United States
Environmental Protection
Agency

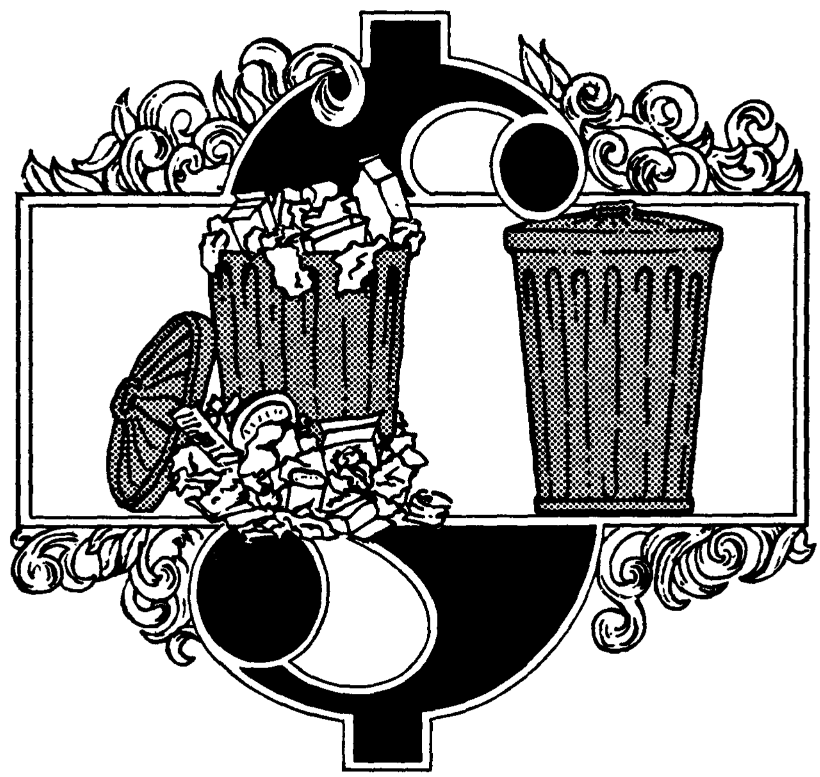
Solid Waste and
Emergency Response
(OS-305)

EPA/530-SW-90-0
September 1990

EPA

Charging Households for Waste Collection and Disposal:

The Effects of Weight- or Volume-Based Pricing on Solid Waste Management



Printed on recycled paper.

The Effects of Weight- or Volume-Based Pricing on Solid Waste Management

Final Report

Prepared for

U.S. Environmental Protection Agency
401 M St. S.W.
Washington, DC 20460

CONTENTS

CONTENTS (continued)

TABLES

FIGURES

ACKNOWLEDGMENTS

Special thanks go to members of the three case-study communities: Linda Good of Perkasie, Pennsylvania; Lisa Skumatz and Jennifer Bagby of Seattle, Washington; and Gale Hatch of Ilion, New York. The support and direction provided by Terry Dinan in her role as EPA Project Officer for this project should also be acknowledged.

Chapter 1
Introduction and Summary

1.1 Background

Most United States households pay for solid waste collection and disposal services directly through a fixed monthly service charge or indirectly through their property taxes. Increasingly, however, communities are turning to unit pricing as a means of financing solid waste collection and disposal. Unit pricing means charging households for waste services based on the amount and type of waste collected: Households that use more of the service pay more for waste collection and disposal.

The unit price can be assessed based on weight, volume, or some combination of weight and volume. For example, some communities charge for collection and disposal by the trash bag with a limit on the bag's weight. Therefore, weight-based and volume-based pricing are simply special examples of unit pricing.

1.2 Purpose

The core idea embodied in unit pricing is that when waste generators have to pay for waste collection and disposal in proportion (or equal) to the marginal cost of those services, they will reduce their use of those services to more efficient levels. This pricing method has proven a powerful incentive to conserve in numerous other settings. The purpose of this study is to examine:

- the effect of unit pricing on the waste generation and disposal behavior of households,
- the effect of unit pricing on the costs of managing solid waste, and
- the role of particular features of unit pricing and other complementary programs (e.g., recycling) in promoting or mitigating the different effects of unit pricing.

1.3 Method

The case study method was employed in this project. First, the trade and professional literature was reviewed and trade organizations and solid waste experts were interviewed to identify communities that currently had some form of unit pricing system. Seventeen communities were contacted and descriptions of these programs and the communities' solid waste management activities were obtained. Relevant reports on each community's solid waste management practices and data on waste flows and solid waste management costs were also evaluated.

Both trade and academic literature related to unit pricing of solid waste were reviewed and analyses were initiated to identify the likely effects of unit pricing. The reviews and analyses were used to help sketch the issues of concern and the potential responses of relevant decision makers to unit pricing--particularly households and waste managers. This, in turn, helped identify the measures of effectiveness that would be most appropriate to the study: price changes, changes in the size and composition of waste flows, and changes in the costs of waste management.

Three communities were selected for detailed case studies based on characteristics of their program, characteristics of the community, and availability of data. They are: Perkasie, Pennsylvania; Ilion, New York; and Seattle, Washington. Further data were requested from these communities and analyses of the community waste management systems and associated data were reviewed by officials in those communities.

1.4 Results

For **Perkasie and Ilion**, the two small communities in suburban and semi-rural settings, respectively, evidence indicates that households

- reduced the amount of total waste generated by 10 percent or more,
- reduced the amount of conventional mixed waste service by 30 percent or more, and
- more than doubled the amount of waste recycled.

These changes should probably be attributed to the unit pricing program in combination with the availability of curbside recycling and a conventional waste service frequency of once a week. As illustrated by the Ilion case, unit pricing does appear to make an important marginal contribution when added to the other programs.

No evidence was found to indicate that unit pricing increased the level of littering in Perkasie or Ilion or that sharp increases in unit prices increased littering in Seattle, although households in **Perkasie** increased backyard burning and disposal of trash in private containers, both inside and outside the service area. These problems in Perkasie were apparently remedied by passage of new statutes and better enforcement of existing ones.

In **Perkasie** and **Ilion** it was also found that unit pricing reduced the total cost of waste management by 10 percent or more, with the cost reductions being shared with most households through reduced fees or property taxes.

In **Seattle** sharp increases in the unit price over two periods had much less dramatic effects on waste flows. Households

- reduced the level of service they subscribed to (the number of barrels they were allowed to put out each week),
- increased their compaction of trash in their remaining barrels,
- slightly increased recycling, and
- first slightly increased then slightly decreased the amount of conventional trash that had to be collected.

The response in Seattle can be attributed to a number of factors including (1) the initial low price levels and subscription design of the Seattle program, (2) the more urban/multifamily dwelling setting, and (3) the absence of a curbside recycling program.

However, these results, as interesting and suggestive as they might be, are based on only three sites and very coarse data. To provide a more complete perspective, other evidence and basic theoretical insights on prospective effects of unit pricing programs accompanies the case study results in the remainder of this report.

Chapter 2

The Role of Unit Pricing in Municipal Solid Waste Generation and Disposal

Unit pricing is the practice of charging waste generators for collection and disposal services based on the weight or volume of their waste. Some communities have had unit pricing or near approximations of unit pricing for 20 or more years. These communities, however, are exceptions; virtually all residential solid waste and much commercial and industrial municipal solid waste collection in the U.S. has been financed through periodic fixed fees or indirectly through general taxes.

In the mid-1970's widespread concern regarding the health and environmental impacts of open refuse dumps stimulated some additional interest in unit pricing as a way of influencing the level and mix of solid waste generation. This interest subsided with the advent of the sanitary landfill. Evidence has accumulated, however, suggesting that sanitary landfills still pose environmental and health risks, especially via water pollution and air emissions (EPA, 1989a, 1989b). Similarly, today's municipal waste combustors (MWCs), while much "cleaner" than earlier generations of MWCs, still emit some pollutants into the atmosphere and require disposal of ash residue (EPA, 1989c).

To help protect against these problems with conventional waste disposal options, state and federal governments developed additional and more stringent regulations and guidelines for solid waste disposal. These initiatives include additional requirements and increasingly stringent restrictions on planning, siting, design, construction, monitoring, and operation of both existing and new landfills and MWCs. These initiatives have also contributed to a parallel increase in the cost of building and operating conventional waste disposal facilities.

With the advent of more stringent solid waste regulations and higher solid waste management costs at a time when many landfills are reaching the end of their useful lives, waste managers have a renewed interest in finding alternative ways to finance solid waste collection and disposal and possibly reduce costs by reducing the flow of solid wastes to conventional waste disposal facilities. Unit pricing of solid waste collection may mitigate the rise in costs and provide additional revenues as it provides waste generators with incentives to reduce waste generation and use alternative means of disposal. The prospect for such favorable outcomes, as well as the existence and extent of possibly undesirable side effects, motivates this study.

2.1 Rationale for Unit Pricing

As the discussion of the recent history of unit pricing suggests, there are several, interrelated reasons why a community waste manager or some households in a community might want to establish a unit pricing program. In this section some of the reasons cited by community representatives for adopting a unit pricing program are discussed. Some of the possible problems of a unit pricing program are also noted.

2.1.1 Equity in Financing

Unit pricing conforms to the equity principle that one should pay the full costs of the services used. In other words, those that generate more waste pay more for the additional service. This notion of equity has been prominent in local finance in recent years as community leaders, fearful of the political consequences of raising general taxes, adopt "user fees" to finance community services.

Of course there are methods to achieve other types of equity objectives within the framework of unit pricing. One method is efficient pricing: unit pricing with price set at marginal cost. Unit pricing is a necessary condition for economic efficiency, but not all unit pricing programs are economically efficient. Indeed, other notions of equity can also be incorporated into unit pricing. For example, unit pricing programs may set special prices based on considerations other than marginal cost, such as a customer's income or the type of waste collected.

2.1.2 Resource Conservation

A fundamental "materials balance" identity describes the flow of all solid waste:

$$X_g = X_c + X_r + X_d$$

where

X_g	=	amount of waste generated,
X_c	=	amount of waste disposed, requiring collection,
X_r	=	amount of waste recycled, and
X_d	=	amount of waste diverted to litter, backyard burning or compacting, or otherwise discarded by the household.

Resources are conserved by lowering X_g (i.e., less waste-intensive consumption) and by increasing X_r. Since unit prices raise the relative price of X_c, they will tend to reduce X_g (waste-intensive consumption is more costly) and increase X_r (the relative cost of recycling is lower). X_d may also be increased (since its relative cost may be lower, too).

2.1.3 Reductions in Cost

Waste Management Perspective

Many community waste managers are particularly interested in unit pricing as a means of reducing the cost of solid waste collection and disposal. Perception of a unit pricing program in terms of cost savings derives from

- lower rates of waste generation leading to reduced collection and disposal costs,
- additional revenues from the sale of higher levels of recycling, and
- cost savings due to the lower amounts of waste being disposed of conventionally.

While these features may reduce some costs of solid waste management, unit pricing may also impose some additional costs on the system. These additional costs derive from

- new materials and equipment requirements,
- transactions costs associated with monitoring quantities of waste collected from each account,
- enforcement costs of the unit pricing program and related restrictions,
- program administration costs, and
- increased litter collection.

It is impossible to generalize the net effect of these influences on the total cost of waste service. The magnitude and sign will vary with the structure of the program and the features of the community.

Household Perspective

As one might imagine, unit pricing is particularly popular with smaller and lower income households in communities where it replaces a system that charged a fixed fee per unit time. Because these households produce less solid waste, their monetary outlay for waste collection and disposal should decline under the unit pricing program. In communities where the unit pricing system replaces a levy on property as the means of financing solid waste collection and disposal, those who own relatively valuable property and generate relatively little waste find unit pricing especially attractive.

Another dimension of unit pricing program costs that will not show up directly "on the books" of the community waste manager are the additional costs that are borne as "home production" costs of the program by households and others. In particular, households may find it efficient to forfeit leisure or work time to increase "waste processing" efforts, such as recycling some items or returning refillable containers.

2.1.4 Health and Aesthetic Appeal

Unit pricing may also improve the aesthetics and health of a community. Because such programs encourage waste reduction and restrict the size and type of waste receptacles, they are sometimes marketed and adopted as "clean" programs. For example, flies cannot breed if solid waste is in an airtight container. The "bag program" variant of unit pricing improves neighborhood attractiveness by requiring closed bags at the curb rather than using open receptacles, which often are left at the curb for the remainder of the day or longer.

To balance this view, however, one should recognize that unit pricing may also result in unhealthy or unaesthetic side effects. For example, generators may litter or burn solid waste, causing adverse aesthetic effects and, possibly, adverse health effects.

2.1.5 Improved Management Information

While unit pricing may prove cost-effective in its own right, there is another reason why unit pricing may be valuable to the community. By virtue of its need to account for the level of use of waste management services at the household level, unit pricing provides additional information on waste flows. This information can be used to redesign or refine waste management programs generally. Thus, the information generated may ultimately lead to further improvements in waste management, including possible additional cost savings.

2.2 Current Structure of Unit Pricing Programs

2.2.1 Unit Pricing Features

Unit pricing programs can be structured to meet the special conditions of the communities they serve. As a result, many forms of unit pricing for solid waste services exist throughout the United States. Initially examined were 17 such communities from literature review and trade association contacts. These programs varied greatly in management, fee structures, services offered, and, most importantly, the kinds of complementary programs offered along with conventional waste disposal. Table 2-1 summarizes the characteristics of 16 of these communities and their waste management programs. (The community program omitted is too new to offer sufficient information for this study.)

Management of the unit pricing programs generally reflected the variety of organizational structures found in solid waste management. The programs could be

- operated as a branch of the municipal government,
- designed and managed by a private collection firm, or
- designed, operated, and monitored by some mix of public and private entities.

All the programs examined have one feature in common: pricing based on volume. Residents use waste containers that meet certain volume specifications. Even so, service providers generally estimate weights per unit volume when setting prices (disposal fees are often based on weight), and 11 of the communities had weight limits. Enforcing such weight limits is costly, however, and few communities provide sufficient enforcement resources or penalties to see that these limits are actually observed.

Most programs require the waste customers to use bags purchased from the service provider; other programs use cans or carts; still others allow consumers to use their own containers, subject to certain specifications. One community marks cans with a sticker purchased from the waste service. Some programs offer service to multi-family and commercial entities while others do not. Fee structures vary widely. Some programs have only per-unit fees, while others have per-unit fees that supplement flat fees that are either billed directly or included in taxes. Finally, levels of service, frequency of collection, placement of waste for collection, and requirements for special services such as bulky waste pickup vary widely.

2.2.2 Complementary Programs

In addition to unit pricing of conventional waste collection and disposal, most of the 16 communities offer other collection and/or disposal programs, including recycling programs and composting and chipping programs for yardwaste. Table 2-2 summarizes the features of waste collection and disposal programs that operate in conjunction with unit pricing in these communities.

The recycling programs vary, but they generally handle

- newsprint,
- glass, and
- aluminum items.

Other items included in certain communities are

- plastics,
- tin,
- corrugated cardboard, and
- paper other than newsprint.

TABLE 2-1. UNIT PRICING PROGRAMS

Community (population)	Date unit pricing program began	Mandatory or optional	If optional, percent participation	(Yes/No) Availability: All Areas	Single Family	Multi-Unit	Commercial	Municipal or Non-Municipal: Collection*	Disposal**	Mgmt	Fees and Containers
Carlisle, PA (19,000)	> 5 years ago	O	not available	Y	Y	Y	N	N/M	N	M	M
Duluthe, GA (10,000)	Early 70's	M		Y	Y	N	N	N/M	N	M,N	M,N
Grand Rapids, MI (170,000)	1973	O	not available	Y	Y	Y	N	M	M	M	M
High Bridge, NJ (4,000)	1988	M		Y	Y	Y if <5 units	N	M	N	M	M
Holland, MI (30,000)	1981	O	10-15%	Y	Y	N	N	N	N	N	N
Ilion, NY (9,500)	June 1, 1988	M		Y	Y	Y	Y-optional	M	N	M	M
Jefferson City, MO (36,000)	> 22 years ago	O	> 90%	Y	Y	N	N	N/M	N	N	N
Lansing, MI (125,000)	1975	O	60-70% (by resident bldgs.)	Y	Y	Y if <5 units	N	M	N	M	M
LaTrobe, PA (12,000)	~10 years ago	M		Y	Y	N	N	M	N	M	M
Newport, NY (2,000)	Couple years ago	M		Y	Y	N	N	N	N	N	N
Olympia, WA (10,400)	1954 or earlier	M		Y	Y	Y	Y	M	M	M	M
Perkasie, PA (6,500)	January 1988	M		Y	Y	Y	Y	M	N	M	M
Plantation, FL (64,000)	15-16 years ago	M		N	Y	Y	Y	N/M	N	N	N
Seattle, WA (500,000)	1981 (revised fee structure)	M		Y	Y	Y limited to few units	N	N/M	N	M	M
Wilkes-Barre, PA (50,000)	1988	O		Y	N	Y 4-20 units	N	M	N	M	M
Woodstock, IL (12,000)	1988	M		Y	Y	N if >2 units	N	N/M	N	N	N

CONTINUED

* M means city employees collect waste. N/M means city contracts private hauler. N means residents contract private hauler.

** N means disposal at a site or facility that is private or owned and operated by another local government entity; e.g., a county landfill.

