Extending the Definition

Waste Reduction, and Municipal and Private Sector
Recycling Rates on Long Island in 1994

Part IV of an Assessment of Recycling on Long Island

marine sciences research center
State University of New York

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Executive Summary

This is the fourth part of a six-part series on recycling on Long Island. This part, Extending the Definition, is an attempt to completely account for waste diversion in Nassau and Suffolk Counties on Long Island as of 1994. Waste diversion can be considered to be the wastes that no longer require disposal, because of waste reduction, re-use, or recycling activities.

Long Island, as considered in this report, is comprised of Nassau and Suffolk Counties. It contains a population of approximately 2.6 million. It is primarily suburban in character (although it has some urban areas in western Nassau County, and the eastern portions of Suffolk County contain agricultural and/or undeveloped land, and tourist resorts). Most of the suburbanization of Long Island occurred after World War II.

The first part of the series, Doing the Right Thing, discussed the growth and extent of municipal recycling programs. Long Island municipal recycling programs began in earnest after the Islip Garbage Barge in 1987. By 1994 (the last year completely discussed in the report), all 15 municipalities in Nassau and Suffolk Counties had mandatory source separation programs. Although each program is unique, all of the mandatory programs recycle newspaper, and glass, metal and plastic containers. All but one of the mandatory programs also target corrugated cardboard; all but one of the municipalities also recycle yard wastes. All of the municipalities target additional materials, as well, although the particulars vary. Differences in the means of amassing recyclables, processing them, and the participants of the recyclables programs also distinguish each municipality.

These programs represent tremendous growth over the preceding ten years. Only one mandatory and several voluntary programs existed in 1986. The second volume, Comparing Apples and Oranges, discussed municipal recycling quantitatively, and found, naturally, that the amount of wastes managed through recycling programs increased tremendously with the qualitative changes in general waste management strategies.

Comparing Apples and Oranges was divided into two parts. Part A was essentially a compilation of waste management statistics from the 15 municipal programs with a focus on recycling statistics. Part B was an analysis of the data presented in Part A. The primary conclusion of Volume II was that the Long Island-wide recycling rate for 1994 was 31% (based on municipally determined recycling of over 800,000 tons, and waste flows accounted for by the municipalities). The recycling tonnages claimed by the municipalities actually account for 25% of the total Long Island waste stream.

Additional analysis found that, on a per capita basis, in 1994 Long Islanders recycled an average of 625 pounds (nearly 2 pounds $person^{-1}$ day^{-1}). Different municipalities could be cited as the "best" recyclers in 1994: the Town of Shelter Island had the best recycling rate, at 45% of its claimed waste stream; the Town of Hempstead recycled the most per capita at 955 pounds $person^{-1}$ $year^{-1}$; the Town of East Hampton separated the most "household recyclables" (the paper and containers collected at curbside or separated at drop-off centers) at 365 pounds $person^{-1}$ $year^{-1}$; and the Town of Huntington had the best curbside collection program, collecting 241 pounds $person^{-1}$ $year^{-1}$.

However, all municipalities had clearly increased the amount of wastes recycled over time. Many Long Island recycling programs appear to have become "mature" by 1994, with slowed or little increases in recycling tonnages from year to year except by adding new materials or changing accounting procedures.

Additionally, there appears to be a disparity between public perception of recycling (the household recyclables) and what accounts for most of Long Island's recycling credits. Household recyclables accounted for less than 30% of all recycling in 1994, yard waste accounted for nearly 40%, and "other materials" was the remaining third of the tonnages.

Part III, Plumbing the Unknown, attempted to document the private sector with the same breadth and detail as the municipal efforts. This was not possible, because waste management companies on Long Island tend to be small and privately-held (limiting public information), and because of the substantial organized crime role in the Long Island carting industry (which also reduces information availability because of illegal practices and intimidation). State and local government oversight was also deemed to be inadequate.

Nonetheless, model projections and estimations based on the limited data base found that 200,000 tons of commercially-generated solid wastes were recycled by carters and associated transfer stations outside of any recycling documented by the municipalities in 1994. Furthermore, at least 75,000 tons of paper were marketed directly by the waste generator to recycling middlemen, and 75,000 tons of yard wastes may have been composted in small sites by landscapers and nursery businesses. Therefore, it is possible to state that some 350,000 tons of materials were recovered outside of the municipalities' accounting in 1994. This additional tonnage represents 11% of annual Long Island waste generation.

This volume, Part IV of the series, Extending the Definition, begins by discussing waste reduction as a waste management concept. Difficulties in enumerating waste reduction efforts are explored. An estimation procedure for the waste reduction effort most easily implemented by local municipalities, the "Don't Bag It" programs for yard wastes is created, and estimated tonnages that might have been therefore diverted in 1994 were assigned to the appropriate municipalities.

The work already accomplished in Part II (B) and Part III was combined with an estimation of recycling credits from the State nickel deposit program. This appeared to create a maximal recycling total for Long Island. This recycling total was combined with the estimate of waste reduction to quantify, in a conservative fashion, the maximum waste diversion that occurred on Long Island in 1994.

The sum of municipally-accounted for and private sector recycling on Long Island was found to be approximately 1.175×10^6 tons in 1994. This totaled to some 900 pounds $person^{-1}$ in 1994, and accounted for approximately 35% of the waste stream. The Town of Shelter Island appeared to recycle the greatest amount per person, at 1000 pounds $person^{-1}$ $year^{-1}$ (albeit that Town's per capita rates are affected by not including seasonal population fluctuations); however, data uncertainties due to rounding make this rate almost indistinguishable from the rates of Hempstead (at 955 pounds $person^{-1}$ $year^{-1}$) and Southold (at 925 pounds $person^{-1}$ $year^{-1}$). The Town of Hempstead received credit for recycling the greatest tonnages of any of the municipalities in this accounting. Nickel deposit recycling was estimated at nearly 2% of the waste stream (approximately 75,000 tons in 1994). This raised the estimates of total recycling to 36% - 38%. Although the relative recycling rates of the municipalities did not change, the following Towns all appeared to recycle more than 900 pounds $person^{-1}$ $year^{-1}$: Hempstead and North Hempstead in Nassau County; and East Hampton, Huntington, Islip, Shelter Island and

Southold in Suffolk County. The Long Island-wide recycling rate was approximately 950 pounds person^{-1} year^{-1}. Because of too many uncertainties in determining overall municipal waste stream sizes, we declined to estimate the individual municipality's percentage recycling rates.

Waste reduction was estimated to also account for 2% of the total Long Island waste stream. This made overall waste diversion, Long Island-wide, between 37% and 40% of the total waste stream. The tonnage diverted from disposal in 1994 appears to have been approximately 1.3×10^6. Islip appeared to divert the most wastes on a per capita basis, at 1125 pounds person^{-1} year^{-1}. The uncertainties associated with rounding errors make it seem that the rates for Shelter Island (1100 pounds person^{-1} year^{-1}) and Southold (1050 pounds person^{-1} year^{-1}) were approximately equal to Islip's rate. Hempstead (1027 pounds person^{-1} year^{-1}) and Huntington (1000 pounds person^{-1} year^{-1}) also appeared to divert wastes at rates equal to or greater than the mean Long Island per capita rate for 1994 (approximately 1000 pounds person^{-1} year^{-1}), and East Hampton and North Hempstead were within error estimates of the Island-wide rate (the Long Island-wide rate was greater than the weighted mean of all the municipalities because of some unallocated credits).

It is possible to construct, therefore, a range of recovery rates for Long Island as a whole (and, indeed, similar ranges for the individual municipalities). The range of values is in keeping with a theme of this report: recycling rate calculations depend greatly on what is included in the calculations (and what is excluded).

Table S-1. Calculated Recovery Rates for Long Island (1994 Data), Using Three Waste Stream Sizes

Estimate Number	Estimate Basis	Percent (2.6 x 10^6 tons)	Percent (3.25 x 10^6 tons)	Percent (3.5 x 10^6 tons)	Per Capita (lbs. $person^{-1}$ $year^{-1}$)
1	Curbside-Dropoff (Paper & Containers)	9%	7%	7%	175
2	All Municipally-reported	31%	25%	24%	625
3	(2) plus Unaccounted-for Commercial Sector		31%	30%	775
4	(3) plus "Other" -- OCC and Yard Wastes		36%	34%	900
5	(4) plus Bottle Bill Returns		38%	36%	950
6	(5) plus "Don't Bag It" Estimates		40%	37%	1000

Each of these measures has a certain validity -- depending on what is counted, of course, and what is not. These rates, as calculated here, do provide support for assertions that Long Islanders recover wastes better than most other areas of the country. In fact, it is likely that no other region can claim per capita rates approaching the half-ton recoveries shown here, and few can document as well the calculated percentages. It must be kept in mind that the large amounts of recovered wastes are due, in part, because Long Islanders are nearly unmatched at generating wastes in the first place.

Introduction

The Waste Reduction and Management Institute (WRMI) was established in 1985 by the New York State Legislature (as the Waste Management Institute). The mission of WRMI is to reduce the impact of waste generation on society through a program of research, assessment, education, and policy analysis. Locally, there is a need to compile accurate and credible information about Long Island's solid waste stream and infrastructure. This need was initially addressed by the publication of Where Does It All Go? in 1992 (Tonjes and Swanson).

Solid waste management on Long Island has evolved considerably since the data were collected for that report. This project began as an update to Where Does It All Go? In the course of data collection and analysis, it became obvious that certain aspects of Long Island's solid waste structure were deserving of study in and of themselves. The focus of the proposed report became recycling and its associated processes. As our assessment grew, it was suggested to us that the report had grown to unwieldy size, and would be of little utility if issued as a single document. We therefore have attempted to break the initial report into manageable pieces.

This paper, Extending the Definition, is the fourth of a series of six related reports. All six of the reports discuss some aspect of recycling in Nassau and Suffolk Counties. Each report is intended to stand alone; however, the reader interested in all aspects of the recycling process on Long Island would reap the most benefit by reading the reports in order.

