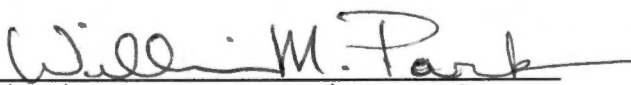


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I am submitting herewith a thesis written by Jeffrey Daniel Holt entitled "Analysis of the Economic Trade-offs In Consideration of Local Versus Regional Processing of Recyclable Materials Collected from Rural Areas: A Case Study of the First Tennessee Development District." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.


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ANALYSIS OF THE ECONOMIC TRADE-OFFS IN CONSIDERATION
OF LOCAL VERSUS REGIONAL PROCESSING OF RECYCLABLE
MATERIALS COLLECTED FROM RURAL AREAS: A CASE
STUDY OF THE FIRST TENNESSEE
DEVELOPMENT DISTRICT

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Jeffrey Daniel Holt
May 1991

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THESIS

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DEDICATION

The author wishes to dedicate this study to his parents, Douglas Eugene Holt and Elizabeth Ann Holt. Their years of love, support, and assistance provided the inspiration needed to complete this research and my graduate program. They always expressed the importance of an education, and encouraged me to achieve my educational goals.

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ABSTRACT

Rural county and municipal governments in Tennessee have been faced with the increasingly important and difficult task of solid waste management. As the costs of solid waste disposal have increased over the past decade, the search for waste disposal alternatives has increased as well. One viable alternative, recycling, has emerged as a popular and sometimes cost effective option. Recycling can be defined as a process of diverting reusable materials from the solid waste stream, processing these materials, and using them in production. While several researchers have suggested that regional approaches to recycling may offer many significant benefits for rural areas over smaller community specific programs, little research has been conducted in this area. This study was designed to analyze the tradeoffs and feasibility of an integrated multi-county recycling approach, using the eight county First Tennessee Development District as a case study area.

Current characteristics of solid waste management were documented for the First Tennessee Development District primarily using mail surveys, and included information on collection, transportation, processing, disposal, and the extent of recycling in the region. This information was used to develop a methodology for projecting the potential for residential sector collection of recyclable materials in each

county. It was estimated that between 6,200 and 11,300 tons of recyclable materials could be collected annually from the region, depending on the participation rate of the citizens.

The costs of operating a recycling system were estimated for each individual county in the region, and for the region as a whole. These costs included those associated with processing, and the transportation of recyclable materials to a regional processing facility, but not initial collection costs or various avoided costs (landfill fees, etc.). The economies of size that could be achieved from a regional processing facility were substantial. Under each of eight scenarios involving low and high levels for participation rates, processing costs, and transportation costs, a regional processing system provided significant cost savings compared to processing in each of the eight counties. These cost savings for the region were estimated at between \$130,000 and \$317,000 annually. Viewed from an individual county perspective, some counties could transport materials over relatively long distances (as far as 100 miles) and still achieve lower costs than processing on their own.

While the potential economic benefits of regional recycling systems appear substantial, the difficulties associated with initiating and sustaining successful inter- or multi-jurisdictional agreements are numerous. Incentives may be necessary to motivate local jurisdictions to look beyond their boundaries for cost effective solutions to their solid waste management challenges.

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CHAPTER 1

INTRODUCTION

Solid waste management has become an increasingly important and costly issue faced by local governments and municipalities. It has been estimated that Tennessee residents generate an average of 6.5 pounds of garbage daily, or over one ton per person annually (Reinhart). With a population of 4.8 million, the per capita rate translates into annual generation of 5.7 million tons statewide. Given this huge and growing quantity of solid waste requiring disposal, and the increasing costs and conflicts associated with landfills and incinerators, consideration and evaluation of disposal alternatives, particularly recycling, has emerged as a top priority in Tennessee.

Recycling is defined as a process of diverting reusable materials from the solid waste stream, processing these materials, selling them in the marketplace, and using them in production. Recycling is more common in metropolitan areas, and in some states and municipalities participation by residents is mandatory. Recycling has been supported for many years on the basis of conservation, environmental, and ethical motivations. In recent years, recycling has also been increasingly viewed as a relatively cost effective method of disposal for a significant portion of the solid waste stream.

Diverting materials through recycling can serve to economize on landfill space and extend the useful life of landfills. According to a recent survey, 56% of the landfills in Tennessee have an estimated remaining life of five years or less, and 76% have remaining lives of ten years or less (U. of Tennessee Waste Management Research and Education Institute).

To be cost effective from a county or municipal government budgetary standpoint, recycling need not turn a profit in the sense of having revenues from the sale of materials to reusers exceed the cost of collection and processing. Instead, cost effectiveness involves incurring a net cost lower than the cost of the primary method of disposal, typically landfilling. This "cost savings" associated with recycling is expected to increase substantially, given the stringent requirements for landfills that will become effective within the next few years. Decisions to implement recycling systems may take into account the broader motivations referred to above (e.g. conservation, environmental, and ethical), in addition to the impact on the local government budget. Moreover, there may be significant local benefits which are not reflected in government budgets, such as job creation, litter reduction and community pride.

Problem Statement

The management of solid waste has become a costly and difficult task for county and municipal governments in

Tennessee, as well as for other states. In the search for feasible alternatives to the traditional landfilling of wastes, recycling has evolved into a viable and sometimes cost effective option.

To date, most analysis of the economic feasibility of recycling has been done within the context of metropolitan areas. Curbside collection of recyclable materials (hereafter referred to as recyclables) within these areas is clearly the most effective way of securing high participation rates and thus large volumes of materials, though the substantial costs of curbside collection systems are causing some municipal leaders to look at drop-off systems. At the present time, it appears that for most urban cities the question is not "whether or not" to recycle, but only "when", and to some extent "how". However, substantial uncertainty remains regarding the economic feasibility of collecting recyclable materials in rural areas and regional coordination of the transportation, processing and marketing functions.

The possibility that a recycling program may be a cost effective method of solid waste management, when compared to the options of landfilling or incineration, is generating the interests of officials in many rural areas. Governments in these areas typically operate under a more limited budget and tax base than their urban counterparts, and financing solid waste management becomes a challenging and sometimes controversial task. Flexibility is also an important factor

for rural areas in designing a recycling program to meet local needs. Options exist in terms of who operates the program (e.g. private sector, public sector, community groups, non-profit organizations) and what type of program is implemented (e.g. curbside, buy-back, drop-off).

Curbside collection systems for recyclables are unlikely to be practical in rural areas at this time, due to their relatively high costs. Most rural areas in Tennessee do not even have curbside collection for their garbage. While there is a trend in some parts of the United States toward curbside collection of garbage in rural areas, this is unlikely to occur in the near future in most of rural Tennessee. Hamblen County is the only county in Tennessee with curbside collection of garbage for every resident of the county, and twenty-two rural counties have no collection system at all (UTWMREI -- University of Tennessee Waste Management Research and Education Institute). In these counties where few or no collection opportunities exist, residents either take their garbage to the nearest landfill, or in many cases, it is dumped in a convenient location or burned in the "backyard incinerator".

The most prevalent types of collection systems for recyclables in rural areas, and even in many urban areas, are buy-back and drop-off systems. Buy-back programs emphasize the financial incentive as a motivation for participation. Buy-back centers typically pay by the pound for recyclable

materials delivered to their center. Drop-off programs emphasize convenience to enhance participation, with drop-off points usually located near shopping districts and main traffic arteries. These types of collection systems generally operate at lower costs per ton (of recyclables) than do curbside systems, and require lower initial capital expenditures since the participants provide the initial transportation of the materials.

Several researchers have suggested that regional approaches to recycling may offer many significant benefits for rural areas over smaller, community-specific programs (Schmidt p.30, Shaw and Park p.40, Brown p.16,27). Economies of size with regards to the processing and marketing functions appear to be a major advantage, but the key trade-off centers on the higher transportation costs associated with regional approaches. With a single regional materials recovery facility (MRF) where recyclables are processed, rather than one facility in each county or municipality, the processing costs can be spread over a larger volume of materials, providing lower average costs per unit of material processed. Economies of size may also occur in the marketing function, with one person, rather than several, involved in negotiating and contracting for the sale of collected materials. Additionally, price premiums may be achieved from offering a larger volume and better consistency or quality of materials for sale than either a single county or municipality could

offer.

The need for research to help guide decisions regarding recycling in rural and mixed rural-urban areas is evident. To date, research on these topics has been quite limited. Most studies have been primarily descriptive in nature, documenting specific experiences of individual programs, with few generalizable findings. This study attempts to provide a more general analysis of rural collection systems and regional coordination of recycling programs.

Research Objectives

The overall objective of this study was to analyze the tradeoffs and feasibility of an integrated multi-county recycling approach for a mixed rural-urban area using one of Tennessee's ten development districts as a case study area. Specific objectives include:

1. To document the current characteristics of solid waste collection, transportation, processing, and disposal, and the extent of recycling, for the municipalities and counties in the case study area;
2. To project the level of resident participation and the volume of recyclable materials that could be expected with appropriate recyclable material collection systems in each municipality and county;
3. To estimate the costs associated with transportation and processing of recyclable materials under the following

scenarios:

a. Each municipality and county implements its own recycling system including collection, processing and marketing;

b. An integrated recycling system for the multi-county area is implemented involving coordination of collection and transportation to a regional MRF for processing and marketing.

The focus of this study was on those factors that would differ the greatest between an individual and regional recycling system, namely the transportation and processing costs. The scope of this study was not intended to be a comprehensive benefit-cost analysis encompassing all costs associated with a recycling system. Therefore certain factors were not explicitly considered, such as collection costs at the local level and various avoided costs (landfill costs, solid waste collection costs, etc..). These factors would have similar overall effects on both types of systems, whether individual or regional.

Procedures For Accomplishing Objectives

The First Tennessee Development District (FTDD) was chosen as a case study area to examine the feasibility of a coordinated regional approach to recycling. This upper East Tennessee district is a mixed rural-urban area containing nineteen municipalities and the following eight counties:

Johnson, Sullivan, Carter, Washington, Unicoi, Hancock, Hawkins and Greene (see Figure 1.1). The Tri-Cities area of the FTDD is one of the seven Standard Metropolitan Statistical Areas (SMSA) in the state, and includes the major cities of Bristol, Johnson City, and Kingsport, and two of the eight counties (Washington and Sullivan).

The FTDD was selected because it represents a mix of both rural and urban counties. Also, significant interest in regional approaches to recycling had been expressed by the FTDD Board of Directors, by local government officials, and by citizens and private industries in the region. The eight counties in the FTDD have diverse demographic and geographic characteristics, and differ in their methods of solid waste collection and disposal. The case study approach was used in this analysis because the virtual absence of regional recycling efforts not only in Tennessee, but the United States as well, would not allow statistical analysis of actual program experiences.

Information was obtained principally through mail surveys conducted by the UTWMREI and from personal visits with private sector representatives and public officials in the FTDD region, and throughout the state. In particular, technology and cost information was obtained from Tennessee Eastman Corporation personnel and Tennessee Valley Authority (TVA) personnel on recyclable material processing costs and

COUNTY	Population:	Population:
CARTER		51,505
Elizabethton	11,931	
Watauga	389 ^a	
GREENE		55,853
Baileyton	309	
Greeneville	13,532	
Mosheim	1,451	
Tusculum	1,918	
HANCOCK		6,739
Sneedville	1,446	
HAWKINS		44,565
Bulls Gap	659 ^a	
Church Hill	4,834	
Mount Carmel	4,082	
Rogersville	4,149 ^a	
Surgoinsville	1,499	
JOHNSON		13,766
Mountain City	2,169	
SULLIVAN		143,596
Bluff City	1,390	
Bristol	23,421 ^a	
Kingsport	36,365 ^b	
UNICOI		16,549
Erwin	5,015	
WASHINGTON		92,315
Johnson City	49,381	
Jonesborough	23,091	
F.T.D.D.	167,031	424,888

^a1980 figures

^bPart of city is in Hawkins County

Figure 1.1 Municipalities in the First Tennessee Development District

transportation costs respectively.

To accomplish objective one, information was obtained from mail surveys conducted in early 1990 by the UTWMREI. Four separate surveys were sent to designated public and private officials in every county and municipality in Tennessee. The four surveys included a landfill and disposal survey, a solid waste collection and recycling survey, a survey of recyclable materials processors, and a financing survey (see Appendices A-D for survey copies). Pertinent information from these surveys was used to document the methods of handling solid waste in the FTDD, and also to diagram the flows of waste within and among its counties.

To accomplish objective two, information was gathered on participation rates and corresponding volumes collected from several existing recycling programs within Tennessee, from documented averages reported in major industry publications, and from previous research on this topic. This information was collected for drop-off and curbside operations, with attention given to the influence of convenience on participation.

Objective three was accomplished by estimating the costs of transporting and processing recyclable materials, using cost and technology information obtained from Tennessee Eastman Corporation and TVA. These costs were estimated for each individual county in the FTDD, and for the region as a whole. These costs were combined under scenario (b) to obtain

estimates of total recycling program costs, and were examined to determine the potential cost effectiveness of a coordinated regional approach.

CHAPTER 2

REVIEW OF LITERATURE

This review of literature is divided into two parts, and provides a look at previous research in the areas of solid waste management and recycling. First, several studies relating to solid waste management and systems of waste collection are reviewed. Then, five studies on the feasibility of recycling are examined.

Solid Waste Management and Collection Studies

Schreiner, Muncrief, and Davis (1973) examined the cost and service requirements for solid waste management in rural areas. First, a general framework was outlined for public solid waste management services. Then, models were developed to estimate the generation of solid wastes in sub-state planning regions, and also to estimate the costs of supplying solid waste collection, transfer, and disposal services in rural areas. Budgeting methods were used to estimate these costs, and regression analysis was used to estimate the functional relationships of costs to explanatory factors.

