ECONOMIC & ENVIRONMENTAL BENEFITS OF A DEPOSIT SYSTEM FOR BEVERAGE CONTAINERS IN THE STATE OF WASHINGTON

Prepared by:

Dr. Jeffrey Morris
Sound Resource Management Group
Olympia, Washington
360-867-1033
jeff.morris@zerowaste.com

Bill Smith
City of Tacoma
Tacoma, Washington
253-593-7719
bsmith@ci.tacoma.wa.us

Rick Hlavka
Green Solutions
South Prairie, Washington
360-897-9533
rick@green-solutions.biz

Prepared for:

City of Tacoma Solid Waste Management
3510 S. Mullen Street
Tacoma, WA 98409

April 2005

ACKNOWLEDGMENTS

The authors would like to give special thanks to the following for providing information that was used in this report:

- the Northwest Product Stewardship Council (NWPSC),
- various organizations and staff in other states,
- several Washington State Department of Ecology staff, and
- the Container Recycling Institute (CRI).

This study was funded by the City of Tacoma Environmental Services Division.

Printed on recyclable, recycled-content paper

CONTENTS

Table of Contents, continued

LIST OF TABLES

LIST OF FIGURES

Executive Summary

The National Overview

Recycling has now come full circle. Where once recyclers collected various materials with hope and a prayer that they could find markets for them, demand now exceeds supply for most materials. At the same time, results of recycling programs across the country have stagnated, and the best efforts for curbside and commercial recycling programs can only expect a 30% to 50% recovery rate. Clearly it is time to examine new approaches to recycling, or perhaps to re-consider old approaches. One such approach is a "bottle bill," or a deposit on containers, which provides a financial incentive for people to recycle their bottles and cans. Granted, this approach only addresses a portion of the resources that are currently being wasted, but other materials in our discards are being addressed through various other programs under development now (as in the case of electronics and compostable materials) or will need to have their own solutions developed soon.

There is no doubt that "bottle bills" are an effective method of boosting recovery rates. The eleven states that have container deposits account for 55% of the national recovery rate with only 29% of the population. These residents account for 490 containers per capita per year at a cost of 1.53 cents per container. The 40 non-deposit states which rely solely on curbside or drop off recycling programs recycle less than half as much, only 191 containers per capita per year, at a cost of 1.25 cents per unit. Either the residents of these 11 states are more environmentally aware and concerned than the rest of us or the container deposits have something to do with the increased recovery rate.

Beverage container sales are growing, particularly for new beverages such as bottled water and other non-carbonated drinks. As sales have increased, so has waste. In 2002, an estimated 118 billion aluminum, glass and plastic beverage containers were wasted nationwide, an 83% increase in wasting since 1992, and a 109% increase since 1982. There are costs associated with managing discarded one-way beverage containers, whether through recycling, disposal or litter clean up. The question for policymakers is "Who should pay these costs?" Refundable deposits shift the costs of managing discarded containers from government and taxpayers to producers and consumers of the beverage products.

Container recovery is down nationwide for all types of containers even though the number of households with access to curbside recycling has increased 600% since the early 1990's. Aluminum recovery is down from a high of 65% in 1992 to 48% in 2002; plastic bottle recovery is down from a high of 40% in 1995 to less than 20% in 2002. Glass container recovery has remained fairly constant at 30% but glass is rapidly becoming a contaminant to the recycling stream because of the way it is collected.

Most recycling systems collect glass commingled or mixed with other recyclables for faster, more efficient collection, which unfortunately results in a mixture of the colors of glass that is highly contaminated. Glass processors would prefer that glass be collected separately and separated by color but to do this is very slow and expensive for the collectors, and difficult for the recycling participants. The advent of "single stream" or commingled recycling has reduced the market value of glass to a negative in most cases. It is estimated that single stream recycling will be the dominant collection method within 5 years. In addition, because of the move away from glass as a container, the volumes of glass in the recycling mix are decreasing as well. As a result of the changes in collection and the resulting negative market value, many jurisdictions already have or are considering dropping curbside glass collection.

At the same time that recovery rates are declining, our domestic aluminum and plastics recyclers are in danger of going out of business for lack of supply. China's emergence as an economic power has enabled the Chinese to effectively compete for the increasingly limited supply of aluminum and plastic containers collected for recycling. This has left our domestic recyclers short of supply, so short that they are in danger of collapse. One major trade group for the plastics bottle recyclers has recently closed all of their satellite offices and another is sponsoring federal legislation to ban the export of bottles to China.