Extending the Definition is a report on waste diversion on Long Island circa 1994. Waste diversion should be understood to encompass recycling (both those activities tallied by the 15 Long Island municipalities, and those that were not included in their data compilations), re-use, and waste reduction.

Doing the Right Thing (Tonjes and Swanson, 1996a), the first report in the series, was a report on the growth and evolution of Long Island's municipal recycling programs. It was a qualitative, descriptive account, examining the differences and similarities among the Long Island municipalities' approaches to recycling. It naturally concentrated on recycling activities accomplished by the municipalities themselves.

Comparing Apples and Oranges: Part A: The Data Report (Tonjes and Swanson, 1996b) followed the format of Doing the Right Thing. Each municipality was given a separate section, and details of changes in recycling tonnages (in total, and by material) and percentages were presented, as available. We believe the detail of Part A is necessary to support the levels of analysis that we presented in its companion volume, Part B; we also recognize that interest in these details may be restricted to a very select audience.

Comparing Apples and Oranges: Part B: The Data Analysis (Tonjes and Swanson, 1996c) used the information from Part A to reach several conclusions regarding municipal recycling efforts. The overall conclusion is that recycling has become an important waste management tool on Long Island, and has grown significantly since 1986 (when recycling could fairly be described as a waste management novelty). Quantitatively, based on data supplied by the municipalities, the Long Island-wide recycling rate for 1994 was 31%. By factoring in the entire Long Island waste stream, this rate was better considered to be 25%. On a per capita basis, in 1994 Long Islanders recycled an average of 625 pounds (nearly 2 pounds person^{-1} day^{-1}).

These rates and percentages varied widely for different municipalities. For 1994, based on claimed tonnages and rates (or our estimations of those rates, where data were not made available), the Town of Shelter Island appeared to have had the best recycling rate (45% of its claimed waste stream). In terms of per capita tonnages claimed, the Town of Hempstead could be considered to have recycled the most (955 pounds person^{-1} year^{-1}). If "household recyclables" (the paper and containers collected at curbside or separated at drop-off centers) only are considered, then the Town of East Hampton separated the most (365 pounds person^{-1} year^{-1}). Huntington could be considered to have had the best curbside collection program, collecting 241 pounds person^{-1} year^{-1}. All municipalities had clearly increased the amount of wastes recycled over time. Many Long Island recycling programs appear to have become "mature" by 1994, however, with slowed or little increases in recycling tonnages from year to year except by adding new materials or changing accounting procedures.

According to municipal statistics, household recyclables accounted for less than 30% of all recycling in 1994. Yard waste accounted for nearly 40% of the claimed tonnages, and "other materials" (predominantly private sector recycling and post-collection recyclables separation) was another third of the tonnages. Of the household recyclables, paper accounted for well over two-thirds of the tonnages, and newspaper alone was more than half of the materials collected.

There appears to be a disparity between public perception of recycling (the household recyclables) and what accounts for most of Long Island's recycling credits.

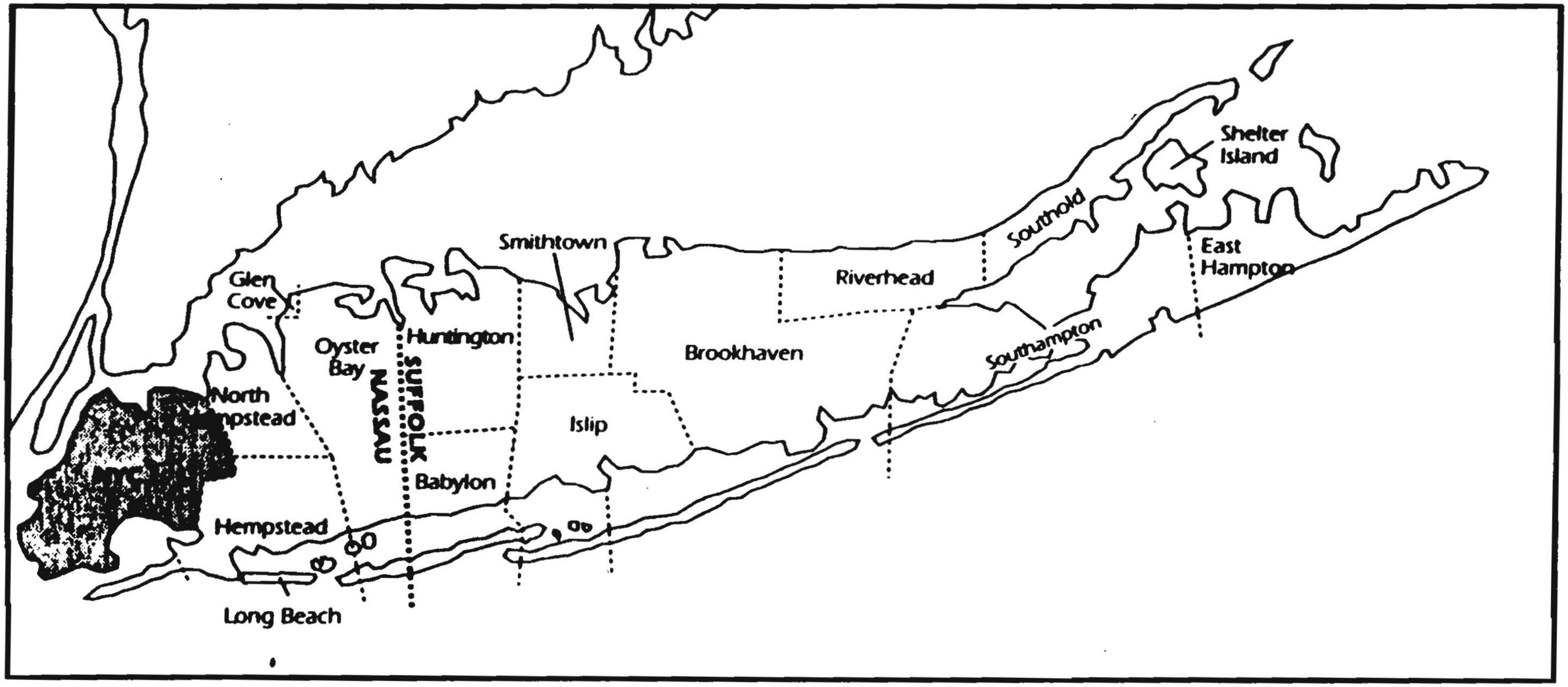
The third volume, Plumbing the Unknown (Tonjes and Swanson, 1996d) attempted to address private sector recycling practices not accounted for in the municipal compilations. This was not completely possible, because waste management companies on Long Island tend to be small and privately-held (limiting public information), and because of the substantial organized crime role in the Long Island carting industry (which also reduces information availability because of illegal practices and intimidation). State and local government oversight was also deemed to be inadequate.

Nonetheless, model projections and estimations based on limited data found that 200,000 tons of commercially-generated solid wastes were recycled by carters and associated transfer stations outside of any recycling documented by the municipalities in 1994. Furthermore, at least 75,000 tons of paper were marketed directly by the waste generator to recycling middlemen, and 75,000 tons of yard wastes may have been composted in small sites by landscapers and nursery businesses. Therefore, it is likely that some 350,000 tons of materials were recovered outside of the municipalities' accounting in 1994. This additional tonnage represents 11% of the annual Long Island waste generation total.

This volume, Extending the Definition, will begin by discussing waste reduction, both as a theoretical waste management technique, and how it might be quantified on Long Island. It will also synthesize the data from the first three volumes, and from this report, to generate some estimates of the total amount of recycling and waste diversion for Long Island in 1994.

Long Island, as considered in this report, is comprised of Nassau and Suffolk Counties. It contains a population of approximately 2.6 million. It is primarily suburban in character; most of the suburbanization occurred after World War II. Some portions of western Nassau County are considered urbanized. The eastern portions of Suffolk County contain agricultural and/or undeveloped land, and tourist resorts. Suffolk County still generates more income from agriculture than any other county in New York (Tonjes and Swanson, 1996a).

Figure 1. Long Island Municipalities



Long Island contains 15 municipal solid waste management planning units -- ten Towns in Suffolk County (Babylon, Brookhaven, East Hampton, Huntington, Islip, Riverhead, Shelter Island, Smithtown, Southampton and Southold), and the three Towns (Hempstead, North Hempstead, and Oyster Bay) and two cities (Glen Cove and Long Beach) in Nassau County (Figure 1). Although Brooklyn (Kings County)and Queens County are geographically part of Long Island, history, political divisions, and common usage exclude them from public policy discussions of Long Island issues. They are not discussed in this report (Tonjes and Swanson, 1996a).

Long Island's municipal waste management infrastructure is organized differently from other areas of New York State. Elsewhere, waste management is the function of county government, or, in some instances, organizations comprised of groups of counties. On Long Island, the responsibility is assumed by Town or City government (the next lower level of government), and, even, in some aspects, by Village government. This has led to a multiplicity of approaches in a relatively restricted geographical space. In addition, changes in waste management control and policies have resulted in most municipalities managing only portions of their total waste streams; the remainder are managed by private industry, most often with little governmental oversight (Tonjes and Swanson, 1996a; Tonjes and Swanson, 1996d).

1. Theoretical Waste Reduction

The theoretical basis of modern integrated waste management is the solid waste management hierarchy. This heirarchy establishes the preferred management options for wastes. It is:

-- waste reduction

-- recycling

-- incineration with energy recovery

-- landfilling

(New York State Department of Environmental Conservation, 1987).

Waste reduction has not often been mentioned explicitly in this series of reports. It plays an important role in New York State solid waste planning, however. Waste reduction (in 1988) was expected to comprise 8 - 10% of the 1997 goal of 50% waste stream recovery (New York

State Department of Environmental Conservation, 1987). This 50% goal was therefore actually an aim for reducing waste disposal tonnages. This waste disposal reduction or minimization is comprised of the tonnages of materials actively recovered ("recycled") from the waste stream, and the tonnages of those materials that were diverted from the waste management process in the first place ("waste reduction" or "waste minimization" or "waste diversion"). These terms are loosely used, and the sum of the process is often called "waste recovery," "waste minimization," "waste reduction," or "waste diversion." Our particular preference for the sum of the process is "waste diversion."