The authors gave an excellent breakdown of the costs associated with rural solid waste management systems. Methodologies were developed for estimating many cost categories including: costs of refuse collection, cost per

collection crew, cost per collection, cost per ton of solid waste, spatial effects on both residential and commercial collection costs, service area collection and transfer costs, costs of refuse disposal, landfill disposal costs, and service area disposal costs.

The main drawback of this study was that the models were not tested on actual rural planning regions even though the models and methodologies appeared to be both plausible and useful. The main finding was that rural communities would probably incur greater costs providing collection and disposal services than small metropolitan areas (defined as 50,000 to 250,000 population). This finding was evident for two reasons. First, rural areas are generally less densely populated than metropolitan areas, which causes collection costs to increase. Second, landfill disposal methods showed significant economies of size, causing disposal costs per ton to be much higher for the smaller rural landfills when compared to large metropolitan landfills. The authors noted that rural areas may be able to reduce total costs by utilizing regional disposal facilities.

Hardy and Grissom (1976) examined the cost savings that could be achieved through cooperative regionalized solid waste management systems in rural areas. The Alabama Regional Planning District 1, a largely rural five-county region, was chosen as the case study area. The main objective of their research was to find the least cost collection and disposal

system for the five-county region. The authors developed two models in their analysis. A location model was first developed to determine the optimal locations for sanitary landfills. The objective was to minimize the total transport miles. Second, a routing algorithm was used to determine the best collection truck routes to travel for each locational pattern designated by the location model. The objective of this model was to minimize the total cost of delivery. Budgeting techniques were also used in their analysis.

The authors found, as did Schreiner, Muncrief, and Davis, that significant economies of size and scale could be achieved with a regional system, as compared to single county systems, for both the disposal and collection functions. Collection costs were found to be dependent on both population density and the size of the service area. Other justifications given by Hardy and Grissom for cooperative efforts were that: (1) cost savings could be realized through less duplication of large and expensive equipment; (2) regional systems may be large enough to operate with maximum economic efficiency; and (3) better services may be provided through regional systems. Although their study did not examine regional recycling systems, one could easily substitute MRF's for landfills, and collection and transportation of recyclable materials for solid waste, and complete similar types of analyses. Regardless of whether one was examining solid waste or recyclable materials, the collection and transportation

results would be very similar since much of the solid waste stream consists of recyclable materials, and also because the same types of trucks would likely be used.

Church, Markley, and Park (1986) examined the costs of alternative solid waste collection systems in four rural Tennessee counties. Their study compared the green box (GB) and convenience center (CC) systems, with the objective of determining which system was more cost effective. The four Tennessee counties included in their study were Grainger, Jefferson, Polk, and Wilson, and all had recently switched from the GB system to the CC system.

Under the GB system, metal containers(or dumpsters) were placed at numerous locations throughout the county where residents could dispose of their trash. This type of system was originally developed to eliminate the problem of open dumping of trash. The GB system was not without problems of its own however, as green boxes frequently faced the difficulties of scavenging, vandalism (including fires), illegal dumping of hazardous waste into the containers, and unsightly trash around the containers (p. 3).

Because of these problems several counties switched to the CC system. Under the CC system, containers are consolidated at a much smaller number of sites (ranging from four to eight sites in the case-study counties), which are located for convenience in areas of population concentration or on heavily traveled routes. Access is controlled and

limited to certain hours, as attendants are stationed at each site and the facilities are surrounded by fencing.

The costs of the two systems were compared, based upon three major cost categories: total annual equipment cost; total annual labor cost; and total annual site cost. Only three of the four counties were used in this part of the analysis, as Polk County had only limited cost data available. In all three counties, total annual costs for the CC system were less than for the GB system. In most cases, equipment and labor costs were lower, offsetting higher site costs for the CC system. Another finding was that economies of size may be present under the CC system as population and population density increase.

Murray, Myles, and Reinschmiedt (1987) examined the economics of trash collection in Mississippi and Alabama. In their study, trash was defined as "those items not normally considered garbage, and typically not bagged. Trash items include....tree limbs and brush, leaves, and other yard trimmings" (p. 1). The objective of their research was to identify methods of trash collection in Mississippi and Alabama, and estimate the costs of alternative systems. Five sites in the two states were chosen and anonymously identified as cities A-E. Time and motion studies were used at each site, and data were collected on the number of households served, trash volumes removed, equipment, and costs. The cities chosen as case studies were largely rural in nature,

and varied in population from 7,500 (City B) to 45,000 (City A).

Different collection systems and equipment were used such as limb truck systems, front end loader systems, leaf truck systems, and compactor truck systems. For cities A, B, C, and E, costs per ton ranged from \$34 (City C) to \$73 (City B). City D's costs were given as \$2.13 per cubic yard. The average costs per household (dollars/month) were: City A (\$4.69); City B (\$3.47); City C (\$1.55); City D (\$2.13); and City E (\$3.25) (p. 19). These ranges in costs were attributed to differences in equipment and efficiency, and also to the different ranges of trash services offered in the case study cities. Trash removal costs were determined to constitute a significant portion of the waste management budgets for the cities studied. Trash volumes were also found to be seasonal in nature, with spring and fall accounting for the largest volumes.

These studies have shown the different types of equipment used in solid waste management, and have focused on the types of collection systems prevalent in many rural areas. Several of the authors recognized that many solid waste services were prohibitively more expensive in rural areas than in metropolitan areas, and that significant economies of size and scale can be achieved through regionalization of services, equipment, and facilities.

Recycling Studies

Susan Schmidt of The Minnesota Project, a non-profit rural community development organization, conducted a case-study analysis of seven rural recycling operations in the United States (1987). These recycling operations were located in California, Maine, Michigan, Minnesota, New Hampshire, and Wisconsin, and all varied in their methods of recyclable materials collection, including drop-off, buy-back, and curbside collection systems. All of the communities participating in the recycling programs were rural in nature, with populations that ranged from 2,145 to 32,126.

Schmidt evaluated the seven recycling programs in terms of many criteria including: tons of recyclables handled; estimated percentage of solid waste diverted from disposal; range and type of materials handled; net cost of recycling program; avoided disposal costs; and pounds of materials recycled per capita. In addition, the author identified several non-monetary or intangible benefits from recycling, and offered suggestions for policy-makers and community groups on implementing recycling operations.

None of the case study recycling programs earned a profit in the sense that revenues from the sale of recyclable materials exceeded the costs of the programs. However, when avoided landfill tipping fees were considered, three of the programs more than broke even. One of those case-study sites, Ithaca, Michigan, was not considered in this part of the

analysis because of a lack of certain revenue and cost figures. The programs studied diverted between 1% and 21% of the solid waste stream from disposal via recycling, and handled between 53 and 856 tons of recyclable materials per year.

Schmidt noted that avoided tipping fees were only part of the costs avoided through recycling. Other costs included avoided environmental clean-up expenses, avoided costs of new landfill space, and avoided collection costs (p. 26). In addition, there were other benefits of recycling that were considered, such as job creation, income, community pride and development, environmental considerations (e.g. resource conservation, energy conservation, etc.), and the ability to provide meaningful work for mentally disabled adults, as with the Morrison County, Minnesota program. The author also recognized that recycling programs were more likely to be successful when: (1) the primary objective of the program was waste management; (2) the unit of government involved in recycling was responsible for both waste collection and disposal; (3) a variety of collection methods were used, such as curbside, buy-back, and drop-off systems; (4) the processing and marketing responsibilities were regional in scope; and (5) mandatory programs were enforced to obtain a greater impact on the solid waste stream.

Shaw and Park (1989) examined three recycling centers in the Southeast. The objectives of their study were to

determine: the start-up costs associated with the three centers; the economic feasibility of their operations; the degree to which economies of size were present in the operations; the factors affecting the volumes of recyclable materials collected; and the factors that influenced the performance of the centers (p. 3). The three recycling centers in their case study were: the Athens-Limestone Recycling Center in Limestone County, Alabama; the Grainger County Recycling Center in Grainger County, Tennessee; and the Watauga County Recycling Center in Watauga County, North Carolina. All three of the centers were buy-back operations, where payment was made for recyclable materials collected by individuals. All locations were rural in nature, with total county populations less than 50,000.

Shaw and Park determined that the cost to construct a new building for recycling operations, in 1984 dollars, ranged between \$35,000 and \$50,000 for the geographic area studied. Also determined were the equipment costs associated with purchasing new equipment. These costs ranged from \$20,000 to \$30,000 without a horizontal bailer, and from \$40,000 to \$60,000 with one. While these costs seemed expensive for rural communities, the authors noted that using existing facilities and equipment whenever possible, along with purchasing used equipment and seeking outside sources of funding (such as government grants), may make recycling more feasible in rural areas.

None of the three centers studied operated at a profit in the sense that revenues from the sale of recyclable materials offset the costs of operation. However, when a full cost accounting methodology was used, including avoided landfill costs, one of the centers (Athens-Limestone) operated at positive net returns. Shaw and Park also noted that the building housing the Grainger County Recycling Center (an abandoned, county-owned school house) most likely had a very low opportunity cost, and grant funds were used for some equipment and labor. Thus, the net cost per ton to Grainger County itself was actually much lower than what would appear from a full-cost accounting perspective.

The potential for economies of size was investigated to determine if costs could be reduced within a given plant size or scale. The authors focused on "the cost per ton disposed of by means of recycling....net of revenues", to obtain costs comparable to either landfill or incineration costs (p. 23). Cost per ton estimates were made for hypothetical minimum and maximum levels of materials processed. These were combined with the actual costs and amounts processed, and it was determined that the potential for substantial economies of size did exist for all three recycling centers.

To determine factors associated with the level of materials collected, simple regression models were developed to obtain estimates of the supply function for recyclable materials. The dependent variable in these models was the

amount of material collected. The demand for recyclable materials was assumed to be perfectly elastic. The variables included in the model were price of corrugated board, price of aluminum cans, a time trend, monthly unemployment rate, and seasonal dummies for spring, summer, and fall. The model was applied to the Athens-Limestone and Grainger County centers, but not to the Watauga County Center due to a lack of data. The significant variables in the model included the price of aluminum cans, the time trend, the unemployment rate (but only for the Athens-Limestone Center), and the spring dummy.

Surveys of center managers were used to determine the factors influencing performance of the recycling operations. The most important factors were found to be center accessibility, prices paid, variety of materials accepted, and education of residents.

Mulvey (1986), in a staff report to the New York Legislative Commission on Solid Waste Management, gave an in-depth discussion of the economics of recycling municipal solid waste (MSW). In Chapter I, Mulvey gave an overview of MSW problems in New York, along with a broad discussion of the benefits of recycling. Also presented in this chapter was a brief history of recycling from ancient times to the present. Chapter II was the most informative section of the report. A very detailed presentation was given on the different recyclable materials found in the MSW stream, and also on the many types of recyclers (e.g. scrap dealers, recycling

centers, export brokers etc..). In Chapter III the concepts and tools of economic theory were applied to recycling, and Mulvey argued that marginal analysis (pricing and cost) should be used in the evaluation of recycling as a MSW management alternative. Current topics were also presented, such as the role of user charges in recycling and solid waste management. In Chapter IV, Mulvey gave an overview of recycling around the world, including the United States, where attention was focused on New York State.

Mulvey presented a detailed description of the composition of the MSW stream, and included discussion on waste paper, plastics, glass recycling, ferrous metals, non-ferrous metals, rubber recycling, and organic materials. Under each material the opportunities for recycling were discussed, and the author's methodology included sections on characteristics, sources, collection methods, benefits from recycling, impediments to recycling, export markets, and future outlook. While the percentages varied among communities, it was reported that the solid waste stream in the United States consisted of the following volumes (in

1986):	(1) paper	33.0%
	(2) plastics	4.0%
	(3) glass	10.5%
	(4) ferrous metals	8.5%
	(5) aluminum	0.7%
	(6) other non-ferrous	0.7%
	(7) organic materials*	39.0%
	(8) other	<u>3.6%</u>
		100.0%

* (food, wood, grass clippings, brush etc..)

Five other interesting and significant findings were made by Mulvey. First, the United States is the major supplier of paper and ferrous scrap in the world export market. Second, "Failure to price solid waste management services based on the amount of waste generated results in both economic inefficiencies and resource misallocations" (p. 72). Third, disposal services have low price elasticities of demand since individuals think that they have few or no alternatives (p. 73). Fourth, many states such as Minnesota and New Jersey are financing recycling at both the local and state levels by small increases in landfill tipping fees. Finally, it was reported that in one New York community (Hamburg) a 20-25% reduction in the solid waste stream from recycling led to a 34% reduction in landfilling (p. 88). The difference was justified by the fact that what remained after recycling tended to compact tighter.

Halstead and Cornelio (1989) surveyed towns and landfills in New Hampshire to obtain detailed information on municipal solid waste management practices in the state. Landfill information was collected on general characteristics (e.g. average size, life remaining, ownership), and also on operating and cost characteristics. The town surveys included information on disposal methods and agreements, and recycling operations in the state.

The authors found that approximately 90% of the state's landfills were owned and operated by local governments. It

was also discovered that the landfill situation was reaching crisis proportions. The number of regional landfills in New Hampshire had decreased from eighty-three in 1980 to sixty-five in 1988 (p. 2). Of more striking importance was the fact that 97% of the remaining landfills were expected to be full by 1992. These closures also contributed to dramatic increases in the tipping fees charged by landfills in the state. Over the period 1984-1989, tipping fees increased by 270%, averaging almost \$48 per ton in 1989 (p. 9).

