present Value of Lifetime per Ton Costs		9.23	14.17

APPENDIX TO CHAPTER 9

CONSTRUCTION/DEBRIS PROCESSING FACILITY CAPITAL COSTS
(LOW TECHNOLOGY - 250 Ton/day)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Site Improvements				
1. Land Purchase	12,000.00	5	acre	60,000
2. Clear and Grub	2,500.00	3	acre	7,500
3. Drainage\Grading	75,000.00	1	ls	75,000
4. Access and Misc.	65,000.00	1	ls	65,000
5. Septic	6,000.00	1	ls	6,000
6. Water	6,000.00	1	ls	6,000
7. Power	14.00	300	ft	4,200
		Subtotal:		223,700
Infrastructure				
1. Office, Maint., & employee bldg	50.00	2,000	sf	100,000
2. Equipment storage	10.00	1,500	sf	15,000
3. Tipping Floor (Slab)	3.00	15,000	sf	45,000
4. Scale	60,000.00	1	ea	60,000
5. Monitoring Wells	3,500.00	4	ea	14,000
6. Leachate Collection Sys.	10,000.00	1	ea	10,000
7. Paving	7.50	3,000	sy	22,500
8. Landscaping (Fert. & Seed)	4,000.00	1	Acres	4,000
		Subtotal:		270,500
Waste Handling Equipment				
1. Wheel Loader (CAT 936 or equiv.)	117,000.00	1	ea	117,000
2. Track Loader (CAT 973 or equiv.)	240,000.00	1	ea	240,000
		Subtotal:		357,000
C & D Recycling equipment				
1. Reed Screen-All (model Rd-150)	99,500.00	1	ls	99,500
2. Portable Wood Waste Recycler	295,000.00	1	ls	295,000
		Subtotal:		394,500
Misc. Equipment				
1. Tools	7,500.00	1	ea	7,500
		Subtotal:		7,500
Professional Services				
1. Design	15,000.00	1	ls	15,000
2. Bid Documents & Review	3,000.00	1	ls	3,000
3. Survey Control	7,000.00	1	ls	7,000
4. Construction Management	25,000.00	1	ls	25,000
5. Shipping & Equipment Set-up	10,000.00	1	ls	10,000
		Subtotal:		60,000
	TOTAL CAPITAL COST			1,313,200
	CONTINGENCY (15%)			196,980
	GRAND TOTAL CAPITAL COSTS:			$1,510,180

CONSTRUCTION/DEBRIS PROCESSING FACILITY OPERATING COSTS
(LOW TECHNOLOGY - 250 Ton/day)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries				
1. Forman	28,000.00	1	ea yr	28,000
2. Scale operator	18,000.00	1	ea yr	18,000
3. Loader Operator	18,000.00	2	ea yr	36,000
4. Laborers	14,000.00	3	ea yr	42,000
5. Secretary	16,000.00	1	ea yr	16,000
	Subtotal without benefits:			140,000
	Fringe Benefits	30%		42,000
	Overtime Allowance	15%		21,000
	Subtotal with benefits:			203,000
Utilities, Taxes, and Insurance				
1. Utilities	700.00	12	mon/yr	8,400
2. Taxes Insurance & Administration	8,000.00	1	ea/yr	8,000
3. Overhead (5% of cap. costs)	65,660	1	ea/yr	65,660
		Subtotal:		82,060
Equip Op & Maint				
1. Loader Fuel	1.25	12,000	gal/yr	15,000
2. Maintenance (5% of cap. costs)	37,575.00	1	ea/yr	37,575
3. Taxes, Insurance, Registration	4,000.00	1	ea/yr	4,000
		Subtotal:		56,575
Contracted Services				
1. Pumping Leachate Holding Tank	500.00	4	/yr	2,000
2. Groundwater Monitoring & Analysis	1,800.00	1	/yr	1,800
3. Non Recyclable Refuse Disposal (40%)	30.00	20,000	ton/yr	600,000
		Subtotal:		603,800
	TOTAL O & M COSTS:			945,435
	CONTINGENCY (15%)			141,815
	GRAND TOTAL OPERATING COSTS			$1,087,250

CAPITAL COSTS SUMMARY
CONSTRUCTION/DEBRIS PROCESSING FACILITY CAPITAL COSTS
(LOW TECHNOLOGY - 250 Ton/day)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Improvements	223,700	0	0	0	0
Infrastructure	270,500	0	0	0	0
Waste Handling Equipment	357,000	0	434,345	0	0
C & D Recycling Equipment	394,500	0	479,970	0	0
Misc. Equipment	7,500	0	0	0	0
Professional Services	60,000	0	0	0	0
Revenues (equipment trade-in @ 20%)	0	0	(71,400)	0	(86,869)
TOTALS	1,313,200	0	842,915	0	(86,869)
CONTINGENCY (15%)	196,980	0	126,437	0	0
GRAND TOTAL	1,510,180	0	969,352	0	(86,869)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period					
Annual Payment @ 8.5%	159,582				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		68,520	68,520	0	0

LIFE CYCLE COSTS: 1990-2010
CONSTRUCTION/DEBRIS PROCESSING FACILITY CAPITAL COSTS
(LOW TECHNOLOGY - 250 Ton/day)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES (EQUIPMENT TRADE-IN)	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED	TIPPING FEE (1990 DOLLARS)
1990	159,582	68,520	1,087,250	0	1,315,352	50,000	26.31	26.31
1995	159,582	68,520	1,322,806	0	1,550,908	50,000	31.02	25.49
2000	159,582	0	1,609,396	0	1,768,978	50,000	35.38	23.90
2005	159,582	0	1,958,076	0	2,117,658	50,000	42.35	23.52
2010	159,582	0	2,382,299	(86,869)	2,455,012	50,000	49.10	22.41

Note: Total tonnage assumes an 80% waste availability factor.

CONSTRUCTION/DEBRIS PROCESSING FACILITY CAPITAL COSTS
(HIGH TECHNOLOGY - 500 Ton/day)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Site Improvements				
1. Land Purchase	12,000.00	5	acre	60,000
2. Clear and Grub	2,500.00	3	acre	7,500
3. Drainage\Grading	75,000.00	1	ls	75,000
4. Access and Misc.	65,000.00	1	ls	65,000
5. Septic	6,000.00	1	ls	6,000
6. Water	6,000.00	1	ls	6,000
7. Power	14.00	300	ft	4,200
		Subtotal:		223,700
Infrastructure				
1. Office, Maint., & employee bldg	50.00	2,500	sf	125,000
2. Equipment storage	10.00	1,500	sf	15,000
3. Tipping Floor (Slab)	3.00	15,000	sf	45,000
4. Scale	60,000.00	1	ea	60,000
5. Monitoring Wells	3,500.00	4	ea	14,000
6. Leachate Collection Sys.	10,000.00	1	ea	10,000
7. Paving	7.50	3,000	sy	22,500
8. Landscaping (Fert. & Seed)	4,000.00	1	Acres	4,000
		Subtotal:		295,500
Waste Handling Equipment				
1. Wheel Loader (CAT 936 or equiv.)	117,000.00	1	ea	117,000
2. Track Loader (CAT 973 or equiv.)	240,000.00	1	ea	240,000
		Subtotal:		357,000
C & D Recycling equipment				
1. Elevating Feeder (Model 1000)		1	ls	
2. Disc Screen (Model 2000)		1	ls	
3. Picking Belt		1	ls	
4. Hammer Hog		1	ls	
5. Belt Conveyors (5)		1	ls	
6. Trommel Screen (Model T-618)		1	ls	
7. Wash Tank (Model 9000)		1	ls	
8. Wood Hog		1	ls	
9. Stacking Belt		1	ls	
10. Magnetic Seperator		1	ls	
		Subtotal:		1,700,000
Misc. Equipment				
1. Tools	7,500.00	1	ea	7,500
		Subtotal:		7,500
Professional Services				
1. Design	15,000.00	1	ls	15,000
2. Bid Documents & Review	3,000.00	1	ls	3,000
3. Survey Control	7,000.00	1	ls	7,000
4. Construction Management	25,000.00	1	ls	25,000
5. Shipping & Equipment Set-up	75,000.00	1	ls	75,000
		Subtotal:		125,000
	TOTAL CAPITAL COST			2,708,700
	CONTINGENCY (15%)			406,305
	GRAND TOTAL CAPITAL COSTS:			$3,115,005

CAPITAL COSTS SUMMARY
CONSTRUCTION/DEBRIS PROCESSING FACILITY CAPITAL COSTS
(HIGH TECHNOLOGY - 500 Ton/day)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Improvements	223,700	0	0	0	0
Infrastructure	295,500	0	0	0	0
Waste Handling Equipment	357,000	0	434,345	0	0
C & D Recycling Equipment	1,700,000	0	2,068,310	0	0
Misc. Equipment	7,500	0	0	0	0
Professional Services	125,000	0	0	0	0
Revenues (equipment trade-in @ 20%)	0	0	(71,400)	0	(86,869)
TOTALS	2,708,700	0	2,431,255	0	(86,869)
CONTINGENCY (15%)	406,305	0	364,688	0	0
GRAND TOTAL	3,115,005	0	2,795,943	0	(86,869)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period					
Annual Payment @ 8.5%	329,166				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		197,634	197,634	0	0

CONSTRUCTION/DEBRIS PROCESSING FACILITY OPERATING COSTS
(HIGH TECHNOLOGY - 500 Ton/day)

ITEM	UNIT COST ($)	QUANTITY UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries			
1. Forman	28,000.00	1 ea yr	28,000
2. Scale operator	18,000.00	1 ea yr	18,000
3. Loader Operators	18,000.00	2 ea yr	36,000
4. Laborers	14,000.00	4 ea yr	56,000
5. Secretary	16,000.00	1 ea yr	16,000
	Subtotal without benefits:		154,000
	Fringe Benefits	30%	46,200
	Overtime Allowance	15%	23,100
	Subtotal with benefits:		223,300
Utilities, Taxes, and Insurance			
1. Utilities	1,200.00	12 mon/yr	14,400
2. Taxes Insurance & Administration	8,000.00	1 ea/yr	8,000
3. Overhead (5% of cap. costs)	135,435	1 ea/yr	135,435
		Subtotal:	157,835
Equip Op & Maint			
1. Loader Fuel	1.25	12,000 gal/yr	15,000
2. Maintenance(5% of Equip. cap. costs)	102,850.00	1 ea/yr	102,850
3. Taxes, Insurance, Registration	4,000.00	1 ea/yr	4,000
		Subtotal:	121,850
Contracted Services			
1. Pumping Leachate Holding Tank	500.00	4 /yr	2,000
2. Groundwater Monitoring & Analysis	1,800.00	1 /yr	1,800
3. Non Recyclable Refuse Disposal (20%)	30.00	20,000 ton/yr	600,000
		Subtotal:	603,800
	TOTAL O & M COSTS:		1,106,785
	CONTINGENCY (15%)		166,018
	GRAND TOTAL OPERATING COSTS		$1,272,803

LIFE CYCLE COSTS: 1990-2010
CONSTRUCTION/DEBRIS PROCESSING FACILITY CAPITAL COSTS
(HIGH TECHNOLOGY - 500 Ton/day)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES (EQUIPMENT TRADE-IN)	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED	TIPPING FEE (1990 DOLLARS)
1990	329,166	197,634	1,272,803	0	1,799,602	100,000	18.00	18.00
1995	329,166	197,634	1,548,559	0	2,075,359	100,000	20.75	17.06
2000	329,166	0	1,884,059	0	2,213,225	100,000	22.13	14.95
2005	329,166	0	2,292,246	0	2,621,411	100,000	26.21	14.56
2010		0	2,788,868	(86,869)	2,701,999	100,000	27.02	12.33

10. WASTE-TO-ENERGY-FACILITIES

This chapter describes two different mass burn, waste-to-energy systems. The systems described below are field-erected mass burn facilities and factory fabricated (modular) mass burn systems.

Mass burning systems burn unprocessed waste. They require limited front-end removal of oversized items and materials that are otherwise unprocessable or hazardous to facility operations. Mass burning systems can be categorized according to the method of construction employed:

- Field-Erected Systems are usually medium-to large-scale (500 to 3000 TPD) waterwall or refractory-lined furnaces that combust MSW under excess air conditions in a single combustion chamber.

- Factory-Fabricated (Modular) Systems are usually small-scale (up to 500 TPD, but generally 200 TPD or less) systems comprised of predesigned modules that are manufactured at a factory and assembled onsite. These systems have separate primary and secondary combustion chambers.

Field-erected mass burning systems typically include either waterwall furnaces with integral boilers or refractory-lined furnaces with waste-heat boilers. Combustion occurs in a single-chamber furnace, usually equipped with grates that move the MSW through the furnace and help control burning.

Factory-fabricated systems, more commonly referred to as modular combustion systems, are comprised of predesigned modules for waste feeding, primary and secondary combustion, energy recovery, and ash handling. The modules are manufactured at the factory and shipped to the facility site, where they are assembled and mounted on footings. Little site work on the facility is required, other than wiring and piping. The installation is housed in a prefabricated building with additional space (usually a concrete tipping floor) for waste storage and handling.

Field-erected mass burning systems use a pit to store incoming refuse. The capacity of the pit is usually several times greater than the plant's daily throughput, so waste can be stored for weekend operations. The waste is retrieved from the pit by an overhead crane equipped with a grapple. In most factory-fabricated systems, refuse vehicles deposit their loads onto a concrete tipping floor. Skid-steer front-end loaders remove bulky or otherwise undesirable items, and push the remaining material to a convenient area for storage.

Field-erected mass burning systems are usually equipped with a feed hopper and chute arrangement that continuously feeds waste onto the first furnace grate by gravity. Most systems include a horizontal hydraulic ram at the bottom of the chute to push waste onto the grates, allowing more control over waste feeding and firing. In most modular systems, waste is charged to the furnace intermittently using a horizontal hydraulic ram. A front-end loader fills the hopper, with the load size depending on the current furnace temperature; and the operator manually activates the feed cycle. However, some modular systems continuously feed waste using a chute similar to that found in field-erected systems.

The key element of the combustion process in mass burning systems is the method of moving waste through the furnace and mixing it with air to achieve good combustion. In field-erected systems, this process is usually accomplished by burning the waste on some kind of grate system that is sloped from the front of the furnace, where waste enters, to the rear of the furnace, where residual ash is removed. The grates are also designed to agitate the waste and mix it with air. The action of the grates combined with gravity causes the waste to tumble slowly downward as it burns.

A refractory-lined or waterwall rotary-kiln can be used for combustion, in place of or in combination with, a grate system. A rotary-kiln consists of an inclined rotating cylinder into which waste is charged at the raised end. The rotation of the kiln thoroughly agitates the waste and mixes it with air.

Steam may be produced as a bi-product of combustion, and electricity can be generated using steam turbines. Turbines convert the thermal energy of the steam to mechanical energy in the form of a rotating turbine shaft, which is connected to an electric generator. Steam entering the turbine is expanded through a set of stationary nozzles. The expanded steam strikes turbine wheel blades, which turn the turbine shaft to which the wheel is connected.

The efficiency of a steam turbine increases with its size. A turbine sized for a small-scale facility of 100 TPD would be able to convert only 55 to 60 percent of the available thermal energy in the steam to mechanical power. This efficiency increases to 75 to 80 percent for a large-scale plant processing 2000 TPD. Consequently, the economics of electrical generation are less attractive for small-scale waste-to-energy facilities; however, the feasibility of any given project will depend on the price for which electricity can be sold, and this price can vary considerably.

Since electrical generation requires higher capital and operating costs and returns a lower market price, it is preferable for the modular mass burn facility to sell steam directly. A properly operating modular mass burn plant will produce approximately 2.4 pounds of steam per pound of solid waste. The proximity of a steam load is essential in making the direct sale of steam profitable. Steam transfer distances of greater than one mile are marginal and greater than two miles are not recommended.

An alternative to production of steam or electrical generation is to recover no usable end product. The reduction of solid waste volume and weight to reduce disposal costs would then be the primary objective.

The major air pollutant produced by waste-to-energy facilities is particulate matter. Acid gas may also be a problem. Particulates from field-erected systems are generally removed by electrostatic precipitators (ESP's). Fabric filters or bag-houses are being used at most new waste-to-energy facilities. Most of the earlier modular systems required no additional air pollution control devices beyond the secondary chamber or afterburner, where combustion of volatile gases is completed. More recently, further particulate removal has been required and can be accomplished by using ESP's, electrified gravel filter beds, or fabric filters (bag-houses). There is a trend in recently developed projects for gas scrubbing to be required for acid gas removal (dry scrubbers/wet scrubbers).

Waste-to-energy facilities produce three types of residue: bottom ash, fly ash, and scrubber product. Bottom ash is what remains in the combustion chamber after burn-out is complete. It is by far the largest residue component. Fly ash consists primarily of particulates carried out of the combustion chamber with the combustion gases. It is collected by air pollution control devices, such as electrostatic precipitators and baghouses. Scrubber product is the residue from gas scrubbing systems. It consists of absorbing material, usually a calcium or sodium based alkali, and neutralized acid gases. Field-erected mass burning systems reduce the volume of incoming refuse by 90 to 95 percent. The residue or bottom ash remaining after combustion in field-erected systems usually drops off the grates into a water-filled quench tank or a dry ash pit. The cooled residue is usually removed from the quench tank by a drag-chain conveyor, or from the dry ash pit by a belt conveyor. Dry ash handling systems have the advantage of reducing the weight of the residue that must be hauled to a landfill.

Early modular incinerators were batch-fed devices that had to be shut down daily for manual ash removal. Today, virtually all municipal-scale systems with energy recovery possess automatic ash removal systems. Both wet and dry systems are used, including quench tanks with drag-chain conveyors or hydraulic scoops, and dry ash bins with conveyors.

Pros:

- Reduces volume and weight of waste, thereby reducing the land area required for landfill disposal or extending the life of an existing landfill;
- Sale of steam or electricity can help offset operating costs;
- Weather generally has no effect on operations because the facility is fully enclosed;
- Plant can be designed to be compatible with populated areas.

Cons:

- Stringent air pollution standards must be met;
- A properly designed ash disposal and backup landfill is required;
- Skilled labor is necessary to operate the facility;
- 24 hour operation is usually necessary for optimum efficiency;
- Incoming waste must be carefully monitored for explosive articles.

COST ANALYSIS OF WASTE-TO-ENERGY OPTIONS

Four types of waste-to-energy facilities will be considered in our cost analysis:

- small modular, 50 tons/day;
- large modular, 150 tons/day;
- small site erected, 200 tons/day;
- large site erected, 400 tons/day.

The cost analysis will include assumptions for incineration both with and without energy recovery for the modular systems. Ash disposal will be in landfills sized for a twenty year life with extra capacity for disposal of MSW during incinerator shutdown. The cost analyses assume that the incinerators will operate 24 hours per day for 345 days per year.

The results of these cost analyses are summarized in Table 10-1, which breaks down the basic cost components of each facility, and in Figure 10-1. A more detailed cost breakdown of these facilities is available in the appendix to this chapter.

Assumptions

In our cost analysis of a **small modular facility** with a capacity of 50 tons/day, we used the following assumptions:

- Tipping floor transfer to storage: Front end loader;
- Storage capacity: 150 Tons;
- Transfer to hopper: Front end loader;
- Number of Units/Capacity: 2 modular units;
- Type of Unit: Modular starved air with secondary combustion;
- Energy Recovery: Steam at 2.75 lb. per lb MSW;
- Price per 1000 lb/steam: $5.50;
- Emission Control: Dry scrubber and baghouse filter;

- Ash removal: Water quenched;
- Volume Reduction: 90%;
- Ash Disposal: 20 miles in lined landfill.

For the **large modular facility** processing 150 tons/day, we made the following assumptions:

- Tipping floor transfer to storage: Front end loader;
- Storage capacity: 500 Tons;
- Transfer to hopper: Individual hydraulic ram feeders;
- Number of Units/Capacity: 2 at 75 TPD;
- Type of Unit: Modular starved air with secondary combustion;
- Energy Recovery: Steam at 2.75 lb. per lb MSW;
- Price per 1000 lb steam: $5.50;
- Emission Control: Dry scrubber and baghouse filter;
- Ash removal: Water quenched;
- Volume Reduction: 90%;
- Ash Disposal: 20 miles in lined landfill.

For the **small site erected facility** processing 400 tons/day, we made the following assumptions:

- Tipping floor transfer to storage: Front end loader;
- Storage capacity: 1200 Tons;
- Transfer to hopper: Overhead crane;
- Number of Units/Capacity: 2 at 200 TPD;
- Type of Unit: Water wall boiler;
- Energy Recovery: Turbine generator (electricity);
- Amount of electricity (for sale) per ton MSW: 325 KW-hr;
- Price per KW-hr of electricity: $.08;
- Emission Control: Dry scrubber and baghouse filter;
- Ash removal: Water quenched conveyors;
- Volume Reduction: 90%;
- Ash Disposal: 20 miles in lined landfill.

For the **large site erected facility** processing 800 tons/day, we made the following assumptions:

- Tipping floor transfer to storage: Direct dump to storage pit;
- Storage capacity: 2400 Tons;
- Transfer to hopper: Overhead crane;
- Number of Units/Capacity: 3 at 400 tons/day;

- Type of Unit: Water wall boiler;
- Energy Recovery: Turbine generator (electricity);
- Amount of electricity (for sale) per ton MSW: 325 KW-hour;
- Price per KW-hr of electricity: $.08;
- Emission Control: Dry scrubbers and baghouse filter;
- Ash removal: Hydraulic ram (bottom ash), screw conveyor (fly ash);
- Volume Reduction: 90%;
- Ash Disposal: 20 miles in lined landfill.

Ash landfills have been sized for each of the incinerators and their associated costs have been analyzed separately. Our cost analysis reflects the following assumptions:

- Volume reduction by incineration = 90%;
- Density of ash = 2000 lb/c.y.;
- Density of MSW in 50 and 150 ton/day ash landfills = 800 lb/c.y.;
- Density of MSW in 400 and 800 ton/day ash landfills = 1000 lb/c.y.;
- Cover to ash ration = 5%;
- Cover to MSW ratio = 15%;
- 50 ton/day incineration facility is open 24 hours/day, 345 days/year;
- 150, 400, and 800 ton/day incineration facilities are open 24 hours/day, 355 days/year;
- Waste handling equipment purchase every 10 years with a 20% resale value
- Inflation factor - 4%;
- Ash landfills are sized for a 20-year life.

Waste-to-Energy Costs

As shown in Table 10-1, clear economies of scale exist for waste-to-energy facilities --costs decrease as daily capacity of the facility increases. The net present value of the life-cycle costs range from a low of $18 per ton for the 800 TPD facility to a high of $104 per ton for the 50 TPD facility with energy generation. The 50 TPD facility without energy recovery is even more expensive at $116 per ton. The net present value costs are significantly lower than the first year costs because waste-to-energy costs have a high proportion of capital costs relative to operating costs. The lifecycle costs are low because the annual capital payments are fixed and decrease in present value more quickly than operating costs which increase due to inflation.

Operating costs have much more dramatic economies of scale than do capital costs. Operating costs per ton, as shown in Table 10-1, drop over 70% from the smallest (50 TPD) to largest (800 TPD) facility, while annualized capital costs per ton decline almost 40%. This reflects the fact that some larger capital expenses, particularly infrastructure (building) and combustion equipment, exhibit no economies of scale. This reduces the overall economies of scale.

Capital Costs

As mentioned above, many waste-to-energy capital components do not have economies of scale. Among the cost items that exhibit little or no economy of scale are infrastructure, combustion equipment, waste handling equipment, and insurance and security bonding. Because infrastructure and combustion equipment, which are the two largest capital cost components, do not exhibit economies of scale, the overall economies of scale for capital costs are modest.

Almost all of the economies of scale for capital costs are for emission control equipment. In the 50 TPD facility (with energy recovery), emissions controls are 31% of total costs, the largest component of capital costs. For the 800 TPD facility emission control equipment is 14%, only the third largest cost component. Of the $21 to $26 drop (depending upon the use of energy recovery in the smaller facility) in 1990 net capital costs from the largest to smallest facility, $15 to $17 can be attributed to decreases in per ton pollution control costs. The fixed costs of a pollution control system are very high, so the additional cost of adding more pollution control capacity for a larger facility is relatively small.

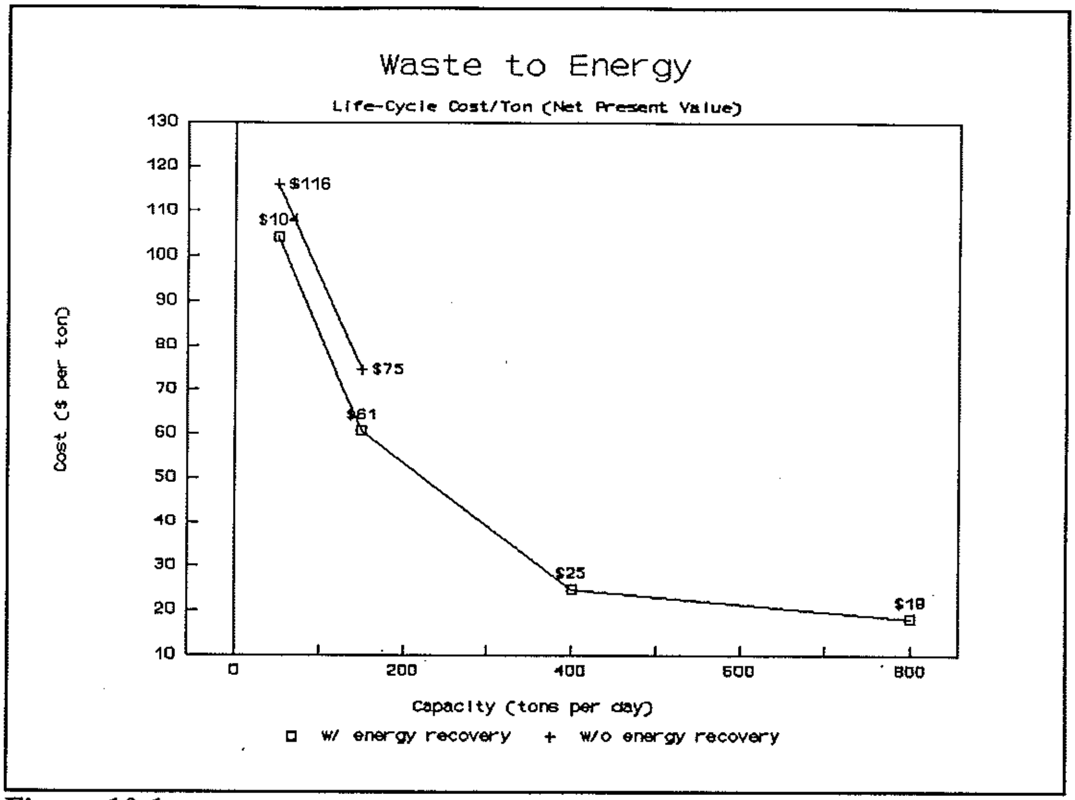


Figure 10-1

Waste-To-Energy Operating Costs

Most economies of scale in operating costs can be attributed to labor and to residue disposal, although several other items, including utilities, taxes and insurance, and equipment operations and maintenance, play a role as well. Labor costs are the largest single operating expense in the 50 TPD facility, accounting for 25-27% of 1990 operating costs. But when capacity increases to 800 TPD, labor accounts for only 12% of operating costs, a greater than two-fold decrease in percentage. Labor costs alone account for more than 35% of the difference in per-ton operating costs between the largest and smallest facilities. This finding reflects the large number of personnel who are needed to operate any waste-to-energy facility. All facilities, regardless of size, require at least one superintendent, four foremen, and four loader operators. While the increase in number of employees is two-fold from the smallest to largest facilities (17 to 36 employees), the capacity increase is sixteen-fold (50 to 800 TPD).

Costs for residue disposal costs follow a pattern very similar to labor costs, because of the assumption that a dedicated ash landfill is constructed specifically for each of the facilities analyzed. The 1990 landfill costs range from $101 per ton of ash for a 50 TPD facility to $21 per ton of ash for a 800 TPD facility. This corresponds to a cost of $30 to $6 per ton of throughput for the waste-to-energy facility. Sources of this economy of scale are discussed in detail in the section on solid waste landfills since reasons for economies of scale are similar for ash landfills and solid waste landfills.

A final cost item worth mentioning is equipment operations and maintenance. These costs are one of the largest expense items, but they exhibit relatively minor economies of scale relative to their magnitude.

Maintenance cost increases are also one of the major impacts of adding steam generation to the two smaller units, accounting for roughly a one-third cost increase in this item. Combustion equipment costs rise roughly $6 per ton as well because of the additions of steam generation. Revenue from energy recovery offsets some operating costs in the two smaller facilities, however. Total cost increases from adding energy production are between $13 and $15 per ton, while the revenues from energy recovered are roughly $28. Though this net savings of $13 to $16 is significant, the costs of operating these facilities are still prohibitively high.

TABLE 10-1

Waste-to-Energy Capital and Operating Costs

Capacity		50	50	150	150	400	800
Tons per Year		15,600	15,600	46,800	46,800	124,800	249,600
Energy Recovery (S=Steam,E=Electric)			S		S	E	E
1990 CAPITAL AND OPERATING COSTS							
Capital Cost		9,501,746	10,390,247	23,017,617	25,656,855	55,108,167	104,222,990
Capital Payment		1,045,863	1,126,498	2,474,627	2,800,859	6,032,406	11,278,969
Operating Costs		1,234,525	1,345,428	2,177,387	2,412,217	4,188,933	6,648,783
Residue Disposal		483,529	483,529	736,216	736,216	1,034,678	1,472,144
Annualized Costs		2,763,917	2,955,455	5,388,230	5,949,292	11,256,017	19,399,896
Revenues (Energy Sale)			426,594		1,317,422	5,276,075	10,522,150
Net Cost		2,763,917	2,528,861	5,388,230	4,631,870	5,979,942	8,877,746
Cost per Ton		177.17	162.11	115.13	98.97	47.92	35.57
LIFECYCLE COSTS							
Lifetime Costs (1990 $)		36,150,780	32,548,308	69,819,779	56,776,652	61,768,927	90,403,425
Per Ton Cost (nominal $)	Year 1	178.18	164.26	116.55	99.38	47.30	37.07
	2	181.42	166.69	118.48	100.39	46.95	36.52
	3	184.78	169.22	120.49	101.43	46.59	35.94
	4	188.28	171.86	122.58	102.52	46.21	35.34
	5	198.44	181.12	127.81	106.71	47.50	36.03
	6	202.23	183.96	130.07	107.89	47.09	35.38
	7	206.16	186.92	132.42	109.11	46.67	34.71
	8	210.25	190.00	134.87	110.38	46.23	34.00
	9	214.51	193.20	137.41	111.71	45.77	33.27
	10	218.93	196.53	140.05	113.09	44.78	32.88
	11	223.27	199.73	143.56	115.27	44.29	32.09
	12	228.06	203.34	146.42	116.76	43.77	31.27
	13	233.04	207.08	149.39	118.31	43.24	30.41
	14	238.22	210.98	152.48	119.92	42.68	29.52
	15	243.60	215.03	155.70	121.60	42.10	28.60
	16	250.05	220.09	159.35	123.65	41.75	26.98
	17	255.87	224.47	162.83	125.46	41.13	25.98
	18	261.93	229.03	166.44	127.34	40.47	24.94
	19	268.23	233.77	170.21	129.30	39.79	23.86
	20	274.78	238.70	174.12	131.34	39.09	22.73
1990 Present Value of Lifetime per Ton Cost		115.87	104.32	74.59	60.66	24.75	18.11

TABLE 10-1 (cont)

Waste-to-Energy Capital and Operating Costs

1990 ITEMIZED WASTE-TO-ENERGY ANNUAL COSTS

Capacity	50	50	150	150	400	800
Energy Recovery (S=Steam,E=Electric)		S		S	E	E
Annualized Capital Costs	1,028,319	1,108,954	2,448,488	2,774,720	5,900,426	11,146,989
Site Prep	54,104	54,104	54,104	54,104	121,205	214,871
Infrastructure	148,864	148,864	213,561	213,561	1,275,977	2,324,761
Combustion Equip	161,043	249,489	978,175	1,243,515	1,585,065	3,068,685
Electrical Generation Equip	0	0	0	0	327,580	650,933
Emmission Control Equip	357,802	338,887	595,033	595,033	797,816	1,580,838
Waste Handling Equip	30,329	30,329	45,570	45,570	243,395	424,760
Misc Equip	5,563	5,563	7,239	7,239	8,001	11,050
Professional Services	116,260	113,781	184,715	201,833	612,748	1,155,595
Insurance and Security Bond	21,663	24,727	52,835	60,232	169,074	278,971
Contingency	132,693	143,211	317,256	353,633	759,565	1,436,523
Operations Costs	1,741,323	1,852,227	2,985,462	3,364,823	5,415,236	8,498,177
Wages and Salary	535,050	532,150	667,000	667,000	955,550	1,003,400
Utilities, Tax, Insurance	218,000	218,000	369,000	369,000	687,000	1,070,000
Equip Operations & Maintenance	318,450	417,788	854,380	1,058,580	1,997,000	3,702,150
Residue Disposal	483,529	483,529	736,216	736,216	1,034,678	1,472,144
Contracted Service	25,269	25,269	74,859	74,859	194,625	383,250
Contingency	161,025	175,491	284,007	459,168	546,383	867,233

ANNUAL COSTS PER TON FOR WASTE TO ENERGY FACILITIES (1990)

Capital Costs	65.21	70.38	51.97	58.94	46.66	44.12
Site Prep	3.47	3.47	1.16	1.16	0.97	0.86
Infrastructure	9.54	9.54	4.56	4.56	10.22	9.31
Combustion Equip	10.32	15.99	20.90	26.57	12.70	12.29
Electrical Generation Equip	0.00	0.00	0.00	0.00	2.62	2.61
Emmission Control Equip	22.94	21.72	12.71	12.71	6.39	6.33
Waste Handling Equip	1.35	1.35	0.68	0.68	1.35	1.18
Misc Equip	0.25	0.25	0.11	0.11	0.04	0.03
Professional Services	7.45	7.29	3.95	4.31	4.91	4.63
Insurance and Security Bond	1.39	1.59	1.13	1.29	1.35	1.12
Contingency	8.51	9.18	6.78	7.56	6.09	5.76
Operations Costs	111.62	118.73	63.79	71.90	43.39	34.05
Wages and Salary	34.30	34.11	14.25	14.25	7.66	4.02
Utilities, Tax, Insurance	13.97	13.97	7.88	7.88	5.50	4.29
Equip Operations & Maintenance	20.41	26.78	18.26	22.62	16.00	14.83
Residue Disposal	31.00	31.00	15.73	15.73	8.29	5.90
Contracted Service	1.62	1.62	1.60	1.60	1.56	1.54
Contingency	10.32	11.25	6.07	9.81	4.38	3.47
Total Costs	176.84	189.11	115.76	130.84	90.05	78.17

APPENDIX TO CHAPTER 10

INCINERATOR CAPITAL COSTS (with no energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS				
Site Preparation				
1. Land Purchase	7,500.00	10	acre	75,000
2. Clear and Grub	2,500.00	4	acre	10,000
3. Drainage\Grading	325,000.00	1	ls	325,000
4. Access and Misc.	65,000.00	1	ls	65,000
5. Sewer & Water	30,000.00	1	ls	30,000
6. Power	14.00	500	ft	7,000
		Subtotal:		512,000
Infrastructure				
1. Buildings	130.00	8,000	sf	1,040,000
2. Scale	65,000.00	1	ea	65,000
3. Monitoring Wells	3,500.00	4	ea	14,000
4. Leachate Collection Sys.	10,000.00	1	ea	10,000
5. Electrical, HVAC	210,000.00	1	ea	210,000
6. Compressed Air System	35,000.00	1	ea	35,000
7. Paving	7.50	3,300	sy	24,750
8. Landscaping (Fert. & Seed)	4,000.00	2.5	Acres	10,000
		Subtotal:		1,408,750
Combustion Equipment				
1. Controlled Air Combustion Unit	762,000.00	2	ea	1,524,000
		Subtotal:		1,524,000
Emission Control Equipment				
1. Dry Scrubber	1,008,000.00	1	ea	1,008,000
2. Baghouse Filter	672,000.00	1	ea	672,000
3. Stack (65'), Including Found.	170,000.00	1	ea	170,000
4. Temperature Control Device	179,000.00	1	ea	179,000
5. Flue Gas Ducting & Fan (Incl. ducting for both combusters)	78,000.00	1	ea	78,000
6. Monitoring Equipment	343,000.00	1	ea	343,000
7. Indirect Costs	936,000.00	1	ea	936,000
		Subtotal:		$3,386,000

INCINERATOR CAPITAL COSTS (with no energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS (continued)				
Waste Handling Equipment				
1. Loader (CAT 936 or equiv.)	117,000.00	1	ea	117,000
2. Pickup	17,000.00	1	ea	17,000
3. Mack 10-whl 10-cy dump	65,000.00	1	ea	65,000
		Subtotal:		199,000
Misc. Equipment				
1. Tools	7,500.00	1	ea	7,500
2. Spare Parts	29,000.00	1	ea	29,000
		Subtotal:		36,500
Professional Services				
1. Design	235,000.00	1	ls	235,000
2. Bid Documents & Review	60,000.00	1	ls	60,000
3. Survey Control	33,000.00	1	ls	33,000
4. Construction Management	270,000.00	1	ls	270,000
5. Start-up & Acceptance Testing	175,000.00	1	ls	175,000
6. Permitting costs	4.50%of capital costs (prof. services excluded)			327,206
		Subtotal:		1,100,206
Miscellaneous Costs				
Insurance and Security Bonds	205,000.00	1	ls	205,000
		Subtotal:		205,000
	TOTAL CAPITAL COST			8,371,456
	CONTINGENCY (15%)			1,255,718
	GRAND TOTAL CAPITAL COSTS:			$9,627,175

INCINERATOR OPERATING COSTS (no energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries				
1. Superintendant	45,000.00	1	ea yr	45,000
2. Foreman	35,000.00	4	ea yr	140,000
3. Scale operator	16,000.00	1	ea yr	16,000
4. Loader Operator	16,000.00	4	ea yr	64,000
5. Laborer	14,000.00	5	ea yr	70,000
6. Drivers	18,000.00	1	ea yr	18,000
7. Secretary	16,000.00	1	ea yr	16,000
	Subtotal without benefits:			369,000
	Fringe Benefits	30%		110,700
	Overtime Allowance	15%		55,350
	Subtotal with benefits:			535,050
Utilities, Taxes, and Insurance				
1. Utilities	2,750.00	12	mon/yr	33,000
2. Taxes Insurance & Administration	10,000.00	12	mon/yr	120,000
3. Overhead	65,000	1	ea/yr	65,000
		Subtotal:		218,000
Equip Op & Maint				
1. Loader Fuel	1.00	34,000	gal/yr	34,000
2. Other fuel	1.00	2,000	gal/yr	2,000
3. Auxilliary MCU Fuel	1.00	5,000	gal/yr	5,000
4. Maintenance		5% of capital costs		255,450
5. Lime	80.00	120	tons/yr	9,600
6. Licenses, tax, and ins.	10,000.00	1	ea	10,000
7. Filter Replacement ($6,000 Every 2 1/2 yrs)	2,400.00	1	ea/yr	2,400
		Subtotal:		318,450
Contracted Services				
1. Pumping Leachate Holding Tank	500.00	4	/yr	2,000
2. Disposal of Non-Burnable Refuse (5%)	30.00	776	tons/yr	23,269
		Subtotal:		25,269
	TOTAL O & M COSTS:			1,096,769
	CONTINGENCY (15%)			164,515
	GRAND TOTAL OPERATING COSTS			$1,261,284

CAPITAL COSTS SUMMARY
INCINERATOR (without energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	512,000	0	0	0	0
Infrastructure	1,408,750	0	0	0	0
Combustion Equipment	1,524,000	0	0	0	0
Emision Control Equipment	3,386,000	0	0	0	0
Waste Handling Equipment	199,000	0	242,114	0	0
Misc. Equipment	36,500	0	13,507	0	0
Professional Services	1,100,206	0	0	0	0
Misc. Costs	205,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(39,800)	0	(48,423)
TOTALS	8,371,456	0	215,821	0	(48,423)
CONTINGENCY (15%)	1,255,718	0	32,373	0	0
GRAND TOTAL	9,627,175	0	248,194	0	(48,423)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period					
Annual Bond Payment @ 8.5%	1,017,313				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		17,544	17,544	0	0

LIFE CYCLE COSTS: 1990-2010
INCINERATOR (without energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED $0.00)	TIPPING FEE (1990 $0.00)
1990	1,017,313	17,544	1,261,284	0	2,296,141	15,513	148.02	148.02
1995	1,017,313	17,544	1,534,545	0	2,569,402	15,513	165.63	136.14
2000	1,017,313	0	1,867,009	0	2,884,321	15,513	185.94	125.61
2005	1,017,313	0	2,271,501	0	3,288,814	15,513	212.01	117.72
2010	1,017,313	0	2,763,629	(48,423)	3,732,519	15,513	240.61	109.81

NOTES

1. The incinerator is assumed to have two 25 TPD MCU's.
2. MCU's units would have a primary air-starved furnace with moving grates, a secondary combustion chamber with ancillary fuel capability , and a wet-ash sump.
3. The facility will operate 24 hours per day, 312 days per year.
4. The loader is assumed to burn 4 gallons of fuel per hour.
5. Waste handling equipment will be traded in at the end of every two stages for 20% of its value.
6. An 85% annual capicity utilization factor was assumed for total tons per year.
7. Bag life is 2 1/2 years (replacement $12,600)
8. Combuster cost includes; combuster and one CO monitor per combuster.
9. Monitoring equipment includes equipment for both particulate matter (opacity monitor and a data reduction system) and PM/acid gas (opacity, inlet/outlet SO_2, inlet/outlet HCL, and inlet/outlet O_2 monitors and a data reduction system)

INCINERATOR CAPITAL COSTS (with energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS				
Site Preparation				
1. Land Purchase	7,500.00	10	acre	75,000
2. Clear and Grub	2,500.00	4	acre	10,000
3. Drainage\Grading	325,000.00	1	ls	325,000
4. Access and Misc.	65,000.00	1	ls	65,000
5. Sewer & Water	30,000.00	1	ls	30,000
6. Power	14.00	500	ft	7,000
		Subtotal:		512,000
Infrastructure				
1. Building	130.00	8,000	sf	1,040,000
2. Scale	65,000.00	1	ea	65,000
3. Monitoring Wells	3,500.00	4	ea	14,000
4. Leachate Collection Sys.	10,000.00	1	ea	10,000
5. Compressed Air System	35,000.00	1	ea	35,000
6. Electrical, HVAC	210,000.00	1	ea	210,000
7. Paving	7.50	3,300	sy	24,750
8. Landscaping (Fert. & Seed)	4,000.00	2.5	Acres	10,000
		Subtotal:		1,408,750
Combustion Equipment				
1. Controlled Air Combustion Unit	762,000.00	2	ea	1,524,000
2. Waste Heat Boilers	336,000.00	2	ea	672,000
3. Boiler Feedback Sys. & Process Piping	165,000.00	1	ea	165,000
		Subtotal:		2,361,000
Emission Control Equipment				
1. Dry Scrubber	1,008,000	1	ea	1,008,000
2. Baghouse Filter	672,000	1	ea	672,000
3. Stack (60'), Including Found.	170,000.00	1	ea	170,000
4. Flue Gas Ducting & Fan (Incl. ducting for both combusters)	78,000.00	1	ea	78,000
5. Monitoring Equipment	343,000.00	1	ea	343,000
6. Indirect Costs	936,000.00	1	ea	936,000
		Subtotal:		3,207,000

INCINERATOR CAPITAL COSTS (with energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS (continued)				
Waste Handling Equipment				
1. Loader (CAT 936 or equiv.)	117,000.00	1	ea	117,000
2. Pickup	17,000.00	1	ea	17,000
3. Mack 10-whl 10-cy dump	65,000.00	1	ea	65,000
		Subtotal:		199,000
Misc. Equipment				
1. Tools	7,500.00	1	ea	7,500
2. Spare Parts	29,000.00	1	ea	29,000
		Subtotal:		36,500
Professional Services				
1. Design	260,000.00	1	ls	260,000
2. Bid Documents & Review	65,000.00	1	ls	65,000
3. Survey Control	33,000.00	1	ls	33,000
4. Construction Management	290,000.00	1	ls	290,000
5. Start-up & Acceptance Testing	190,000.00	1	ls	190,000
6. Permitting costs	4.50% of capital costs (prof. services excluded)			358,121
		Subtotal:		1,196,121
Miscellaneous Costs				
Insurance and Security Bonds	234,000.00	1	ls	234,000
		Subtotal:		234,000
	TOTAL CAPITAL COST			9,154,371
	CONTINGENCY (15%)			1,373,156
	GRAND TOTAL CAPITAL COSTS:			$10,527,527

INCINERATOR OPERATING COSTS (with energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries			
1. Superintendant	45,000.00	1 ea yr	45,000
2. Foreman	35,000.00	4 ea yr	140,000
3. Scale operator	16,000.00	1 ea yr	16,000
4. Loader Operator	16,000.00	4 ea yr	64,000
5. Laborer	14,000.00	5 ea yr	70,000
6. Driver	18,000.00	1 ea yr	18,000
7. Secretary	16,000.00	1 ea yr	16,000
	Subtotal without benefits:		369,000
	Fringe Benefits	30%	110,700
	Overtime Allowance	15%	55,350
	Subtotal with benefits:		535,050
Utilities, Taxes, and Insurance			
1. Utilities	2,750.00	12 mon/yr	33,000
2. Taxes Insurance & Administration	10,000.00	12 mon/yr	120,000
3. Overhead	65,000.00	1 /yr	65,000
		Subtotal:	218,000
Equip Op & Maint			
1. Loader Fuel	1.00	30,000 gal/yr	30,000
2. Other fuel	1.00	2,000 gal/yr	2,000
3. Auxilliary MCU Fuel	1.00	5,000 gal/yr	5,000
4. Maintenance		5% of capital costs	358,788
5. Lime	80.00	120 tons/yr	9,600
6. Licenses, tax, and ins.	10,000.00	1 ea	10,000
7. Filter replacement ($6,000 every 2 1/2 years)	2,400.00	1 ea/yr	2,400
		Subtotal:	417,788
Contracted Services			
1. Pumping Leachate Holding Tank	500.00	4 /yr	2,000
2. Disposal of Non-Burnable Refuse (5%)	30.00	776 tons/yr	23,269
		Subtotal:	25,269
	TOTAL O & M COSTS:		1,196,106
	CONTINGENCY (15%)		179,416
	GRAND TOTAL OPERATING COSTS		$1,375,522

CAPITAL COSTS SUMMARY
INCINERATOR (with energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	512,000	0	0	0	0
Infrastructure	1,408,750	0	0	0	0
Combustion Equipment	2,361,000	0	0	0	0
Emision Control Equipment	3,207,000	0	0	0	0
Waste Handling Equipment	199,000	0	242,114	0	0
Misc. Equipment	36,500	0	13,507	0	0
Professional Services	1,196,121	0	0	0	0
Misc. Costs	234,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(39,800)	0	(48,423)
TOTALS	9,154,371	0	215,821	0	(48,423)
CONTINGENCY (15%)	1,373,156	0	32,373	0	0
GRAND TOTAL	10,527,527	0	248,194	0	(48,423)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period					
Annual Bond Payment @ 8.5%	1,112,454				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		17,544	17,544	0	0

LIFE CYCLE COSTS: 1990-2010
INCINERATOR (with energy recovery)
SMALL MODULAR (50 TON/DAY) FACILITY

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES (equipment Trade-in)	REVENUES (Steam)	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED $0.00)	TIPPING FEE (1990 $0.00)
1990	1,112,454	17,544	1,375,522	0	(426,594)	2,078,926	15,513	134.02	134.02
1995	1,112,454	17,544	1,673,533	0	(519,017)	2,284,514	15,513	147.27	121.04
2000	1,112,454	0	2,036,109		(631,463)	2,517,100	15,513	162.26	109.62
2005	1,112,454	0	2,477,238	0	(768,271)	2,821,421	15,513	181.88	100.99
2010	1,112,454	0	3,013,938	(48,423)	(934,719)	3,143,250	15,513	202.63	92.48

NOTES

1. The incinerator is assumed to have two 25 TPD MCU's.

2. MCU's units would have a primary air-starved furnace with moving grates, a secondary combustion chamber with ancillary fuel capability , and a wet-ash sump.