Waste reduction is important as a waste management technique first of all because it decreases the size of the waste stream to be managed. This is accomplished without any overt use of waste management resources (time, energy, or money), because the wastes are simply not available to be managed. Thus, simplistically, waste reduction appears to be a cost-free means of waste management.

Secondly, waste reduction occurs at or near the source or generation point of the waste production (thus, another sobriquet for the process: "source reduction"). The production and use of goods is a dispersive process, generally. Materials that have been gathered together (at a manufacturer, for example) are distributed throughout the consumer system. This requires a large energy expenditure. Likewise, if the materials are to be gathered again after use, in their "waste" states, this requires an expenditure of energy. Thus, the collection process of waste management, whether for disposal at a landfill or incinerator, or for recycling, is costly. This is because energy use often equates to cost, whether considered as fossil fuel usage, or as the effort applied through labor. Waste collection is often a heavy user of both forms of energy (Black et al., 1991; Reaven, 1991; Breslin et al., 1993).

When the wastes are managed at the source, or eliminated from the process, the expensive collection element of the waste management equation is eliminated, or minimized. It should be realized that often the energy or environmental costs of the process are sometimes just shifted in waste reduction. If environmental costs associated with composting are considered, for example, it matters little whether the process occurs at one municipal site or in many backyards -- unless there is a change in impacts with increasing or decreasing pile sizes. In fact, it has been argued that the greater regulation of large-scale composting sites will ensure that environmentally-sounder practices are followed at those sites, as opposed to backyard piles (Heil and Tonjes, in press). The "pure" form of waste reduction (the elimination of something as any kind of waste -- such as the use of less wood pulp in the production of paper) appears to be cost-free and benefit-rich, however.

Most solid waste planners see great portions of the waste reduction process as occurring outside of the domain of traditional, facility- or government-oriented solid waste management, per se. Waste reduction includes shoppers making more educated packaging choices, for example. It also includes manufacturing changes, such as in thinner, lighter packaging (plastics and cardboards) or products (such as newspapers). Better product designs allowing for longer lifespans or functional changes can be part of this process. One example is tires, which now last much longer, and often are "all-season." These two changes should substantially reduce the number of tires being discarded, as snow tires are no longer widely used, and tires in general may last for 60,000 miles rather than 30,000 to 40,000 mile lifespans of only a decade or so ago (Allaway, 1992; Tonjes, 1992; United States Environmental Protection Agency, 1992; Tonjes, 1993; CSI Resource Systems, 1993; Dvirka and Bartilucci, 1993; Town of North Hempstead, 1993; New York State Department of Environmental Conservation, 1995).

These kinds of waste reduction should all reduce the amount of wastes produced. The result of this, for recycling rate determination purposes, is to diminish the denominator of the recycling percentage calculation. This leads to increases in the recycling rate, if the materials reduced were not to be part of the recycling waste stream (the numerator of the calculation). If the materials were to be recycled (but instead were waste reduced), the effect is to diminish the waste stream.

As an example, suppose in a waste stream of 10 tons, 4 tons are recycled (40% recycling). Now add a 10% waste reduction. This reduces the total waste stream to 9 tons. If none of the recyclables were affected by the reduction in waste stream size, the recycling rate is now 44% (4/9). However, if the 10% reduction in the waste stream was made in recyclable materials, then the recycling rate would fall from 40% (4/10) to 33% (3/9). Such discussions are not entirely theoretical, as much waste reduction (see below) is targeted at recyclable waste streams -- paper products, packaging in general, and yard wastes.

There are many guides to individual waste reduction strategies. These usually call for buying in bulk where possible, making consumer choices on the basis of appropriate amounts of packaging, reusing scrap paper, and home composting for organic wastes. Two of the most widely distributed are 50 Simple Things You Can Do to Save the Planet (The Earth Works Group, 1989) and a booklet from the United States Environmental Protection Agency (1992). The advice in such guides must be applied judiciously. There are no savings from buying in bulk, for example, if the product must be disposed because it was not used in a timely fashion.

Certainly, many factors affect consumer purchasing habits, and packaging choices may be only one (relatively lightly weighted) part of the decision (Harrison, 1996). This makes it unlikely that major changes in the size of the waste stream will result from direct consumer purchasing choices -- although waste generation as a basis for such decision-making should continue to be encouraged. We say this, although "reduced packaging" products may in some cases actually lead to more consumer wastes. For example, it may be more difficult to remove products from some forms of packaging than others. The consumer thus disposes of more products with the "reduced packaging" than the consumer would have with the original packaging. Depending on the balance between packaging reductions and increased product disposal, the reduced packaging may (or may not) lead to decreased waste generation per container. Additionally, because less product was removable from the package, if the consumer consumes at the same rate, purchases will be accelerated. This leads to relatively greater waste generation rates over slower purchasing rates, and, in tandem with the calculation of packaging reduction versus product disposal, may lead to increases in actual waste generation rates.

We are in the process of preparing a report on some of the issues that may bear on environmentally-based consumer choices, using the varieties of orange juice packaging as examples. It may be that waste generation rates may not be the best measure of environmental impacts -- even in terms of waste management issues. The recyclability of some packaging (in a particular environment) may make that packaging form preferrable, although it weighs more or is bulkier. Similarly, waste issues may not be as important as the amount of water pollution associated with generating the package, or increased air pollution impacts resulting from the transport of heavier or bulkier product lines -- or even nutrition levels associated with different processing levels (which can bear on waste generation because of differing shelf lives) (Waste Reduction and Management Institute, in prep.).

Much has been written about the processes industries and businesses can use to reduce waste production. Many plans are focussed on the reduction of either the amount of hazardous wastes produced, or to reduce the toxicity of waste streams, rather than to reduce solid wastes (Cheremisinoff and King, 1991; Allaway, 1992; Parvin, 1994). New York State has established a "Waste Exchange" program, where businesses can trade manufacturing residues with one another, recognizing that someone's wastes can be someone else's raw materials. Other states also have similar programs.

Plans for businesses that reduce other facets of the waste stream are less common. Paper reduction strategies, such as double-sided copying, electronic- and phone-mail use in place of letters, and use of used paper as scrap paper have been widely disseminated (Earth Works Group, 1989; CSI Resources, Inc., 1993; Dvirka and Bartilucci, 1993; Green and Rickmers, 1993; Tonjes, 1993; Town of North Hempstead, 1993). A few other plans, notably the Environmental Defense Fund (EDF) - McDonald's Corporation collaboration, center around efforts to reduce solid waste production and increase recycling and recycled products use for materials other than paper (McDonalds Corporation and Environmental Defense Fund, 1991).

The McDonald's initiative, which was widely promoted when first announced, has received little followup attention, and therefore cannot be judged for its impact. Superficial effects that have been widely noted include labelling by McDonald's on all recycled content materials that consumers would come into contact with, and the elimination of polystyrene clamshells for hamburger packaging[1]. It is not clear that these steps lead to less wastes produced at McDonald's restaurants. McDonald's, like other large chains, can claim large aggregate waste reduction tonnages for the corporation in general, through use of thinner corrugated cardboards, less plastic wrap for product shipments, and other "back of the store" waste reductions (Reaven and Tonjes, 1991).

Another restaurant project initiated about the same time as the McDonald's-EDF collaboration was more local in nature. The Town of Islip produced a manual for restaurants to

[1] It should be noted that McDonald's is now test-marketing a new cup and a new clamshell. These products, made by EarthShell Corporation, are composed of starch, limestone, and water. The intent is they should be completely compostable. Testing by WRMI at the East Hampton MSW composting facility indicates that the products appear to be completely compatible with such composting operations.

reduce the size of their waste streams, working with researchers from WRMI (Reaven et al., 1991). This effort, too, has not been subjected to any measures of effectiveness.

The Waste Reduction and Management Institute has attempted to implement some other modest waste reduction initiatives. One of these nicely illustrates how naive understandings concerning multiple use products can lead to simplistic solutions. The Institute worked with several large regional malls in an attempt to reduce the amount of packaging used at point-of-sales. The concept explored was to reduce the number of bags and sacks issued by individual retailers. Many retailers agreed that it was not necessary for convenience or product protection needs to provide so many sales bags. However, the bags also served as a first line of defense in controlling shoplifting, and other pilferage. This function is important enough for the retailers to resist minimization of shopping bags issued by each store (although advertising also had a large role in continuing to use individualized bags). Anecdotally, there does seem to be greater reliance on "Paid" stickers for easily-carried large items in supermarkets; some supermarkets also offer nominal rebates for using bags brought from home (a practice that was given impetus in Suffolk County by early versions of the Suffolk County Plastics Ban) (Swanson et al., 1993).

An initial defense of the Suffolk County plastics law by some supporters was that the law was a waste reduction measure. The law was to ban certain plastic products from use in Suffolk County (primarily in consumer and secondary packaging applications -- plastic bags and polystyrene coffee cups were prototypical examples). It was soon clear that removing these products from use would almost certainly lead to a waste increase, as their replacements weighed more, and may not have been used as efficiently. The bill's sponsor preferred to call the aim of the measure "waste stream simplification" (Swanson et al., 1993). Although marketplace efficiencies for secondary concerns (such as waste generation is in most consumer situations) are probably overrated, many products that are shipped long distances and have low marginal profit rates have carefully accounted for packaging. Broad-brush laws such as Suffolk County's plastic ban may therefore have unintended waste stream and other environmental consequences. Therefore, although legislation may be a means of reducing wastes, any such initiatives must be carefully considered, especially in terms of unmeant side effects (Swanson and Ross, in prep.).

Another means of reducing the waste stream is to match solid waste generators with potential users of the solid waste, similar to the waste exchanges for hazardous wastes. These can be as loosely organized as the "ledge treasures" program run by the Town of Shelter Island at its transfer station (Tonjes and Swanson, 1996a), or can be more ambitious efforts seeking to match industrial waste generators with potential "wastes" users (Sullivan, 1996).