Because of the landfill crisis, and also because of a state mandate, many communities in New Hampshire began looking for more cost effective alternatives for solid waste management. Recycling emerged as a forerunner in this search for feasible alternatives. Approximately 70% of towns surveyed by Halstead and Cornelio recycled part of their waste, and on average diverted from disposal between 10% and 15% of the solid waste stream (p. 10). Incineration of waste also increased in the state during this period. It was reported that in 1989, approximately 14% of the state's solid waste was disposed of through incineration (p. 1).

In July 1989, Douglas, Roberts, and Park determined the willingness to participate in and pay for a curbside recycling program in North Chattanooga, Tennessee. Telephone surveys were conducted on 146 randomly selected households in North Chattanooga, with a 71% response rate (103 completed surveys).

The results from the survey showed that 94% of the

respondents were willing to participate in a curbside recycling program, with 63% indicating a strong willingness to participate (p. 3). Of the 94% willing to participate, 91% were willing to separate their recyclables into four groups -- newspaper, glass bottles, aluminum cans, and plastic soft drink and milk bottles (p. 3). Respondents were also asked for their willingness to participate in a drop-off recycling program. Nearly 53% of those surveyed were willing to drop off recyclables at a convenience center, but only if the center was in a conveniently accessible location (p. 4).

Douglas, Roberts, and Park also found that 54% of the respondents were willing to pay a monthly fee to finance a recycling program (p. 4). Of those respondents willing to pay, 54% were willing to pay between \$1 and \$10 per month, while 46% would not commit to any particular amount (p. 4). The results from their survey encouraged North Chattanooga public officials and policymakers to seriously consider a pilot curbside program of 500 households.

Summary

The review of literature presented in this chapter described the equipment and systems of collection for both solid waste and recyclable materials. Several authors (Schreiner, Muncrief, and Davis, Hardy and Grissom, Church, Markley, and Park, Schmidt, Shaw and Park) found that economies of size did exist in processing, collection, and

even disposal, and most suggested that these economies could be captured in a regional system. After reviewing the literature in this area, it is evident that additional research is needed concerning regional recycling systems and the significance of transportation costs for recyclable materials. While many studies have suggested the benefits of regional systems, few have collected data or developed models supporting these suggestions.

CHAPTER 3

CURRENT CHARACTERISTICS OF SOLID WASTE MANAGEMENT IN THE FIRST TENNESSEE DEVELOPMENT DISTRICT

The current (mid 1990) characteristics of solid waste in the FTDD were documented in this chapter. Sections were included on the collection, transportation, processing and disposal of solid waste. The chapter concludes with a discussion on the extent of recycling in the FTDD.

Collection

The manner of household solid waste collection was quite uniform in most of the FTDD. Typically, most cities were serviced by curbside collection of garbage. The remaining residents of smaller cities and rural counties were generally served by a convenience center system, where residents provided the transportation of their garbage to a central location in the county. There were three exceptions to the norm with regard to collection in the FTDD. First, in Hancock County, there was no system of collection outside the City of Sneedville, though residents could take their garbage directly to the county-owned landfill. Second, Greene County had a green box collection system instead of a convenience center system for the county residents. Under this system, approximately 400 greenboxes (or dumpsters) were placed along

the roadsides in numerous locations throughout the county, where residents would deposit their garbage. Third, Sullivan County operated two transfer stations¹ in place of convenience centers for county residents. For this analysis there was no real difference between a transfer station and a convenience center.

A summary of the solid waste collection systems for the FTDD was presented in Figure 3.1. Approximately 31% of the FTDD households were served by curbside collection of garbage. Curbside percentages ranged from a low of 13.0% in Hawkins County to a high of 42.4% in Washington County. For the counties with convenience centers, each center served an average of approximately 4,200 households. The number of convenience centers varied from one in Johnson County to eight in Hawkins County (excluding Greene and Hancock Counties which do not have convenience centers).

Solid waste collection in the FTDD was conducted by both public (city and county) and private haulers. The major private firm collecting waste was Waste Management Inc., who offered service in Carter, Sullivan, and Unicoi Counties. Additionally, every county had individuals who provided other types of solid waste collection services. However, the services were usually limited in scope, and focused more on

¹A transfer station is a solid waste drop-off point where waste is deposited into large compactor trucks, rather than into greenboxes as in the case of a convenience center. When full, the trucks transport the waste directly to the landfill.

COUNTY	TOTAL NUMBER OF HOUSEHOLDS	HOUSEHOLDS WITH CURBSIDE COLLECTION ^a	HOUSEHOLDS WITHOUT CURBSIDE COLLECTION	PERCENTAGE OF HOUSEHOLDS WITH CURBSIDE COLLECTION	NUMBER OF CONVENIENCE CENTERS	NUMBER OF GREEN BOXES
Carter	18,623	2,550	16,073	13.7%	2	---
Greene	20,471	4,998	15,473	24.4%	---	418
Hancock	2,321	593	1,728	25.5%	---	---
Hawkins	15,769	2,050	13,719	13.0%	8	---
Johnson	4,982	1,000	3,982	20.1%	1	4
Sullivan	53,564	21,200	32,364	39.6%	2 ^b	---
Unicoi	6,131	1,800	4,331	29.4%	3	---
Washington	33,764	14,300	19,464	42.4%	5	---
F.T.D.D.	155,625	48,491	107,134	31.2%	21	422

^aThe figures for curbside collection are likely to be underestimated somewhat due to difficulty in obtaining information from private haulers.

^bTwo transfer stations also serve as convenience centers for county residents.

Figure 3.1 Characteristics of Current Solid Waste Collection in the First Tennessee Development District

commercial waste than residential waste.

Transportation

Transportation of solid waste in the FTDD typically occurred in two phases. Residents provided the initial transportation of waste from their homes to either the curb, a convenience center, a greenbox, or a transfer station. Then, either a public or private hauler provided solid waste transportation from the point of collection to the point of ultimate disposal (i.e. the landfill).

There were two exceptions to the typical two-phase method of transportation of waste in the FTDD. In Hancock County, transportation occurred in one phase. As noted previously, Hancock County residents outside of the City of Sneedville took their garbage directly from their homes to the landfill. Secondly, transportation of solid waste in Sullivan County occurred in three phases in many areas where curbside collection was available. In the initial phase, residents took their garbage to the curb. In phase two, public or private haulers transported the garbage from the curb to one of two transfer stations operated by the county. Finally, in phase three the county transported the waste from the transfer stations to the landfill for disposal.

Transportation of waste from convenience centers or transfer stations to the point of disposal normally occurred using sixty cubic yard top-loading compactor trucks. In

contrast, transportation of waste from curbside collection to the point of disposal usually involved thirty cubic yard side-or-rear-loading compactor trucks.

Processing and Disposal

The major method of processing waste before disposal in the FTDD was through compaction. Compactor trucks were able to achieve a three-to-one compaction rate on average. For example, ninety cubic yards of uncompacted municipal solid waste was able to be compacted into a thirty cubic yard compactor truck. This type of processing offered two main advantages to local governments and private haulers. First, travel time and mileage were reduced as more customers or convenience centers were serviced on each route, and fewer trips were needed to the landfill. Second, compacted waste occupied less volume in the landfill than would have uncompacted waste. Thus, the useful life of landfills in the FTDD was extended.

Carter County also used one further method of processing before disposal. The county operated a demolition site at their landfill where natural wood waste was burned rather than deposited into the landfill. After incineration, the wood ash was buried, along with general waste, in the landfill.

Most landfill operators in the FTDD also collected white goods (e.g. discarded refrigerators, stoves, dryers, etc.) from the waste stream. There were three principal reasons for

removing the goods: 1) white goods, if deposited, would occupy a relatively large volume of space in the landfill; 2) many older white goods contained parts filled with PCBs, a known carcinogen and hazardous waste banned from landfills; 3) the goods could be salvaged for money.

Landfilling of solid waste was the only method of disposal in the FTDD, outside of illegal dumping. Every county in the FTDD, with the exception of Unicoi, had an operating landfill. Unicoi County's waste was transported to the Johnson City Regional Landfill in Washington County. Figure 3.2 shows the characteristics of landfills in the FTDD, including type of ownership, average size, current tipping fee rates, and estimated life remaining.

Recycling

While much interest in recycling had been expressed by the citizens of the FTDD, few public recycling programs have been established. The major public recycling effort on-going at the time of this study in the FTDD was the Johnson City curbside program. In 1989, Johnson City began a pilot curbside recycling program which serviced approximately 4000 households. Residents were given a fourteen gallon container into which they deposited recyclables they had separated from their garbage. The program provided for collection of newspapers, aluminum cans, plastic jugs (P.E.T. and

COUNTY (LANDFILL)	TYPE OF OWNERSHIP	AVERAGE SIZE (acres)	TIPPING FEES/TON (1989)	ESTIMATED REMAINING LIFE (years)	QUANTITY OF WASTE RECEIVED (tons/day)	SCALES USED?
CARTER -Carter Co./ Elizabethon Landfill	Joint City and County	100	\$8.50	13	100	yes
GREENE -Greene Co./ Greeneville Landfill	Joint City and County	100	\$10.00	9	120	yes
HANCOCK -Hancock Co. Landfill	County	6	None	2	10	no
HAUKINS -Carter Valley Landfill	County	60	None	1.5	14	no
JOHNSON -Johnson Co. Landfill	County	n/a	\$12.00	9	18	yes
SULLIVAN -Sullivan Co. Landfill	County	65	\$12.85	1	450	yes
WASHINGTON -Johnson City Regional Landfill	City	n/a	\$10.00	2	489	no
UNICOI	No Landfill	n/a	n/a	n/a	n/a	n/a

Source: 1990 UTMREI mail surveys.

Figure 3.2 Characteristics of Landfills in the First Tennessee Development District

H.D.P.E.)², and glass (clear, green, and brown). These items were collected on the same day as regular curbside garbage collection by a separate truck, and were transported to a city-owned facility for processing, storage, and marketing. The Johnson City program has operated successfully for two years, and the city will add an additional 8000 households to expand the program city-wide in late 1990.

Various recyclables were also collected at four convenience centers in Washington County, one in Unicoi County, and at the Elizabethton/Carter County Landfill. There was also a significant number of private industry recyclers who operated in the FTDD. However, these businesses tended to focus on one or two items rather than offering a full service recycling center where many recyclables were accepted. In total there were twenty-four firms, including scrap metal dealers, operating recycling buy-back³ centers in the FTDD.

This chapter has presented an overview of the solid waste framework of the FTDD. Through surveys and personal visits, information was collected and presented on solid waste collection, transportation, processing and disposal. In addition, a summary of both public and private recycling efforts was given.

²Polyethylene Tetracycline and High Density Polyethylene, respectively.

³A buy-back center is a collection point for recyclables where money is exchanged for the materials collected. These centers may be mobile units.

CHAPTER 4

PARTICIPATION AND RECYCLING POTENTIAL IN THE FIRST TENNESSEE DEVELOPMENT DISTRICT

In this chapter, the potential level of resident participation in recycling programs was projected for the FTDD. Those figures in turn were used to project the amount of recyclable materials that potentially could be collected from these programs. These calculations form the basis for completing the second objective by establishing ranges for collection of recyclable materials in each county in the FTDD, and in the FTDD as a region.

In order to complete this analysis, several important assumptions had to be made. The first assumption was that in each county two types of recyclable collections programs would be established -- curbside and drop-off, so that all residents would be given the opportunity to participate. The rationale behind this assumption was three-fold. First, background data from existing recycling programs were most readily available for these two types of collection systems. Second, these were two of the most prevalent types of full service collection systems in both the FTDD and the State of Tennessee. Third, information collected from buy-back programs, the other prevalent type of recycling program in the state, appeared to fall between the ranges established for curbside and drop-off

programs. For simplicity and lack of reliable buy-back recycling data, this analysis was limited to curbside and drop-off systems.

A second key assumption was that a curbside recycling system would be established for all those households currently receiving curbside collection of garbage. The remaining, typically rural, households would be served by a drop-off recycling system. This assumption was justified on the basis that, as stated earlier, most of rural Tennessee does not have curbside collection of garbage, and most likely will not have this service in the near future. Therefore, it would have been unrealistic to assume that households without curbside collection of garbage would have curbside collection of recyclables. This assumption also offered a similar level of convenience to households in that, in most cases, their recyclables could be dropped-off at the same location as their garbage (i.e. the curb or convenience center).

A third assumption, which placed parameters on the analysis, related to the level of participation in the two recycling systems. Based upon previous research, and from experiences of existing recycling operations, rates of participation were specified for both the curbside and drop-off recycling systems considered in the FTDD. While 80% participation rates have been achieved in some curbside programs, most notably in Seattle, Washington, this is considered an excellent level by industry standards. As a

point of reference, the Johnson City curbside recycling program averaged 73% participation over its first full year of operation.

Low and high participation rates were chosen to account for all scenarios, and to realistically represent the results of potential recycling programs in the FTDD. A low curbside participation rate of 60% was chosen. This would allow for more innovative programs whose costs, and thus break-even points, would be lower than most. A high curbside participation rate of 80% was selected. As noted earlier, this level of participation was judged superior by industry standards. Few programs in the United States, including mandatory ones, achieve results greater than 80%.

For drop-off recycling systems, a realistic range of participation rates was determined to be 15% to 40% of eligible households⁴. There were two main reasons for this range being considerably lower than the curbside participation range. First, it would be much less convenient for residents to separate their recyclables from their garbage and then drive them to a drop-off point, than to carry them to the curb. Second, some residents may take their recyclables to a buy-back center where money could be received for the materials, rather than donating the recyclables in a drop-off

⁴Eligible households refer to those households that may participate in the recycling program. For example, while Johnson City had over 16,000 households, in Phase One of their curbside program only 4,000 were eligible to participate.

program⁵. Forty percent participation was among the highest rates achieved for the drop-off programs examined. Thus, 40% was chosen as the high participation rate. Since most drop-off programs achieve participation rates in the 20% to 30% range, a conservative low participation level of 15% was chosen for this part of the analysis.