3. The facility will operate 24 hours per day, 345 days per year.

4. The loader is assumed to burn 4 gallons of fuel per hour.

5. Equipment will be traded in at the end of every two stages for 20% of its value.

6. An 85% annual capacity utilization factor was assumed for total tons per year.

7. Steam piping and accessories from the incineration plant to the customers facility is paid for by the customer.

8. Combuster cost includes; combuster and one CO monitor per combuster.

9. Monitor equipment includes equipment for both particulate matter (opacity monitor and a data reduction system) and PM/acid gas (opacity, inlet/outlet SO_2, inlet/outlet HCL, and inlet/outlet O_2 monitors and data reduction system).

Ash Landfill Capital Costs (50 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995				Stage 2 1995-2000				Stage 3 2000-2005				Stage 4 2005-2010			
	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	30	acre	150,000												
Mobilization/Demobiliz	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	20	acre	50,000	3,041.63	1	acre	3,042	3,700.61	1	acre	3,701	4,502.36	1	acre	4,502
Erosion Control Silt F	2.84	2,000	lf	5,680	3.46	400	lf	1,382	4.20	400	lf	1,682	5.11	400	lf	2,046
Excavation/Stockpile	2.30	127,660	cy	293,618	2.80	22,915	cy	64,123	3.40	22,915	cy	78,016	4.14	22,915	cy	94,918
Access Road	22.00	240	lf	5,280	26.77	45	lf	1,204	32.57	45	lf	1,465	39.62	45	lf	1,783
Operational Berm	30.00	500	lf	15,000	36.50	175	lf	6,387	44.41	175	lf	7,771	54.03	175	lf	9,455
		SUBTOTAL:		524,578		SUBTOTAL:		82,222		SUBTOTAL:		100,036		SUBTOTAL:		121,709
INFRASTRUCTURE																
Maintenance/Office Bld	70.00	700	sf	49,000												
Equipment Storage	20.00	2,000	sf	40,000												
Fuel pumps / Storage	12,000.00	1	ea	12,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	20,000.00	1	ea	20,000												
Fencing	16.00	5,280	lf	84,480												
Landscaping	10,000.00	0.6	ea	6,000												
Groundwater Monitoring	3,500.00	4	ea	14,000	4,258.29	1	ea	4,258	5,180.85	1	ea	5,181	6,303.30	2	ea	12,607
Sedimentation Ponds	45,000.00	1	ea	45,000												
		SUBTOTAL:		338,230		SUBTOTAL:		4,258		SUBTOTAL:		5,181		SUBTOTAL:		12,607

Ash Landfill Capital Costs (50 Ton/Day Incineration Facility)

	Stage 1 1990-1995				Stage 2 1995-2000				Stage 3 2000-2005				Stage 4 2005-2010			
ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	1	ea	30,000												
		SUBTOTAL:		31,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	71,355	sf	10,703	0.18	15,857	sf	2,894	0.22	15,857	sf	3,521	0.27	15,857	sf	4,284
Clay Layer	30.00	5,286	cy	158,568	36.50	1,175	cy	42,871	44.41	1,175	cy	52,160	54.03	1,175	cy	63,460
60 mil PVC Geomembrane	0.70	71,355	sf	49,949	0.85	15,857	sf	13,505	1.04	15,857	sf	16,430	1.26	15,857	sf	19,990
Sand Blanket Drain	15.00	5,286	cy	79,284	18.25	1,175	cy	21,436	22.20	1,175	cy	26,080	27.01	1,175	cy	31,730
Geotextile	0.06	142,711	sf	8,563	0.07	31,714	sf	2,315	0.09	31,714	sf	2,817	0.11	31,714	sf	3,427
Washed Stone	15.00	661	cy	9,910	18.25	147	cy	2,679	22.20	147	cy	3,260	27.01	147	cy	3,966
6" SDR 21 Slotted PVC	7.25	285	lf	2,069	8.82	63	lf	559	10.73	63	lf	681	13.06	63	lf	828
6" Cleanouts	1,750.00	3	ea	5,250	2,129.14	1	ea	2,129	2,590.43	1	ea	2,590	3,151.65	1	ea	3,152
		SUBTOTAL:		324,296		SUBTOTAL:		88,389		SUBTOTAL:		107,538		SUBTOTAL:		130,837
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembran	0.70	71,355	sf	49,949	0.85	15,857	sf	13,505	1.04	15,857	sf	16,430	1.26	15,857	sf	19,990
Washed Stone	15.00	661	cy	9,910	18.25	147	cy	2,679	22.20	147	cy	3,260	27.01	147	cy	3,966
Sand Blanket Drain	15.00	5,286	cy	79,284	18.25	1,175	cy	21,436	22.20	1,175	cy	26,080	27.01	1,175	cy	31,730
6" SDR 21 Slotted PVC	7.25	285	lf	2,069	8.82	63	lf	559	10.73	63	lf	681	13.06	63	lf	828
6" Cleanouts	1,750.00	3	ea	5,250	2,129.14	1	ea	2,129	2,590.43	1	ea	2,590	3,151.65	1	ea	3,152
		SUBTOTAL:		146,462		SUBTOTAL:		40,308		SUBTOTAL:		49,041		SUBTOTAL:		59,666

Ash Landfill Capital Costs (50 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE																				
Cap Underlainment					12.21	850	cy	10,379	14.86	850	cy	12,627	18.07	850	cy	15,363	21.99	1,700	cy	37,382
40 mil HDPE Geomembrane					0.55	57,970	sf	31,884	0.67	57,970	sf	38,791	0.81	57,970	sf	47,195	0.99	116,000	sf	114,900
Drainage layer					15.00	1,700	cy	25,500	18.25	1,700	cy	31,025	22.20	1,700	cy	37,746	27.01	3,400	cy	91,848
Subsoil					12.00	850	cy	10,200	14.60	850	cy	12,410	17.76	850	cy	15,098	21.61	1,700	cy	36,739
Topsoil					16.00	850	cy	13,600	19.47	850	cy	16,546	23.68	850	cy	20,131	28.82	1,700	cy	48,986
Seed, Fertilizer, Mulch, Lime					2,500.00	1.00	acres	2,500	3,041.63	1.00	acres	3,042	3,700.61	1.00	acre	3,701	4,502.36	2.0	acres	9,005
Terrace Swales					15.00	525	lf	7,875	18.25	525	lf	9,581	22.20	525	lf	11,657	27.01	1,054	lf	28,473
		SUBTOTAL:		0		SUBTOTAL:		101,937		SUBTOTAL:		124,022		SUBTOTAL:		150,892		SUBTOTAL:		367,333
EQUIPMENT (3)																				
Dozer (Cat D4H or eqv.	125,000.00	1	ea	125,000			ea	0	185,030.54	1	ea	185,031			ea	0				0
Loader (CAT 910 or eqv	60,000.00	1	ea	60,000			ea	0	88,814.66	1	ea	88,815			ea	0				0
Office Equipment	1,500.00	1	ea	1,500		0	ea	0	2,220.37	1	ea	1,776			ea	0				0
Maintenance Equipment	2,000.00	1	ea	2,000		0	ea	0	2,960.49	1	ea	2,368			ea	0				0
		SUBTOTAL:		188,500		SUBTOTAL:		0		SUBTOTAL:		277,990		SUBTOTAL:		0		SUBTOTAL:		0
PROFESSIONAL SERVICES																				
Hydro, Permitting	180,000.00	1	ea	180,000																
Bid Documents & Review	68,000.00	1	ea	68,000	24,000.00	1	ea	24,000	29,199.67	1	ea	29,200	35,525.86	1	ea	35,526	43,222.64	1	ea	43,223
Survey Control	28,000.00	1	ea	28,000	8,000.00	1	ea	8,000	9,733.22	1	ea	9,733	11,841.95	1	ea	11,842	14,407.55	1	ea	14,408
Construction Insp.	84,000.00	1	ea	84,000	28,000.00	1	ea	28,000	34,066.28	1	ea	34,066	41,446.84	1	ea	41,447	50,426.42	1	ea	50,426
Topo Map & Vol. Calc.	24,000.00	1	ea	24,000																
				384,000		SUBTOTAL:		60,000		SUBTOTAL:		72,999		SUBTOTAL:		88,815		SUBTOTAL:		108,057
	TOTAL CAPITAL COST			1,937,266	TOTAL CAPITAL COST			377,114	TOTAL CAPITAL COST			736,807	TOTAL CAPITAL COST			564,525	TOTAL CAPITAL COST			475,390
	CONTINGENCY (15%)			290,590	CONTINGENCY (15%)			56,567	CONTINGENCY (15%)			110,521	CONTINGENCY (15%)			84,679				
	GRAND TOTAL CAPITAL COSTS:			2,227,856	GRAND TOTAL CAPITAL COSTS			433,682	GRAND TOTAL CAPITAL COSTS:			847,328	GRAND TOTAL CAPITAL COSTS:			649,203	GRAND TOTAL CAPITAL COSTS:			475,390

Ash Landfill Operating Costs (50 Ton/Day Incineration Facility)

Stage 1, 1990-1995

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	22,000.00	1	yr	22,000
Occasional Labor	3,000.00	1	ls	3,000
	Subtotal Without Benefits:			25,000
Fringe Benefits		@ 30%		7,500
Overhead		@ 25%		6,250
	Subtotal With Benefits:			38,750
Utilities	725.00	12	mo	8,700
Leachate Disposal	0.22	17,839	gal	3,925
Equip Op & Maint	15,000.00	1	ls	15,000
Contracted Services	15,000.00	1	ls	15,000
Soil Cover	8.00	40	cy/mo	3,840
Insurance	5,000.00	1	yr	5,000
	TOTAL OPERATING COSTS:			90,215
	CONTINGENCY (15%)			13,532
	GRAND TOTAL OPERATING COSTS			103,747

Stage 2, 1995-2000

ITEM	UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	26,766.36	1	yr	26,766
Occasional Labor	3,649.96	1	ls	3,650
	Subtotal Without Benefits			30,416
Fringe Benefits		@ 30%		9,125
Overhead		@ 25%		7,604
	Subtotal With Benefits:			47,145
Utilities	882.07	12	mo	10,585
Leachate Disposal	0.27	59,403	gal	15,900
Equip Op & Maint	18,249.79		ls	18,250
Contracted Services	18,249.79		ls	18,250
Soil Cover	9.73	40	cy/mo	4,672
Insurance	6,083.26	1	yr	6,083
	TOTAL OPERATING COSTS:			120,885
	CONTINGENCY (15%)			18,133
	GRAND TOTAL OPERATING COS			139,018

Stage 3, 2000-2005

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	32,565.37	1	yr	32,565
Occasional Labor	4,440.73	1	ls	4,441
	Subtotal Without Benefits:			37,006
Fringe Benefits		@ 30%		11,102
Overhead		@ 25%		9,252
	Subtotal With Benefits:			57,359
Utilities	1,073.18	12	mo	12,878
Leachate Disposal	0.33	89,105	gal	29,017
Equip Op & Maint	22,203.66		ls	22,204
Contracted Services	22,203.66		ls	22,204
Soil Cover	11.84	40	cy/mo	5,684
Insurance	7,401.22	1	yr	7,401
	TOTAL OPERATING COSTS:			156,748
	CONTINGENCY (15%)			23,512
	GRAND TOTAL OPERATING COST			180,260

Stage 4, 2005-2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	39,620.76	1	yr	39,621
Occasional Labor	5,402.83	1	ls	5,403
	Subtotal Without Benefits:			45,024
Fringe Benefits		@ 30%		13,507
Overhead		@ 25%		11,256
	Subtotal With Benefits:			69,787
Utilities	1,305.68	12	mo	15,668
Leachate Disposal	0.40	98,016	gal	38,835
Equip Op & Maint	27,014.15		ls	27,014
Contracted Services	27,014.15		ls	27,014
Soil Cover	14.41	40	cy/mo	6,916
Insurance	9,004.72	1	yr	9,005
	TOTAL OPERATING COSTS:			194,238
	CONTINGENCY (15%)			29,136
	GRAND TOTAL OPERATING COST			223,374

CLOSURE, 2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	48,204.71	1	yr	48,205
Occasional Labor	6,573.37	1	ls	6,573
	Subtotal Without Benefits:			54,778
Fringe Benefits		@ 30%		16,433
Overhead		@ 25%		13,695
	Subtotal With Benefits:			84,906
Utilities	1,588.56	12	mo	19,063
Leachate Disposal	0.48	99,651	gal	48,036
Equip Op & Maint	32,866.85		ls	32,867
Contracted Services	32,866.85		ls	32,867
Soil Cover	17.53	40	cy/mo	8,414
Insurance	10,955.62	1	yr	10,956
	TOTAL OPERATING COSTS:			237,108
	CONTINGENCY (15%)			35,566
	GRAND TOTAL OPERATING COSTS			272,675

Ash Landfill
Capital Cost summary
(50 TPD Incineration Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	524,578	82,222	100,036	121,709		
Infrastructure	338,230	4,258	5,181	12,607		
Landfill Expansion	501,958	128,697	156,580	190,503		
Equipment	188,500		277,990		0	
Final Cover and Drainage		101,937	124,022	150,892	367,333	
Post-Closure						2,028,687
Professional Services	384,000	60,000	72,999	88,815	108,057	
Income (Equip. trade-in @ 20%)			(37,700)		(55,598)	
TOTALS	1,937,266	377,114	699,107	564,525	419,792	2,028,687
CONTINGENCY (20%)	387,453	75,423	139,821	112,905	83,958	405,737
---GRAND TOTAL	2,324,720	452,537	838,929	677,430	503,750	2,434,424
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Bond Payment @ 8.5 %	245,655					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		77,911	144,434	116,629	86,728	56,216

Ash Landfill Post-Closure Costs
(50 TPD Incineration Facility)

ITEM	COST ($)	QUANTITY UNIT	PER ITEM ($)	COST ($)	QUANTITY UNIT	PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR	NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	6 ea	1	1,752.90	6	10,517
	800.00	3 ea	29	1,752.90	87	152,502
Vegetation Maintenance	4,000.00	1 acres	5	8,764.49	5	43,822
	4,000.00	0.25 acres	25	8,764.49	6	54,778
Drainage Maintenance	500.00	1 ls	30	1,095.56	30	32,867
Groundwater Monitoring	2000.00	8 ea	5	4,382.25	40	175,290
	2000.00	4 ea	25	4,382.25	100	438,225
Leachate Monitoring	1,200.00	12 ea	5	2,629.35	60	157,761
	1,200.00	4 ea	25	2,629.35	100	262,935
Leachate Treatment	0.22	99,651 gal	5	0.48	498,254	240,182
	0.22	24,913 gal	10	0.48	249,127	120,091
	0.22	4,983 gal	15	0.48	74,738	36,027
Cap Maintenance	15,000.00	0.5 acres	2	32,866.85	1	32,867
	15,000.00	0.25 acres	28	32,866.85	7	230,068
Replace Monitoring Wel	3,100.00	1 /5 yrs	30	6,792.48	6	40,755
				TOTAL POSTCLOSURE COST:		2,028,687
				CONTINGENCY (15%)		304,303
				GRAND TOTAL POSTCLOSURE C		2,332,990

Ash Landfill Life-Cycle Costs, 1990-2010
(50 TPD Incineration Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED	TIPPING FEE (1990 DOLLARS)
1990	245,655	77,911	56,216	103,747	483,529	4,781	101.13	101.13
1995	245,655	144,434	56,216	139,018	585,323	4,781	122.42	100.62
2000	245,655	116,629	56,216	180,260	598,761	4,781	125.23	84.60
2005	245,655	86,728	56,216	223,374	611,973	4,781	127.99	71.07
2010				272,675	272,675	4,781	57.03	26.03

INCINERATOR CAPITAL COSTS (with no energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS				
Site Preparation				
1. Land Purchase	7,500.00	10	acre	75,000
2. Clear and Grub	2,500.00	4	acre	10,000
3. Drainage\Grading	325,000.00	1	ls	325,000
4. Access and Misc.	65,000.00	1	ls	65,000
5. Sewer & Water	30,000.00	1	ls	30,000
6. Power	14.00	500	ft	7,000
		Subtotal:		512,000
Infrastructure				
1. Buildings	130.00	11,000	sf	1,430,000
2. Scale	70,000.00	1	ea	70,000
3. Monitoring Wells	3,500.00	4	ea	14,000
4. Leachate Collection Sys.	10,000.00	1	ea	10,000
5. Electrical, HVAC	420,000.00	1	ea	420,000
6. Compressed Air System	40,000.00	1	ea	40,000
7. Paving	7.50	3,600	sy	27,000
8. Landscaping (Fert. & Seed)	4,000.00	2.5	Acres	10,000
		Subtotal:		2,021,000
Combustion Equipment				
1. Controlled Air Combustion Unit	4,628,400.00	2	ea	9,256,800
		Subtotal:		9,256,800
Emission Control Equipment				
1. Dry Scrubber	1,714,000.00	1	ea	1,714,000
2. Baghouse Filter	1,142,000.00	1	ea	1,142,000
3. Stack (65'), Including Found.	185,000.00	1	ea	185,000
4. Temperature Control Device	448,000.00	1	ea	448,000
5. Flue Gas Ducting & Fan (Incl. ducting for both combusters)	139,000.00	1	ea	139,000
6. Monitoring Equipment	343,000.00	1	ea	343,000
7. Indirect Costs	1,660,000.00	1	ea	1,660,000
		Subtotal:		5,631,000

Table

INCINERATOR CAPITAL COSTS (with no energy recovery)

LARGE MODULAR (150 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS (continued)			
Waste Handling Equipment			
1. Loader (CAT 980 or equiv.)	217,000.00	1 ea	217,000
2. Pickup	17,000.00	1 ea	17,000
3. Mack 10-whl 10-cy dump	65,000.00	1 ea	65,000
		Subtotal:	299,000
Misc. Equipment			
1. Tools	7,500.00	1 ea	7,500
2. Spare Parts	40,000.00	1 ea	40,000
		Subtotal:	47,500
Professional Services			
1. Design	260,000.00	1 ls	260,000
2. Bid Documents & Review	70,000.00	1 ls	70,000
3. Survey Control	35,000.00	1 ls	35,000
4. Construction Management	660,000.00	1 ls	660,000
5. Start-up & Acceptance Testing	175,000.00	1 ls	175,000
6. Permitting costs	3.00% of capital costs (prof. services excluded)		548,019
		Subtotal:	1,748,019
Miscellaneous Costs			
Insurance and Security Bonds	500,000.00	1 ls	500,000
		Subtotal:	500,000
	TOTAL CAPITAL COST		20,015,319
	CONTINGENCY (15%)		3,002,298
	GRAND TOTAL CAPITAL COSTS:		$23,017,617

INCINERATOR OPERATING COSTS (no energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries				
1. Superintendant	50,000.00	1	ea yr	50,000
2. Foreman	40,000.00	4	ea yr	160,000
3. Scale operator	16,000.00	1	ea yr	16,000
4. Loader Operator	16,000.00	4	ea yr	64,000
5. Laborer	14,000.00	8	ea yr	112,000
6. Drivers	18,000.00	1	ea yr	18,000
7. Secretary	16,000.00	1	ea yr	16,000
8. Accountant	24,000.00	1	ea yr	24,000
	Subtotal without benefits:			460,000
	Fringe Benefits	30%		138,000
	Overtime Allowance	15%		69,000
	Subtotal with benefits:			667,000
Utilities, Taxes, and Insurance				
1. Utilities	5,000.00	12	mon/yr	60,000
2. Taxes Insurance & Administration	16,000.00	12	mon/yr	192,000
3. Overhead	117,000	1	ea/yr	117,000
		Subtotal:		369,000
Equip Op & Maint				
1. Loader Fuel	1.00	34,000	gal/yr	34,000
2. Other fuel	1.00	2,000	gal/yr	2,000
3. Auxilliary MCU Fuel	1.00	12,000	gal/yr	12,000
4. Maintenance		5% of capital costs		759,340
5. Lime	80.00	400	tons/yr	32,000
6. Licenses, tax, and ins.	10,000.00	1	ea	10,000
7. Filter Replacement ($12,600 Every 2 1/2 yrs)	5,040.00	1	ea/yr	5,040
		Subtotal:		854,380
Contracted Services				
1. Pumping Leachate Holding Tank	500.00	6	/yr	3,000
2. Disposal of Non-Burnable Refuse (5%)	30.00	2,395	tons/yr	71,859
		Subtotal:		74,859
	TOTAL O & M COSTS:			1,965,239
	CONTINGENCY (15%)			294,786
	GRAND TOTAL OPERATING COSTS			$2,260,025

CAPITAL COSTS SUMMARY
INCINERATOR (without energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	512,000	0	0	0	0
Infrastructure	2,021,000	0	0	0	0
Combustion Equipment	9,256,800	0	0	0	0
Emision Control Equipment	5,631,000	0	0	0	0
Waste Handling Equipment	299,000	0	363,779	0	0
Misc. Equipment	47,500	0	17,578	0	0
Professional Services	1,748,019	0	0	0	0
Misc. Costs	500,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(59,800)	0	(72,756)
TOTALS	20,015,319	0	321,557	0	(72,756)
CONTINGENCY (15%)	3,002,298	0	48,234	0	0
GRAND TOTAL	23,017,617	0	369,791	0	(72,756)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period					
Annual Bond Payment @ 8.5%	2,432,294				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		26,139	26,139	0	0

LIFE CYCLE COSTS: 1990-2010
INCINERATOR (without energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED $0.00)	TIPPING FEE (1990 $0.00)
1990	2,432,294	26,139	2,260,025	0	4,718,458	47,906	98.49	98.49
1995	2,432,294	26,139	2,749,666	0	5,208,099	47,906	108.71	89.36
2000	2,432,294	0	3,345,390	0	5,777,684	47,906	120.60	81.48
2005	2,432,294	0	4,070,178	0	6,502,472	47,906	135.73	75.37
2010	2,432,294	0	4,951,994	(72,756)	7,311,532	47,906	152.62	69.65

NOTES

1. The incinerator is assumed to have two 75 TPD MCU's.

2. MCU's units would have a primary air-starved furnace with moving grates, a secondary combustion chamber with ancillary fuel capability , and a wet-ash sump.

3. The facility will operate 24 hours per day, 355 days per year.

4. The loader is assumed to burn 4 gallons of fuel per hour.

5. Waste handling equipment will be traded in at the end of every two stages for 20% of its value.

6. An 87.5% annual capacity utilization factor was assumed for total tons per year.

7. Bag life is 2 1/2 years (replacement $12,600)

8. Combuster cost includes; combuster and one CO monitor per combuster.

9. Monitoring equipment includes equipment for both particulate matter (opacity monitor and a data reduction system) and PM/acid gas (opacity, inlet/outlet SO_2, inlet/outlet HCL, and inlet/outlet O_2 monitors and a data reduction system)

INCINERATOR CAPITAL COSTS (with energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS				
Site Preparation				
1. Land Purchase	7,500.00	10	acre	75,000
2. Clear and Grub	2,500.00	4	acre	10,000
3. Drainage\Grading	325,000.00	1	ls	325,000
4. Access and Misc.	65,000.00	1	ls	65,000
5. Sewer & Water	30,000.00	1	ls	30,000
6. Power	14.00	500	ft	7,000
		Subtotal:		512,000
Infrastructure				
1. Building	130.00	11,000	sf	1,430,000
2. Scale	70,000.00	1	ea	70,000
3. Monitoring Wells	3,500.00	4	ea	14,000
4. Leachate Collection Sys.	10,000.00	1	ea	10,000
5. Compressed Air System	40,000.00	1	ea	40,000
6. Electrical, HVAC	420,000.00	1	ea	420,000
7. Paving	7.50	3,600	sy	27,000
8. Landscaping (Fert. & Seed)	4,000.00	2.5	Acres	10,000
		Subtotal:		2,021,000
Combustion Equipment				
1. Controlled Air Combustion Unit	4,628,400.00	2	ea	9,256,800
2. Waste Heat Boilers	1,008,000.00	2	ea	2,016,000
3. Boiler Feedback Sys. & Process Piping	495,000.00	1	ea	495,000
		Subtotal:		11,767,800
Emission Control Equipment				
1. Dry Scrubber	1,714,000	1	ea	1,714,000
2. Baghouse Filter	1,142,000	1	ea	1,142,000
3. Stack (60'), Including Found.	185,000.00	1	ea	185,000
4. Flue Gas Ducting & Fan (Incl. ducting for both combusters)	139,000.00	1	ea	139,000
5. Monitoring Equipment	343,000.00	1	ea	343,000
6. Indirect Costs	1,660,000.00	1	ea	1,660,000
		Subtotal:		5,183,000

INCINERATOR CAPITAL COSTS (with energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS (continued)				
Waste Handling Equipment				
1. Loader (CAT 980 or equiv.)	217,000.00	1	ea	217,000
2. Pickup	17,000.00	1	ea	17,000
3. Mack 10-whl 10-cy dump	65,000.00	1	ea	65,000
		Subtotal:		299,000
Misc. Equipment				
1. Tools	7,500.00	1	ea	7,500
2. Spare Parts	40,000.00	1	ea	40,000
		Subtotal:		47,500
Professional Services				
1. Design	280,000.00	1	ls	280,000
2. Bid Documents & Review	70,000.00	1	ls	70,000
3. Survey Control	33,000.00	1	ls	33,000
4. Construction Management	690,000.00	1	ls	690,000
5. Start-up & Acceptance Testing	225,000.00	1	ls	225,000
6. Permitting Costs	3.00% of capital costs (prof. services excluded)			612,009
		Subtotal:		1,910,009
Miscellaneous Costs				
Insurance and Security Bonds	234,000.00	1	ls	570,000
		Subtotal:		570,000
	TOTAL CAPITAL COST			22,310,309
	CONTINGENCY (15%)			3,346,546
	GRAND TOTAL CAPITAL COSTS:			$25,656,855

INCINERATOR OPERATING COSTS (with energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries			
1. Superintendant	50,000.00	1 ea yr	50,000
2. Foreman	40,000.00	4 ea yr	160,000
3. Scale operator	16,000.00	1 ea yr	16,000
4. Loader Operator	16,000.00	4 ea yr	64,000
5. Laborer	14,000.00	8 ea yr	112,000
6. Drivers	18,000.00	1 ea yr	18,000
7. Secretary	16,000.00	1 ea yr	16,000
8. Accountant	24,000.00	1 ea yr	24,000
	Subtotal without benefits:		460,000
	Fringe Benefits	30%	138,000
	Overtime Allowance	15%	69,000
	Subtotal with benefits:		667,000
Utilities, Taxes, and Insurance			
1. Utilities	5,000.00	12 mon/yr	60,000
2. Taxes Insurance & Administration	16,000.00	12 mon/yr	192,000
3. Overhead	117,000.00	1 /yr	117,000
		Subtotal:	369,000
Equip Op & Maint			
1. Loader Fuel	1.00	34,000 gal/yr	34,000
2. Other fuel	1.00	2,000 gal/yr	2,000
3. Auxilliary MCU Fuel	1.00	12,000 gal/yr	12,000
4. Maintenance	5%	of capital costs	963,540
5. Lime	80.00	400 tons/yr	32,000
6. Licenses, tax, and ins.	10,000.00	1 ea	10,000
7. Filter replacement	5,040.00	1 ea/yr	5,040
		Subtotal:	1,058,580
Contracted Services			
1. Pumping Leachate Holding Tank	500.00	6 /yr	3,000
2. Disposal of Non-Burnable Refuse (5%)	30.00	2,395 tons/yr	71,859
		Subtotal:	74,859
	TOTAL O & M COSTS:		2,169,439
	CONTINGENCY (15%)		325,416
	GRAND TOTAL OPERATING COSTS		$2,494,855

CAPITAL COSTS SUMMARY
INCINERATOR (with energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Preparation	512,000	0	0	0	0
Infrastructure	2,021,000	0	0	0	0
Combustion Equipment	11,767,800	0	0	0	0
Emision Control Equipment	5,183,000	0	0	0	0
Waste Handling Equipment	299,000	0	363,779	0	0
Misc. Equipment	47,500	0	17,578	0	0
Professional Services	1,910,009	0	0	0	0
Misc. Costs	570,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(59,800)	0	(72,756)
TOTALS	22,310,309	0	321,557	0	(72,756)
CONTINGENCY (15%)	3,346,546	0	48,234	0	0
GRAND TOTAL	25,656,855	0	369,791	0	(72,756)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund

Amortization period					
Annual Bond Payment @ 8.5%	2,711,185				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		26,139	26,139	0	0

LIFE CYCLE COSTS: 1990-2010
INCINERATOR (with energy recovery)
LARGE MODULAR (150 TON/DAY) FACILITY

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES (equipment Trade-in)	REVENUES (Steam)	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED $0.00)	TIPPING FEE (1990 $0.00)
1990	2,711,185	26,139	2,494,855	0	(1,317,422)	3,914,757	47,906	81.72	81.72
1995	2,711,185	26,139	3,035,373	0	(1,602,845)	4,169,852	47,906	87.04	71.54
2000	2,711,185	0	3,692,995	0	(1,950,106)	4,454,074	47,906	92.97	62.81
2005	2,711,185	0	4,493,093	0	(2,372,602)	4,831,676	47,906	100.86	56.00
2010	2,711,185	0	5,466,535	(72,756)	(2,886,634)	5,218,331	47,906	108.93	49.71

NOTES

1. The incinerator is assumed to have two 75 TPD MCU's.
2. MCU's units would have a primary air-starved furnace with moving grates, a secondary combustion chamber with ancillary fuel capability , and a wet-ash sump.
3. The facility will operate 24 hours per day, 355 days per year.
4. The loader is assumed to burn 4 gallons of fuel per hour.
5. Equipment will be traded in at the end of every two stages for 20% of its value.
6. An 87.5% annual capacity utilization factor was assumed for total tons per year.
7. Steam piping and accessories from the incineration plant to the customers facility is paid for by the customer.
8. Combuster cost includes; combuster and one CO monitor per combuster.
9. Monitor equipment includes equipment for both particulate matter (opacity monitor and a data reduction system) and PM/acid gas (opacity, inlet/outlet SO_2, inlet/outlet HCL, and inlet/outlet O_2 monitors and data reduction system).

Ash Landfill Capital Costs (150 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	50	acre	250,000												
Mobilization/Demobiliz	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	20	acre	50,000	3,041.63	2	acre	6,083	3,700.61	2	acre	7,401	4,502.36	2	acre	9,005
Erosion Control Silt F	2.84	2,000	lf	5,680	3.46	400	lf	1,382	4.20	400	lf	1,682	5.11	400	lf	2,046
Excavation/Stockpile	2.30	205,114	cy	471,762	2.80	36,820	cy	103,033	3.40	36,820	cy	125,356	4.14	36,820	cy	152,515
Access Road	22.00	385	lf	8,470	26.77	70	lf	1,874	32.57	70	lf	2,280	39.62	70	lf	2,773
Operational Berm	30.00	500	lf	15,000	36.50	175	lf	6,387	44.41	175	lf	7,771	54.03	175	lf	9,455
		SUBTOTAL:		805,912		SUBTOTAL:		124,843		SUBTOTAL:		151,891		SUBTOTAL:		184,798
INFRASTRUCTURE																
Maintenance/Office Bld	70.00	1,000	sf	70,000												
Equipment Storage	20.00	2,000	sf	40,000												
Fuel pumps / Storage	12,000.00	1	ea	12,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	20,000.00	1	ea	20,000												
Fencing	16.00	6,000	lf	96,000												
Landscaping	15,000.00	0.6	ea	9,000												
Groundwater Monitoring	3,500.00	4	ea	14,000	4,258.29	1	ea	4,258	5,180.85	1	ea	5,181	6,303.30	2	ea	12,607
Sedimentation Ponds	60,000.00	1	ea	60,000												
		SUBTOTAL:		388,750		SUBTOTAL:		4,258		SUBTOTAL:		5,181		SUBTOTAL:		12,607

Ash Landfill Capital Costs (150 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	2	ea	60,000												
		SUBTOTAL:		61,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	159,373	sf	23,906	0.18	35,416	sf	6,463	0.22	35,416	sf	7,864	0.27	35,416	sf	9,567
Clay Layer	30.00	11,805	cy	354,163	36.50	2,623	cy	95,754	44.41	2,623	cy	116,499	54.03	2,623	cy	141,739
60 mil PVC Geomembrane	0.70	159,373	sf	111,561	0.85	35,416	sf	30,163	1.04	35,416	sf	36,697	1.26	35,416	sf	44,648
Sand Blanket Drain	15.00	11,805	cy	177,081	18.25	2,623	cy	47,877	22.20	2,623	cy	58,250	27.01	2,623	cy	70,870
Geotextile	0.06	318,746	sf	19,125	0.07	70,833	sf	5,171	0.09	70,833	sf	6,291	0.11	70,833	sf	7,654
Washed Stone	15.00	1,476	cy	22,135	18.25	328	cy	5,985	22.20	328	cy	7,281	27.01	328	cy	8,859
6" SDR 21 Slotted PVC	7.25	637	lf	4,622	8.82	142	lf	1,250	10.73	142	lf	1,520	13.06	142	lf	1,850
6" Cleanouts	1,750.00	6	ea	10,500	2,129.14	1	ea	2,129	2,590.43	1	ea	2,590	3,151.65	1	ea	3,152
		SUBTOTAL:		723,093		SUBTOTAL:		194,791		SUBTOTAL:		236,993		SUBTOTAL:		288,338
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembran	0.70	159,373	sf	111,561	0.85	35,416	sf	30,163	1.04	35,416	sf	36,697	1.26	35,416	sf	44,648
Washed Stone	15.00	1,476	cy	22,135	18.25	328	cy	5,985	22.20	328	cy	7,281	27.01	328	cy	8,859
Sand Blanket Drain	15.00	11,805	cy	177,081	18.25	2,623	cy	47,877	22.20	2,623	cy	58,250	27.01	2,623	cy	70,870
6" SDR 21 Slotted PVC	7.25	637	lf	4,622	8.82	142	lf	1,250	10.73	142	lf	1,520	13.06	142	lf	1,850
6" Cleanouts	1,750.00	6	ea	10,500	2,129.14	1	ea	2,129	2,590.43	1	ea	2,590	3,151.65	1	ea	3,152
		SUBTOTAL:		325,900		SUBTOTAL:		87,403		SUBTOTAL:		106,339		SUBTOTAL:		129,378

Ash Landfill Capital Costs (150 Ton/Day Incineration Facility)

	Stage 1 1990-1995				Stage 2 1995-2000				Stage 3 2000-2005				Stage 4 2005-2010				CLOSURE 2010			
ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE																				
Cap Underlairment					12.21	1,375	cy	16,789	14.86	1,375	cy	20,426	18.07	1,375	cy	24,851	21.99	2,750	cy	60,471
40 mil HDPE Geomembrane					0.55	93,700	sf	51,535	0.67	93,700	sf	62,700	0.81	93,700	sf	76,284	0.99	187,450	sf	185,673
Drainage layer					15.00	2,750	cy	41,250	18.25	2,750	cy	50,187	22.20	2,750	cy	61,060	27.01	5,500	cy	148,578
Subsoil					12.00	1,375	cy	16,500	14.60	1,375	cy	20,075	17.76	1,375	cy	24,424	21.61	2,750	cy	59,431
Topsoil					16.00	1,375	cy	22,000	19.47	1,375	cy	26,766	23.68	1,375	cy	32,565	28.82	2,750	cy	79,242
Seed, Fertilizer, Mulch, Lime					2,500.00	1.50	acres	3,750	3,041.63	1.50	acres	4,562	3,700.61	1.50	acre	5,551	4,502.36	4.0	acres	18,009
Terrace Swales					15.00	850	lf	12,750	18.25	850	lf	15,512	22.20	850	lf	18,873	27.01	1,700	lf	45,924
		SUBTOTAL:		0		SUBTOTAL:		164,574		SUBTOTAL:		200,229		SUBTOTAL:		243,609		SUBTOTAL:		597,328
EQUIPMENT (3)																				
Dozer (Cat D4H or eqv.	125,000.00	1	ea	125,000			ea	0	185,030.54	1	ea	185,031			ea	0				0
Loader (CAT 910 or eqv	60,000.00	1	ea	60,000			ea	0	88,814.66	1	ea	88,815			ea	0				0
Office Equipment	1,500.00	1	ea	1,500		0	ea	0	2,220.37	1	ea	1,776			ea	0				0
Maintenance Equipment	2,000.00	1	ea	2,000		0	ea	0	2,960.49	1	ea	2,368			ea	0				0
		SUBTOTAL:		188,500		SUBTOTAL:		0		SUBTOTAL:		277,990		SUBTOTAL:		0		SUBTOTAL:		0
PROFESSIONAL SERVICES																				
Hydro, Permitting	170,000.00	1	ea	170,000																
Bid Documents & Review	64,000.00	1	ea	64,000	23,000.00	1	ea	23,000	27,983.02	1	ea	27,983	34,045.62	1	ea	34,046	41,421.70	1	ea	41,422
Survey Control	25,000.00	1	ea	25,000	9,000.00	1	ea	9,000	10,949.88	1	ea	10,950	13,322.20	1	ea	13,322	16,208.49	1	ea	16,208
Construction Insp.	76,000.00	1	ea	76,000	27,500.00	1	ea	27,500	33,457.95	1	ea	33,458	40,706.72	1	ea	40,707	49,525.95	1	ea	49,526
Topo Map & Vol. Calc.	14,000.00	1	ea	14,000																
				349,000		SUBTOTAL:		59,500		SUBTOTAL:		72,391		SUBTOTAL:		88,075		SUBTOTAL:		107,156
	TOTAL CAPITAL COST			2,842,355	TOTAL CAPITAL COST			635,369	TOTAL CAPITAL COST			1,051,014	TOTAL CAPITAL COST			946,805	TOTAL CAPITAL COST			704,484
	CONTINGENCY (15%)			426,353	CONTINGENCY (15%)			95,305	CONTINGENCY (15%)			157,652	CONTINGENCY (15%)			142,021				
	GRAND TOTAL CAPITAL COSTS:			3,268,708	GRAND TOTAL CAPITAL COSTS:			730,674	GRAND TOTAL CAPITAL COSTS:			1,208,666	GRAND TOTAL CAPITAL COSTS:			1,088,826	GRAND TOTAL CAPITAL COSTS:			704,484

Ash Landfill Operating Costs (150 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS												
Wages and Salaries												
Forman	26,000.00	1	yr	26,000	31,632.98	1	yr	31,633	38,486.35	1	yr	38,486
Operator/mechanic	18,000.00	1	yr	18,000	21,899.75	1	yr	21,900	26,644.40	1	yr	26,644
Occasional Labor	3,000.00	1	ls	3,000	3,649.96	1	ls	3,650	4,440.73	1	ls	4,441
Subtotal Without Benefits:				47,000				57,183				69,571
Fringe Benefits		@ 30%		14,100		@ 30%		17,155		@ 30%		20,871
Overhead		@ 25%		11,750		@ 25%		14,296		@ 25%		17,393
Subtotal With Benefits:				72,850				88,633				107,836
Utilities	1,050.00	12	mo	12,600	1,277.49	12	mo	15,330	1,554.26	12	mo	18,651
Leachate Disposal	0.22	39,843	gal	8,766	0.27	132,678	gal	35,513	0.33	199,017	gal	64,811
Equip Op & Maint	15,000.00	1	ls	15,000	18,249.79		ls	18,250	22,203.66		ls	22,204
Contracted Services	20,000.00	1	ls	20,000	24,333.06		ls	24,333	29,604.89		ls	29,605
Soil Cover	8.00	80	cy/mo	7,680	9.73	80	cy/mo	9,344	11.84	80	cy/mo	11,368
Insurance	9,000.00	1	yr	9,000	10,949.88	1	yr	10,950	13,322.20	1	yr	13,322
TOTAL OPERATING COSTS:				145,896				202,353				267,797
CONTINGENCY (15%)				21,884				30,353				40,169
GRAND TOTAL OPERATING COSTS				167,780				232,706				307,966

ITEM	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS								
Wages and Salaries								
Forman	46,824.53	1	yr	46,825	56,969.20	1	yr	56,969
Operator/mechanic	32,416.98	1	yr	32,417	39,440.22	1	yr	39,440
Occasional Labor	5,402.83	1	ls	5,403	6,573.37	1	ls	6,573
Subtotal Without Benefits:				84,644				102,983
Fringe Benefits		@ 30%		25,393		@ 30%		30,895
Overhead		@ 25%		21,161		@ 25%		25,746
Subtotal With Benefits:				131,199				159,623
Utilities	1,890.99	12	mo	22,692	2,300.68	12	mo	27,608
Leachate Disposal	0.40	218,919	gal	86,737	0.48	222,571	gal	107,290
Equip Op & Maint	27,014.15		ls	27,014	32,866.85		ls	32,867
Contracted Services	36,018.87		ls	36,019	43,822.46		ls	43,822
Soil Cover	14.41	80	cy/mo	13,831	17.53	80	cy/mo	16,828
Insurance	16,208.49	1	yr	16,208	19,720.11	1	yr	19,720
TOTAL OPERATING COSTS:				333,701				407,759
CONTINGENCY (15%)				50,055				61,164
GRAND TOTAL OPERATING COSTS				383,756				468,922

Ash Landfill
Capital Cost summary
(150 TPD Incineration Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	805,912	124,843	151,891	184,798		
Infrastructure	388,750	4,258	5,181	12,607		
Landfill Expansion	1,110,193	282,194	343,332	417,716		
Equipment	188,500		277,990		0	
Final Cover and Drainage		164,574	200,229	243,609	597,328	
Post-Closure						2,769,507
Professional Services	349,000	59,500	72,391	88,075	107,156	
Income (Equip. trade-in @ 20%)			(37,700)		(55,598)	
TOTALS	2,842,355	635,369	1,013,314	946,805	648,886	2,769,507
CONTINGENCY (20%)	568,471	127,074	202,663	189,361	129,777	553,901
---GRAND TOTAL	3,410,826	762,443	1,215,976	1,136,166	778,663	3,323,408
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Bond Payment @ 8.5 %	360,425					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		131,266	209,348	195,608	134,058	76,745

Ash Landfill Post-Closure Costs
(150 TPD Incineration Facility)

ITEM	COST ($)	QUANTITY UNIT	PER ITEM ($)	COST ($)	QUANTITY	UNIT PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR	NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	6 ea	1	1,752.90	6	10,517
	800.00	3 ea	29	1,752.90	87	152,502
Vegetation Maintenance	4,000.00	3 acres	5	8,764.49	15	131,467
	4,000.00	1 acres	25	8,764.49	25	219,112
Drainage Maintenance	500.00	1 ls	30	1,095.56	30	32,867
Groundwater Monitoring	2000.00	8 ea	5	4,382.25	40	175,290
	2000.00	4 ea	25	4,382.25	100	438,225
Leachate Monitoring	1,200.00	12 ea	5	2,629.35	60	157,761
	1,200.00	4 ea	25	2,629.35	100	262,935
Leachate Treatment	0.22	222,571 gal	5	0.48	1,112,856	536,449
	0.22	55,643 gal	10	0.48	556,428	268,225
	0.22	11,129 gal	15	0.48	166,928	80,467
Cap Maintenance	15,000.00	0.5 acres	2	32,866.85	1	32,867
	15,000.00	0.25 acres	28	32,866.85	7	230,068
Replace Monitoring Wel	3,100.00	1 /5 yrs	30	6,792.48	6	40,755
						===========
				TOTAL POSTCLOSURE COST:		2,769,507
				CONTINGENCY (15%)		415,426
						===========
				GRAND TOTAL POSTCLOSURE CO		3,184,933

Ash Landfill Post-Closure Costs
(400 TPD Incineration Facility)