TABLE 2-1. UNIT PRICING PROGRAMS (CONTINUED)

Community	Containers	Volume or Weight Limited	Cost (1989) Minimum	Cost (1989) Per Container	Collection Times/week	Collection Curbside or Backdoor	Disposal Landfill, Incinerator, Transfer Station	Data Available
Carlisle, PA	Program bags	V		$1.10 / 30 gal. $0.60 / 15 gal.	1	C	L	N
Duluthe, GA	Program bags	V	In taxes	$8.50 / 20 bags	1	C	L	N
Grand Rapids, MI	Program bags, own cans w/ tags	V,W	1.1 mill tax	$0.45 / bag $0.35 / tag	1	C	L	Limited
High Bridge, NJ	Stickers for own bags or cans	V	$35/qtr gets 52 stickers/year	$1.65 each additional sticker	1	C	T,L	Y
Holland, MI	Program bags, program carts	V		$1.30 / bag or $8-10 / mo. / cart	1	C	L	Limited
Ilion, NY	Program bags	V,W		$1.50 / 30 gal $1.20 / 16 gal	1	C	L	Y
Jefferson City, MO	Program bags	V		$1.30 / bag	2	C	T, L	N
Lansing, MI	Program bags	V,W		$7.50 / 10 bags	1	C	L	N
LaTrobe, PA	Program bags	V,W	$51 / 6 mos.	$0.25 / bag	1	C	T,L	Limited
Newport, NY	Program bags	V,W		$1.50 / 32 gal $1.10 / 28 gal $0.80 / 20 gal	1	C	L	N
Olympia, WA	Own cans; bags cost extra	V,W	Yes	Variety of services	1	C	L	Limited
Perkasie, PA	Program bags	V,W		$0.80 / 20 lb. $1.50 / 40 lb.	1	C	T, L	Y
Plantation, FL	Program bags	V,W		$16 / 20 bags	2	C	L	N
Seattle, WA	Wheeled toters	V,W	At least $10.70 for mini-can	$13.75 / 30 gal can $9.00 / ea. add'l can	1	C, B	T, L	Y
Wilkes-Barre, PA	Program bags	V		$9.30/8, 30-gal bags $5.55/8, 16-gal bags	1	C	T, L	N
Woodstock, IL	Program bags	V,W		$1.22 / bag	1	C	L	Y

TABLE 2-2. COMPLEMENTARY WASTE MANAGEMENT PROGRAMS

Community	Recycling							
	Voluntary/ Mandatory	Operator	Container	Additional Cost to Residents	Drop-off or Curbside	Materials Collected*	Complementary Program Start in Relation to Unit Pricing**	If Curbside, How Often Collected?
Carlisle, PA	V	Private	N/A†	0	D	G,H,C,A	A	N/A
Duluthe, GA	No program	—	—	—	—	—	—	—
Grand Rapids, MI	V	Private	N/A	0	D	G,N,M,F,A,P	A	N/A
High Bridge, NJ	M	City	Residents provide reusable container	0	C,D	G,N,M,C,A	Voluntary – B Mandatory – S	2/mo.
Holland, MI	V	Private	Clear bag	$0.50 per bag	C,D	G,N,M,F,A,P	A	1/mo.
Ilion, NY	V before 6/89 M after	City	Residents provide containers	0	C,D	G,N,C,F	Voluntary – B	1/wk.
Jefferson City, MO	V	Private	N/A	0	D	G,N,C,F,A	A	N/A
Lansing, MI	V	City	N/A	0	D	G,N,F,A,P	A	N/A
LaTrobe, PA	V	Civic Groups	N/A	0	D	G,N,A	A	N/A
Newport, NY	V	Private	Clear bag	1 incl. w/ 6 regular bags; ea. add'l 50¢	C,D	G,N,A	S	1/wk.
Olympia, WA	V	City	Recycle cart furnished by city	0	C,D	G,N,M,F,A	A	1/wk.
Perkasie, PA	M	City	Bucket provided by city	0	C,D	G,N,M,C,A	Voluntary-B Mandatory-S	1/wk.
Plantation, FL	V	Civic Groups	N/A	0	D	A	A	N/A
Seattle, WA	V	Private, city contracted	Carts provided by contractors	0	C,D	G,N,M,H,C, F,A	A	1/wk (Northend) 1/mo (Southend)
Wilkes-Barre, PA	M	City	Residents provide containers	0	C,D	N,A	Voluntary – B	1/wk.
Woodstock, IL	V	Private	Bucket provided by city	0	C,D	G,N,F,A	S	1/wk.

CONTINUED

* G = Glass; N = Newsprint; M = Mixed paper; C = Corrugated Cardboard; F = Ferrous Cans; A = Aluminum

** B = Before; A = After; S = Simultaneous

† N/A = Not applicable.

TABLE 2-2. COMPLEMENTARY WASTE MANAGEMENT PROGRAMS (CONTINUED)

Community	Yardwaste Recycled						
	Voluntary/ Mandatory	Drop-off or Curbside	Complementary Program Start in Relation to Unit Pricing**	Composting or Chipping	How Often Collected	Container Specified	Additional Cost to Residents
Carlisle, PA	V	C,D	A	Composting	As needed	No	0
Duluthe, GA	No program						
Grand Rapids, MI	No program						
High Bridge, NJ	M	C,D	B	Composting and chipping	2/month	No	0
Holland, MI	No program						
Ilion, NY	M	C,D	B	Composting	1/week	No	0
Jefferson City, MO	No program						
Lansing, MI	No program						
LaTrobe, PA	M	C,D	A	Composting and chipping	As needed	Yes- Clear bags	$0 25/bag
Newport, NY	No program						
Olympia, WA	No program						
Perkasie, PA	V (leaves)	C	B	Composting	As needed	No	0
Plantation, FL	No program						
Seattle, WA	M	C,D	A	Composting	At least 1/mo.	No	$2/mo
Wilkes-Barre, PA	V	C,D	B	Composting	As needed (Oct-Dec)	No	0
Woodstock, IL	V	D	A	Composting and chipping	N/A	No	0

The types of containers used for these recycling programs differ. Most communities provide recycling containers at no charge to residents, while in a few cases recycling participants pay for them. However, in all cases, the price charged for the recyclables container is less than the price of non-recyclables waste container. Some recycling programs began with the community's unit priced solid waste program, while others began either before or after that program. Finally, some communities that had recycling programs prior to their unit pricing programs have since altered the quality of the recycling service offered.

Chapter 3

Assessment Framework

The effectiveness of unit pricing, however measured, depends on its effects on waste management decision making. This chapter examines solid waste decision making from the perspective of

- households,
- community solid waste managers, and
- public policy makers.

This examination helps determine what questions to ask about unit pricing and how to interpret the answers received. It also suggests specific measures of effectiveness to use when evaluating the unit pricing experience of the case study communities.

For this examination, economic models of waste management behavior were used. Earlier work in this vein, both empirical and theoretical, is sketched in Appendix A. The approach outlined here is quite general, specifying only that decision makers are maximizing some objective subject to resource or other constraints. The objective need not be monetary (e.g., households are assumed to maximize overall satisfaction or, in the terminology of economics, utility). The constraints need not be only economic or technical (e.g., decision makers may be constrained by institutional limits, such as landfill design regulations). The objectives and constraints postulated for decision makers are based on both conventional economic theory and observations made in Chapter 2 regarding the purposes and concerns associated with unit pricing.

3.1 Household Decision Making

3.1.1 Household Options

Figure 3-1 depicts the choices a household faces when determining its waste generation and disposal behavior. These choices determine both the size and the direction of the household's waste flows. They will be affected by the pricing of waste disposal collection and disposal services and by household tastes and preferences, institutional constraints, and technical conditions.

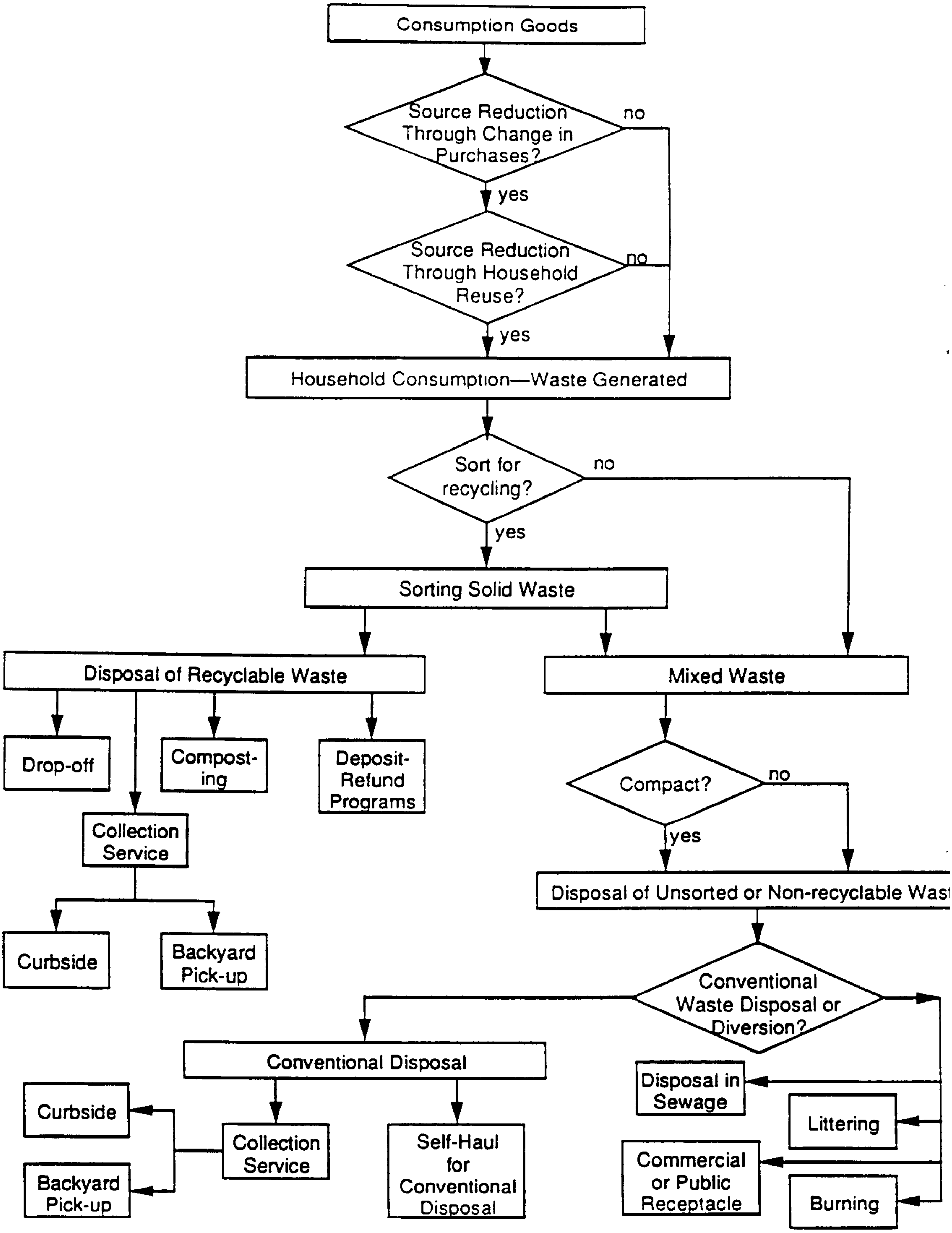


Figure 3-1. Household Solid Waste Flows

In particular, the array of options actually available to a household depend in large part on opportunities offered by local waste managers.

All households first face decisions affecting the waste they generate when they purchase goods for household use. Consumption of these goods usually produces solid waste and, since the kind and quantity of waste generated varies from one good to another, any change in the goods a household purchases likely changes the waste generated. Consumers trying to reduce the amount of waste they generate may choose to purchase fewer packaged goods and throw-away items. In addition, a household may choose to reuse products they purchase—for example, jars—or donate them to other users—for example, clothes. This behavior is often referred to as source reduction because it reduces the amount of waste generated. Or if a recycling program is available, consumers may choose items with more recyclable components or packaging.

Once waste is generated, the household must decide whether and how it will "process" the waste. One can think of the household as something like a firm, making decisions on what type of waste to produce and how to produce it. Recycling is clearly one of the production options available to the household. If something valuable to either the household or to someone else can be recovered through recycling, then recycling may be an attractive alternative to conventional disposal or other means of waste "diversion." Decisions on what to recycle and how to recycle it depend on the recycling options available to the household. These often vary depending on community recycling programs, the material recycled, and market conditions when recycling takes place.

Households can also process waste by compaction. By decreasing the volume of waste, compaction may reduce the handling or other costs of waste generation. Compaction may also become especially attractive to the household in the case of a volume-based unit pricing program.[1]

---

[1]The household also has storage or inventory decisions to make, especially if it chooses to recycle. For example, it must decide where and how to store sorted recyclables and how much to store before either recycling them or disposing of them in conventional fashion with mixed waste. Household decisions in this regard depend on recycling options (such as collection frequency), the amount of storage capacity, and the value of the recycled material.

Figure 3-1 shows that even when a household chooses to sort out recyclables, it will dispose of some portion of the remaining household waste stream in other ways. The most common way, of course, is for the household to use a collection service to pick up the waste (at that point, the ultimate disposal of the waste is up to the collector) or to self-haul waste to a transfer station, incinerator, or landfill. The household may also choose other methods of disposal, including some that may be either illegal or impose costs on others in the community. These other mixed waste disposal options are referred to as waste "diversion." Forms of waste diversion include household disposal by sewage, burning, littering, and disposing in commercial or public receptacles. These disposal methods and recycling are of particular interest because most unit pricing programs provide an incentive to households to avoid conventional waste collection. In instances where waste diversion is illegal, the chances of being caught and the penalty associated with conviction also affect the household's choice of a disposal option.

3.1.2 Analysis of Household Decisions

In keeping with the underlying economic rationale for unit pricing, it is assumed that households maximize utility by combining limited time and other household resources with purchased goods and services (Becker, 1965). A household uses resources to adjust the size and direction of consumption patterns and waste flows so as to attain the highest possible level of household utility or satisfaction.

It is important to observe that in this analysis the household "pays" to generate additional solid waste, even if this payment is not always in the form of an out-of-pocket expense. The payment takes the form of time and other costs (e.g., unpleasantness, or disutility, of handling trash, remembering to put it out on certain days, picking it up after bags or containers have been broken or spilled). In response to such costs of solid waste generation households purchase trash compactors, assign children to the trash detail, and spend time reminding the children every week to do that job. In short, holding all other conditions the same, households probably suffer a loss in utility as they generate more solid waste, even in the absence of a unit pricing program.

It is expected that such costs are factored into household decisions of the sort depicted by the household waste flow diagram of Figure 3-1. The household's choice of goods affects both the

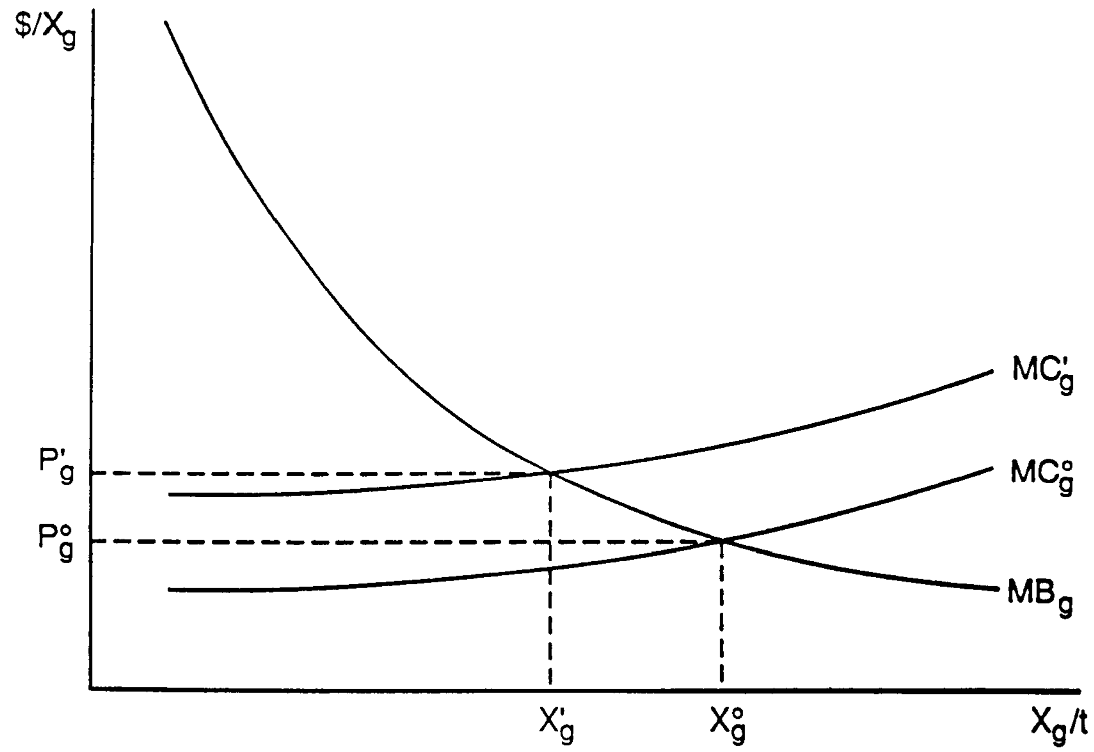


Figure 3-2. Household Waste Generation Associated with Good X

utility it obtains from consumption and the level and composition of waste it generates. More consumption yields additional utility in consumption but also more disutility associated with any jointly produced solid waste. How will the household balance these considerations and select a level of waste generation?

It can be shown that a utility-maximizing household subject to resource constraints will select that combination of goods consumption and waste generation that equates the ratios of marginal benefits to marginal costs across the different choices. This finding is represented in Figure 3-2, in which the conditions for maximizing utility have been transformed into equivalent expressions for selecting a utility-maximizing level of the waste generation. The household's selected rate of waste generation occurs when the marginal benefit (MB_g) of additional waste generation (the benefit of associated increases in consumption) and the marginal costs (MC_g^o) of waste generation (the price of associated consumption goods and the cost of associated solid waste disposal) are equal. In the diagram in Figure 3-2, this occurs at waste generation rate X_g^o. Put another way, an additional unit of waste generation beyond X_g^o will add more to the household's costs than to its benefits, resulting in lower total net benefits.

Effect on Waste Generation

The marginal cost of each additional unit of waste generated increases when a commodity's pricing structure shifts from a flat fee to unit pricing. This being the case, the marginal cost schedule shifts up to a level such as MC_g' in Figure 3-2. The new utility-maximizing level of household waste generation after the shift will be lower, X_g'. The household would achieve this new, lower level by

- changing the mix of goods and services toward less waste-intensive items, and
- improving the technology of household waste management to reduce the weight or volume of waste generated (e.g., buying commodities in bulk, or with little packaging.)

Based on this analysis, the household's waste generation is expected to decline with the introduction of, or increase in, the unit pricing of waste collection and disposal. The magnitude of this decline will probably depend on the initial unit price (initial unit price is zero if the program has just been introduced) and on the size of the unit price increase.[2]

Effect on Conventional Waste Disposal

If unit pricing increases the relative price of conventional waste service then a utility maximizing household will reduce its conventional waste disposal. This is illustrated in Figure 3.3. The marginal benefit function for conventional waste, MB_c, is the household demand schedule for conventional waste disposal. This function is shown as declining with conventional waste disposal as a reflection of the declining benefits of the consumption that underlies the waste flows. The household's initial marginal cost schedule, MC_c^o, reflects the out-of-pocket and other costs of conventional waste disposal. The initial optimum level of conventional waste disposal is X_c^o. Unit pricing shifts the marginal cost schedule up to MC_c' in Figure 3-3 because conventional disposal of each unit of now costs more. The new, lower level of optimum conventional waste disposal for the household is now X_c'. As in the case of waste generation, conventional waste disposal by households should decline as the unit price of conventional waste disposal increases. It is also expected that the reduction will increase with the number and ease of alternative disposal options (by shifting MB_c downward).

The marginal benefit or demand schedule upon which this response is predicated depends on fixing the household's tastes and preferences, all other prices, incomes, and other technical and institutional constraints. If these should change coincident with an increase in the unit price, a different demand schedule (MB_c') may apply and the net effect of all changes will determine X_c'. Furthermore, in cases in which there is a transition from a flat fee to unit pricing of solid waste there is also usually a change in disposable household income as the household no longer has to pay the flat fee. This complicates even qualitative estimation of effects of a change in the pricing policy (Taylor, 1975.)

---

[2]There are special conditions under which unit pricing may lead to increases in waste generated. increased generation might occur if 1) alternative, low-cost, waste disposal options were available to the household; 2) the cost of these alternatives are not affected by unit pricing; and 3) disposal using these alternative disposal options is particularly suited to solid-waste-intensive commodities. For example, this might happen if, in response to an increase in the unit price of conventional waste disposal, a household switched from consumption of beverages in plastic containers that are conventionally collected and disposed to glass containers that are recycled.