For simplification, a fourth assumption of this analysis was that the amount of recyclable materials collected per household per week was the same for both curbside and drop-off programs throughout the FTDD. This assumption was made due to lack of data to suggest otherwise. If future research were to show that the amounts collected from the two systems could be expected to be different, this would involve a simple change and recalculation of the analysis.

A fifth assumption, implicit in the fourth assumption, was that the amount of recyclable materials collected per household per week was the same in both urban and rural areas. While previous research has not compared recyclable collection rates between urban and rural areas, work conducted by the UTMREI in 1990 suggested that the amount of garbage generated by households varied significantly between these areas. However, no universal standard for rural versus urban garbage generation rates were determined. As with the fourth assumption, if future research were to update this

⁵This argument may also apply to curbside systems, but to a lesser extent due to convenience to the household.

information, this would involve a simple change in the analysis.

Results from the Johnson City curbside program were used to represent the FTDD in regards to the types and amounts of recyclable materials collected. The actual results of an established local program were deemed to better represent the region than a national average. In addition, the types of recyclable materials collected in the Johnson City program represented those for which reliable markets had been established in the region.

The Johnson City program averaged a collection rate of 5.29 pounds per participating household per week. This rate was comparable to other curbside programs researched. The 5.29 pounds were distributed among materials as follows:

(1) newspaper	3.52 lbs.	66.5%
(2) glass	1.25 lbs.	23.7%
(3) aluminum	0.12 lbs.	2.3%
(4) plastic	<u>0.40 lbs.</u>	<u>7.5%</u>
	5.29 lbs.	100.0%

This rate, along with the high and low participation rates, was used to project the amount of recyclable materials that could be collected in the FTDD, given the assumptions of the analysis. Figure 4.1 outlines in sequential steps the format of the calculations, and explains how the projections were determined.

The projections of recyclable materials collection were calculated in seven steps, which are explained below. The left hand side of Figure 4.1 represents calculations using

Steps (in parentheses)

Curbside Potential:	Curbside Potential:
Low Participation (60%)	High Participation (80%)
(1) HH* X 60% = PH#	(1) HH* X 80% = PH#
*Households	*Households
#Participating households	#Participating households
(2) PH X 5.29 ^g = lbs/week	(2) PH X 5.29 ^g = lbs/week
^g lbs/PH/week	^g lbs/PH/week
Drop-Off Potential:	Drop-Off Potential:
Low Participation (15%)	High Participation (40%)
(3) HH X 15% = PH	(3) HH X 40% = PH
(4) PH X 5.29 ^g = lbs/week	(4) PH X 5.29 ^g = lbs/week
^g lbs/PH/week	^g lbs/PH/week
Total Potential:	Total Potential:
Low Participation	High Participation
Curbside + Drop-Off	Curbside + Drop-Off
(5) Steps (2) + (4) = total lbs/week	(5) Steps (2) + (4) = total lbs/week
(6) Step (5) X 52 weeks = lbs/ year	(6) Step (5) X 52 weeks = lbs/ year
(7) Step (6)/2,000 = tons/year {total}	(7) Step (6)/2,000 = tons/year {total}

Figure 4.1 Methodology for Projecting the Potential for Recyclable Materials Collection in the First Tennessee Development District

the low participation rates previously established for both the curbside and drop-off programs. The right hand side of the figure followed the same steps, using the high participation rates established earlier. When applied to a specific county or region, a range, in tons of recyclables per year, can be generated. This range represents the amount of recyclable materials that could be expected from a recycling program, given the assumptions of the analysis.

In step (1), the total number of households served by curbside collection of garbage in the county (or other designation, such as city, region, community etc.) was multiplied by the previously determined curbside recycling participation rate to obtain the number of participating households in the recycling program.

In step (2) the number of participating households was multiplied by 5.29. This 5.29 represents the average pounds of recyclables collected from each participating household each week. As noted earlier, this figure was based on experience in the Johnson City curbside recycling program. The total number of pounds per week represented a subtotal for the curbside portion of the model.

Steps (3) and (4) referred to the drop-off portion of the model. In step (3), the number of households in the county not served by curbside collection of garbage was multiplied by the drop-off participation rate to obtain the number of participating households. Step (4) involves multiplying the

number of participating households by 5.29, for the same reasons explained in step (2) above. The total number of pounds per week represents a subtotal for the drop-off portion of the model.

Step (5) involves the summation of the subtotals achieved in steps (2) and (4) to obtain the total pounds collected per week for both recycling programs. Step (6) entails multiplying this total by 52 (weeks) to obtain the total pounds of recyclables collected for the year. Finally, in step (7), this annual total is divided by 2,000 (pounds) to express the total in tons, rather than pounds.

An example using data from Carter County was presented in Figure 4.2. As was shown in Figure 3.1, 2,550 households in Carter County were served by curbside collection of garbage, and 16,073 were not. This information was used in the following projections.

As can be seen from Figure 4.2, Carter County could reasonably expect to collect between 542 and 1,165 tons of recyclable materials per year, given its population and garbage collection characteristics, and the participation rates assumed. Results for each county in the FTDD are summarized in Figure 4.3. As shown in this figure, the FTDD as a region could expect to collect between 6,213 and 11,255 tons of recyclables per year depending on the participation rates achieved.

This chapter focused on the assumptions and parameters

Steps (in parentheses)

Curbside Potential:

Low Participation (60%)

$$(1) 2,550^* \times 60\% = 1,530^{\#}$$

***Households**

#Participating households

(2) 1,530 X 5.29^Q = 8,094
lbs/week

⁶lbs/PH/week

Drop-Off Potential:

Low Participation (15%)

$$(3) 16,073 \times 15\% = 2,411$$

$$(4) \ 2,411 \times 5.29^g = 12,754 \text{ lbs/week}$$

^elbs/PH/week

Total Potential:

Low Participation

Curbside + Drop-Off

(5) 8,084 + 12,754 = 20,848
total lbs/week

(6) 20,848 X 52 = 1,084,090
lbs/year

(7) 1,084,090/2,000 = 542
tons/year
{total}

Curbside Potential:

High Participation (80%)

$$(1) 2,550^* \times 80\% = 2,040^\#$$

***Households**

#Participating households

$$(2) \ 2,040 \times 5.29^{\text{g}} = 10,792 \text{ lbs/week}$$

^elbs/PH/week

Drop-Off Potential:

High Participation (40%)

$$(3) 16,073 \times 40\% = 6,429$$

$$(4) \quad 6,429 \times 5.29^{\text{e}} = 34,009 \text{ lbs/week}$$

@1bs/PH/week

Total Potential:

High Participation

Curbside + Drop-Off

(5) $10,792 + 34,009 = 44,801$
total lbs/week

(6) $44,801 \times 52 = 2,329,653$
lbs/year

(7) $2,329,653/2,000 = 1,165$
tons/year
{total}

Figure 4.2 Methodology for Projecting the Potential for Recyclable Materials Collection in Carter County

COUNTY	LOW ^b PARTICIPATION	%	HIGH ^c PARTICIPATION	%
Carter	542	8.7	1,165	10.4
Greene	732	11.8	1,401	12.5
Hancock	85	1.4	160	1.4
Hawkins	452	7.3	980	8.7
Johnson	165	2.7	329	2.9
Sullivan	2,417	38.9	4,113	36.6
Unicoi	238	3.8	463	4.1
Washington	1,582	25.5	2,644	4.1
F.T.D.D.	6,213	100.0	11,255	100.0

^aMaterials are assumed to be distributed by weight as in the Johnson City Curbside Program: aluminum cans - 2.3%, glass - 23.7%, newspaper - 66.5%, and plastic - 7.5%.

^bLow participation was defined as 60% for curbside and 15% for drop-off at convenience centers.

^cHigh participation was defined as 80% for curbside and 40% for drop-off at convenience centers.

Figure 4.3 Recyclable Materials Collection Potential
(Tons/year) for the First Tennessee Development
District

underlying the projections of recyclable material collection levels in the FTDD. The resulting projections were used in the next chapter to estimate the costs associated with recycling under alternative scenarios reflecting individual county versus regional processing.

CHAPTER 5

REGIONAL VERSUS SINGLE COUNTY RECYCLING IN THE FIRST TENNESSEE DEVELOPMENT DISTRICT

In this chapter, the costs associated with recycling were estimated and compared for two scenarios: (a) each county in the FTDD implements their own recycling program, including collection, processing, and marketing; (b) an integrated recycling program is implemented for the multi-county region (FTDD) involving the coordination of collection and transportation to a centralized materials recovery facility (MRF) for processing and marketing. Processing costs of recyclables were estimated both for the individual counties and for the FTDD as a region. Costs of transporting recyclables from each county to a regional MRF were also estimated. These costs were examined to determine the potential costs savings of a regional recycling system.

This analysis was conducted from the perspective of an individual county (or municipality) considering the initiation of a system of collection for recyclable materials. Once collected (either through drop-off or curbside systems as discussed in Chapters 3 and 4), the key decision is whether or not to process the materials. That is, each individual county could set up and operate a small scale processing center, or each county could transport the recyclable materials as cost

effectively as possible to an existing larger-scale MRF. This decision depends upon three key factors:

1. processing cost per ton at their own facility, based upon the volume of materials they could expect to generate;
2. the differential in costs between transporting recyclable materials to their own processing center and transporting them to the nearest existing larger-scale MRF;
3. the financial agreement associated with the delivery of materials to the existing MRF.

Given recent levels of market prices for recyclable materials and processing cost levels for large-scale processing operations, revenues from processed materials barely cover processing costs of \$50-60 per ton. While a program could expect to receive a price of \$600 to \$800 per ton for delivery of aluminum, delivery of most other materials could be expected to bring as little as \$0 to \$20 per ton (newspaper for example). Given that relatively little aluminum may be collected with any recycling system (as a percentage of the total weight of recyclables collected), substantial revenue from aluminum should not be expected. Many recycling programs achieve aluminum collection amounts of well under 5% of the total weight of materials collected. Much of the aluminum that is recycled is collected through buy-back centers, rather than from donations in a curbside or drop-off recycling program. From experiences in several Tennessee programs, a weighted average price of \$40-60 per ton is reasonable to expect for processed materials. For a point

of reference, the Johnson City Curbside Recycling program received a weighted average price per ton of \$61.88 for their recyclables.

Processing Costs

The first step in achieving the objective three was to estimate the processing costs both for individual counties and for the FTDD as a whole. These costs were based upon the amount of recyclable materials that were projected in Chapter 4 (see Figure 4.3). As with the specification of participation rates and materials collected in the last chapter, two alternative processing cost levels (high and low) were specified to reflect the current uncertainty in costs and to account for differences in processing methods and equipment. Processing cost specifications were based primarily on the Tennessee Eastman Corporation base model developed by David Cornell, although the actual experiences of a few Tennessee processing operations were also taken into account. The model, MUNI321, is a mathematical computer simulation of a comprehensive curbside recycling program. The integrity and validity of the model has been documented by comparisons with experiences in a number of communities. MUNI321 was used to project costs for more than a dozen existing curbside recycling programs around the United States, and each time projected costs very similar to actual costs of the programs. Repeated runs of this model assuming different

population levels allowed for the derivation of an average cost function that reflected the potential for economies of size in processing, an important factor for scenario b--regional recycling (see Appendix E for MUNI321 cost graph). The MUNI321 projection costs were chosen as an upper bound for this analysis because the base model assumptions reflected new buildings and equipment, as well as relatively high labor costs. A low processing cost level was set at 75% of the MUNI321 cost figures. This lower level allowed for the possibility of utilizing existing building space, availability of used equipment, and lower labor costs. The estimated processing costs for recyclable materials for the FTDD are shown in Figure 5.1. Because there were ranges (high and low) of both participation rates and processing costs, there were four combinations, or scenarios, for total processing costs (and also processing costs per ton). These were as follows:

1. low participation rate, low processing costs;
2. low participation rate, high processing costs;
3. high participation rate, low processing costs;
4. high participation rate, high processing costs.

Total processing costs were calculated as follows. High processing costs per ton of material were determined from the MUNI321 program by inserting data into the model from the FTDD. The low processing costs were determined by reducing the high costs figures by 25%. These costs were then multiplied by the respective tons of materials projected per

County	Total Number of Households	Tons of Material Collected Per Year ^a		Processing Costs ^c						Total Processing Costs					
				Per Ton of Materials ^c			Per Ton of Materials ^c			Per Ton of Materials ^c			Per Ton of Materials ^c		
		Low	High	Low Part Low Cost	Low Part High Cost	High Part Low Cost	High Part High Cost	Low Part Low Cost	Low Part High Cost	High Part Low Cost	High Part High Cost	Low Part Low Cost	Low Part High Cost	High Part Low Cost	High Part High Cost
Carter	18,623	542	1,165	108	144	87	116					\$ 58,536	\$ 78,048	\$101,355	\$135,140
Greene	20,471	732	1,401	99	132	83	110					72,468	96,624	116,283	154,110
Hancock	2,321	85	160	128	170	125	166					10,880	14,450	20,000	26,560
Hawkins	15,769	452	980	111	148	92	122					50,172	66,896	90,160	119,560
Johnson	4,982	165	329	125	166	117	156					20,625	27,390	38,493	51,324
Sullivan	53,564	2,417	4,113	69	92	56	74					166,773	222,364	230,328	304,362
Unicoi	6,131	238	463	122	162	111	148					29,036	38,556	51,393	68,524
Washington	23,764	1,582	2,644	78	104	68	90					123,396	164,528	179,792	237,960
Total-County Processing	115,625	6,213	11,255									531,886	708,856	827,804	1,097,540
Total-Regional Processing	155,625	6,212	11,230	48	64	44	58					298,224	397,632	495,220	652,790

^aMaterials are assumed to be distributed by weight as in Johnson City Curbside Program: aluminum cans - 2.3%, glass - 23.7%, newspaper 66.5%, and plastic 7.5%.