ITEM	COST ($)	QUANTITY	UNIT	PER ITEM ($)	COST ($)	QUANTITY	UNIT PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR		NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	6	ea	1	1,752.90	6	10,517
	800.00	3	ea	29	1,752.90	87	152,502
Vegetation Maintenance	4,000.00	5	acres	5	8,764.49	25	219,112
	4,000.00	1	acres	25	8,764.49	25	219,112
Drainage Maintenance	2,000.00	1	ls	30	4,382.25	30	131,467
Groundwater Monitoring	2000.00	8	ea	5	4,382.25	40	175,290
	2000.00	4	ea	25	4,382.25	100	438,225
Leachate Monitoring	1,200.00	12	ea	5	2,629.35	60	157,761
	1,200.00	4	ea	25	2,629.35	100	262,935
Leachate Treatment	0.22	276,418	gal	5	0.48	*********	666,234
	0.22	69,105	gal	10	0.48	691,046	333,117
	0.22	13,821	gal	15	0.48	207,314	99,935
Cap Maintenance	15,000.00	1	acres	2	32,866.85	2	65,734
	15,000.00	0.5	acres	28	32,866.85	14	460,136
Replace Monitoring Wells	3,100.00	1	/5 yr	30	6,792.48	6	40,755
					TOTAL POSTCLOSURE COST:		3,432,832
					CONTINGENCY (15%)		514,925
					GRAND TOTAL POSTCLOSURE C		3,947,756

Ash Landfill Capital Costs (400 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlainment				
40 mil HDPE Geomembrane				
Drainage layer				
Subsoil				
Topsoil				
Seed, Fertilizer, Mulch, Lime				
Terrace Swales				
		SUBTOTAL:		0
EQUIPMENT (3)				
Dozer (Cat D4H or eqv.)	125,000.00	1	ea	125,000
Loader (Cat 936 or eqv.)	117,000.00	1	ea	117,000
Dump truck(3 axle,10 yd)	65,000.00	1	ea	65,000
Office Equipment	1,500.00	1	ea	1,500
Maintenance Equipment	4,000.00	1	ea	4,000
		SUBTOTAL:		312,500
PROFESSIONAL SERVICES				
Hydro, Permitting	375,000.00	1	ea	375,000
Bid Documents & Review	85,000.00	1	ea	85,000
Survey Control	37,500.00	1	ea	37,500
Construction Inspection	57,500.00	1	ea	57,500
Topo Map & Vol. Calc.	20,000.00	1	ea	20,000
				575,000
	TOTAL CAPITAL COST			4,052,397
	CONTINGENCY (15%)			607,860
	GRAND TOTAL CAPITAL COSTS:			4,660,257

ITEM	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlainment	12.21	2,370	cy	28,938
40 mil HDPE Geomembrane	0.55	161,480	sf	88,814
Drainage layer	15.00	4,740	cy	71,100
Subsoil	12.00	2,370	cy	28,440
Topsoil	16.00	2,370	cy	37,920
Seed, Fertilizer, Mulch, Lime	2,500.00	2.50	acre	6,250
Terrace Swales	15.00	850	lf	12,750
		SUBTOTAL:		274,212
EQUIPMENT (3)				
Dozer (Cat D4H or eqv.)			ea	0
Loader (Cat 936 or eqv.)			ea	0
Dump truck(3 axle,10 yd)			ea	0
Office Equipment		0	ea	0
Maintenance Equipment		0	ea	0
		SUBTOTAL:		0
PROFESSIONAL SERVICES				
Hydro, Permitting				
Bid Documents & Review	24,000.00	1	ea	24,000
Survey Control	10,000.00	1	ea	10,000
Construction Inspection	24,000.00	1	ea	24,000
Topo Map & Vol. Calc.				
		SUBTOTAL:		58,000
	TOTAL CAPITAL COST			916,371
	CONTINGENCY (15%)			137,456
	GRAND TOTAL CAPITAL COSTS			1,053,827

ITEM	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlainment	14.86	2,370	cy	35,207
40 mil HDPE Geomembrane	0.67	161,480	sf	108,056
Drainage layer	18.25	4,740	cy	86,504
Subsoil	14.60	2,370	cy	34,602
Topsoil	19.47	2,370	cy	46,135
Seed, Fertilizer, Mulch, Lime	3,041.63	2.50	acre	7,604
Terrace Swales	18.25	850	lf	15,512
		SUBTOTAL:		333,620
EQUIPMENT (3)				
Dozer (Cat D4H or eqv.)	185,030.54	1	ea	185,031
Loader (Cat 936 or eqv.)	173,188.58	1	ea	173,189
Dump truck(3 axle,10 yd)	96,215.88	1	ea	96,216
Office Equipment	2,220.37	1	ea	1,776
Maintenance Equipment	5,920.98	1	ea	4,737
		SUBTOTAL:		460,948
PROFESSIONAL SERVICES				
Hydro, Permitting				
Bid Documents & Review	29,199.67	1	ea	29,200
Survey Control	12,166.53	1	ea	12,167
Construction Inspection	29,199.67	1	ea	29,200
Topo Map & Vol. Calc.				
		SUBTOTAL:		70,566
	TOTAL CAPITAL COST			1,575,854
	CONTINGENCY (15%)			236,378
	GRAND TOTAL CAPITAL COSTS:			1,812,232

ITEM	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlainment	18.07	2,370	cy	42,835
40 mil HDPE Geomembrane	0.81	161,480	sf	131,466
Drainage layer	22.20	4,740	cy	105,245
Subsoil	17.76	2,370	cy	42,098
Topsoil	23.68	2,370	cy	56,131
Seed, Fertilizer, Mulch, Lime	3,700.61	2.50	acre	9,252
Terrace Swales	22.20	850	lf	18,873
		SUBTOTAL:		405,900
EQUIPMENT (3)				
Dozer (Cat D4H or eqv.)			ea	0
Loader (Cat 936 or eqv.)			ea	0
Dump truck(3 axle,10 yd)			ea	0
Office Equipment			ea	0
Maintenance Equipment			ea	0
		SUBTOTAL:		0
PROFESSIONAL SERVICES				
Hydro, Permitting				
Bid Documents & Review	35,525.86	1	ea	35,526
Survey Control	14,802.44	1	ea	14,802
Construction Inspection	35,525.86	1	ea	35,526
Topo Map & Vol. Calc.				
		SUBTOTAL:		85,854
	TOTAL CAPITAL COST			1,356,453
	CONTINGENCY (15%)			203,468
	GRAND TOTAL CAPITAL COSTS			1,559,921

ITEM	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlainment	21.99	4,740	cy	104,230
40 mil HDPE Geomembrane	0.99	322,960	sf	319,898
Drainage layer	27.01	9,475	cy	255,959
Subsoil	21.61	4,740	cy	102,438
Topsoil	28.82	4,740	cy	136,584
Seed, Fertilizer, Mulch, Lime	4,502.36	8.0	acre	36,019
Terrace Swales	27.01	1,700	lf	45,924
		SUBTOTAL:		1,001,052
EQUIPMENT (3)				
Dozer (Cat D4H or eqv.)				0
Loader (Cat 936 or eqv.)				0
Dump truck(3 axle,10 yd)				0
Office Equipment				0
Maintenance Equipment				0
		SUBTOTAL:		0
PROFESSIONAL SERVICES				
Hydro, Permitting				
Bid Documents & Review	43,222.64	1	ea	43,223
Survey Control	18,009.44	1	ea	18,009
Construction Inspection	43,222.64	1	ea	43,223
Topo Map & Vol. Calc.				
		SUBTOTAL:		104,455
	TOTAL CAPITAL COST			1,105,506
	GRAND TOTAL CAPITAL COSTS:			1,105,506

Ash Landfill Capital Costs (400 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	2	ea	60,000												
		SUBTOTAL:		61,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	197,931	sf	29,690	0.18	43,985	sf	8,027	0.22	43,985	sf	9,766	0.27	43,985	sf	11,882
Clay Layer	30.00	14,662	cy	439,846	36.50	3,258	cy	118,920	44.41	3,258	cy	144,684	54.03	3,258	cy	176,031
60 mil PVC Geomembrane	0.70	197,931	sf	138,552	0.85	43,985	sf	37,460	1.04	43,985	sf	45,576	1.26	43,985	sf	55,450
Sand Blanket Drain	15.00	14,662	cy	219,923	18.25	3,258	cy	59,460	22.20	3,258	cy	72,342	27.01	3,258	cy	88,015
Geotextile	0.06	395,862	sf	23,752	0.07	87,969	sf	6,422	0.09	87,969	sf	7,813	0.11	87,969	sf	9,506
Washed Stone	15.00	1,833	cy	27,490	18.25	407	cy	7,433	22.20	407	cy	9,043	27.01	407	cy	11,002
6" SDR 21 Slotted PVC Pi	7.25	792	lf	5,740	8.82	176	lf	1,552	10.73	176	lf	1,888	13.06	176	lf	2,297
6" Cleanouts	1,750.00	8	ea	14,000	2,129.14	2	ea	4,258	2,590.43	2	ea	5,181	3,151.65	2	ea	6,303
		SUBTOTAL:		898,992		SUBTOTAL:		243,531		SUBTOTAL:		296,293		SUBTOTAL:		360,486
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembrane	0.70	197,931	sf	138,552	0.85	43,985	sf	37,460	1.04	43,985	sf	45,576	1.26	43,985	sf	55,450
Washed Stone	15.00	1,833	cy	27,490	18.25	407	cy	7,433	22.20	407	cy	9,043	27.01	407	cy	11,002
Sand Blanket Drain	15.00	14,662	cy	219,923	18.25	3,258	cy	59,460	22.20	3,258	cy	72,342	27.01	3,258	cy	88,015
6" SDR 21 Slotted PVC Pi	7.25	792	lf	5,740	8.82	176	lf	1,552	10.73	176	lf	1,888	13.06	176	lf	2,297
6" Cleanouts	1,750.00	8	ea	14,000	2,129.14	2	ea	4,258	2,590.43	2	ea	5,181	3,151.65	2	ea	6,303
		SUBTOTAL:		405,705		SUBTOTAL:		110,163		SUBTOTAL:		134,030		SUBTOTAL:		163,067

Ash Landfill Capital Costs (400 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	75	acre	375,000												
Mobilization/Demobilizat	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	20	acre	50,000	3,041.63	2	acre	6,083	3,700.61	2	acre	7,401	4,502.36	2	acre	9,005
Erosion Control Silt Fen	2.84	1,600	lf	4,544	3.46	400	lf	1,382	4.20	400	lf	1,682	5.11	400	lf	2,046
Excavation/Stockpile	2.30	327,120	cy	752,376	2.80	72,700	cy	203,437	3.40	72,700	cy	247,512	4.14	72,700	cy	301,136
Access Road	22.00	615	lf	13,530	26.77	140	lf	3,747	32.57	140	lf	4,559	39.62	140	lf	5,547
Operational Berm	30.00	500	lf	15,000	36.50	150	lf	5,475	44.41	150	lf	6,661	54.03	150	lf	8,104
		SUBTOTAL:		1,215,450		SUBTOTAL:		226,207		SUBTOTAL:		275,216		SUBTOTAL:		334,842
INFRASTRUCTURE																
Maintenance/Office Bldg	80.00	1,500	sf	120,000												
Equipment Storage	20.00	3,000	sf	60,000												
Fuel pumps / Storage	12,000.00	1	ea	12,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	20,000.00	1	ea	20,000												
Fencing	16.00	7,300	lf	116,800												
Landscaping	55,000.00	0.6	ea	33,000												
Groundwater Monitoring W	3,500.00	4	ea	14,000	4,258.29	1	ea	4,258	5,180.85	1	ea	5,181	6,303.30	1	ea	6,303
Sedimentation Ponds	70,000.00	2	ea	140,000												
		SUBTOTAL:		583,550		SUBTOTAL:		4,258		SUBTOTAL:		5,181		SUBTOTAL:		6,303

LIFE CYCLE COSTS: 1990-2010
INCINERATOR (with energy recovery)
MASS BURN\WATERWALL (400 TON/DAY) FACILITY

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES (equipment Trade-in)	REVENUES (elec.)	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED)	TIPPING FEE (1990 DOLLARS)
1990	5,823,334	131,980	4,188,933	0	(5,276,075)	4,868,171	127,750	38.11	38.11
1995	5,823,334	131,980	5,096,477	0	(6,419,152)	4,632,639	127,750	36.26	29.81
2000	5,823,334	0	6,200,643	0	(7,809,880)	4,214,097	127,750	32.99	22.28
2005	5,823,334	0	7,544,031	0	(9,501,913)	3,865,451	127,750	30.26	16.80
2010	5,823,334	0	9,178,467	(388,599)	(11,560,530)	3,052,672	127,750	23.90	10.91

NOTES

1. The incinerator is assumed to have two 200 TPD Waterwall combustors.

2. The facility will operate 24 hours per day, 355 days per year with 10 days for scheduled maintenance.

3. The loader is assumed to burn 4 gallons of fuel per hour.

4. Waste handling equipment will be traded in at the end of every two stages for 20% of its value.

5. An 87.5% annual capacity utilization factor was assumed for total tons per year.

6. Combuster cost includes; combuster and one CO monitor per combuster, ash handling system, cooling tower, etc.

7. Pollution control equipment includes both dry scrubbers and baghouses. Monitoring equipment for both particulate matter (opacity monitor and a data reduction system) and PM/acid gas (opacity, inlet/outlet SO_2, inlet/outlet HCL, and inlet/outlet O_2 monitors and data reduction system) are also included.

8. Baghouse filter replacement every 2 1/2 years (total cost $ 31,000).

CAPITAL COSTS SUMMARY
INCINERATOR (with energy recovery)
MASS BURN\WATERWALL (400 TPD) FACILITY

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Developement	1,147,000	0	0	0	0
Infrastructure	12,075,000	0	0	0	0
Combustion Equipment	15,000,000	0	0	0	0
Electrical Generation	3,100,000	0	0	0	0
Emision Control Equipment	7,550,000	0	0	0	0
Waste Handling Equipment	1,597,000	0	1,942,995	0	0
Misc. Equipment	52,500	0	0	0	0
Professional Services	5,798,645	0	0	0	0
Misc. Costs	1,600,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(319,400)	0	(388,599)
TOTALS	47,920,145	0	1,623,595	0	(388,599)
CONTINGENCY (15%)	7,188,022	0	243,539	0	0
GRAND TOTAL	55,108,167	0	1,867,134	0	(388,599)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period					
Annual Bond Payment @ 8.5%	5,823,334				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		131,980	131,980	0	0

INCINERATOR OPERATING COSTS (with energy recovery)
MASS BURN\WATERWALL (400 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries				
1. Superintendant	55,000.00	1	ea yr	55,000
2. Foreman	45,000.00	4	ea yr	180,000
3. Scale operator	16,000.00	1	ea yr	16,000
4. Loader Operator	16,000.00	4	ea yr	64,000
5. Crane Operator	16,000.00	5	ea yr	80,000
6. Laborer	14,000.00	12	ea yr	168,000
7. Driver	18,000.00	2	ea yr	36,000
8. Maintenance Person	18,000.00	1	ea yr	18,000
9. Secretary	16,000.00	1	ea yr	16,000
10. Accountant	26,000.00	1	ea yr	26,000
	Subtotal without benefits:			659,000
	Fringe Benefits	30%		197,700
	Overtime Allowance	15%		98,850
	Subtotal with benefits:			955,550
Utilities, Taxes, and Insurance				
1. Utilities	11,000.00	12	mon/yr	132,000
2. Taxes Insurance & Administration	405,000.00	1	/yr	405,000
3. Overhead	150,000.00	1	/yr	150,000
		Subtotal:		687,000
Equip Op & Maint				
1. Loader Fuel	1.00	34,000	gal/yr	34,000
2. Other fuel	1.00	2,000	gal/yr	2,000
3. Auxilliary Combustor Fuel	1.00	30,000	gal/yr	30,000
4. Maintenance		5% of capital costs		1,811,100
5. Lime	80.00	1,030	tons/yr	82,400
6. Licenses, tax, and ins.	25,000.00	1	ea	25,000
7. Filter replacement	12,500.00	1	ea/yr	12,500
		Subtotal:		1,997,000
Contracted Services				
1. Pumping Leachate Holding Tank	500.00	6	/yr	3,000
		Subtotal:		3,000
	TOTAL O & M COSTS:			3,642,550
	CONTINGENCY (15%)			546,383
	GRAND TOTAL OPERATING COSTS			$4,188,933

INCINERATOR CAPITAL COSTS (with energy recovery)
MASS BURN\WATERWALL (400 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS (continued)				
Waste Handling Equipment				
1. Receiving, Storage & Handling	1,500,000.00	1	ea	1,500,000
2. Pickup	17,000.00	1	ea	17,000
3. Mack 10-whl 14-cy dump	80,000.00	1	ea	80,000
		Subtotal:		1,597,000
Misc. Equipment				
1. Tools	7,500.00	1	ea	7,500
2. Spare Parts	45,000.00	1	ea	45,000
		Subtotal:		52,500
Professional Services				
1. Engineering & Design	2,660,000.00	1	ls	2,660,000
2. Bid Documents & Review	85,000.00	1	ls	85,000
3. Survey Control	40,000.00	1	ls	40,000
4. Construction Management	1,500,000.00	1	ls	1,500,000
5. Start-up & Acceptance Testing	250,000.00	1	ls	250,000
6. Permitting Costs	3.00%	of capital costs (prof. services excluded)		1,263,645
		Subtotal:		5,798,645
Miscellaneous Costs				
Insurance and Security Bonds	1,600,000.00	1	ls	1,600,000
		Subtotal:		1,600,000
	TOTAL CAPITAL COST			47,920,145
	CONTINGENCY (15%)			7,188,022
	GRAND TOTAL CAPITAL COSTS:			$55,108,167

INCINERATOR CAPITAL COSTS (with energy recovery)
MASS BURN\WATERWALL (400 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS				
Site Developement Costs				
1. Land Purchase	7,500.00	10	acre	75,000
2. Clear and Grub	2,500.00	6	acre	15,000
3. Roads & Parking	500,000.00	1	ls	500,000
4. Site Preparation & Landscaping	450,000.00	1	ls	450,000
5. Sewer & Water	60,000.00	1	ls	60,000
6. Power	14.00	500	ft	7,000
7. Site Surveys & Testing	40,000.00	1	ls	40,000
		Subtotal:		1,147,000
Infrastructure				
1. Building (Incl. Foundations, Stacks, Electrical, HVAC, Overhead Cranes, etc.	12,075,000.00	1	ls	12,075,000
		Subtotal:		12,075,000
Combustion Equipment				
1. Combustion\Steam Generation	15,000,000.00	1	ls	15,000,000
		Subtotal:		15,000,000
Electrical Generation Equipment				
1. Turbine-Generator (10 MW) (Includes utility interconnection)	3,100,000.00	1	ls	3,100,000
		Subtotal:		3,100,000
Emission Control Equipment				
Air Pollution Control	7,550,000	1	ea	7,550,000
		Subtotal:		7,550,000

Ash Landfill Life-Cycle Costs, 1990-2010
(150 TPD Incineration Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED	TIPPING FEE (1990 DOLLARS)
1990	360,425	131,266	76,745	167,780	736,216	13,331	55.22	55.22
1995	360,425	209,348	76,745	232,706	879,224	13,331	65.95	54.21
2000	360,425	195,608	76,745	307,966	940,744	13,331	70.57	47.67
2005	360,425	134,058	76,745	383,756	954,984	13,331	71.64	39.78
2010				468,922	468,922	13,331	35.17	16.05

Ash Landfill
Capital Cost summary
(400 TPD Incineration Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	1,215,450	226,207	275,216	334,842		
Infrastructure	583,550	4,258	5,181	6,303		
Landfill Expansion	1,365,897	353,694	430,323	523,553		
Equipment	312,500		460,948		0	
Final Cover & Drainage		274,212	333,620	405,900	1,001,052	
Post-Closure						3,432,832
Professional Services	575,000	58,000	70,566	85,854	104,455	
Income (Equip. trade-in @ 20%)			(62,500)		(92,190)	
TOTALS	4,052,397	916,371	1,513,354	1,356,453	1,013,317	3,432,832
CONTINGENCY (20%)	810,479	183,274	302,671	271,291	202,663	686,566
---GRAND TOTAL	4,862,877	1,099,645	1,816,025	1,627,744	1,215,980	4,119,398
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Payment @ 8.5 %	513,865					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		189,320	312,655	280,240	209,349	95,126

Ash Landfill Operating Costs (400 Ton/Day Incineration Facility)

Stage 1 (1990-1995)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	26,000.00	1	yr	26,000
Operator/mechanic	18,000.00	1	yr	18,000
Occasional Labor	5,000.00	1	ls	5,000
	Subtotal Without Benefits:			49,000
Fringe Benefits		@ 30%		14,700
Overhead		@ 25%		12,250
	Subtotal With Benefits:			75,950
Utilities	1,425.00	12	mo	17,100
Leachate Disposal	0.22	49,483	gal	10,886
Equip Op & Maint	20,000.00	1	ls	20,000
Contracted Services	45,000.00	1	ls	45,000
Soil Cover	8.00	225	cy/mo	21,600
Insurance	15,000.00	1	yr	15,000
	TOTAL OPERATING COSTS:			205,536
	CONTINGENCY (15%)			30,830
	GRAND TOTAL OPERATING COST			$236,367

Stage 2 (1995-2000)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	31,632.98	1	yr	31,633
Operator/mechanic	21,899.75	1	yr	21,900
Occasional Labor	6,083.26	1	ls	6,083
	Subtotal Without Benefits			59,616
Fringe Benefits		@ 30%		17,885
Overhead		@ 25%		14,904
	Subtotal With Benefits:			92,405
Utilities	1,733.73	12	mo	20,805
Leachate Disposal	0.27	164,777	gal	44,105
Equip Op & Maint	24,333.06		ls	24,333
Contracted Services	54,749.38		ls	54,749
Soil Cover	9.73	225	cy/mo	26,280
Insurance	18,249.79	1	yr	18,250
	TOTAL OPERATING COSTS:			280,926
	CONTINGENCY (15%)			42,139
	GRAND TOTAL OPERATING COS			$323,065

Stage 3 (2000-2005)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	38,486.35	1	yr	38,486
Operator/mechanic	26,644.40	1	yr	26,644
Occasional Labor	7,401.22	1	ls	7,401
	Subtotal Without Benefits:			72,532
Fringe Benefits		@ 30%		21,760
Overhead		@ 25%		18,133
	Subtotal With Benefits:			112,425
Utilities	2,109.35	12	mo	25,312
Leachate Disposal	0.33	247,166	gal	80,491
Equip Op & Maint	29,604.89		ls	29,605
Contracted Services	66,610.99		ls	66,611
Soil Cover	11.84	225	cy/mo	31,973
Insurance	22,203.66	1	yr	22,204
	TOTAL OPERATING COSTS:			368,620
	CONTINGENCY (15%)			55,293
	GRAND TOTAL OPERATING COST			$423,913

Stage 4 (2005-2010)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	46,824.53	1	yr	46,825
Operator/mechanic	32,416.98	1	yr	32,417
Occasional Labor	9,004.72	1	ls	9,005
	Subtotal Without Benefits			88,246
Fringe Benefits		@ 30%		26,474
Overhead		@ 25%		22,062
	Subtotal With Benefits:			136,782
Utilities	2,566.34	12	mo	30,796
Leachate Disposal	0.40	271,883	gal	107,722
Equip Op & Maint	36,018.87		ls	36,019
Contracted Services	81,042.46		ls	81,042
Soil Cover	14.41	225	cy/mo	38,900
Insurance	27,014.15	1	yr	27,014
	TOTAL OPERATING COSTS:			458,276
	CONTINGENCY (15%)			68,741
	GRAND TOTAL OPERATING COS			$527,017

CLOSURE (2010)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	56,969.20	1	yr	56,969
Operator/mechanic	39,440.22	1	yr	39,440
Occasional Labor	10,955.62	1	ls	10,956
	Subtotal Without Benefits:			107,365
Fringe Benefits		@ 30%		32,210
Overhead		@ 25%		26,841
	Subtotal With Benefits:			166,416
Utilities	3,122.35	12	mo	37,468
Leachate Disposal	0.48	276,418	gal	133,247
Equip Op & Maint	43,822.46		ls	43,822
Contracted Services	98,600.54		ls	98,601
Soil Cover	17.53	225	cy/mo	47,328
Insurance	32,866.85	1	yr	32,867
	TOTAL OPERATING COSTS:			559,749
	CONTINGENCY (15%)			83,962
	GRAND TOTAL OPERATING COSTS			$643,711

LIFE CYCLE COSTS: 1990-2010
INCINERATOR (with energy recovery)
MASS BURN\WATERWALL (800 TON/DAY) FACILITY

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	OPERATING COSTS	REVENUES (equipment Trade-in)	REVENUES (elec.)	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED $0.00)	TIPPING FEE (1990 $0.00)
1990	11,013,345	230,325	7,089,520	0	(10,552,150)	7,781,040	255,500	30.45	30.45
1995	11,013,345	230,325	8,625,485	0	(12,838,304)	7,030,851	255,500	27.52	22.62
2000	11,013,345	0	10,494,221	0	(15,619,760)	5,887,807	255,500	23.04	15.57
2005	11,013,345	0	12,767,825	0	(19,003,826)	4,777,344	255,500	18.70	10.38
2010	11,013,345	0	15,534,011	(678,162)	(23,121,060)	2,748,134	255,500	10.76	4.91

NOTES

1. The incinerator is assumed to have two 400 TPD Waterwall combustors.

2. The facility will operate 24 hours per day, 355 days per year with 10 days for scheduled maintenance.

3. The loader is assumed to burn 4 gallons of fuel per hour.

4. Equipment will be traded in at the end of every two stages for 20% of its value.

5. An 87.5% annual capacity utilization factor was assumed for total tons per year.

6. Combuster cost includes; combuster and one CO monitor per combuster, ash handling system, cooling tower, etc.

7. Pollution control equipment includes both dry scrubbers and baghouses. Monitoring equipment for both particulate matter (opacity monitor and a data reduction system) and PM/acid gas (opacity, inlet/outlet SO_2, inlet/outlet HCL, and inlet/outlet O_2 monitors and data reduction system) are also included.

8. Baghouse filter replacement every 2 1/2 years (total cost $ 63,000)

CAPITAL COSTS SUMMARY
INCINERATOR (with energy recovery)
MASS BURN\WATERWALL (800 TPD) FACILITY

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE
Year Constructed	1990	1995	2000	2005	2010
Site Developement	2,033,400	0	0	0	0
Infrastructure	22,000,000	0	0	0	0
Combustion Equipment	29,040,000	0	0	0	0
Electrical Generation	6,160,000	0	0	0	0
Emision Control Equipment	14,960,000	0	0	0	0
Waste Handling Equipment	2,787,000	0	3,390,812	0	0
Misc. Equipment	72,500	0	0	0	0
Professional Services	10,935,787	0	0	0	0
Misc. Costs	2,640,000	0	0	0	0
Revenues (equipment trade-in)	0	0	(557,400)	0	(678,162)
TOTALS	90,628,687	0	2,833,412	0	(678,162)
CONTINGENCY (15%)	13,594,303	0	425,012	0	0
GRAND TOTAL	104,222,990	0	3,258,423	0	(678,162)
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period					
Annual Bond Payment @ 8.5%	11,013,345				
Fund Accumulation Period		1990-1994	1995-1999	2000-2004	2005-2010
Annual Contribution @ 7.5%		230,325	230,325	0	0

INCINERATOR OPERATING COSTS (with energy recovery)
MASS BURN\WATERWALL (800 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Wages and Salaries				
1. Superintendant	60,000.00	1	ea yr	60,000
2. Foreman	50,000.00	4	ea yr	200,000
3. Scale Operator	16,000.00	2	ea yr	32,000
4. Loader Operator	16,000.00	4	ea yr	64,000
5. Crane Operator	16,000.00	6	ea yr	96,000
6. Laborers	14,000.00	12	ea yr	168,000
7. Drivers	18,000.00	2	ea yr	36,000
8. Maintenance Person	18,000.00	2	ea yr	36,000
9. Secretary	18,000.00	2	ea yr	36,000
10. Accountant	26,000.00	1	ea yr	26,000
	Subtotal without benefits:			692,000
	Fringe Benefits	30%		207,600
	Overtime Allowance	15%		103,800
	Subtotal with benefits:			1,003,400
Utilities, Taxes, and Insurance				
1. Utilities	24,500.00	12	mon/yr	294,000
2. Taxes Insurance & Administration	555,000.00	1	/yr	555,000
3. Overhead	221,000.00	1	/yr	221,000
		Subtotal:		1,070,000
Equip Op & Maint				
1. Loader Fuel	1.00	34,000	gal/yr	34,000
2. Other fuel	1.00	2,000	gal/yr	2,000
3. Auxilliary Combustor Fuel	1.00	12,000	gal/yr	12,000
4. Maintenance		5% of capital costs		3,439,350
5. Lime	80.00	2,060	tons/yr	164,800
6. Licenses, tax, and ins.	25,000.00	1	ea	25,000
7. Filter replacement	25,000.00	1	ea/yr	25,000
		Subtotal:		3,702,150
Contracted Services				
1. Pumping Leachate Holding Tank	500.00	12	/yr	6,000
2. Disposal of Non-Burnable Refuse	30.00	12,775	tons/yr	383,250
		Subtotal:		389,250
	TOTAL O & M COSTS:			6,164,800
	CONTINGENCY (15%)			924,720
	GRAND TOTAL OPERATING COSTS			$7,089,520

INCINERATOR CAPITAL COSTS (with energy recovery)
MASS BURN\WATERWALL (800 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS				
Waste Handling Equipment				
1. Receiving, Storage & Handling	2,640,000.00	1	ea	2,640,000
2. Pickup	17,000.00	1	ea	17,000
3. Mack 10-whl 14-cy dump	65,000.00	2	ea	130,000
		Subtotal:		2,787,000
Misc. Equipment				
1. Tools	7,500.00	1	ea	7,500
2. Spare Parts	65,000.00	1	ea	65,000
		Subtotal:		72,500
Professional Services				
1. Engineering & Design	5,300,000.00	1	ls	5,300,000
2. Bid Documents & Review	120,000.00	1	ls	120,000
3. Survey Control	45,000.00	1	ls	45,000
4. Construction Management	2,640,000.00	1	ls	2,640,000
5. Start-up & Acceptance Testing	440,000.00	1	ls	440,000
6. Permitting Costs	3.00% of capital costs (prof. services excluded)			2,390,787
		Subtotal:		10,935,787
Miscellaneous Costs				
Insurance and Security Bonds	2,640,000.00	1	ls	2,640,000
		Subtotal:		2,640,000
	TOTAL CAPITAL COST			90,628,687
	CONTINGENCY (15%)			13,594,303
	GRAND TOTAL CAPITAL COSTS:			$104,222,990

INCINERATOR CAPITAL COSTS (with energy recovery)
MASS BURN\WATERWALL (800 TON/DAY) FACILITY

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
CAPITAL COSTS				
Site Developement Costs				
1. Land Purchase	7,500.00	30	acre	225,000
2. Clear and Grub	2,500.00	6	acre	15,000
3. Roads & Parking	872,000.00	1	ls	872,000
4. Site Preparation & Landscaping	784,000.00	1	ls	784,000
5. Sewer & Water	60,000.00	1	ls	60,000
6. Power	14.00	500	ft	7,000
7. Site Surveys & Testing	70,400.00	1	ls	70,400
		Subtotal:		2,033,400
Infrastructure				
1. Building (Incl. Foundations, Stacks, Electrical, HVAC, Overhead Cranes, etc.	22,000,000.00	1	ls	22,000,000
		Subtotal:		22,000,000
Combustion Equipment				
1. Combustion\Steam Generation	29,040,000.00	1	ls	29,040,000
		Subtotal:		29,040,000
Electrical Generation Equipment				
1. Turbine-Generators (2-10 MW) (Includes utility interconnection)	6,160,000.00	1	ls	6,160,000
		Subtotal:		6,160,000
Emission Control Equipment				
Air Pollution Control	14,960,000	1	ea	14,960,000
		Subtotal:		14,960,000

Ash Landfill Life-Cycle Costs, 1990-2010
(400 TPD Incineration Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS
1990	513,865	189,320	95,126	236,367	1,034,678	35,550	29.10	29.10
1995	513,865	312,655	95,126	323,065	1,244,712	35,550	35.01	28.78
2000	513,865	280,240	95,126	423,913	1,313,144	35,550	36.94	24.95
2005	513,865	209,349	95,126	527,017	1,345,357	35,550	37.84	21.01
2010				643,711	643,711	35,550	18.11	8.26

Ash Landfill Capital Costs (800 Ton/Day Incineration Facility)

	Stage 1 1990-1995				Stage 2 1995-2000				Stage 3 2000-2005				Stage 4 2005-2010			
ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNI	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	2	ea	60,000												
		SUBTOTAL:		61,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	280,624	sf	42,094	0.18	62,361	sf	11,381	0.22	62,361	sf	13,846	0.27	62,361	sf	16,846
Clay Layer	30.00	20,787	cy	623,609	36.50	4,619	cy	168,604	44.41	4,619	cy	205,132	54.03	4,619	cy	249,574
60 mil PVC Geomembrane	0.70	280,624	sf	196,437	0.85	62,361	sf	53,110	1.04	62,361	sf	64,617	1.26	62,361	sf	78,616
Sand Blanket Drain	15.00	20,787	cy	311,805	18.25	4,619	cy	84,302	22.20	4,619	cy	102,566	27.01	4,619	cy	124,787
Geotextile	0.06	561,248	sf	33,675	0.07	124,722	sf	9,105	0.09	124,722	sf	11,077	0.11	124,722	sf	13,477
Washed Stone	15.00	2,598	cy	38,976	18.25	577	cy	10,538	22.20	577	cy	12,821	27.01	577	cy	15,598
6" SDR 21 Slotted PVC	7.25	1,122	lf	8,138	8.82	249	lf	2,200	10.73	249	lf	2,677	13.06	249	lf	3,257
6" Cleanouts	1,750.00	11	ea	19,250	2,129.14	2	ea	4,258	2,590.43	2	ea	5,181	3,151.65	2	ea	6,303
		SUBTOTAL:		1,273,983		SUBTOTAL:		343,497		SUBTOTAL:		417,917		SUBTOTAL:		508,460
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembran	0.70	280,624	sf	196,437	0.85	62,361	sf	53,110	1.04	62,361	sf	64,617	1.26	62,361	sf	78,616
Washed Stone	15.00	2,598	cy	38,976	18.25	577	cy	10,538	22.20	577	cy	12,821	27.01	577	cy	15,598
Sand Blanket Drain	15.00	20,787	cy	311,805	18.25	4,619	cy	84,302	22.20	4,619	cy	102,566	27.01	4,619	cy	124,787
6" SDR 21 Slotted PVC	7.25	1,122	lf	8,138	8.82	249	lf	2,200	10.73	249	lf	2,677	13.06	249	lf	3,257
6" Cleanouts	1,750.00	11	ea	19,250	2,129.14	2	ea	4,258	2,590.43	2	ea	5,181	3,151.65	2	ea	6,303
		SUBTOTAL:		574,605		SUBTOTAL:		154,408		SUBTOTAL:		187,861		SUBTOTAL:		228,562

Ash Landfill Capital Costs (800 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNI	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	132	acre	660,000												
Mobilization/Demobiliz	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	30	acre	75,000	3,041.63	2	acre	6,083	3,700.61	2	acre	7,401	4,502.36	2	acr	9,005
Erosion Control Silt F	2.84	2,400	lf	6,816	3.46	500	lf	1,728	4.20	500	lf	2,102	5.11	500	lf	2,557
Excavation/Stockpile	2.30	464,000	cy	1,067,200	2.80	103,100	cy	288,505	3.40	103,100	cy	351,010	4.14	103,100	cy	427,058
Access Road	22.00	870	lf	19,140	26.77	200	lf	5,353	32.57	200	lf	6,513	39.62	200	lf	7,924
Operational Berm	30.00	700	lf	21,000	36.50	250	lf	9,125	44.41	250	lf	11,102	54.03	250	lf	13,507
		SUBTOTAL:		1,854,156		SUBTOTAL:		316,877		SUBTOTAL:		385,530		SUBTOTAL:		469,056
INFRASTRUCTURE																
Maintenance/Office Bld	80.00	1,500	sf	120,000												
Equipment Storage	20.00	2,000	sf	40,000												
Fuel pumps / Storage	12,000.00	1	ea	12,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	20,000.00	1	ea	20,000												
Fencing	16.00	8,300	lf	132,800												
Landscaping	130,000.00	0.6	ea	78,000												
Groundwater Monitoring	3,500.00	4	ea	14,000	4,258.29	2	ea	8,517	5,180.85	2	ea	10,362	6,303.30	2	ea	12,607
Sedimentation Ponds	70,000.00	2	ea	140,000												
		SUBTOTAL:		624,550		SUBTOTAL:		8,517		SUBTOTAL:		10,362		SUBTOTAL:		12,607

Ash Landfill Operating Costs (800 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	26,000.00	1	yr	26,000
Operator	18,000.00	1	yr	18,000
Operator/mechanic	18,000.00	1	yr	18,000
Occasional Labor	5,000.00	1	ls	5,000
	Subtotal Before Benefits:			67,000
Fringe Benefits		@ 30%		20,100
Overhead		@ 25%		16,750
	Subtotal With Benefits:			103,850
Utilities	1,425.00	12	mo	17,100
Leachate Disposal	0.22	70,156	gal	15,434
Equip Op & Maint	40,000.00	1	ls	40,000
Contracted Services	75,000.00	1	ls	75,000
Soil Cover	8.00	560	cy/mo	53,760
Insurance	30,000.00	1	yr	30,000
	TOTAL OPERATING COSTS:			335,144
	CONTINGENCY (15%)			50,272
	GRAND TOTAL OPERATING COST			$385,416

ITEM	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	31,632.98	1	yr	31,633
Operator	21,899.75	1	yr	21,900
Operator/mechanic	21,899.75	1	yr	21,900
Occasional Labor	6,083.26	1	ls	6,083
	Subtotal Before Benefits:			81,516
Fringe Benefits		@ 30%		24,455
Overhead		@ 25%		20,379
	Subtotal With Benefits:			126,349
Utilities	1,733.73	12	mo	20,805
Leachate Disposal	0.27	233,620	gal	62,531
Equip Op & Maint	48,666.12		ls	48,666
Contracted Services	91,248.97		ls	91,249
Soil Cover	9.73	560	cy/mo	65,407
Insurance	36,499.59	1	yr	36,500
	TOTAL OPERATING COSTS:			451,508
	CONTINGENCY (15%)			67,726
	GRAND TOTAL OPERATING COS			$519,234

ITEM	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	38,486.35	1	yr	38,486
Operator	26,644.40	1	yr	26,644
Operator/mechanic	26,644.40	1	yr	26,644
Occasional Labor	7,401.22	1	ls	7,401
	Subtotal Before Benefits:			99,176
Fringe Benefits		@ 30%		29,753
Overhead		@ 25%		24,794
	Subtotal With Benefits:			153,723
Utilities	2,109.35	12	mo	25,312
Leachate Disposal	0.33	350,429	gal	114,119
Equip Op & Maint	59,209.77		ls	59,210
Contracted Services	111,018.32		ls	111,018
Soil Cover	11.84	560	cy/mo	79,578
Insurance	44,407.33	1	yr	44,407
	TOTAL OPERATING COSTS:			587,368
	CONTINGENCY (15%)			88,105
	GRAND TOTAL OPERATING COSTS			$675,473

ITEM	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	46,824.53	1	yr	46,825
Operator	32,416.98	1	yr	32,417
Operator/mechanic	32,416.98	1	yr	32,417
Occasional Labor	9,004.72	1	ls	9,005
	Subtotal Before Benefits:			120,663
Fringe Benefits		@ 30%		36,199
Overhead		@ 25%		30,166
	Subtotal With Benefits:			187,028
Utilities	2,566.34	12	mo	30,796
Leachate Disposal	0.40	385,472	gal	152,727
Equip Op & Maint	72,037.74		ls	72,038
Contracted Services	135,070.76		ls	135,071
Soil Cover	14.41	560	cy/m	96,819
Insurance	54,028.31	1	yr	54,028
	TOTAL OPERATING COSTS:			728,507
	CONTINGENCY (15%)			109,276
	GRAND TOTAL OPERATING COST			$837,783

ITEM	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	56,969.20	1	yr	56,969
Operator	39,440.22	1	yr	39,440
Operator/mechanic	39,440.22	1	yr	39,440
Occasional Labor	10,955.62	1	ls	10,956
	Subtotal Before Benefits:			146,805
Fringe Benefits		@ 30%		44,042
Overhead		@ 25%		36,701
	Subtotal With Benefits:			227,548
Utilities	3,122.35	12	mo	37,468
Leachate Disposal	0.48	391,903	gal	188,916
Equip Op & Maint	87,644.93		ls	87,645
Contracted Services	164,334.24		ls	164,334
Soil Cover	17.53	560	cy/mo	117,795
Insurance	65,733.69	1	yr	65,734
	TOTAL OPERATING COSTS:			889,440
	CONTINGENCY (15%)			133,416
	GRAND TOTAL OPERATING COST			$1,022,856

Ash Landfill Capital Costs (800 Ton/Day Incineration Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)
FINAL COVER AND DRAINAGE								
Cap Underlaiment					12.21	3,415	cy	41,697
40 mil HDPE Geomembrane					0.55	232,760	sf	128,018
Drainage layer					15.00	6,830	cy	102,450
Subsoil					12.00	3,415	cy	40,980
Topsoil					16.00	3,415	cy	54,640
Seed, Fertilizer, Mulch, Lime					2,500.00	4.00	acre	10,000
Terrace Swales					15.00	2,120	lf	31,800
SUBTOTAL:				0				409,585
EQUIPMENT (3)								
Dozer (Cat D7H)	280,000.00	1	ea	280,000			ea	0
Loader (Cat 936)	117,000.00	1	ea	117,000			ea	0
Dump truck	85,000.00	1	ea	85,000			ea	0
Service Truck	27,750.00	1	ea	27,750			ea	0
Office Equipment	1,500.00	1	ea	1,500		0	ea	0
Maintenance Equipment	5,000.00	1	ea	5,000		0	ea	0
SUBTOTAL:				516,250				0
PROFESSIONAL SERVICES								
Hydro, Permitting	340,000.00	1	ea	340,000				
Bid Documents & Bid Re	94,000.00	1	ea	94,000	24,000.00	1	ea	24,000
Survey Control	42,000.00	1	ea	42,000	10,000.00	1	ea	10,000
Construction Inspectio	150,000.00	1	ea	150,000	32,000.00	1	ea	32,000
Topo Map & Vol. Calcul	17,500.00	1	ea	17,500				
SUBTOTAL:				643,500				66,000
TOTAL CAPITAL COST				5,548,244				1,298,884
CONTINGENCY (15%)				832,237				194,833
GRAND TOTAL CAPITAL COSTS:				$6,380,481				$1,493,717

ITEM	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE								
Cap Underlaiment	14.86	3,415	cy	50,731	18.07	3,415	cy	61,722
40 mil HDPE Geomembrane	0.67	232,760	sf	155,753	0.81	232,760	sf	189,498
Drainage layer	18.25	6,830	cy	124,646	22.20	6,830	cy	151,651
Subsoil	14.60	3,415	cy	49,858	17.76	3,415	cy	60,660
Topsoil	19.47	3,415	cy	66,478	23.68	3,415	cy	80,881
Seed, Fertilizer, Mulch, Lime	3,041.63	4.00	acre	12,167	3,700.61	4.00	acr	14,802
Terrace Swales	18.25	2,120	lf	38,690	22.20	2,120	lf	47,072
SUBTOTAL:				498,323				606,286
EQUIPMENT (3)								
Dozer (Cat D7H)	414,468.40	1	ea	414,468			ea	0
Loader (Cat 936)	173,188.58	1	ea	173,189			ea	0
Dump truck	125,820.76	1	ea	125,821			ea	0
Service Truck	41,076.78	1	ea	41,077			ea	0
Office Equipment	2,220.37	1	ea	1,776			ea	0
Maintenance Equipment	7,401.22	1	ea	5,921			ea	0
SUBTOTAL:				762,252				0
PROFESSIONAL SERVICES								
Hydro, Permitting								
Bid Documents & Bid Re	29,199.67	1	ea	29,200	35,525.86	1	ea	35,526
Survey Control	12,166.53	1	ea	12,167	14,802.44	1	ea	14,802
Construction Inspectio	38,932.89	1	ea	38,933	47,367.82	1	ea	47,368
Topo Map & Vol. Calcul								
SUBTOTAL:				80,299				97,696
TOTAL CAPITAL COST				2,342,543				1,922,666
CONTINGENCY (15%)				351,381				288,400
GRAND TOTAL CAPITAL COSTS:				$2,693,925				$2,211,066

ITEM	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlaiment	21.99	6,830	cy	150,188
40 mil HDPE Geomembrane	0.99	465,520	sf	461,106
Drainage layer	27.01	13,660	cy	369,013
Subsoil	21.61	6,830	cy	147,605
Topsoil	28.82	6,830	cy	196,807
Seed, Fertilizer, Mulch, Lime	4,502.36	10.0	acre	45,024
Terrace Swales	27.01	4,230	lf	114,270
SUBTOTAL:				1,484,014
EQUIPMENT (3)				
Dozer (Cat D7H)				0
Loader (Cat 936)				0
Dump truck				0
Service Truck				0
Office Equipment				0
Maintenance Equipment				0
SUBTOTAL:				0
PROFESSIONAL SERVICES				
Hydro, Permitting				
Bid Documents & Bid Re	43,222.64	1	ea	43,223
Survey Control	18,009.44	1	ea	18,009
Construction Inspectio	57,630.19	1	ea	57,630
Topo Map & Vol. Calcul				
SUBTOTAL:				118,862
TOTAL CAPITAL COST				1,602,876
GRAND TOTAL CAPITAL COSTS:				$1,602,876

Ash Landfill Post-Closure Costs
(800 TPD Incineration Facility)

ITEM	COST ($)	QUANTITY	UNIT	PER ITEM ($)	COST ($)	QUANTITY	UNIT PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR		NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	6	ea	1	1,752.90	6	10,517
	800.00	3	ea	29	1,752.90	87	152,502
Vegetation Maintenance	4,000.00	5	acres	5	8,764.49	25	219,112
	4,000.00	1	acres	25	8,764.49	25	219,112
Drainage Maintenance	2,500.00	1	ls	30	5,477.81	30	164,334
Groundwater Monitoring	2000.00	10	ea	5	4,382.25	50	219,112
	2000.00	5	ea	25	4,382.25	125	547,781
Leachate Monitoring	1,200.00	12	ea	5	2,629.35	60	157,761
	1,200.00	4	ea	25	2,629.35	100	262,935
Leachate Treatment	0.22	391,903	gal	5	0.48	1,959,516	944,579
	0.22	97,976	gal	10	0.48	979,758	472,290
	0.22	19,595	gal	15	0.48	293,927	141,687
Cap Maintenance	15,000.00	2	acres	2	32,866.85	4	131,467
	15,000.00	0.5	acres	28	32,866.85	14	460,136
Replace Monitoring Wel	3,100.00	1	/5 yr	30	6,792.48	6	40,755
					TOTAL POSTCLOSURE COST:		4,144,081
					CONTINGENCY (15%)		621,612
					GRAND TOTAL POSTCLOSURE C		4,765,693

Ash Landfill
Capital Cost summary
(800 TPD Incineration Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	1,854,156	316,877	385,530	469,056		
Infrastructure	624,550	8,517	10,362	12,607		
Landfill Expansion	1,909,788	497,905	605,778	737,021		
Equipment	516,250		762,252		0	
Final Cover & Drainage		409,585	498,323	606,286	1,484,014	
Post-Closure						4,144,081
Professional Services	643,500	66,000	80,299	97,696	118,862	
Income (Equip. trade-in @ 20%)			(103,250)		(152,450)	
TOTALS	5,548,244	1,298,884	2,239,293	1,922,666	1,450,426	4,144,081
CONTINGENCY (20%)	1,109,649	259,777	447,859	384,533	290,085	828,816
GRAND TOTAL	6,657,893	1,558,661	2,687,152	2,307,199	1,740,511	4,972,897
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Bond Payment @ 8.5 %	703,546					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		268,346	462,633	397,218	299,655	114,835

Ash Landfill Life-Cycle Costs, 1990-2010
(800 TPD Incineration Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE (INFLATED	TIPPING FEE (1990 DOLLARS
1990	703,546	268,346	114,835	385,416	1,472,144	71,100	20.71	20.71
1995	703,546	462,633	114,835	519,234	1,800,248	71,100	25.32	20.81
2000	703,546	397,218	114,835	675,473	1,891,072	71,100	26.60	17.97
2005	703,546	299,655	114,835	837,783	1,955,818	71,100	27.51	15.27
2010				1,022,856	1,022,856	71,100	14.39	6.57

11. LANDFILLS

All solid waste management systems require some provision for land disposal. Whether the residue comes from recycling or composting operations, or incinerator ash, landfills will always be a part of solid waste management. This final chapter describes the design characteristics of the landfills that will be used for the landfill cost analyses.