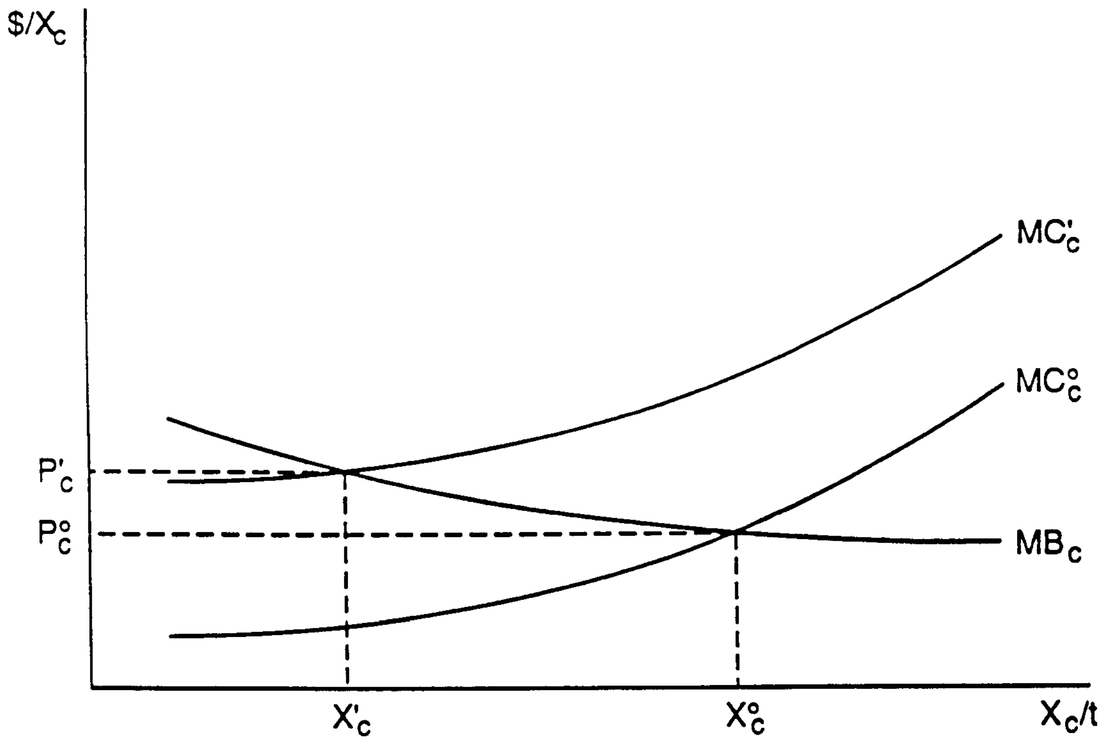


Figure 3-3. Household Conventional Disposal

Effect on Waste Diversion

Application of unit pricing to only selected types of service (e.g., conventional disposal) encourages the utility-maximizing household to either adopt or intensify use of other disposal options. As noted above, households often enjoy quite a range of such choices, some of which may even be illegal. These options include investment in capital equipment that reduces the net cost, either monetary or personnel, of managing waste. For example, the household may buy a garbage disposal so it doesn't generate and handle as much "wet" waste.

Increases in the unit price of conventional waste disposal will likely increase the amount of waste diverted. While the case studies examined as many options for diverting waste as seem appropriate to the community, most attention is directed toward recycling. This is because recycling programs are

- the most widely promoted method for diverting waste from conventional waste disposal,
- part of the waste management system for most of the communities that have unit pricing of conventional waste, and
- generally monitored by the waste manager.

The effect of unit pricing on recycling for a utility-maximizing household is illustrated in Figure 3-4. The initial level of recycling is X_r^o. This is the point at which the marginal benefits of recycling (MB_r^o), such as marginal revenues from the sale of recycled materials and avoided cost associated with conventional waste disposal, are equal to the marginal costs to the household of recycling (MC_r).

With higher prices for conventional waste disposal, the avoided costs of conventional waste disposal attributable to recycling are now greater and the marginal benefit function shifts up to a level such as MB_r^1 in Figure 3-4. With the shift, the new utility maximizing level of household recycling is X_r^1.

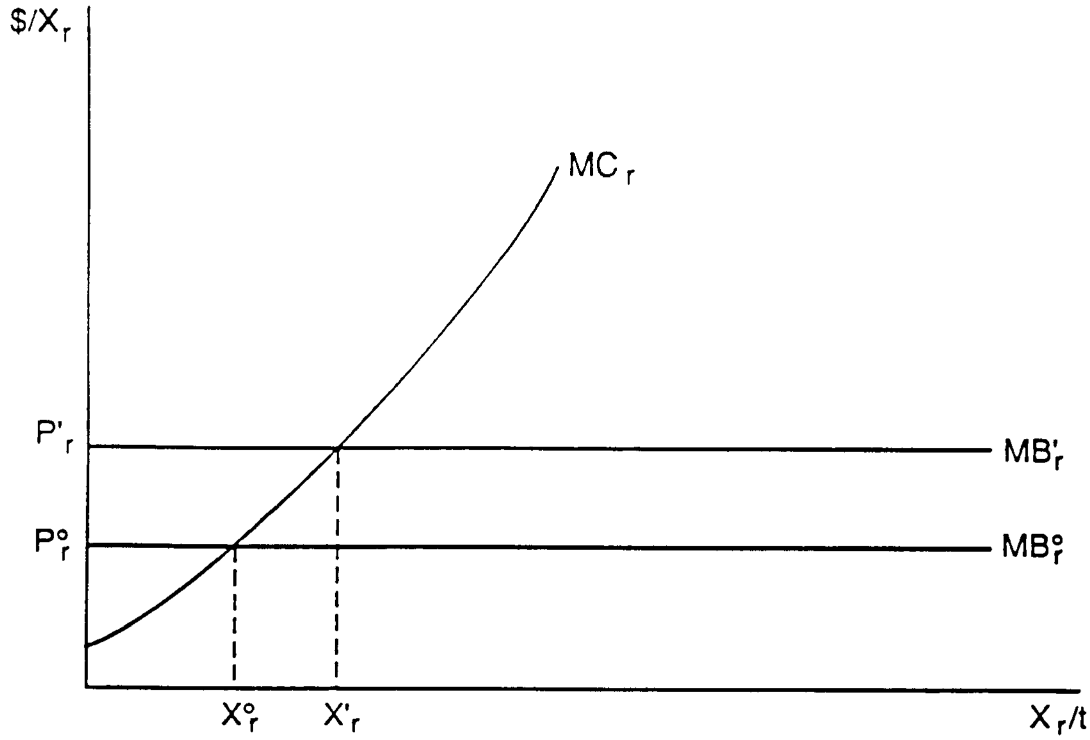


Figure 3-4. Household Recycling

The increase in recycling occurs because households

- recycle more of the waste that is currently generated, and
- change the composition of purchases so as to raise the fraction of waste that can be readily recycled.

3.2 Community Waste Management Decision Making

While in some sense we are all waste managers, the particular waste managers referred to here are the private firms or public entities and officials that direct and provide municipal solid waste collection services. These waste managers usually initiate and design unit pricing programs. While they exercise more control than households over terms and conditions associated with waste collection in general and a unit pricing program in particular, they still choose among a variety of economic and technical options that affect the magnitude and composition of solid waste flows and the effectiveness of a unit pricing program.

3.2.1 Waste Managers' Choices

Some of the major choices waste managers face are described in Figure 3-5. Waste managers must first decide what services to offer their customers and what the terms of each of the service options will be. Numerous options are available including changes in the collection point, frequency of collection, and type of material collected. Figure 3-5 focuses on choices involving unit pricing, conventional disposal, and recycling. If a recycling program is attractive in principle, the waste manager must decide whether and how to involve the waste generator. The waste manager must select curbside or drop-off programs (or some combination), the type of materials to be covered by the program, and the requirements on households to process materials before collection. The waste manager must also decide what options are available to households for conventional waste collection: Where will conventional waste be collected? How frequently will it be collected? What will be collected? These decisions affect the household response to the community waste management program in general and the unit pricing program in particular.

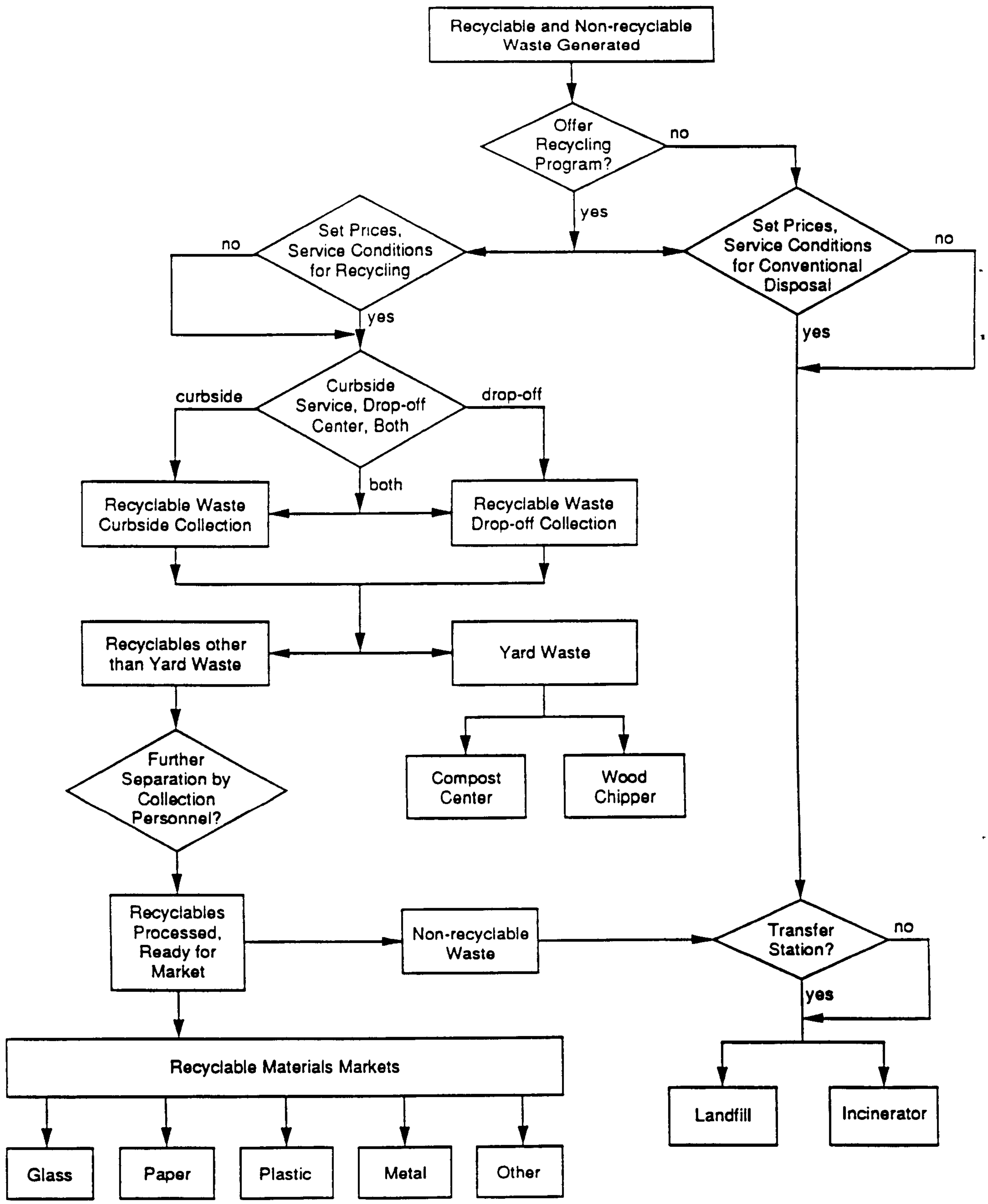


Figure 3-5. Waste Management System Solid Waste Flows

The waste manager must then decide how the collected waste is to be processed. Will there be a recycling facility for mixed waste? Will there be a transfer station? If so, what waste will be processed there? Where will the community dispose of conventional solid waste and culls from recycling facilities? All these decisions help determine the ultimate size and disposition of solid waste streams for the community.

Collecting, processing, and disposing of solid waste is costly, and the waste manager must also decide how to finance these activities. The primary options available include

- indirect financing through general taxes,
- a fixed fee per unit of time, or
- a unit price based on weight or volume.

Of course, there are many options involving variations and combinations of these three financing strategies. An important point to remember, however, is that in setting these financing strategies the waste manager affects the household's incentives and, ultimately, the level and composition of solid waste collected.

3.2.2 Analysis of Waste Managers' Choices

Since solid waste managers operate within a variety of institutional settings and market organizations, it is difficult to generalize regarding their objectives or the constraints under which they operate. This section briefly considers the objective of cost minimization in conjunction with several common constraints that condition the cost of service ultimately achieved. Inasmuch as the unit price is a major decision variable available to the waste manager, discussion here focuses on how selection of a unit price affects costs.

Cost Minimization

The prospect of reduced costs of service attracts many waste managers to unit pricing. Of course, the manager must obtain these cost reductions while still meeting any overriding conditions on the extent and quality of service imposed by law or contract. In order to make the choice between unit pricing and some other financing system, however, the waste manager must first know what unit pricing program is most cost-effective.

Because waste flows depend on household response to the unit pricing program, selection of the unit price offered to households affects costs. As the price of conventional waste disposal increases, a decline in the quantity of conventional mixed waste offered for disposal and an increase in the quantity of waste sorted for recycling or other waste diversion can be expected. Assuming that collection and disposal of either recycled or conventional wastes are increasing-cost activities, increasing the price of conventional waste disposal would reduce the total cost of conventional waste service but increase the total cost of recycling. This is illustrated in Figure 3-6, in which the total costs of a hypothetical waste management system first decline when declines in conventional waste service cost dominate. Then they increase when increases in the cost of recycling services begin to dominate. Thus, there is probably some unit price that minimizes the total cost of service from the waste manager's perspective and puts unit pricing on a "best" basis for comparison with the cost of service under other financing strategies.

Revenues Requirements

The unit price that minimizes cost will not necessarily result in revenues that cover the costs of associated service. Indeed, within the wide variety of pricing options available in a unit pricing framework, the waste manager may obtain revenues that either exceed or fall short of the costs of collection and disposal. The ultimate relationship depends on specific community conditions including

- design of the unit pricing program (e.g., scope and magnitude of unit pricing),
- the constraints to which the waste manager is subjected (e.g., level of service requirements),
- customer response to the unit pricing program, and
- the manner in which costs vary with the level of different waste flow (e.g., economies of scope and scale).

The unit pricing program may have to be designed with a revenue requirement that revenues must cover costs. Adding this constraint can only raise the total cost of providing service, but the program that will minimize the extent of this rise depends, again, on community conditions.

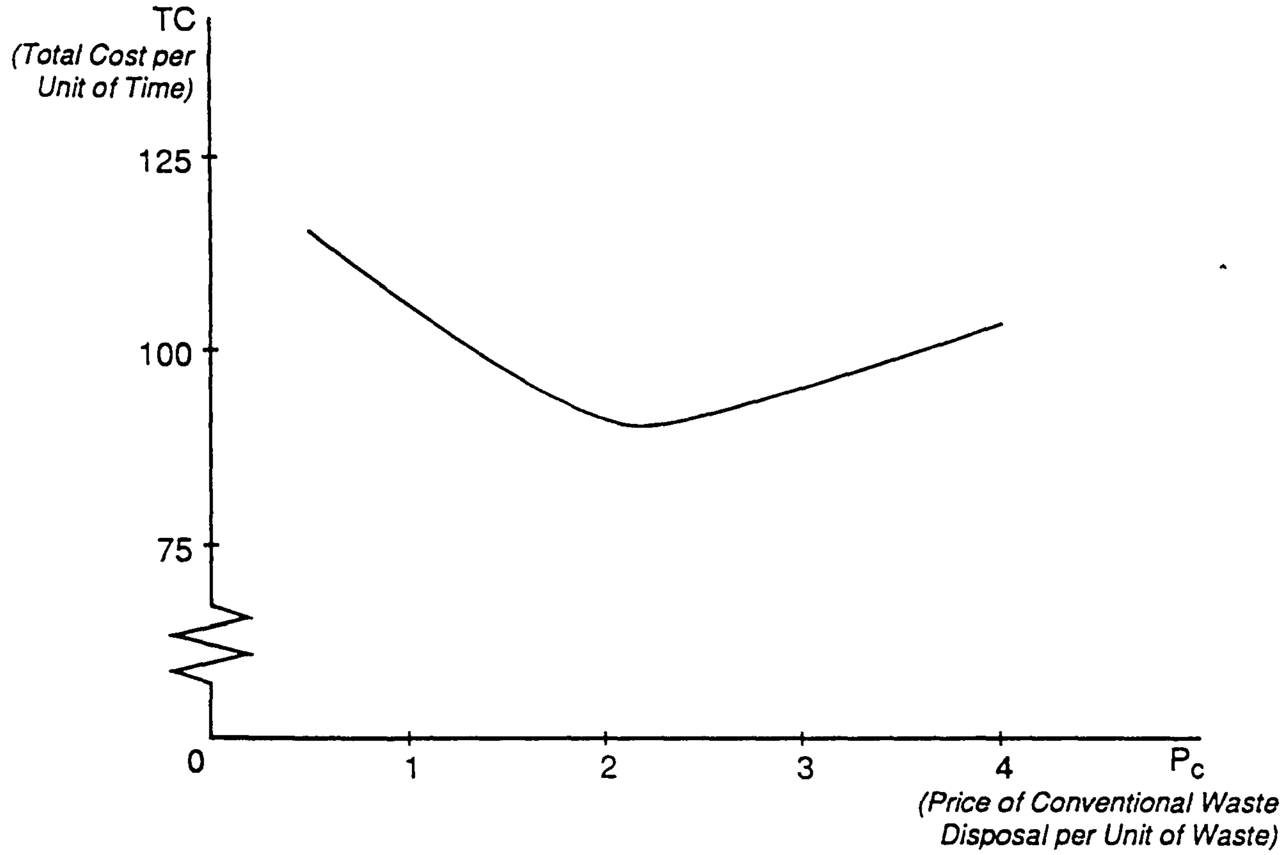


Figure 3-6. Total Cost of Community Waste Disposal as a Function of the Unit Price of Conventional Waste Disposal

Recycling Requirements

Anticipated effects of unit pricing include increased waste recycling and diversion. Indeed, a waste manager may be required to meet a certain recycling goal. This might be achieved by increasing the differential in the unit price between conventional waste disposal and waste recycling. As in the case of the revenue requirements constraint, such a recycling requirement can only raise the costs associated with a unit pricing. The unit pricing program that meets this constraint at least cost will again depend on conditions in the community.

Economic Efficiency

This objective is inspired by the economic efficiency notion that the user should not only pay in proportion to the service received, but that the rate they should pay is equal to the marginal costs incurred to provide another unit of service. In its broadest form, the objective of economic efficiency suggests that all services provided by the waste manager should be priced—even recycling, composting, and other diversion activities. The effect of this objective on waste flows and costs depends on the range of solid waste categories over which unit pricing is applied, the way in which costs are allocated to these categories, and, as in the cases discussed above, on household response to these prices.

3.3 Social Waste Management Decision Making

Ordinarily, competitive markets provide a mechanism whereby real resource costs are introduced as elements into the waste manager's decisions and promote economically efficient decisions. For example, the cost of a collection truck reflects the real resource cost used in producing the truck and the productive opportunities foregone when using the truck to provide waste management services. However, when competition or markets break down, community waste managers' decisions may not account for all the costs to society. In selecting a unit pricing program to minimize cost, waste managers with some degree of market power may exclude from consideration those effects that do not show up as costs on their books but that impose real costs on both those the program serves and, sometimes, on firms or households outside the service area. For example, the waste managers' calculations may not reflect the cost of any additional time and inconvenience that unit pricing imposes on households.