^bLow participation was defined as 60% for curbside and 15% for drop-off at convenience centers; high participation, 80% for curbside and 40% for drop-off at convenience centers.

^cHigh processing cost per ton of material was taken directly from Tennessee Eastman base model; low processing cost was assumed to be three-fourths as much, allowing for factors such as lower labor costs, availability of used equipment, existing building space, etc.

^dParticipation Rate

Figure 5.1 Estimated Annual Processing Costs for Recyclable Materials from the Residential Sector in the First Tennessee Development District

year to obtain estimates of total processing costs. Total annual processing costs, assuming individual county processing, were determined by summing the individual county costs. These costs ranged from \$531,886 to \$1,097,540. Annual processing costs were then calculated on a regional basis using the average cost function developed in Muni321, assuming that the same total amount of materials would be transported to a single regional MRF. These costs ranged from \$298,224 to \$652,790. By comparing the total individual county processing costs with the total regional processing costs, the gains that could be achieved through exploitation of the economies of size with a regional MRF were determined. The absolute reductions in total processing costs utilizing a regional MRF were substantial, averaging from 40% to 44%. These figures are highlighted in Figure 5.2.

Transportation Costs

Costs of transporting recyclables were estimated using a methodology similar to that used with processing costs. As before, two alternative cost levels were specified (high and low) to allow for uncertainty and variations in factors such as equipment and labor rates. While no cost figures were readily available for transportation of uncompacted recyclables, costs for transportation of municipal solid waste could be obtained. Given that recyclables make up a substantial percentage of municipal solid waste, these

	<u>Total Processing Costs</u>			
	Low Part ^a Low Proc ^b	Low Part High Proc	High Part Low Proc	High Part High Proc
Total Processing Costs (County)	\$531,886	\$708,856	\$827,804	\$1,097,540
Total Processing Costs (Regional)	298,224	397,632	495,220	652,790
Absolute Reduction in Processing Costs	233,662	311,224	332,584	444,750
Percentage Reduction in Processing Costs	43.9%	43.9%	40.2%	40.5%

^aParticipation Rate

^bProcessing Cost

Figure 5.2 Estimated Annual Processing Cost Savings for a Regional Materials Processing Facility in the First Tennessee Development District

transportation cost levels were used as a point of reference. Transportation cost figures were obtained from Ron Black, a Tennessee Valley Authority (TVA) transportation specialist. Black's figures represented uncompacted municipal solid waste, and were validated by two private solid waste firms operating in Tennessee. Realizing that it was virtually impossible to transport loads of separated recyclable materials as cost effectively as transporting mixed municipal solid waste, the cost figures were adjusted upward. It was assumed that a rate twice that for municipal solid waste would be a reasonable lower bound on transportation rates for recyclables in this study. An upper bound on transportation costs was set at 50% higher than the lower bound. While somewhat arbitrary, this appeared in line with experiences from a few existing recycling programs in which uncompacted, but separated, recyclables were transported some distance to a regional processor. As with the recyclable materials projections in Chapter 4, if future research were to reveal different, or better defined, ranges of transportation costs, this would involve a simple change and recalculation to improve the analysis.

Estimated transportation costs for recyclables in the FTDD are shown in Figure 5.3. The assumptions behind the estimated costs were as follows. First, the regional processing center was assumed to be in Washington County, where Johnson City does have an existing processing center.

County	Total Number of Households	Tons of Material Collected Per Year Participation		Distance to Regional Processing Center (miles) ^a	Transportation Cost Per Tpn of Material ^b		Total Transportation Cost					
		Low	High		Low	High	Low Part ^c Low Cost	Low Part High Cost	High Part Low Cost	High Part High Cost		
Carter	18,653	542	1,165	20	\$12.72	\$19.08	\$ 6,894	\$10,341	\$14,819	\$22,228		
Greene	20,471	732	1,401	30	16.36	24.54	11,976	17,963	22,920	34,381		
Hancock	2,321	85	160	55	25.46	38.19	2,164	3,246	4,074	6,110		
Hawkins	15,769	452	980	30	16.36	24.54	7,395	11,092	16,033	24,049		
Johnson	4,982	165	329	35	18.18	27.27	3,000	4,500	5,981	8,972		
Sullivan	53,564	2,417	4,113	25	14.54	21.81	35,143	52,715	59,803	89,705		
Unicoi	6,131	238	463	15	10.90	16.35	2,594	3,891	5,047	7,570		
Washington	23,764	1,582	2,644	--	---	---	---	---	---	---		
Total	155,625	6,213	11,255				69,166	103,748	128,677	193,015		

^aRegional processing center assumed to be in Washington County, where Johnson City does have an existing processing center.

^bThis represented the differential in cost between transporting to a local site versus the regional site. Low cost figures came from estimates of current costs for handling uncompacted solid waste by a TVA transportation specialist, which must be considered a lower bound; high cost figures were one and a half times the low cost figures which, though somewhat arbitrary, appear more in line with evidence from actual experiences.

^cParticipation Rate

Figure 5.3 Estimated Cost for Transportation of Recyclable Materials to a Regional Processing Center in the First Tennessee Development District

where Johnson City does have an existing processing center. Johnson City is roughly at the geographic center of the FTDD. Second, the distance to the regional processing center was measured from a center point in each county. Transportation costs per ton were based upon these distances. Thus, this distance represented the differential in costs between transporting recyclables to a local processing center (assumed to be near the center of each county) and transporting them to the regional processing center.

Transportation costs were estimated for the tons of recyclable materials projected for collection in the FTDD (see Figure 4.3), in a manner similar to processing cost estimates. Total transportation costs were calculated by multiplying the tons of materials projected per year by the transportation cost per ton for each county. Because there were high and low ranges for both participation rates and transportation costs per ton, four possible combinations or scenarios for total transportation costs existed:

1. low participation rate, low transportation costs;
2. low participation rate, high transportation costs;
3. high participation rate, low transportation costs;
4. high participation rate, high transportation costs.

Total estimated annual transportation costs for recyclables in the FTDD ranged from \$69,166 to \$193,015.

Regional Recycling

Now that the processing and transportation costs associated with recycling have been estimated for scenarios (a) and (b), these were compared to determine the potential cost savings of a regional recycling system. A weighted average net revenue of \$61.88 per ton of recyclables was factored in the analysis, based on the recent experience in the Johnson City curbside recycling program.

The individual county versus regional comparison was completed by examining the total processing and transportation costs to each county under both scenarios. The individual county costs were estimated by calculating the difference between total processing costs and total revenues from the sale of recyclables. These individual county costs are shown in Figure 5.4, with four combinations of total costs because of the range (high and low) of participation rates and processing costs:

1. low participation rate, low processing costs;
2. low participation rate, high processing costs;
3. high participation rate, low processing costs;
4. high participation rate, high processing costs.

For example, the low participation/low processing cost scenario for Carter County in Figure 5.4 was calculated as follows:

$$\begin{array}{rcl}
 & \text{Total Processing Cost} & = \$58,536 \text{ (from Figure 5.1)} \\
 - & \text{Total Revenues} & = \$33,539 \text{ (542 tons X \$61.88)} \\
 & \text{Total Individual Cost} & = \$24,997.
 \end{array}$$

COUNTY	LOW PART ¹ LOW PROC ²	COST/TON	LOW PART HIGH PROC	COST/TON	HIGH PART LOW PROC	COST/TON	HIGH PART HIGH PROC	COST/TON
Carter	\$24,997	\$46	\$44,509	\$82	\$29,265	\$25	\$63,050	\$54
Greene	27,172	37	51,328	70	29,589	21	67,416	48
Hancock	5,620	66	9,190	108	10,099	63	16,659	104
Hawkins	22,202	49	38,926	86	29,815	30	58,918	60
Johnson	10,415	63	17,180	104	18,134	55	30,965	94
Sullivan	17,209	7	72,800	30	-24,184	-6	49,850	12
Unicoi	14,309	60	23,829	100	22,743	49	39,874	86
Washington	25,502	16	66,634	42	16,181	6	74,349	28
Total	147,426		324,396		131,642		401,081	

¹ Participation Rate
² Processing Cost

Figure 5.4 Estimated Annual Net Costs of Processing (Including Revenues from the Sale of Recyclables) for Individual Counties in the First Tennessee Development District Under Scenario (a).

The costs per ton were also given in Figure 5.4. Of the four combinations of costs, the high participation/high processing cost option appears to be "pro-regional", and the high participation/low processing cost combination appears to be the "pro-individual" option. Note that under this "pro-individual" combination for Sullivan County, revenues from the sale of recyclables would more than offset the costs of processing the recyclables.

To estimate the county costs associated with a regional recycling approach utilizing economies of size in processing, a methodology was used similar to that in Figure 5.4. The estimated annual net (processing costs minus revenues) regional processing costs are estimated in Figure 5.5, with four combinations of regional costs (due to high and low ranges of participation rates and processing costs) which include:

1. low participation rate, low processing costs;
2. low participation rate, high processing costs;
3. high participation rate, low processing costs;
4. high participation rate, high processing costs.

Net regional costs were calculated as follows:

	Regional Processing Costs	(from Figure 5.1)
-	<u>Total Regional Revenues</u>	(tons X \$61.88)
	Net Regional Processing Costs	

Regional costs ranged from a low of \$-202,339 to a high of \$13,108. This suggests that by exploiting the significant economies of size in regional processing, revenues from the

	LOW PART ¹ LOW PROC ²	LOW PART HIGH PROC	HIGH PART LOW PROC	HIGH PART HIGH PROC
REGIONAL PROCESSING COSTS	\$298,176	\$397,568	\$494,120	\$651,340
REGIONAL REVENUE	384,460	384,460	696,459	696,459
NET REGIONAL PROCESSING COST	-86,284	13,108	-202,339	-45,119

¹ Participation Rate

² Processing Cost

Figure 5.5 Estimated Annual Net Regional Costs of Processing Recyclable Materials in the First Tennessee Development District (Regional Processing Costs Minus Regional Revenues).

sale of recyclables would more than offset regional processing costs in three of the four scenarios in Figure 5.5. These net regional processing costs were distributed among the counties by their percentage of the total region's recyclables in Figure 5.6. These percentages are shown in Figure 4.3, and were different for the low and high participation rates.

In Figure 5.7, transportation costs (from Figure 5.3) were added to the net regional processing costs of Figure 5.6 to determine the total costs of transporting and processing recyclables on a regional scale. Because there were high and low levels of all three variables (participation rates, processing costs, and transportation costs), there were eight combinations of costs:

1. low participation rate, low processing costs, and low transportation costs;
2. low participation rate, low processing costs, and high transportation costs;
3. low participation rate, high processing costs, and low transportation costs;
4. low participation rate, high processing costs, and high transportation costs;
5. high participation rate, low processing costs, and low transportation costs;
6. high participation rate, low processing costs, and high transportation costs;
7. high participation rate, high processing costs, and low transportation costs;
8. high participation rate, high processing costs, and high transportation costs.

COUNTY	Low Part ^a Low Proc ^b	Low Part High Proc	High Part Low Proc	High Part High Proc
Carter	-7,527	1,143	-20,944	-4,670
Greene	-10,166	1,544	-25,187	-5,616
Hancock	-1,180	179	-2,876	-641
Hawkins	-6,277	954	-17,618	-3,929
Johnson	-2,291	348	-5,915	-1,319
Sullivan	-33,566	5,099	-73,942	-16,488
Unicoi	-3,305	502	-8,324	-1,856
Washington	-21,970	3,338	-47,533	-10,599
TOTAL	-86,284	13,108	-202,339	-45,119

^aParticipation Rate

^bProcessing Cost

Figure 5.6 Distribution of Estimated Annual Net Regional Processing Costs (Including Revenues from the Sale of Recyclables) Among Counties in the First Tennessee Development District

COUNTY	LOW PART ¹ LOW PROC ² LOW TRAN ³	LOW PART LOW PROC HIGH TRAN	LOW PART HIGH PROC LOW TRAN	LOW PART HIGH PROC HIGH TRAN	HIGH PART LOW PROC HIGH TRAN	HIGH PART LOW PROC HIGH TRAN	HIGH PART HIGH PROC LOW TRAN	HIGH PART HIGH PROC HIGH TRAN
Carter	-633	2,814	8,037	11,484	-6,125	1,284	10,149	17,558
Greene	1,810	7,797	13,520	19,507	-2,267	9,194	17,304	28,765
Hancock	984	2,066	2,343	3,425	1,198	3,234	3,433	5,469
Hawkins	1,118	4,815	8,349	12,046	-1,585	6,431	12,104	20,120
Johnson	709	2,209	3,348	4,848	66	3,057	4,662	7,653
Sullivan	1,577	19,149	40,242	57,814	-14,139	15,763	43,315	73,217
Unicoi	-711	586	3,096	4,393	-3,277	-754	3,191	5,714
Washington	-21,970	-21,970	3,338	3,338	-47,533	-47,533	10,599	10,599
TOTAL	-17,118	17,464	82,274	116,856	-73,662	-9,324	83,558	147,896

¹ Participation Rate

² Processing Cost

³ Transportation Cost

Figure 5.7 Net Regional Costs (Including Revenues from the Sale of Recyclables and Transportation Costs) Distributed Among Counties

Net regional costs of transporting and processing recyclables were calculated as follows:

	Net Regional Processing Costs	(from Figure 5.6)
+	<u>Transportation Costs</u>	(from Figure 5.3)
	Net Regional Cost	

Estimated annual net regional costs ranged from a low of \$-73,662 to a high of \$147,896. For several of the combinations, revenues from the sale of recyclables would more than offset both regional processing costs and transportation costs.