A much broader based attempt to decrease the general waste stream size is the German packaging law (the Green Dot Law). In a simplified description, this legislation requires that all packaging and durable products be either made to be recycled or reused, or forces the manufacturer to pay a penalty. Manufacturers were also required to provide financial support for recycling markets through funding for a recycling clearinghouse. Results have certainly not been as dire as some critics expected -- Germany has not lost its competitive place in the world's markets for example. However, allegations concerning disposal of recyclables (especially in third world countries) persist (Genillard, 1993; Boerner and Chilton, 1994; Fishbein, 1994).

Two programs have been explicitly implemented by Long Island municipalities, with the intent of decreasing waste stream sizes. One is the "Don't Bag It"-style programs, and the other is "Pay-per-Bag"-style waste collection systems.

Yard waste is the target for "Don't Bag It" programs. On Long Island, the first such program was in the Town of Islip. It was primarily meant as a management tool for the odor problems at the Town's compost site, as it was believed if grass clippings were no longer included in the yard waste stream, then the odors from debagging rotting clippings would certainly decrease. The Town thus set in place a ban on grass clipping collections. Residents were encouraged to leave the clippings on lawns, or to home compost (Tonjes and Swanson, 1996a).

It was also understood that decreasing the amounts of wastes managed by the Town should result in significant cost reductions. Therefore, Islip (and other implementors) also targeted other portions of the yard waste stream, such as leaves and gardening wastes, for home management. Some programs also touted benefits from using more locally-oriented landscaping, often under a general xeriscaping rubric (xeriscaping meaning landscaping in a fashion that requires less water). From a waste management perspective, plants requiring less water over a summer were thought to produce less plant material requiring disposal (Tonjes and Swanson, 1996a; Town of Brookhaven Department of Waste Management, 1996).

The programs were implemented in two general fashions. One was the mandatory version, as at Islip. Grass clippings were no longer considered to be acceptable solid wastes, and therefore were ineligible for collection or management services. Such programs usually allowed for some disposal services for the "banned" materials, albeit under restrictions. The second was to have a voluntary program, where home management was encouraged and supported. Municipalities employing mandatory "Don't Bag It" programs for grass clippings usually employ voluntary approaches for leaves and other yard wastes (Tonjes and Swanson, 1996a).

A special initiative should be mentioned in line with the home management of yard wastes. Residents of the Village of Bellport (in the Town of Brookhaven) are being asked to participate in a home composting experiment. Food and other decomposable wastes are specifically targeted in this program, along with yard wastes (Cooley, 1995). This program is a refinement of other, more ambitious projects piloted in Ontario earlier in the 1990s. Many of the results from those programs were somewhat disappointing. There were considerable expenses to set up the home composters, and apparently very little waste stream impact. Many participants did not maintain their initial enthusiasm, and the inclusion of inappropriate materials in the composters led to system failures. Ultimately, these projects were abandoned prior to the planned experimental end date, and never accurately assessed (Reaven and Tonjes, 1992).

"Pay-per-Bag" systems attempt to allocate the costs of waste management based on waste generation. Two general approaches are used: weight-based, or volume-based. Because weight-based pricing is difficult to implement when any kind of collection services are available, volume-based pricing has become more common. The largest implementation of such a strategy is probably in Seattle, WA.

The charges can be developed by selling and/or renting a reusable container for curbside set-out. Different sizes can be offered at different prices. A variation on this is what has been implemented in several Towns on Long Island. That is to offer non-reusable plastic bags, requiring that all wastes be disposed in an approved bag. The bag-system is somewhat cheaper to implement, and offers flexibility in disposal needs over time. Plastic bags can be more difficult to "overstuff" as compared to sturdier, rigid cans, addressing a perceived problem with the use of cans (and leading to the use of rather flimsy plastic films in the bag programs). Single-use plastics have an image problem with many people, and their association with an "environmentally-friendly" program causes some conceptual problems; indeed, the concept of creating wastes through single-use bags is a trade-off for the benefits listed above. Creating widespread availability and maintaining inventory controls on the bags can be difficult, as well (Bunchuck, 1994; Sherman, 1994; Tonjes and Swanson, 1996a).

The waste reduction component of this waste charging system is that it presumably makes the waste generator more cognizant of the amount of wastes being generated, and provides an immediate incentive for reducing that amount. Generally, such programs are implemented along with no-cost recycling, and so the waste generator is presented with a choice of paying for wastes, or avoiding the costs through recycling or by not creating the wastes in the first place (Tonjes and Swanson, 1996a). Some illegitimate choices can also be made to dispose of the wastes outside of the pay-per-bag system: through illegal dumping, backyard burning, disposal in someone else's container, or access to another waste disposal system where costs are not allocated by volume or weight.

There are also "administrative" waste reduction strategies. In New York, for example, there is a classification of materials deposited in a landfill (or sometimes otherwise disposed) called a "Beneficial Use Determination" (BUD) (New York State Department of Environmental Conservation, 1993). This is when a potential waste material is used in such a fashion as it displaces another material from being used, and yet the use is not one that the State wishes to call "recycling." Examples of materials receiving BUDs are Islip's use of treated WTE incinerator ash as a sand/gravel replacement in aspects of its landfill capping program, and fines from construction and demolition debris processing being used as landfill cover materials (Alternate Daily Cover Material -- ADCM). The BUD ash and ADCM are no longer included in waste stream calculations, and therefore may result in reductions of the overall waste stream. We have not commented on such BUDs more extensively as we do not tend to include those materials in our definitions of municipal solid waste. From our perspective, such determinations do not affect the size of the waste stream, and therefore are not true waste reductions.

Waste reduction, therefore, is the elimination or delay of materials' entry into the waste stream. It tends to be of two general types: elimination or minimization of wastes through process changes and modifications, or elimination or minimization of wastes by changing or modifying the description of the materials as "wastes." The first kind is generally performed by manufacturers, or product users; the second is often a function of disposal system management.

2. The Theory of Waste Reduction Quantification

Quantification of waste reduction efforts is somewhat complicated. The intent, for New York State in 1988, was to use waste reduction as a major portion (about a fifth of the total recycling-composting-reduction/reuse amount of 50%) of its overall waste disposal reduction rate. The original concept was to use 1988 as a baseline year (and tonnage). The State thought it could calculate waste reduction based on locally-generated data, especially in light of a philosophical stance of no growth in waste generation rates (Vitale, 1993).

Mathematically the intent was something like this. If the waste stream, at baseline, consisted of 100 parts, and waste reduction was 10 parts, the remaining waste stream would be 90 parts. Then a recycling rate of 44% would be required to achieve 50% waste minimization in all (40/90 = 44%; 40 parts recycling + 10 parts waste reduction = 50 of 100 parts). This could lead to confusion, as the public might be told that 44% recycling with 10% waste reduction would equal a 50% waste minimization rate.

Therefore, in determining the overall waste minimization rate in pursuit of the 50% goal, planners were counselled to include waste reduction in both the numerator and denominator of the calculation.

The actual calculation of waste reduction seemed simple. Given a baseline waste tonnage, the amount of waste reduction should simply be that portion of wastes no longer managed by the appropriate waste management system. Given that populations change, waste streams are difficult to define and a baseline figure may be unavailable or inaccurate, and that changes in responsibilities for various portions of the waste stream occur, the mathematics are probably impossible in "the real world" (Allaway, 1992; New York State Department of Environmental Conservation, 1995). The simple calculation method was quickly identified as flawed. The Town of Brookhaven found New York State quite unsympathetic to its attempt to define the change in the Town's waste stream from 492,174 tons in 1991 to 344,384 tons in 1994 as "waste reduction." The State preferred to discuss the change as "waste diversion[2]," and saw no role for the change in recycling calculations (Tonjes, 1995).

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[2] Waste diversion in this case meaning a diverting of MSW from the particular municipal system, being neither a reduction in waste generation, nor even a diversion from the State's waste management systems, considered as a whole.

The New York State Department of Environmental Conservation has discussed a second means of calculating waste reduction. That would be to count (and verify) each instance of waste reduction, at individual businesses, in homes, and through government initiatives. This is regarded as much too complex a data gathering effort to be practical.

Therefore, New York State has chosen not to attempt to quantify waste reduction at this time. Its recommendation is to focus on a 50% reduction in waste disposal needs, considering all wastes generated (New York Department of Environmental Conservation, 1995). Presumably, since recycling is supposed to be countable, the amount that is the difference between the 50% disposal reduction, and the determined recycling rate, can be attributed to "net" waste reduction (waste reduction based on the baseline waste stream, factoring in allowable waste stream growth from population increases). That this neglects annual waste production fluctuations, and does not require any means of verification or validation, is recognized but accepted as a cost of practical implementation.

3. Quantifying Long Island Waste Reduction Initiatives

We believe it is possible to estimate at least some of the effects of waste reduction initiatives on Long Island. The kind of changes caused by modifications of behaviors such as consumer choices, or office practices, or by changes in product formulations, do not appear to be amenable to measurement. The kind of effect that springs from municipal waste planning, however, such as the "Don't Bag It" or "Pay-per-Bag" approaches, may be quantifiable.

"Don't Bag It" program effects calculations are not easy. The Town of Islip, since it made major efforts to compost the majority of its yard wastes at its own compost site, has used the decrease in Town composting as a measure of waste reduction tonnage in its calculations of its "residential recycling and waste reduction" rate (Scully, 1994; Tonjes and Swanson, 1996b). This calculation would neglect pre-1992 home composting efforts, however, and requires an assumption that a baseline tonnage for yard waste generation, or even municipal composting, can be calculated. Most municipalities do not have data for such calculations (Tonjes and Swanson, 1996b).