There are many reasons why social costs (and benefits) of waste management decisions might not be fully reflected in the costs seen by community waste managers. These range from the public enterprise nature of waste management in many communities to the existence of technical environmental "externalities" such as air and water emissions from landfills that impose costs on third parties. Addressing these problems and their remedies in a comprehensive way is outside the scope of this report. As noted above, however, unit pricing is a likely element of any plan to provide household and waste management decision makers with better measures of the social cost of their decisions. It is also possible to identify some components of the social costs and benefits not incorporated into community waste management decisions and observe how these costs are affected by unit pricing programs. For example, one might observe increasing waste flows in adjoining communities (a likely social cost) or decreasing levels of air pollution (a likely social benefit) in communities downwind from the MSW combustor.

3.4 Measures of Effectiveness

3.4.1 Waste Flows

As described above, unit pricing influences household decisions and, consequently, household waste flows. Unfortunately, only aggregate data are available from case study communities, covering all the households of a service area rather than individual households. For this reason, the measures of effectiveness adopted are based on aggregate waste flows.

Gross Waste Flows

Based on the preceding analysis, gross waste flows of interest will be waste generated (X_g), waste recycled (X_r), waste conventionally disposed (X_c), and waste diverted (X_d). The last term, waste diverted, refers to waste flows associated with all the self disposal options exclusive of recycling. These options, many of which were referred to above, may be legal or illegal, benign or costly.

The basic relationship between these flows is given in Equation 3.1.

$$X_g - X_d = X_r + X_c \qquad (3.1)$$

The amount of waste generated, less the amount of waste diverted, equals the sum of waste recycled and waste conventionally disposed (mixed waste). Based on past research and the analysis of this chapter, it is expected that as the unit price increases, X_c and X_g decline and X_r and X_d increase. By examining these flows before and after a change in the unit price, one can obtain estimates of how, in the aggregate, households have responded to the change.

The case studies present rough measures of the flows on the right-hand side of Equation 3.1 both before and after a change in unit price. Quantitative measures of waste generated or diverted, however, are not directly available and estimates of the effect of the unit pricing on their magnitudes are more speculative.

Changes in Waste Flows

By computing changes in X_c (ΔX_c) and X_r (ΔX_r), preliminary estimates can be made of the absolute changes in waste flows due to unit pricing. One qualification, an important one in each of the case studies, is that other program changes often occurred coincident with the change in unit price. Unless one is willing to assume that these other changes had no effect on waste flows, the ΔX_c and ΔX_r observed are the joint product of unit pricing and coincident changes in other conditions in service. This problem with joint effects is an inevitable by-product of analysis with limited data because it is infeasible to use the statistical tools that might distinguish among the different effects.

By making assumptions about the magnitudes of change in one or the other of the variables on the left-hand side of Equation 3.1, one can also deduce what changes, conditional on the accuracy of the assumptions, occurred in the remaining variable based on the net effect on X_c and X_r.

Average Response to Price Change

While changes in waste flows can be observed in the case study communities over relatively short intervals, comparison among the communities requires at a minimum some "normalization" to account for differences in the absolute size of the service area. Therefore average estimates of changes in flows based on population are computed. While this doesn't address all the underlying differences in the communities, these average values do provide a raw notion of how the absolute magnitudes and changes in waste flows compare. These average values are also useful for comparison across periods in a single, fast-growing community or service area.

Arc Elasticities

The size of waste flow changes relative to the change in unit price is clearly important to assessing the effects of unit pricing. The arc elasticity of demand is the measure most often used to assess the effects of such discrete changes. The arc elasticity is defined in Equation 3.2.

$$E_{xp} = \frac{\Delta X}{\Delta P} * \frac{\left(\frac{P_2+P_1}{2}\right)}{\left(\frac{X_2+X_1}{2}\right)} = \frac{\Delta X}{\Delta P} * \frac{(P_2+P_1)}{(X_2+X_1)} \qquad (3.2)$$

These arc elasticities are computed for the various waste flow changes estimated and are interpreted as the percentage change in the flow due to a percentage change in the price. In instances where we are dealing with changes in recycling, diversion, or generation, the elasticities are "cross elasticities" in that the waste flow that has changed is not the waste flow whose price has changed. For example, a cross elasticity is used to measure the percentage change in recycling brought about by a percentage change in the price of conventional disposal.

The expectation for the signs of the arc elasticities is based on an expectation for the direction of change in waste flow quantities.

EX_gP_c = negative

EX_rP_c = positive

EX_cP_c = negative

EX_dP_c = positive

3.4.2 Cost of Waste Management

Community Waste Management

The cost-effectiveness of unit pricing from the waste manager's perspective may be measured in terms of the expenditures needed to satisfy service requirements under the different pricing conditions. In the case studies, information was examined on both total cost and line item information to see how the expenditures have changed under unit pricing. This includes consideration of capital expenditures or depreciation, where such data are available, and system credits for avoided costs or revenues from sale of recyclables.

Attributing cost changes to unit pricing has problems similar to attributing flow changes. While an attempt was made to try to isolate cost changes associated with the unit pricing program, it is often difficult to separate them from other, coincident changes in waste management and service.

Household Waste Management

Households alter their waste generation behavior to take advantage of savings offered by unit pricing. Consequently, from a household's perspective the effectiveness of unit pricing is in part represented by changes in household costs or waste expenditures. In Chapter 4 calculations are made for some selected households for what this cost might be. A broader measure of cost to households, based on nonmonetary costs coincident with unit pricing as well as changes in out-of-pocket expenses, is beyond the scope of this study.

3.4.3 Financing Waste Management

Monetary costs to the household are also revenues from the perspective of the waste manager. Revenues generated by unit pricing are reported in the case studies. These revenues are compared to the costs actually borne by the waste manager to see how they relate to total costs and the costs of collection and disposal of conventional waste. In other words, the study addresses how closely the unit pricing conforms to pricing service on an "enterprise" basis or, in pursuit of economic efficiency, the estimated marginal cost of service.

3.4.4 Community Health Aesthetics

While quantitative measures do not exist for the health or aesthetic effects of unit pricing, information on community perceptions was collected for the case studies. These perceptions, particularly as they relate to questions associated with waste diversions such as littering, backyard composting, and backyard burning, are included in the discussion of the effects of unit pricing.

Chapter 4
Selection of Case Study Communities

A literature search was conducted to begin locating communities with unit pricing programs for solid waste collection and disposal. To obtain additional information, sources, including trade organizations, identified through the search were contacted. This list of unit pricing communities grew as some of the first communities contacted were able to identify other areas with such programs. In all, 17 such communities were identified (see Chapter 2). Initial contacts were made with each of these communities to get a description of the community and its program for handling solid waste. During these initial contacts valuable information was obtained regarding

- when and why a unit pricing program was adopted,
- how the program was operated and managed,
- what kind of recycling program, if any, was available to waste disposal customers,
- what data were available, and
- general comments on the purpose and degree of success of the unit pricing program in the community.

Summary descriptions of the programs in each of the communities are given in Chapter 2. Based on the compiled information, communities were evaluated to determine which were most suitable for case study purposes.

4.1 Selection Criteria

4.1.1 Mandatory Unit Pricing Program

The first criterion used for selecting a community as a case study community was that the community's unit pricing program be mandatory for residents of the area. Of the 16 unit pricing programs examined, 12 were mandatory, meaning residential customers either were not offered or were not allowed to choose alternative waste handling programs provided by the municipality or private haulers. Studying programs with mandatory participation is essential since information

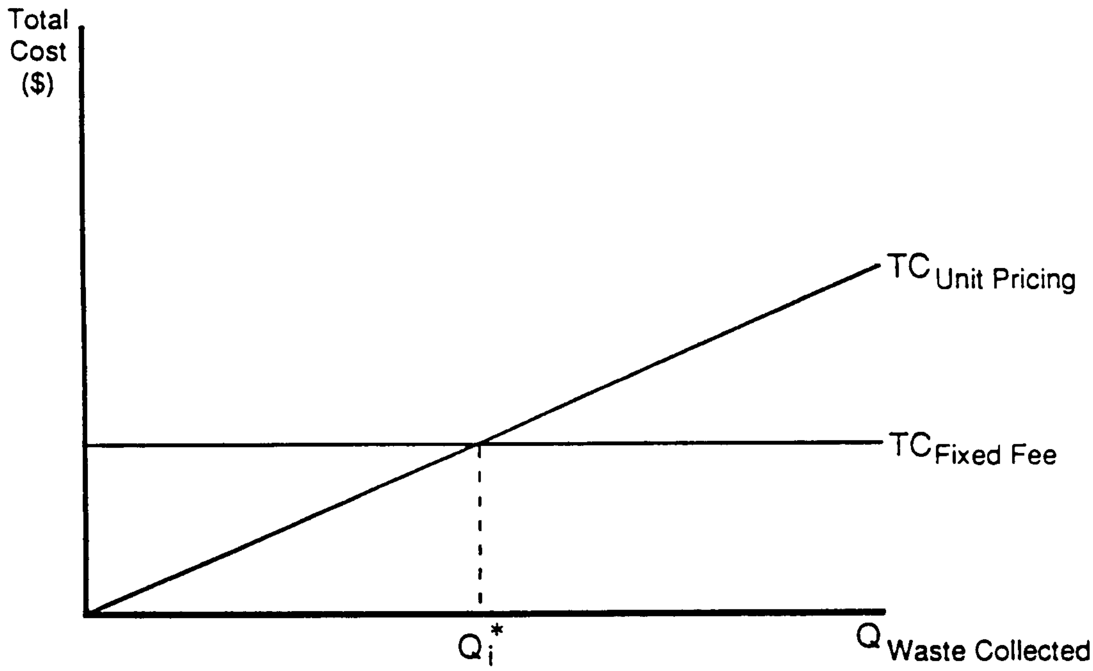


Figure 4-1. A Household's Total Cost for Solid Waste Disposal Under Fixed Fee and Unit Pricing Programs

from areas where residents may choose whether or not to use a unit priced service may not reflect the full effects resulting from these programs. Those likely to subscribe voluntarily will be persons with previous inclinations to limit the waste they dispose of. When a unit pricing program is in place, a customer's cost of disposing of an additional unit of waste is the same as for every other unit disposed of. In contrast, when a flat fee service is available, the cost of disposing of an additional unit is zero. Figure 4-1 illustrates the total cost curves for these two scenarios. The quantity of waste marked by the intersection of these two curves is the quantity that determines which method of payment customers would choose if they made their decision based solely on out-of-pocket cost. A customer who generated less than Q_1^* would choose the unit pricing program, and one who produced a quantity to the right of Q_1^* would choose the flat fee system. In areas where residents are given a choice, those households choosing to participate in the unit pricing program would be those who already generate less waste. Consequently, the behavior of waste generators in voluntary unit pricing programs, even when measured at participating households, does not represent the full potential for changes in behavior under unit pricing.

4.1.2 Available Data

A second criterion used for determining a program's suitability as a case study was the availability of existing data that could be used to evaluate the program's effectiveness. Contacts at seven of the programs indicated that such data were available. Some of these seven communities had very limited or incomplete data at this time, especially those whose programs were less than two years old.

4.1.3 Recycling Program

Another criterion used for selecting case study communities was whether or not some kind of recycling program was involved, or at least available. User fee waste collection programs provide incentives to find alternatives to conventional landfill disposal, such as recycling. Consequently, the case studies of the effectiveness of unit pricing needed to include a representation of complementary recycling programs. Nearly all the recycling programs described by the communities contacted were voluntary, not mandatory, whether they were operated by the municipalities, private companies, or volunteer organizations. In communities where recycling was mandatory, some were made so to comply with recycling laws made at the state level. Recycling was not strictly enforced, however, as the penalty a person paid for not recycling was simply the cost of waste disposal that they could have avoided had they recycled. All but 1 of the 17 communities had some kind of recycling program available to its residents, and 9 of these offered curbside collection.

4.1.4 Community and Program Variations

Finally, programs were selected from those that had met the above standards that offered variations in community characteristics and the waste programs themselves. Differences in area and population were looked at, and whether the community was urban, suburban, or rural was considered. Programs differed in age, fee structure, service features, and how they were operated. The small final group of programs needed to include both large and small communities with variations in their waste programs, so that the case studies could provide a broad information base about unit pricing programs.

4.2 Selected Communities

Based on the criteria discussed above, three communities were selected for case studies. They include the Borough of Perkasie, Pennsylvania; the Village of Ilion, New York; and the City of Seattle, Washington. These selected communities and their unit pricing programs for solid waste collection are described below.

4.2.1 Borough of Perkasie, Pennsylvania

Community Profile

The Borough of Perkasie, located in Bucks County, is a small suburban community about 25 miles north of Philadelphia, Pennsylvania. There have been substantial changes in the community over the past decade—particularly in the last five years. In 1980 Perkasie had a population of 5,241. County census data in 1987 reported the population as 6,247, and the borough's planning department estimates its 1988 population as 6,564. The growth in Perkasie is not attributable to growth in industry there. Rather, the presence of available older housing and land made Perkasie attractive for development as a bedroom community. Many residents are employed by businesses located to the south in Philadelphia or to the north in Allentown or along the Route 309 corridor, which connects Perkasie to these two cities. The borough's population is generally described as white, upper middle-class. In the past, the borough had many older residents, but now the population tends to consist of younger, better educated households, with small children. The majority of housing is single-family dwellings. Substantial increases in median housing costs have been accompanied by less than proportionate increases in salaries. The median sales price of a house in Perkasie increased 91 percent between 1980 and 1987 to $93,250, while median household income rose only 66 percent to $30,373 over the same period. Similar disproportionate changes throughout Bucks County have targeted the housing market primarily towards repeat buyers with higher than average incomes. Consequently, the economic profile for the population of Bucks County, including Perkasie, has shifted upwards during the 1980's (Bucks County Planning Commission, 1989).

Waste Management Program

History

Responding to the sharply rising cost of solid waste disposal, Perkasie began a unit pricing program January 1, 1988. Perkasie's program is a bag program—residents pay for having their waste collected and disposed entirely through purchasing the official borough trash bags. Solid waste must be placed in these bags or it will not be collected.

The borough has always operated a waste collection system, but prior to 1988 residents paid a flat fee of $120 per year, billed quarterly, for curbside pickup of unlimited amounts of waste, including bulky items. The borough set this fee by estimating the costs of collecting and disposing of its solid waste, and then allocating these costs across households and commercial customers. Fees were set similarly when the unit pricing program was developed, but the borough needed additional estimates of the number of trash bags a household would use annually and the quantity of waste per trash bag. Based on these estimates, bags were priced at $1.50 for a 40-lb size and $0.80 for a 20-lb size. These bags are exempt from state sales tax and are available for purchase at the Borough Hall and at local stores.

Relative to the previous $120 annual fee, households under the new pricing structure may dispose of 80 large-sized bags of waste per year for the same price, or just over 1.5 bags per week. A survey sent to borough residents in August 1988 asked residents to estimate the number of waste disposal bags they used either weekly or monthly. Of the 3,230 households and commercial operations surveyed, 42 percent (1,341 households) responded. Of these, nearly one-fourth (325 households) appeared to be spending less than $75.00 annually under the unit pricing program, and the average large bag user was spending less than the prior year's $120 fee. An even larger portion of households benefit financially from unit pricing, if one accounts for the planned increase in the flat fee for 1988 to $145. Under this scenario, a household in the unit pricing program could dispose of 96 large bags of waste each year, or 1.8 bags each week, for the same price as the flat fee.

Service Features

Some features of Perkasie's waste collection service changed with the introduction of the bag program in 1988. While all dwellings and businesses within the borough's limits are still eligible to use the borough's waste service, commercial customers and multi-family dwellings with four or more units may choose instead to contract with private haulers. Other residents must use the borough's service. Prior to 1988, waste was collected twice each week curbside. Since then, collection is still curbside, but mixed waste is collected only once per week, recyclable aluminum and glass collected on a different day once a week, and other recyclables collected once a month. This change could account for some of the reduction in waste generation, since studies have shown that decreasing collection from twice per week to once per week can decrease generation by 30 percent or more (see Appendix).

One important change in the waste service is the restrictions now placed on customers disposing of bulky waste. Prior to the bag program, unlimited quantities of such items would be collected any regular collection day at no additional cost to the customer. Since 1988, however, bulky waste is collected only once per month, and only one item, equivalent in volume to a refrigerator, is permitted per household per month. Beginning in 1989 residents must purchase and attach stickers costing five dollars each to appliances they wish to have collected.

Complementary Programs

A major change in Perkasie's waste service has been the start of curbside recycling coincident with the start of the bag program in January 1988. Residents could previously recycle glass and newsprint through programs operated by volunteer organizations. Glass was collected at drop-off points twice monthly, and newsprint was collected curbside once monthly. As of January 1988 Perkasie requires residents to recycle and provides them with buckets for their aluminum and glass items, which are collected once each week. These two items are sorted by the collection personnel. Glass is sorted additionally by color. Residents pay no fee for the buckets or collection, and the only penalty facing those who do not recycle is the price of the bags they must use to dispose of recyclable items as solid waste. Besides glass and aluminum, the borough collects bundled newsprint, junk mail, newspaper inserts, and corrugated cardboard. These items are also collected curbside, but only one time each month. Residents may choose to transport their recyclables to central drop-off points available 24 hours a day, rather than place them curbside for collection.

In addition to this recycling program, Perkasie encourages, but does not regulate, composting of yardwaste. Leaves are collected curbside during two months of the year, with collection days announced in the local paper. They are taken to a local farmer who composts them for his own use. This service was provided before the bag program began, so yardwaste was not a part of the borough's landfilled waste even before 1988.

Effects of Unit Pricing

Impacts on System Waste Flows

Gross Flows. Residents have responded to unit pricing in Perkasie to reduce some quantities in the waste stream and to divert some flows to alternate disposal options. A Wall Street Journal article (June 21, 1989) described the change in behavior of one Perkasie household, the Campbells, that typifies many households in the borough. Residents, since the introduction of unit pricing, give much more thought to the waste they throw away. They save recyclables to take advantage of the borough's free recycling program and to divert waste from the conventional disposal stream. They compost food waste, grass clippings, and leaves in their backyards, which reduces the quantities of waste collected by the borough. Residents have also reduced the quantities of waste they generate by changing their buying behavior. The Campbells have reduced the quantities of some products they buy, such as paper towels; they avoid elaborately packaged products, such as cosmetics; and they buy beverages in aluminum cans or returnable bottles, not in non-returnable plastic. As a result of these changes in behavior, the Campbells spent only $116 for waste services in 1988, compared to the proposed $145 flat fee. For elderly residents unit pricing offers even greater potential savings. One elderly resident reported his 1988 expenditure for waste services was only $14, since he had reduced the quantity of waste he generated to about one bag each six weeks.

These specific examples describe the effects on unit pricing on certain households, but a broader analysis required an examination of the borough's waste streams. For this analysis, the study first examined gross flows for the years before and after the start of unit pricing. Perkasie was able to provide data for two of the components of the gross flow equation described in Chapter 3 of this report. The borough reported tonnages for the conventionally disposed waste (landfilled waste) and for recycled waste. The quantity of waste generated was not available, however, because of the difficulty of quantifying the amount of waste diverted from the waste stream. These last two quantities were estimated based on comparisons of 1988 and 1989 data.