A sanitary landfill uses engineering principles to confine waste to the smallest practicable area without creating nuisance or hazards to public health or safety. A good sanitary landfill design includes a double liner system and a landfill cap. The primary reason for the liner and cap system is to minimize groundwater contamination, which was a problem with old dumps. The best liner system combines a soil liner with a synthetic material (high density polyethylene). A high-permeability leak detection system is included between the liners. The landfill cap is either a synthetic material such as polyethylene or polyvinyl chloride (PVC) or a soil layer.

Features which must be designed into a sanitary landfill include leachate collection, gas control, groundwater monitoring, and drainage control. Leachate collection systems are comprised of a network of pipes integrated with the liner system. These pipes are perforated to allow leachate (liquid that has percolated through the waste) to be collected. The leachate that is collected in the landfill is conveyed to a wastewater treatment plant (WWTP). Conveyance may be either by direct sewer connection or tanker transport. On-site tank storage and partial pretreatment at the landfill may be necessary.

Gas and drainage controls must also be designed into the facility. The decomposition of refuse generates methane, carbon dioxide, and other gases. In order to prevent the migration of these gases off site, the gas must be controlled. Passive or active measures can be used. The gas collected can be used as an energy source or it can be vented into the atmosphere.

In order to reduce the potential erosion and runoff caused by development at the facility, drainage controls must be installed. In addition, monitoring wells should be placed around the site to monitor gas and groundwater quality.

The physical plant at a sanitary landfill includes a scale and scalehouse, leachate tanks, equipment storage and maintenance buildings, employee restrooms, access roads, and fencing. The scale is necessary to determine the fee that will be charged to haulers for each load that is delivered. Equipment storage and maintenance buildings complete with restrooms will aid in efficient operations. Access roads must be constructed and maintained to prevent excessive dust and erosion. Fencing around the facility is required to control access to the facility as well as to help prevent windblown litter from leaving the site.

Landfill operation typically involves placement of waste in individual sections, called cells, of the landfill. In the cells, refuse is spread in layers no greater than two feet in thickness. Each layer is compacted by at least three passes of compacting equipment. Subsequent layers are placed on top of each compacted layer until the maximum height of the cell, typically eight feet, is reached. Six inches of soil is uniformly compacted over all areas of exposed refuse when a cell that reaches its maximum height and at the end of each day's operations.

An intermediate cover layer is uniformly compacted on all sides of a working face that will not be receiving waste placement for a period of greater than one month. This layer is 12 inches thick including daily cover, and it is sloped at greater than 2 percent but less than 33 percent. The final cover material is uniformly compacted on all areas of the landfill that will not be used for a period of 12 months. The capping material and final cover is placed over the intermediate cover layer and seeded with a grass mix. Erosion control measures are usually needed to prevent the grass mix from washing off of the landfill slopes.

A careful conservative design in the development of a solid waste landfill will minimize risk of failure. Strict adherence to the design during construction is also important. The failure of containment systems at landfills can be avoided if a rigorous construction quality assurance program is in effect during all phases of construction.

Proper operation of a landfill is as important as good design and construction to minimize negative impacts on the environment. A critical activity in the landfill operations is the compaction of the waste. Compacting minimizes wind blown litter and increases the landfill life by decreasing the volume of the refuse. Applying daily cover likewise decreases the volume of wind blown litter, minimizes odors, impedes the downward percolation of precipitation and snowmelt, and minimizes vector infestation by limiting access to the waste.

The design requirements for sanitary landfills need to account for USEPA's pending Subtitle-D Guidelines for waste disposal facilities. These guidelines assume all MSW landfills will receive a certain quantity of household and small quantity generator hazardous waste. Another assumption of the Guidelines is that even well designed and constructed landfills generate leachate and will leak, an assumption based upon "real world" experience. The Guidelines provide criteria for reducing the leakage to nondetectible levels, on the order of one to two gallons per acre per day (GPAD). With soil and weather conditions typical of the State of Vermont, the Guidelines require a synthetic membrane primary liner and a composite (soil and synthetic membrane) secondary liner.

The leachate collection system above the primary liner must maintain a liquid level, or "head", over the synthetic membrane of less than one foot. Between the primary and secondary liner is a secondary leachate collection system which serves to detect leakage through the primary liner and a collection mechanism for the leakage. A composite secondary liner is required for this secondary collection system to work properly. Without it, leakage rates would average 100-1000 GPAD, even with well-constructed synthetic membranes.

The guidelines specify other design criteria, the most important of which pertain to leachate treatment. The guidelines require leachate disposal at a facility capable of providing the proper degree of treatment. On-site pretreatment of the leachate at the landfill may be necessary.

The ideal site for a sanitary landfill is centrally located relative to the communities that would be using it. It consists of relatively level ground and permits a sufficient depth of soil between the bottom of the liner and groundwater and bedrock. The site should be chosen to minimize the impact on aquifers, surface waters, floodplains, critical habitats for endangered species, areas of archeological importance, wetlands, air, and ground traffic.

Pros:

- Sanitary landfill is the ultimate means of disposal;
- Easily expandable;
- Can handle most wastes;
- Land can be used for passive recreation upon closure;
- Variations in the waste stream do not affect operations.

Cons:

- Proper engineering and designs are expensive;
- Acceptable land for a site can be scarce;
- The useful life of a site may be limited;
- Permitting activities can take a long time;
- Large quantities of soil are required for proper construction and operations.

COST ANALYSIS OF LANDFILLS

Four sizes of landfills were selected for cost analysis:

- 12 tons/day capacity;

- 40 tons/day capacity;
- 150 tons/day capacity;
- 500 tons/day capacity.

The results of these cost analyses are summarized in Tables 11-1 and 11-2, where the first year operating costs are presented. Results also are summarized in Figure 11-1. A more detailed analysis of costs, with further breakdown and full lifecycle costs, is available in the appendix to this chapter.

Assumptions

In our analysis of a **small landfill handling 12 tons/day,** we made the following assumptions:

- Land requirements - 50 acres;
- Compacted solid waste density - 800 lb/c.y.;
- Cover to MSW ratio - 25%;
- Compaction equipment: JD 450 compactor or equivalent;
  CAT D4H dozer or equivalent;
- Cover soil available within 10 miles;
- Cover soil hauling is contracted;
- Leachate collected and transported by tanker, 50 miles;
- Unheated equipment storage;
- Facility life - 20 years;
- Inflation factor - 4%;
- Waste growth factor - 2%;
- Staff 2.

For the analysis of the **small landfill handling 40 tons/day,** we made the following assumptions:

- Land requirements - 75 acres;
- Compacted solid waste density - 800 lb/C.Y.;
- Cover to MSW ratio - 20%;
- Compaction equipment: CAT D4H Dozer or equivalent;
  JD 450 compactor or equivalent;
- Earth moving equipment: CAT 936 loader or equivalent;
- Cover soil available within 10 miles;
- Leachate collected and transported by tanker, 50 miles;
- Unheated equipment storage;
- Facility life - 20 years;
- Staff: 2.5

In our analysis of a **medium landfill handling 150 tons/day**, we made the following assumptions:

- Land requirements: 125 acres;
- Compacted solid waste density - 1000 lb/C.Y.;
- Cover to MSW ratio - 20%;
- Compaction equipment: CAT 816 compactor or equivalent;
  CAT D7L Dozer or equivalent;
- Earth moving equipment: CAT 966 Loader or equivalent;
  3 axle, 10 yd dump truck;
- Unheated equipment storage;
- Leachate piped to WWTP, 4 miles;
- Facility life - 20 years;
- Staff: 4.

For the **large landfill handling 500 tons/day,** we made the following assumptions:

- Land requirements: 200 acres;
- Compacted solid waste density: 1200 lb/C.Y.;
- Cover to MSW ratio - 15%;
- Compaction equipment: Two CAT 826 compactor or equivalent;
  CAT D7L Dozer or equivalent;
- Earth moving equipment: CAT 980 Loader or equivalent;
  3 axle 14 yd dump truck;
  Service truck;
- Leachate hauling equipment: 6000 Gallon tanker trailer with tractor;
- Unheated equipment storage;
- Leachate pretreated onsite, effluent transported by tanker to WWTP 15 miles;
- Facility life - 20 years;
- Staff: 4.

Capital and Operating Costs

Unlike other solid waste facilities we have analyzed, landfill costs must be approached on a lifecycle basis. The staged development of landfill cells - spreading capital expenditures over time - and changing operating costs, resulting primarily from the increased generation of leachate as the landfill ages, mean that no one year is truly representative of landfill costs. The landfill costs in the appendix present the lifecycle costs for the 12, 40 , 150, and 500 TPD facilities analyzed, including capital development of four cells over 20 years, as well as annual operations and post-closure costs. A summary of the first year costs of these facilities are presented in Tables 11-1 and 11-2. These costs include initial site development, construction of the first of four cells, first year operations and a post-closure fund payment.

The economies of scale in favor of larger landfill facilities are very clear. First-year costs per ton drop from $162 per ton in the 12 TPD facility to $24 per ton for the 500 TPD facility. First-year costs are significantly higher than the present value of life-cycle costs, which range from $91 per ton for the 12 TPD facility to $14 per ton for the 500 TPD facility. In this case, life-cycle landfill costs are much lower because many of the capital expenditures are delayed into the future, and operating costs increase nominally in future years, due to increased costs for such items as leachate disposal.

In this first year, the majority of costs result from capital expenses. There is over a three to one ratio between capital and operating expenses. This relationship changes over time as capital, costs in the form of bond payments and capital reserve funds, stay relatively constant; and operating costs increase as the result of increased leachate generation and inflation. By the last operating years of the landfill, the capital costs are only 40% larger than operating costs (see summary cost tables for each landfill in the appendix to this section).

Many landfill costs are directly proportional to the physical area (acreage) of the landfill. Secondary containment (liners), primary leachate collection, and final cover and drainage all have constant per acre costs for each of the facilities analyzed. Economies of scale associated with these costs come from the increased capacity per acre for larger landfills. One source of efficiency in larger landfills is the increase in fill depth as the size of the site increases. Comparing daily capacity per acre for the four types of landfills, we found capacity increases from about 3 tons per acre in the smallest facility to about 16 tons per acre in the largest. In addition, capacity per acre increases with landfill size because larger, more efficient compaction equipment means a higher compaction ratio for larger landfills. Our analysis shows a ratio of capacity per acre from the largest to the smallest landfills is about 16:3 -- more than a five-fold difference. This ratio is also the ratio for capital costs per ton of capacity ($/TPD), because capacity per acre is the key source of economies of scale in landfill capital expenses.

Other capital costs show economies of scale beyond those gained from more efficient use of acreage. Infrastructure costs (buildings, utility hookups, and monitoring wells) show the greatest economy of scale, dropping from $28,000 per TPD for the 12 TPD facility to $2,000 per TPD for the 500 TPD facility (a ratio of 14:1). Equipment costs show similar economies, dropping from $21,000 per TPD for the 12 TPD facility to $1,800 per TPD in the 500 TPD facility.

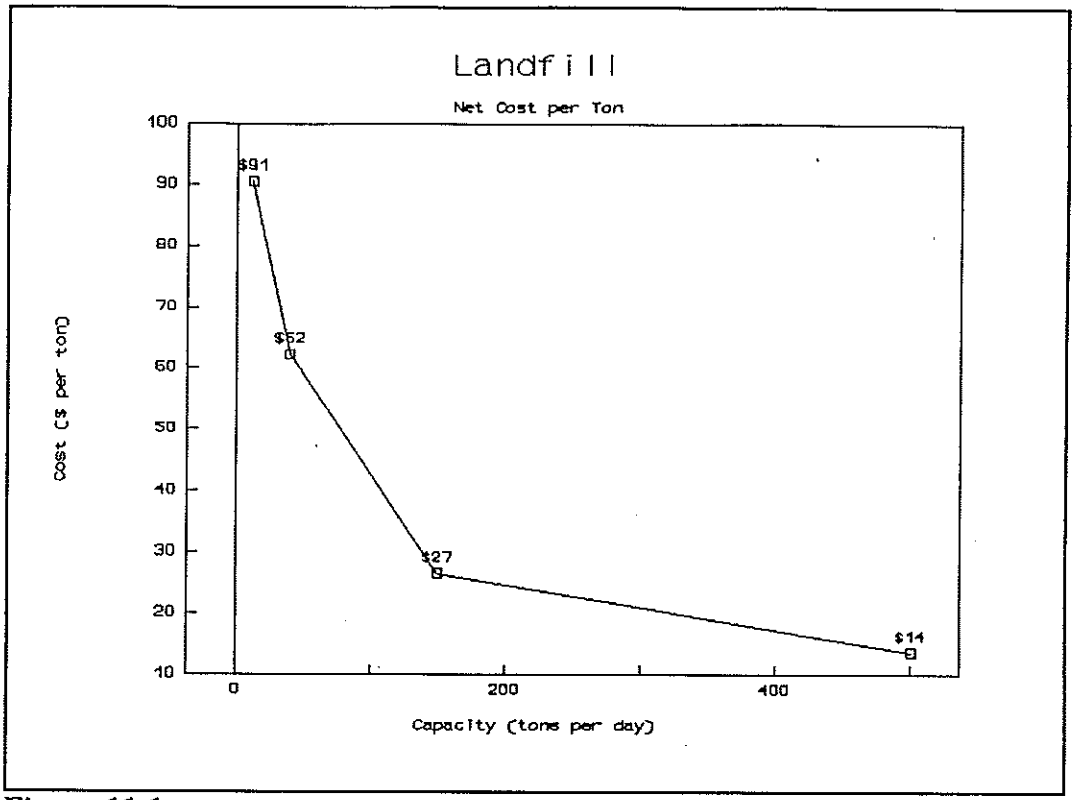


Figure 11-1

Operating costs show economies of scale as well, as shown in the last part of Table 11-2. With the exception of soil cover, these cost all show significant and relatively similar economies. The ratio of the per ton costs for several items (leachate disposal, labor and equipment operation, and maintenance) in the largest and smallest facilities are very close to the 5.3 ratio associated with increased disposal per acre. However, there is no clear operational or technical connection between any of these costs and acreage, with the exception of leachate disposal, to justify any causality. For leachate disposal, acreage is somewhat proportional to the amount of water entering the landfill. Soil costs show no economies because the garbage-to-cover ratio is constant for all landfills (except for the 500 TPD fill where there is a slight decrease) and the per ton soil cost is constant.

The increased amount of waste disposed per acre as the size of the site increases is clearly the most significant factor in the large economies of scale for landfills. Capacity per acre is important because capital costs per ton are far greater than operating costs, and these capital costs are constant per acre. Additional economies may come from more efficient use of labor and equipment in the operations, but these impacts are much smaller than the effect of constant per acre capital costs.

TABLE 11-1

FIRST YEAR (1990) LANDFILL CAPITAL AND OPERATING COSTS

300days/yr.

Capacity	12	40	150	500
Annual Tonnage	3,600	12,000	45,000	150,000
Site Area	4	8	20	32
Development Stages	4	4	4	4
Ratio of Capacity : Acres	3.0	5.0	7.5	15.6
Capital Costs (includes bond, capital reserve & post closure)	477,532	948,522	1,649,982	2,816,229
Cost per Ton	132.65	79.04	36.67	18.77
Operating Costs	105,306	356,063	445,658	767,614
Cost per Ton	29.25	29.67	9.90	5.12
	-------	-------	-------	-------
Net Cost	582,838	1,304,585	2,095,640	3,583,843
Cost per ton	161.90	108.72	46.57	23.89

LIFECYCLE COSTS

	Year				
Per Ton Cost (nominal $)	1	161.02	108.59	46.46	23.77
	2	160.29	108.57	46.41	23.67
	3	159.72	108.64	46.41	23.58
	4	159.31	108.82	46.46	23.52
	5	159.07	109.11	46.57	23.48
	6	176.74	119.41	51.03	25.91
	7	176.31	119.60	51.10	25.87
	8	176.06	119.90	51.24	25.85
	9	176.01	120.32	51.44	25.85
	10	176.17	120.86	51.72	25.88
	11	168.33	116.11	49.54	25.97
	12	168.67	116.78	49.86	26.02
	13	169.21	117.59	50.25	26.11
	14	169.97	118.52	50.72	26.22
	15	170.95	119.59	51.28	26.36
	16	149.80	109.90	45.80	23.75
	17	150.90	111.07	46.38	23.94
	18	152.21	112.38	47.05	24.16
	19	153.74	113.83	47.79	24.41
	20	153.74	113.83	47.79	24.41
1990 Present Value of Lifetime per Ton Costs		90.52	62.46	26.62	13.58

Figure 11-1

TABLE 11-2

NET FIRST YEAR CAPITAL AND OPERATING COSTS

Capital Cost per Ton of Capacity ($/TPD)				
Preparatory Work	43,875	24,622	11,277	6,367
Infrastructure	28,488	12,859	5,566	2,121
Leachate Pump and Storage	2,600	1,530	2,995	182
Secondary Containment	43,404	28,337	13,549	8,031
Primary Leachate Collection	19,617	12,786	6,114	3,623
Final Cover and Drainage *	15,767	10,321	4,961	2,956
Equipment	21,000	11,369	4,985	1,791
Professional Services	13,333	21,225	8,633	3,300
Operating Costs per ton disposed ($/First Year Tons)				
Labor	8.61	6.33	3.00	1.45
Utilities	3.00	1.05	0.58	0.21
Leachate Disposal	1.39	0.91	0.44	0.26
Equip Operations & Maint	4.17	1.67	1.22	0.60
Contracted Services	4.17	2.50	1.00	0.50
Soil Cover	1.60	1.60	1.60	1.20
Insurance	2.50	1.33	0.78	0.23
First Stage Capital Cost per Acre ($/TPD)				
Preparatory Work	526,495	492,449	338,305	397,931
Infrastructure	341,850	257,175	166,990	132,544
Leachate Pump and Storage	31,200	30,600	89,836	11,400
Secondary Containment	520,847	566,745	406,479	501,925
Primary Leachate Collection	235,408	255,723	183,423	226,424
Final Cover and Drainage *	189,208	206,424	148,834	184,740
Equipment	252,000	227,375	149,550	111,906
Professional Services	160,000	424,500	259,000	206,250
First Year Operating Costs per acre ($/First Year Tons)				
Labor	31,000	37,975	26,970	27,125
Utilities	10,800	6,300	5,220	3,975
Leachate Disposal	5,011	5,460	3,916	4,836
Equip Operations & Maint	15,000	10,000	11,000	11,250
Contracted Services	15,000	15,000	9,000	9,375
Soil Cover	5,760	9,600	14,400	22,500
Insurance	9,000	8,000	7,000	4,375

* Stage 2 costs are used.

APPENDIX TO CHAPTER 11

Sanitary Landfill Capital Costs (12 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	30	acre	150,000												
Mobilization/Demobilizati	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	25	acre	62,500	3,041.63	1	acre	3,042	3,700.61	1	acre	3,701	4,502.36	1	acre	4,502
Erosion Control Silt Fenc	2.84	480	lf	1,363	3.46	320	lf	1,106	4.20	320	lf	1,345	5.11	320	lf	1,637
Excavation/Stockpile	2.30	126,240	cy	290,352	2.80	63,120	cy	176,629	3.40	63,120	cy	214,896	4.14	63,120	cy	261,454
Access Road	22.00	240	lf	5,280	26.77	120	lf	3,212	32.57	120	lf	3,908	39.62	120	lf	4,754
Operational Berm	30.00	400	lf	12,000	36.50	200	lf	7,300	44.41	200	lf	8,881	54.03	200	lf	10,806
		SUBTOTAL:		526,495		SUBTOTAL:		197,371		SUBTOTAL:		240,132		SUBTOTAL:		292,158
INFRASTRUCTURE																
Maintenance/Office Bldg	70.00	800	sf	56,000												
Equipment Storage	25.00	1,500	sf	37,500												
Fuel pumps / Storage	12,000.00	1	ea	12,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	20,000.00	1	ea	20,000												
Fencing	16.00	3,000	lf	48,000												
Landscaping	35,000.00	0.6	ea	21,000												
Groundwater Monitoring We	3,500.00	4	ea	14,000	4,258.29	2	ea	8,517	5,180.85	2	ea	10,362	6,303.30	2	ea	12,607
Gas Control	1,400.00	4	ea	5,600	1,703.31	2	ea	3,407	2,072.34	2	ea	4,145	2,521.32	2	ea	5,043
Sedimentation Ponds	60,000.00	1	ea	60,000												
		SUBTOTAL:		341,850		SUBTOTAL:		11,923		SUBTOTAL:		14,506		SUBTOTAL:		17,649

Sanitary Landfill Capital Costs (12 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-20 0 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	1	ea	30,000												
		SUBTOTAL:		31,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	114,532	sf	17,180	0.18	25,452	sf	4,645	0.22	25,452	sf	5,651	0.27	25,452	sf	6,876
Clay Layer	30.00	8,484	cy	254,515	36.50	1,885	cy	68,813	44.41	1,885	cy	83,721	54.03	1,885	cy	101,859
60 mil PVC Geomembrane	0.70	114,532	sf	80,172	0.85	25,452	sf	21,676	1.04	25,452	sf	26,372	1.26	25,452	sf	32,086
Sand Blanket Drain	15.00	8,484	cy	127,258	18.25	1,885	cy	34,406	22.20	1,885	cy	41,860	27.01	1,885	cy	50,930
Geotextile	0.06	229,064	sf	13,744	0.07	50,903	sf	3,716	0.09	50,903	sf	4,521	0.11	50,903	sf	5,500
Washed Stone	15.00	1,060	cy	15,907	18.25	1,025	cy	18,706	22.20	1,025	cy	22,759	27.01	1,025	cy	27,690
6" SDR 21 Slotted PVC Pip	7.25	458	lf	3,321	8.82	102	lf	898	10.73	102	lf	1,093	13.06	102	lf	1,329
6" Cleanouts	1,750.00	5	ea	8,750	2,129.14	1	ea	2,129	2,590.43	1	ea	2,590	3,151.65	1	ea	3,152
		SUBTOTAL:		520,847		SUBTOTAL:		154,989		SUBTOTAL:		188,567		SUBTOTAL:		229,421
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembrane	0.70	114,532	sf	80,172	0.85	25,452	sf	21,676	1.04	25,452	sf	26,372	1.26	25,452	sf	32,086
Washed Stone	15.00	1,060	cy	15,907	18.25	1,025	cy	18,706	22.20	1,025	cy	22,759	27.01	1,025	cy	27,690
Sand Blanket Drain	15.00	8,484	cy	127,258	18.25	1,885	cy	34,406	22.20	1,885	cy	41,860	27.01	1,885	cy	50,930
6" SDR 21 Slotted PVC Pip	7.25	458	lf	3,321	8.82	102	lf	898	10.73	102	lf	1,093	13.06	102	lf	1,329
6" Cleanouts	1,750.00	5	ea	8,750	2,129.14	1	ea	2,129	2,590.43	1	ea	2,590	3,151.65	1	ea	3,152
		SUBTOTAL:		235,408		SUBTOTAL:		77,815		SUBTOTAL:		94,674		SUBTOTAL:		115,186

Sanitary Landfill Capital Costs (12 Ton/Day Facility)

Stage 1 (1990-1995)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlainment				
40 mil HDPE Geomembrane				
Drainage layer				
Subsoil				
Topsoil				
Seed, Fertilizer, Mulch, Lime				
Gas Vents				
Gas Vent Riser Pipes				
Terrace Swales				
SUBTOTAL:				0
EQUIPMENT (3)				
Dozer (Cat D4H or eqv.)	125,000.00	1	ea	125,000
Loader (Cat 936 or eqv.)	117,000.00	1	ea	117,000
Office Equipment/Furnitur	5,000.00	1	ea	5,000
Maintenance Equipment	5,000.00	1	ea	5,000
SUBTOTAL:				252,000
PROFESSIONAL SERVICES				
Hydro, Permitting	75,000.00	1	ea	75,000
Bid Documents & Review	30,000.00	1	ea	30,000
Survey Control	12,000.00	1	ea	12,000
Construction Inspection	36,000.00	1	ea	36,000
Topo Map & Vol. Calcs	7,000.00	1	ea	7,000
				160,000
TOTAL CAPITAL COST				2,067,801
CONTINGENCY (15%)				310,170
GRAND TOTAL CAPITAL COSTS:				$2,377,971

Stage 2 (1995-2000)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Cap Underlainment	12.21	1,370	cy	16,728
40 mil HDPE Geomembrane	0.55	93,200	sf	51,260
Drainage layer	15.00	2,730	cy	40,950
Subsoil	12.00	1,370	cy	16,440
Topsoil	16.00	1,370	cy	21,920
Seed, Fertilizer, Mulch, Lime	2,500.00	2.0	acre	5,000
Gas Vents	20.00	8	lf	160
Gas Vent Riser Pipes	600.00	40	ea	24,000
Terrace Swales	15.00	850	lf	12,750
SUBTOTAL:				189,208
Dozer (Cat D4H or eqv.)		0	ea	0
Loader (Cat 936 or eqv.)		0	ea	0
Office Equipment/Furnitur		0	ea	0
Maintenance Equipment		0	ea	0
SUBTOTAL:				0
Hydro, Permitting				
Bid Documents & Review	10,000.00	1	ea	10,000
Survey Control	15,000.00	1	ea	15,000
Construction Inspection	20,000.00	1	ea	20,000
Topo Map & Vol. Calcs				
SUBTOTAL:				45,000
TOTAL CAPITAL COST				676,306
CONTINGENCY (15%)				101,446
GRAND TOTAL CAPITAL COSTS				$777,752

Stage 3 (2000-2005)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Cap Underlainment	14.86	1,370	cy	20,352
40 mil HDPE Geomembrane	0.67	93,200	sf	62,366
Drainage layer	18.25	2,730	cy	49,822
Subsoil	14.60	1,370	cy	20,002
Topsoil	19.47	1,370	cy	26,669
Seed, Fertilizer, Mulch, Lime	3,041.63	2.0	acre	6,083
Gas Vents	24.33	8	lf	195
Gas Vent Riser Pipes	729.99	40	ea	29,200
Terrace Swales	18.25	850	lf	15,512
SUBTOTAL:				230,200
Dozer (Cat D4H or eqv.)	185,030.54	1	ea	148,024
Loader (Cat 936 or eqv.)	173,188.58	1	ea	138,551
Office Equipment/Furnitur	7,401.22	1	ea	5,921
Maintenance Equipment	7,401.22	1	ea	5,921
SUBTOTAL:				298,417
Hydro, Permitting				
Bid Documents & Review	12,762.82	1	ea	12,763
Survey Control	19,144.22	1	ea	19,144
Construction Inspection	25,525.63	1	ea	25,526
Topo Map & Vol. Calcs				
SUBTOTAL:				57,433
TOTAL CAPITAL COST				1,123,931
CONTINGENCY (15%)				168,590
GRAND TOTAL CAPITAL COSTS				$1,292,520

Stage 4 (2005-2010)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Cap Underlainment	18.07	1,370	cy	24,761
40 mil HDPE Geomembrane	0.81	93,200	sf	75,877
Drainage layer	22.20	2,730	cy	60,616
Subsoil	17.76	1,370	cy	24,335
Topsoil	23.68	1,370	cy	32,447
Seed, Fertilizer, Mulch, Lime	3,700.61	2.0	acre	7,401
Gas Vents	29.60	8	lf	237
Gas Vent Riser Pipes	888.15	40	ea	35,526
Terrace Swales	22.20	850	lf	18,873
SUBTOTAL:				280,074
Dozer (Cat D4H or eqv.)		0	ea	0
Loader (Cat 936 or eqv.)		0	ea	0
Office Equipment/Furnitur		0	ea	0
Maintenance Equipment		0	ea	0
SUBTOTAL:				0
Hydro, Permitting				
Bid Documents & Review	16,288.95	1	ea	16,289
Survey Control	24,433.42	1	ea	24,433
Construction Inspection	32,577.89	1	ea	32,578
Topo Map & Vol. Calcs				
SUBTOTAL:				73,300
TOTAL CAPITAL COST				1,007,788
CONTINGENCY (15%)				151,168
GRAND TOTAL CAPITAL COSTS:				$1,158,956

CLOSURE (2010)

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL CO[ST] PER ITEM
Cap Underlainment	21.99	2,730	cy	60,03
40 mil HDPE Geomembrane	0.99	186,350	sf	184,58
Drainage layer	27.01	5,465	cy	147,63
Subsoil	21.61	2,730	cy	58,99
Topsoil	28.82	2,730	cy	78,66
Seed, Fertilizer, Mulch, Lime	4,502.36	2.5	acres	11,25
Gas Vents	36.02	10	lf	36
Gas Vent Riser Pipes	1,080.57	90	ea	97,25
Terrace Swales	27.01	1,700	lf	45,92
SUBTOTAL:				684,70
Dozer (Cat D4H or eqv.)				
Loader (Cat 936 or eqv.)				
Office Equipment/Furnitur				
Maintenance Equipment				
Hydro, Permitting				
Bid Documents & Review	20,789.28	1	ea	20,78
Survey Control	31,183.92	1	ea	31,18
Construction Inspection	41,578.56	1	ea	41,57
Topo Map & Vol. Calcs				
SUBTOTAL:				93,55
TOTAL CAPITAL COST				778,25
GRAND TOTAL CAPITAL COSTS:				$778,25

Sanitary Landfill Operating Costs (12 Ton/Day Facility)

Stage 1, 1990-1995

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	15,000.00	1	yr	15,000
Occasional Labor	5,000.00	1	ls	5,000
	Subtotal Before Benefits:			20,000
Fringe Benefits		@ 30%		6,000
Overhead		@ 25%		5,000
	Subtotal With Benefits:			31,000
Utilities	900.00	12	mo	10,800
Leachate Disposal	0.175	28,633	gal	5,011
Equip Op & Maint	15,000.00		ls	15,000
Contracted Services	15,000.00		ls	15,000
Soil Cover	8.00	60	cy/mo	5,760
Insurance	9,000.00	1	yr	9,000
	TOTAL OPERATING COSTS:			91,571
	CONTINGENCY (15%)			13,736
	GRAND TOTAL OPERATING COST			$105,306

Stage 2, 1995-2000

ITEM	UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	18,249.79	1	yr	18,250
Occasional Labor	6,083.26	1	ls	6,083
	Subtotal Before Benefits:			24,333
Fringe Benefits		@ 30%		7,300
Overhead		@ 25%		6,083
	Subtotal With Benefits:			37,716
Utilities	1,094.99	12	mo	13,140
Leachate Disposal	0.21	95,348	gal	20,301
Equip Op & Maint	18,249.79		ls	18,250
Contracted Services	18,249.79		ls	18,250
Soil Cover	9.73	66	cy/mo	7,737
Insurance	10,949.88	1	yr	10,950
	TOTAL OPERATING COSTS:			126,344
	CONTINGENCY (15%)			18,952
	GRAND TOTAL OPERATING COS			$145,295

Stage 3, 2000-2005

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	22,203.66	1	yr	22,204
Occasional Labor	7,401.22	1	ls	7,401
	Subtotal Before Benefits:			29,605
Fringe Benefits		@ 30%		8,881
Overhead		@ 25%		7,401
	Subtotal With Benefits:			45,888
Utilities	1,332.22	12	mo	15,987
Leachate Disposal	0.26	143,022	gal	37,049
Equip Op & Maint	22,203.66		ls	22,204
Contracted Services	22,203.66		ls	22,204
Soil Cover	11.84	73	cy/mo	10,393
Insurance	13,322.20	1	yr	13,322
	TOTAL OPERATING COSTS:			167,046
	CONTINGENCY (15%)			25,057
	GRAND TOTAL OPERATING COS			$192,103

Stage 4, 2005-2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	27,014.15	1	yr	27,014
Occasional Labor	9,004.72	1	ls	9,005
	Subtotal Before Benefits:			36,019
Fringe Benefits		@ 30%		10,806
Overhead		@ 25%		9,005
	Subtotal With Benefits:			55,829
Utilities	1,620.85	12	mo	19,450
Leachate Disposal	0.32	143,022	gal	45,075
Equip Op & Maint	27,014.15		ls	27,014
Contracted Services	27,014.15		ls	27,014
Soil Cover	14.41	81	cy/mo	13,961
Insurance	16,208.49	1	yr	16,208
	TOTAL OPERATING COSTS:			204,553
	CONTINGENCY (15%)			30,683
	GRAND TOTAL OPERATING COSTS			$235,236

CLOSURE, 2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Operator/mechanic	32,866.85	1	yr	32,867
Occasional Labor	10,955.62	1	ls	10,956
	Subtotal Before Benefits:			43,822
Fringe Benefits		@ 30%		13,147
Overhead		@ 25%		10,956
	Subtotal With Benefits:			67,925
Utilities	1,972.01	12	mo	23,664
Leachate Disposal	0.38	159,948	gal	61,332
Equip Op & Maint	32,866.85		ls	32,867
Contracted Services	32,866.85		ls	32,867
Soil Cover	17.53	89	cy/mo	18,754
Insurance	19,720.11	1	yr	19,720
	TOTAL OPERATING COSTS:			257,128
	CONTINGENCY (15%)			38,569
	GRAND TOTAL OPERATING COST			$295,698

Sanitary Landfill
Capital Cost Summary
(12 TPD Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	526,495	197,371	240,132	292,158	0	0
Infrastructure	341,850	11,923	14,506	17,649	0	0
Landfill Expansion	787,455	232,804	283,242	344,607	0	0
Equipment	252,000	0	298,417	0	0	0
Final Cover & Drainage	0	189,208	230,200	280,074	684,702	0
Post-Closure	0	0	0	0	0	2,728,223
Professional Services	160,000	45,000	57,433	73,300	93,552	0
Revenues (equip. trade-in @ 20%)	0	0	(50,400)	0	(59,683)	0
TOTALS	2,067,801	676,306	1,073,531	1,007,788	718,570	2,728,223
CONTINGENCY (20%)	413,560	135,261	214,706	201,558	143,714	545,645
GRAND TOTAL	2,481,361	811,568	1,288,237	1,209,345	862,285	3,273,868
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Bond Payment @ 8.5 %	262,208					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		139,723	221,789	208,207	148,455	75,601

Sanitary Landfill Post-Closure Costs
(12 Ton/Day Facility)

ITEM	COST ($)	QUANTITY	UNIT	PER ITEM ($)	COST ($)	QUANTITY	UNIT PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR		NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	4	ea	1	1,752.90	4	7,012
	800.00	2	ea	29	1,752.90	58	101,668
Vegetation Maintenance	4,000.00	5	acres	5	8,764.49	25	219,112
	4,000.00	1	acres	25	8,764.49	25	219,112
Drainage Maintenance	2,000.00	1	ls	30	4,382.25	30	131,467
Groundwater Monitoring	2000	10	ea	5	4,382.25	50	219,112
	2000	5	ea	25	4,382.25	125	547,781
Leachate Monitoring	1,200.00	10	ea	5	2,629.35	50	131,467
	1,200.00	4	ea	25	2,629.35	100	262,935
Leachate Treatment	0.175	159,948	gal	5	0.38	799,742	306,658
	0.175	39,987	gal	10	0.38	399,871	153,329
	0.175	7,997	gal	15	0.38	119,961	45,999
Cap Maintenance	15,000.00	1	acres	2	32,866.85	2	65,734
	15,000.00	0.3	acres	28	32,866.85	8	276,082
Replace Monitoring Wells	3,100.00	1	/5 yr	30	6,792.48	6	40,755
							===========
					TOTAL POSTCLOSURE COST:		2,728,223
					CONTINGENCY (15%)		409,233
							===========
					GRAND TOTAL POSTCLOSURE C		$3,137,457

Sanitary Landfill Life-Cycle Costs, 1990-2010
(12 TPD Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS)
1990	262,208	139,723	75,601	105,306	582,838	3,600	161.90	161.90
1995	262,208	221,789	75,601	145,295	704,893	3,975	177.35	145.76
2000	262,208	208,207	75,601	192,103	738,118	4,388	168.20	113.63
2005	262,208	148,455	75,601	235,236	721,499	4,845	148.91	82.69
2010	0	0	0	295,698	295,698	5,349	55.28	25.23

2%/yr.

Sanitary Landfill Capital Costs (40 Ton/Day Facility)

	Stage 1 1990-1995				Stage 2 1995-2000				Stage 3 2000-2005				Stage 4 2005-2010			
ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	50	acre	250,000												
Mobilization/Demobilizat	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	25	acre	62,500	3,041.63	1	acre	3,042	3,700.61	1	acre	3,701	4,502.36	1	acre	4,502
Erosion Control Silt Fen	2.84	1,400	lf	3,976	3.46	700	lf	2,419	4.20	700	lf	2,943	5.11	700	lf	3,580
Excavation/Stockpile	2.30	275,040	cy	632,592	2.80	137,520	cy	384,822	3.40	137,520	cy	468,195	4.14	137,520	cy	569,631
Access Road	22.00	515	lf	11,330	26.77	260	lf	6,959	32.57	260	lf	8,467	39.62	260	lf	10,301
Operational Berm	30.00	650	lf	19,500	36.50	200	lf	7,300	44.41	200	lf	8,881	54.03	200	lf	10,806
		SUBTOTAL:		984,898		SUBTOTAL:		410,625		SUBTOTAL:		499,588		SUBTOTAL:		607,826
INFRASTRUCTURE																
Maintenance/Office Bldg	70.00	1,000	sf	70,000												
Equipment Storage	20.00	2,000	sf	40,000												
Fuel pumps / Storage	12,000.00	1	ea	12,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	20,000.00	1	ea	20,000												
Fencing	16.00	7,000	lf	112,000												
Landscaping	55,000.00	0.6	ea	33,000												
Groundwater Monitoring W	3,500.00	4	ea	14,000	4,258.29	2	ea	8,517	5,180.85	2	ea	10,362	6,303.30	2	ea	12,607
Gas Control	1,400.00	4	ea	5,600	1,703.31	2	ea	3,407	2,072.34	2	ea	4,145	2,521.32	2	ea	5,043
Sedimentation Ponds	70,000.00	2	ea	140,000												
		SUBTOTAL:		514,350		SUBTOTAL:		11,923		SUBTOTAL:		14,506		SUBTOTAL:		17,649

Sanitary Landfill Capital Costs (40 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	2	ea	60,000												
		SUBTOTAL:		61,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	249,594	sf	37,439	0.18	55,465	sf	10,122	0.22	55,465	sf	12,315	0.27	55,465	sf	14,983
Clay Layer	30.00	18,488	cy	554,653	36.50	4,109	cy	149,960	44.41	4,109	cy	182,449	54.03	4,109	cy	221,977
60 mil PVC Geomembrane	0.70	249,594	sf	174,716	0.85	55,465	sf	47,237	1.04	55,465	sf	57,472	1.26	55,465	sf	69,923
Sand Blanket Drain	15.00	18,488	cy	277,326	18.25	4,109	cy	74,980	22.20	4,109	cy	91,225	27.01	4,109	cy	110,989
Geotextile	0.06	499,188	sf	29,951	0.07	110,931	sf	8,098	0.09	110,931	sf	9,852	0.11	110,931	sf	11,987
Washed Stone	15.00	2,311	cy	34,666	18.25	514	cy	9,372	22.20	514	cy	11,403	27.01	514	cy	13,874
6" SDR 21 Slotted PVC Pi	7.25	998	lf	7,238	8.82	222	lf	1,957	10.73	222	lf	2,381	13.06	222	lf	2,897
6" Cleanouts	1,750.00	10	ea	17,500	2,129.14	2	ea	4,258	2,590.43	2	ea	5,181	3,151.65	2	ea	6,303
		SUBTOTAL:		1,133,489		SUBTOTAL:		305,985		SUBTOTAL:		372,278		SUBTOTAL:		452,933
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembrane	0.70	249,594	sf	174,716	0.85	55,465	sf	47,237	1.04	55,465	sf	57,472	1.26	55,465	sf	69,923
Washed Stone	15.00	2,311	cy	34,666	18.25	514	cy	9,372	22.20	514	cy	11,403	27.01	514	cy	13,874
Sand Blanket Drain	15.00	18,488	cy	277,326	18.25	4,109	cy	74,980	22.20	4,109	cy	91,225	27.01	4,109	cy	110,989
6" SDR 21 Slotted PVC Pi	7.25	998	lf	7,238	8.82	222	lf	1,957	10.73	222	lf	2,381	13.06	222	lf	2,897
6" Cleanouts	1,750.00	10	ea	17,500	2,129.14	2	ea	4,258	2,590.43	2	ea	5,181	3,151.65	2	ea	6,303
		SUBTOTAL:		511,446		SUBTOTAL:		137,805		SUBTOTAL:		167,661		SUBTOTAL:		203,985

Sanitary Landfill Operating Costs (40 Ton/Day Facility)

Stage 1, 1990-1995

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	26,000.00	1	yr	26,000
Operator/mechanic	18,000.00	1	yr	18,000
Occasional Labor	5,000.00	1	ls	5,000
	Subtotal Before Benefits:			49,000
Fringe benefits		@ 30%		14,700
Overhead		@ 25%		12,250
	Total With Benefits:			75,950
Utilities	1,050.00	12	mo	12,600
Leachate Disposal	0.175	62,398	gal	10,920
Equip Op & Maint	20,000.00		ls	20,000
Contracted Services	30,000.00		ls	30,000
Soil Cover	8.00	200	cy/mo	19,200
Insurance	16,000.00	1	yr	16,000
	TOTAL OPERATING COSTS:			309,620
	CONTINGENCY (15%)			46,443
	GRAND TOTAL OPERATING COSTS			$356,063

Stage 2, 1995-2000

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	31,632.98	1	yr	31,633
Operator/mechanic	21,899.75	1	yr	21,900
Occasional Labor	6,083.26	1	ls	6,083
	Subtotal Before Benefits:			59,616
Fringe benefits		@ 30%		17,885
Overhead		@ 25%		14,904
	Total With Benefits:			92,405
Utilities	1,277.49	12	mo	15,330
Leachate Disposal	0.21	207,787	gal	44,241
Equip Op & Maint	24,333.06		ls	24,333
Contracted Services	36,499.59		ls	36,500
Soil Cover	9.73	221	cy/mo	25,791
Insurance	19,466.45	1	yr	19,466
	TOTAL OPERATING COSTS:			410,086
	CONTINGENCY (15%)			61,513
	GRAND TOTAL OPERATING COST			$471,599

Stage 3, 2000-2005

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	38,486.35	1	yr	38,486
Operator/mechanic	26,644.40	1	yr	26,644
Occasional Labor	7,401.22	1	ls	7,401
	Subtotal Before Benefits:			72,532
Fringe benefits		@ 30%		21,760
Overhead		@ 25%		18,133
	Total With Benefits:			112,425
Utilities	1,554.26	12	mo	18,651
Leachate Disposal	0.26	311,680	gal	80,738
Equip Op & Maint	29,604.89		ls	29,605
Contracted Services	44,407.33		ls	44,407
Soil Cover	11.84	244	cy/mo	34,645
Insurance	23,683.91	1	yr	23,684
	TOTAL OPERATING COSTS:			529,111
	CONTINGENCY (15%)			79,367
	GRAND TOTAL OPERATING COSTS			$608,478

Stage 4, 2005-2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	46,824.53	1	yr	46,825
Operator/mechanic	32,416.98	1	yr	32,417
Occasional Labor	9,004.72	1	ls	9,005
	Subtotal Before Benefits:			88,246
Fringe benefits		@ 30%		26,474
Overhead		@ 25%		22,062
	Total With Benefits:			136,782
Utilities	1,890.99	12	mo	22,692
Leachate Disposal	0.32	345,965	gal	109,036
Equip Op & Maint	36,018.87		ls	36,019
Contracted Services	54,028.31		ls	54,028
Soil Cover	14.41	269	cy/mo	46,538
Insurance	28,815.10	1	yr	28,815
	TOTAL OPERATING COSTS:			658,937
	CONTINGENCY (15%)			98,841
	GRAND TOTAL OPERATING COST			$757,778