It may be possible to back-calculate into an estimate, however. Yard waste is generally assumed to constitute 15-20% of the Long Island waste stream, with some of this data based on actual waste stream audits (Dvirka and Bartilucci, 1984; Dvirka and Bartilucci, 1988; CSI Resource Systems, 1993; Malcolm Pirnie, 1993; Town of North Hempstead, 1993; Tonjes, 1993). Given the weight of grass clippings (especially when wet), and the length of the lawn growing season on Long Island, it seems reasonable to suppose grass clippings are approximately half of the yard waste stream. Therefore, given a waste generation rate on Long Island of approximately 2500 pounds per person per year, grass clippings generation should be 175 - 250 pounds $person^{-1}$ $year^{-1}$ (in terms of a fifteen-week "peak" growing season, approximately 10-15 pounds $person^{-1}$ $week^{-1}$). Therefore, in an attempt to quantify the effects of these programs, we believe it is reasonable for a municipality with a mandatory "Don't Bag It" program for grass clippings to take a 200 pound $person^{-1}$ $year^{-1}$ waste reduction credit; a voluntary program might reasonably be given a 75 pound $person^{-1}$ $year^{-1}$ credit. In order to avoid overcrediting these programs, the credits also include other yard waste reductions, such as voluntary backyard leaf composting.

Table 1 shows estimates of 1994 waste reduction effects from "Don't Bag It" programs, based on the existence of voluntary programs in one Nassau municipality and eight Suffolk Towns, and the one mandatory program (in Islip), using this estimation process.

Table 1. Estimates of 1994 Long Island Waste Reduction from "Don't Bag It" Programs (in tons)

		Don't Bag It[3]
Nassau County		11000
	Glen Cove	
	Hempstead	
	Long Beach	
	North Hempstead	
	Oyster Bay	11000
Suffolk County		59750
	Babylon	
	Brookhaven	15000
	East Hampton	
	Huntington	7000
	Islip	30000
	Riverhead	900
	Shelter Island	100
	Smithtown	4000
	Southampton	2000
	Southold	750
Long Island Total		70000
Est. Percent of Waste Stream		2%

Preliminary data from the East End Towns that have adopted Pay-per-Bag systems suggests that these municipalities are indeed managing fewer tons of MSW with such programs than before they had them (considering the sum of disposed and recycled tonnages), but suggest that the difference may not be significant (Tonjes and Swanson, 1996b; Tonjes and Swanson, 1996c). There are also questions as to whether most of this difference is due to homeowners producing less wastes, or merely managing the wastes differently. Riverhead businesses

[3] All tonnages were rounded to (at most) two significant figures, and usually to one. This includes the sum of tonnages developed for Suffolk County as a whole. For example, given the uncertainties associated with the process, although the Long Island-wide sum totals 70,750 tons (from the nine individual municipalities), the tonnage estimate for Long Island more accurately is depicted as 70,000 tons (+/- 10,000 tons) -- or even 75,000 tons (+/- 25,000 tons).

complained of wastes, apparently from Southold, being illegally disposed into their dumpsters, for example (Freedman, 1994). Both Southold and Shelter Island officials believe that at-home disposal may be occurring (backyard burn cans, or in-the-woods dumping) to some extent (Tonjes and Swanson, 1996a). When waste disposal economics are important, the "Pay-per-Bag" system certainly encourages adoption of two different strategies: reductions in waste generation, or use of "alternative" disposal methodologies. Use of these alternative disposal technologies is not easy to verify. It is far from clear that consumer buying habits will be guided by desires to decrease disposal costs (Allaway, 1992).

Finally, "Pay-per-Bag" systems were only in place in two Long Island municipalities by 1994, where the sum of wastes managed may not be as great as 1% of the total Long Island waste stream (Tonjes and Swanson, 1992). The effects of the "Pay-per-Bag" systems are too small, and the uncertainties in estimating the effects are too large to be meaningful in the context of the overall Long island waste management system. We have therefore declined to create estimates of the effects of "Pay-per-Bag" programs. Table 1, therefore, will serve as the sole estimate of 1994 waste reduction efforts on Long Island.

4. Combining Municipal, Private Sector, and Waste Reduction Data

It now should be possible, given the data collected and analyzed thus far in this series of reports, to construct a more complete estimate of waste diversion on Long Island for 1994. Waste diversion is considered to be the sum of recycling and waste reduction (with composting considered to be recycling, and re-use considered to be waste reduction).

The estimate will be constructed in several steps. The first will be to determine the total amount of recycling on Long Island in 1994. In Comparing Apples and Oranges: Part B: The Data Analysis (Tonjes and Swanson, 1996c), we created tables that accounted for municipally-defined recycling tonnages. In Plumbing the Unknown (Tonjes and Swanson, 1996d), we created a model that expanded on the small amount of data available on recycling outside of municipal systems, and estimated the tonnages collected by the private sector without municipal accounting. Table 2 combines these two amounts. Note that in Table 2, and all other estimates of total waste stream percentages, we continue to rely on our 1992 estimate of a total Long Island solid waste generation rate of approximately 3.25 x 10^6 tons per year. Also note that certain data points have been rounded (from earlier presentations) to account for some data uncertainties.

Table 2. 1994 Long Island Municipal Recycling Data, Augmented by Modelled Private Sector Recycling (in tons)

	Estimated or Known (1994)[4]	Modelled Private Sector	Estimated Total (1994)
Nassau County	**508000**	**19000**	**525000**
Glen Cove	3250	1500	4750
Hempstead	346418		346418
Long Beach	3655	2100	5800
North Hempstead	76442	15500	92000
Oyster Bay	78278		78278
Suffolk County	**300000**	**180000**	**500000**
Babylon	45658	29000	75000
Brookhaven	75500	59000	134500
East Hampton	6178	1000	7250
Huntington	56001	28000	84000
Islip	90000	43000	133000
Riverhead	3000	3400	6400
Shelter Island	1000	140	1140
Smithtown	13281	16000	29000
Southampton	9571	2800	12500
Southold	8000	1200	9250
Long Island Total	**825000**	**200000**	**1025000**
Estimated Percent of Total Waste Stream	25%	6%	31%

[4] Columns and rows in this table, and in others in this report, have a tendency not to sum because of rounding, or other precision factors. For example, the sum of municipal recycling in Nassau County is the sum of four exact scale tonnages and one estimated tonnage (from Glen Cove). The sum of the data is 508,043; because the Glen Cove data was rounded to 250 tons, the County data was rounded to the thousands (508,000) to reflect the uncertainty. In the same fashion, the sum of municipal recycling in the ten Towns in Suffolk is 308,189; however, because of the use of estimated tonnages in Islip, Riverhead, Shelter Island, and Southold, this data point was rounded to 25,000 tons to be conservative. Similarly, the sum for Long Island (816,232 tons) was rounded to 25,000 tons (825,000 tons). Although this is somewhat subjective, strict application of data precision rules would limit the results excessively.

Another means of presenting this data is in terms of pounds recycled $person^{-1}$ $year^{-1}$. This allows for easy understanding of the data across municipalities of vastly different sizes (and allows for the inevitable comparisons). Table 3 therefore translates Table 2 into per capita data (note that some of the data rounding in Table 2 has been accounted for in this presentation; nonetheless, uncertainties in the data may not be fully measured).

Table 3. 1994 Long Island Per Capita Recycling Rates, by Municipality (Municipal and Private Sector Data) (in lbs. $person^{-1}$ $year^{-1}$)

		1994	Degree of Rounding[5]
Nassau County		**825**	**25**
	Glen Cove	400	25
	Hempstead	955	1
	Long Beach	340	10
	North Hempstead	870	10
	Oyster Bay	536	1
Suffolk County		**750**	**25**
	Babylon	740	10
	Brookhaven	660	10
	East Hampton	900	10
	Huntington	880	10
	Islip	900	25
	Riverhead	550	50
	Shelter Island	1000	50
	Smithtown	510	10
	Southampton	550	10
	Southold	925	25
	Long Island Total	**775**	**25**

[5] The "degree of rounding" indicates the amount that the data were rounded to. The size of this rounding is dependent on the reported accuracy of the underlying tonnages or the use of (rounded) estimates, and, in these cases, size of the populations that were divided into the tonnages. For Hempstead, for example, the tonnages were reportedly accurate and precise to six figures, as was the population; nonetheless, the per capita data is only reported as accurate and precise to three figures. For Glen Cove, the tonnages were estimated to be accurate to 250 tons; dividing by the population, that suggested that the per capita data should be rounded to approximately 25 pounds $person^{-1}$ $year^{-1}$.

Tables 2 and 3 represent conservative and yet complete estimates of total recycling tonnages on Long Island in 1994. By that, we mean that these data compilations correspond to the kind of data presented by nearly all Long Island municipalities in one form or another. There was no major expansion of the kinds of recyclables accountings. These two tables do include flaws such as of counting non-MSW wastes (such as C&D recyclables), and include wastes that may not have actually reached recycling markets. Some of the data are estimates of actual waste flows (albeit what we believe to be well-justified estimates). These evaluations are similar in development and intent to most others attempted in New York State, or for the country as a whole. In fact, we hope that the methodology we have used is more careful than most others used nationwide. Therefore, the quantities found in Tables 2 and 3 are what most authorities would consider to be Long Island's recycling tonnages and rates.

However, two additional, possible sources for recycling credits had been discussed in Plumbing the Unknown. These were paper recovery directly by the producer (as with Waldbaum Supermarkets' extensive corrugated cardboard recycling program), and the hypothesized composting of yard wastes by landscapers (Tonjes and Swanson, 1996d). These tonnages are somewhat "irregular" in terms of most recycling calculations.

A major concern is that these particular materials have usually been excluded (unintentionally) from most accountings of Long Island's wastes. These credits, as noted in our report, may not have been included in the data sets that we based our 1992 estimations of the total Long Island waste stream. Factors such as these are among the reasons that the waste stream size was reported as 3.25×10^6 +/- 0.25×10^6 tons year^{-1}, although generally we have ignored the uncertainty factors in this current series of reports. Adding the tons of recyclables to the numerator of the recycling rate calculation while keeping the denominator unchanged is perhaps an additional source of error and uncertainty. However, given that the overall waste stream uncertainty is approximately 0.25×10^6 tons year^{-1}, the addition of these materials is not yet sufficient to change the overall waste stream estimate, in our judgement.