Although the data were inadequate to accurately quantify the diverted flow, Perkasie sources described existing disposal options that contributed to this flow. At least 3.1 percent of the reduction in municipal waste collected was attributable to the attrition of commercial customers from the borough's collection system to private haulers. Additionally, the borough reported a substantial increase in household trash-burning in backyards, fireplaces, and wood stoves. The borough was forced to enact a burning ban, which became effective March 1989. Other possible disposal alternatives include backyard composting, illegal dumping, garbage disposal through the sewage system, and exporting of waste. Perkasie officials indicated there had been no noticeable problem with littering and no change at the water utility that would indicate an increase in the use of the sewage system. There have, however, been numerous reports that residents of Perkasie are taking their waste to commercial dumpsters and outside the borough to neighboring Sellersville. In fact, the mayor of Sellersville has offered a $25 reward to persons who help catch persons bringing waste into the Sellersville limits. While a survey sent to Perkasie residents showed a high level of approval for the bag program, there have been many complaints by businesses and persons outside the borough.

All the solid waste figures and the 1988 recycling figures were taken from the borough's 1988 report on its per-bag disposal fee, waste reduction, and recycling program. The recycling figures prior to 1988 came from persons associated with those recycling programs. Walt Wimmer, who is in charge of glass collection for the civic organization Brothers of the Bush, estimated that prior to

1988 they collected about 200 tons of glass yearly in the Perkasie area. Of this amount he estimated that 50 percent came from inside the borough limits. All 1988 figures are for tonnages collected inside the limits. Tuturice Brothers shredded and sold the paper collected by the volunteer fire department before 1988. Charles Tuturice estimated that the firemen collected 30,000 pounds per month, or 180 tons per year, on average from 1985 to 1987.

The waste flow changes described in Table 4-1 resulted from all changes that took place in Perkasie between the 1985-87 time period and 1988 that affected the waste generation and disposal behavior of the borough's residents. In particular, the changes reflect the effects of the introduction of unit pricing and curbside recycling. In 1988 the quantity of waste Perkasie collected for conventional disposal was less than half its previous yearly average, and the quantity of recyclables collected more than doubled. Of the 1,320 ton decrease in conventionally disposed waste, increased recycling accounts for 420 tons. This leaves a decrease in total waste collected of 900 tons, which is the result of some combination of a decrease in waste generated and an increase in waste diverted to other means of disposal.

Table 4-1. Perkasie Solid Waste and Recyclable Flow Data

	1985-87 Annual Average (tons[1])	1988 Reported (tons)	1988 Adjusted for Commercial Attrition[2] (tons)	Change (tons)	Change (%)
Conventional Solid Waste Collected (includes bulky waste), X_c	2,520	1,160	1,200	-1,320	-52
Recyclables Collected, X_r	280	700	700	+420	+150
Paper	(180)	(470)			
Aluminum	(0)	(10)			
Glass	(100)	(220)			
Total Conventional and Recycled Waste Collected, X_t	2,800	1,860	1,900	-900	-32

[1]All quantities in English tons.
[2]3.1 percent of the reduction in waste collected is attributable to commercial attrition from the borough's collection system to private haulers. This increases collected tonnage by 40 tons.
Source: Good, 1988.

As discussed earlier, backyard burning increased when unit pricing became effective. While the borough has no measure of how much burning occurred, an estimate can be obtained using 1989 data after the burning ban was enacted. The quantities of paper recycled were compared for the second and third quarters of 1988 and 1989, since the burning ban took effect in March 1989, and since paper is likely to be the waste material that was being burned. The quantity of paper recycled in 1989, relative to 1988, was 32 and 8 percent greater for the second and third quarters, respectively. Using the average, one can estimate that 20 percent, or 120 tons, of the recyclable waste paper generated in 1988 was burned.

Some portion of conventionally disposed solid waste was likely also to have been diverted from the waste stream. In addition to implementing a ban to control burning in 1989, the borough and neighboring communities increased policing efforts aimed at stopping waste from being diverted by exporting it or by using privately hauled commercial containers. Assuming these measures have been effective in eliminating most diversion problems in 1989, one can estimate the quantity diverted in 1988. Again, 20 percent appears to be the best available estimate of the conventional waste diverted in 1988, since the quantities of conventionally disposed waste in the first three quarters of 1989 were, on average, about 20 percent higher than the 1988 quantities. Based on these estimates, the values given in Table 4-2 approximate waste generated for collection, waste collected and disposed, and waste diverted in 1988 (adjusted for commercial attrition).

Table 4-2. Perkasie Solid Waste and Recyclable Flow Data for 1988 After Adjustments for Waste Diversion

	Tons Generated	Tons Collected and Disposed	Tons Diverted
Conventional Waste	1,490	1,200	290
Recyclables:	820	700	120
Paper	(590)	(470)	(120)
Aluminum	(10)	(10)	(0)
Glass	(220)	(220)	(0)
Total Waste	2,310	1,900	410

The flat fee system used prior to unit pricing did not provide waste generators an incentive to divert waste from the collection streams, so negligible diversion can be assumed prior to 1988. Furthermore, assuming the change in waste compacted by households is negligible, waste collected would roughly equal waste generated.[1] Working on those assumptions, the effects of unit pricing and curbside recycling on Perkasie's waste flows are described in Table 4-3.

Table 4-3. Perkasie Waste Streams Including Diversion

	1985-87 Annual Average (tons)	1988 Adjusted for Commercial Attrition (tons)	Change (tons)	Change (%)
Waste Generated, X_g	2,800	2,310	-490	-18
Waste Diverted, X_d	0	410	+410	
Waste Collected and Disposed (Conventional and Recyclables, $X_c + X_r$)	2,800	1,900	-900	-32

Table 4-3 shows a substantial, but much smaller, effect of unit pricing and curbside recycling on waste generation than on waste collected and disposed. Of the 900 ton decrease in waste collected and disposed, approximately half resulted from a reduction in waste generated and half from waste diversion. The 18 percent decrease in waste generated is the result of a combination of altered purchasing patterns, increased backyard composting, and other behavioral changes that actually reduced the quantity of waste that must be disposed through channels outside the household.

For the purposes of analysis, assume that if Perkasie's burning ban and policing measures had been in place in 1988, no waste would have been diverted; rather, the borough would have either recycled or conventionally disposed of all waste generated. Table 4-4 gives the effects of unit pricing accompanied by curbside recycling under such a scenario.

[1]The change in waste diversion due to changes in household composting are difficult to estimate because some yard wastes (e.g., leaves) are not collected by the municipality.

Table 4-4. Perkasie Waste Streams with Diversion Allocated to Conventional Disposal or Recycling

	1985-87 Annual Average (tons)	1988 Adjusted for Commercial Attrition (tons)	Change (tons)	Change (%)
Conventional Solid Waste, X_c	2,520	1,490	-1,030	-41
Recyclables, X_r	280	820	+540	+193
Paper	(180)	(590)		
Aluminum	(0)	(10)		
Glass	(100)	(220)		
Total Waste Generated, X_g	2,800	2,310	-490	-18

Average Change Per Dollar. The per unit price, P, of disposing of solid waste was zero before 1988, since residents paid a flat annual fee, not directly related to the quantities they disposed. With the introduction of unit pricing, however, residents paid a price directly related to the quantity of waste they disposed, through the purchase of either large or small borough bags. In 1988 large bag sales (86,600 bags) accounted for 84 percent of all bag sales. Assuming these large bags contained 84 percent of all bagged waste collected (X_c less 120 tons of bulky waste), each bag held approximately 20 pounds of waste. Therefore, residents paid $1.50 to dispose of 20 pounds of waste, or $150 per ton. The calculations in Table 4-5 are based on these prices and the information in Table 4-4.

Table 4-5. Perkasie ANNUAL Waste Flow Changes Per Dollar Price Increase

	DX/DP [ton/($/ton)]	% DX/DP [(ton/100) / ($/ton)]
X_c	-6.9	-0.27
X_r	+3.6	+1.29
X_g	-3.3	-0.12

These calculations indicate that placing a per-unit charge on waste services, in combination with curbside recycling (a relative ready alternative to conventional collection), gave Perkasie residents an incentive to reduce the total amount of waste they generated.

Arc Elasticity. Arc elasticity calculations based on Table 4-4 relate changes in quantities of waste to the change in a waste customer's price. These elasticities are:

$$EX_g, P_c = -0.10$$
$$EX_c, P_c = -0.26$$
$$EX_r, P_c = +0.49$$

Negative elasticities here represent a decrease in quantity, and positive ones an increase. These elasticities suggest that a price increase for conventional waste disposal of 10 percent, in combination with instituting free curbside recycling of paper, aluminum, and glass, will lead to a 1 percent decrease in waste generated, a 2.6 percent decrease in waste disposed conventionally, and a 4.9 percent increase in material recycled.

Average Flows per Person. Another way to examine the data is to measure waste-per-resident changes. County records give the population of Perkasie Borough at the beginning of 1987 as 6,247. This is assumed to be the 1985-87 average for the calculations below. Since that count was taken, the borough's population has grown because of residential developments, not annexation. Perkasie's population in 1988, as estimated by the borough's planning department, was 6,564. This figure is used as the 1988 population for the calculations in Table 4-6.

Table 4-6. Changes in Perkasie's Annual Waste Per Resident

	1985-87 Average	1988	Change	% Change
Population	6,247	6,564	+317.00	+5.1
X_g (T/person)	0.45	0.35	-0.10	-22.0
X_c (T/person)	0.40	0.23	-0.17	-42.0
X_r (T/person)	0.04	0.12	+0.08	+200.0
Households	2,499[1]	2,615[2]	+116.00	+4.6
X_g (T/HH)	1.12	0.88	-0.24	-21.0
X_c (T/HH)	1.01	0.57	-0.44	-44.0
X_r (T/HH)	0.11	0.31	+0.20	+182.0

[1]Calculated from 1985-87 population by using 1988 data to determine persons per household.
[2]Estimate of dwelling units.
Source: Bucks County Planning Commission, 1989.

Impacts on System Costs and Revenues

Perkasie's 1988 and 1989 reports on this program include financial data, reproduced in Table 4-7. The data provide information on a cash basis, and do not include any analysis of the tipping fee costs avoided by reducing the quantity of waste that was landfilled. Neither do they include capital or administrative expenses. Capital costs are viewed as fixed, and such purchases are made from an account that is separate from the operating expenses account. This is standard practice for all departments in the borough. Administrative costs are handled similarly. The borough has only thirty full-time employees, and while administrative expenses were initially heavy in the planning and startup stages they have been relatively small since the program has been operating.

The waste program in 1988 realized a loss of $6,160.84. The borough, however, only took a loss of $4,335.95, because in 1988 the borough neither obtained revenue from nor incurred the labor costs associated with glass recycling. This operation was handled by the Brothers of the Brush in 1988, but in 1989 Perkasie Borough took over.

Table 4-7. Perkasie Financial Analysis

	1988		(Jan.-Sept.) 1989	
Revenue				
Bag Sales	$155,516.50	$ 137,094.80		
Bulky waste stickers	0.00		1,310.00	
Recyclables	27,679.71		14,634.87	
Total Revenue		$ 183,196.21		$ 153,039.67
Operating & Maintenance Expenses				
Tipping Fees (includes bulky waste disposal)	$ 74,618.53		$ 69,407.97	
Additional bulky waste disposal	2,400.00		1,550.00	
Collection labor	54,585.80		44,973.35	
Disposal bags	23,360.86		16,230.88	
Glass processing labor	14,048.96		7,641.00	
Truck expenses	6,349.05		3,127.85	
Fuel	2,009.50		2,063.45	
Paper disposal	0.00		1,635.30	
Miscellaneous/Other	11,984.35		4,365.85	
Total O&M Expenses		$189,357.05		$150,995.65
Income (Loss) from Operations		$(6,160.84)		$2,044.02

Source: Good, 1988; Good, 1989.

Revenues in 1988 were dramatically lower than in the previous years under the flat fee system. At $120 for each of the 2,499 households in 1987, revenues were approximately $300,000. Revenues in 1988 were only 61 percent of this value. Had the flat-fee system stayed in effect in 1989 at the planned cost of $145 per household, 1988 revenues would have been nearly $380,000.

Although on a strictly cash basis the borough shows a loss in 1988, it actually saved money when avoided costs are considered. For each ton the borough did not collect for conventional disposal in 1988, relative to the 1985-87 average, the borough saved the tipping fee of $58.95. Table 4-1 shows Perkasie reduced the quantity of waste collected for conventional disposal by 1,320 tons, part of which went to recycling and part to diversion or reduced generation. At $58.95 per ton, the borough avoided $77,800 in landfill costs. Recycling and diversion have costs, however, that offset some of these savings. Costs directly related to the start of the recycling program include labor for collection and sorting recyclables, recycling pail purchases, and maintaining and improving the recycling area. The increase in labor costs for recycling was accompanied by a decrease in cost of conventional collection, since solid waste was collected only once each week in 1988, rather than twice as in previous years.

The recycling costs described thus far have been accounted for in the cash-based financial analysis given, such that subtracting the operating loss from the avoided tipping fee costs takes into account cost changes resulting from the switch to unit pricing and the addition of curbside recycling. One item of capital equipment, a recycling trailer, was purchased for $18,000 specifically for the recycling program. It was purchased with state grant money, so Perkasie did not bear this cost. Still, to give a complete picture of the borough's waste program, it is necessary to amortize the cost of the trailer over its useful life. Assuming a life of seven years, the cost of the trailer in the first year was $2,570. Finally, net savings from unit pricing and curbside recycling in 1988 were:

$$\$77,800 - 6,200 - 2,570 = \$69,000 .$$

Estimating what Perkasie's waste management costs would have been without extensive waste diversion in 1988 further illuminates the cost impacts of unit pricing. First, if the estimated 120 tons of recyclables and 290 tons of conventional waste that were diverted had been collected and disposed, the measurable avoided costs would have been lower. Recyclables revenue would have increased $3,300 ($25-$30 per ton of newsprint), and landfill tipping costs would have increased $17,100; combined, these add to a loss of $13,800. In addition, operating costs would have been higher, since 410 tons more waste would have been collected. This represents an increase in the conventional and recyclable waste collected of about 22 percent (410 tons on a base of 1,860 tons). Based on a 22 percent increase in labor and in truck and fuel expenses for collection, operating costs would have increased $14,000, a conservative estimate since operating costs would probably have increased less than proportionately with the increased waste collected. These estimates taken together lead to a net cost increase of $27,800, if no waste had been diverted. Total avoided costs therefore become:

$$\$69{,}000 \;-\; 27{,}800 \;=\; \$41{,}200\,.$$

Perkasie's waste program has been successful at covering its operating costs during the first nine months of 1989. As seen from the financial data for this time period, the borough has realized an income of just over $2,000.

Future Changes in the Program

Presently Perkasie has some changes in mind for its waste handling service, but these changes relate to the recycling program, not the bag program. The borough recently conducted a trial program for recycling plastic and hopes to be able to start a recycling program for steel cans.

One problem facing Perkasie presently is that the newsprint market has been glutted since the State of Pennsylvania made recycling mandatory in 1989. Tuturice Brothers paid Perkasie $25 to 30 per ton for the newsprint it collected in 1988. However, in 1989 the price offered by paper mills for shredded newsprint fell dramatically, making it necessary for Tuturice Brothers to charge $30 per ton to accept the papers. Perkasie chose another recycler to take its papers in 1989. Container Corporation charges the borough $165 per load, with one load averaging 8 to 9 tons of paper. Had Perkasie paid this price for paper disposal in 1988, the borough would have incurred an additional expense of about $9,000 and a reduction in recyclables revenue of about $13,000. Net savings, on an avoided cost basis, would have been $22,000 less than the $69,000 calculated earlier. Still, Perkasie would have seen a savings equal to $47,000 ($69,000 — 22,000).

If the tonnage that was diverted had also been collected in 1988, we estimate Perkasie would have paid another $2,300 for paper disposal, rather than receive $3,300 for its sale. The avoided cost savings would then have been further reduced to:

$$\$41{,}200 \;-\; 27{,}600 \;=\; \$13{,}600\,.$$

Under this scenario, Perkasie would still have realized a savings as a result of introducing unit pricing and curbside recycling in 1988, but the savings would have been sharply lower taking into account waste diversion and, especially, the collapse in the recycled paper market.

4.2.2 Village of Ilion, New York

Community Profile

The Village of Ilion is part of Herkimer County, New York, which is centrally located in the state, halfway between New York City and Buffalo. Herkimer County records list Ilion's population in 1980 as 9,190. Other demographic features specific to Ilion are not available. Rather, a profile of Herkimer County provides the best available description of the village. Projections for population growth in the county between 1989 and 1990 are 3.1 percent to 4.7 percent. The Village Clerk's estimation of Ilion's population in 1989 as 9,500 is consistent with the predicted growth rate of the county. The county's labor supply, taken to be descriptive of Ilion's labor supply, consists generally of high school graduates employed as assembly line workers, farm workers, and production workers. In 1984, manufacturing provided the source for approximately 25 percent of the county's personal income. Major employers in Ilion include Duofold, Inc., which manufactures sportswear and knitwear, and Remington Arms, which produces firearms and traps. For Herkimer County, the estimated effective buying income of median income households in 1980 was $14,033 (Herkimer County Chamber of Commerce and Herkimer County Area Development Corporation, 1989).

Ilion is a rural area with predominantly single-family dwellings. There are two multi-unit dwellings for elderly residents and three for low-income residents, and there are a few two- and three-unit dwellings within the village. No descriptive statistics other than population are available specifically for Ilion, but the Village Clerk stated that the population base and demographics of the village have not changed measurably within the last five years (1984-1989). Consequently, no such changes occurred coincidental with the start of Ilion's unit pricing program to cause the effects of the program to be distorted.

History of Waste Management Program

The Village of Ilion implemented a unit pricing program for solid waste services on June 1, 1988, the beginning of fiscal year 1988-1989, hoping that this pricing mechanism would help combat the escalating cost of solid waste disposal and promote recycling. Like Perkasie, Ilion's program is a bag program. Residents pay entirely for waste disposal and collection services by purchasing the village's designated bags. The municipality manages the program and collects the waste, which is disposed in a privately owned landfill. Prior to the bag program, the Sanitation Department provided a similar collection and disposal service, but this service was funded through general taxes appropriated to meet the sanitation budget. To set the price of the bags for the unit pricing program, village officials estimated the number of bags that would be used by residents, and priced the bags to cover their cost and the sanitation budget. Two sizes of bags are sold at local stores at the following prices:

	F/Y 88-89	F/Y 88-90
30 gallon size	$ 1.15	$ 1.50
16 gallon size	0.85	1.20

Residents are required to limit the amount of waste put into a bag to 50 pounds.

Service Features

The Sanitation Department changed some features of the service it offered when unit pricing was adopted. Until that time residents used containers of their choice as waste receptacles. Ilion chose to adopt unit pricing through a bag system, meaning residents must put their waste in the designated bags, or it will not be collected. Waste is still collected curbside, once each week, except for bulky waste which is no longer picked up each regular collection day. Rather, large trash items can be disposed of by arranging with the village barn to have them collected curbside on the last Friday of each month for a fee of five dollars per item. Alternatively, residents can haul such items to the village barn on the last Saturday of each month at predetermined rates per vehicle load. Thirdly, residents may arrange for overnight use of a dumpster, at a price equal to the village's cost of disposal.