In Figure 5.8 the cost savings of a regional recycling system are estimated for the FTDD by calculating the difference between the individual county costs and the net regional costs. The savings were substantial, and ranged from \$129,962 to \$317,523. A regional approach would result in the lowest cost for the FTDD in any of the eight scenarios. The low participation rate-low processing cost-high transportation cost scenario had the lowest cost savings for the region. Also note that four of the eight scenarios for Sullivan County actually resulted in negative cost savings (i.e. the individual costs were lower than the regional costs). This suggests that, given the large population and thus large potential amounts of recyclables, it may be more economically feasible for Sullivan County to operate their own recycling system at the county level, including their own processing center, rather than participate in a regional system. This is in fact what is actually occurring, as Sullivan County is

COUNTY	LOW PART ¹ LOW PROC ² LOW TRAN ³	LOW PART LOW PROC HIGH TRAN	LOW PART HIGH PROC LOW TRAN	LOW PART HIGH PROC HIGH TRAN	HIGH PART LOW PROC LOW TRAN	HIGH PART LOW PROC HIGH TRAN	HIGH PART HIGH PROC LOW TRAN	HIGH PART HIGH PROC HIGH TRAN
Carter	\$25,630	\$22,183	\$36,472	\$33,025	\$35,390	\$27,981	\$52,901	\$45,492
Greene	25,362	19,375	37,808	31,821	31,856	20,395	50,112	38,651
Hancock	4,636	3,554	6,847	5,765	8,901	6,865	13,226	11,190
Hawkins	21,084	17,387	30,577	26,880	31,400	23,384	46,814	38,798
Johnson	9,706	8,206	13,832	12,332	18,068	15,077	26,303	23,312
Sullivan	15,632	-1,940	32,558	14,986	-10,045	-39,947	6,535	-23,367
Unicoi	15,020	13,723	20,733	19,436	26,020	23,497	36,683	34,160
Washington	47,472	47,472	63,296	63,296	63,714	63,714	84,948	84,948
Total	164,544	129,962	242,122	207,540	205,304	140,966	317,523	253,185

¹ Participation Rate
² Processing Cost
³ Transportation Cost

Figure 5.8 Estimated Annual Cost Savings (Individual County Costs - Regional Costs) of a Regional Recycling System in the First Tennessee Development District

currently developing a MRF in a joint venture with Waste Management Inc.

Decision-Making from an Individual County Perspective

The previous section analyzed the trade-offs between processing and transportation costs from a regional perspective, as if a set of counties were considering establishment of a regional processing facility and concerned only about overall costs to the region as a whole. However, a more likely or realistic situation would be that of an individual county (or municipality) that has decided to begin collecting recyclables but is uncertain whether to establish a small processing center itself or simply transport the collected materials to an existing larger-scale processor in a metropolitan area. Given the existence of the Johnson City processing facility in Washington County and the plans for another large-scale processing facility in Sullivan County, this is exactly the kind of question that may be faced by the other six counties and individual municipalities in the FTDD. This decision hinges upon the three key factors discussed on page 49:

1. processing cost per ton at the possible local center, based upon the volume of materials expected;
2. the differential in costs between transporting recyclable materials to the local processing center and transporting them to the nearest existing larger-scale processing center; and
3. the financial agreement associated with the delivery of materials to the existing processor.

larger-scale processing center; and

3. the financial agreement associated with the delivery of materials to the existing processor.

As previously mentioned, with recent levels of market prices for recyclable materials and processing cost levels for relatively large-scale processing operations, revenues from processed materials are approximately equal to average processing costs, both in the \$50-60 per ton range. At the current time it would seem likely that if Johnson City or another existing processor were willing to take recyclables from one of the surrounding counties or municipalities, they would not be willing to pay anything for the materials, except perhaps aluminum cans (even though the marginal cost of processing additional material might be well below the average cost). In this case, then, the county's decision to process or not would depend upon a comparison of its processing cost net of revenue received from marketing its material and the costs of transporting the material to an existing processor. Actually, the decision would hinge upon the same comparison even if material prices were much higher or lower than current levels, as long as this differential were reflected in a payment or charge for delivery to the existing processor.

Consider the case of Greene County, the most highly populated of the six rural counties in the FTDD, with regard to such a decision, based upon the "pro-individual" scenario of high participation rates, low processing costs, and high transportation costs, and material revenues of \$60 per ton.

(\$83⁶ minus \$60), or \$32,223 in total (\$23 X 1,401 tons). Transportation costs to Johnson City would be \$25 per ton, or \$35,025 in total. Thus, under the "pro-individual" scenario, Greene county would come out about the same whether it established its own processing center or delivered materials to Johnson City. More generally, for counties with populations similar to Greene County, the "break-even" distance for such a decision is approximately 30 miles. However, under the "pro-regional" scenario, Greene County's processing costs net of material revenue would be \$50 per ton, while transportation costs would be \$16 per ton, suggesting that tieing in with Johnson City would save almost \$50,000 annually. Under the "pro-regional" scenario, only if Greene county were located more than 90 miles from a regional processor would it pay to establish its own processing center.

Because the other counties have lower populations than Greene and thus higher processing costs per ton, their break-even distances would be greater than 30 miles under the pro-individual scenarios. Information for the other counties similar to that discussed for Greene County above is presented in Figure 5.9, indicating that even under "pro-individual" assumptions, transporting to a regional processor is the more cost effective option for each county. Furthermore while break-even distances exceed actual distances by only 14-15

⁶The \$83 represents processing cost per ton from Table 5.1, page 51.

County	Tons of Material Collected per Year (High Part. Level)	Distance to Regional Processing Center (Miles)	County Processing Cost Net of Material Revenues (per ton) ^b	Regional Processing Transportation Cost Net of Material Revenue (per ton) ^c	Break-even Distance ^d (miles)
Carter	1,165	20	\$27	\$19	35
Greene	1,401	30	23	25	27
Hancock	160	55	65	38	104
Hawkins	980	30	32	25	44
Johnson	329	35	57	27	89
Unicoi	463	15	51	16	78

^aNote that costs associated with collection and transport to a local processing center or transfer site are not included, since they can be assumed to be the same under either processing option.

^bAssuming low processing cost level and \$60 per ton revenue.

^cAssuming high transportation cost level and zero revenue.

^dDistance at which cost of two options are equal.

Figure 5.9 Estimated County Costs^a and Break-even Distances Associated with Processing Options (Pro-Individual County Assumptions).

miles for Carter and Hawkins counties, the range is 49-63 miles for the other three counties. Under "pro-regional" assumptions, the regional option would be far less costly, with break-even distances well over 100 miles for each county. A graphical representation of the same information is provided in Figure 5.10.

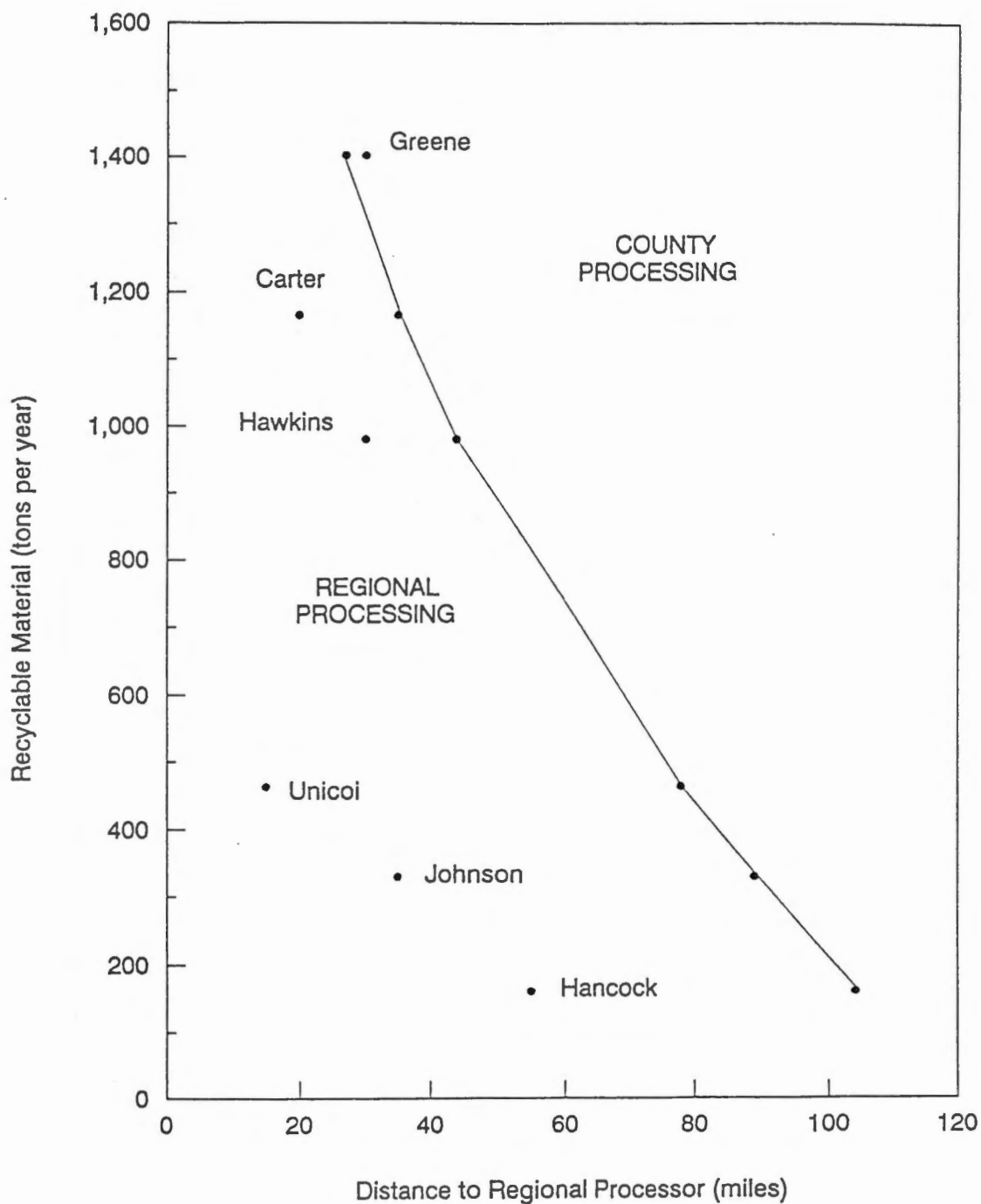


Figure 5.10 Break-even Line for Processing Options Facing Rural Counties in the First Tennessee Development District (Pro-Individual County Assumptions)

CHAPTER 6

CONCLUSIONS

Summary of Findings

The overall objective of this study was to analyze the tradeoffs and feasibility of an integrated multi-county recycling approach in the First Tennessee Development District. Specific objectives included:

1. To document the current characteristics of solid waste collection, transportation, processing, and disposal, and the extent of recycling, for the municipalities and counties in the case study area;

2. To project the level of resident participation and the volume of recyclable materials that could be expected with appropriate recyclable material collection systems in each municipality and county;

3. To estimate the costs associated with transportation and processing of recyclable materials under the following scenarios:

- a. Each municipality and county implements its own recycling system including collection, processing and marketing;

- b. An integrated recycling system for the multi-county area is implemented involving coordination of collection and transportation to a regional MRF for processing

and marketing.

Current characteristics of the solid waste system in the FTDD were documented. It was found that two types of solid waste collection typically occurred, curbside collection in the municipalities, and drop-off collection at convenience centers or green boxes in rural areas. Very little processing was done to solid waste, with the exception of compaction achieved via the compactor trucks used to transport waste to landfills. Landfills were the only method of disposal, as there were no incinerators located in the FTDD. Seven of the eight counties had an operating landfill located in their county. The eighth county, Unicoi, transported its waste to the Johnson City Regional Landfill located in Washington County. While interest in recycling was widespread in the FTDD, actual programs were limited mostly to the Johnson City Curbside Recycling Program, scrap metal dealers, and a few small-scale, non-profit organizations such as churches, Ruritan, and Boy Scouts. Sullivan County appeared to be moving in the direction of county-wide (or larger) recycling as they began a joint venture in 1990 with Waste Management, Incorporated, to build a MRF near the Tennessee Eastman Corporation plant in Kingsport. This documentation of current characteristics of solid waste provided the background and starting point for the regional recycling analysis of objectives two and three.

Levels of residential participation, and potential levels

of recyclables collection, were estimated. Once a range (high and low) of participation rates had been determined for both curbside and drop-off recycling systems, a methodology was developed which provided estimates for the amount of recyclables that could be collected in each county. This potential amount of recyclables in the FTDD ranged from 6,213 (low participation) to 11,255 (high participation) tons per year.

The total costs associated with the transportation and processing of recyclables were estimated for both individual counties, and for the region as a whole utilizing economies of size in processing. To give an overall picture of the different possible scenarios, and to provide a framework for performing sensitivity analysis to the cost estimates, a methodology was developed that allowed for variations (high and low) in both participation rates, transportation costs, and processing costs. Under each of the eight possible combinations of these variables (see Figure 5.8), a regional recycling system provided significant cost savings compared to an individual county system. These cost savings ranged from \$129,962 to \$317,523 annually. By exploiting the extensive economies of size that can be achieved from a large-scale processing center, per ton processing costs in a recycling program can be greatly reduced.