CLOSURE, 2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	56,969.20	1	yr	56,969
Operator/mechanic	39,440.22	1	yr	39,440
Occasional Labor	10,955.62	1	ls	10,956
	Subtotal Before Benefits:			107,365
Fringe benefits		@ 30%		32,210
Overhead		@ 25%		26,841
	Total With Benefits:			166,416
Utilities	2,300.68	12	mo	27,608
Leachate Disposal	0.38	348,568	gal	133,657
Equip Op & Maint	43,822.46		ls	43,822
Contracted Services	65,733.69		ls	65,734
Soil Cover	17.53	297	cy/mo	62,513
Insurance	35,057.97	1	yr	35,058
	TOTAL OPERATING COSTS:			808,589
	CONTINGENCY (15%)			121,288
	GRAND TOTAL OPERATING COS			$929,878

Sanitary Landfill
Capital Cost summary
(40 TPD Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	984,898	410,625	499,588	607,826		
Infrastructure	514,350	11,923	14,506	17,649		
Landfill Expansion	1,706,135	443,790	539,939	656,918		
Equipment	454,750		579,294			
Final Cover & Drainage		412,848	502,293	611,116	1,592,768	
Post-Closure						3,566,463
Professional Services	849,000	66,000	80,299	97,696	118,862	
Income (equip. trade-in @ 20%)			(90,950)		(115,859)	
TOTALS	4,509,133	1,345,187	2,124,969	1,991,205	1,595,772	3,566,463
CONTINGENCY (20%)	901,827	269,037	424,994	398,241	319,154	713,293
GRAND TOTAL	5,410,960	1,614,224	2,549,963	2,389,446	1,914,926	4,279,755
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Bond Payment @ 8.5 %	571,781					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		277,912	439,014	411,378	329,683	98,829

Sanitary Landfill Capital Costs (40 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE																				
Cap Underlaimment					12.21	2,977	cy	36,349	14.86	2,977	cy	44,224	18.07	2,977	cy	53,806	21.99	5,960	cy	131,058
40 mil HOPE Geomembrane					0.55	203,060	sf	111,683	0.67	203,060	sf	135,879	0.81	203,060	sf	165,318	0.99	406,120	sf	402,270
Drainage layer					15.00	5,960	cy	89,400	18.25	5,960	cy	108,769	22.20	5,960	cy	132,334	27.01	11,910	cy	321,739
Subsoil					12.00	2,977	cy	35,724	14.60	2,977	cy	43,464	17.76	2,977	cy	52,880	21.61	5,960	cy	128,803
Topsoil					16.00	2,977	cy	47,632	19.47	2,977	cy	57,952	23.68	2,977	cy	70,507	28.82	5,960	cy	171,738
Seed, Fertilizer, Mulch, Lime					2,500.00	3.5	acre	8,750	3,041.63	3.5	acre	10,646	3,700.61	3.5	acre	12,952	4,502.36	8.0	acre	36,019
Gas Vents					20.00	18	lf	360	24.33	18	lf	438	29.60	18	lf	533	36.02	37	lf	1,333
Gas Vent Riser Pipes					600.00	92	ea	55,200	729.99	92	ea	67,159	888.15	92	ea	81,709	1,080.57	185	ea	199,905
Terrace Swales					15.00	1,850	lf	27,750	18.25	1,850	lf	33,762	22.20	1,850	lf	41,077	27.01	7,400	lf	199,905
		SUBTOTAL:		0		SUBTOTAL:		412,848		SUBTOTAL:		502,293		SUBTOTAL:		611,116		SUBTOTAL:		1,592,768
EQUIPMENT																				
Compactor (JD 450 or eqv	110,000.00	1	ea	110,000			ea	0	162,826.87	1	ea	162,827			ea					0
Service Truck (4WD 1T)	27,750.00	1	ea	27,750			ea	0	41,076.78	1	ea	41,077			ea					0
Dozer (Cat D4H or equiv.	125,000.00	1	ea	125,000		0	ea	0	185,030.54	1	ea	148,024			ea					0
Loader (Cat 936 or equiv	117,000.00	1	ea	117,000		0	ea	0	173,188.58	1	ea	138,551			ea					0
Office Equipment/Furnitu	5,000.00	1	ea	5,000		0	ea	0	7,401.22	1	ea	5,921			ea					0
Maintenance Equipment	5,000.00	1	ea	5,000		0	ea	0	7,401.22	1	ea	5,921			ea					0
Dump Truck (3 axle, 10 y	65,000.00	1	ea	65,000		0	ea	0	96,215.88	1	ea	76,973			ea					0
		SUBTOTAL:		454,750		SUBTOTAL:		0		SUBTOTAL:		579,294		SUBTOTAL:		0		SUBTOTAL:		0
PROFESSIONAL SERVICES																				
Hydro, Permitting	495,000.00	1	ea	495,000																
Bid Documents & Review	108,000.00	1	ea	108,000	24,000.00	1	ea	24,000	29,199.67	1	ea	29,200	35,525.86	1	ea	35,526	43,222.64	1	ea	43,223
Survey Control	45,000.00	1	ea	45,000	12,000.00	1	ea	12,000	14,599.83	1	ea	14,600	17,762.93	1	ea	17,763	21,611.32	1	ea	21,611
Construction Inspection	180,000.00	1	ea	180,000	30,000.00	1	ea	30,000	36,499.59	1	ea	36,500	44,407.33	1	ea	44,407	54,028.31	1	ea	54,028
Topo Map & Vol. Calculat	21,000.00	1	ea	21,000																
				849,000		SUBTOTAL:		66,000		SUBTOTAL:		80,299		SUBTOTAL:		97,696		SUBTOTAL:		118,862
	TOTAL CAPITAL COST			4,509,133	TOTAL CAPITAL COST			1,345,187	TOTAL CAPITAL COST			2,215,919	TOTAL CAPITAL COST			1,991,205	TOTAL CAPITAL COST			1,711,630
	CONTINGENCY (15%)			676,370	CONTINGENCY (15%)			201,778	CONTINGENCY (15%)			332,388	CONTINGENCY (15%)			298,681				
	GRAND TOTAL CAPITAL COSTS:			$5,185,503	GRAND TOTAL CAPITAL COSTS:			$1,546,965	GRAND TOTAL CAPITAL COSTS:			$2,548,307	GRAND TOTAL CAPITAL COSTS:			$2,289,886	GRAND TOTAL CAPITAL COSTS			$1,711,630

Sanitary Landfill Post-Closure Costs
(40 Ton/Day Facility)

ITEM	COST ($)	QUANTITY UNIT	PER ITEM ($)	COST ($)	QUANTITY	UNIT PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR	NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	4 ea	1	1,752.90	4	7,012
	800.00	2 ea	29	1,752.90	58	101,668
Vegetation Maintenance	4,000.00	5 acres	5	8,764.49	25	219,112
	4,000.00	1 acres	25	8,764.49	25	219,112
Drainage Maintenance	2,000.00	1 ls	30	4,382.25	30	131,467
Groundwater Monitoring	2000.00	10 ea	5	4,382.25	50	219,112
	2000.00	5 ea	25	4,382.25	125	547,781
Leachate Monitoring	1,200.00	10 ea	5	2,629.35	50	131,467
	1,200.00	4 ea	25	2,629.35	100	262,935
Leachate Treatment	0.175	345,965 gal	5	0.38	1,729,825	663,295
	0.175	86,491 gal	10	0.38	864,913	331,648
	0.175	17,298 gal	15	0.38	259,474	99,494
Cap Maintenance	15,000.00	2 acres	2	32,866.85	4	131,467
	15,000.00	0.5 acres	28	32,866.85	14	460,136
Replace Monitoring Wells	3,100.00	1 /5 yrs	30	6,792.48	6	40,755
				TOTAL POSTCLOSURE COST:		3,566,463
				CONTINGENCY (15%)		534,969
				GRAND TOTAL POSTCLOSURE CO		4,101,432

Sanitary Landfill Life-Cycle Costs, 1990-2010
(40 TPD Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS)
1990	571,781	277,912	98,829	356,063	1,304,585	12,000	108.72	108.72
1995	571,781	439,014	98,829	471,599	1,581,223	13,249	119.35	98.09
2000	571,781	411,378	98,829	608,478	1,690,467	14,628	115.56	78.07
2005	571,781	329,683	98,829	757,778	1,758,071	16,150	108.86	60.44
2010				929,878	929,878	17,831	52.15	23.80

Sanitary Landfill Capital Costs (150 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	75	acre	375,000												
Mobilization/Demobilizat	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	40	acre	100,000	3,041.63	1	acre	3,042	3,700.61	1	acre	3,701	4,502.36	1	acre	4,502
Erosion Control Silt Fen	2.84	2,500	lf	7,100	3.46	1,250	lf	4,319	4.20	1,250	lf	5,255	5.11	1,250	lf	6,393
Excavation/Stockpile	2.30	493,120	cy	1,134,176	2.80	246,560	cy	689,949	3.40	246,560	cy	839,429	4.14	246,560	cy	1,021,293
Access Road	20.00	925	lf	18,500	24.33	460	lf	11,193	29.60	460	lf	13,618	36.02	460	lf	16,569
Operational Berm	30.00	1,725	lf	51,750	36.50	575	lf	20,987	44.41	575	lf	25,534	54.03	575	lf	31,066
		SUBTOTAL:		1,691,526		SUBTOTAL:		735,574		SUBTOTAL:		894,938		SUBTOTAL:		1,088,829
INFRASTRUCTURE																
Maintenance/Office Bldg	80.00	2,500	sf	200,000												
Equipment Storage	30.00	2,500	sf	75,000												
Fuel pumps / Storage	12,000.00	1	ea	12,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	35,000.00	1	ea	35,000												
Fencing	16.00	9,300	lf	148,800												
Landscaping	95,000.00	0.6	ea	57,000												
Groundwater Monitoring W	3,500.00	6	ea	21,000	4,258.29	3	ea	12,775	5,180.85	3	ea	15,543	6,303.30	3	ea	18,910
Gas Control	1,400.00	6	ea	8,400	1,703.31	3	ea	5,110	2,072.34	3	ea	6,217	2,521.32	3	ea	7,564
Sedimentation Ponds	70,000.00	3	ea	210,000												
		SUBTOTAL:		834,950		SUBTOTAL:		17,885		SUBTOTAL:		21,760		SUBTOTAL:		26,474

Sanitary Landfill Capital Costs (150 Ton/Day Facility)

	Stage 1 1990-1995				Stage 1995-2000				Stage 3 2000-2005				Stage 4 2005-2010			
ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	1	ea	30,000												
		SUBTOTAL:		31,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
LEACHATE PUMPING TO WASTEWATER TREATMENT PLANT																
Pump Station	80,000.00	1	ea	80,000												
Force Main	16.00	21,120	lf	337,920												
				417,920												
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	447,505	sf	67,126	0.18	99,446	sf	18,149	0.22	99,446	sf	22,081	0.27	99,446	sf	26,864
Clay Layer	30.00	33,149	cy	994,457	36.50	7,366	cy	268,869	44.41	7,366	cy	327,120	54.03	7,366	cy	397,991
60 mil PVC Geomembrane	0.70	447,505	sf	313,254	0.85	99,446	sf	84,694	1.04	99,446	sf	103,043	1.26	99,446	sf	125,367
Sand Blanket Drain	15.00	33,149	cy	497,228	18.25	7,366	cy	134,434	22.20	7,366	cy	163,560	27.01	7,366	cy	198,996
Geotextile	0.06	895,011	sf	53,701	0.07	198,891	sf	14,519	0.09	198,891	sf	17,664	0.11	198,891	sf	21,492
Washed Stone	15.00	4,144	cy	62,154	18.25	921	cy	16,804	22.20	921	cy	20,445	27.01	921	cy	24,874
6" SDR 21 Slotted PVC Pi	7.25	1,790	lf	12,978	8.82	398	lf	3,509	10.73	398	lf	4,269	13.06	398	lf	5,194
6" Cleanouts	1,750.00	18	ea	31,500	2,129.14	4	ea	8,517	2,590.43	4	ea	10,362	3,151.65	4	ea	12,607
		SUBTOTAL:		2,032,396		SUBTOTAL:		549,494		SUBTOTAL:		668,543		SUBTOTAL:		813,385
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembrane	0.70	447,505	sf	313,254	0.85	99,446	sf	84,694	1.04	99,446	sf	103,043	1.26	99,446	sf	125,367
Washed Stone	15.00	4,144	cy	62,154	18.25	921	cy	16,804	22.20	921	cy	20,445	27.01	921	cy	24,874
Sand Blanket Drain	15.00	33,149	cy	497,228	18.25	7,366	cy	134,434	22.20	7,366	cy	163,560	27.01	7,366	cy	198,996
6" SDR 21 Slotted PVC Pi	7.25	1,790	lf	12,978	8.82	398	lf	3,509	10.73	398	lf	4,269	13.06	398	lf	5,194
6" Cleanouts	1,750.00	18	ea	31,500	2,129.14	4	ea	8,517	2,590.43	4	ea	10,362	3,151.65	4	ea	12,607
		SUBTOTAL:		917,113		SUBTOTAL:		247,957		SUBTOTAL:		301,678		SUBTOTAL:		367,038

- Sanitary Landfill Capital Costs (150 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
FINAL COVER AND DRAINAGE				
Cap Underlaiment				
40 mil HDPE Geomembrane				
Drainage layer				
Subsoil				
Topsoil				
Seed, Fertilizer, Mulch, Lime				
Gas Vents				
Gas Vent Riser Pipes				
Terrace Swales				
		SUBTOTAL:		0
EQUIPMENT				
Compactor(CAT 816 or eqv	148,000.00	1	ea	148,000
Service Trk (4WD 1T)	27,750.00	1	ea	27,750
Dozer (Cat D7L or eqv.)	280,000.00	1	ea	280,000
Loader (Cat 980 or eqv.)	217,000.00	1	ea	217,000
Dump Trk (3 axle, 10 yd)	65,000.00	1	ea	65,000
Office Equipment	5,000.00	1	ea	5,000
Maintenance Equipment	5,000.00	1	ea	5,000
		SUBTOTAL:		747,750
PROFESSIONAL SERVICES				
Hydro, Permitting	690,000.00	1	ea	690,000
Bid Documents & Review	180,000.00	1	ea	180,000
Survey Control	80,000.00	1	ea	80,000
Construction Inspection	310,000.00	1	ea	310,000
Topo Map & Vol. Calc.	35,000.00	1	ea	35,000
				1,295,000
	TOTAL CAPITAL COST			7,967,856
	CONTINGENCY (15%)			1,195,178
	GRAND TOTAL CAPITAL COSTS:			$9,163,034

ITEM	Stage 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Cap Underlaiment	12.21	5,370	cy	65,568
40 mil HDPE Geomembrane	0.55	365,970	sf	201,284
Drainage layer	15.00	10,740	cy	161,100
Subsoil	12.00	5,370	cy	64,440
Topsoil	16.00	5,370	cy	85,920
Seed, Fertilizer, Mulch, Lime	2,500.00	6.5	acre	16,250
Gas Vents	20.00	33	lf	660
Gas Vent Riser Pipes	600.00	165	ea	99,000
Terrace Swales	15.00	3,330	lf	49,950
		SUBTOTAL:		744,171
Compactor(CAT 816 or eqv			ea	0
Service Trk (4WD 1T)			ea	0
Dozer (Cat D7L or eqv.)		0	ea	0
Loader (Cat 980 or eqv.)		0	ea	0
Dump Trk (3 axle, 10 yd)		0	ea	0
Office Equipment		0	ea	0
Maintenance Equipment		0	ea	0
		SUBTOTAL:		0
Hydro, Permitting				
Bid Documents & Review	21,000.00	1	ea	21,000
Survey Control	9,000.00	1	ea	9,000
Construction Inspection	36,000.00	1	ea	36,000
Topo Map & Vol. Calc.				
		SUBTOTAL:		66,000
	TOTAL CAPITAL COST			2,361,081
	CONTINGENCY (15%)			354,162
	GRAND TOTAL CAPITAL COSTS:			$2,715,243

ITEM	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Cap Underlaiment	14.86	5,370	cy	79,773
40 mil HDPE Geomembrane	0.67	365,970	sf	244,892
Drainage layer	18.25	10,740	cy	196,003
Subsoil	14.60	5,370	cy	78,401
Topsoil	19.47	5,370	cy	104,535
Seed, Fertilizer, Mulch, Lime	3,041.63	6.5	acre	19,771
Gas Vents	24.33	33	lf	803
Gas Vent Riser Pipes	729.99	165	ea	120,449
Terrace Swales	18.25	3,330	lf	60,772
		SUBTOTAL:		905,398
Compactor(CAT 816 or eqv	219,076.15	1	ea	219,076
Service Trk (4WD 1T)	41,076.78	1	ea	41,077
Dozer (Cat D7L or eqv.)	414,468.40	1	ea	331,575
Loader (Cat 980 or eqv.)	321,213.01	1	ea	256,970
Dump Trk (3 axle, 10 yd)	96,215.88	1	ea	76,973
Office Equipment	7,401.22	1	ea	5,921
Maintenance Equipment	7,401.22	1	ea	5,921
		SUBTOTAL:		937,513
Hydro, Permitting				
Bid Documents & Review	25,549.71	1	ea	25,550
Survey Control	10,949.88	1	ea	10,950
Construction Inspection	43,799.50	1	ea	43,800
Topo Map & Vol. Calc.				
		SUBTOTAL:		80,299
	TOTAL CAPITAL COST			3,810,128
	CONTINGENCY (15%)			571,519
	GRAND TOTAL CAPITAL COSTS:			$4,381,648

ITEM	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Cap Underlaiment	18.07	5,370	cy	97,056
40 mil HDPE Geomembrane	0.81	365,970	sf	297,949
Drainage layer	22.20	10,740	cy	238,467
Subsoil	17.76	5,370	cy	95,387
Topsoil	23.68	5,370	cy	127,183
Seed, Fertilizer, Mulch, Lime	3,700.61	6.5	acres	24,054
Gas Vents	29.60	33	lf	977
Gas Vent Riser Pipes	888.15	165	ea	146,544
Terrace Swales	22.20	3,330	lf	73,938
		SUBTOTAL:		1,101,555
Compactor(CAT 816 or eqv			ea	
Service Trk (4WD 1T)			ea	
Dozer (Cat D7L or eqv.)			ea	
Loader (Cat 980 or eqv.)			ea	
Dump Trk (3 axle, 10 yd)			ea	
Office Equipment			ea	
Maintenance Equipment			ea	
		SUBTOTAL:		0
Hydro, Permitting				
Bid Documents & Review	31,085.13	1	ea	31,085
Survey Control	13,322.20	1	ea	13,322
Construction Inspection	53,288.79	1	ea	53,289
Topo Map & Vol. Calc.				
		SUBTOTAL:		97,696
	TOTAL CAPITAL COST			3,494,976
	CONTINGENCY (15%)			524,246
	GRAND TOTAL CAPITAL COSTS:			$4,019,223

ITEM	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Cap Underlaiment	21.99	10,740	cy	236,167
40 mil HDPE Geomembrane	0.99	731,950	sf	725,010
Drainage layer	27.01	21,475	cy	580,129
Subsoil	21.61	10,740	cy	232,106
Topsoil	28.82	10,740	cy	309,474
Seed, Fertilizer, Mulch, Lime	4,502.36	15.0	acre	67,535
Gas Vents	36.02	67	lf	2,413
Gas Vent Riser Pipes	1,080.57	335	ea	361,990
Terrace Swales	27.01	6,654	lf	179,752
		SUBTOTAL:		2,694,577
Compactor(CAT 816 or eqv				0
Service Trk (4WD 1T)				0
Dozer (Cat D7L or eqv.)				0
Loader (Cat 980 or eqv.)				0
Dump Trk (3 axle, 10 yd)				0
Office Equipment				0
Maintenance Equipment				0
				0
	EQUIPMENT TRADE IN			0
Hydro, Permitting				
Bid Documents & Review	37,819.81	1	ea	37,820
Survey Control	16,208.49	1	ea	16,208
Construction Inspection	64,833.97	1	ea	64,834
Topo Map & Vol. Calc.				
		SUBTOTAL:		118,862
	TOTAL CAPITAL COST			2,813,439
	GRAND TOTAL CAPITAL COSTS:			$2,813,439

Sanitary Landfill Operating Costs (150 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	28,000.00	1	yr	28,000
Operator	18,000.00	2	yr	36,000
Operator/mechanic	18,000.00	1	yr	18,000
Occasional Labor	5,000.00	1	ls	5,000
	Subtotal Before Benefits:			87,000
Fringe Benefits		@ 30%		26,100
Overhead		@ 25%		21,750
	Subtotal With Benefits:			134,850
Utilities	2,175.00	12	mo	26,100
Leachate Disposal	0.175	111,876	gal	19,578
Equip Op & Maint	55,000.00		ls	55,000
Contracted Services	45,000.00		ls	45,000
Soil Cover	8.00	750	cy/mo	72,000
Insurance	35,000.00	1	yr	35,000
	TOTAL OPERATING COSTS:			387,528
	CONTINGENCY (15%)			58,129
	GRAND TOTAL OPERATING COST			$445,658

ITEM	Stage 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	34,066.28	1		34,066
Operator	21,899.75	2		43,800
Operator/mechanic	21,899.75	1		21,900
Occasional Labor	6,083.26	1		6,083
	Subtotal Before Benefits:			105,849
Fringe Benefits		@ 30%		31,755
Overhead		@ 25%		26,462
	Subtotal With Benefits:			164,066
Utilities	2,646.22	12		31,755
Leachate Disposal	0.21	372,548		79,321
Equip Op & Maint	66,915.91	1		66,916
Contracted Services	54,749.38	1		54,749
Soil Cover	9.73	828		96,716
Insurance	42,582.85	1		42,583
	TOTAL OPERATING COSTS:			536,106
	CONTINGENCY (15%)			80,416
	GRAND TOTAL OPERATING COST			$616,522

ITEM	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	41,446.84	1	yr	41,447
Operator	26,644.40	2	yr	53,289
Operator/mechanic	26,644.40	1	yr	26,644
Occasional Labor	7,401.22	1	ls	7,401
	Subtotal Before Benefits:			128,781
Fringe Benefits		@ 30%		38,634
Overhead		@ 25%		32,195
	Subtotal With Benefits:			199,611
Utilities	3,219.53	12	mo	38,634
Leachate Disposal	0.26	558,822	gal	144,759
Equip Op & Maint	81,413.44	1	ls	81,413
Contracted Services	66,610.99	1	ls	66,611
Soil Cover	11.84	914	cy/mo	129,917
Insurance	51,808.55	1	yr	51,809
	TOTAL OPERATING COSTS:			712,755
	CONTINGENCY (15%)			106,913
	GRAND TOTAL OPERATING COST			$819,668

ITEM	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	50,426.42	1	yr	50,426
Operator	32,416.98	2	yr	64,834
Operator/mechanic	32,416.98	1	yr	32,417
Occasional Labor	9,004.72	1	ls	9,005
	Subtotal Before Benefits:			156,682
Fringe Benefits		@ 30%		47,005
Overhead		@ 25%		39,171
	Subtotal With Benefits:			242,857
Utilities	3,917.05	12	mo	47,005
Leachate Disposal	0.32	620,293	gal	195,495
Equip Op & Maint	99,051.89	1	ls	99,052
Contracted Services	81,042.46	1	ls	81,042
Soil Cover	14.41	1,009	cy/mo	174,516
Insurance	63,033.02	1	yr	63,033
	TOTAL OPERATING COSTS:			903,000
	CONTINGENCY (15%)			135,450
	GRAND TOTAL OPERATING COST			$1,038,450

ITEM	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	61,351.45	1	yr	61,351
Operator	39,440.22	2	yr	78,880
Operator/mechanic	39,440.22	1	yr	39,440
Occasional Labor	10,955.62	1	ls	10,956
	Subtotal Before Benefits:			190,628
Fringe Benefits		@ 30%		57,188
Overhead		@ 25%		47,657
	Subtotal With Benefits:			295,473
Utilities	4,765.69	12	mo	57,188
Leachate Disposal	0.38	624,960	gal	239,639
Equip Op & Maint	120,511.77	1	ls	120,512
Contracted Services	98,600.54	1	ls	98,601
Soil Cover	17.53	1,114	cy/mo	234,424
Insurance	76,689.31	1	yr	76,689
	TOTAL OPERATING COSTS:			1,122,526
	CONTINGENCY (15%)			168,379
	GRAND TOTAL OPERATING COSTS			$1,290,905

Sanitary Landfill
Capital Cost summary
(150 TPD Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	1,691,526	735,574	894,938	1,088,829	0	0
Infrastructure	834,950	17,885	21,760	26,474	0	0
Landfill Expansion	3,398,630	797,451	970,221	1,180,422	0	0
Equipment	747,750	0	937,513	0	0	0
Closure	0	744,171	905,398	1,101,555	2,694,577	0
Post-Closure	0	0	0	0	0	5,478,872
Professional Services	1,295,000	66,000	80,299	97,696	118,862	0
Income (Equip. trade-in @ 20%)	0	0	(149,550)	0	(187,503)	0
TOTALS	7,967,856	2,361,081	3,660,578	3,494,976	2,625,937	5,478,872
CONTINGENCY (20%)	1,593,571	472,216	732,116	698,995	525,187	1,095,774
GRAND TOTAL	9,561,427	2,833,297	4,392,694	4,193,972	3,151,124	6,574,647
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Bond Payment @ 8.5 %	1,010,365					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		487,794	756,267	722,054	542,512	151,823

Sanitary Landfill Post-Closure Costs
(150 TPD Facility)

ITEM	COST ($)	QUANTITY UNIT	PER ITEM ($)	COST ($)	QUANTITY UNIT	PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR	NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	4 ea	1	1,752.90	4	7,012
	800.00	2 ea	29	1,752.90	58	101,668
Vegetation Maintenance	4,000.00	5 acres	5	8,764.49	25	219,112
	4,000.00	1 acres	25	8,764.49	25	219,112
Drainage Maintenance	3,000.00	1 ls	30	6,573.37	30	197,201
Groundwater Monitoring	2000.00	15 ea	5	4,382.25	75	328,668
	2000.00	8 ea	25	4,382.25	200	876,449
Leachate Monitoring	1,200.00	10 ea	5	2,629.35	50	131,467
	1,200.00	4 ea	25	2,629.35	100	262,935
Leachate Treatment	0.18	624,960 gal	5	0.38	3,124,799	1,198,193
	0.18	156,240 gal	10	0.38	1,562,399	599,097
	0.18	31,248 gal	15	0.38	468,720	179,729
Cap Maintenance	15,000.00	3 acres	2	32,866.85	6	197,201
	15,000.00	1 acres	28	32,866.85	28	920,272
Replace Monitoring Wells	3,100.00	1 /5 yr	30	6,792.48	6	40,755
				TOTAL POSTCLOSURE COST:		5,478,872
				CONTINGENCY (15%)		821,831
				GRAND TOTAL POSTCLOSURE CO		$6,300,703

Sanitary Landfill Life-Cycle Costs, 1990-2010
(150 TPD Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS)
1990	1,010,365	487,794	151,823	445,658	2,095,640	45,000	46.57	46.57
1995	1,010,365	756,267	151,823	616,522	2,534,977	49,684	51.02	41.94
2000	1,010,365	722,054	151,823	819,668	2,703,910	54,855	49.29	33.30
2005	1,010,365	542,512	151,823	1,038,450	2,743,151	60,564	45.29	25.15
2010				1,290,905	1,290,905	66,868	19.31	8.81

Sanitary Landfill Capital Costs (500 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
PREPARATORY WORK																
Land Purchase	5,000.00	130	acre	650,000												
Mobilization/Demobilizat	5,000.00	1	ea	5,000	6,083.26	1	ea	6,083	7,401.22	1	ea	7,401	9,004.72	1	ea	9,005
Clear and Grub	2,500.00	75	acre	187,500	3,041.63	5	acre	15,208	3,700.61	5	acre	18,503	4,502.36	5	acre	22,512
Erosion Control Silt Fen	2.84	5,000	lf	14,200	3.46	2,400	lf	8,293	4.20	2,400	lf	10,089	5.11	2,400	lf	12,275
Excavation/Stockpile	2.30	974,560	cy	2,241,488	2.80	487,280	cy	1,363,556	3.40	487,280	cy	1,658,975	4.14	487,280	cy	2,018,397
Access Road	22.00	1,830	lf	40,260	26.77	915	lf	24,491	32.57	915	lf	29,797	39.62	915	lf	36,253
Operational Berm	30.00	1,500	lf	45,000	36.50	500	lf	18,250	44.41	500	lf	22,204	54.03	500	lf	27,014
		SUBTOTAL:		3,183,448		SUBTOTAL:		1,435,882		SUBTOTAL:		1,746,970		SUBTOTAL:		2,125,456
INFRASTRUCTURE																
Maintenance/Office Bldg	80.00	3,000	sf	240,000												
Equipment Storage	30.00	3,000	sf	90,000												
Fuel pumps / Storage	22,000.00	1	ea	22,000												
Scale	60,000.00	1	ea	60,000												
Water Supply	5,000.00	1	ea	5,000												
Septage System	2,750.00	1	ea	2,750												
Utilities	35,000.00	1	ea	35,000												
Fencing	16.00	11,800	lf	188,800												
Landscaping	130,000.00	0.6	ea	78,000												
Groundwater Mon. Wells	3,500.00	12	ea	42,000	4,258.29	6	ea	25,550	5,180.85	6	ea	31,085	6,303.30	6	ea	37,820
Gas Control	1,400.00	12	ea	16,800	1,703.31	6	ea	10,220	2,072.34	6	ea	12,434	2,521.32	6	ea	15,128
Sedimentation Ponds	70,000.00	4	ea	280,000												
		SUBTOTAL:		1,060,350		SUBTOTAL:		35,770		SUBTOTAL:		43,519		SUBTOTAL:		52,948

Sanitary Landfill Capital Costs (500 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
LEACHATE PUMPING AND STORAGE																
Transfer Line	15.00	80	lf	1,200												
Holding Tanks	30,000.00	3	ea	90,000												
		SUBTOTAL:		91,200		SUBTOTAL:		0		SUBTOTAL:		0		SUBTOTAL:		0
SECONDARY CONTAINMENT																
Subbase Preparation	0.15	884,356	sf	132,653	0.18	196,523	sf	35,865	0.22	196,523	sf	43,635	0.27	196,523	sf	53,089
Clay Layer	30.00	65,508	cy	1,965,235	36.50	14,557	cy	531,335	44.41	14,557	cy	646,451	54.03	14,557	cy	786,506
60 mil PVC Geomembrane	0.70	884,356	sf	619,049	0.85	196,523	sf	167,371	1.04	196,523	sf	203,632	1.26	196,523	sf	247,749
Sand Blanket Drain	15.00	65,508	cy	982,617	18.25	14,557	cy	265,668	22.20	14,557	cy	323,225	27.01	14,557	cy	393,253
Geotextile	0.06	1,768,711	sf	106,123	0.07	393,047	sf	28,692	0.09	393,047	sf	34,908	0.11	393,047	sf	42,471
Washed Stone	15.00	8,188	cy	122,827	18.25	1,820	cy	33,208	22.20	1,820	cy	40,403	27.01	1,820	cy	49,157
6" SDR 21 Slotted PVC Pi	7.25	3,537	lf	25,646	8.82	786	lf	6,934	10.73	786	lf	8,436	13.06	786	lf	10,264
6" Cleanouts	1,750.00	35	ea	61,250	2,129.14	8	ea	17,033	2,590.43	8	ea	20,723	3,151.65	8	ea	25,213
		SUBTOTAL:		4,015,401		SUBTOTAL:		1,086,106		SUBTOTAL:		1,321,414		SUBTOTAL:		1,607,702
PRIMARY LEACHATE COLLECTION																
60 mil HDPE Geomembrane	0.70	884,356	sf	619,049	0.85	196,523	sf	167,371	1.04	196,523	sf	203,632	1.26	196,523	sf	247,749
Washed Stone	15.00	8,188	cy	122,827	18.25	1,820	cy	33,208	22.20	1,820	cy	40,403	27.01	1,820	cy	49,157
Sand Blanket Drain	15.00	65,508	cy	982,617	18.25	14,557	cy	265,668	22.20	14,557	cy	323,225	27.01	14,557	cy	393,253
6" SDR 21 Slotted PVC Pi	7.25	3,537	lf	25,646	8.82	786	lf	6,934	10.73	786	lf	8,436	13.06	786	lf	10,264
6" Cleanouts	1,750.00	35	ea	61,250	2,129.14	8	ea	17,033	2,590.43	8	ea	20,723	3,151.65	8	ea	25,213
		SUBTOTAL:		1,811,390		SUBTOTAL:		490,214		SUBTOTAL:		596,420		SUBTOTAL:		725,636

Sanitary Landfill Capital Costs (500 Ton/Day Facility)

ITEM	Stage 1 1990-1995 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 2 1995-2000 UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)
FINAL COVER AND DRAINAGE								
Cap Underlainment					12.21	10,650	cy	130,037
40 mil HDPE Geomembrane					0.55	726,110	sf	399,361
Drainage layer					15.00	21,300	cy	319,500
Subsoil					12.00	10,650	cy	127,800
Topsoil					16.00	10,650	cy	170,400
Seed, Fertilizer, Mulch, Lime					2,500.00	13.0	acre	32,500
Gas Vents					20.00	66	lf	1,320
Gas Vent Riser Pipes					600.00	330	ea	198,000
Terrace Swales					15.00	6,600	lf	99,000
		SUBTOTAL:		0		SUBTOTAL:		1,477,917
EQUIPMENT								
Compactor (CAT 816 or eq	148,000.00	1	ea	148,000			ea	0
Service Truck (4WD 1T)	27,750.00	1	ea	27,750			ea	0
Dozer (Cat D7L or eqv.)	280,000.00	1	ea	280,000		0	ea	0
Loader (Cat 980 or eqv.)	217,000.00	1	ea	217,000		0	ea	0
Dump Truck (3 axle, 14 y	80,000.00	1	ea	80,000		0	ea	0
Leachate Tank Truck (600	130,000.00	1	ea	130,000		0	ea	0
Office Equipment/Furnitu	7,500.00	1	ea	7,500		0	ea	0
Maintenance Equipment	5,000.00	1	ea	5,000		0	ea	0
		SUBTOTAL:		895,250		SUBTOTAL:		0
PROFESSIONAL SERVICES								
Hydro, Permitting	960,000.00	1	ea	960,000				
Bid Documents & Bid Revi	200,000.00	1	ea	200,000	28,000.00	1	ea	28,000
Survey Control	80,000.00	1	ea	80,000	20,000.00	1	ea	20,000
Construction Inspection	380,000.00	1	ea	380,000	50,000.00	1	ea	50,000
Topo Map & Vol. Calculat	30,000.00	1	ea	30,000				
				1,650,000		SUBTOTAL:		98,000
	TOTAL CAPITAL COST			12,707,038	TOTAL CAPITAL COST			4,623,888
	CONTINGENCY (15%)			1,906,056	CONTINGENCY (15%)			693,583
	GRAND TOTAL CAPITAL COSTS:			$14,613,094	GRAND TOTAL CAPITAL COSTS:			$5,317,471

ITEM	Stage 3 2000-2005 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	Stage 4 2005-2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)	CLOSURE 2010 UNIT COST ($)	QUANTITY	UNIT	TOTAL COS PER ITEM ()
FINAL COVER AND DRAINAGE												
Cap Underlainment	14.86	10,650	cy	158,209	18.07	10,650	cy	192,486	21.99	21,300	cy	468,377
40 mil HDPE Geomembrane	0.67	726,110	sf	485,883	0.81	726,110	sf	591,151	0.99	1,452,220	sf	1,438,451
Drainage layer	18.25	21,300	cy	388,721	22.20	21,300	cy	472,938	27.01	42,600	cy	1,150,803
Subsoil	14.60	10,650	cy	155,488	17.76	10,650	cy	189,175	21.61	21,300	cy	460,321
Topsoil	19.47	10,650	cy	207,318	23.68	10,650	cy	252,234	28.82	21,300	cy	613,762
Seed, Fertilizer, Mulch, Lime	3,041.63	13.0	acre	39,541	3,700.61	13.0	acre	48,108	4,502.36	27.0	acre	121,564
Gas Vents	24.33	66	lf	1,606	29.60	66	lf	1,954	36.02	132	lf	4,754
Gas Vent Riser Pipes	729.99	330	ea	240,897	888.15	330	ea	293,088	1,080.57	660	ea	713,174
Terrace Swales	18.25	6,600	lf	120,449	22.20	6,600	lf	146,544	27.01	1,320	lf	35,659
		SUBTOTAL:		1,798,112		SUBTOTAL:		2,187,678		SUBTOTAL:		5,006,864
EQUIPMENT												
Compactor (CAT 816 or eq	219,076.15	1	ea	219,076			ea					0
Service Truck (4WD 1T)	41,076.78	1	ea	41,077			ea					0
Dozer (Cat D7L or eqv.)	414,468.40	1	ea	331,575			ea					0
Loader (Cat 980 or eqv.)	321,213.01	1	ea	256,970			ea					0
Dump Truck (3 axle, 14 y	118,419.54	1	ea	94,736			ea					0
Leachate Tank Truck (600	192,431.76	1	ea	153,945			ea					0
Office Equipment/Furnitu	11,101.83	1	ea	8,881			ea					0
Maintenance Equipment	7,401.22	1	ea	5,921			ea					0
												0
		SUBTOTAL:		1,112,182		SUBTOTAL:		0				0
PROFESSIONAL SERVICES												
Hydro, Permitting												
Bid Documents & Bid Revi	34,066.28	1	ea	34,066	41,446.84	1	ea	41,447	50,426.42	1	ea	50,426
Survey Control	24,333.06	1	ea	24,333	29,604.89	1	ea	29,605	36,018.87	1	ea	36,019
Construction Inspection	60,832.65	1	ea	60,833	74,012.21	1	ea	74,012	90,047.18	1	ea	90,047
Topo Map & Vol. Calculat												
		SUBTOTAL:		119,232		SUBTOTAL:		145,064		SUBTOTAL:		176,492
	TOTAL CAPITAL COST			6,737,848	TOTAL CAPITAL COST			6,844,484	TOTAL CAPITAL COST			5,183,357
	CONTINGENCY (15%)			1,010,677	CONTINGENCY (15%)			1,026,673				
	GRAND TOTAL CAPITAL COSTS:			$7,748,526	GRAND TOTAL CAPITAL COSTS:			$7,871,157	GRAND TOTAL CAPITAL COSTS:			$5,183,357

Sanitary Landfill Operating Costs (500 Ton/Day Facility)

Stage 1 — 1990-1995

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
OPERATING COSTS				
Wages and Salaries				
Foreman	32,000.00	1	yr	32,000
Equipment operator	18,000.00	3	yr	54,000
Operator/mechanic	20,000.00	1	yr	20,000
Scale operator	18,000.00	1	yr	18,000
Laborer	16,000.00	1	yr	16,000
	Subtotal With Benefits:			140,000
Fringe Benefits		@ 30%		42,000
Overhead		@ 25%		35,000
	Total With Benefits:			217,000
Utilities	2,650.00	12	mo	31,800
Leachate Disposal	0.175	221,089	gal	38,691
Equip Op & Maint	90,000.00		ls	90,000
Contracted Services	75,000.00		ls	75,000
Soil Cover	8.00	1,875	cy/mo	180,000
Insurance	35,000.00	1	yr	35,000
	TOTAL OPERATING COSTS:			667,491
	CONTINGENCY (15%)			100,124
	GRAND TOTAL OPERATING COSTS			$767,614

Stage 2 — 1995-2000

ITEM	UNIT COST ($)	QUANTITY	UNIT	PER ITEM ($)
Foreman	38,932.89	1	yr	38,933
Equipment operator	21,899.75	3	yr	65,699
Operator/mechanic	24,333.06	1	yr	24,333
Scale operator	21,899.75	1	yr	21,900
Laborer	19,466.45	1	ls	19,466
	Subtotal With Benefits:			170,331
Fringe Benefits		@ 30%		51,099
Overhead		@ 25%		42,583
	Total With Benefits:			264,014
Utilities	3,224.13	12	mo	38,690
Leachate Disposal	0.21	736,226	gal	156,753
Equip Op & Maint	109,498.76	1	ls	109,499
Contracted Services	91,248.97	1	ls	91,249
Soil Cover	9.73	2,070	cy/mo	241,791
Insurance	42,582.85	1	yr	42,583
	TOTAL OPERATING COSTS:			944,578
	CONTINGENCY (15%)			141,687
	GRAND TOTAL OPERATING COST			$1,086,264

Stage 3 — 2000-2005

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Foreman	47,367.82	1	yr	47,368
Equipment operator	26,644.40	3	yr	79,933
Operator/mechanic	29,604.89	1	yr	29,605
Scale operator	26,644.40	1	yr	26,644
Laborer	23,683.91	1	ls	23,684
	Subtotal With Benefits:			207,234
Fringe Benefits		@ 30%		62,170
Overhead		@ 25%		51,809
	Total With Benefits:			321,213
Utilities	3,922.65	12	mo	47,072
Leachate Disposal	0.26	1,104,339	gal	286,071
Equip Op & Maint	133,221.99	1	ls	133,222
Contracted Services	111,018.32	1	ls	111,018
Soil Cover	11.84	2,286	cy/mo	324,794
Insurance	51,808.55	1	yr	51,809
	TOTAL OPERATING COSTS:			1,275,198
	CONTINGENCY (15%)			191,280
	GRAND TOTAL OPERATING COST			$1,466,478

Stage 4 — 2005-2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COST PER ITEM ($)
Foreman	57,630.19	1	yr	57,630
Equipment operator	32,416.98	3	yr	97,251
Operator/mechanic	36,018.87	1	yr	36,019
Scale operator	32,416.98	1	yr	32,417
Laborer	28,815.10	1	ls	28,815
	Subtotal With Benefits:			252,132
Fringe Benefits		@ 30%		75,640
Overhead		@ 25%		63,033
	Total With Benefits:			390,805
Utilities	4,772.50	12	mo	57,270
Leachate Disposal	0.32	1,225,816	gal	386,335
Equip Op & Maint	162,084.92	1	ls	162,085
Contracted Services	135,070.76	1	ls	135,071
Soil Cover	14.41	2,524	cy/mo	436,290
Insurance	63,033.02	1	yr	63,033
	TOTAL OPERATING COSTS:			1,630,888
	CONTINGENCY (15%)			244,633
	GRAND TOTAL OPERATING COSTS			$1,875,521

CLOSURE — 2010

ITEM	UNIT COST ($)	QUANTITY	UNIT	TOTAL COS PER ITEM ()
Foreman	70,115.94	1	yr	70,116
Equipment operator	39,440.22	3	yr	118,321
Operator/mechanic	43,822.46	1	yr	43,822
Scale operator	39,440.22	1	yr	39,440
Laborer	35,057.97	1	ls	35,058
	Subtotal With Benefits:			306,757
Fringe Benefits		@ 30%		92,027
Overhead		@ 25%		76,689
	Total With Benefits:			475,474
Utilities	5,806.48	12	mo	69,678
Leachate Disposal	0.38	1,235,039	gal	473,571
Equip Op & Maint	197,201.08	1	ls	197,201
Contracted Services	164,334.24	1	ls	164,334
Soil Cover	17.53	2,786	cy/mo	586,061
Insurance	76,689.31	1	yr	76,689
	TOTAL OPERATING COSTS:			2,043,008
	CONTINGENCY (15%)			306,451
	GRAND TOTAL OPERATING COST			$2,349,460

Sanitary Landfill
Capital Cost summary
(500 TPD Facility)

DESCRIPTION	STAGE 1	STAGE 2	STAGE 3	STAGE 4	CLOSURE	POSTCLOSURE MAINTENANCE
Year Constructed	1990	1995	2000	2005	2010	2010-2040
Site Preparation	3,183,448	1,435,882	1,746,970	2,125,456		
Infrastructure	1,060,350	35,770	43,519	52,948		
Landfill Expansion	5,917,990	1,576,320	1,917,834	2,333,339		
Equipment	895,250		1,112,182			
Final Cover & Drainage		1,477,917	1,798,112	2,187,678	5,006,864	
Post-Closure						9,008,337
Professional Services	1,650,000	98,000	119,232	145,064	176,492	
Income (Equip. trade-in @ 20%)			(179,050)		(222,436)	
TOTALS	12,707,038	4,623,888	6,558,798	6,844,484	4,960,920	9,008,337
CONTINGENCY (20%)	2,541,408	924,778	1,311,760	1,368,897	992,184	1,801,667
GRAND TOTAL	15,248,446	5,548,666	7,870,558	8,213,381	5,953,105	10,810,005
Method of Payment	Bond	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund	Reserve Fund
Amortization period	1990-2010					
Annual Bond Payment @ 8.5 %	1,611,318					
Fund Accumulation Period		1990-1995	1995-2000	2000-2005	2005-2010	1990-2010
Annual Contribution @ 7.5 %		955,284	1,355,032	1,414,054	1,024,915	249,627

Sanitary Landfill Post-Closure Costs
(500 TPD Facility)

ITEM	COST ($)	QUANTITY UNIT	PER ITEM ($)	COST ($)	QUANTITY	UNIT PER ITEM ($)
POSTCLOSURE COSTS	1990 UNIT COST	NO./YR	NO. OF YRS.	2010 UNIT COST	TOTAL UNITS	2010 TOTAL COST
Engineer Inspections	800.00	4 ea	1	1,752.90	4	7,012
	800.00	2 ea	29	1,752.90	58	101,668
Vegetation Maintenance	4,000.00	10 acres	5	8,764.49	50	438,225
	4,000.00	2 acres	25	8,764.49	50	438,225
Drainage Maintenance	4,000.00	1 ls	30	8,764.49	30	262,935
Groundwater Monitoring	2000.00	30 ea	5	4,382.25	150	657,337
	2000.00	15 ea	25	4,382.25	375	1,643,342
Leachate Monitoring	1,200.00	10 ea	5	2,629.35	50	131,467
	1,200.00	4 ea	25	2,629.35	100	262,935
Leachate Treatment	0.175	1,235,039 gal	5	0.38	6,175,195	2,367,857
	0.175	308,760 gal	10	0.38	3,087,598	1,183,929
	0.175	61,752 gal	15	0.38	926,279	355,179
Cap Maintenance	15,000.00	3 acres	2	32,866.85	6	197,201
	15,000.00	1 acres	28	32,866.85	28	920,272
Replace Monitoring Wells	3,100.00	2 /5 yr	30	6,792.48	6	40,755
						===========
				TOTAL POSTCLOSURE COST:		9,008,337
				CONTINGENCY (15%)		1,351,251
						===========
				GRAND TOTAL POSTCLOSURE CO		10,359,588

Sanitary Landfill Life-Cycle Costs, 1990-2010
(500 TPD Facility)

YEAR	BOND PAYMENT	CAPITAL RESERVE FUND	POST CLOSURE RESERVE FUND	OPERATING COSTS	NET COST	ANNUAL TONNAGE	TIPPING FEE INFLATED	TIPPING FEE (1990 DOLLARS)
1990	1,611,318	955,284	249,627	767,614	3,583,843	150,000	23.89	23.89
1995	1,611,318	1,355,032	249,627	1,086,264	4,302,242	165,612	25.98	21.35
2000	1,611,318	1,414,054	249,627	1,466,478	4,741,477	182,849	25.93	17.52
2005	1,611,318	1,024,915	249,627	1,875,521	4,761,381	201,880	23.59	13.10
2010				2,349,460	2,349,460	222,892	10.54	4.81

PART B

Cost Analyses of Alternative Approaches to Solid Waste Management

12. STRUCTURE OF THE ANALYSIS

As was shown in Part A, strong effects of scale exist for both collection systems and processing and disposal facilities. These effects are in opposing directions: As capacity or region served increases, facility costs decrease per ton while collection costs increase. That means system costs for waste disposal will rise for both extremely large and extremely small regions because of the large costs incurred by either collection or processing/disposal systems. This part of the report analyzes the costs of managing solid wastes in Vermont using three different regional approaches in an effort to understand the interaction of these two opposing components in recycling, composting and disposal systems. The analysis is not a solid waste plan for Vermont, nor is it an effort to determine the appropriate region sizes. A thorough analysis of region sizes was not performed, nor a thorough analysis of differences in optimal region size for different technologies.