As in the years prior to the start of the unit pricing program, the village's sanitation service is the only one offered to residents. It is provided to all residences, single-family and multi-family, within the city limits. Commercial entities are offered a dumpster service for a specified rate per yard of waste, or they, unlike residences, may contract with private haulers. Along with these changes in the waste collection service, Ilion made changes to its recycling program as described below.

Complementary Programs

Before the unit pricing program was implemented, Ilion operated a voluntary recycling program with both a drop-off recycling center and weekly curbside collection, at no direct costs to participants. This did not change with the start of unit pricing, but Ilion expanded its recycling program to include more than just the newsprint, corrugated cardboard, and glass it had been collecting. Ilion began recycling tin cans and white goods as well. Residents wanting curbside collection of recyclables are required to separate these items from other wastes, and place them in containers they provide themselves—boxes or clearly marked bags. Recyclables are collected once each week, the same day as solid waste, as a recycling truck follows the garbage packer.

An important change in Ilion's recycling program came on June 1, 1989, when recycling became mandatory by a county law passed September 1, 1988. Herkimer and Oneida counties have only one landfill operating presently. If this landfill should close, the cost of disposal will increase 4 to 5 times due to the costs of transporting the waste to distant landfills. For this reason, and to meet New York State waste reduction goals, the counties made recycling mandatory for all residents, businesses, and organizations in the area, placing the burden of enforcing recycling on communities. The county set a baseline fine of $50 for violating the recycling law, and towns have added to this to make the penalty more stringent. Police departments, constables, and waste collectors check for violators, in some cases by actually opening bags of trash to see that they contain no recyclable materials. The law prohibits the disposal of the following materials at the landfill according to the time schedule below:

April 1, 1989	Batteries, tires, major appliances
June 1, 1989	Glass containers, newspapers
September 1, 1989	Yardwaste
Spring 1990	Household metal cans, plastics

The counties accept these materials for processing and marketing. To get better cooperation for recycling, the counties separate the recyclable materials after they are collected, rather than requiring participants to do the separating. Participation and cooperation have improved since the start of the program, as indicated by the monthly increases in total recyclables collected. The two counties are planning to build a joint $7 million center for processing recyclable materials.

In addition to curbside recycling, Ilion offers its residents, at no charge, weekly curbside grass and brush collection year-round. These materials are deemed recyclable, and though they must be containerized or bundled, they must not be placed in the Ilion-labeled garbage bags. Collection is coincident with garbage pick-up. Also, residents may drop these materials off at the village barn, where they are composted. This program operates the same now as it did before the introduction of unit pricing.

Effects of Unit Pricing

Impacts on System Waste Flows

Gross Flows. The Village of Ilion provided data for fiscal year 1987-88, before the unit pricing program began, and for fiscal year 1988-89, after the unit pricing programs began. These data and the changes associated with them are calculated in Table 4-8.

Based on the data in Table 4-8, unit pricing, along with some expansion in the recycling program, effected major changes in Ilion's waste streams. In the first year of the new waste management program, Ilion reduced the quantity of waste collected for landfilling by more than one-half of the previous year's quantity. The quantity of recyclables collected increased to nearly 2.5 times the quantity collected in 1987-88.

Had Ilion implemented unit pricing with no changes in its recycling program, the waste collected in the added recycling categories would have gone to conventional collection and landfilling. The numbers in Table 4-8 can be adjusted accordingly to better approximate the effect of unit pricing only. This adjustment is provided in Table 4-9.

Table 4-8. Ilion Solid Waste and Recyclable FLOW DATA

	F/Y 87-88 (tons1)	F/Y 88-89 (tons)	Change (tons)	Change (%)
Conventional Solid Waste Collected and Landfilled, X_c	**4,380**	**2,120**	**-2,260**	**-52**
Recyclables Collected				
Corrugated cardboard	24	108		
Newsprint	120	216		
Glass	21	71		
Tin cans	0	9		
White goods	0	7		
Total, X_r	**170**	**410**	**+240**	**+141**
Total Waste Collected (X_c + X_r)	**4,550**	**2,530**	**-2,020**	**-44**

Note: The information received from Ilion gave Xc in yards. This was converted to tonnage using the factor, 3 cu. yd. = 1 ton.
1All quantities are English tons.
Source: Personal communication, Hatch, 1989

This adjustment still shows a decrease of more than 50 percent in the quantity of waste landfilled, and a slightly lower response in recycling than was previously indicated. The change in the amount of waste landfilled can be attributed to source reduction, increased recycling, and, possibly, diversion. The village reports no noticeable increase in burning or illegal dumping, two potential diversion methods. If, in fact, diversion did not increase, waste generated in Ilion decreased by 44 percent after unit pricing. Because Ilion is located in a rural area, diversion may be more difficult to detect than more urban areas such as Perkasie. Therefore, the 44 percent decrease may overstate the reduction in waste generation. In addition, commercial customers have the option of contracting with private haulers. No information was available to suggest the level of commercial attrition, but assuming 3 percent of the reduction in waste collected stemmed from this, as in Perkasie's case, Ilion would have collected about 2,200 tons of conventional waste in fiscal year 1988-89. Adjusting upwards for diversion by 20 percent overall, again estimated on the basis of the Perkasie study, Ilion would have reported the waste flows given in Table 4-10.

Table 4-9. Ilion Solid Waste and Recyclable Flow Data Adjusted to Reflect Unit Pricing Only

	F/Y 87-88 (tons[1])	F/Y 88-89 (tons)	Change (tons)	Change (%)
Conventional Solid Waste Collected and Landfilled, X_c	**4,380**	**2,136**	**-2,244**	**-51**
Recyclables Collected				
Corrugated cardboard	24	108		
Newsprint	120	216		
Glass	21	71		
Total, X_r	**170**	**395**	**+225**	**+132**
Total Waste Collected (X_c + X_r)	**4,550**	**2,530**	**-2,020**	**-44**

Note: The information received from Ilion gave X_c in yards. This was converted to tonnage using the factor, 3 cu. yd. = 1 ton.

[1]All quantities are English tons.

Table 4-10. Ilion Solid Waste and Recyclable Flows Adjusted FOR Possible Diversion and Customer Attrition

	F/Y 87-88 (tons[1])	F/Y 88-89 (tons)	Change (tons)	Change (%)
Conventional Solid Waste Collected and Landfilled, X_c	4,380	2,750	-1,630	-37
Recyclables Collected, X_r	170	490	+320	+188
Waste Generated, X_g[1]	4,550	3,240	-1,310	-29

[1]Assumes no diversion beyond the 20 percent adjustment in X_c.

Though these changes should be viewed with caution because of the limits in the data available, Ilion's experience appears to indicate that the marginal contribution of unit pricing, given a voluntary recycling program, can be substantial. In fact, Ilion reduced resulting waste generated for collection and disposal outside household means by more than 25 percent.

Average Change Per Dollar. With the introduction of unit pricing, residents paid $1.15 for a 30-gallon bag. Assuming all conventional waste was disposed in this size bag at an average weight per bag of 30 pounds, Ilion residents paid $1.15 per 30 pounds of waste, or $77 per ton, to dispose of waste after the introduction of unit pricing. Table 4-11 describes flow changes per dollar change in price (based on data derived from Table 4-10 for a conservative estimate). Since Ilion residents paid indirectly for waste services through taxes prior to unit pricing, the previous cost associated with each additional ton disposed was zero.

Table 4-11. Ilion Annual Waste Flow Changes Per Dollar Price Increase

	DX/DP [ton/($/ton)]	% DX/DP [(ton/100) / ($/ton)]
X_c	-21	-0.48
X_r	+4	+2.40
X_g	-17	-0.38

These calculations suggest that unit pricing had a significant impact on Ilion's waste generation behavior and stimulated participation in the voluntary curbside recycling program.

Arc Elasticity. As another measure of unit pricing's impact in Ilion, the arc elasticities listed below are calculated and are also based on the conservative changes described in Table 4-10.

$$EX_g, P_c = -0.17$$
$$EX_c, P_c = -0.22$$
$$EX_r, P_c = +0.48$$

These elasticity calculations suggest that a 10 percent increase in the unit price will lead to a 1.7 percent decrease in waste generated, a 2.2 percent decrease in waste landfilled, and a 4.8 percent increase in recyclables collected. These estimates are quite similar to those obtained for the Borough of Perkasie.

Average Flows Per Person. The Village Clerk estimated Ilion's population as 9,500. She reported no measurable degree of change within the last 5 years, so 9,500 was used as the population base to calculate average waste flows per person (with the conservative flows of Table 4-10) for the year before and the year after the introduction of unit pricing. These calculations are presented in Table 4-12.

Table 4-12. Ilion Waste Generation Per Resident

	F/Y 87-88	F/Y 88-89	Change	% Change
X_g (T/person)	0.48	0.34	-0.14	-29
X_c (T/person)	0.46	0.29	-0.17	-37
X_r (T/person)	0.02	0.05	+0.03	+150

Impacts on System Costs and Revenues

Financial data from Ilion were not available when this study was conducted. The Village Clerk reported a 40 percent decrease in landfill costs for the first six months after the introduction of unit pricing relative to the same six months the previous year. This sizeable decrease was observed despite a 28 percent increase in the landfill tipping fee, from $10 per yard to $14 per yard. Based on these tipping fees and the yearly reduction in landfilled waste reported by Ilion in Table 4-8, Ilion saw a decrease in landfill disposal costs from $131,400 in fiscal year 1987-88 to $89,000 in 1988-89.

The only cost-related problem reported by the village was the glut in the newsprint market, which led to Ilion's having to pay $5 per ton for disposal. As of August 1989, the village reported that it had found an outlet for its newsprint such that the village could break even on the disposal of this material.

The only other cost information from Ilion characterized the cost of waste services to households. Taxes were used to pay for waste disposal prior to unit pricing, and taxes did, in fact, decrease $10 per thousand when unit pricing was introduced. Too little information was provided to assess what this decrease meant to an average Ilion household in terms of comparative amounts spent on waste services before and after unit pricing. Taxes rose in the second year of the unit pricing program, but the increase was not related to any increase in the cost of the waste program. Even with this increase, taxes are still lower than they were prior to unit pricing.

Future Changes in Program

The most significant change in Ilion's waste management program was the county's requirement for mandatory recycling as of June 1, 1989. This change is discussed earlier in this case study. The village plans to continue its program with no other modifications.

4.2.3 City of Seattle, Washington

Community Profile

Located on the Pacific Coast just 113 miles from the Canadian border, the City of Seattle offers a study of unit pricing in an urban area, where the population density was 5,635 persons per square mile in 1988. The city's population increased over the period 1980-88 by 0.4 percent to an estimated population of 495,900. In 1988 there were 246,845 housing units in the city of which 54 percent were one unit structures and the remainder two or more unit structures. Average household size was expected to decrease during the 1980's from 2.15 persons in 1980 to 2.01 persons in 1990. Of total land area in Seattle in 1980, 41 percent was classified as residential and

13 percent as commercial and industrial. No change was projected in total area throughout the 1980's, and the percentages of land devoted to each of the two classifications described was expected to remain fairly constant.

Seattle's population is predominantly white and educated. Blacks, Asians, and Native Americans, combined, represented only 21 percent of the city's 1987 population. Seventy-seven percent were white. Seattle reports nearly 80 percent of its residents have 12 or more years of education, and 28 percent 16 or more years.

Seattle incomes are relatively high in comparison to other large cities throughout the United States. In 1988 median household income was projected as $38,000. Nearly 40 percent of all households were classified as upper or upper middle-income in the 1980's.

Employment in metropolitan Seattle in 1987 was described as 20 percent manufacturing and 80 percent nonmanufacturing. The largest employer in the area is Boeing Company, an aircraft manufacturer. The city reported a 5.5 percent growth in employment between June 1987 and June 1988, the result of growth in the aerospace, transportation equipment, food products, wood products, and fish-processing industries. Total employment, reported as the number of full-time equivalent positions, was projected to increase from 409,000 in 1980 to 460,000 in 1990 (Seattle Department of Community Development, 1989).

A study of Seattle offers quite a contrast to small suburban Perkasie, Pennsylvania, and rural Ilion, New York. Unit pricing is not new to Seattle as it is to the other two selected communities. Consequently, the Seattle study gives a different look at unit pricing.

Waste Management Program

History

Before 1961 Seattle's waste collection and disposal was paid for with tax money. In that year a utility was formed, designed to be completely self-supporting with no general fund or tax revenue subsidies. With the formation of this utility came the start of mandatory garbage charges, as the utility provided unlimited residential garbage pick-up for a flat fee.

In December 1969 the city started moving toward unit pricing. Residents paid a base rate for one to four cans and an additional fee for each additional unit (bundle/can). The base rate, which was $2.70 in 1969, had reached $6.85 by 1981, but the fee for each additional unit beyond the base level of service stayed constant at $0.50 throughout this period. In January 1981 the fee structure was revised such that residents paid a fixed fee for the first can and an additional fee for others. This change was made to make the system more equitable for users and to provide an incentive to recycle.

The utility manages the waste service and handles the billing, but it contracts with private haulers for waste collection. These haulers take the waste to transfer stations owned and managed by the city and from there to a regional county landfill. Special rates are offered (based on established eligibility requirements) to low-income, elderly, and handicapped customers. All residences, whether single-family or multi-family, are required to use the utility's variable rate waste service. Service is not provided for commercial or industrial enterprises. They must use private contractors or self-haul their waste.

Service Features

Though the fee structure changed over the years, the service provided by the utility essentially remained the same. The major difference is the service level; that is, the quantity of waste collected per unit price. Unlike the other communities studied, Seattle's unit pricing program is not a bag program. Residents provided their own waste cans, until the city began providing wheeled carts in 1989. Customers select a subscription level based on the number of cans or units (which may be bundles) of waste they wish to have collected weekly. They are billed accordingly. Waste collection is either curbside or backyard, and not until 1989 was there a differential in the price of waste service depending on which collection location was selected.

Complementary Programs

Seattle currently has voluntary recycling and composting programs. Residents are not allowed to comingle yard waste with other waste, as of January 1989. They may choose to compost it themselves, self-haul it to a transfer station for composting, or leave it for curbside pickup. The third option costs $2 per month, and the collection frequency depends on the time of year. Landfilled waste has decreased since the January 1989 restriction against landfilling yardwaste.

Private recyclers have operated voluntary recycling programs in Seattle for many years. Curbside collection programs, operated by two different private contractors, began in February 1988. North end residents who participate in curbside programs are provided three-bin carts for separating containers (glass and cans), newsprint, and mixed paper. These carts are collected once each week. Seventy-seven percent of all eligible customers in this area have signed up to participate. South end residents are offered a monthly curbside collection program. They are provided 90-gallon plastic wheeled toters in which they place mixed recyclables. In this area 55 percent of all eligible customers are signed up for the program. The cost to the city of contracting with these private recyclers is included in the rates set for regular waste service. It should be noted, however, that unlike Perkasie and Ilion, a curbside recycling program was not in place during the time period of our Seattle analysis.

Effects of Unit Pricing

Impacts on System Waste Flows

Gross Flows. Seattle's unit pricing program could not be examined exactly as were the other two unit pricing programs, because this type of program is not new in Seattle. To study the effects of unit pricing in Seattle, three years were selected, 1985-87, when program services and complementary programs stayed essentially the same, but rates increased substantially. Rates were set for a basic level of service equal to one unit, and prices for higher levels of service increased proportionately with the level of service. The base rate was priced differently for single and multi-family customers, but the incremental rate for additional units of service was the same. Table 4-13 lists the incremental rates for each additional unit of service for residential customers over that time period.

Table 4-13. Seattle Monthly Residential Incremental Rates

Effective Date	Rate per unit
1/1/85	$1.50
8/1/86	$3.30
6/1/87	$5.00

Source: Skumatz, 1989.

Service level options changed between 1985 and 1986. In 1985 customers could request one or two units of service, but beyond that, service was only offered in two-unit increments. These units could be either cans or bundles of waste. Beginning in 1986 customers could subscribe to any level of service desired in one-unit increments. For this study, the 1985 rate given in Table 4-13 is half the rate for the two-unit increment offered in that year. This adjustment was made to permit comparisons between the years. Based on these unit rates, a yearly unit rate was calculated depending on how much of each year was affected by the rate increases. These yearly per unit rates and corresponding average monthly per unit rates are given in Table 4-14.

Table 4-14. Seattle Incremental Unit Rates

	Yearly	Monthly Average	Change	% Change
1985	$18.00	$1.50		
1986	27.00	2.25	0.75	50%
1987	51.50	4.29	2.04	91

Waste flows and changes over the time period studied are described in Table 4-15. As expected, recycling tonnages increased as rates increased; however, total residential conventional tonnage for the first years compared did not reflect the decrease expected in response to a rate change. The tonnage changes are the result of not only rate changes, but also of program, demographic, economic, and product changes occurring simultaneously.[2] Consequently, a pure unit price effect is difficult to determine from tonnage data alone. In addition, tonnage data includes all residential tonnage, single and multi-family. While multi-family residents must use Seattle's unit priced service, those whose rent includes their costs for waste services are not subject to the waste reduction incentives offered by unit pricing. As a result, the response to unit pricing, as measured by the change in total residential tonnage data, may be understated. No measure or estimate of the portion of residential waste collected from multi-family units was available, but the portion is likely to be substantial since over 40 percent of Seattle's households in 1980 resided in multi-family structures. Seattle sources indicated that the difficulty of passing on unit pricing incentives

[2]See Table 4-18 for changes in the subscription level.

to multi-family households is a problem for which they have not yet found a suitable solution. This problem would be shared by other metropolitan areas with many large multi-family - complexes.

Average Change Per Dollar. Based on data in Tables 4-14 and 4-15, the average changes in tonnages were calculated (see Table 4-16).

Table 4-15. Seattle Solid Waste and Recyclable Flow Data

	1985 (tons)	1986 (tons)	1987 (tons)	1985-86 Change (tons)	1986-87 Change (tons)	1985-86 Change (%)	1986-87 Change (%)
X_c[1]	185,000	190,000	188,000	+5,000	-2,000	+2.7	-1.1
X_r[2]	40,600	41,600	44,400	+1,000	+2,800	+2.5	+6.7

[1]X_c = Conventional residential waste collected (estimated from Skumatz, 1989)
[2]X_r = Residential recycling (Source: Bagby, 1989)

Table 4-16. Seattle Waste Flow Changes Per Dollar Price Increase

		DX/DP [ton/($/unit/month)]	% DX/DP [(ton/100)/($/unit/month)]
X_c	1985-86	+6,700	+3.60
	1986-87	-980	-0.54
X_r	1985-86	+1,300	+3.33
	1986-87	+1,400	+3.28

Again, the calculations show conventional tonnage increasing as rate increased between 1985 and 1986. The expected decrease is seen the following year. The responses to a one dollar increase in price are not at all similar for the two years. Even for recycling, though both changes are positive, the size of change per dollar increase varies.

Average Flows Per Household. Table 4-17 describes changes per household over the period of interest. Again an increase is seen in conventional waste collected during the 1985-86 period. The percentage change per household is smaller than the percentage change in tonnage calculated previously, indicating that some of the growth in conventional tonnage collected was the result of the increase in population. The percentage decrease in waste per household in 1986-87 is larger than the percentage decrease in total residential tonnage collected, showing a greater effect of rate increases and other factors when the population growth is accounted for than originally indicated by the overall tonnage change. No change in recycling per household is seen during 1985-86, indicating the tonnage change calculated earlier may simply be due to population growth. In 1986-87, factors influencing recycling behavior showed a smaller effect when measured per household, a 5.5 percent increase, than when measured as total tonnage change, a 6.7 percent increase. Again, some of the increase in recycling can be attributed to population growth.