Finally, an indifference map was developed which represented "break even" distances where individual counties

would be indifferent to either develop their own processing center, or tie in with a regional system. The results indicated that with the high per ton costs associated with developing a small-scale processing center, and the extensive economies of size that could be achieved with a large-scale regional MRF, some counties could transport materials over large distances (over 100 miles in some cases) and still achieve costs lower than "going alone".

Implications of Findings

This study has addressed a rather critical aspect of the tradeoffs to be considered in assessing the feasibility of regional coordination for processing of recyclables from rural areas. The findings indicate that, subject to the qualifications noted in the analysis and others highlighted below, for many rural counties the most cost effective strategy under current conditions would be to transport materials to an existing processor rather than processing the materials and marketing them alone. This is due primarily to the significant economies of size in the processing function. The overall costs savings from a regional perspective could be expected to be sizeable.

The most important qualification of this conclusion comes from the fact that it is based on a case study analysis of a single eight-county region. Care must be taken in generalizing, and site-specific analyses would be needed

before decisions are made in other areas. While the general conclusion was not sensitive to the uncertainty with regard to costs and participation, more narrow ranges on these parameters may be needed to draw definitive conclusions for other regions.

Another qualification stems from the fact that this study considered only recyclables generated by the residential sector. Inclusion of particularly cardboard and office paper from the commercial, industrial, institutional and public sectors could increase the overall scale of operation substantially and reduce the processing costs per ton. However, given that one would expect lower per capita generation rates for these materials the more rural the county considered, their inclusion might not make too much difference for the most sparsely populated rural counties (Hancock, Johnson, and Unicoi). For the more highly populated counties with substantial activity in these non-residential sectors (Carter, Greene, and Hawkins), the expanded scale of processing might make a significant difference. Further investigation of this question is needed.

There were other factors ignored as well that could make either individual county or regional processing more attractive. On the individual county side, communities may consider the community pride and jobs created by having their own processing center as significant benefits. The visibility of local processing may be considered important for

stimulating participation. The potential for reducing processing costs per ton by integrating recyclables processing with a balefill operation for solid waste in general may also be a consideration. On the regional side, possible advantages besides lower processing costs were ignored. One would be lower marketing costs per ton in terms of the time spent in obtaining information on options and negotiating contracts. A second would be price premiums from material buyers due to higher volumes and quality of processed materials.

An important finding was that for three of the eight regional scenarios, revenues from the sale of recyclables would more than offset the costs of transporting and processing those recyclables. However, it should be emphasized that the question of whether recycling can "break even" in terms of total costs and revenues would require inclusion of initial collection costs (curbside or drop-off) and avoided costs related to landfilling or other factors. A brief discussion of the idea of avoided costs may be useful.

Because recycling programs divert materials from disposal in landfills, many programs justify their relatively high costs by crediting back to the program the avoided landfill tipping fees. Because these materials are not disposed of in the landfill (or incinerator), these programs have saved the county or municipality the amount of the tipping fee. This in effect reduces the per ton net cost of the recycling program by the amount of the landfill tipping fee. These fees range

from \$8.50 to \$12.85 in the FTDD (see Figure 3.2), and are low compared to other parts of the country. In some areas, especially the densely populated Northeast, tipping fees well over \$50 per ton are normal. Landfill costs (and fees) continue to rise in most areas. As this occurs, it enhances the economic feasibility of recycling as a solid waste management alternative to landfilling, reducing the per ton net costs of recycling. Some researchers (for example Schmidt, p. 26) have suggested that tipping fees rarely represent the true cost of operating a landfill, and that these are only part of the costs avoided through recycling. Other avoided costs may include: avoided costs of siting new landfill space, avoided collection costs (as there is less garbage to collect with the recyclables removed from the waste stream), and avoided environmental clean-up expenses. While these costs are difficult to measure, their likely existence suggests that the net cost of recycling may be lower than typically reported.

Perhaps the most important consideration ignored to this point is the difficulty and costs of initiating and sustaining successful inter- or multi-jurisdictional agreements. Substantial cost savings or other advantages have been documented or projected for regionalization of a number of public services or activities. However, regional cooperation for such purposes has not been pursued to a great extent, and the political difficulties appear numerous. While the

economic pressures for regionalization of solid waste management will build over the next few years, additional incentives may be necessary to motivate local jurisdictions to look beyond their boundaries for cost effective solutions to their solid waste management challenges.

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APPENDICES

Appendix A

Collection and Recycle Survey

Name of Person
Completing Form _____
Title _____
Phone Number _____

COLLECTION AND RECYCLE SURVEY

COLLECTION

1. Does your jurisdiction provide for solid waste collection?
(Through such ways as curbside, door-to-door, convenience
centers, green boxes/dumpsters, etc.).

Yes _____ No _____

2. Do you contract with public or private haulers for
collection?

Yes _____ No _____

If Yes, please list those haulers under contract.

3. If you do not provide for solid waste collection, please
list haulers operating in your jurisdiction, not under
contract.

IF YOU, OR YOUR CONTRACTED HAULERS, PROVIDE COLLECTION SERVICES, PLEASE COMPLETE THE FOLLOWING.

4. How many single-family residences are served through curbside or door-to-door collections? _____

5. What is the frequency of collection? (please check)

Once a week? _____ Twice a week? _____ Three times a week? _____

Other (explain)

6. How many "convenience centers" are operated, if any, where residences can bring their trash? _____

7. How many "green boxes"/dumpsters are distributed throughout your jurisdiction, if any, that are not located at "convenience centers"?

Of the total above, how many are located at the following?

apartments and/or condominiums _____

commercial establishments _____

along the roadside for general public use _____

8. Does your jurisdiction also provide for non-household solid waste collection?

Yes _____ No _____

If Yes, indicate in which sectors. (please check)

Industrial _____

Commercial/Institutional _____

Other (explain)

9. Where is the solid waste you, or your contractor, collect hauled? (Please name transfer station, incinerator, or landfill, if applicable.)

RECYCLING

10. Are there any permanent collection programs for recyclable materials in your jurisdiction?

Yes _____ No _____

IF YES, describe:

Sponsor	Type of Materials Collected	Location	Method (drop-off/ curbside)	Contact Person and Phone No.
---------	-----------------------------------	----------	-----------------------------------	------------------------------------

IF NO, is a recycling program planned in the next 12 months? Describe in terms stated above.

11. Please list the names of recycling processing centers in your jurisdiction (collection such things as scrap metal, paper, plastic, aluminum cans, waste oil, automobile batteries, tires).

12. Does your municipality or county compost solid waste or have any plans for composting operations in the next 12 months?

Yes _____ No _____

If Yes, please describe.

Appendix B

Tennessee Recyclable Processing and Marketing Survey

UNIVERSITY OF TENNESSEE
WASTE MANAGEMENT RESEARCH AND EDUCATION INSTITUTE

Tennessee Recyclable Processing and Marketing Survey

The purpose of this survey is to examine current market conditions for specific recyclables and to identify opportunities for developing and expanding markets for these materials. The results of the survey will be used in the Tennessee Solid Waste Management Plan. Please complete the questionnaire as completely and accurately as you can and return to the University of Tennessee Waste Management Research and Education Institute in the enclosed envelop. If you have any questions, contact Peggy Douglas (615) 974-4251.

1. Name of your recycling processing facility, address, contact person, phone number, years in business.

2.

<u>Materials accepted</u>	<u>Buyer (Broker)</u>	<u>Tons sold in '89</u>
<u>for recycling</u>	<u>Name and Location</u>	<u>per buyer</u>

Aluminum

Non-ferrous

Glass bottles and jars

Other glass

Appendix C

Survey of County Governments Financing Solid Waste Collection and Disposal

Name of County: _____
 Name of person completing form: _____
 Telephone number: _____

SURVEY OF COUNTY GOVERNMENTS
 FINANCING SOLID WASTE COLLECTION AND DISPOSAL

Solid Waste Collection

1. Does your county provide solid waste collection services for:

Residential properties:	Yes _____	No _____
Commercial/institutional properties:	Yes _____	No _____
Industrial properties:	Yes _____	No _____
Others (please indicate) _____	Yes _____	No _____

2. Does the county contract to have the services provided?

Residential:	Yes _____	No _____
Commercial/institutional:	Yes _____	No _____
Industrial:	Yes _____	No _____
Other:	Yes _____	No _____

If so, who is the current contractor?

3. How much did the county pay during the past year for collection services provided under contract?

Residential:	\$ _____
Commercial/institutional:	\$ _____
Industrial:	\$ _____
Other:	\$ _____
Total:	\$ _____

IF YOUR COUNTY DOES NOT OPERATE OR CONTRACT FOR SOLID WASTE COLLECTION SERVICES, PLEASE GO TO QUESTION #8

4. If your county operates a collection system, do you charge a collection fee for:

Residential:	Yes _____	No _____
Commercial/Institutional:	Yes _____	No _____
Industrial:	Yes _____	No _____
Other:	Yes _____	No _____

PLEASE RETURN BY APRIL 20, 1990

5. If you charge a collection fee, on what basis do you apply the charges (flat fee, per container, cubic yds., per ton, etc.)?

<u>Basis of Charge</u>	<u>Amount</u>
Residential: _____	\$ _____
Commercial/Institutional: _____	\$ _____
Industrial: _____	\$ _____
Other: _____	\$ _____

6. What is the annual income generated from collection services?

Residential:	\$ _____
Commercial/Institutional:	\$ _____
Industrial:	\$ _____
Other:	\$ _____
Total income	\$ _____

7. What is the annual cost for providing collection services?

	<u>Resident</u>	<u>Commerc</u>	<u>Indust</u>	<u>Other</u>
Salaries/Benefits:	\$ _____	\$ _____	\$ _____	\$ _____
Operating:	\$ _____	\$ _____	\$ _____	\$ _____
Capital Outlays:	\$ _____	\$ _____	\$ _____	\$ _____
Debt Service:	\$ _____	\$ _____	\$ _____	\$ _____
Total cost	\$ _____	\$ _____	\$ _____	\$ _____

8. Does your county incur any costs (i.e. extra collection route, containers, processing, advertising, staff, etc.) associated with a county-sponsored recycling program? Please describe:
(IF YOUR COUNTY DOESN'T SPONSOR A RECYCLING PROGRAM, PLEASE NOTE BELOW AND GO TO QUESTION #17)

<u>Item</u>	<u>Amount</u>
_____	\$ _____
_____	\$ _____
_____	\$ _____
_____	\$ _____
_____	\$ _____

PLEASE RETURN BY APRIL 20, 1990

9. How are the costs listed in question #8 financed (i.e. tax revenues, user fees, etc.)? Please describe:

10. Does your county realize any cost savings from its county-sponsored recycling programs (i.e. reduced collection, transportation, or landfill costs)? Please describe:

11. Does your county receive any income from county-sponsored recycling programs (i.e. sale of materials)?

<u>Item</u>	<u>Amount</u>
	\$
	\$
	\$
	\$

12. How do you identify markets for your recyclable products?

13. Describe any other income received from solid waste collection or recycling services provided by your county.

<u>Source</u>	<u>Annual Amount</u>
	\$
	\$
	\$
	\$

PLEASE RETURN BY APRIL 20, 1990

14. How are capital expenditures for solid waste collection financed?

Operating revenues _____

Debt _____

Grants _____

Other (please explain) _____

15. If capital expenditures for solid waste collection are financed by issuance of debt, please identify the most commonly used means:

Capital outlay notes _____

General obligation bonds _____

Revenue bonds _____

Tax exempt private activities bonds _____

Other (please explain) _____

16. If capital expenditures for solid waste collection are financed by grants, please identify the source:

Solid Waste Disposal

17. How does your county provide solid waste disposal services?

County provides no form of disposal services _____
 Operates landfill or balefill _____
 Operates waste to energy facility _____
 Contracts for disposal services _____ (If so, who is the
 current contractor?)

18. If your county contracts for disposal services, how much did the county pay during the past year for disposal services provided under contract?

\$ _____

19. How much annual income is produced by tipping fees at your disposal facility?

Residential: _____	\$ _____
Commercial/Institutional: _____	\$ _____
Industrial: _____	\$ _____
Other: _____	\$ _____
Total Income _____	\$ _____

20. Describe any other income produced from sources involving your disposal facility (e.g. disposal contracts with other communities, etc.)

Source	Amount
_____	\$ _____
_____	\$ _____
_____	\$ _____
_____	\$ _____

21. How much money is appropriated from your budget (including local, state, and federal sources) to support the operation of your disposal facility?

Source (property tax, sales tax, etc.)	Amount
_____	\$ _____
_____	\$ _____
_____	\$ _____
_____	\$ _____
_____	\$ _____
_____	\$ _____
_____	\$ _____

PLEASE RETURN BY APRIL 20, 1990

22. How are capital expenditures for solid waste disposal financed?

Operating revenues _____
 Debt _____
 Grants _____
 Other (please explain) _____

23. If capital expenditures for solid waste disposal are financed by issuance of debt, please identify the most commonly used means:

Capital outlay notes _____
 General obligation bonds _____
 Revenue bonds _____
 Tax exempt private activities bonds _____
 Other (please explain) _____

24. If capital expenditures for solid waste disposal are financed by grants, please identify the source:

25. Is any solid waste from your county shipped and disposed of outside your county?

Yes _____ No _____

26. What type of solid waste is shipped and disposed of outside your county?

Residential _____ Commercial/Institutional _____
 Industrial _____ Other _____

27. For solid waste shipped outside your county, please provide the following information:

Approximate tonnage shipped (by type)	Shipping Destination (facility, county, state)	Name of Hauler
---	--	-------------------

PLEASE RETURN BY APRIL 20, 1990

28. Do your future solid waste disposal plans include using facilities located:

in your county only

Yes _____

No _____

in other Tennessee counties

Yes _____

No _____

in other states

Yes _____

No _____

PLEASE RETURN BY APRIL 20, 1990

Please list in the appropriate columns the amounts budgeted by your county in the current fiscal year for operating costs, capital costs, and debt service costs associated with solid waste collection and disposal. Also, please indicate any income or revenues associated with your solid waste collection and/or disposal operations.