Three Vermont state integrated solid waste systems are analyzed with increasing regionalization as the primary difference between the scenarios. The first scenario models each solid waste district developing an individual plan, with district sized recycling and disposal facilities. The second scenario divides the state into four regions with each having its own recycling and disposal facility. Finally, the third scenario splits the state in half (down the Green Mountain ridge) into two regions, each with its recycling and disposal facility.

The solid waste systems modelled include various recycling, composting and waste disposal programs targeted for different types of demographic areas. Urban areas receive curbside collection of recyclables, leaf and yard waste, and garbage. Residential communities, or as we will call them "suburban" areas, have curbside recycling and garbage collection, and use dropoff sites for leaf and yard wastes. Rural areas use dropoff sites for recyclables, leaf and yard waste, and garbage.

These analyses consider only the systems which handle residential waste. Commercial waste, businesses, institutions, and construction operations were not considered for several reasons. The collection of waste from commercial sources is highly varied, depending upon the size of the business, frequency of collection and type of waste. This variability in collection makes accurate modelling of commercial collection extremely difficult, if not impossible. This contrasts greatly with residential collection, where each household generates a very similar waste stream and one collection system can service all residential generation, thus facilitating accurate modelling. In addition to this difficulty in modelling, there was limited data available for the costs of commercial recycling facilities, particularly with regard to determining their economies of scale.

The estimation of the costs of managing solid wastes in each of the three scenarios relies heavily on Tellus Institute's WastePlan© computer model. WastePlan is designed to perform a complete planning and cost analysis of a region's solid waste system, including the definition of waste types and quantities, collection systems for waste, compostables, and recyclables, and processing and disposal facilities. All analyses except the lifecycle cost and the cost estimations of a few systems were modelled using WastePlan. Data used for the analysis was developed in Part A, where the costs of different solid waste collection systems and facilities were developed. Vermont specific demographic and waste generation data (reported in Appendix 2) were also used.

WastePlan was used to model the total costs, both annual capital payments and operating costs, of the integrated waste management system in each region for each scenario (actually, in Scenario I, districts are grouped together into three different categories). These regional costs were then combined to arrive at a total cost for managing all of Vermont's wastes. These statewide costs can then be compared to determine the benefits and costs of various regional approaches to managing Vermont's wastes.

This chapter describes in further detail the methodology used for estimating system costs, and the demographic regions defined by each of the scenarios. The methodology is broken down into three sections, corresponding to the different programs within the WastePlan model: Waste Generation, Waste Collection, and Processing and Disposal Facilities. Chapter 13 describes the types of solid waste programs included in the scenarios and the assumptions used in estimating the costs and amount of materials handled. The state cost estimates of each scenario (and individual regions) are presented in Chapter 14.

WASTE GENERATION

WastePlan uses information about waste composition and demographics to model the waste stream with a specific quantity and composition for each region studied. Demographic inputs include population, waste generated per capita, people per household, and number of road miles.

Using demographic and waste generation data presented in Appendix 2, a waste generation file was created using WastePlan for each of the eleven Vermont solid waste districts. Population and housing data were obtained from various Vermont state agencies. Waste generation data were developed from information gathered from throughout the state. District populations were further categorized by population density per road mile. The following categories were used:

urban	> 27.25 households per roadmile
suburban	13 - 27.25 households per roadmile
rural	0 - 13 household per roadmile.

Descriptions of the three regional scenarios are presented below.

Scenario I - Eleven Solid Waste Districts

Vermont is divided into 11 solid waste districts, with varying populations, areas, and population densities. Scenario I models the development of individual district plans, where each district develops its own facilities and collection programs. In order to simplify the analysis, this scenario was modelled by categorizing the 11 solid waste districts into three separate groups based upon the population of the district. This results in the following breakdown (populations in parentheses):

		Average Population
Large	Chittenden (122,570)	122,570
Medium	Central Vermont (71,424) Northeast (51,529) Rutland (56,146)	59,572
Small	Addison (28,784) Bennington (33,108) Lamoille (18,378) Northwest (39,401) Southern Windsor (33,938) Upper Valley (30,904) Windham (33,255).	31,110

A WastePlan run was performed for each of these three groups. For the medium and small groups, a generic or average region was created by combining data from each of the districts within the group. The population of this average region is listed above. The "medium districts" WastePlan run includes three average sized medium population regions, while the "small districts" run includes seven average size population districts. The urban, suburban and rural breakdowns are based upon average population density per road mile. These breakdowns are important because different types of collection service will be provided for urban, suburban, and rural areas.

Scenario II - Four Waste Management Regions

In Scenario II, Vermont is divided into four regions, each with its own regionwide recycling and disposal facility, with a larger number of compost facilities. The criteria for forming regions included transportation corridors, spatial proximity, and equity of population in each region. These regions are not recommendations for the grouping of districts into an optimal regional configuration, but only used to illustrate the impacts of regionalization on the economies of scale of collection systems and solid waste facilities. The regions are comprised of several solid waste districts as listed below:

North East	Central Vermont Lamoille Northeast
North West	Chittenden Northwest
South East	Southern Windsor Upper Valley Windham
South West	Addison Bennington Rutland.

For each of these regions, an individual WastePlan analysis was performed. This analysis uses the demographic characteristics of each district within the region to form a composite demographic profile. The size of rural, suburban, and urban populations is based on the significant demographics of the individual districts within the region, so these figures are different for each region. This difference has impacts on the results because different types of collection service are used in rural, suburban and urban areas.

The type of solid waste system modelled in each of the four regions is very similar to that modelled in Scenario I. The only major difference is that rather than having 11 recycling and disposal facilities (one for each district), there are now 4 recycling and disposal facilities. With economies of scale in recycling depots, mixed waste composting facilities, and landfills, the cost per ton of operating these facilities drops. However, offsetting this cost will be the increased cost of collecting and transporting the recyclables, compostables and waste. The collection vehicles now have a longer distance to transport materials to the recycling depot, so their costs rise. Regionalization creates these two opposing cost impacts; the question is whether the systems cost (the combined costs of collection and facility) increase or decrease.

Scenario III - Two Waste Management Regions

In Scenario III, the state is divided into two regions split by the Green Mountain ridge. The breakdown of districts within each region is as follows:

East	Central Vermont Lamoille Northeast Southern Windsor Upper Valley Windham
West	Addison Bennington Chittenden Northwest Rutland.

As in the previous two scenarios, each of the two regions has one region-wide recycling and disposal facility, and a set of smaller composting facilities. However, additional changes in the solid waste system are caused by the increased size of the region. First, the curbside recycling program still collects commingled materials, but separation is no longer performed at the curb. Instead, materials are delivered to a materials recovery facility, or MRF, and separation of the two basic streams, paper and mixed containers, is performed by a combination of manual and mechanical means.

Second, a system of long-haul transfer stations is used for the transport of recyclables and waste to the regional facilities. The long transport distances (roughly 40 miles on average) which result from having only two facilities in the entire state make delivery of the materials by individual recycling trucks and garbage packers no longer economical. The transfer system allows materials to be transported in bulk, thus reducing the transport costs.

Third, the size of compost facilities is increased from the one acre sites used in Scenarios I and II to a two acre site. The slight decrease in compost processing cost can be tested against the increase in collection costs resulting from the longer haul distance.

WASTE COLLECTION

Collection of materials generated by a specific Waste Generation File or set of files can be modelled in WastePlan's Collection program. Separate modules for the collection of recyclables, compostables and garbage are available. Costs and truck requirements for the collection of materials from a specific region are calculated based upon a set of program assumptions, including the type of collection vehicle and its cost and physical characteristics, crew size, collection efficiency (households collected per hour), and distance to the processing or disposal facility. The amount of material collected is based upon the Waste Generation File for the region being modelled and the participation and capture rates of the particular recycling and composting programs used.

(1) The program characteristics used in this analysis of an integrated solid waste system are the same as were used in the Part A, where individual programs were analyzed independently. This information (listed under Assumption in Chapter 13) includes truck type and characteristics, crew size, collection efficiencies, and program schedules.

(2) Depending upon the region and scenario being modelled, a rough estimate of the number of roadmiles to the facility(ies) modelled in that region was determined using Vermont state maps. These estimates were then input into WastePlan.

(3) Costs for the collection of garbage from rural regions through dropoff transfer stations and the transfer of recyclables (Scenario IIA and all III scenarios) was estimated externally to WastePlan and results were added to the totals output by WastePlan. This process was necessary because the other collection options used in these scenarios made it impossible to model all collection programs simultaneously.

PROCESSING AND DISPOSAL FACILITIES

The Facilities Program of WastePlan models the costs of processing and disposal facilities based on the amount of materials received from the collection programs. Modules for recycling, leaf and yard waste composting, mixed waste composting, incineration and landfill are available to the user. Costs are calculated either through the use of unit costs (such as cost per ton of daily capacity or acre) or through the input of lump sum costs.

(1) Capacity requirements (in tons per day) were determined for each of the facilities by running the WastePlan Facilities Program and observing the amount of waste being delivered by the collection programs to each of the designated facilities. In several cases, waste from several collection programs or other sources are delivered to a facility. Recyclables from both satellite dropoff sites and curbside collection are delivered to one recycling facility, and residues from the recycling facility, mixed waste composting, and garbage collection arrive at the landfill.

(2) Using information from Part A and the facilities sizes determined in the previous steps, capital costs, annual operating costs and annual revenues were estimated for each of the facilities. This information was input into WastePlan.

SYSTEMS COST ANALYSIS

With information about waste generation, collection, and facilities for each of the solid waste systems input into WastePlan, a total systems cost is calculated along with the costs of each of the individual program and facilities. The costs output by WastePlan are first year systems costs.

A calculation of the lifecycle costs for each system was finally performed because of the inadequacy of first year systems costs in considering such lifetime factors as the effect of inflation on systems with differing proportions of capital to operating costs. This analysis uses the first year capital and operating costs of each program and facility to determine the net present value per ton over a twenty-year lifetime. (Results are presented in Appendix 1).

13. SOLID WASTE SYSTEMS USED IN SCENARIOS

In each of the three scenarios for managing Vermont solid wastes, the solid waste systems use the same types of recycling, composting and garbage programs. The major difference arises in the size of the region that each of these programs serves. By keeping the systems and technologies consistent, the analysis can focus on the effect of regionalization upon systems costs.

This Chapter describes the solid waste systems used in these scenarios and present the assumptions used for the analysis of costs and the flow of waste through different facilities and programs. This chapter also addresses the changes in assumptions made by the sensitivity. The WastePlan computer model used in this analysis requires a large number of data inputs to model the generation of waste and the solid waste system which subsequently handles it. However, before discussing the specific assumptions for each program and facility, we summarize the systems used in each of the scenarios and the sensitivity analyses performed.

Scenario I - Eleven Solid Waste Districts

Recycling

Collection - Curbside commingled with curbside separation in urban, suburban communities.
Dropoff in rural.

Facility - 11 Depots, one per district.
Capacities: Large - 38 TPD
Medium - 16 TPD (48 TPD total)
Small - 9 TPD (63 TPD total)

Composting

Collection - Curbside in urban.
Dropoff in rural, suburban communities.

Facility - 1-acre municipal low-tech compost facility.
Sites per district: Large District - 7 sites
3 Medium Districts - 11 sites
7 Small Districts - 13 sites

Garbage

Collection - Curbside in urban, suburban communities.
Dropoff transfer in rural.

Facility - 11 MSW Composting, one per district.
Capacities: Large - 175 TPD
Medium - 85 TPD (255 TPD total)
Small - 45 TPD (315 TPD total)
11 Residue Landfills, one per district.
Capacities: Large - 35 TPD
Medium - 17 TPD (51 TPD total)
Small - 9 TPD (63 TPD total)

Sensitivity Analyses for Scenario I

A - Increase the collection efficiency (i.e. households collected per hour) of recycling collection vehicles.
B - Remove MSW Composting, with landfill as the sole disposal source.
C - Curbside collection of recyclables in rural areas as well as urban and suburban areas.

Scenario II - Four Waste Management Regions

Recycling

Collection - Curbside commingled with curbside separation in urban, suburban communities.
Dropoff in rural.

Facility - 4 Multi-district Depots.
Capacities: NE - 39 TPD
NW - 49 TPD
SE - 26 TPD
SW - 36 TPD

Composting

Collection - Curbside in urban.
Dropoff in rural, suburban communities.

Facility - 1-acre low-tech compost facility.
Sites per Region: NE - 8
NW - 10
SE - 6
SW - 7

Garbage

Collection - Curbside in urban, suburban communities.
Dropoff transfer in rural.

Facility - 4 Regional MSW composting facilities.
Capacities: NE - 200 TPD
NW - 225 TPD
SE - 135 TPD
SW - 165 TPD
4 Regional residue landfills.
Capacities: NE - 40 TPD
NW - 45 TPD
SE - 25 TPD
SW - 35 TPD

Sensitivity Analyses for Scenario II

A - Use transfer facilities for transporting recyclables and garbage from districts without facilities.

B - Remove MSW Composting, with landfill as the sole disposal source.

C - Increase diversion rates of recycling and composting programs.

Scenario III - Two Waste Management Regions

Recycling

Collection - Curbside in urban, suburban communities.
Dropoff in rural.
Transfer of recyclables through district transfer sites.

Facility - 2 state-wide MRFs (east and west of Green Mountains).
Capacities: East - 64 TPD
West - 84 TPD

Composting

Collection - Curbside in urban.
Dropoff in rural, suburban communities.

Facility - 2-acre low-tech compost facilities.
Sites per Region: East - 7
West - 8

Garbage

Collection -	Curbside in urban, suburban communities.	
	Dropoff transfer in rural.	
	Transfer of waste through district transfer sites.	
Facility -	2 Regional MSW Composting Facilities.	
	Capacities:	East - 335 TPD
		West - 390 TPD
	2 Regional residue landfills.	
	Capacities:	East - 65 TPD
		West - 80 TPD

Sensitivity Analyses for Scenario III

A - Replace some landfill capacity with existing waste-to-energy facilities.
B - Remove MSW Composting, with landfill as the sole disposal source.
C - Use medium-technology leaf and yard waste composting in place of low technology.

Each of these scenarios will estimate the costs of managing the entire Vermont residential-solid waste stream. The difference between the scenarios is the number of solid waste disposal and processing facilities throughout the state, or the extent of regionalization. In scenario I, recycling and disposal occurs at 11 recycling depots and 11 mixed waste composting facilities, one for each solid waste district. There are 31 leaf and yard waste compost sites in the state, spread evenly by population throughout the districts. In Scenario II, the number of recycling and disposal facilities decreases to 4, while the number of compost sites stays the same as Scenario I. In Scenario III, there are only 2 recycling and disposal facilities, and the number of compost sites decreases to 15.

ASSUMPTIONS FOR ALL PROGRAMS USED IN ALL THREE SCENARIOS

Waste Generation

- Populations, number of households, people per household and urban/suburban/rural breakdowns as reported in Appendix 2.
- Waste Generation - 2.6 pounds per person per day.
- Waste Composition - The Tellus Institute estimate presented in Appendix 2.

Recycling Collection

Recycling programs include dropoff collection for rural areas and commingled-curbside sort collection in urban and suburban areas. Dropoff collection provides residents with a set of roll-off containers in which they can deposit various recyclable materials. These containers are periodically collected and transported to the district's recycling depot. Only the costs of containers and transportation have been included. We have assumed that the containers will be stored at the dropoff garbage collection site or at another location with no site costs. This program will be used to serve rural residents in all scenarios, and the same assumptions have been used in all cases.

Residents in urban and suburban areas can set out recyclables at the curb in a commingled fashion: papers in one pile and mixed containers in a blue box. As they are collecting, crews sort the materials at the curb into compartmentalized recycling vehicles. Once full, the vehicles dump recyclables at the recycling depot where some sorting (such as separating glass by color) and processing occurs. Only one recycling depot will exist in each district, receiving all materials collected within that district. The full costs of collection systems and processing/disposal facilities have been modelled, using the same assumptions and costs found in Part A and summarized below.

Satellite Recycling Collection

- 100% of population in rural areas is served by satellite collection sites.
- Participation/Capture Rates[1]

	Participation Rate	Capture Rate
Newspaper	50	85
Corrugated Cardboard	55	75
Glass	55	75
Aluminum Cans	55	65
Tin/ferrous Cans	55	35
HDPE	55	75
PET	55	75

[1] Diversion rate is a combination of participation rate and capture rate. Participation rate is the percentage of households that participate in the recycling or composting program. Capture rate is the percentage of potentially recyclable or compostable materials that are actually recycled, whether through setout at the curb or dropoff. When multiplied together, they form the diversion rate, which measures the actual percentage of material that is recycled or composted.

- 5 - 20 cy rolloff containers at each site.
- $2,800 per roll-off.
- No site costs.
- $0.30 per ton-mile for transportation.

		Number of sites per region	Average Distance to Drop
Scenario I -	Small	4	5
	Medium	12	5
	Large	28	5
Scenario II		10	12
Scenario III		20	5

Drop off

Commingled, Separated at Curb Recycling Collection (Scenarios I and II)

- Only urban and rural households are served.
- Participation/Capture Rates

	Participation Rate	Capture Rate
Newspaper	80	85
Corrugated Cardboard	65	75
Glass	65	75
Aluminum Cans	65	65
Tin/ferrous Cans	65	65
HDPE	65	75
PET	65	75

- Low body, side loading recycling trucks used.
  - 25 cy capacity
  - $62,000 per truck
  - 3 miles per gallon with gasoline at $1.00 per gallon.
  - 20 minute dump time.
  - maintenance at $0.16 per mile.
  - 7 year lifetime.
- 1 person crew, at $20,000 per year.
- Collection efficiency: 100 households per hour on route in urban, 80 hh/hr on route in suburban.

Note: Collection efficiency is measured only for time spent actually collecting materials. Time spent transporting materials to the drop site (e.g. landfill or recycling facility) are not included in determining this average.

- Weekly collection, with trucks collecting 5 day per week.
- Setout frequency of every other week.
- Program administration cost of $0.80 per household.
- Bluebox containers at $5 apiece, with a 5 year lifetime and 5% replacement rate.
- Distance to Dropoff (miles)/Speed (miles per hour): distances are one-way to the facility:

		Base		**Scenario II - Sensitivity A**	
		Distance	MPH	Distance	MPH
Scenario I		7	20		
Scenario II -	NE	17	25	7	20
	NW	13	25	7	20
	SE	25	30	7	20
	SW	23	30	7	20
Scenario III		40	30		

Commingled Curbside Collection (Scenario III)

- All data the same as commingled with curbside separation except the following:
  - Collection efficiency: 120 households per hour on route in urban, 90 hh/hr on route in suburban.

Recycling Depots

- Recycling depot costs developed under the same methodology and assumptions as used in Part A. Costs for different sized facilities are unique to the size and throughput of the facility.
- Operates 260 days per year, one 8-hour shift per day.
- Newspaper and corrugated cardboard are received commingled and manually sorted on the tipping floor. Separated materials are baled.
- Glass is received commingled and is manually color sorted to market specifications on a basic conveyor. Separated glass is crushed in a glass crusher before marketing.
- Plastics are received commingled, manually separated, and baled for markets.
- Aluminum and tin/ferrous can are commingled, separated with a simple magnetic separator and processed individually.
- Facility capacities for each region are as follows:

Scenario I - Large - 38 TPD
Medium - 16 TPD (48 TPD total)
Small - 9 TPD (63 TPD total)
Scenario II - NE - 39 TPD
NW - 49 TPD
SE - 26 TPD
SW - 36 TPD
Scenario II/Sensitivity C
NE - 50 TPD
NW - 60 TPD
SE - 32 TPD
SW - 44 TPD

Materials Recovery Facility

- Materials recovery facility costs developed under the same methodology and assumptions as used in Part A. Costs for different sized facilities are unique to the size and throughput of the facility.
- Operates 260 days per year, one 8-hour shift per day.
- Newspaper and corrugated cardboard are commingled and separated at picking stations off of a conveyor. The final materials are baled.
- All containers (glass, aluminum, tin/ferrous, plastic) are separated using technology which combines manual and mechanical processes. Final processing, such as baling and crushing, is performed before marketing.
- Facility capacities for each region are as follows:

Scenario III - East - 64 TPD
West - 84 TPD

Leaf and Yard Waste Collection

The collection of leaf and yard wastes is performed through two programs: dropoff collection for suburban and rural areas, and curbside collection during an eight week period in the fall for urban areas. The yardwastes collected from both programs will be brought to the same composting site where materials will be placed into windrows and composted using low-technology methods. The low-technology method utilizes a front-end loader to form and turn windrow piles, which are turned once every three months. Composting sites have much smaller economies of scale (i.e. the cost to process one ton changes very little as facility size increases) in comparison to other solid waste facilities. The implication is that the appropriate region size for compost programs and sites is much smaller than for recycling or disposal facilities. It makes little sense to transport leaves a large distance if there is no saving in the processing. Therefore, rather than model one compost facility for the entire district, a number of much smaller 1-acre facilities have been modelled. This size site is able to process about 500 tons of leaf and yard waste per year or about the amount generated by four to five typical municipalities.

Backyard Composting

- 10% participation and 100% capture of leaf and yard wastes.
- No costs to system.

Dropoff Composting

- Rural and Suburban areas are serviced by dropoff at the closest compost facility.
- 60% participation and 80% capture of leaf and yard wastes.

Bagged Compost Collection

- Only urban households are served.
- 20 cy packer trucks used.
    - 20 cy capacity
    - $100,000 per truck.
    - 3 miles per gallon with gasoline at $1.00 per gallon.
    - 15 minute dump time.
    - maintenance at $0.70 per mile.
    - 7 year lifetime.
    - Compaction ratio of 3:1.
- 2 person crew, at $20,000 per year/worker.
- Collection efficiency: 45 households per hour on route in urban.
- Bi-weekly collection, with trucks collecting 5 day per week, 8 weeks per year.
- Program administration/education cost of $0.50 per household.
- Distance to Dropoff/Speed: 3 miles to site in Scenario I and II, 7 miles to site in Scenario III; Average Speed of 20 miles per hour.

Low Technology Windrow Composting

- An acre of land is needed for each 5000 C.Y. of leaves. Volume reduction due to settling and decomposition of leaves is assumed to be 50 percent during the first year. Therefore, for an 18 month composting period, 1.5 acres are needed for a 5000 C.Y. facility (the first year's leaves will have decreased in volume to 2500 C.Y., requiring one half acre, and the second year's leaves will require a full acre.) A 10,000 C.Y. facility will require 3 acres and a 20,000 C.Y. facility will require 6 acres. The cost of site preparation assumed in our analysis takes into account the full acreage necessary for these sites, although the cost of windrow formation and turning only accounts for one year's leaves. Our specific assumptions are as follows:

- Clearing and grading - $2000/acre.
- Gravel - A gravel pad of approximately 1.5 inches is required, or 200 C.Y./acre.
- Gate - $500 for materials and installation.
- Front-end loader - Assigned 10% of the cost of a $100,000 (4 C.Y.) loader to the composting program, amortized @ 8% over 10 years.
- Windrow dimensions - Windrow height is 8 ft, windrow width is 20 ft.
- Windrow formation - 4 C.Y. bucket can turn 480 C.Y. of leaves/hr, assuming 5000 C.Y./acre - 10.4 hrs/acre.
- Windrow turning - Windrows will be turned only 6 times over the 18 month period, but the average volume being turned will be half of the incoming volume.
- Average bulk density of leaves is 300 lbs/C.Y.
- Scenarios I and II use 1-acre sites;
  Scenario III uses 2-acre sites.
- The number of sites per region for each scenario is as follows:

Scenario I -	Large Region - 7
	3 Medium Regions - 11
	7 Small Regions - 13
Scenario II -	NE - 8
	NW - 10
	SE - 6
	SW - 7
Scenario III -	East - 7
	West - 8

Medium Level Technology Composting

Wildcat Model	C700
Capacity/hr	700 C.Y./hr
Maximum windrow height	4 ft
Windrow width	8 ft
Wildcat windrow turner costs	$17,500
Cost of front end loader	$42,000
Windrow layout at each site	2500 C.Y./acre

- Materials handling assumptions - Leaves delivered to the site will be handled 3 times with a loader. The three "handlings" are initial windrow layout, pile combination for the winter and windrow relayout in spring. Each handling requires 6.3 hrs/acre based on the 480 C.Y. of leaves/hr assumption above.
- The Wildcat will turn the leaves 2 - 4 times in the fall, and every week for 6 months in the spring and summer, or 30 times total.
- Operational costs for the loader are estimated at $8/hr and $2/hr for the Wildcat.
- The average volume of leaves turned by the Wildcat will be decreased to half the original volume in the spring.
- The time needed to turn the compost is calculated based on the (C.Y./2)/capacity of the turner.
- 2-acre sites are used.
- The number of sites per region for each scenario is as follows:

  Scenario III/Sensitivity C

  East - 7

  West - 8

Garbage Collection

Garbage is collected at the curb for urban and suburban residents, while rural residents bring their materials to a dropoff garbage transfer station. For the rural dropoff sites, we have used a fixed per ton costs, since a large number of sites will be needed and modelling of each site is beyond the scope of this project. Waste from curbside collection and rural transfer stations will be brought to a district mixed waste composting facility. At this facility, wastes will first be sorted to remove non-compostable materials which makeup about 20% of incoming material. This residue is sent to a landfill. The remaining organic waste is size reduced before being placed in large windrow piles. A forced aeration process is used: Pipes underneath the compost piles force air through the organic waste to accelerate the decomposition process.

- Only urban and suburban households are served.
- 31 cy packer trucks used.
  - 31 cy capacity
  - $120,000 per truck.
  - 3 miles per gallon with gasoline at $1.00 per gallon.
  - 15 minute dump time.
  - maintenance at $0.70 per mile.
  - 7 year lifetime.
  - Compaction ratio of 3:1.
- 2 person crew, at $20,000 per year/worker.

- Collection efficiency: 100 households per hour on route in urban, 70 hh/hr on route in suburban.
- Weekly collection, with trucks collecting 5 day per week, 52 weeks per year.
- Program administration cost of $0.80 per household.
- Distance to Dropoff/Speed: same as recycling collection.

Mixed Waste Composting

- Receiving area - Space for 2 day storage
  Convert TPD to C.Y. using bulk density of 500 lb/C.Y. Assume MSW piled 10 ft high as a basis to calculate floor space needed.
- Composting area - Assume 20% of incoming material is rejected, remainder gets shredded and densified (new bulk density is approx 750 lbs/C.Y.) Floor space needed for composting is 250 - 300 sf/C.Y. A forced air system is employed to speed the composting process.
- Receiving and processing building costs - $50/sf
- Composting building costs - $25/sf
- Curing area costs - $1.5/sf
- Land cost - $5000/acre
- Assumptions on equipment sizing: Shear shredders can handle up to 50 tons per hour (daily throughput divided by 7 hours working time. Above that volume, hammermills are necessary. Two trommels are needed for the medium and the large facility. Medium throughput trommels, up to 25 TPH, cost approx $150K. Large throughput trommels (50 TPH) cost $250K each.
- Annualized capital cost - Amortize all capital costs at 10% over 20 years.
- Personnel requirements - Salaries: supervisor - $35K, Equipment operators - $25K, mechanic and electrician - $30K, Laborers and scale operators - $20K.
- Electricity costs - $0.08/kwh
- Maintenance and supplies - Moving equipment and shredder maintenance is 0.075 of cost, structures and other processing equipment is 0.025 of cost.
- Landfill cost - Assume 20% material rejected.

- Facility capacities for each scenario are as follows:
  Scenario I - Large - 130 TPD
  Medium - 85 TPD (255 TPD total)
  Small - 45 TPD (315 TPD total)
  Scenario II - NE - 200 TPD
  NW - 225 TPD
  SE - 135 TPD
  SW - 165 TPD
  Scenario II/Sensitivity C

NE - 175 TPD
NW - 200 TPD
SE - 122 TPD
SW - 145 TPD
Scenario III - East - 335 TPD
West - 390 TPD

Landfill

- Compacted solid waste density - 800 lb/C.Y.
- Cover to MSW ratio - 20% - 25%.
- Compaction equipment: varies with size, e.g.
  CAT D4H Dozer or equivalent, and
  JD 450 compactor or equivalent for 40 TPD facility.
  Earth moving equipment: varies with size, e.g.
  CAT 936 loader or equivalent for 40 TPD.
- Cover soil available within 10 miles.
- Leachate collected and transported by tanker, 50 miles.
- Unheated equipment storage.
- Facility life - 20 years.
- Double composite liner: 60 mil HDPE, 60 mil PVC and 2 clay layers.
- Leachate collection with both washed stone and sand layers. PVC pipe is used as collection method.
- Final cover of 40 mil HDPE and soil layers.
- Number of groundwater testing wells varies with landfill size.
- Other cost factors such as labor, maintenance, utilities, and infrastructure vary with facility size.
- Operate 6 days per week.
- Daily capacities for residue landfills:
  Scenario I - Large - 35 TPD
  Medium - 17 TPD (51 TPD total)
  Small - 9 TPD (63 TPD total)
  Scenario II - NE - 40 TPD
  NW - 45 TPD
  SE - 25 TPD
  SW - 35 TPD
  Scenario II/Sensitivity C
  NE - 32 TPD
  NW - 35 TPD
  SE - 22 TPD
  SW - 26 TPD
  Scenario III - East - 65 TPD
  West - 80 TPD

- Daily capacities for landfills in Sensitivity B in each scenario:
  - Scenario I - Large - 145 TPD
    Medium - 70 TPD (210 TPD total)
    Small - 35 TPD (245 TPD total)
  - Scenario II - NE - 170 TPD
    NW - 190 TPD
    SE - 110 TPD
    SW - 135 TPD
  - Scenario III - East - 280 TPD
    West - 325 TPD

SENSITIVITY ANALYSES

For each of the three scenarios, three sensitivity analyses have been performed. In these sensitivities, one parameter of the solid waste system is changed to examine the impact upon the total systems costs, and the costs of individual programs if relevant. Because the results of an analysis with the scope and complexity of these WastePlan scenarios depends upon a large number of assumptions, sensitivity analyses are necessary to test whether assumptions or decisions have a large or small impact upon final costs. With this in mind, the sensitivity analyses we have chosen reflect a broad range of changes from changes of single variables to entire changes in programs or systems. The remainder of this section will describe the sensitivity analyses performed in this report.

Landfill as only disposal source (Sensitivity B, all scenarios)

For each of the three scenarios, Sensitivity B changes the disposal facility. Instead of assuming a mixed solid waste composting facility with residues going to a landfill, Sensitivity B assumes all wastes go directly to a landfill. The daily capacities for landfills in Sensitivity B for each scenario are listed below.

Scenario I - Large - 145 TPD
Medium - 70 TPD (210 TPD total)
Small - 35 TPD (245 TPD total)
Scenario II - NE - 170 TPD
NW - 190 TPD
SE - 110 TPD
SW - 135 TPD
Scenario III - East - 280 TPD
West - 325 TPD

Scenario I - Sensitivity A: Increase collection efficiency of recycling collection vehicles

The rate at which recycling vehicles can collect materials was increased as follows:

	Base	Sensitivity A
Urban	100	120
Suburban	80	95

(measured in households per hour)

Sensitivity A decreases the costs of recycling collection. Vehicles collect more quickly and therefore fewer trucks are needed and fewer labor hours will be paid.

Scenario I - Sensitivity C: Lower recyclable material revenues

The per ton revenues received by recycling facilities for the sale of materials are decreased in Sensitivity C. The amount of this decrease is as follows:

	Base	Sensitivity C
Newspaper	5	0
Corrugated	30	20
Glass (clear)	55	45
Glass (green)	35	25
Glass (brown)	45	35
Aluminum	1000	850
Tin/ferrous cans	60	45
HDPE	100	85
PET	100	85

These changes reduce the revenues of the recycling depots and therefore increase their net costs.

Scenario II - Sensitivity A: Long-haul transfer of recyclables and waste

In this sensitivity analysis, the same transfer system used in Scenario III for recyclables and waste is used for the four regions in Scenario II. Collection vehicles for both recyclables and mixed waste dump at transfer stations where large trailers move materials to their final destination.

Scenario II - Sensitivity C: Increase diversion rates of recyclable and compostable materials

Increased diversion rates produce a series of impacts on the solid waste system. More materials will be handled by the recycling and composting systems, so their total costs will increase. However, cost per ton decreases because more material is collected each stop and the processing facilities will be larger and therefore more cost-efficient. Costs of garbage collection and disposal react in exactly the opposite direction. Total cost will decrease because less material needs to be collected and disposed, but because less material is collected per stop, and facilities are smaller, costs per ton increase.

- Capture rates are the same as in the base scenario (see above). Only participation rates have been changed. These changes are reported below.

Recyclables	Commingled	Dropoff
Newspaper	95	65
Corrugated	80	55
Glass (clear)	80	55
Glass (green)	80	55
Glass (brown)	80	55
Aluminum	80	55
Tin/ferrous cans	80	55
HDPE	80	55
PET	80	55

Compost	
Backyard	20
Dropoff	75
Bagged Collection	75

(All figures measure participation rates)

Scenario III - Sensitivity A: Include existing waste incineration capacity in Vermont

Two existing incinerators have a large influence on any analysis of disposal capacity in Vermont. The Claremont, NH facility accepts waste from 13 Vermont towns as a part of the Vermont-New Hampshire Solid Waste Project, and it accepts a limited amount of waste from other municipalities on a spot basis. The other incinerator is the Vicon facility in Rutland, which is not operating since Vicon went bankrupt and was forced to close the facility. The facility is currently seeking an operator and some speculate that it may be reopened in the near future.

Sensitivity A includes these two facilities in the disposal capacity of the East and West regions being modelled.[2] The annual tonnage and per ton cost of each facility is listed below:

	Annual Tonnage	Cost per ton
Claremont	14,000	70
Vicon	30,000	75.

The Claremont facility received roughly 23,000 tons from the 13 Vermont municipalities in the Vermont-New Hampshire Project, but this waste included commercial waste, which is not included in this analysis. By estimating the residential portion at roughly 50% of all waste and including 2,500 tons of additional spot tonnage, 14,000 tons is estimated to be sent to the Claremont facility annually. The current tipping fee for members of the Project is about $78 per ton, with spot fees at about $50-$55 per ton. Using these two fees, we have used a rough estimate of $70 per ton as the tipping fee for this facility.

The Vicon facility is permitted to handle about 60,000 tons of waste annually. Using the estimate of 50% residential waste, we have included 30,000 tons of the facility's annual capacity in this analysis. Two estimates of facility's cost when opened made by VTPIRG and DuBois and King were $89 and $85 respectively. However, the spot price, based upon the regional market for waste incineration would be in the $50-$55 range, similar to the Claremont facility. We have therefore adjusted the facility price per ton to $75 to reflect some waste being disposed at this spot market fee.

In addition to displacing some of the capacity of the mixed waste composting facilities, another impact of this change is the increased amount of residue which will be generated by the facilities. While this residue will impact the needed landfill capacity, it will not increase costs because residue disposal costs are included in the per ton costs listed above. Therefore, this analysis assumes that the facility operators will find their own ash landfill capacity and the additional residue tonnage will not be included in the landfill requirements. Ash residue is presently sent to specially designed monofill in Newport, New Hampshire that is owned and operated by the Vermont-New Hampshire Solid Waste Project.

---

[2]Sources used in designing this sensitivity analysis include the following: 1989 Vermont Solid Waste Management Program, Vermont Agency of Natural Resources; Spencer, Robert, "Can a Dormant Incinerator be Recycled ?", Biocycle, March 1990; and data collected from solid waste districts.

Scenario III - Sensitivity C: Use medium technology composting

Each of the scenarios modelled used the same low-technology system where leaf and yard waste is turned every two months using a front-end loader. While this system is cheap, there are a number of disadvantages to its operation: long composting time, low quality product, and large space requirements. Medium technology composting addresses some of these disadvantages.

14. RESULTS OF WASTEPLAN SCENARIO ANALYSIS

This economic analysis of three solid waste systems considers only financial costs. It does not consider other relevant factors such as environmental impacts, siting constraints, and convenience or costs external to the formal system (such as the cost of driving to dropoff collection facilities.) Therefore, results represent only a portion of the total picture involved in developing solid waste plans. The analysis is not intended to develop an optimal plan for the state of Vermont, but rather to analyze the effect of increasing region size on collection systems and solid waste facilities, and on the total systems costs of managing solid wastes. Although determination of the exact regional configuration, size, and number and type of facilities was not a part of this investigation, these results may be helpful in arriving at such decisions.

Three Regional Scenarios

A summary of the results of the cost estimates for each of the three Vermont solid waste management scenarios is presented in Table 14-1. This table is a combination of each of the individual region systems costs which were modelled separately using WastePlan. Therefore, the costs of the 11 regions used in Scenario I (which are actually grouped into 3 WastePlan runs), the 4 regions modelled in Scenario II and the 2 regions modelled in Scenario III were each estimated in their own WastePlan runs and totalled together to arrive at Vermont state totals. The costs of each individual region's recycling, composting and disposal system is listed in Appendix 2, where a more detailed summary table is presented for each scenario and sensitivity analyses. Table 14-1 shows that in Scenario II, where Vermont is divided into four regions, the costs of managing waste in Vermont is lowest ($16.78 million), though only slightly lower than Scenario III ($17.11 million) with two regions. The difference in cost is roughly 2% which should be considered within the margin of error of these results. Therefore choosing a preference between these two options would only be marginally supported by the data. Scenario I has higher costs ($18.00 million). In this case, the difference in costs from Scenario II is about 7%.

Implications concerning the net impact of regionalization in Vermont are somewhat ambiguous. Two different interpretations are possible. One interpretation focuses on Scenario II as a median among alternative plans to regionalize Vermont solid waste planning. Scenario II plans for four regions within the state while Scenario I calls for eleven and Scenario III calls for two. Because the costs of Scenario II are slightly lower, this suggests that there may exist an "optimal" region size between large state-wide plans with one or two regions and individual district plans. Figure 14-1 graphically represents this idea of an optimal point in between two planning extremes.

However, the marginal difference in costs between Scenarios II and III suggests another possible conclusion: Increasing the size of planning regions, once a minimum region size has been achieved, has little impact upon total systems costs because decreases in facility costs and increases in collection costs roughly cancel each other out. Under this interpretation, cost savings from different regional scenarios would be marginal; and other planning factors such as siting, transportation impacts, and administrative structures would become more important.

Clearly "optimal" region sizes exist for all technologies considered. For example, shipping waste to California would clearly result in incredible shipping costs which could not possibly be offset by any saving in facility costs. The question becomes, given the geographic and demographic parameters of Vermont, is there a clearly preferable region size, or is there a range where costs are roughly equal and other non-economic factors will become more important. Closer analysis of the costs of individual components of the solid waste system may help answer this question.

The counteracting effects of collection and facility costs can be seen in Table 14-1. For garbage collection and disposal, the final cost per ton differs by only $2 across all three scenarios. While total costs are nearly constant, however, collection and disposal costs examined separately change greatly as region size varies. Garbage collection costs rise from $30 per ton in Scenario I to $43 per ton in Scenario III, while disposal costs decrease from $50 per ton to $35 per ton.

Because garbage costs are such a large proportion of total waste system costs, the balancing of increases in garbage collection costs against decreases in garbage disposal costs are a significant factor in the stability of overall costs across the three scenarios. This relationship is shown in Figure 14-2 where both collection and facility costs are represented along with total systems costs. As region size increases, the cost of all collection programs increases from $6.86 million in the 11 district scenario to $9.81 million in the 2 region scenario. This corresponds to an increase in per ton costs from $29 to $41. While these costs are escalating, facility costs are declining from $11.15 million to $7.30 million, or $47 to $31 per ton.

TABLE 14-1

ANNUAL SYSTEMS COSTS FOR THREE ALTERNATIVE VERMONT WASTE MANAGEMENT SCENARIOS
(Net Annual Costs - $)

	Scenario I	Scenario II	Scenario III
Collection			
Recycling	1,311,552	1,595,995	1,897,884
Composting	160,373	160,374	172,244
Garbage	5,385,518	6,388,187	7,741,067
Total	6,857,443	8,144,556	9,811,195
Facilities			
Recycling	2,017,251	997,100	841,619
Composting	109,908	109,908	96,226
Garbage	9,018,274	7,532,341	6,362,841
Total	11,145,433	8,639,349	7,300,686
Total System Cost			
Recycling	3,328,803	2,593,095	2,739,503
Composting	270,281	270,282	268,470
Garbage	14,403,792	13,920,528	14,103,908
Total	18,002,876	16,783,905	17,111,881
($ per ton)			
Collection			
Recycling	34	42	49
Composting	28	28	30
Garbage	30	35	43
Total	29	34	41
Facilities			
Recycling	53	26	22
Composting	6	6	5
Garbage	50	42	35
Total	47	36	31
Total System Cost			
Recycling	87	68	71
Composting	15	15	15
Garbage	79	77	78
Total	76	71	72

Note: Costs include Capital Payments and Operations and Maintenance

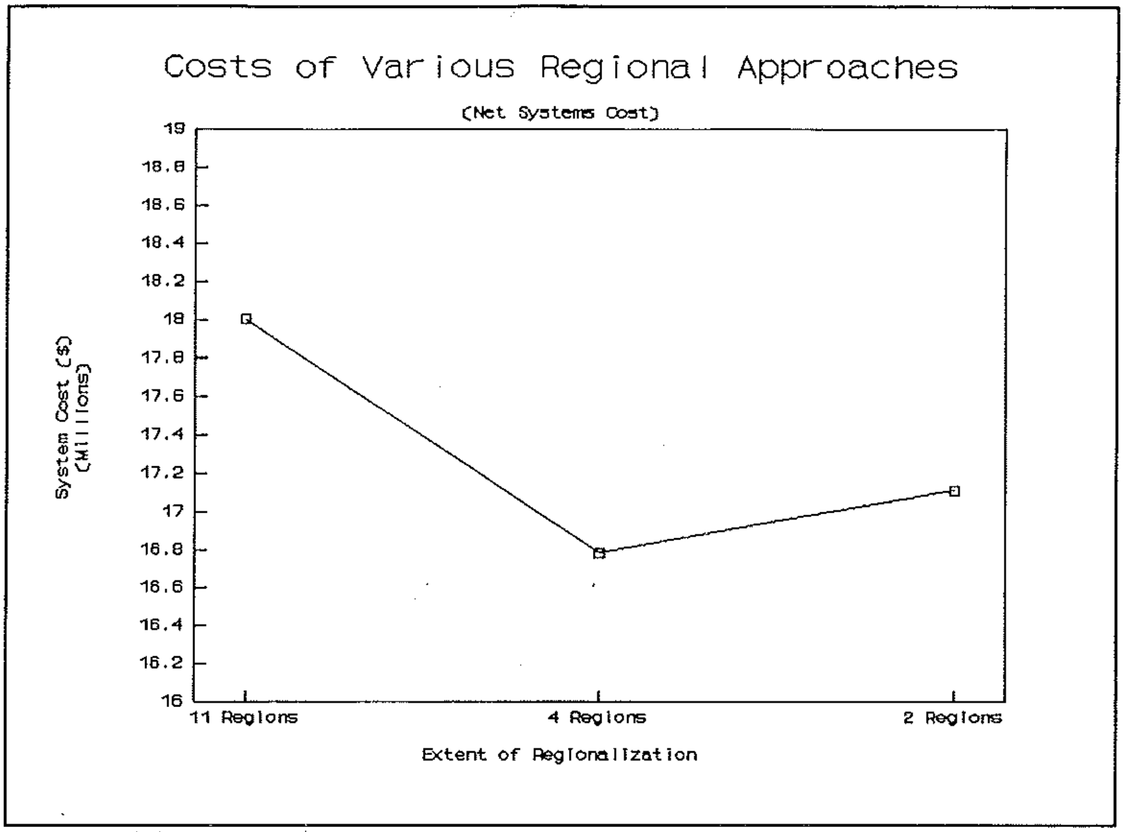


Figure 14-1

Though the direction of collection and facility costs is similar for the recycling system as region size increases, their magnitudes and absolute differences are very different. The recycling collection costs for individual districts in Scenario I is $34/ton. Recycling collection costs increase to $49/ton in the two region Scenario III, a $15/ton difference. Facility costs, however, decrease from $53/ton to $22/ton, a $31/ton difference. This accounts for the fact that the overall recycling program (collection and facility) is $16/ton less expensive in going from Scenario I ($87/ton) to Scenario III ($71/ton).