Table 4-17. Seattle Waste Generation Per Household

	1985	1986	1987	1985-86 Change (tons)	1985-86 Change (%)	1986-87 Change (tons)	1986-87 Change (%)
Households	223,850	226,200	229,500	+2,350	+1.0	+3,300	+1.4
X_c/HH (ton/HH)	0.83	0.84	0.82	+0.01	+1.2	-0.02	-2.4
X_r/HH (ton/HH)	0.18	0.18	0.19	0.00	0.0	+0.01	+5.5

Other Waste Behavior Measures. More descriptive measures of Seattle's waste behavior may be single-family subscription levels, single-family weighted average number of cans of conventional waste, and recycling as a percentage of total waste generated. Skumatz (1989) discussed these measures in a study of Seattle's solid waste rates. Table 4-18 presents these measures.

Table 4-18. Additional Measures of Seattle Waste Behavior

	1985	1986	1987
Subscription Level Distribution:			
1 can	33%	45%	58%
2 cans	21%	31%	33%
3 cans	—	2%	4%
4 or more cans	46%	22%	5%
Weighted Average Number of Cans	2.7	2.3	1.7
Recycling as a percent of Waste Generated[1]	22%	24%	26%

[1]Recycling here is the total of all recyclables, residential and commercial, collected as a percent of total residential and commercial waste, including recyclables, collected or self-hauled for disposal.
Source: Skumatz, 1989.

Although total collected residential conventional tonnage increased between 1985 and 1986, single-family households tended to subscribe to lower levels of service and averaged fewer cans of waste. This may account for the low or apparently contradictory responses to Seattle's rate increase during this period. That is, while subscription levels declined, collected tonnage grew. For the 1986-87 rate increase, the direction of change for the measures in Table 4-18 are consistent with that of the change in tonnage collected. Subscription levels and the weighted average number of cans decreased, and collected residential conventional tonnage did likewise. Over the three-year period examined, the percentage of total waste generated that was recycled increased steadily, as one would expect during a time of increasing rates.

Efforts to explain Seattle's waste behavior first led to an examination of the type of data used for analysis. The data present a problem in that tonnages are a weight-based measure, and rates are set per can, a volume measure. While weight limits exist, they are difficult to enforce. Noting this distinction between weight- and volume-based measures helps to explain Seattle's waste behavior over the period studied, in terms of both tonnages and subscription levels. Seattle sources indicated that customers began compacting more waste into each can disposed as rates increased, often by stepping on the trash in the can. Such behavior was so noticeable that it was dubbed the "Seattle Stomp."

In 1985, unit prices were so low ($18 per year) that consumers apparently had little trouble justifying the purchase of subscription levels they did not need to cover the weight of trash they disposed. The excess levels purchased made handling the trash more convenient. Customers had ample service during peak waste generation periods and could keep their cans lighter, since there was no need to compact the trash. This helps to explain the difference between subscription changes and tonnage changes in 1985-86. When costs jumped in 1985-86, the response was primarily to reduce the subscription level and keep flows roughly the same, since weight limits were not really binding. This helps explain why tonnage collected increased, while subscription levels decreased. As more households reduced their subscriptions to levels consistent with the amount of **packed waste** they generated (by weight), the incentive to reduce the amount of waste generated, increased by yet another rate increase in 1986-87, was apparently more effective and waste collected actually declined. Part of this decline may also be the result of higher use of waste diversion methods as discussed in the previous two case studies.

Seattle sources believed that some problems with illegal dumping were experienced during rapid rate increases. This belief was substantiated by reports from charitable organizations of unwanted donations and garbage being left at unattended drop stations. Measures of diverted waste are very difficult to obtain, however, and no such data were available. For all analyses discussed here, no assumptions were made to attempt to estimate or incorporate the level of waste diverted.

Arc Elasticity. Based on information in Table 4-15, arc elasticities are calculated for conventional waste collected and for recycling. They are:

	1985-86	1986-87
EX_c,P_c	+0.065	-0.017
EX_r,P_c	+0.060	+0.104

The negative elasticity reported for residential waste collected in 1986-87 is an indication that the incentive to reduce waste began to take hold in that year, as was discussed earlier. This elasticity is a very rough measure of the response to a rate increase given the accuracy of the data on collected tonnage, the need to use a weighted price, and the likelihood that the full response to the price increase had not yet been observed (the actual incremental price increase in 1987 occurred only in the last six months of that year). An alternative, perhaps a more long-run measure, of the effect of Seattle's variable can rate structure is provided by Skumatz's (1989) report on the city's solid waste rates.

Skumatz evaluated the effectiveness of unit pricing by examining Seattle's multivariate tonnage forecast. The most important variables affecting waste tonnage were household income, household size, secondary recycling market prices, and rates. The results of this analysis showed a negative relation between rates and the quantity of waste disposed by customers, holding all other factors constant. The estimated constant point elasticity was -0.14, meaning a 10 percent increase in rates would be accompanied by a 1.4 percent decline in waste disposed. In 1985-86 the quantity of waste collected increased as the effects of factors other than the rate increase overshadowed the negative price effect. Skumatz concludes that although a simple comparison does not show a decrease in conventional waste quantities, these quantities are lower than they would have been had price been hidden in a flat fee or taxes. Skumatz reports that 1987-88 data support this conclusion. Data for those years indicate that tonnage disposed, tonnage per capita, and tonnage per household decreased in response to a rate increase and the introduction of curbside recycling programs. Again, difficulties arise in trying to attribute these changes to the rate increase only (Skumatz 1989).

Impacts on System Costs

Over the three-year period 1985-87, nominal waste service rates increased rapidly because of major changes in Seattle's waste disposal options. Seattle quit accepting waste at city landfills and had to increase customer rates to cover the costs of closing its landfills and paying high tipping fees to use King County Cedar Hills landfill. These cost increases were related to final disposal of the waste and not to changes in the unit pricing program offered to customers. The average monthly waste service bill is listed in Table 4-19.

Table 4-19. Seattle Average Single-Family Monthly Garbage Bill(discounted by inflation)

	Average Bill ($)	Change ($)	Change (%)
1985	$10.00		
1986	12.60	$2.60	26%
1987	16.20	3.60	29

Source: Skumatz, 1989.

The average bill increased over the three-year period examined. Although there were efforts by customers after a rate increase to change waste generation behavior and lower their bills, the changes that did occur were not sufficient to offset the rate increases, on average.

Program Changes Since 1987

Rates have continued to increase since 1987. In 1989 the rate per unit increased to nine dollars. Other changes since 1987 have included the introduction of curbside recycling in 1988 and the mandatory requirement that yardwaste not be landfilled, changes discussed earlier. Also in 1989 a 40 percent price differential was introduced to make backyard pickup more expensive than curbside collection. As a result, 95 percent of all customers chose curbside collection, and those customers were given wheeled carts to use, rather than their own waste containers. Rate increases, in combination with Seattle's program changes, have led to a decrease in the quantity of waste landfilled in 1989, relative to 1988.

Seattle has set a goal to recycle 60 percent of its total waste generated by 1998. Consequently, plans for the future include extending organized recycling to multi-unit dwellings and commercial entities. Costs avoided by reducing conventional waste by offering convenient curbside recycling, in combination with unit pricing, may be as high as $77 per ton. Even though the city pays $48 per ton to contract private haulers to collect and market recyclables, it can still realize a savings from recycling. Because of high start-up costs, savings from recycling have not been realized yet, but the city expects the program to be cost-effective over its life.

In Seattle unit pricing seems to have helped to curb increases in waste tonnages relative to what they would have been had a flat fee or taxes been used for purchasing waste services. Perhaps unit pricing would be more effective if waste could be priced by weight rather than volume units. In an effort to study the effect of such pricing, Seattle plans to start a pilot program for weight-based pricing.

Chapter 5
Conclusions and Issues

5.1 Introduction

Unit pricing programs come in many varieties and are part of broader systems of waste generation, collection, and disposal. These systems involve many decision makers and multiple investment, consumption, and process choices. It comes as no surprise, then, that unit pricing programs can have many effects, not all of which may be attractive, and that these effects depend as much on other features of the system as on the features of the unit pricing program itself.

This chapter reviews the effects observed when unit pricing programs were introduced or changed in the three case study communities and draws some tentative conclusions regarding their effectiveness in various settings. These conclusions are tentative because of both the limited number of case studies involved and the inherent weaknesses of the data bases used as the basis for these conclusions. This chapter also discusses some of the outstanding issues associated with both the results of this study and the use and effectiveness of unit pricing generally.

5.2 Evidence of Effects from the Case Studies

5.2.1 Effects on Waste Generation, Collection, and Recycling

Examined here are the effects of two unit pricing programs, for Perkasie, Pennsylvania, and Ilion, New York, when there was a switch from a flat fee for service to charging by the bag. It was estimated that both cities saw a large reduction in the weight of conventional waste collected: 41 percent for Perkasie and 37 percent for Ilion. In both instances, an effort was made to at least partially adjust waste flow data to correct for concurrent changes in the community size, its waste management programs, and household behavior that might bias estimates of reduced conventional waste collection attributable to the unit pricing program.

Because both communities had curbside recycling programs, it might be argued that these recycling programs, not unit pricing, resulted in the substantial reductions in conventional solid waste collection. The tentative conclusion, however, is that unit pricing programs and voluntary recycling programs are complementary; the two programs operated together are more effective in reducing conventional waste collection and increasing recycling than each is independently. In support of this viewpoint, the observed changes in Ilion are coincident with a unit pricing program begun after the curbside recycling program had been established. This, in combination with observations from the Seattle case study, suggest that

- recycling programs and unit pricing programs are most effective in reducing conventional waste collections when they are operated together, and
- joint curbside recycling and unit pricing programs can lead to substantial reductions in conventional waste collection.

The Perkasie and Ilion case studies also suggest that unit pricing has a significant impact on the amount of waste generated. While it was not possible to observe waste generation directly, reductions in waste generation were estimated based on assumptions regarding the amount of waste diverted, combined with estimates of other waste flows before, during, and after the period of analysis. Percentage reductions in waste generated were estimated to be 18 percent for Perkasie and 29 percent for Ilion. Even allowing for some error in estimates of related waste flows, these values are large enough to suggest that changes in waste generation are an important component of changing waste flows when a community moves from a fee system to a unit pricing system.
As expected, unit pricing resulted in large increases in recycling. In Perkasie, the 190 percent increase in the weight of recycled materials was attributed to the simultaneous introduction of unit pricing, mandatory curbside recycling, and reduction from twice-a-week to once-a-week conventional waste collection. In Ilion, the 130 percent increase in the weight of voluntarily recycled materials was attributed to the introduction of unit pricing.

Seattle differs from Perkasie and Ilion in a number of important respects: it is a major urban area; it has had a unit pricing program, albeit a subscription program (defined below), in place since 1961; its unit prices are based on a "barrel" or "bundle" of solid waste and initially were considerably lower than those in effect in Perkasie and Ilion; and it did not have a voluntary curbside recycling program in operation during the two years in which waste flows and unit prices were examined. In those two years, there were some minor adjustments to the terms and conditions of service and large increases in the price per unit.

It was found that there was actually a small increase in the amount of conventional waste collected in Seattle during the first year of analysis and a slight decline in the second year. The hypothesis, one that is supported both by observations on subscription levels during this time period and by casual observation by Seattle residents, is that households initially responded to the price increase by lowering their subscription level (the maximum number of units per week a household could put out for collection) and compacting the waste in their barrels. After making best use of this easy option, Seattle households began to reduce the amount of waste they generated, increase their recycling, and divert waste toward some other means of disposal.

Data on recycling in Seattle were difficult to obtain for the period of analysis. The amount of waste recycled was relatively high, even without a curbside program, but it didn't increase much during the two years of analysis.

The Seattle experience suggests that aggregate household response to unit price increases may be markedly less either where recycling facilities are not easily accessible or in a more urban setting where the incentives of unit pricing are attenuated by a large proportion of multifamily housing. Because of the special conditions associated with the Seattle experience, including unit prices that initially were very low, one should hesitate to conclude that Seattle's lower response reflects either a general condition faced by established unit pricing programs or a substantial weakening of the effects of unit price changes at higher price levels.

5.2.2 Diversion of Solid Waste

The prospect of increased littering, backyard burning, and other unattractive means of waste "disposal" is always a concern with unit pricing. It was found that backyard burning and disposal of trash in commercial bins or in other service areas was a problem in Perkasie before burning was prohibited and the enforcement of proper disposal requirements increased. All the jurisdictions, however, claimed that they hadn't noticed that the unit pricing program or an increase in the unit price charged increased littering or sewerage. Furthermore, Perkasie claims that the changes it introduced in 1989 have eliminated the waste diversion problem in its service area. While these assurances are accepted for the purpose of analysis, there are no hard data to support these observations (e.g., litter collection rates).

5.2.3 Elasticities

While not nearly as high as prices charged for other public services such as electric or telephone service, the unit prices charged by the three case study communities were large enough to catch the household's attention and affect their behavior. For example, the annual charge for an additional bag of waste was $1.50 in Perkasie and $1.15 in Ilion. In Seattle in 1987 an additional container cost $5.00 per month. The arc elasticity measures of waste flow response to these prices in Perkasie and Ilion were relatively small: -0.10 to -0.17 for waste generation, -0.26 to -0.22 for conventional waste collection, and 0.49 to 0.48 for recycling. The Seattle arc elasticities we calculated were five to ten times lower than those of Perkasie and Ilion, reflecting both the special conditions surrounding its unit pricing program as well as the large number of multifamily units characteristic of a major city. Recall also that Seattle's price elasticity of waste collection has been estimated to be -0.14 using an alternative method of estimation.

Like the effects on waste flows noted before, these rather coarse elasticity estimates indicate that households in the smaller communities did make significant changes in waste generation in response to unit pricing. The substantial elasticities for conventional waste collection and recycling in the smaller cities should be attributed to the combination of waste management programs in those communities. While the marginal contribution of unit pricing to changes in household behavior will vary with both background conditions and the method of measurement, the case study evidence, especially that from Ilion, indicate that the marginal effects of unit pricing have non-trivial effects on waste flows and waste management economics.

5.2.4 Costs and Revenues

The additional monetary cost of unit pricing and recycling programs in Perkasie and Ilion were apparently more than offset by savings from reducing the amount of waste that had to be conventionally disposed, and, in the case of Perkasie, reducing the frequency of conventional waste service. Annual costs in Perkasie were roughly 10 percent lower than they would have been without the programs. The cost data provided by Ilion are less complete, but by assuming that disposal costs were half of total costs one can estimate that the unit pricing program decreased cost by roughly 15 percent.

In Seattle, increasing the unit price did not reduce costs very much if at all because there was such a small decrease in the amount of conventional waste collection. The increase in price apparently did, however, create something of a financial bind for the utility during the first year of the analysis in that customers lowered their subscription level. This reduced utility revenues and prompted an even greater price increase during the second period of analysis.

Some households shared in the cost reductions observed in Ilion and Perkasie. The average Perkasie household reduced solid waste collection and disposal expenses by at least an estimated $25 per year. In Ilion, where waste collection had been financed out of general tax revenues, property taxes were reduced by $10 per $1,000 assessed valuation.

5.2.5 Community Acceptance

In all three communities, but especially in the two small communities that just initiated unit pricing, unit pricing was apparently well accepted by most of the population. The cost reductions experienced by most households were apparently part of the reason for this acceptance. One might suspect that a sense of satisfaction from both contributing to resource conservation and knowing that those who generated the most mixed waste paid for that privilege also probably helped promote initial acceptance. Perkasie apparently solved problems with compliance (e.g., backyard burning) fairly inexpensively.

5.2.6 Health and Aesthetics

General community acceptance of the waste management programs in these unit pricing communities reflects a certain degree of satisfaction with their aesthetic and, perhaps, health attributes. As noted above, increased littering does not appear to be a problem for the programs in the short run; and Perkasie addressed the health and aesthetic costs of backyard burning by a new statute.

The frequency of collection has health and aesthetic implications and is an important feature of waste management systems that employ unit pricing. Twice a week collection has been the norm in many areas because of the odor associated with decaying waste and the breeding cycle of flies. The bag system, or a closed cart, is an integral part of a unit pricing program that also addresses the odor and fly problem. Adopting a bagging or closed cart requirement as part of unit pricing may remedy these aesthetic and health problems. In that case the waste manager can, as in the case of Perkasie, reduce the frequency of collection. Consequently, he can either free resources for use in other programs or reduce the costs of waste management.

5.3 Unresolved Issues Related to Unit Pricing

An important unresolved issue, perhaps the most important one, pertains to the propriety of extrapolating the findings of this study to other periods, other settings, and other unit pricing programs. These are legitimate concerns and some of them are elaborated on to both caution the reader and identify future research topics related to waste management generally and unit pricing in particular.

5.3.1 Issues of Stability

It is difficult to know whether the observed effects are permanent. It is quite possible for short-term effects of the sort identified in the case studies to differ from the long-term effects. It may be that households have not fully responded to the price incentives or, having responded vigorously, will revise their response to reduce the time and energy they devote to reducing waste generation or increasing recycling.

To address these issues one needs to track the longer term experience of current unit pricing programs. Programs such as that in Seattle, while they have a long history, differ in important ways from most current programs. For example, most current unit pricing programs have "bag" or "container" requirements, higher prices, and more elaborate complementary recycling programs. These features were very uncommon even five years ago.

5.3.2 Issues of Design

Pricing All Waste Collected and Disposed

Designing a unit pricing program naturally raises the question of what price to charge for collection and disposal of various categories of waste. All the case studies examined set a positive price on collection of conventional mixed waste and a zero price on collection of recyclable wastes. It may be that such a strategy is either cost minimizing or economically efficient, especially when factoring in administrative costs or incentives to "cheat," but this is not necessarily the case. There are some categories of waste, such as aluminum containers or hazardous liquids, that may merit a negative price by virtue of their value in recycling or their potential for doing damage if conventionally disposed. Similarly, some recyclable materials that have such a high cost of processing that they should (in theory, at least) have a price that is positive but less than that applied to conventional mixed waste. Indeed, one can imagine a system in which the relative prices change over time depending on market and other conditions. Of course, the resulting price complexity raises another set of problems. In any case, the opportunities for, and effects of, pricing of sorted waste need to be examined if one is to fully understand the full potential and limitations of unit pricing.

Units of Measure

In principle, the units of measure employed in a unit pricing program should be definitive enough to reward small changes in behavior and to be related to the costs of collection and disposal. While Perkasie and Ilion offer two sizes of bags, Seattle's container may be too large to provide the full range of incentives, particularly for households that generate only small amounts of waste. The 1989 introduction of a mini-can (20 gallons as opposed to the regular 30-gallon can size) in Seattle may help to address this problem. Furthermore, the case studies examined are volume-based with weight limits, yet disposal charges are often based on weight. In effect, the case studies don't address the effectiveness of a broad range of measurement options, including actually weighing the amount of waste collected. Seattle, for example, is currently testing the feasibility of weighing and recording the waste collected from each residence.