Operating Costs

	101 Co. Gen. Fund	116 Solid/San. Fund	131 Hwy & Br. Fund	207 Ent/Land Fund	Other Fund
Direct Cost					
55710 Sanitation and Waste Removal (Sanitation Services)					
100-199 Salaries					
200-299 Empl. ben.					
300-399 Cont. svc.					
400-499 Supplies					
500-599 Other chgs.					
700-799 Capital out. (please indicate amount of interest expense)					
55720 Landfill					
100-199 Salaries					
200-299 Empl. ben.					
300-399 Cont. svc.					
400-499 Supplies					
500-599 Other chgs.					
700-799 Capital out. (please indicate amount of interest expense)					

PLEASE RETURN BY APRIL 20, 1990

Operating Cost (cont.)

	101 Co. Gen. Fund	116 Solid/San. Fund	131 Hwy & Br. Fund	207 Ent/Land Fund	Other Fund
64000 Litter & Trash Collection (please separate expenditures for landfill operations from abandoned dump site cleanup expenses)					
100-199 Salaries					
200-299 Empl. ben.					
300-399 Cont. svc.					
400-499 Supplies					
500-599 Other chgs.					
700-799 Capital out.					
(please indicate amount of interest expense)					
Indirect Cost					
58000 Other General Government (include obj.)					
58900 Miscellaneous (include obj.)					
Total Operating					

PLEASE RETURN BY APRIL 20, 1990

CAPITAL COSTS (Funded from Capital Project Funds)

	Fund____	Fund____	Fund____
91100 General Capital Projects			
700-799 Capital outlay (incl. obj.)			
91200 Highway and Street Capital Projects			
700-799 Capital outlay (incl. obj.)			
Total Capital Outlay			

DEBT SERVICE (Funded from Debt Service Fund)

	Fund____	Fund____	Fund____
81100 General Government Debt Service			
500-599 Other charges			
600-699 Debt service			
81200 Highway and Street Debt Service			
500-599 Other charges			
600-699 Debt service			
Total Debt Service			

TOTAL COST

(Operating + Capital Outlay + Debt Service)_____

PLEASE RETURN BY APRIL 20, 1990

INCOME/REVENUES

	101 Co. Gen. Fund	116 Solid/San. Fund	131 Hwy & Br. Fund	207 Ent/Land Fund	Other Fund
43110 Refuse Disposal Charges					
43190 Other Gen. Service Charges					
43990 Other Charges for Services					
44120 Lease/Rentals					
44130 Sale of Materials and Supplies					
44530 Sale of Equipment					
46430 Litter Program					
48140 Other Governments and Citizens Groups, Contracted Services					
TOTAL INCOME					

PLEASE PROVIDE ANY ADDITIONAL INFORMATION OR REMARKS WHICH MIGHT HELP
US UNDERSTAND HOW YOUR COUNTY CURRENTLY PAYS FOR SOLID WASTE
COLLECTION AND DISPOSAL: (attach another sheet if necessary)

PLEASE RETURN BY APRIL 20, 1990

Appendix D

Landfill Survey

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

Name of person completing form _____

Title _____

Phone number _____

LANDFILL SURVEY

Name of Landfill _____

Ownership (government or non-government) _____

Operator in charge _____

Landfill Location _____

City and County _____

Phone Number _____

Landfill Characteristics

1. What is the approximate age of the landfill? _____ years
2. What year was the landfill permitted by the State of Tennessee? _____
3. What is the approximate size of the landfill?
 - a. permitted fill areas _____ acres
 - b. closed areas _____ acres
 - c. currently in use areas _____ acres

PLEASE RETURN BY JANUARY 12, 1990

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

4. What is the estimated closing date of your landfill? _____ year

5. Are there expansion plans under consideration for your site?

_____ Yes

_____ No

If yes, how much capacity would be added to the landfill?

_____ acres

_____ cubic yards

Landfill Operations

6. How much waste is received daily on average?

a. compacted

_____ tons

_____ cubic yards

b. non-compacted

_____ tons

_____ cubic yards

7. What methods are used to determine waste quantity?

_____ scales

_____ cubic yard

_____ estimate of truck size

_____ none

PLEASE RETURN BY JANUARY 12, 1990

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

8. Where does the waste come from?
(Please include all communities served, including municipalities)

	Name	Percentage
Own county	_____	_____
Other counties	_____	_____
	_____	_____
	_____	_____
Out of state:	_____	_____

9. Who brings waste to the landfill?

	Percentage
Private haulers	_____
County	_____
City	_____
Private citizens	_____
Other (specify)	_____

10. Please list the names of haulers

PLEASE RETURN BY JANUARY 12, 1990

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

11. Approximately what percentage of the waste comes from:

	Percentage
Residential	_____
Commercial/Institutional	_____
Industrial	_____
Special	_____
Other (specify)	_____

12. Do you separate materials for recycling at the landfill? If so, what materials?

13. Do you chip, mulch or compost materials at the landfill?

_____ Yes _____ No

14. Do you bale the waste prior to landfilling?

_____ Yes _____ No

15. Do you charge tipping fees?

_____ Yes _____ No

If yes, who is charged and what is fee for 1989?

Who

Fee

(per ton, per cubic
yard or per load)

PLEASE RETURN BY JANUARY 12, 1990

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

16. If there has been a significant increase in tipping fees over the past few years, please list the reasons for the increase.

17. Do you receive reimbursement for your disposal services from contract?
Who do you contract with?

18. What equipment is currently operational at your site (such as, scrappers, pans, bulldozers, loaders, landfill compactors, fork lifts, etc.)?

MAKE	MODEL	YEAR	NUMBER OF MACHINES

PLEASE RETURN BY JANUARY 12, 1990

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

19. What equipment is occasionally rented/borrowed at your site (such as, scrapers, pans, bulldozers, loaders, landfill compactors, fork lifts, etc.)?

MAKE	MODEL	NUMBER OF MACHINES	FREQUENCY (MO.; QUARTERLY)
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

20. How many employees work at the landfill? _____

21. Operating hours? _____

22. What operator training/certification courses have landfill personnel attended in the last five years?

COURSE NAME	AGENCY CONDUCTING COURSE	DATE TAKEN
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Waste Characteristics

23. Have any waste composition studies been performed?

_____ Yes

_____ No

PLEASE RETURN BY JANUARY 12, 1990

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

- . If yes, please give the date and organization performing the study.

24. Are any waste products specifically banned from entry into your landfill?

_____ Yes _____ No

If yes, please list products.

25. Do you accept the following: (please check)

	Yes	No
Construction/Demolition waste (concrete rubble, brush, lumber, etc.)		
Combustion ash (incinerator)		
Automobiles		
Sludges		
Used Oil		
Auto batteries		
Infectious/biomedical waste (needles, syringes, bandages, etc.)		
Asbestos		
Tires		
White Goods (refridgerators, stoves, etc.)		

PLEASE RETURN BY JANUARY 12, 1990

IF EXACT FIGURES ARE UNKNOWN,
PLEASE PROVIDE YOUR BEST ESTIMATE

Regulations

26. Does the current operational area have the following?

	Yes	No
Re-compacted clay liners	_____	_____
Synthetic liners	_____	_____
Gas monitoring system	_____	_____
Leachate collection system	_____	_____
Groundwater monitoring system (wells, etc.)	_____	_____
Sedimentation Ponds	_____	_____
Surface Water Monitoring Program	_____	_____

27. Do you intend to meet new state and federal landfill requirements or will you close the landfill? Please explain.

28. Are you familiar with the proposed regulations on solid waste management?

_____ Yes _____ No

If no, would you be interested in a workshop explaining these details?

_____ Yes _____ No

Please use the rest of this page, or any other, to convey important information not covered in the previous questions.

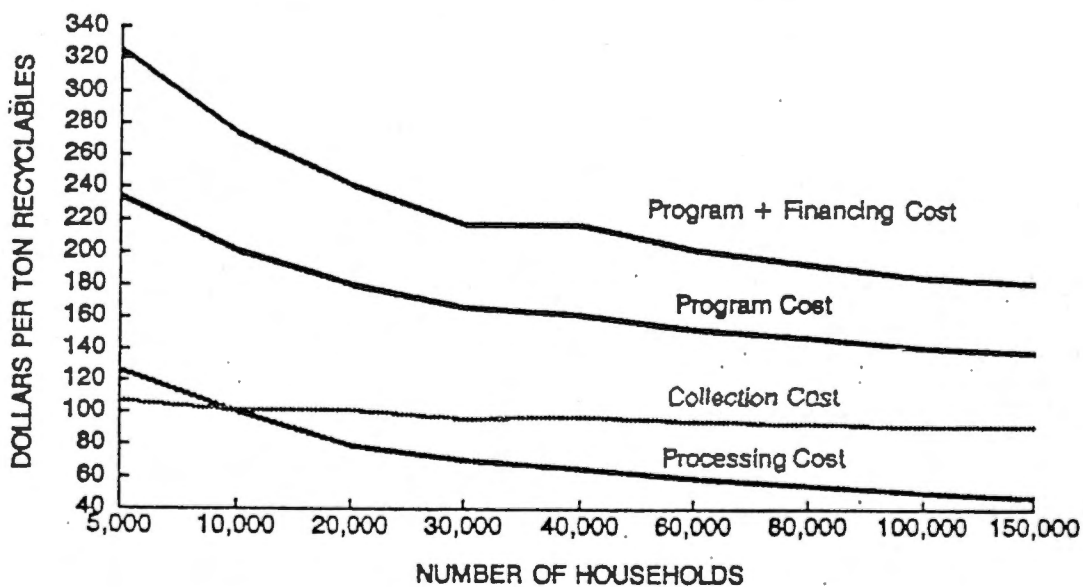
PLEASE RETURN BY JANUARY 12, 1990

Appendix E

MUNI321 Cost Graph

CURBSIDE RECYCLING ECONOMICS

Costs Only, No Credits Or Revenue



Source: David Cornell, taken from Muni321, courtesy of Tennessee Eastman Corporation.

Appendix F

Ron Black's Transportation Figures for Municipal Solid Waste

TRUCKLOAD RATES ON UNCOMPACTED AND SHREDDED MUNICIPAL
SOLID WASTE BASED ON HIGHWAY MILEAGE

Highway Miles	Truck Operating Hours Per Trip	Cost Per Truckload	Cost Per Ton Uncompacted	Cost Per Ton Shredded
10	1.25	\$50.00	\$4.55	\$2.27
11	1.30	\$52.00	\$4.73	\$2.36
12	1.35	\$54.00	\$4.91	\$2.45
13	1.40	\$56.00	\$5.09	\$2.55
14	1.45	\$58.00	\$5.27	\$2.64
15	1.50	\$60.00	\$5.45	\$2.73
16	1.55	\$62.00	\$5.64	\$2.82
17	1.60	\$64.00	\$5.82	\$2.91
18	1.65	\$66.00	\$6.00	\$3.00
19	1.70	\$68.00	\$6.18	\$3.09
20	1.75	\$70.00	\$6.36	\$3.18
21	1.80	\$72.00	\$6.55	\$3.27
22	1.85	\$74.00	\$6.73	\$3.36
23	1.90	\$76.00	\$6.91	\$3.45
24	1.95	\$78.00	\$7.09	\$3.55
25	2.00	\$80.00	\$7.27	\$3.64
26	2.05	\$82.00	\$7.45	\$3.73
27	2.10	\$84.00	\$7.64	\$3.82
28	2.15	\$86.00	\$7.82	\$3.91
29	2.20	\$88.00	\$8.00	\$4.00
30	2.25	\$90.00	\$8.18	\$4.09
31	2.30	\$92.00	\$8.36	\$4.18
32	2.35	\$94.00	\$8.55	\$4.27
33	2.40	\$96.00	\$8.73	\$4.36
34	2.45	\$98.00	\$8.91	\$4.45
35	2.50	\$100.00	\$9.09	\$4.55
36	2.55	\$102.00	\$9.27	\$4.64
37	2.60	\$104.00	\$9.45	\$4.73
38	2.65	\$106.00	\$9.64	\$4.82
39	2.70	\$108.00	\$9.82	\$4.91
40	2.75	\$110.00	\$10.00	\$5.00

ASSUMPTIONS:

Uncompacted waste weighs 350-400 pounds per cubic yard (average 375 lbs.). Shredded waste weighs 600-900 pounds per cubic yard (average 750 lbs.). The average payload for uncompacted waste would be 11 tons and for shredded waste 22 tons. Costs per truckload have been calculated on the basis of \$40 hour with an average speed of 40 miles per hour, allowing 30 minutes to load 15 minutes to unload.

VITA

Jeffrey Daniel Holt was born in Elizabethton, Tennessee on April 25, 1966. He was graduated from Happy Valley High School in May 1984. In August of 1984 he entered King College, Bristol, Tennessee. He remained at King College for two years before enrolling at the University of Tennessee, Knoxville in the Spring of 1987. He received a Bachelor of Science degree in Business Administration, majoring in Economics, in August 1988. He remained at the University of Tennessee, Knoxville, and began study toward a Master's degree,. The Master's of Science degree in Agricultural Economics was awarded in May 1991.

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