This wasting of containers has environmental impacts as well. Since the first Earth Day in 1970, 2.3 trillion beverage containers have been wasted (landfilled, littered or incinerated) in the United States. This includes:

- 961 billion wasted aluminum beverage cans weighing about 17 million tons,
- 324 billion wasted steel beverage cans weighing about 28 million tons,
- 276 billion wasted PET plastic beverage bottles weighing about 11 million tons,
- 190 billion wasted HDPE plastic beverage bottles weighing about 12 million tons, and
- 600 billion wasted one-way glass beverage bottles weighing about 166 million tons.

While all this beverage container waste has taken up landfill space, and has contributed to litter on our nation's roads, parks, beaches and other public places the more significant environmental impacts of wasting these containers are in replacement production. That is, using virgin materials and vast amounts of energy to make new containers to replace those that were never recycled. Pound for pound, replacement production also creates more pollution - in the air, water and on land - than recycling does. Had the 2 trillion containers been recycled, the equivalent of 800 million barrels of crude oil could have been saved, and the emission of an estimated 600 million tons of greenhouse gasses could have been avoided.

Many other environmental impacts could have been avoided as well, including the strip mining of raw bauxite ore and the flooding of vast forests to provide hydropower for the primary aluminum industry; oil drilling and its associated spills; many of the impacts of coal mining and burning; the generation of sulfur and nitrogen oxides (contributors to acid rain and smog) from energy production and other industrial processes and the emissions of toxic fluorides which harm livestock and vegetation.

The Situation in Washington State

Current recycling programs in Washington State are doing much to provide economic and environmental benefits. Economic benefits include the additional jobs created by industries using the recovered resources and reductions in disposal costs. Environmental benefits are numerous and widespread. The existing approach to recycling, however, appears to have hit a point of maximum returns, unfortunately well short of the actual amount of recyclable materials being generated. At the same time, other states have clearly demonstrated the success of deposit systems for increasing the amount of bottles and cans recycled. With the existing programs, approximately 33% of the beverage containers are being recycled. If a 10¢ deposit were placed on beverage bottles and cans, the recycling rate could climb to 90% or more.

A deposit system in the State of Washington would provide quantifiable economic and environmental benefits with an estimated annual monetary value of $93 million (see Table E-1, or see Table 6-1 for more detail). For the City of Tacoma, the benefits would amount to $2.1 million. There would also be extensive economic and environmental benefits that cannot yet be quantified.

The costs of a deposit system depend critically on the structure of the container redemption and handling system. This report examines three different approaches for how returned containers and deposits could be handled: 1) redemption by retail stores, 2) the use of redemption centers, and 3) involvement by third-party organizations. The cost for each of these different approaches is shown in Table E-1. As can be seen by the results, a well designed and effective system could have a positive bottom line, even without

Table E-1
Summary of Costs and Benefits

Cost or Benefit	State of Washington	City of Tacoma
Benefits from Reduced Public Health and Environmental Impacts of Beverage Container Disposal	$20,900,000	$707,000
Economic Benefits of Increased Beverage Container Recovery	$72,361,000	$1,400,400
Total Environmental and Economic Benefits	**$92,969,000**	**$2,102,400**
Total Cost of Deposit System:		
Option A) "Retail Store" Approach	$150,293,500	$4,423,300
Option B) Redemption Centers	$61,043,500	$1,801,300
Option C) Third-Party Organization	$82,533,500	$2,433,300
Range of Costs	**$61,043,500 to $150,293,500**	**$1,801,300 to $4,423,300**
Total Net Gain or Cost	**Total impact ranges from a net gain of $31,925,500 to a net cost of $57,324,500**	**Total impact ranges from a net gain of $301,100 to a net cost of $2,320,900**

counting part of the benefits (such as additional employment opportunities or the economic value of part of the reduced public health costs and environmental damages).

The benefits of a container deposit system can be summarized as shown below.

A. Amount of Materials Captured through a Deposit System

The deposit system's benefits result from a projected total recovery of 190,100 tons per year of beverage containers statewide. This includes an additional 112,500 tons per year of beverage containers, plus the 77,550 tons already being recycled. Total collections would include:

- 135,500 tons of glass bottles;
- 21,600 tons of plastic bottles; and
- 32,380 tons of aluminum cans.