Nonetheless, we have identified these tons of paper and composting as recycled materials from the Long Island waste stream. This suggests that they should be included in any complete accounting.

We have applied these tonnages at the county levels. The generation of these materials almost certainly varies from locale to locale. Corrugated cardboard recovery rates depend on the density of supermarkets. This should generally correspond with populations, but only on a regional scale. Yard wastes recovery might be thought to vary with lot size (in typical suburban settings). However, use of lawn services may correlate more closely with income, and incomes (in general) are greater in Nassau County (where lot sizes, in general, are smaller). These complications suggest that attempting to distribute these credits on the municipal level would not have much credibility. At the level of precision (approximately 25,000 tons year^{-1}) associated with these tonnages, there does not seem to be good reason to assign more credits to either county. We have thus applied them equally, to produce Table 4 (a modification of Table 2).

Table 4. 1994 Long Island Recycling Data: Municipal, Private Sector, and Unreported Activities (in tons)

	Estimated or Known (1994)	Modelled Private Sector Recycling	Super-market OCC	Land-scaper Compost-ing	Estimated Total (1994)
Nassau County	**508000**	**19000**	**37500**	**37500**	**600000**
Glen Cove	3250	1500			4750
Hempstead	346418				346418
Long Beach	3655	2100			5800
North Hempstead	76442	15500			92000
Oyster Bay	78278				78278
Suffolk County	**300000**	**180000**	**37500**	**37500**	**575000**
Babylon	45658	29000			75000
Brookhaven	75500	59000			135000
East Hampton	6178	1000			7250
Huntington	56001	28000			84000
Islip	90000	43000			135000
Riverhead	3000	3400			6500
Shelter Island	1000	140			1150
Smithtown	13281	16000			29000
Southampton	9571	2800			12500
Southold	8000	1200			9250
Long Island Total	**825000**	**200000**	**75000**	**75000**	**1175000**
Estimated Percent of Total Waste Stream	25%	6%	2%	2%	36%
1994 Per Capita Rate (lbs.):					
Nassau County					925
Suffolk County					875
Long Island					900

Table 4 suggests that Long Island, as a whole, had a recycling rate of approximately 36% (in the vicinity of 900 pounds per person) in 1994. Again, in considering the rate in terms of percentages of the waste stream, the reader should be aware that we have generally been increasing the numerator of the calculation without concurrently changing the denominator. This may lead to some rate inflation, as discussed above.

One final recycling element should be considered. In an idiosyncratic manner, New York State does not allow municipalities to include nickel-deposit containers in recycling statistics (New York State Department of Environmental Conservation, 1993). The same material thus can be counted as a recyclable if it is placed in a curbside recycling bin, but not if it is returned to a supermarket and redeemed for the nickel deposit. The number of containers so affected is quite large, and sums to large tonnages. In 1993 - 1994 (an undefined one-year period), the State estimated 324,168 tons were recovered. This data is an estimate calculated from a redemption rate of 76.4% in terms of container numbers. The tonnages were calculated by using averages of container weights, and applying the redemption rate equally to cans and bottles. The actual weight of the redeemed containers is not known (New York State Department of Environmental Conservation, 1995).

Long Island is believed to be not as good at redeeming the containers as are other parts of the State. A large number of the unredeemed containers have ended up in recycling bins, however, based on personal observations, and some experimental work conducted for the Town of Brookhaven.

Data generated by the Town of Hempstead suggested that its residents recovered 26,167 tons in 1991 (CSI Resource Systems, 1993). This would compute to a rate of approximately 72 pounds person^{-1}. This per capita redemption weight is approximately double the per capita rate State-wide (300,000 tons divided by 18 million people results in per capita returns of 30 - 40 pounds person^{-1} for New York State as a whole). The Hempstead estimate is based on a recovery rate of 80% of the returnable waste stream. This recovery rate, generated by the Town's consultant, is contrary to the anecdotal data that Long Island does not collect containers as well as other parts of the State.

The Hempstead data do accord with perceptions that the much higher per capita incomes found on Long Island should result in the greater generation of deposit bottles (soda and beer containers), and therefore, perhaps lead to greater recovery rates per capita. The greater income on Long Island could result in proportionately greater generation of cans and bottles than would be expected as in a linear relation between income and container generation rate. This would be so if these containers (and their contained products) are considered to be part of discretionary spending -- which seems to be the case.

All of these considerations create a great deal of uncertainty regarding the data for deposit container redemption in Hempstead. We have thus created a model of deposit container returns by Long Island municipalities that depends partially on the Hempstead data (the only Long Island-specific data that was easily accessed). We used a return rate of 50 pounds per person per year (two-thirds the reported Hempstead rate), except in Hempstead (where we used the published data). Combining this data with previous recycling data leads to Table 5. From the model, we can see that bottle return tonnages appear to be approximately equivalent to the tonnages assigned to supermarket cardboard recycling and private landscapers' composting.

Table 5. Augmented 1994 Long Island Recycling, using Published and Modelled Data (in tons)

	Estimated or Known (1994)	Modelled Priv. Sect.	OCC and Compost	Bottle Returns	Estimated Total 1994
Nassau County	**508000**	**19000**	**75000**	**40000**	**650000**
Glen Cove	3250	1500		600	5250
Hempstead	346418			26167	372585
Long Beach	3655	2100		800	6600
North Hempstead	76442	15500		5250	97000
Oyster Bay	78278			7250	86000
Suffolk County	**300000**	**180000**	**75000**	**33000**	**600000**
Babylon	45658	29000		5000	80000
Brookhaven	75500	59000		10250	145000
East Hampton	6178	1000		400	7500
Huntington	56001	28000		4750	90000
Islip	90000	43000		7500	140000
Riverhead	3000	3400		600	7000
Shelter Island	1000	140		50	1200
Smithtown	13281	16000		2750	32000
Southampton	9571	2800		1100	13500
Southold	8000	1200		500	9750
Long Island Total	**825000**	**200000**	**150000**	**75000**	**1250000**
Estimated Percent of the Total Waste Stream	25%	6%	5%	2%	38%
Estimated Percent of Adjusted Waste Stream	24%	6%	4%	2%	36%

Another row was added in Table 5 to the familiar format. The percentages of the waste stream have been calculated throughout this report series using 3.25×10^6 tons year^{-1} as a total waste stream size, based on our earlier work (Tonjes and Swanson, 1992). The data presented there, however, suggested that the uncertainties associated with the calculation could result in a waste stream as large as 3.5×10^6 tons year^{-1} (or as small as 3.0×10^6 tons year^{-1}), because of the 0.25×10^6 tons year^{-1} estimate uncertainty. In our discussion of additional sources of recycling tonnages, we have mentioned that it is possible that the denominator of the percentage calculation could need to be increased as the numerator was increased. The adjusted waste stream calculation shown in Table 5 uses the larger waste stream estimate of 3.5×10^6 tons year^{-1}. It seems reasonable to consider the recycling rates in light of this larger tonnage, given that three 0.075×10^6 tons year^{-1} recycling credits have been added to the recycling estimates, and we are not excluding certain wastes (recovered construction and demolition debris, for example) that are sometimes considered not to be municipal solid wastes. All-in-all, it appears that our recycling tonnage inclusions are based upon a maximal Long Island waste stream definition.

This adjustment is not directly based on the addition of approximately 0.25×10^6 tons year^{-1} of recycling credits that had not been considered in earlier work. Rather, the adjustment speaks to what is suggested by the discovery of these recycling credits. It is that the data collected on Long Island regarding waste stream size do not match exactly with the actual waste streams (and appear, overall, to undercount that waste stream somewhat). We have previously discussed how the waste streams counted by municipalities (for example) include materials that should not be counted, and do not account for other materials that should be included (Tonjes and Swanson, 1992; Tonjes and Swanson, 1994; Tonjes and Swanson, 1996a). As we have expanded the count of recyclables gathered on Long Island, beyond those usually counted, we believe that this supports the use of the maximal waste stream size as well. Whichever waste stream size is used, the data shown here suggests that it is possible to create a reasonable Long Island-wide recycling rate in excess of 35%, based on a recycling approximately 1.25×10^6 tons in 1994.

Using the data from Table 5, it is possible to construct a per capita recycling rate for each municipality, again following the format seen before. Technically, this rate should merely be 50 pounds person^{-1} year^{-1} greater than that calculated in Table 3 -- as that was what was modelled -- and for most municipalities it is, approximately; however, rounding of the data did cause a few distortions of the model.

Table 6. Maximal Long Island Per Capita Recycling Rates (pounds person^{-1} year^{-1})

Nassau County		**1000**
	Glen Cove	425
	Hempstead	1027
	Long Beach	400
	North Hempstead	925
	Oyster Bay	600
Suffolk County		**900**
	Babylon	800
	Brookhaven	700
	East Hampton	925
	Huntington	950
	Islip	925
	Riverhead	600
	Shelter Island	1050
	Smithtown	575
	Southampton	600
	Southold	975
	Long Island Total	**950**

The County-wide rates in Table 6 are greater than a calculation of population-weighted means for each municipality because of the undistributed credits for supermarket cardboard and landscapers' composting. The data suggests that recycling rates for Long Island as a whole exceeds 2.5 pounds person^{-1} day^{-1}.

There is a large variation among the municipalities. This is somewhat troubling, as (for example) there does not seem to be as great a difference in total recycling operations from Glen

Cove to Hempstead, as is suggested in the data. This is despite efforts on our part to reduce disparities between what is counted as recycled in the different jurisdictions. However, it is important to note that the "worst" recycling rate still exceeded a pound $person^{-1}$ day^{-1}, and the "best" rates approached 3 pounds $person^{-1}$ day^{-1}.

The first portion of this volume discussed waste reduction. Part of that exercise was to create an estimate of potential waste reduction tonnages for the individual Long Island municipalities in 1994. Since a complete understanding of waste diversion includes the combination of waste reduction and recycling, we present Table 7 (a combination of Table 1 and Table 5).