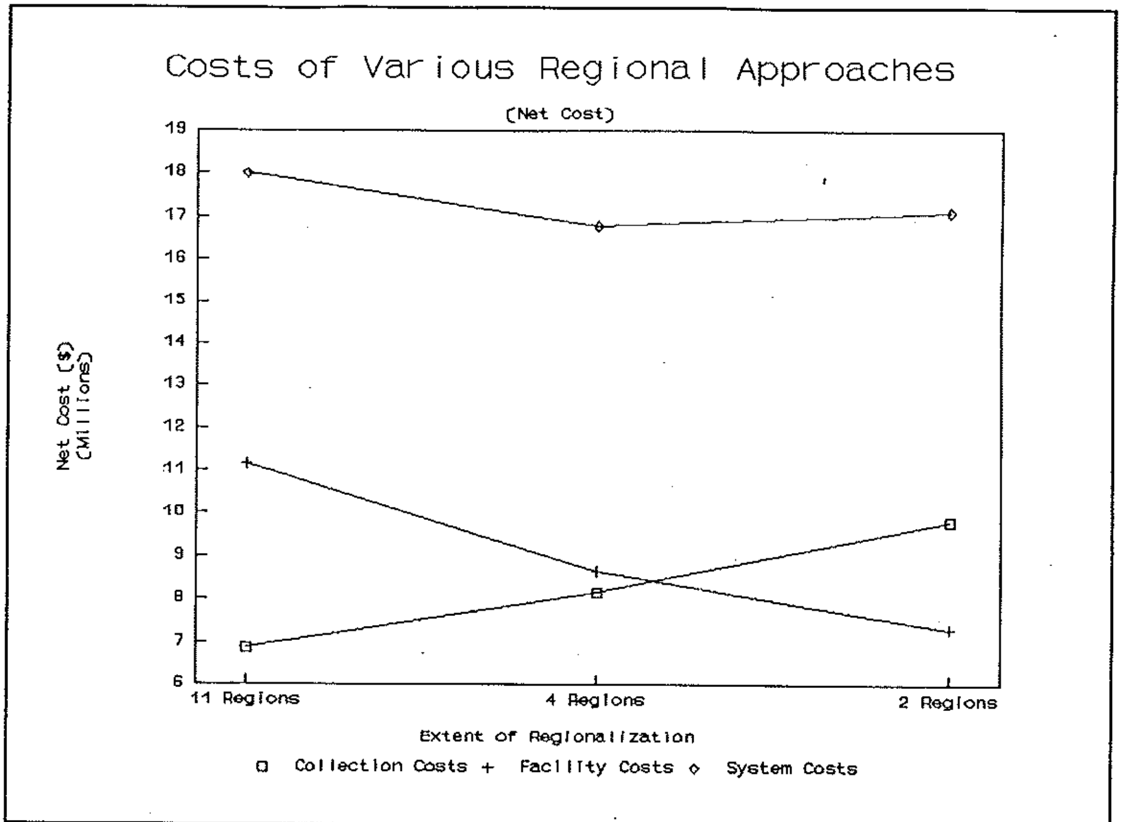


Figure 14-2

Because the costs of garbage collection and disposal is quite similar for all three scenarios, the major difference in total systems costs results from differences in the costs of recycling. There is a small difference ($3 per ton) in recycling costs between Scenarios II and III, which results in about one-half of the minor difference in total cost between the scenarios. However, recycling costs in Scenario I are significantly higher ($87 per ton versus $68 and $71 in Scenario II and III respectively) and are the main cause of the significantly higher systems costs of Scenario I.

Sensitivity Analyses

A summary of results of the sensitivity analyses is presented in Table 14-2. More detailed cost summaries, including costs from individual regions, for each sensitivity analysis is available in Appendix 1. Table 14-2 shows that there were both major and minor impacts to systems costs resulting from the changes made in the sensitivity analyses. The common factor among analyses producing major cost changes was that the parameter being tested involved the garbage collection or disposal system. Analyses where changes were made to recycling or composting systems produced only minor changes in overall systems costs. Sensitivities A and B in Scenarios II and III produced significant cost changes. All three sensitivity analyses for Scenario I, Sensitivity C in Scenario II, and Sensitivity C for Scenario III produced only minor impacts.

Results of the sensitivity analyses are discussed here, beginning with Sensitivity B, which replaced mixed solid waste composting with land disposal for each scenario. Next, analyses showing a major impact are discussed. Finally, we examine those sensitivities analyses where there was little impact.

TABLE 14-2

COMPARISON OF SENSITIVITY ANALYSES

	System Costs ($)	Per Ton Costs ($/ton)
Scenario I	18,002,875	76
A - High Recycle Collect Rate	17,908,572	75
B - Landfill Only	18,577,593	78
C - Lower Recycle Revenues	18,311,257	77
Scenario II	16,783,906	71
A - Long-haul transfer	17,803,762	75
B - Landfill Only	14,574,664	61
C - High Diversion	16,466,261	70
Scenario III	17,111,882	72
A - Existing Incinerators	19,701,017	83
B - Landfill only	14,523,746	61
C - Medium-Tech Compost	17,223,164	72

Replace mixed waste composting with landfill (Sensitivity B)

Changing the disposal system from a mixed waste composting facility with residue disposal at a landfill to a landfill-only system produces different results in the three regional scenarios. Little change in cost is seen in Scenario I, while costs decrease significantly in Scenarios II and III. In Scenarios II and III, there is roughly a $10-$11 difference between the costs of the system with mixed waste composting versus the system with landfills.

Cost differences between the mixed solid waste system and the landfill-only system are strongly influenced by the shape of the cost curve for landfills (see Figure 14-3). Among the facilities analyzed in Phase I, landfill costs exhibit amongst the strongest economies of scale due to the increasing heights that larger sites can achieve. Smaller landfills are disadvantaged because they cannot achieve the same fill depths.

Economies of scale in landfill facilities are important to this sensitivity analysis because mixed solid waste composting systems require landfill disposal of residues (20% of incoming material). Landfills accepting these residues are so small that their unit costs are very high -- $66 and $51 per ton in Scenarios II and III respectively. If residue disposal costs are ignored, costs for mixed waste composting and landfill-only are quite similar (Appendix 1). In Scenario II, mixed waste composting costs are $28 per ton and landfill costs are $29 per ton, while in Scenario III, mixed waste composting is $24 and landfill $21. Consequently, one conclusion from this sensitivity analysis is that mixed waste composting facilities should share residue landfills, thus lowering the per ton cost of residue disposal.

While a landfill-only system is less expensive than mixed-waste composting in Scenarios II and III, systems costs increase slightly (about $2 per ton) when only landfills are used for disposal in Scenario I.

The reason for the slight cost increase is the high cost of the small landfill used in many districts, particularly the seven smaller districts where $67 per ton costs were estimated. In this situation, the significant diseconomies of scale for smaller landfills produces significantly higher costs than landfills for other regions. The larger Chittenden district, for example, has landfill costs of $28 per ton.

Other factors not included in this study should be considered in comparing landfills over mixed waste compost facilities. For example, we have assumed that the final product from the mixed waste compost facility receives no revenue, although it often does have value as a soil amendment or landfill cover. The landfill analysis in Phase II assumes the cost of cover material to be $8 per cubic yard, which translates into roughly $8 per ton of incoming waste if one credits the mixed waste compost with avoiding this, or similar, costs.

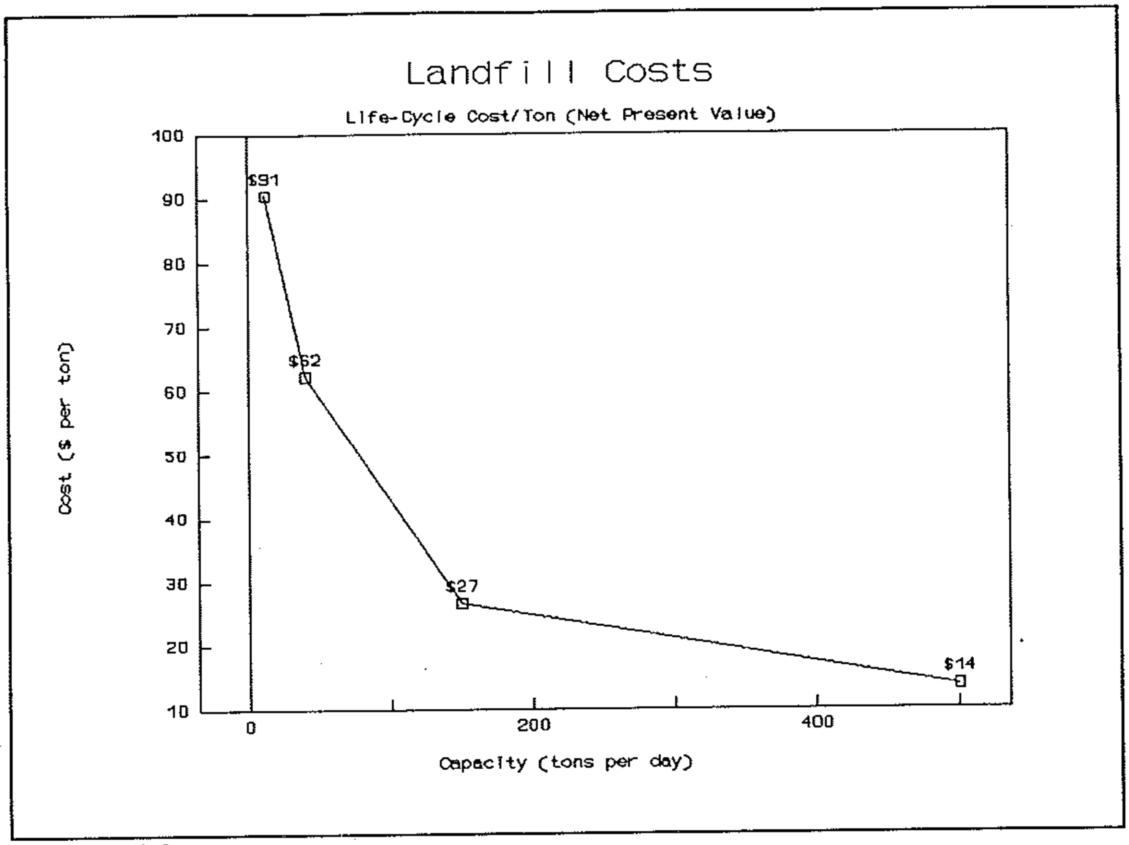


Figure 14-3

Another consideration is that the landfill costs modelled here only represent the engineering costs of landfill and not necessarily the "true costs" of landfills. True costs include environmental impacts, siting impacts, and future, potentially more stringent regulations. With landfills closing and few new ones being sited, many people have begun to look at the true cost of landfilling as incorporating many of these externalities.

Finally, if these scenarios are to represent an approach that meets the Vermont State Act 78 goal of diverting 40% of waste from landfills then mixed waste composting must be used as a component of future solid waste systems. Figure 14-4 shows the total waste diversion from either incineration or landfill produced in the scenarios with and without mixed waste composting. Without mixed waste composting, waste diversion modelled is roughly 25% (60,500 of 242,000 net tons), with recycling accounting for 16% (38,356 tons) and composting 9% (22,060 tons). Even in the scenario with increased diversion, this figure rises to only 31% (76,000 of 242,000 tons).

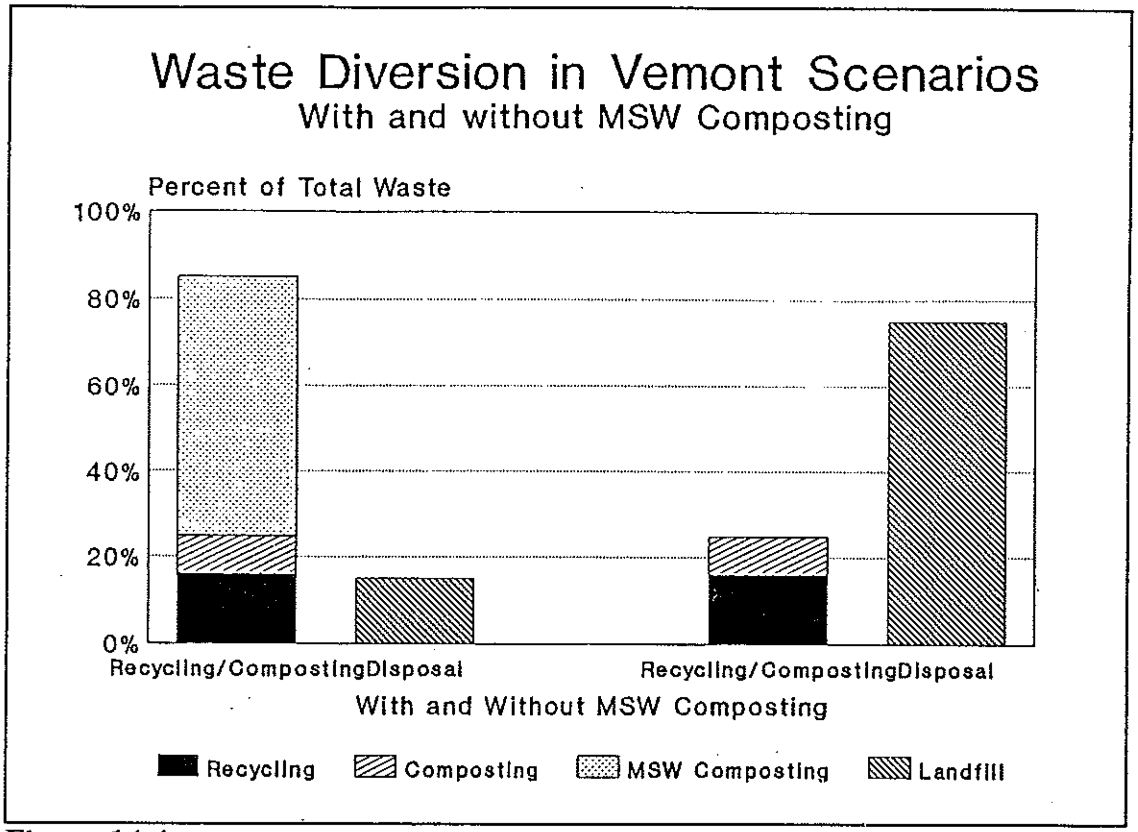


Figure 14-4

However, when mixed waste composting is included in the solid waste system, the diversion rate rises to 85%, which is well above the state goal. The only waste not recycled or composted is residue from the materials recovery facility and mixed waste compost facility, which is roughly 15% of the total initial waste.

Given the assumptions used by this study, there appear to be one of two option for districts to meet the 40% recycling goal. One is to divert more than 40% of the waste from the commercial waste stream which is not modelled here. The increased diversion in the commercial sector will offset the lower diversion in residential sector so the diversion rate for the combined waste stream is 40%. Using our results of 25% diversion from the residential sector and assuming the commercial waste stream is 50% of the entire waste stream, the diversion from the commercial waste stream would have to be 55% if there were no mixed waste composting facilities. This level of diversion from the commercial sector would be very difficult to achieve and would require great cooperation with the district haulers and businesses.

The other option for meeting the 40% goal is to use mixed waste composting for some or all of the residential waste. When all garbage is sent to a mixed waste composting facility, roughly 85% of the total waste is diverted from landfill or incineration. This greatly exceeds the state goal, so mixed waste composting capacity would not necessary have to handle all residential garbage. Assuming 25% diversion from recycling and composting programs, at least 25% of the garbage (or 19% of all waste) would need to be sent to a mixed waste composting facility.

SENSITIVITIES WITH LARGE SYSTEM COST IMPACTS

Scenario II - Long-haul transfer system for delivery of recyclables and waste (Sensitivity A)

The use of long-haul transfer facilities to move materials to the four regional recycling and mixed waste composting facilities increased total systems costs substantially, from $71 per ton to $65 per ton. The increase in costs results solely from increased cost of collection of recyclables and garbage. Table 14-3 shows the net and per ton cost increase to each program. The costs of recycling collection rise from $42 per ton to $46 per ton, while garbage collection rises from $34 to $40 per ton.

Transfer costs varied from region to region depending upon the region's size and the distance to a centrally located regional facility. Recycling transfer costs ranged from about $16 to $20 per ton, while costs for garbage collection ranged from $12 to $15 per ton. Corresponding to the additional transfer costs was a decrease in the cost of curbside service to residents. The decrease averaged $11 per ton across the four regions for recycling collection, and $6 per ton for garbage collection. However, this decrease in collection costs was not enough to offset the increased transfer costs, so total costs went up. The assumption that disposal facilities were centrally located may in practice not be a reality for every region, and therefore the results may be slightly biased against the transfer station.

TABLE 14-3
IMPACT OF LONG HAUL TRANSFER ON COLLECTION COSTS

Recycling		
Total Cost	1,595,995	1,756,773
Cost per Ton	42	46
Garbage		
Total Cost	6,086,402	7,243,700
Cost per Ton	34	40

Scenario III - Include existing incineration capacity (Sensitivity A)

The inclusion of existing waste incineration in the cost analysis results in a large increase in systems costs due to the high costs of the Claremont and Vicon facilities in comparison to mixed waste composting facilities. The $75 and $70 per ton costs of the Vicon and Claremont facilities compare to $34 mixed waste composting costs (including residue disposal) in the base scenario. Including existing incinerators results in a net cost increase of roughly $1.6 million or $11 per ton.

SENSITIVITIES WITH SMALL SYSTEM COSTS IMPACTS

Several of the sensitivities produced marginal impacts. In some cases, there was clearly an increase or decrease in costs, but the total impact was small. In other cases, the changes affected several programs, but again, the overall impact was marginal.

Scenario I - Increased recycling collection efficiency (Sensitivity A)

Increasing the efficiency of recycling collection by 20% has only a minor impact on systems costs. Total costs decreased about $100,000, or less than $1 per ton. The impact on recycling collection costs was relatively small as well, with costs decreasing only about $3 per ton, or about 8% of curbside collection costs (see Appendix 1).

There are two reasons for the minor impact of increasing collection efficiency on total systems costs. First, curbside recycling collection only accounts for about 8% of the total systems costs ($1.2 million of $18 million systems cost), so producing a major cost reduction will require these costs to be changed substantially by a much larger % increase in collection efficiency. In this case, the curbside costs only declined 8%, so the total impact was of the order of 0.6%.

Even the impact on recycling collection costs was relatively small considering the increases in efficiency were only 20% (increase from 100 to 120 households per hour in urban areas, and 80 to 95 in suburban). Some of the impact of increasing efficiency is diluted by the other major time expenditure of collection crews - driving to and dumping materials at the recycling (or other solid waste) facility. Though increased efficiency reduces the time on the route, the number of loads needing transport to the facility and the time required to transport them is not affected.

Scenario I - Decreased Recyclable Revenues (Sensitivity C)

Decreasing the price received for the sale of recyclable materials increases the cost of the recycling depots but has only a minor impact upon system costs. The decrease in revenues is roughly $300,000 or $8 per ton at the recycling depot. While the impact upon the recycling depot is substantial, the resulting impact upon the solid waste system is small because of the small fraction of total costs accounted for by the recycling depot. The depots comprise only about 11% of total costs in the base case and roughly 13% when revenues are decreased (see Appendix 1).

Scenario II - Increased Material Diversion (Sensitivity C)

Increasing the amount of waste diverted by recycling and leaf and yard waste programs has only a minimal impact on lowering total systems costs because decreases in garbage collection and disposal (avoided costs) are offset by increases in the cost of collecting and processing diverted material. The total amount of waste diverted by the increase in participation rates (see Appendix 1 for a summary of these increases) is substantial -- 16,495 in total (9% additional diversion from 181,345 tons) with 9,360 coming from recycling and 7,135 from composting.

The results of increasing diversion rates are summarized in Table 14-4. The table shows that there is only a small impact on total costs, though the costs of individual programs vary greatly. For example, the recycling depot costs decrease $6 per ton, while recycling collection costs decrease $3 per ton. The recycling program handles an additional 9,360 tons of material with an increase in costs of only $255,000 -- a marginal cost of only $27 per ton for each additional ton recycled! Similar low marginal costs exist for composting, which has a marginal cost of about $7 per ton.

However, these savings made through recycling and compost programs are offset by increases in per ton costs of garbage collection and disposal. There is a net cost savings of about $625,000 for handling 16,495 tons less waste - a marginal cost of about $38 per ton. Because the marginal costs of garbage collection are higher than recycling and composting marginal costs, there is a net saving to the system. For each additional ton of recyclables collected, there is a savings of roughly $11 per ton ($38 minus $27) and for each additional ton of compost, a savings of about $31 per ton ($38 minus $7). This savings accrue only on additional tons diverted through increased participation rates and not for all waste recycled and composted. Therefore, the total impact on the systems costs is not substantial. However, this also means that if this cost structure holds it will always be economically advantageous to increase the amount of materials recycled or composted in source separation programs.

TABLE 14-4
SCENARIO II - SENSITIVITY C
Increased Recycling and Compost Diversion

	Scenario II	Increased Diversion
Collection		
Recycling	1,595,995	1,879,913
Composting	160,374	194,717
Garbage	6,388,187	6,077,007
Facilities		
Recycling	997,100	968,689
Composting	109,908	129,959
Garbage	7,532,341	7,215,976
Total System Cost		
Recycling	2,593,095	2,848,602
Composting	270,282	324,676
Garbage	13,920,528	13,292,982
Total	16,783,905	16,466,261
	($ per ton)	
Collection		
Recycling	42	39
Composting	28	32
Garbage	35	37
Facilities		
Recycling	26	20
Composting	6	6
Garbage	42	44
Total System Cost		
Recycling	68	60
Composting	15	15
Garbage	77	81
Total	71	70

In comparison to the average program costs (see Table 14-4), the marginal costs of additional recycling, composting, and disposal are much lower. This is another way of representing the economies of scale that have been documented for the solid waste facilities. Because the average costs are decreasing as size increases, the cost of each additional ton must be substantially lower than the costs of all previous tons. If economies of scale did not exist, then marginal costs and average costs would be roughly equal.

Scenario III - Use medium-technology composting (Sensitivity C)

Composting facility costs comprise a relatively small portion of total costs and therefore the impact of this change in technology produced almost no change in systems costs. However, the costs of the composting facility did increase $6 per ton, resulting in about a $110,000 net cost increase.

SENSITIVITY OF COSTS TO FACILITY AND PROGRAM ESTIMATES

The systems cost estimates developed in this report depend heavily upon the accuracy of estimates developed in Part A. These facility and program estimates in turn depend upon a large number of assumptions about the type of technology used, labor efficiency, facility reliability, and specific characteristics of the collection programs and facilities. The accuracy of these estimates is only as good as the assumptions and should not be used as a substitute for developing cost estimates specific to the context of a specific region and program.

TABLE 14-5

SENSITIVITY TO MSW COMPOSTING COST
(not including residue disposal cost)

	System Costs ($)	Per Ton Costs ($/ton)	Percentage Change
Scenario I			
+ 15%	18,882,651	79	4.9%
Base	18,002,875	76	
- 15%	17,123,099	72	-5.1%
Scenario II			
+ 15%	17,539,417	74	4.5%
Base	16,783,906	71	
- 15%	16,028,395	67	-4.7%
Scenario III			
+ 15%	17,756,604	75	3.8%
Base	17,111,882	72	
- 15%	16,467,160	69	-3.9%

To illustrate the sensitivity of the total systems costs to these estimates, in Table 14-5, the costs of mixed waste composting facilities have been increased and decreased 15% to determine the impact upon system costs. This 15% figure represents a reasonable estimate of the range of uncertainty that can be expected from estimates such as these. The mixed waste composting costs analyzed only include the facility costs and do not include residue disposal, a substantial part of the entire facility's costs.

As seen from Table 14-5, the sensitivity of system costs to the accuracy of only one facility cost estimate ranges from about 4% to 5%. These results are graphically depicted in Figure 14-5. Though the range of certainty of most systems will not produce such large differences, the combination of differences for several programs or facilities could be significant. Uncertainty in costs for landfills alone will result in a large potential range in systems costs for scenarios where landfilling is the sole source of disposal. When using the data in this report these issues should be seriously considered.

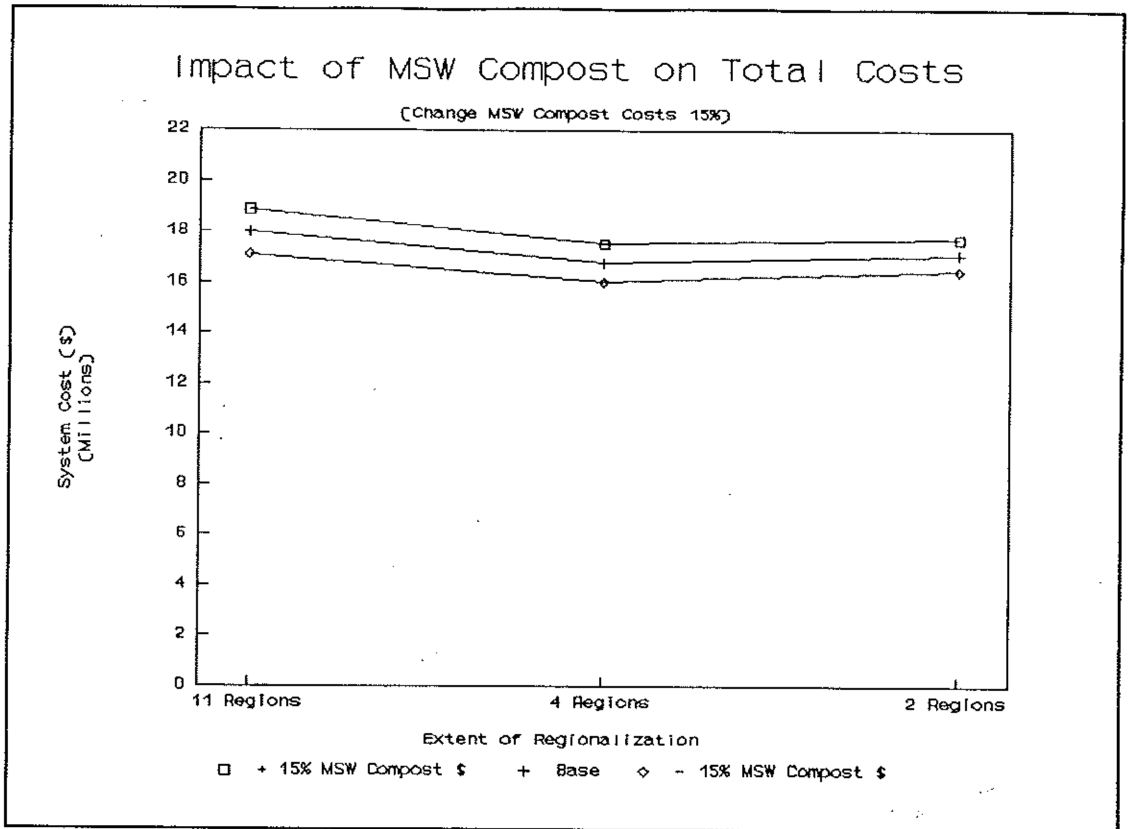

Impact of MSW Compost on Total Costs
(Change MSW Compost Costs 15%)
System Cost ($)
(Millions)
22
20
18
16
14
12
10
8
6
4
2
0
11 Regions
4 Regions
2 Regions
Extent of Regionalization
+ 15% MSW Compost $
Base
- 15% MSW Compost $

Figure 14-5

APPENDIX 1

Systems Cost Summaries for Scenarios and Sensitivity Analyses

LIFECYCLE SYSTEM COST ANALYSIS   SCENARIO I - Sensitivity A -- Increased Reycling Collection Efficiency

1. NET COSTS (dollars per year)	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	240,424	407,467	494,229	1,142,119
Recycling Depot	193,523	580,855	1,242,873	2,017,251
Single-Family Satellite Collection	7,644	21,770	45,715	75,129
COMPOSTING				
Paper Bag Compost Collection	50,690	52,380	57,303	160,373
Compost Facility	25,979	38,352	45,577	109,908
GARBAGE				
Single-Family Garbage Collection	835,341	1,499,165	1,843,872	4,178,378
(Rural Transfer Station)	186,380	450,360	570,400	1,207,140
RESOURCE RECOVERY				
Mixed Waste Composting Facility	1,199,072	2,002,169	2,663,929	5,865,171
LANDFILL				
Existing Landfill Facility	602,385	1,124,916	1,425,802	3,153,103
TOTAL SYSTEM COSTS	3,341,438	6,177,434	8,389,699	17,908,572
2. WEIGHTS (tons per year)				
RECYCLING				
Single-Family Commingled Collection	8,285	9,909	11,142	29,336
Recycling Depot	9,648	13,222	15,486	38,356
Single-Family Satellite Collection	1,363	3,313	4,344	9,020
COMPOSTING				
Backyard Compost Collection	908	1,322	1,573	3,803
Dropoff Compost Collection	1,962	4,609	5,875	12,446
Paper Bag Compost Collection	2,398	1,736	1,676	5,810
Compost Facility	4,360	6,346	7,551	18,257
GARBAGE				
Single-Family Garbage Collection	33,505	40,622	46,860	120,987
Rural Transfer Station	9,319	22,518	28,520	60,357
RESOURCE RECOVERY				
Mixed Waste Composting Facility	42,824	63,140	75,380	181,344
LANDFILL				
Existing Landfill Facility	8,951	13,157	15,696	37,804
TOTAL SYSTEM WEIGHTS	56,833	82,707	98,417	237,957
3. COST PER TON				
RECYCLING				
Single-Family Commingled Collection	32	46	49	39
Recycling Depot	20	44	80	53
Single-Family Satellite Collection	6	7	11	8
COMPOSTING				
Paper Bag Compost Collection	22	31	35	28
Compost Facility	5	5	5	6
GARBAGE				
Single-Family Garbage Collection	25	37	39	35
Rural Transfer Station	20	20	20	20
RESOURCE RECOVERY				
Mixed Waste Composting Facility	28	32	35	32
LANDFILL				
Existing Landfill Facility	67	86	95	83
SYSTEM COST PER TON	59	75	85	75

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO I - 11 Vermont Regions (Solid Waste Districts)

1. NET COSTS (dollars per year)	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	259,817	445,127	531,479	1,236,423
Recycling Depot	193,523	580,855	1,242,873	2,017,251
Single-Family Satellite Collection	7,644	21,770	45,715	75,129
COMPOSTING				
Paper Bag Compost Collection	50,690	52,380	57,303	160,373
Compost Facility	25,979	38,352	45,577	109,908
GARBAGE				
Single-Family Garbage Collection	835,341	1,499,165	1,843,872	4,178,378
(Rural Transfer Station)	186,380	450,360	570,400	1,207,140
RESOURCE RECOVERY				
Mixed Waste Composting Facility	1,199,072	2,002,169	2,663,929	5,865,171
LANDFILL				
Existing Landfill Facility	602,385	1,124,916	1,425,802	3,153,103
TOTAL SYSTEM COSTS	3,360,831	6,215,095	8,426,949	18,002,875

2. WEIGHTS (tons per year)	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	8,285	9,909	11,142	29,336
Recycling Depot	9,648	13,222	15,486	38,356
Single-Family Satellite Collection	1,363	3,313	4,344	9,020
COMPOSTING				
Backyard Compost Collection	908	1,322	1,573	3,803
Dropoff Compost Collection	1,962	4,609	5,875	12,446
Paper Bag Compost Collection	2,398	1,736	1,676	5,810
Compost Facility	4,360	6,346	7,551	18,257
GARBAGE				
Single-Family Garbage Collection	33,505	40,622	46,860	120,987
Rural Transfer Station	9,319	22,518	28,520	60,357
RESOURCE RECOVERY				
Mixed Waste Composting Facility	42,824	63,140	75,380	181,344
LANDFILL				
Existing Landfill Facility	8,951	13,157	15,696	37,804
TOTAL SYSTEM WEIGHTS	56,833	82,707	98,417	237,957

3. COST PER TON	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	32	46	49	42
Recycling Depot	20	44	80	53
Single-Family Satellite Collection	6	7	11	8
COMPOSTING				
Paper Bag Compost Collection	22	31	35	28
Compost Facility	5	5	5	6
GARBAGE				
Single-Family Garbage Collection	25	37	39	35
Rural Transfer Station	20	20	20	20
RESOURCE RECOVERY				
Mixed Waste Composting Facility	28	32	35	32
LANDFILL				
Existing Landfill Facility	67	86	95	83
SYSTEM COST PER TON	59	75	86	76

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO I - Sensitivity B -- Landfill Only

1. NET COSTS (dollars per year)	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	259,817	445,127	531,479	1,236,423
Recycling Depot	193,523	580,855	1,242,873	2,017,251
Single-Family Satellite Collection	7,644	21,770	45,715	75,129
COMPOSTING				
Paper Bag Compost Collection	50,690	52,380	57,303	160,373
Compost Facility	25,979	38,352	45,577	109,908
GARBAGE				
Single-Family Garbage Collection	835,341	1,499,165	1,843,872	4,178,378
(Rural Transfer Station)	186,380	450,360	570,400	1,207,140
LANDFILL				
Existing Landfill Facility	1,205,067	3,314,850	5,073,074	9,592,991
TOTAL SYSTEM COSTS	2,764,442	6,402,859	9,410,292	18,577,593

2. WEIGHTS (tons per year)	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	8,285	9,909	11,142	29,336
Recycling Depot	9,648	13,222	15,486	38,356
Single-Family Satellite Collection	1,363	3,313	4,344	9,020
COMPOSTING				
Backyard Compost Collection	908	1,322	1,573	3,803
Dropoff Compost Collection	1,962	4,609	5,875	12,446
Paper Bag Compost Collection	2,398	1,736	1,676	5,810
Compost Facility	4,360	6,346	7,551	18,257
GARBAGE				
Single-Family Garbage Collection	33,505	40,622	46,860	120,987
Rural Transfer Station	9,319	22,518	28,520	60,357
LANDFILL				
Existing Landfill Facility	42,824	63,140	75,380	181,344
TOTAL SYSTEM WEIGHTS	56,833	82,707	98,417	237,957

3. COST PER TON	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	32	46	49	42
Recycling Depot	20	44	80	53
Single-Family Satellite Collection	6	7	11	8
COMPOSTING				
Paper Bag Compost Collection	22	31	35	28
Compost Facility	5	5	5	6
GARBAGE				
Single-Family Garbage Collection	25	37	39	35
Rural Transfer Station	20	20	20	20
LANDFILL				
Existing Landfill Facility	28	53	67	53
SYSTEM COST PER TON	49	77	96	78

LIFECYCLE SYSTEM COST ANALYSIS   SCENARIO I - Sensitivity C - Decreased Material Revenues

1. NET COSTS (dollars per year)	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	259,817	445,127	531,479	1,236,423
Recycling Depot	271,193	687,136	1,367,303	2,325,632
Single-Family Satellite Collection	7,644	21,770	45,715	75,129
COMPOSTING				
Paper Bag Compost Collection	50,690	52,380	57,303	160,373
Compost Facility	25,979	38,352	45,577	109,908
GARBAGE				
Single-Family Garbage Collection	835,341	1,499,165	1,843,872	4,178,378
(Rural Transfer Station)	186,380	450,360	570,400	1,207,140
RESOURCE RECOVERY				
Mixed Waste Composting Facility	1,199,072	2,002,169	2,663,929	5,865,171
LANDFILL				
Existing Landfill Facility	602,385	1,124,916	1,425,802	3,153,103
TOTAL SYSTEM COSTS	3,438,502	6,321,375	8,551,380	18,311,257

2. WEIGHTS (tons per year)	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	8,285	9,909	11,142	29,336
Recycling Depot	9,648	13,222	15,486	38,356
Single-Family Satellite Collection	1,363	3,313	4,344	9,020
COMPOSTING				
Backyard Compost Collection	908	1,322	1,573	3,803
Dropoff Compost Collection	1,962	4,609	5,875	12,446
Paper Bag Compost Collection	2,398	1,736	1,676	5,810
Compost Facility	4,360	6,346	7,551	18,257
GARBAGE				
Single-Family Garbage Collection	33,505	40,622	46,860	120,987
Rural Transfer Station	9,319	22,518	28,520	60,357
RESOURCE RECOVERY				
Mixed Waste Composting Facility	42,824	63,140	75,380	181,344
LANDFILL				
Existing Landfill Facility	8,951	13,157	15,696	37,804
TOTAL SYSTEM WEIGHTS	56,833	82,707	98,417	237,957

3. COST PER TON	Chittendon	Central Rutland North East	7 other districts	Vermont Total
RECYCLING				
Single-Family Commingled Collection	32	46	49	42
Recycling Depot	28	52	88	61
Single-Family Satellite Collection	6	7	11	8
COMPOSTING				
Paper Bag Compost Collection	22	31	35	28
Compost Facility	5	5	5	6
GARBAGE				
Single-Family Garbage Collection	25	37	39	35
Rural Transfer Station	20	20	20	20
RESOURCE RECOVERY				
Mixed Waste Composting Facility	28	32	35	32
LANDFILL				
Existing Landfill Facility	67	86	95	83
SYSTEM COST PER TON	61	76	87	77

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO II - 4 Vermont Regions

1. NET COSTS (dollars per year)	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	371,279	390,719	313,440	426,137	1,501,574
Recycling Depot	245,605	221,107	277,443	252,945	997,100
Single-Family Satellite Collection	25,866	20,249	26,328	21,978	94,421
COMPOSTING					
Paper Bag Compost Collection	32,975	61,026	22,652	43,721	160,374
Compost Facility	29,766	34,739	20,290	25,113	109,908
GARBAGE					
Single-Family Garbage Collection	1,231,658	1,301,368	1,040,078	1,306,158	4,879,262
Rural Transfer Station	555,575	344,725	364,300	244,325	1,508,925
RESOURCE RECOVERY					
Mixed Waste Composting Facility	1,375,861	1,519,739	978,813	1,162,325	5,036,739
LANDFILL					
Existing Landfill Facility	646,722	720,837	535,227	592,816	2,495,602
TOTAL SYSTEM COSTS	4,515,307	4,614,509	3,578,571	4,075,518	16,783,906

2. WEIGHTS (tons per year)	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	6,696	10,447	4,520	7,674	29,337
Recycling Depot	9,992	12,530	6,683	9,151	38,356
Single-Family Satellite Collection	3,296	2,083	2,163	1,477	9,019
COMPOSTING					
Backyard Compost Collection	1,041	1,196	694	871	3,802
Dropoff Compost Collection	3,977	3,027	2,794	2,649	12,447
Paper Bag Compost Collection	1,022	2,716	538	1,534	5,810
Compost Facility	4,998	5,743	3,332	4,183	18,256
GARBAGE					
Single-Family Garbage Collection	27,936	42,791	18,846	31,415	120,988
Rural Transfer Station	22,223	13,789	14,572	9,773	60,357
RESOURCE RECOVERY					
Mixed Waste Composting Facility	50,159	56,580	33,418	41,188	181,345
LANDFILL					
Existing Landfill Facility	10,431	11,817	6,951	8,848	38,047
TOTAL SYSTEM WEIGHTS	65,149	74,853	43,433	54,522	237,957

3. COST PER TON	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	55	37	69	56	51
Recycling Depot	25	18	42	28	26
Single-Family Satellite Collection	8	10	12	15	10
COMPOSTING					
Paper Bag Compost Collection	32	22	42	29	28
Compost Facility	6	6	6	6	6
GARBAGE					
Single-Family Garbage Collection	44	30	55	42	40
Rural Transfer Station	25	25	25	25	25
RESOURCE RECOVERY					
Mixed Waste Composting Facility	27	27	29	28	28
LANDFILL					
Existing Landfill Facility	62	61	77	67	66
SYSTEM COST PER TON	69	62	82	75	71

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO B - Sensitivity A -- Bulk Transfer of Garbage and Recyclables

1. NET COSTS (dollars per year)	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	303,615	336,297	231,221	302,055	1,173,188
Recycling Depot	245,605	221,107	277,443	252,945	997,100
Single-Family Satellite Collection	25,866	20,249	26,328	21,978	94,421
(Recycling Transfer)	125,500	123,300	106,393	133,971	489,164
COMPOSTING					
Paper Bag Compost Collection	32,975	61,026	22,652	43,721	160,374
Compost Facility	29,766	34,739	20,290	25,113	109,908
GARBAGE					
Single-Family Garbage Collection	1,061,520	1,165,397	812,737	1,038,428	4,078,082
(Rural Transfer Station)	444,460	275,780	291,440	195,460	1,207,140
(Long-haul Transfer)	502,393	552,221	407,432	496,432	1,958,478
RESOURCE RECOVERY					
Mixed Waste Composting Facility	1,375,861	1,519,739	978,813	1,162,325	5,036,739
LANDFILL					
Existing Landfill Facility	649,255	716,357	538,069	595,488	2,499,169
TOTAL SYSTEM COSTS	4,796,816	5,026,211	3,712,818	4,267,917	17,803,762
2. WEIGHTS (tons per year)					
RECYCLING					
Single-Family Commingled Collection	6,696	10,447	4,520	7,674	29,337
Recycling Depot	9,992	12,530	6,683	9,151	38,356
Single-Family Satellite Collection	3,296	2,083	2,163	1,477	9,019
COMPOSTING					
Backyard Compost Collection	1,041	1,196	694	871	3,802
Dropoff Compost Collection	3,977	3,027	2,794	2,649	12,447
Paper Bag Compost Collection	1,022	2,716	538	1,534	5,810
Compost Facility	4,998	5,743	3,332	4,183	18,256
GARBAGE					
Single-Family Garbage Collection	27,936	42,791	18,846	31,415	120,988
Rural Transfer Station	22,223	13,789	14,572	9,773	60,357
RESOURCE RECOVERY					
Mixed Waste Composting Facility	50,159	56,580	33,418	41,188	181,345
LANDFILL					
Existing Landfill Facility	10,431	11,817	6,951	8,848	38,047
TOTAL SYSTEM WEIGHTS	65,149	74,853	43,433	54,522	237,957
3. COST PER TON					
RECYCLING					
Single-Family Commingled Collection	45	32	51	39	40
Recycling Depot	25	18	42	28	26
Single-Family Satellite Collection	8	10	12	15	10
COMPOSTING					
Paper Bag Compost Collection	32	22	42	29	28
Compost Facility	6	6	6	6	6
GARBAGE					
Single-Family Garbage Collection	38	27	43	33	34
Rural Transfer Station	20	20	20	20	20
RESOURCE RECOVERY					
Mixed Waste Composting Facility	27	27	29	28	28
LANDFILL					
Existing Landfill Facility	62	61	77	67	66
SYSTEM COST PER TON	74	67	85	78	75

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO II - Sensitivity B -- Landfill Only

1. NET COSTS (dollars per year)	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	371,279	390,719	313,440	426,137	1,501,574
Recycling Depot	245,605	221,107	277,443	252,945	997,100
Single-Family Satellite Collection	25,866	20,249	26,328	21,978	94,421
COMPOSTING					
Paper Bag Compost Collection	32,975	61,026	22,652	43,721	160,374
Compost Facility	29,766	34,739	20,290	25,113	109,908
GARBAGE					
Single-Family Garbage Collection	1,231,658	1,301,368	1,040,078	1,306,158	4,879,262
Rural Transfer Station	555,575	344,725	364,300	244,325	1,508,925
LANDFILL					
Existing Landfill Facility	1,293,099	1,416,763	1,320,345	1,292,891	5,323,099
TOTAL SYSTEM COSTS	3,785,823	3,790,697	3,384,876	3,613,268	14,574,664

2. WEIGHTS (tons per year)	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	6,696	10,447	4,520	7,674	29,337
Recycling Depot	9,992	12,530	6,683	9,151	38,356
Single-Family Satellite Collection	3,296	2,083	2,163	1,477	9,019
COMPOSTING					
Backyard Compost Collection	1,041	1,196	694	871	3,802
Dropoff Compost Collection	3,977	3,027	2,794	2,649	12,447
Paper Bag Compost Collection	1,022	2,716	538	1,534	5,810
Compost Facility	4,998	5,743	3,332	4,183	18,256
GARBAGE					
Single-Family Garbage Collection	27,936	42,791	18,846	31,415	120,988
Rural Transfer Station	22,223	13,789	14,572	9,773	60,357
LANDFILL					
Existing Landfill Facility	50,159	56,580	33,418	41,188	181,345
TOTAL SYSTEM WEIGHTS	65,149	74,853	43,433	54,522	237,957

3. COST PER TON	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collectionle	55	37	69	56	51
Recycling Depot	25	18	42	28	26
Single-Family Satellite Collection	8	10	12	15	10
COMPOSTING					
Paper Bag Compost Collection	32	22	42	29	28
Compost Facility	6	6	6	6	6
GARBAGE					
Single-Family Garbage Collection	44	30	55	42	40
Rural Transfer Station	25	25	25	25	25
LANDFILL					
Existing Landfill Facility	26	25	40	31	29
SYSTEM COST PER TON	58	51	78	66	61

LIFECYCLE SYSTEM COST ANALYSIS   SCENARIO II - Sensitivity C -- Increased Recycling and Compost Diversion

1. NET COSTS (dollars per year)	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	429,876	473,453	365,530	503,405	1,772,264
Recycling Depot	230,961	232,110	273,277	232,341	968,689
Single-Family Satellite Collection	29,951	22,401	30,572	24,725	107,649
COMPOSTING					
Paper Bag Compost Collection	39,141	75,369	26,838	53,370	194,717
Compost Facility	37,210	39,445	25,363	27,941	129,959
GARBAGE					
Single-Family Garbage Collection	1,217,836	1,289,219	1,026,526	1,290,501	4,824,082
Rural Transfer Station	469,950	277,425	307,500	198,050	1,252,925
RESOURCE RECOVERY					
Mixed Waste Composting Facility	1,268,115	1,417,061	901,536	1,085,789	4,672,501
LANDFILL					
Existing Landfill Facility	683,256	737,002	512,627	610,589	2,543,474
TOTAL SYSTEM COSTS	4,406,296	4,563,486	3,469,769	4,026,711	16,466,261

2. WEIGHTS (tons per year)	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	8,124	12,674	5,484	9,310	35,592
Recycling Depot	12,555	15,474	8,391	11,296	47,716
Single-Family Satellite Collection	4,431	2,800	2,907	1,986	12,124
COMPOSTING					
Backyard Compost Collection	2,083	2,393	1,388	1,743	7,607
Dropoff Compost Collection	4,971	3,783	3,492	3,311	15,557
Paper Bag Compost Collection	1,277	3,395	673	1,917	7,262
Compost Facility	6,248	6,521	4,165	4,654	21,588
GARBAGE					
Single-Family Garbage Collection	26,508	40,564	17,882	29,779	114,733
Rural Transfer Station	18,798	11,097	12,300	7,922	50,117
RESOURCE RECOVERY					
Mixed Waste Composting Facility	45,306	51,661	30,182	37,701	164,850
LANDFILL					
Existing Landfill Facility	9,715	10,951	6,372	7,992	35,030
TOTAL SYSTEM WEIGHTS	64,108	73,656	43,433	53,651	234,848