Voluntary vs. Mandatory Programs

This study intentionally selected unit pricing programs that were mandatory for residential customers. As it turned out, the recycling programs for Perkasie and Ilion are now both mandatory. What, if any, are the advantages of voluntary unit pricing in waste management? What are the pros and cons of voluntary and mandatory recycling when unit pricing of waste is mandatory? Some are (1) voluntary recycling programs are more compatible with ideals of personal freedom, (2) households may be more compliant with recycling programs coupled with a positive monetary incentive, and (3) enforcement cost of voluntary recycling programs may be lower. On the other hand, there may be less participation in voluntary programs and a certain amount of good will associated with mandatory programs because everyone has to participate. The relative advantages of mandatory vs. voluntary design in either unit pricing or complementary programs remains to be studied.

Enforcement

The case studies did not address optimal enforcement or penalties for violation of the conditions of service for unit pricing, such as overfilling bags or putting waste in more containers than contracted for. By the same token, and perhaps of equal importance, there was no examination of the effects of changing enforcement and penalties for violating the terms of service for recycling or littering. The case studies did suggest that: (1) contamination of recyclables with non-recyclables or poor quality recyclables was not a problem and (2) littering was not significant. Nevertheless, one may be concerned that they may be problems at higher unit prices.

Urban, Suburban, and Rural Settings

While the case studies do reflect different degrees of urbanization, only one community was sampled in each setting; and the "rural" community, while it was in a rural setting, may not reflect the effects of unit pricing in a service area with widely scattered homesites. For example, in some rural settings "self-disposal" of household waste may be the norm even with free collection. Since both case studies and literature review suggest that differences in the setting are important to the effectiveness of different unit pricing program designs, one needs to examine additional programs in each setting to obtain a more general understanding of what designs, if any, really make a difference.

5.3.3 Issues of Purpose

As discussed earlier in this report, a community may have many reasons to adopt a unit pricing program. The community's purpose provides the standard against which the effectiveness of its program should be measured. In this section, some issues associated with the different purposes for having a unit pricing program that arose during our study are discussed. Three instances are noted in which unit pricing programs may operate at cross purposes even when increased littering is not a problem.

Minimizing Waste Generation and Increasing Recycling

One concern is that the unit price structure that most encourages recycling may discourage reductions in waste generation. In particular, if easily recyclable materials are heavier or bulkier than non-recyclable materials, increasing the price paid for collection of conventional waste may actually increase the amount of waste generated as it increases the amount available for recycling. An increase in X_g with an increase in P_c is most likely to occur when E_{Xr},P_c is very high and E_{Xc},P_c is very close to zero.

Minimizing Cost and Increasing Recycling

Another conflict may arise if the unit pricing program is used to provide revenues that are used to subsidize the recycling program. Such a design may increase costs and conflict with the goal of cost minimization.

Minimization of Which Costs?

As observed in Chapter 2, unit pricing programs can be designed and evaluated from a number of different cost perspectives: the household, the waste manager, and the larger society. In these case studies, an analysis framework was used that assumed households would respond to unit pricing programs by minimizing their opportunity costs. There was no detailed examination, however, in whether changes in household costs, defined in similarly broad terms, were positive or negative. The facts that public "acceptance" of the programs was good and that monetary costs for most households were lower in two communities are suggestive of a positive effect, but much uncertainty surrounds the question of household costs.

By the same token, it was not possible to make a detailed examination of the "externalities" of waste collection and disposal based on unit pricing. While qualitative assessments of externalities associated with a variety of health and aesthetic concerns were obtained, it was not possible to obtain specific estimates of changes that would contribute to a "net social cost" calculation of the unit pricing programs. While, again, the observed costs are suggestive of a reduction in social cost in at least two of the three programs examined, much uncertainty remains due to the absence of cost estimates for externalities associated with waste management.

5.3.4 Other Issues

Unit pricing, and any user fee system, will cause taxpayers to forfeit that portion of the local income tax deduction associated with waste management services. This loss only applies to communities that switch from general revenue financing and households that itemize deductions, but it will effectively raise the cost of waste services for affected households by as much as 50 percent, all other things equal.

APPENDIX

A REVIEW OF LITERATURE ON THE ECONOMICS OF MUNICIPAL SOLID WASTE MANAGEMENT

APPENDIX

A REVIEW OF LITERATURE ON THE ECONOMICS OF MUNICIPAL SOLID WASTE MANAGEMENT

Introduction

The effects of various municipal solid waste management and policy options have been examined using a variety of methods and in many contexts over the last 20 years. In this section earlier papers addressing the theoretical issues and empirical effects of unit pricing as related to consumer decision making and waste management organization are briefly reviewed.

Household Behavior

J.M. McFarland's report in 1972 is seminal in that he concluded, based on a cross-section regression analysis of 13 California municipalities, that the price elasticity for conventional waste collection (Ex_cP_c) was -0.455. McFarland also estimated an income elasticity for conventional waste collection of 0.178 but did not find it to be significantly different from zero statistically. Eflaw and Lanen (1979) have been critical of McFarland's estimates, claiming that the method used was flawed in a variety of ways. In their own work, using time-series data for three cities, Eflaw and Lanen estimated a mix of positive and negative price elasticities of demand for waste collection and, for the most part, could not reject the null hypothesis that the own price elasticity of conventional waste collection is zero. Goddard (1975) recognized problems with the McFarland data and approach but appeared most concerned that the estimates are biased downward. Goddard computed a 95 percent confidence interval of -0.333 to -0.777 for the elasticity estimate of McFarland's estimated equation.

Gueron (1972) provided a broad and farsighted mathematical expression of the problems surrounding MSW collection and disposal, especially problems associated with environmental externalities and public goods dimensions of waste management. She did not use the model for mathematically based analysis, however, and acknowledged a scarcity of data needed for implementation. She instead used the framework and the results of other empirical studies to structure verbal arguments and arrive at tentative policy recommendations. In particular, Gueron was concerned that the price elasticity of demand for waste collection observed on other studies may have been high due to increased diversion to burning, littering, etc., rather than reduced waste generation. While noting various assumptions and qualifying conditions, she argued that "the pricing of solid waste per container or pound collected would lead to an increase in pollution and social damages from own disposal" that "would exceed the direct cost of collective handling" (Gueron, 1972, p. 200). In the terminology of the report, Gueron was concerned that the cross elasticity of demand for waste diversion is positive and greater than one and that the cross elasticity of demand for waste generation is negative and close to zero.

By contrast, Goddard (1975) noted that "there is no good evidence pricing raises littering significantly" (p. 173) and that even if the cross elasticity of demand for littering is positive, it is probably not very large. Goddard suggested that control of littering possibly associated with unit pricing can be achieved at relatively low cost by other policy instruments and that rejection of unit pricing on the basis of Gueron's concerns is not warranted.

Wertz (1976) cited two early studies that claim to show large reductions in conventional solid waste collection with reductions in the frequency of service from twice to once a week: a 30 percent reduction found by Quon et. al. (1968) for Chicago communities and a 47 percent reduction cited by Hirsch (1965) for California municipalities. Wertz counts these observations as "indirect evidence that the substitution effect of a higher price for service is not insubstantial" (p. 267). Wertz apparently based this contention on a finding from his theoretical model that the response to a change in the frequency of collection is a scalar multiple of the effect of price on waste generation/collection.[1] The basis for this conclusion was disputed by Eflaw and Lanen (1979).

Goddard (1975) cited an EPA report (EPA, 1973) that used Chicago area data and single equation regressions to conclude that the income elasticity of conventional solid waste collection is positive and statistically significant. While the citation does present several forms of the estimated equations, the data necessary to estimate elasticity measures for these specifications is only provided for the double-logarithmic form where the income elasticity estimate is 0.404.

[1]Wertz's model treats waste generation and waste collection as equivalent.

Wertz (1976) developed a rich model of household behavior. The model includes household response to the price, frequency, and site of collection; household income; and a measure of convenience that enters as an argument in the household's utility function. While the model has many interesting features, it does not introduce recycling or diverting activities as options available to the household. Wertz provides a comparative static analysis of household decision making using this model, enriching the discussion with references to relevant empirical research. For example, he reported the similarity of his income elasticity estimates for communities in the Detroit area (of 0.279 and 0.272 evaluated at the means) and to the estimate reported by Downing (1975) for observations made in Riverside, CA. ($E_{x,I} = 0.39$). Wertz also estimated an arc elasticity of demand for conventional waste collection of -0.15 based on an acknowledged simplistic comparison of San Francisco with average waste collected per capita of other American cities that don't charge unit prices. Wertz also used the model's comparative static results, along with the estimates of price and frequency elasticities of demand, to conclude that his analysis indicated the presence of "a nontrivial substitution against waste intensive goods on the part of buyers" (p. 268) when they are faced with unit prices for waste collection.

Eflaw and Lanen (1979) examine the impact of user charges in five communities. Three of these case study communities—Sacramento, Grand Rapids, and Tacoma—have unit pricing programs of various kinds. Eflaw and Lanen were careful to try to develop simultaneous equation models of household demand for waste collection that suited the programs found in each of the communities. They then estimated various forms of the models using regressions of time-series data. The data required to estimate these models, however, were formidable and data problems were compounded by the relatively short interval over which some data were available. As noted above, they were only able to demonstrate statistically that the price elasticity of conventional waste collection was negative in a small number of cases. They observed "demand for household solid waste service, in most cases, seems to be highly inelastic with respect to price" (p. 3). Eflaw and Lanen did, however, find significant income elasticities of demand in the range of 0.20 to 0.40. They observed that these values are on the low end of the estimates (0.3 to 0.7) made for Chicago waste service areas by Tolley et al. (1978).

Miedema (1983) approached the question of unit pricing within the context of a general equilibrium model of waste management. This model includes production relationships for (1) a good that can be manufactured from either virgin or recycled material, (2) consumption, and (3) policy variables such as subsidies, fees, and flat rate charges. Miedema specified particular functional relationships and solved the model for a range of parameters to determine how the policy variables perform under different states of the world, including status quo policies. Disposal charges on virgin materials often results in superior outcomes [e.g., higher levels of real income and lower levels of beverage consumption (waste generation)]. Some innovative policies such as user fees (unit pricing), litter taxes, and recycling subsidies are actually inferior to the status quo under diseconomies of scale in virgin materials manufacture. Unfortunately, Miedema did not estimate the elasticities implicit in the various simulations that he ran so it is difficult to relate his model and its results to the models and empirical information available from partial equilibrium analyses.

Organizing Waste Management

Another essential dimension to waste management decision making is the selection of private or public entities for directing or conducting waste management and collection. Communities can chose to:

- provide solid waste collection service through a public utility,
- regulate solid waste service as a private monopoly, or
- allow private firms to provide this service under terms and conditions of the firms' choosing.

While there is some evidence that the second of these options is most economically efficient, at least for collection (Kemper and Quigley, 1976; Savas, 1978) many communities still select the other types of market organization.[2] The market structure selected affects the analysis because it suggests the possibility of different objectives on the part of solid waste managers depending on the market organization. In particular, a public entity is unlikely to be subject to quite the same pricing and service discipline as a private firm in a competitive market. Similarly, the market organization is likely to affect the attractiveness of unit pricing as a financing option.

[2]Dubin and Navarro (1988) attribute these this choice to "the political power of rent-seeking interest groups and the ideological preferences of the community" (1988, p. 220).

References

Allan, Theresa, Brenda Platt, and David Morris. 1989. *Beyond 25 Percent: Materials Recovery Comes of Age*. Washington, DC: The Institute of Local Self-Reliance.

Brown, Patricia Leigh. 1989. "Making Space for Trash: A New Frontier of Design." *The New York Times*, July 27, Y13.

Bucks County Planning Commission. 1989. "Perkasie Borough Comprehensive Plan." Draft #1, April 11.

Cook, James. 1988. "Not in Anybody's Backyard." *Forbes* (November 28): 172-174, 176, 180, 182.

Downing, P.B. 1975. *The Distributional Impact of User Charges for Refuse Collection*. Mimeo, Virginia: Polytechnic Institute and State University.

Dubin, Jeffrey A., and Peter Navarro. 1988. "How Markets for Impure Public Goods Organize: The Case of Household Refuse Collection." *Journal of Law, Economics, and Organization* 4(2):8756-6222.

Eflaw, Fritz, and William N. Lanen. 1979. *Impact of User Charges on Management of Household Solid Waste*. Report prepared for the U.S. Environmental Protection Agency under Contract No. 68-03-2634. Princeton, New Jersey: Mathtech, Inc.

Ferguson, C.E. 1969. *Microeconomic Theory*. Homewood, Ill: Richard D. Irving, Inc.

Franklin Associates, Ltd. 1988. *Characterization of Municipal Solid Waste in the United States, 1960 to 2000*. Final report prepared for U.S. Environmental Protection Agency.

Goddard, Haynes C. 1975. *Managing Solid Waste*. New York: Praeger Publishers.

Good, Linda C. 1988. "Annual Report of the Borough of Perkasie Per Bag Disposal Fee, Waste Reduction and Recycling Program."

Good, Linda C. 1989. "Financial Analysis of Recycling Program to 9;/30/89."

Gueron, Judith M. 1972. "Economics of Solid Waste Handling." In *Public Prices for Public Products*, ed. Selma Mushkin. Washington, DC: The Urban Institute, pp. 173-216.

Herkimer County Area Development Corporation. 1989. "Herkimer County Industrial Guide."

Herkimer County Chamber of Commerce and Herkimer County Area Development Corporation. 1989. "Economic Profile, Herkimer County."

Hirsch, W. 1965. "Cost Functions of an Urban Government Service: Refuse Collection." *Review of Economic Statistics* 47:87-92.

Holthousen, Duncan M. 1988. "The Analytics of Fully Pricing Household Waste Generation." Draft working paper. September.

Jantzef, Monica F. 1988. "Seattle's Two-Contractor Recycling Approach." *Waste Age* (August): 107-110.

Johnson, Bruce. 1988. "Public Participation Helps Seattle Set Recycling Goals." *Resource Recovery* (December 30: 20-22.

Katz, Marvin G. 1989. "Collection Strategies for the Nineties?" *Waste Age* (February): 60-68.

Kemper, Peter, and John M. Quigley. 1976. *The Economics of Refuse Collection.* Cambridge, Massachusetts: Ballinger Publishing Company.

McFarland, J.M. 1972. "Economics of Solid Waste Management." In *Comprehensive Studies of Solid Waste Management, Final Report.* Sanitary Engineering Research Laboratory, College of Engineering and School of Public Health, Report no. 72-3, University of California, Berkeley, California, pp. 41-106.

Miedema, Allen K. 1983. "Fundamental Economic Comparisons of Solid Waste Policy Options." *Resources and Energy* 5(1): 21-43.

Morris, David and Brenda Platt. 1987. *Garbage Disposal Economics: A Statistical Snapshot.* Institute for Local Self Reliance.

Mushkin, Selma, ed. 1972. *Public Prices for Public Products.* Washington, DC: The Urban Institute.

Naber, Thomas. 1986. "Jefferson City Dreamin'." *Waste Age* (September): 34-38.

O'Leary, Philip R., Patrick W. Walsh, and Robert K. Ham. 1988. "Managing Solid Waste." *Scientific American* (December): 36-42.

Paul, Bill. 1989. "Pollution Solution—Pennsylvania Town Finds a Way to Get Locals to Recycle Trash." *The Wall Street Journal,* June 21, A-1.

Paul, Bill. 1989. "For Recyclers, the News is Looking Bad." The Wall Street Journal, August 31, B-1.

Personal communication. November 14, 1989. Byrd, Denise, Research Triangle Institute, with Bagby, Jennifer, City of Seattle Solid Waste Utility.

Personal communication. August 10, 1989. Byrd, Denise, Research Triangle Institute, with Hatch, Gale M., Village Clerk-Treasurer, Ilion, New York.

Personal communication. September 20, 1989. Byrd, Denise, Research Triangle Institute, with Hatch, Gale M., Village Clerk-Treasurer, Ilion, New York.

"Pollution Solution—Pennsylvania Town Finds a Way to Get Locals to Recycle Trash." *The Wall Street Journal,* 21 June 1989, p.1, col. 1, p.A-4, col. 4-6.

Quon, J., M. Tanaka, and A. Charnes. 1968. "Refuse Quantities and Frequency of Service." *Journal of Sanitary Engineering Division* 94:403-420.

Rennie, Caroline and Alair MacLean. 1989. "Salvaging the Future: Waste-Based Production." Washington, DC: Institute for Local Self-Reliance.

Robinson, William D., ed. 1986. *The Solid Waste Handbook, A Practical Guide.* Wiley-Interscience.

Savas, Emmanuel S. 1977. The Organization and Efficiency of Solid Waste Collection. Lexington, Massachusetts: Lexington Books.

Savas, E.S., and C. Niemczewski. 1976. "Who Collects Solid Waste?" *1976 Municipal Year Book,* pp. 167-172. Washington, DC: International City Management Association.

Seattle Department of Community Development. 1989. "Seattle Datasheet."

Seattle Department of Community Development. 1989. "Seattle Economic and Demographic Databook."

Sherman, Stratford P. 1989. "Trashing a $150 Billion Business." *Fortune* (August 28): 90-98.

Skumatz, Lisa A. 1989. "A History of Seattle's Solid Waste Rates." Draft working paper.

Sproule, Kimberly A. and Jeanne M. Cosulich. 1988. "Higher Recovery Rates: the Answer's in the Bag." *Resource Recycling* (November/December): 20-21, 43-44.

Stevens, B.J. 1978. "Scale, Market Structure, and the Cost of Refuse Collection." *The Review of Economics and Statistics* 40(3):438-448.

Stout, Hilary. "The Economics of the Waste Crisis." *The New York Times,* 23 October 1988, p. 4F, cols. 2-4.

Temple, Barker & Sloan, Inc., ICF, Inc., Pope-Reid Associates, and American Management Systems, Inc. 1988. *Regulatory Impact Analysis of Proposed Revisions to Subtitle D Criteria for Municipal Solid Waste Landfills.* Draft report prepared for the U.S. Environmental Protection Agency, Office of Solid Waste. Washington, DC, August 5.

Tolley, G.S., V.S. Hastings, and G. Rudzitis. *Economics of Municipal Solid Waste Management: The Chicago Case.* EPA-600/8-78-013, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1978.

Ujihara, Alyce M. and Paul R Portney. 1989. "Making It Easy to Cut Waste." *EPA Journal* (March/April): 44-45.

U.S. Congress, Office of Technology Assessment. 1989. *Facing America's Trash: What Next for Municipal Solid Waste?* Interim Report.

U.S. Environmental Protection Agency. 1973. *Socioeconomic Factors Affecting Demand for Municipal Collection of Household Refuse.* Washington, DC.

U.S. Environmental Protection Agency. 1987. *Assessment of Health Risks Associated with Exposure to Municipal Waste Combustion Emissions.* EPA/530-SW-87-021g.

U.S. Environmental Protection Agency. 1988. "Health and Welfare Effects of Air Emissions from Municipal Solid Waste Landfills." In *Air Emissions from Municipal Solid Waste Landfills Proposed Standards and Guidelines.* Preliminary draft. March.

U.S. Environmental Protection Agency. 1989. *Background Document for "The Solid Waste Dilemma: An Agenda for Action."* Final Report prepared by the Municipal Solid Waste Task Force, Office of Solid Waste. February. EPA 1530-SW-88-054A.

Wertz, K.L. 1976. "Economic Factors Influencing Households' Production of Refuse." *Journal of Environmental Economics and Management* 2:263-272.