Table 7. 1994 Long Island Waste Diversion Data (in tons)

	Estimated or Known (1994)	Modelled Priv. Sect.	OCC and Compost	Bottle Returns	Don'tBag It	Estimated Total 1994
Nassau County	**508000**	**19000**	**75000**	**40000**	**10000**	**650000**
Glen Cove	3250	1500		600		5250
Hempstead	346418			26167		372585
Long Beach	3655	2100		800		6600
North Hempstead	76442	15500		5250		97000
Oyster Bay	78278			7250	11000	97000
Suffolk County	**300000**	**183540**	**75000**	**33000**	**60000**	**650000**
Babylon	45658	29000		5000		80000
Brookhaven	75500	59000		10250	15000	160000
East Hampton	6178	1000		400		7500
Huntington	56001	28000		4750	7000	96000
Islip	90000	43000		7500	30000	170000
Riverhead	3000	3400		600	900	8000
Shelter Island	1000	140		50	100	1300
Smithtown	13281	16000		2750	4000	36000
Southampton	9571	2800		1100	2000	15500
Southold	8000	1200		500	750	10500
Long Island Total	**825000**	**200000**	**150000**	**75000**	**70000**	**1300000**
Estimated Percent of the Total Waste Stream	25%	6%	5%	2%	2%	40%
Estimated Percent of Adjusted Waste Stream	24%	6%	4%	2%	2%	37%

Table 5 suggests that it is possible that Long Island diverted something on the order of 1.3 x 10^6 tons of material from its waste stream in 1994, for a percentage diversion rate of between 35% and 40%. These numbers are noticeably higher than would have been reported had the reported municipal recycling data alone been used.

Table 8 presents the summed data from Table 7 on a per capita basis (and attempts to account for some of the data variation due to the use of rounded numbers). Again, the variation between different municipalities is striking, considering that the underlying structure of all Long

Island recycling programs in 1994 was essentially the same. The large amounts of wastes diverted from the waste stream by Long Islanders are most notable.

Table 8. 1994 Long Island Waste Diversion Rates (pounds $person^{-1}$ $year^{-1}$)

	Waste Diversion Rate	Degree of Rounding
Nassau County	**1000**	**50**
Glen Cove	450	50
Hempstead	1027	1
Long Beach	400	25
North Hempstead	925	25
Oyster Bay	675	25
Suffolk County	**1000**	**50**
Babylon	800	25
Brookhaven	775	25
East Hampton	950	50
Huntington	1000	25
Islip	1125	25
Riverhead	700	50
Shelter Island	1100	100
Smithtown	650	25
Southampton	675	25
Southold	1050	50
Long Island Total	**1000**	**100**

As a result of these calculations, it is possible to develop a Long Island-wide waste balance for 1994. This rough estimate will use a 0.25×10^6 tons waste increment, to account for the manifold uncertainties. The Waste-to-Energy incinerators on Long Island disposed of approximately 1.5×10^6 tons in 1994. Much less than 0.25×10^6 tons were landfilled -- approximately 100,000 tons -- and so this has been considered to be 0 (Tonjes and Swanson, 1996b). Approximately 1.25×10^6 tons were recovered through waste diversion. This suggests that $0.5 - 0.75 \times 10^6$ tons were transported off-Long Island. Considering that nearly 0.5×10^6

tons were supposed to have been transported by municipalities alone in 1994, the estimate for transported wastes appears to be biased low. However, because "spot market" wastes accounted for a good deal of the incinerator tonnages, it is possible that some wastes thought to have been destined for off-Island disposal were actually disposed at Long Island incinerators instead. This accounting appears to be credible, given the uncertainties involved.

Table 9. Estimated Long Island Waste Balance (tons per year)

	WTE Incineration	Waste Diversion	Off-Island Transport	Total
1994	1500000	1250000	750000	3500000
(approximate)	45%	35%	20%	

Conclusions

Waste reduction is considered to be the highest form of waste management in the hierarchical ranking of general waste management techniques. Nonetheless, it has often been given short shrift in general discussions of waste management, and can be difficult to describe and define.

We have defined waste reduction as two processes. One is the elimination or minimization of wastes through process changes and modifications. The other is the elimination or minimization of wastes by changing or modifying the description of the materials as "wastes" -- that is to say, excluding the materials from waste stream definitions. The first kind is generally performed by manufacturers, or product users; the second is often a function of disposal system management.

The first, especially when conducted by manufacturers in the normal course of business, appears to be much more effective in reducing waste production than the second process. Choices made by individuals to reduce wastes are also effective, especially when sponsored by the organization within which the action occurs (such as when a company espouses paper use minimization strategies by promoting double-sided copying or e-mail use). It is more difficult to eliminate wastes by, say, refusing to collect these materials -- as in "Don't Bag It" programs, where the amount of wastes is not decreased, but the management of the wastes changes.

Waste reduction has been relied upon to provide significant portions of the total waste diversion amounts targeted by regulatory agencies. New York State assigned nearly one-quarter of the reduction in the overall waste stream to waste reduction (8 - 10% of the overall 50% reduction goal). Nonetheless, recent State advisories have allowed that direct computation of waste reduction appears to be impossible.

We were able to create a credible estimation of waste reduction credits generated on Long Island through the "Don't Bag It" programs for yard wastes. We estimated that in 1994 approximately 70,000 tons were not managed through waste management programs because of this effort. It did not seem possible to calculate other credits due to waste reduction efforts.

Finally, it was possible to create an estimate of the tonnage recovered due to the nickel deposit program for containers. Another 75,000 tons are believed to be removed from the Long Island waste stream because of this.

Previous reports and the work here appear to account for all quantifiable waste recovery programs on Long Island. Therefore, we set out to generate comprehensive (and yet conservative) recycling and waste diversion statistics.

The sum of municipally-accounted for and private sector recycling on Long Island was found to be approximately 1.175×10^6 tons in 1994 (Table 4, page 34). This totaled to some 900 pounds $person^{-1}$ in 1994, and accounted for approximately 35% of the waste stream. The Town of Shelter Island appeared to recycle the greatest amount per person, at 1000 pounds $person^{-1}$ $year^{-1}$ (albeit that Town's per capita rates are affected by not including seasonal population fluctuations); however, data uncertainties due to rounding make this rate almost indistinguishable from the rates of Hempstead (at 955 pounds $person^{-1}$ $year^{-1}$) and Southold (at 925 pounds $person^{-1}$ $year^{-1}$). The Town of Hempstead would receive credit for recycling the greatest tonnages of any of the municipalities in this accounting.

Of some concern is the spread between different municipalities that do not appear to have such distinctly different recycling programs. For example, there appear to be many parallels between the Town of Hempstead and the City of Glen Cove recycling and overall waste management programs. Nonetheless, by the time all the recycling sources are tallied, residents of Hempstead had approximately twice the per capita recycling rate as residents of Glen Cove. We do not see any serious methodological problems in our analysis; it may be that differences between what is and is not counted in these municipalities is what creates the difference in rates. The situation appears to be the same for other Long Island municipality groupings.

We estimated that nickel deposit recycling was nearly 2% of the waste stream (approximately 75,000 tons in 1994). This raised the estimates for the Long Island-wide recycling percent to 36% - 38% (the lower percent resulted from using a somewhat larger waste stream size estimate -- justified because of the continuing expansion in the determination of "recycled") (see Table 5, page 37).

Although the relative rank order of the municipalities (in terms of recycling rates) did not change, the following Towns all appeared to recycle more than 900 pounds person^{-1} year^{-1} in 1994: Hempstead and North Hempstead in Nassau County; and East Hampton, Huntington, Islip, Shelter Island and Southold in Suffolk County. The Long Island-wide recycling rate was approximately 950 pounds person^{-1} year^{-1}. Because of too many uncertainties in municipal waste stream sizes, we have declined to estimate the individual municipality's percentage recycling rates.

Waste reduction was estimated to also account for 2% of the total Long Island waste stream. This made overall waste diversion, Long Island-wide, between 37% and 40% of the total waste stream (see Table 7, page 41). Waste diversion tonnages totalled to approximately 1.3 x 10^6. Islip appeared to divert the most wastes on a per capita basis, at 1125 pounds person^{-1} year^{-1}. The uncertainties associated with rounding errors make it seem that the rates for Shelter Island (1100 pounds person^{-1} year^{-1}) and Southold (1050 pounds person^{-1} year^{-1}) were approximately equal to Islip's rate. Hempstead (1027 pounds person^{-1} year^{-1}) and Huntington (1000 pounds person^{-1} year^{-1}) also appeared to divert wastes at rates equal to or greater than the mean Long

Island per capita rate for 1994 (approximately 1000 pounds $person^{-1}$ $year^{-1}$), and East Hampton and North Hempstead were within error estimates of the Island-wide rate (the Long Island-wide rate was greater than the weighted mean of the municipalities because of some unallocated credits).

It is possible to construct, therefore, a range of recovery rates for Long Island as a whole (and, indeed, similar ranges for almost all of the individual municipalities). The variability in the data presented in Table 10 stems from the fact that all calculations of recycling for Long Island have hitherto not included some aspects of wastes recovery. The range of values is in keeping with a theme of this report: recycling rate calculations depend greatly on what is included in the calculations (and what is excluded).

Table 10. Calculated Recovery Rates for Long Island (1994 Data), using Three Waste Stream Sizes[6]

Estimate Number	Estimate Basis	Percent (2.6 x 10^6 tons)	Percent (3.25 x 10^6 tons)	Percent (3.5 x 10^6 tons)	Per Capita (lbs. $person^{-1}$ $year^{-1}$)
1	Curbside-Dropoff (Paper & Containers)	9%	7%	7%	175
2	All Municipally-reported	31%	25%	24%	625
3	(2) plus Unaccounted-for Commercial Sector		31%	30%	775
4	(3) plus "Other" – OCC and Yard Wastes		36%	34%	900
5	(4) plus Bottle Bill Returns		38%	36%	950
6	(5) plus "Don't Bag It" Estimates		40%	37%	1000

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[6] 2.6 x 10^6 tons is the waste stream size developed from municipally-reported data in 1994 (Tonjes and Swanson, 1996c); 3.25 x 10^6 tons is the total waste stream size we developed for Long Island in the early 1990s (Tonjes and Swanson, 1992), and argued was still valid for 1994 (Tonjes and Swanson, 1994c); 3.5 x 10^6 tons is the upper limit of the total Long Island waste stream according to our calculations (Tonjes and Swanson, 1992); the use of this as the total waste stream may be most appropriate when all-inclusive measures of recycling are considered.