3. COST PER TON	NorthEast	NorthWest	SouthEast	SouthWest	Vermont Total
RECYCLING					
Single-Family Commingled Collection	53	37	67	54	50
Recycling Depot	18	15	33	21	20
Single-Family Satellite Collection	7	8	11	12	9
COMPOSTING					
Paper Bag Compost Collection	31	22	40	28	27
Compost Facility	6	6	6	6	6
GARBAGE					
Single-Family Garbage Collection	46	32	57	43	44
Rural Transfer Station	25	25	25	25	25
RESOURCE RECOVERY					
Mixed Waste Composting Facility	28	27	30	29	28
LANDFILL					
Existing Landfill Facility	70	67	80	76	73
SYSTEM COST PER TON	69	62	80	75	70

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO III - 2 Vermont Regions

1. NET COSTS (dollars per year)

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	523,607	643,609	1,167,216
Commingled Facility	439,220	402,399	841,619
Single-Family Satellite Collection	36,188	33,341	69,529
(Recycling Transfer)	300,150	360,989	661,139
COMPOSTING			
Paper Bag Compost Collection	58,814	113,430	172,244
Compost Facility	50,056	46,170	96,226
GARBAGE			
Single-Family Garbage Collection	1,910,347	2,253,764	4,164,111
(Rural Transfer Stations)	735,900	471,240	1,207,140
(Long-haul Transfer Stations)	1,092,184	1,277,632	2,369,816
RESOURCE RECOVERY			
Mixed Waste Composting	2,036,771	2,261,374	4,298,145
LANDFILL			
Existing Landfill Facility	994,888	1,069,809	2,064,696
TOTAL SYSTEM COSTS	8,178,125	8,933,757	17,111,882

2. WEIGHTS (tons per year)

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	11,216	18,120	29,336
Commingled Facility	16,675	21,681	38,356
Single-Family Satellite Collection	5,459	3,561	9,020
COMPOSTING			
Backyard Compost Collection	1,736	2,068	3,804
Dropoff Compost Collection	6,771	5,676	12,447
Paper Bag Compost Collection	1,560	4,250	5,810
Compost Facility	8,331	9,926	18,257
GARBAGE			
Single-Family Garbage Collection	46,782	74,206	120,988
Rural Transfer Station	36,795	23,562	60,357
RESOURCE RECOVERY			
Mixed Waste Composting Facility	83,577	97,768	181,345
LANDFILL			
Existing Landfill Facility	18,383	21,722	40,105
TOTAL SYSTEM WEIGHTS	108,582	129,375	237,957

3. COST PER TON

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	47	36	40
Commingled Facility	26	19	22
Single-Family Satellite Collection	7	9	8
(Recycling Transfer Stations)	18	17	17
COMPOSTING			
Paper Bag Compost Collection	38	27	30
Compost Facility	6	5	5
GARBAGE			
Single-Family Garbage Collection	41	30	34
Rural transfer stations	20	20	20
(Long-haul Transfer Stations)	23	17	20
RESOURCE RECOVERY			
Mixed Waste Composting Facility	24	23	24
LANDFILL			
Existing Landfill Facility	54	49	51
SYSTEM COST PER TON	75	69	72

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO III - Sensitivity A -- Include Existing Waste to Energy

	EAST	WEST	VERMONT TOTALS
1. NET COSTS (dollars per year)			
RECYCLING			
Single-Family Commingled Collection	523,607	643,609	1,167,216
Commingled Facility	439,220	402,399	841,619
Single-Family Satellite Collection	36,188	33,341	69,529
(Recycling Transfer)	300,150	360,989	661,139
COMPOSTING			
Paper Bag Compost Collection	58,814	113,430	172,244
Compost Facility	50,056	46,170	96,226
GARBAGE			
Single-Family Garbage Collection	1,910,347	2,253,764	4,164,111
(Rural Transfer Stations)	735,900	471,240	1,207,140
(Long-haul Transfer Stations)	1,092,184	1,277,632	2,369,816
RESOURCE RECOVERY			
Mixed Waste Composting	1,955,114	1,919,867	3,874,981
Existing Waste to Energy	980,000	2,250,000	3,230,000
LANDFILL			
Existing Landfill Facility	919,397	927,598	1,846,995
TOTAL SYSTEM COSTS	9,000,977	10,700,040	19,701,017
2. WEIGHTS (tons per year)			
RECYCLING			
Single-Family Commingled Collection	11,216	18,120	29,336
Commingled Facility	16,675	21,681	38,356
Single-Family Satellite Collection	5,459	3,561	9,020
COMPOSTING			
Backyard Compost Collection	1,736	2,068	3,804
Dropoff Compost Collection	6,771	5,676	12,447
Paper Bag Compost Collection	1,560	4,250	5,810
Compost Facility	8,331	9,926	18,257
GARBAGE			
Single-Family Garbage Collection	46,782	74,206	120,988
Rural Transfer Station	36,795	23,562	60,357
RESOURCE RECOVERY			
Mixed Waste Composting Facility	69,577	67,768	137,345
Existing Waste to Energy	14,000	30,000	44,000
LANDFILL			
Existing Landfill Facility	15,583	15,722	31,305
TOTAL SYSTEM WEIGHTS	108,582	129,375	237,957
3. COST PER TON			
RECYCLING			
Single-Family Commingled Collection	47	36	40
Commingled Facility	26	19	22
Single-Family Satellite Collection	7	9	8
(Recycling Transfer Stations)	18	17	17
COMPOSTING			
Paper Bag Compost Collection	38	27	30
Compost Facility	6	5	5
GARBAGE			
Single-Family Garbage Collection	41	30	34
Rural transfer stations	20	20	20
(Long-haul Transfer Stations)	23	17	20
RESOURCE RECOVERY			
Mixed Waste Composting Facility	28	28	28
Existing Waste to Energy	70	75	73
LANDFILL			
Existing Landfill Facility	59	59	59
SYSTEM COST PER TON	83	83	83

LIFECYCLE SYSTEM COST ANALYSIS — SCENARIO III - Sensitivity B -- Landfill Only

1. NET COSTS (dollars per year)

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	523,607	643,609	1,167,216
Commingled Facility	439,220	402,399	841,619
Single-Family Satellite Collection	36,188	33,341	69,529
(Recycling Transfer)	300,150	360,989	661,139
COMPOSTING			
Paper Bag Compost Collection	58,814	113,430	172,244
Compost Facility	50,056	46,170	96,226
GARBAGE			
Single-Family Garbage Collection	1,910,347	2,253,764	4,164,111
(Rural Transfer Stations)	735,900	471,240	1,207,140
(Long-haul Transfer Stations)	1,092,184	1,277,632	2,369,816
LANDFILL			
Existing Landfill Facility	1,814,457	1,960,248	3,774,705
TOTAL SYSTEM COSTS	6,960,923	7,562,823	14,523,746

2. WEIGHTS (tons per year)

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	11,216	18,120	29,336
Commingled Facility	16,675	21,681	38,356
Single-Family Satellite Collection	5,459	3,561	9,020
COMPOSTING			
Backyard Compost Collection	1,736	2,068	3,804
Dropoff Compost Collection	6,771	5,676	12,447
Paper Bag Compost Collection	1,560	4,250	5,810
Compost Facility	8,331	9,926	18,257
GARBAGE			
Single-Family Garbage Collection	46,782	74,206	120,988
Rural Transfer Station	36,795	23,562	60,357
LANDFILL			
Existing Landfill Facility	83,577	97,768	181,345
TOTAL SYSTEM WEIGHTS	108,582	129,375	237,957

3. COST PER TON

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	47	36	40
Commingled Facility	26	19	22
Single-Family Satellite Collection	7	9	8
(Recycling Transfer Stations)	18	17	17
COMPOSTING			
Paper Bag Compost Collection	38	27	30
Compost Facility	6	5	5
GARBAGE			
Single-Family Garbage Collection	41	30	34
Rural Transfer Stations	20	20	20
(Long-haul Transfer Stations)	23	17	20
LANDFILL			
Existing Landfill Facility	22	20	21
SYSTEM COST PER TON	64	58	61

LIFECYCLE SYSTEM COST ANALYSIS SCENARIO III - Sensitivity C -- Intermediate Level Composting

1. NET COSTS (dollars per year)

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	523,607	643,609	1,167,216
Commingled Facility	439,220	402,399	841,619
Single-Family Satellite Collection	36,188	33,341	69,529
(Recycling Transfer)	300,150	360,989	661,139
COMPOSTING			
Paper Bag Compost Collection	58,814	113,430	172,244
Compost Facility	96,837	110,671	207,508
GARBAGE			
Single-Family Garbage Collection	1,910,347	2,253,764	4,164,111
Rural Transfer Stations	735,900	471,240	1,207,140
(Long-haul Transfer Stations)	1,092,184	1,277,632	2,369,816
RESOURCE RECOVERY			
Mixed Waste Composting	2,036,771	2,261,374	4,298,145
LANDFILL			
Existing Landfill Facility	994,888	1,069,809	2,064,696
TOTAL SYSTEM COSTS	8,224,907	8,998,258	17,223,164

2. WEIGHTS (tons per year)

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	11,216	18,120	29,336
Commingled Facility	16,675	21,681	38,356
Single-Family Satellite Collection	5,459	3,561	9,020
COMPOSTING			
Backyard Compost Collection	1,736	2,068	3,804
Dropoff Compost Collection	6,771	5,676	12,447
Paper Bag Compost Collection	1,560	4,250	5,810
Compost Facility	8,331	9,926	18,257
GARBAGE			
Single-Family Garbage Collection	46,782	74,206	120,988
Rural Transfer Station	36,795	23,562	60,357
RESOURCE RECOVERY			
Mixed Waste Composting Facility	83,577	97,768	181,345
LANDFILL			
Existing Landfill Facility	18,383	21,722	40,105
TOTAL SYSTEM WEIGHTS	108,582	129,375	237,957

3. COST PER TON

	EAST	WEST	VERMONT TOTALS
RECYCLING			
Single-Family Commingled Collection	47	36	40
Commingled Facility	26	19	22
Single-Family Satellite Collection	7	9	8
(Recycling Transfer Stations)	18	17	17
COMPOSTING			
Paper Bag Compost Collection	38	27	30
Compost Facility	12	11	11
GARBAGE			
Single-Family Garbage Collection	41	30	34
(Rural transfer stations)	20	20	20
(Long-haul Transfer Stations)	23	17	20
RESOURCE RECOVERY			
Mixed Waste Composting Facility	24	23	24
LANDFILL			
Existing Landfill Facility	54	49	51
SYSTEM COST PER TON	63	59	72

APPENDIX 2

Vermont Waste Generation, Composition, and Demographic Characteristics

Appendix 2. Vermont Waste Generation, Composition, and Demographic Characteristics

A Vermont specific waste generation and composition analysis, for both residential and commercial generators, was collected from solid waste management districts, regional planning commissions, landfill studies, and the *Vermont Solid Waste Management Plan*. Data sources specific to Vermont are vital for ensuring that this information will accurately reflect Vermont conditions. National data sources include waste composition studies from Massachusetts, Michigan, Wisconsin, and California. A complete listing of data sources are compiled in the bibliography at the end of this section.

This information relies on Vermont specific data and is tailored to Vermont conditions. However, where Vermont data is either unavailable or the methodology used to collect the data provides only rough estimates, other data sources are employed. While some aspects of waste composition vary from community to community, other aspects are surprisingly consistent across the country. In general, the level of yard waste, and the amount and type of commercial waste, will be most variable; residential waste composition, exclusive of yard waste and beverage containers, tend to be less variable.

In compiling the Vermont waste generation and composition data, municipal solid waste is separated into two categories: residential and commercial (including: industrial and institutional solid waste generators). In Vermont, some solid waste management districts/regional planning commissions identified a third waste stream: farms. Since many districts/commissions did not calculate farm waste separately, farm waste is aggregated into the commercial stream.

The National Solid Waste Management Association reports that residential generation of solid waste ranges from 2.5 to 3.5 pounds per person per day on average (NSWMA, 1985). Wastes from commercial and industrial sources account for an additional 2 to 3 lbs per person per day (NSWMA, 1985; Rhyner and Green, 1988; and Michigan DNR, 1987). However, this figure varies greatly from area to area, depending upon the amount of local commercial and industrial activity. A recent study for the EPA by Franklin Associates estimates daily per capita generation of residential and commercial waste (but not industrial and demolition) at 3.4 lbs per person per day (Franklin, 1988).

Residential waste is separated into single- and multi-family generators. In this report, "single-" family refers to housing structures of 1-3 units. Multi-family refers to housing structures of 4 units and above. Commercial waste is generated by retail and wholesale businesses, offices, and institutions such as hospitals, schools, and governmental agencies. Each type of commercial generator has a unique waste stream with a composition depending upon the type of business activity. For example, offices generate a high percentage of white paper, retail stores and supermarkets generate high volumes of corrugated cardboard, and restaurants generate large amounts of food wastes.

Industrial waste is the most difficult to quantify because its composition and quantity varies among individual manufacturing plants depending upon what is produced, the extent of in-house recycling, and the efficiency of the equipment being used. Generation is often measured on a per employee basis, and varies from 4 to 25 pounds per employee per day (.7 to 4.3 tons per employee per year).

Vermont Composition Studies

Residential Solid Waste

The Vermont solid waste districts have recently generated residential generation and composition estimates in one of two ways. Some of the Vermont districts conducted limited weigh and sort studies at landfills or transfer stations, through sampling or curbside solid waste or by sampling waste delivered to solid waste dropoff facilities by volunteer generators. Most Districts/Commissions estimated their residential solid waste generation rates based on data from the Vermont Solid Waste Management Plan, surveys of the area, and available literature. As in the State Plan, all residential waste composition estimates include returnable beverage containers. Often states with bottle bills omit returnable beverages from waste composition estimates.

The figures used in the Vermont Solid Waste Management Plan are derived from weight measurements at the SES Claremont facility (1987); engineering reports (NH/VT Solid Waste Project and Central Vermont Solid Waste Management District); the Fillip (Vermont) landfill study (see Table 1-1); and available national figures (such as the Franklin study). The Vermont Solid Waste Management Plan aggregates waste composition figures for the plastic, glass, and food/yard waste categories (see Table 1-1, Vermont Plan). Whereas most district/commission estimates disaggregate these categories (see Table 1-2). Also the Vermont Plan aggregates residential and commercial wastes into one category.

TABLE 1-1

	VERMONT PLAN	VERMONT LANDFILL STUDY (%)		WINDHAM LANDFILL STUDY		TELLUS
WASTE COMPOSITION	Res/Comm/Ind (net waste, %) (1989)	(1989) C-V Landfill E. Montpelier	Gross Landfill Roxbury	(1989) Dover (%)	Brattleboro (%)	Vermont (%)
Paper	40.8	25.4	32.3	49.1	55.1	35.4
UNP	15.9	3.3	5.0	18.0	5.6	10.4
UCC	7.3	0.2	0.4	5.3	16.9	5.4
MOP	3.6	2.0			2.8	2.2
Other Paper	14.1	20.0	26.9	25.8	29.9	17.4
Glass	14.3	12.9	7.9	10.9	3.0	14.9
Clear		8.2	6.4	6.1	2.6	10.3
Green		3.5	0.7	3.8	0.2	2.8
Amber		1.2	1.4	0.9	0.1	1.4
Other				0.2	0.1	0.4
Plastic	4.0	6.3	9.5	5.9	12.9	6.3
HDPE				0.6	3.5	1.6
PET				3.6	3.4	0.4
Other				1.7	6.0	4.3
Ferrous metals	5.8	9.4	4.2	1.2	1.4	5.2
Light						
Heavy						
Non-ferrous metals	1.0	0.4	0.7	2.1	0.8	1.0
Yard Waste	21.1 (yard/ food)	6.7	NR			15.1
Food waste		28.6	28.8	20.7	21.6	8.7
Wood Waste		0.7	1.8	8.4	2.4	
Other wastes	13.1	9.6	14.8	1.8	2.8	13.4
TOTAL	100	100	100.0	100	100	100.0

TABLE 1-2

WASTE COMPOSITION	NORTHEAST Residential (% gross)	RUTLAND Residential (% gross)	CHITTENDEN Residential (% gross)	S. WINDSOR Residential (% gross)	LAMOILLE Residential (% gross)	ADDISON Residential (% gross)	NORTHWEST Residential (% gross)	MEDIAN (for each row)
Paper	34.2	32.2	36.7	32.0	38.4	33.3	39.8	34.2
ONP/UNP	11.3	10.1	20.2	10.4	13.2	10.7		11.0
OCC/UCC	4.7	4.6		4.5	5.5	4.7		4.7
MOP	0.0	0.0		0.0	9.9	0.0		0.0
other paper	18.1	17.5	16.5	17.2	9.8	17.9		17.4
Glass	14.9	14.4	13.8	17.9	17.0	14.7	17.0	14.9
Clear	10.5	10.0		10.4	}	10.3		10.3
Green	3.0	2.9		4.1	} 15.3	2.9		2.9
Amber	1.5	1.4		3.3	}	1.5		1.5
Other	0.0	0.0		0.0	1.7	0.0		0.0
Plastic	4.1	5.3	4.5	4.9	5.5	4.9	4.0	4.9
HDPE	0.0	0.7		1.5	2.8	1.6		1.6
PET	0.0	0.3		0.5	1.1	0.3		0.4
Other	4.1	4.3		2.8	1.6	2.9		2.9
Ferrous metals	6.8	10.0	4.5	7.3	4.4	7.9	4.6 (inc. non-ferrous)	6.8
Light	6.8	10.0		7.3	4.0	7.9		
Heavy	0.0	0.0		0.0	0.4	0.0		
Non-ferrous metal	0.9	1.1	0.9	1.3	0.9	1.0		1.0
Yard Waste	15.2	15.0	14.5	14.4	6.7	15.1	22.8 (yard/ food)	15.1
Food waste	9.4	8.4	7.3	8.5	16.9	8.9		8.7
Wood Waste				1.5		0.0		
C & D								
Other wastes	14.4	13.7	10.3	12.3	10.3	14.2	11.7	13.7
Special Wastes			7.3					
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3

Residential waste composition estimates from seven districts/commissions are listed in Table 1-2. The far right column provides the median waste composition percentage for each row. Therefore the subcategories under paper do not total 34.2, they total 33.1. One anomaly between the seven waste composition estimates is the food and yard waste categories for Lamoille, which estimated yard waste as being lower than food waste, directly opposite that of five other studies. One plausible reason for this anomaly is that yard wastes dropped "over the fence and in the woods" is excluded from Lamoille's calculations. But it is important to note that Lamoille's food to yard waste ratio is comparable to the two landfill studies (see Table 1-1).

Three districts/commissions did base their estimates on weight data: Lamoille, Northwest, and Windham. Lamoille and Northwest relied on data from weighing solid waste at 542 residences in the Northwest District and the Vermont Solid Waste Management Plan (see Table 1-1). But one shortcoming of this survey is that paper, glass, and plastics are not disaggregated into specific categories. For example, most solid waste districts disaggregated paper into four subsets: used newspaper (UNP), used corrugated containers (UCC), mixed office paper (MOP), and other paper. To overcome this shortcoming, C.T. Donovan Associates (the consultant for both the Lamoille and Northwest waste generation studies), in their Lamoille waste generation estimated UNP, UCC, MOP, and other paper generation rates using data from the Vermont Solid Waste Management Plan.

In Windham (Windham Regional Planning Commission and Windham Solid Waste Management District), used a landfill sort (of three landfills) as a basis for their solid waste composition estimates. The waste composition percentages of two landfill sorts (out of eight) are listed in Table 1-1. The landfill sorts did not distinguish between residential and commercial solid waste.

Assuming that the most reliable waste composition estimates are those derived through weighing the waste, the estimates from Windham, Northwest, Lamoille, the landfill study, and the State Plan provide the most comprehensive waste composition estimates for Vermont. Yet none of these studies were performed in each season of the year to account for the seasonal fluctuations in solid waste composition. Seasonal fluctuations in waste composition are a factor in Vermont, especially with leaves in the fall and yard wastes in the spring and summer. However, in rural areas of Vermont, yard wastes are of minimal concern.

Comparing Vermont waste composition to other studies done throughout the U.S. is often complicated by the use of different methodology procedures, seasonal variations, varying public policy measures (e.g., bottle bills), and demographics. Nonetheless, many components of residential waste are similar throughout the country. Table 1-3 lists three U.S. waste composition studies: 1) Michigan; 2) Milwaukee; and 3) Franklin Associates. The Michigan waste composition percentages were derived by

Tellus from a compilation of studies done or sponsored by the State throughout the 1980's (Michigan, DNR, 1981, 1986, and 1987). The Milwaukee waste composition study ("The Milwaukee Garbage Project") was done by William Rathje and Barry Thompson in 1981 (McCamic, 1985). And the Franklin study are national waste composition percentages published in 1988.

The Milwaukee and Michigan waste composition studies both examine residential waste. Most of the Michigan studies sorted and weighed residential solid waste at either landfills or transfer stations (Michigan, DNR, 1987). The Michigan studies done by SCS Engineering in 1986 were performed over one year, with a waste sort done in four one-week increments (one week each season). The Milwaukee waste composition study sorted and weighed residential waste (mostly from single-unit homes) collected at curbside during a one week period. The primary similarity between Michigan, Milwaukee, and Vermont is that each state has similar seasons. Michigan is also a bottle-bill state and redeemed bottles were excluded from the Michigan study, unlike in Vermont.

In 1988, the Franklin Associates produced a national waste composition study under contract to the U.S. Environmental Protection Agency (EPA). But this study (like the Vermont Solid Waste Plan) aggregates residential and commercial categories together.

In comparison to other waste composition studies, the Vermont residential studies collected by Tellus reveal that:

* glass is much higher than estimates from other municipalities and national estimates
* plastic, yard, and food wastes are on the low end of other composition studies
* paper, ferrous, and non-ferrous are equivalent to other studies

That yard and food wastes are lower than in other municipalities is attributable to the rural nature of Vermont, making "composting" (i.e., dumping in the woods) convenient. Plastic may be less prevalent, and glass more prevalent, in Vermont because of the bottle bill. The high glass composition estimates are reflected in the Vermont landfill studies. And accounting for the redeemable bottles not landfilled, the glass estimate seems plausible. Yet regarding plastics, the Vermont landfill studies reveal a much higher percentage of plastics in residential waste than revealed in the district/commission waste composition studies.

The waste composition estimates by Tellus (see Table 1-1) generally reflect the median percentages in Table 1-3. The notable difference is that plastic is higher and ferrous metals lower. The lower ferrous percentage and higher plastic percentage both reflect the Vermont landfill studies as well as the national trend towards greater plastics use.

TABLE 1-3

WASTE COMPOSITION	MICHIGAN Median (%)	MICHIGAN Low (%)	MICHIGAN High (%)	MILWAUKEE Residential (%) (curbside sort) low	MILWAUKEE Residential (%) (curbside sort) high	FRANKLIN ASSOCIATES Net Waste (%)	FRANKLIN ASSOCIATES Gross (%)
Paper	41.4	30.6	53.6	30.3	38.5	35.6	41.0
UNP	8.1	5.2	11.9	8.7	15.4	6.3	8.0
UCC	6.7	2.9	11.2			9.2	6.2
MOP	2.6	1.0	4.2			3.6	12.3
Other Paper	24.0	21.5	26.3	20.1	23.6	16.5	14.5
Glass	5.4	3.1	7.0	7.6	19.1	8.4	8.2
Clear							
Green							
Amber							
Other							
Plastic	6.3	5.4	9.2	4.2	7.1	7.3	6.5
HDPE							
PET							
Other							
Ferrous metals	5.2	3.1	6.6	7.1	8.1	7.5	7.0
Light							
Heavy							
Non-ferrous metals	1.0	0.5	2.8	1.2	2.4	1.4	1.7
Yard Waste	16.4	4.1	39.4	1.5	16.0	20.1	17.9
Food waste	6.3	3.3	11.5	18.2	24.6	8.9	7.9
Wood Waste	3.3	1.2	5.4			4.1	3.7
Other wastes	14.7	5.6	26.8	5.0	13.6	6.7	6.1
TOTAL	100	56.9	162.3	75.1	129.3	100	100

Commercial Solid Waste

Unlike residential waste composition, commercial[1] waste varies more from region to region. This is due to the number of commercial establishments in the region and the type of business they conduct. In Vermont, the commercial solid waste stream reflects the rural nature of the state where agriculture, forestry, and tourism (service industry) are principal generators of gross solid waste.

The two primary methods of estimating commercial waste generation and composition are through field observations (e.g., sorting and weighing) or by using available information on generation rates and composition studies for individual commercial sectors and then compiling total economic activity in each sector to produce a total quantity and composition of commercial waste. Field observations are typically made either on-site or at the landfill or transfer station. In the absence of comprehensive weigh studies, there are two available methods for estimating commercial and industrial waste generation. The first uses average per-employee generation figures for the commercial and industrial sector as a whole, as shown, in Table 1-4 (Rhyner and Green, 1988; and Michigan DNR, 1987). Waste generation estimates are calculated by multiplying these figures by total commercial and industrial employment. This method, however, fails to distinguish between the multitude of commercial activities and fails to break out waste composition.

Table 1-4

Daily Solid Waste Generation

Residential	2.7 lbs/person/day
Commercial	5.5 lbs/employee/day
Industrial	7.2 lbs/employee/day

The second method utilizes differentiated per-employee or per-activity waste generation figures for the various types of commercial establishments, as shown in Table 1-5 (NSWMA, 1985; Michigan DNR, 1981; Mecklenburg County, 1988; and Rhyner and Green, 1988). Commercial and industrial waste generation estimates are determined in this second method by assessing the Activity Level for each of the

---

[1]Unless otherwise noted, "commercial" also refers to the manufacturing industry and institutions (e.g., hospitals, universities, government agencies, etc.)

commercial categories. This data is generally available from the U.S. Department of Commerce census documents, for most of the commercial sectors, while others are collected by local Economic Development and Planning agencies. Once the activity level is determined, multiply by the generation factor listed in Table 1-5 to determine total waste generation for each type of commercial sector. The waste generation factors for each commercial sector are derived from several commercial waste composition studies (NSWMA, 1985; Michigan DNR, 1981; Mecklenburg County, 1988; and Rhyner and Green, 1988).

Table 1-5

Commercial Waste Generation

	Activity Type	Activity Level	X	Generation Factor (tons/unit activity)	=	Waste Generation (tons/yr)
General Merchandise Stores	Sales ($1000/yr)			0.045		
Furniture, Home Furnishings & Supplies	Sales ($1000/yr)			0.045		
Food Stores	Sales ($1000/yr)			0.083		
Restaurants	Sales ($1000/yr)			0.100		
Schools	students			0.080		
Nursing Homes	occupants			0.800		
Hospitals	occupied beds			3.200		
Offices	100 sq. ft.			0.135		
Manufacturing Large	employee			0.910		
Small	employee			0.550		
Total						

The advantage to this method is that the number of employees is not always the best determinant of solid waste generation. For many commercial sectors, factors, such as sales, floor space (square feet), occupied beds, etc., are better indicators of waste generation.

To estimate commercial waste composition, Vermont took a two step approach. In the first step, each district/commission was assigned a set of SIC (Standard Industrial Classification) codes based on the number of SIC code businesses in the region. The district then estimated waste generation coefficients (pounds/employee/year) based on a combination of on-site and mail survey evaluations. The on-site evaluations sorted and weighed a generator's solid waste or estimated waste generation based on interviews and/or "eyeballing" solid waste in roll-offs or dumpsters. The result of this data collection is a listing of approximately 100 SIC codes and their respective generation coefficient. In Table 1-6, the column "master" lists the gross generation coefficients developed in this process.

TABLE 1-6

GROSS COMMERCIAL GENERATION COEFFICIENTS
(pounds/employee/year)

SIC CODE	ACTIVITITES	SWMD COEFFICIENT low	high	master	OTHER SOURCES A	ref	B	ref	TELLUS
A.	AGRICULTURE AND FORESTRY								
13	FIELD CROPS	800							800
18	HORTICULTURAL SPECIALTIES	800							800
21	LIVESTOCK, EXCEPT DAIRY	624							624
24	DAIRY FARMS	1326							1326
7	AGRICULTURAL SERVICES	8465							8465
72	CROP PRODUCTION SERVICES	2763							2763
74	VETERINARY SERVICES	1700							1700
75	ANIMAL SERVICES	1700							1700
78	LANDSCAPE & HORTICULTURE	4000							4000
8	FORESTRY	800							800
B.	MINING								
14	NONMETALLIC MINERALS	1038							1038
142	CRUSHED AND BROKEN STONE	3928							3928
C.	CONSTRUCTION								
	(NOTE: GENERATION = LBS./FTE EMPLOYEE)								
152	RES. BUILDING CONST.	7540		7540					7540
154	NONRESIDENTIAL BLDG. CONST.	4380		4380					4380
16	HEAVY CONSTRUCTION	3381							3381
161	HWY. & STREET CONST.	5160		5160					5160
1795	WRECKING & DEMOLITION	18566	30000	30000					18566
*	ALL OTHER CONSTRUCTION	800		800					800
	TOTAL CONSTRUCTION								
E.	TRANSPORTATION & PUBLIC UTILITIES								
	(NOTE: GENERATION = LBS./FTE EMPLOYEE)								
417	BUS TERMINAL & SERVICE FACILITY	1113	1143	1143					1143
423	TRUCKING TERMINAL FACILITIES	3600		3600					3600
43	U.S. POSTAL SERVICE	4600	7462	4600					4600
458	AIRPORTS,FLYING FIELDS & SERVICES	575		575					575
48	COMMUNICATIONS	160	803	160					160
*	ALL OTHER TRANS & UTILITIES	1000	1143	2000					2000
	TOTAL TRANSPORTATION & PUBLIC UTILITIES								
F.	WHOLESALE TRADE								
	(NOTE: GENERATION = LBS./FTE EMPLOYEE)								
501	MOTOR VEHICLE PARTS(EXCEPT TIRES)	4018	4160	4160	4380	d (SIC 50)			4160
5044	TIRES	8000	8540	0					8270
503	LUMBER & CONSTRUCTION MATERIALS	5778	110000	110000					110000
515	FARM PRODUCT RAW MATERIALS	1285		1285	4380	d (SIC 51)			1285
*	ALL OTHER WHOLESALE TRADE	1000	4160	1000					1000
	TOTAL WHOLESALE TRADE								

GROSS COMMERCIAL GENERATION COEFFICIENTS
(pounds/employee/year)

SIC CODE	ACTIVITITES	SWMD COEFFICIENT low	SWMD COEFFICIENT high	SWMD COEFFICIENT master	OTHER SOURCES A	ref	B	ref	TELLUS
	MANUFACTURING								
20	FOOD AND KINDRED PRODUCTS	6364	37840	37840	4000	a	9125	d	15842
201	MEAT PACKING								
202	DAIRY PRODUCTS	1724	375000	85340					85340
2026	FLUID MILK	44952							44952
203	PRESERVED FRUITS & VEGETABLES	21510							21510
204	FOOD PRODUCTS	8035		8035					8035
206	SUGAR & CONFECTIONARY PRODUCTS	6364							6364
208	BOTTLED & CANNED SOFT DRINKS	16300							16300
209	OTHER FOOD MFG	10225		10225					10225
23	APPAREL & ALLIED PRODUCTS	2240	6370	3540	2500	a	1825	d	2500
239	DRAPERIES	1850							1850
24	LUMBER AND WOOD PRODUCTS	4320	34278	3263	29000	a	7300	d	7300
241	LOGGING	1772	19910	19910					19910
242	SAWMILLS	3456	462346	462436					462436
243	MILLWORK & STRUCTURAL MEMBERS	4320	54495						29407
244	WOOD CONTAINERS								
245	WOOD BLDGS & MOBILE HOMES	6617	119000						62808
249	MISC WOOD PRODUCTS	4300	4320						4320
25	HOUSEHOLD FURNITURE	1235	66616	2586	5000	a	9490	d	9490
26	PAPER AND ALLIED PRODUCTS	5760	5780	5760	3000	a	18250	d	5780
262	PAPER MILLS	18140							18140
263	PAPERBOARD MILLS	4673	34893						19873
267	SANITARY PAPER PRODUCTS	2500							2500
27	PRINTING & PUBLISHING	2947	15089		1500	a	2920	d	2920
271	NEWSPAPER PRINT AND PUBLISHING	1500	3420	2210					2318
273	PRINTING AND PUBLISHING	2029	14750	4370					4370
275	COMMERCIAL PRINTING		15562						15562
276	MANIFOLD BUSINESS FORMS	18400	34919	110					18400
28	CHEMICALS & ALLIED PRODUCTS	1000			8030	d			4500
30	RUBBER AND PLASTIC GOODS	2000	29003	2000	7300	d			6040
307	MISC PLASTIC PRODUCTS	1879							1879
308	MISCELLANEOUS PLASTICS	1328	1582	1135					1328
31	LEATHER AND LEATHER PRODUCTS	2020	2800	2020	5840	d			2420
32	STONE AND CLAY PRODUCTS	1389	10682	7660	40880	d			8860
322	GLASS PRODUCTS	3790	12000	12000					7790
327	CONCRETE BLOCK		11000						11000
328	CUT STONE	1250							1250
33	PRIMARY METALS			0	14600	d			14600
34	METAL FABRICATION	959	3240	3240	7300	d			3240
35	INDUSTRIAL MACHINERY AND EQUIPMENT	2319	9475	9475	5475	d			5475
354	METALWORKING MACHINERY	2160	7540						4823
355	SPECIAL INDUSTRY MACHINERY	1880							1880
357	COMPUTER & OFFICE EQUIPMENT	5160							5160
358	REFRIGERATORS	1880							1880
359	INDUSTRIAL MACHINERY	2085	3076						2580
36	ELECTRONIC AND ELECTRIC EQUIPMENT	1822	7280	7280	3650	d			3650
364	ELECTRIC LIGHTING & WIRING	2278	7040						4659
37	TRANSPORTATION EQUIPMENT	824	2190	4280	3650	d			2920
372	AIRCRAFT & PARTS	2760							2760
386	PHOTOGRAPHIC EQUIPMENT	1000							1000
39	MISC MANUFACTURING INDUSTRIES	400	9008						4700
*	ALL OTHER MANUFACTURING	2319	3000	3000					3000

a = St. Paul, Minnesota, "Ramsey County Master Plan for Solid Waste Management," 1987.
b = Mecklenburg County, 1987; and NSWMA, 1985.
c = R.W. Beck
d = Lake County, 1988.

GROSS COMMERCIAL GENERATION COEFFICIENTS
(pounds/employee/year)

SIC CODE	ACTIVITITES	SWMO COEFFICIENT low	SWMO COEFFICIENT high	SWMO COEFFICIENT master	OTHER SOURCES A	ref	B	ref	TELLUS
G.	RETAIL TRADE								
	(NOTE: GENERATION = LBS./FTE EMPLOYEE)								
521	LUMBER,OTHER BUILDING MATERIALS, PAINT,GLASS,WALLPAPER STORES AND HARDWARE STORES	5780	12788	5780	5110	d (SIC 52)			5780
526	RETAIL NURSERIES & GARDEN STORES	1420	4000	4000					4000
531	DEPARTMENT and VARIETY STORES	7900		7900	1460	d			7900
541	GROCERY STORES (LARGE)	13600	110833	13600	6570	d (SIC 54)			13600
	GROCERY STORES (MOM & POP)	11500	11800	11500					11500
542	MEAT & FISH STORES	2000		2000					2000
543	FRUIT & VEGETABLE MARKETS	3900		3900					3900
551	DEALERS OF NEW & USED CAR,MOTORCYCLE RV, AND TRUCKS	4500	5610	5610	3650	d (SIC 55)			5610
553	AUTO & HOME SUPPLY STORES	3000		3000					3000
554	GASOLINE SERVICE STATION	3000	7829	3000					3000
56	APPAREL & ACCESSORY STORES	1351	5913	3120	1460	d			3120
57	FURNITURE & HOME FURNISHING STORES	3440	3500	3500	7300	d			3500
581	EATING PLACES (FAST FOOD)	8400	8500	8500	4560	c	3650	d	8500
5812	EATING PLACES (RESTAURANTS)	2000	2537	2000		(both SIC 58)			2000
5813	DRINKING PLACES	2000	2210	2000					2000
592	LIQUOR STORES	1565	1625	1625					1625
*	ALL OTHER RETAIL	3000	4865	3000					3000
	TOTAL RETAIL								
H.	FINANCE, INSURANCE & REAL ESTATE(ALL)	467	1000	1000	600	b	480	c	1000
					1825	d			
I.	SERVICES								
	(NOTE: GENERATION = LBS./FTE EMPLOYEE)								
701	HOTELS,MOTELS,BED & BREAKFAST, & INNS	2580	2600	7243	1825	d (SIC 70)			7243
702	ROOMING & BOARDING HOUSES	2580	2953	2580					2580
703	CAMPS & RECREATIONAL VEHICLE PARKS	1500	15000	15000					15000
72	PERSONAL SERVICES	480	500	500	1095	d			500
721	LAUNDRY/DRY CLEANING	1000	1060	1000					1000
73	BUSINESS SERVICES(EXCEPT COMPUTER)	690	700	700	480	c	1825	d	700
737	COMPUTER & DATA PROCESSING SERVICES	354	1500	1500					1500
75	AUTO REPAIR,SERVICES & PARKING(ALL)	4500		4500	5475	d			4500
799	MISC. AMUSEMENT & RECREATION SERVICES (SKI RESORTS)	931	1600	1600	3650	d (SIC 79)			1600
80	HEALTH SERVICES(EXCEPT HOSPITALS)	1700	1759	1700	1600	b	1825	d	1700
806	HOSPITALS	865	2300	1550	730 - 1642	a			1550
81	LEGAL SERVICES	690	1000	1000	480	c	1095	d	1000
821	ELEMENTARY & SECONDARY SCHOOLS	108	2200	2716	1095	d (SIC 82)			2716
822	COLLEGES & UNIVERSITIES	1107	5348	3423					3423
823	LIBRARIES	700	1084	700					700
824	VOCATIONAL SCHOOLS		0	3423					3423
83	SOCIAL SERVICES(EXCEPT CHILD CARE)	1000	1084	1000	1095	d			1000
835	CHILD DAY CARE SERVICES	225	1250	2716					2716
86	MEMBERSHIP ORGANIZATIONS	323	1084	100	1095	d			100
87	ENGINEERING & MANAGEMENT SERVICES	385	2018	1000					1000
	TOTAL SERVICES								
J.	PUBLIC ADMINISTRATION								
	(NOTE: GENERATION = LBS./FTE EMPLOYEES)								
91	EXECUTIVE,LEGISLATIVE & GENERAL OFFICES	700	1500	1000					1000

In the second step each district/commission then used this master list, while for others, especially manufacturing facilities, several on-site visits were conducted by industrial districts and/or commissions. Table 1-6 lists the low and high coefficients developed during this process. As shown in Table 1-6, variation from the master list of coefficients is slight for the construction, wholesale trade, retail trade, FIRE (finance, insurance, and real estate), services, and public administration categories. Exceptions are SIC code 503 (lumber and construction materials): 5,778 to 110,000; SIC code 541 (large grocery stores): 13,600 to 110,833; SIC code 703 (camps and recreation vehicles): 1,500 to 15,000; and SIC code 87 (engineering and management services): 385 to 2018.

However, the ranges found in the manufacturing category are much greater. Two extreme examples are SIC code 202 (dairy products): 1,724 to 375,000; and SIC code 242 (sawmills): 3,456 to 462,346. One likely reason for these extreme variations is whether or not on-site disposal was accounted for in these coefficients. The assumption is that these are gross generation coefficients which include on-site disposal. The solid waste generation ranges found in the manufacturing sector also reflect how waste is plant specific rather than industry specific.

In Table 1-6, the columns under the heading "Other Sources," list gross generation coefficients by SIC code as developed by other communities or researchers.[2] Again, the differences between the Vermont generation coefficients and the "other" coefficients are greatest under the manufacturing SIC codes.

What is not reflected in Table 1-6, but effects the accuracy of generation coefficients, is the specificity of the SIC code. As the number of digits in the SIC code increases (up to a possible five), so does the level of detail, of business type. Typically a generation coefficient for a four-digit SIC code (e.g., 2421) will be more accurate to that business than a generation coefficient for a two-digit SIC code (e.g., 24). However, even five-digit SIC codes do not differentiate between plant age, manufacturing processes, in-house recycling, etc.

For the purpose of this study, Tellus will use the gross generation coefficients developed in the master list for the construction, wholesale trade, retail trade, FIRE, services, and public administration categories. For agriculture and forestry, we will use the coefficients listed in Table 1-6. The coefficients listed were generated by the

---

[2]In some cases two sources are referenced, thus the two columns "A" and "B." In the "ref" column is an endnote letter; the endnotes are listed on the third page of this table. In some instances the SIC code was broader than the one listed. If so, the broader number was noted (e.g., "SIC 50" for SIC 501, "motor vehicle parts...").

Addison SWMD (SIC codes 72, 74, 74, and 78) and the Northeast Vermont Development commission (SIC codes 7, 8, 13, 18, 21, and 24). For the SIC codes listed under manufacturing, Tellus developed a generation coefficient based on the best available data (Table 1-6).

Vermont Demographics

The Tellus/Wehran team made a survey of the demographic characteristics of Vermont communities and districts. The purpose of this research was two-fold. First, to compare Vermont demographic characteristics to the national figures used in the WastePlan default data. WastePlan will be used in subsequent phases of this project as a tool for performing the costs analyses of the individual collection and processing systems, as well as the integrated solid waste systems. The second reason is that these demographic characteristics are important for determining the types of collection programs which are appropriate for Vermont conditions. This is particularly important for garbage and recycling collection.

In Table 1-7, basic demographic information for each district, population and people per household, is listed. In Appendix 1, the demographic characteristics of each town has been summarized, including population, area, road miles, housing units and houses per road mile and per square mile.

Table 1-7

Solid Waste Generation (tons)

	Pop.	Persons/ Household	Total gross	Total net	Residential gross	Residential net	Commercial gross	Commercial net	Farm gross	Farm net	C & D gross	C & D net
Addison	28,784	3.03	64,026	24,163	15,329	11,434	47,549	11,771			1,148	958
Bennington	33,108	2.68 (est.)			16,382 (est.)		11,244					
Central	71,424	2.81	82,209	61,794	33,295	26,315	48,914	35,479				
Chittenden	122,570	3.35	120,336	97,553	58,651	46,053	53,833	44,263			7,852	7,237
Lamoille	18,378	2.55	21,690	17,391	6,396	5,291	14,177	11,976	150	124	967	
Northeast	51,529	2.62	82,552	49,406	32,283	22,390	45,981	23,722			4,288	[illegible]
Northwest	39,401	2.51	31,808	26,107	13,500	11,431	15,270	13,081	1,522	1,379	1,516	216
Rutland	56,146	2.59	118,272	62,178	35,578	30,126	82,694	32,052				
Southern Windsor	33,938	2.61	43,646	27,438	17,338	12,812	24,401	14,627			1,907	
Two Rivers-Ottauquechee/ Upper Valley	30,904	2.24	61,391	32,387	17,882	14,078	43,509	16,289			2,573	2,020
Windham SWMD and Regional Planning Commission	29,248	2.02	45,050	38,208	19,750	14,320	25,300	23,888				
Windham Regional Planning Commission	9,663 (1987)	2.02	12,350		6,300		6,050					

from Bennington

31.03 / 12 = 2.58 272,684 418,922

rounded 273,000 419,000

692,000
7.66

Table 1-8

Solid Waste Generation (pounds/capita/day)

	Total		Residential		Commercial		Farm		C & D	
	gross	net	gross	net	gross	net	gross	net	gross	net
Addison	12.50	4.72	2.99	2.23	9.28	2.30			0.22	0.19
Bennington										
Central	6.47	4.86	2.62	2.07	3.85	2.79				
Chittenden	5.52	4.47	2.69	2.11	2.47	2.03			0.36	0.33
Lamoille	6.63	5.32	1.96	1.62	4.33	3.66	0.05	0.04	0.30	
Northeast	9.00	5.39	3.52	2.44	5.01	2.59			0.47	0.36
Northwest	4.54	3.72	1.92	1.63	2.18	1.87	0.22	0.20	0.22	0.03
[illegible]	11.83	6.22	3.56	3.01	8.27	3.21				
Southern Windsor	7.22	4.54	2.87	2.12	4.04	2.42			0.32	0.00
Two Rivers-Ottaquechee/Upper Valley	11.16	5.89	3.25	2.56	7.91	2.96			0.47	0.37
Windham SWMD and Regional Planning Commission	8.65	7.34	3.79	2.75	4.86	4.59				

R Net
184,250 = 212,5
396,791
less Bennington
416 w Bennington

BIBLIOGRAPHY

Vermont Sources

Addison County Solid Waste District. "Addison County Solid Waste Generation Worksheet." 1989.

Central Vermont Solid Waste Management District. *Current Solid Waste Management Practices and Recommendations for a Long-Term Approach to Solid Waste Management*. Wehran Engineering, 1987.

Central Vermont Solid Waste Management District. *Projection of Future Conditions (1987-2007)*. 1990.

Chittenden Regional Solid Waste Management District. *Waste Generation Study*. Lamoureux & Stone, November 1989.

Lamoille Regional Solid Waste Management District and Lamoille County Planning Commission. *Lamoille Regional Solid Waste Generation and Recycling Analysis*. C.T. Donovan Associates Inc., November 1989.

Northeastern Vermont Development Association. *Analysis of Solid Waste Generation and Composition in the Northeast Kingdom*. Gershman, Brickner & Bratton, Inc., November 1989 (Draft).

Northwest Vermont Solid Waste Management District. *Northwest Vermont Solid Waste Generation and Recycling Analysis*. C.T. Donovan Associates Inc., June 1989.

Rutland County Solid Waste District. *An Analysis of Solid Waste Management Alternatives*. DuBois & King, Inc., December 1989.

Southern Windsor/Windham Counties Solid Waste Management District. "Waste Composition Spreadsheet." 1989.

Two Rivers--Ottauquechee Regional Commission/Upper Valley Lake Sunapee Council. *Analysis of Solid Waste Generation: Two Rivers--Ottauquechee Regional Commission and Upper Valley Lake Sunapee Council*. Prepared with DSM Environmental Services, Inc., December 1989 (Draft).

Vermont, Agency of Natural Resources. *Vermont Solid Waste Management Program*. Waterbury, Vermont, 1989.