We are not asserting that any of these rates is a better measure of Long Island's recovery prowess, at this time, although we expect to discuss the matter in the last volume of this report. Each has a certain validity -- depending on what is counted, of course, and what is not. These rates, as calculated here, do provide support for assertions that Long Islanders recover wastes better than most other areas of the country. In fact, it is likely that no other region can claim per capita rates approaching the half-ton recoveries shown here, and few can document as well the calculated percentages. In fact, 50% recycling rates of the nation-wide waste generation rate would result in per capita recoveries of only three-quarters (approximately 750 pounds) of what we have credited Long Islanders with.

It must be acknowledged that the large amounts of recovered wastes we have credited Long Islanders with at least partially stems from Long Island's waste generation rate. Although nation-wide estimates for waste generation have increased over the past few years, Long Island still generates much more waste than most other Americans do (approximately 7 pounds $person^{-1}$ day^{-1} here as compared with approximately 4 pounds $person^{-1}$ day^{-1} for the nation as a whole. Only Los Angeles has reliable waste stream data showing a considerably higher generation rate (approximately 9 pounds $person^{-1}$ day^{-1}).

Finally, this data allowed for the construction of an estimate for various elements of the waste management hierarchy on Long Island for 1994. Waste reduction could only be documented to recover less than 5% of the waste stream, and therefore was included with recycling as an overall "waste diversion" category. Waste diversion accounted for approximately

35% of the waste stream (to 5% accuracy). Incineration with energy recovery accounted for 45% of the waste stream. Landfilling was considered to be effectively 0%, as the Long Island Landfill law approached full implementation. Transport of wastes outside of the region for disposal, which is not part of the formal waste management hierarchy, accounted for the remaining 20% of Long Island's waste stream.

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References

Allaway, David. 1992. Does source reduction work? Resource Recycling. July, pp. 52-62.

Boerner, Christopher, and Kenneth Chilton. 1994. False economy: the folly of demand-side recycling. Environment. 36(1):6-15, 32.

Breslin, V., S. Reaven, M. Schwartz, L. Swanson, M. Zweig and M. Bortman. 1993. Secondary Materials: Engineering Properties, Environmental Consequences, and Social and Economic Impacts. L. Swanson, M. Bortman and J. Schubel, eds. Final Report. New York State Energy Research and Development Agency, Albany, NY.

CSI Resource Systems, Inc. 1993. Town of Hempstead Comprehensive Recycling Analysis. CSI Resource Systems, Inc., Boston, MA.

Cheremisinoff, Paul N. and John A. King. 1991. Waste minimization. Pollution Engineering. 23(3):64-72.

Dvirka and Bartilucci. 1984. Town of Huntington Solid Waste Quantification and Characterization. Dvirka and Bartilucci, Syosset, NY.

Dvirka and Bartilucci. 1988. Town of Brookhaven Draft Generic Environmental Impact Statement/Solid Waste Management Plan. Dvirka and Bartilucci, Syosset, NY.

Dvirka and Bartlucci. 1993. Town of Huntington Draft Solid Waste Management Plan and Generic Environmental Impact Statement. Dvirka and Bartilucci, Syosset, NY.

The Earth Works Group. 1989. 50 Simple Things You Can Do to Save the Planet. Earthworks Press. Berkeley, CA.

Fishbein, Bette K. 1994. Germany, Garbage, and the Green Dot: Challenging the Throwaway Society. Inform, Inc., New York, NY.

Freedman, Mitchell. 1994. One Town's merchants left holding the bag? Newsday. February 16, p. 33.

Genillard, Ariane. 1993. Too much of a good thing. The Financial Times (London, UK). June 23, p. 10.

Green, Rosalie, and Tanis Rickmers. 1993. Office paper recycling procedures. In: The BioCycle Guide to Maximum Recycling. The JG Press, Emmaus, PA. pp. 157-160.

Harrison, E.Z. 1996. Waste Reduction through Consumer Education. Report 96-8. New York State Energy Research and Development Agency, Albany, NY.

Heil, J.H. and D.J. Tonjes. In press. Compost and composting. In: The Collected Papers of the Long Island Solid Waste Composting Conference. Waste Reduction and Management Institute, Marine Sciences Research Center, The University at Stony Brook.

Malcolm Pirnie. 1993. Design, Construct, Operate and Maintain a Solid Waste Recycling and Composting System. Draft Request for Proposals. Town of Southampton, Southampton, NY.

McDonalds Corporation and Environmental Defense Fund. 1991. Waste Reduction Task Force: Final Report. Environmental Defense Fund, New York, NY.

National Recycling Coalition. 1989. The National Recycling Coalition Measurement Standards and Reporting Guyidelines (Draft). The National Recycling Coalition, Washington, DC.

New York State Department of Environmental Conservation. 1995. Draft New York State Solid Waste Management Plan 1995-1996 Update. New York State Department of Environmental Conservation, Albany, NY.

New York Department of Environmental Conservation. 1993. 6 NYCRR Part 360: Solid Waste Management Facilities. New York Department of Environmental Conservation, Albany, NY.

New York State Department of Environmental Conservation. 1987. The New York State Solid Waste Management Plan. New York State Department of Environmental Conservation, Albany, NY.

Parvin, Jean. 1994. A pound of prevention. Resources. 16(1):13-14.

Reaven, SJ and DJ Tonjes. 1991. Waste avoidance in the restaurant industry. Waste Management Research Report. 3(1):15-16.

Reaven, S.J. and D.J. Tonjes, with E. Gallagher and S. Buckner. 1991. Town of Islip Restaurant Waste Reduction and Recycling Manual. Town of Islip, Islip, NY.

Swanson, R.L., V. Breslin, S. Reaven, S. Ross, R. Young and R. Becker. 1993. An Assessment of Impacts Associated with Implementation of the Suffolk County Plastics Law, Local Law 10-1988. Special Report # 106. Marine Sciences Research Center, The University at Stony Brook, Stony Brook, NY.

Tonjes, D.J. 1993. Town of Brookhaven Revised Solid Waste Management Plan. Town of Brookhaven, Medford, NY.

Tonjes, D.J. and R.L. Swanson. 1996a. Doing the Right Thing: Municipal Recycling Programs on Long Island in the 1990s: Part I of an Assessment of Recycling on Long Island. Special Report # 116. Marine Sciences Research Center, The University at Stony Brook, Stony Brook, NY.

Tonjes, D.J. and R.L. Swanson. 1996b. Comparing Apples and Oranges: Municipal Recycling Tonnages and Rates on Long Island in the 1990s: A. The Data Report: Part II of an Assessment of Recycling on Long Island. Special Report # 117. Marine Sciences Research Center, The University at Stony Brook, Stony Brook, NY.

Tonjes, D.J. and R.L. Swanson. 1996c. Comparing Apples and Oranges: Municipal Recycling Tonnages and Rates on Long Island in the 1990s: B. The Data Analysis: Part II of an Assessment of Recycling on Long Island. Special Report # 118. Marine Sciences Research Center, The University at Stony Brook, Stony Brook, NY.

Tonjes, D.J. and R.L. Swanson. 1996d. Plumbing the Unknown: Recycling Practices, Tonnages and Rates in the Private Sector on Long Island in the 1990s: Part III of an Assessment of Recycling on Long Island. Special Report # 119. Marine Sciences Research Center, The University at Stony Brook, Stony Brook, NY.

Tonjes, D.J. and R.L. Swanson. 1992. Where Does It All Go? The Size and Method of Disposal of Long Island's Solid Waste 1986 and 1991. Special Report # 103. Marine Sciences Research Center, The University at Stony Brook, Stony Brook, NY.

Town of Brookhaven Department of Waste Management. 1996. Talkin' Trash. Town of Brookhaven, Medford, NY. Spring edition.

Town of North Hempstead. 1993. Town of Babylon/Town of North Hempstead Solid Waste Management Plan/Generic Environmental Impact Statement. Town of North Hempstead, Port Washington, NY.

United States Environmental Protection Agency. 1992. The Consumer's Handbook for Reducing Solid Wastes. EPA530-K-92-003. United States Environmental Protection Agency, Washington, DC.

Vitale, David. 1993. NYSDEC comments on the Town of Brookhaven Solid Waste Management Plan and Revised Comprehensive Recycling Analysis. In: Tonjes, D.J. 1993. Town of Brookhaven Revised Solid Waste Management Plan. Town of Brookhaven, Medford, NY.

Personal Communications

Black, J.A., J.H. Heil and John Bockino. 1991. Thermodynamics, MSW, supply/demand, NIMBYs, PIGs, and NIMTOFFs. Unpublished manuscript. Received from J.A. Black.

Bunchuck, Jim. 1994. Supervisor, Department of Public Works. Town of Southold, NY.

Reaven, S.J. 1991. The concept of recycling. Department of Technology and Society, The University at Stony Brook. Unpublished manuscript.

Scully, Peter. 1994. Commissioner, Department of Environmental Control, Town of Islip, and President, Islip Resource Recovery Agency, Town of Islip, NY.

Sherman, Huson. 1994. Supervisor, Town of Shelter Island, NY.

Sullivan, Julie. 1996. President, Association for Resource Conservation, Centerport, NY. Personal communication, and flyer.

Swanson, R.L. and S. Ross. In preparation. LI Plastics Bill. Unpublished manuscript.

Tonjes, D.J. 1992. A Waste Reduction Plan for the Sayville Inn. Masters Project, Department of Technology and Society, The University at Stony Brook. Unpublished manuscript.

Waste Reduction and Management Institute. In preparation. Consumer choices in orange juice containers. Unpublished manuscript.