B. Quantifiable Benefits

A container deposit system would have many economic and environmental benefits, some of which are quantified in the following report. Quantifiable benefits include:

- $28.1 million in revenues from selling recovered beverage containers to recycling markets;
- $10.4 million from reduced litter and waste management costs;
- $11.3 million in reduced greenhouse gas emissions, mostly from energy savings as a result of not manufacturing as many beverage containers from virgin materials; and
- Another $9.6 million in reduced public health and environmental costs.

C. Non-Quantifiable Benefits

Many other positive impacts of the container deposit system are discussed in the report, but are not included in the monetary estimates for economic and environmental benefits because these impacts have not yet been accurately quantified. Non-quantifiable benefits include:

- Stronger and more sustainable local economies as a result of using recycled materials to manufacture products;
- Recreational and aesthetic gains from reduced litter;
- Reduced emissions of pollutants whose public health and environmental costs have not yet been quantified;
- Slower on-site accumulation of solid and hazardous wastes at resource extraction and processing, energy generation, and manufacturing operations; and
- Productivity improvements in agriculture, fishing and forestry due to reduced ecosystem impacts.

D. Bottle Bill: Significant Additional Benefits at Reasonable Cost

Based on the data and analysis contained in the report, we expect that a beverage container deposit system would:

1. Recover more containers at a more reasonable cost than other recycling systems:

- Existing recycling systems are estimated to recover only 28% (by weight) of the beverage containers;
- Many of the targeted containers are being lost during the recycling process, either due to breakage of glass or by being incompletely sorted and then sent to the wrong market (such as cans and bottles being carried along in bales of paper);
- Glass containers are causing problems for recycling programs throughout the state, and a deposit system would provide an alternative method to handle over two-thirds of these;
- The results of curbside recycling programs have neared their peak, and there is no other method (not even mandatory recycling) that can achieve the same recovery rate for containers as a deposit system.

2. Generate additional public health and environmental benefits totaling approximately $20.9 million each year from recovery of additional containers, as a result of:

- Substitution of recycled containers for virgin raw materials in manufacturing new containers and other products (which reduces the amount of pollution that occurs during virgin raw materials drilling, digging, or cutting and refining, smelting, or pulping);
- Reduced disposal of beverage containers (which lessens the release of chemical pollutants during garbage collection and landfill/incinerator disposal);
- Reduced greenhouse gas and other emissions (because the use of virgin materials in manufacturing beverage containers and other products is very energy intensive); and
- Decreased litter, which:
  - ➢ reduces public health costs because of fewer hospital emergency room visits resulting from cuts on broken glass,
  - ➢ reduces agricultural damage, and
  - ➢ reduces private and public costs from cleanup.

Conclusion

Container deposits increase container recovery, reduce environmental pollution, create jobs and place the cost of recovery on those who produce and consume the containers. If these are legitimate public policy goals, then container deposits are a proven way to get there.

If there is interest in pursuing container deposits for Washington State, there needs to be a process that includes the key stakeholders in discussions that result in the preferred type of deposit system. Several methods exist for setting up deposit systems, and some of those will work better in Washington than others.

I. Current Systems

A. Current Programs in Washington State and the City of Tacoma

1. Recycling Programs: recycling programs in Washington State have successfully mined the waste stream for valuable materials for the past 20 years. Recycling and waste reduction existed long before 20 years ago, of course, but the 1980s saw the beginnings of municipal involvement and joint partnerships that have helped expand the universe of recycling to new sources and new materials. As shown in the *13th Annual Status Report* from the Department of Ecology (Ecology 2004), the measurable overall recycling rate grew from 15% to 38% during that period (see Table 1-1).

In terms of current (2003) tonnage, the difference between 15% and 38% means that another 1.8 million tons of material was recycled in 2003 that might otherwise have been wasted if society had not deemed it important in the 1980s to start doing things differently. The *13th Annual Status Report* also tells us that we have done a good job of providing citizens with the opportunity to recycle. In 2003, residents in 159 cities and unincorporated areas were able to recycle through curbside pickup. Most of those areas (77%) also received curbside collection of yard debris. As of late 2004, 81.5% of the state's population had access to curbside recycling services. The number of commercial and industrial recycling opportunities is more difficult to count, but in most areas the commercial sector is also doing its share of recycling.

Table 1-1: Historical Recycling Rate

1986	15%
1988	28%
1989	27%
1990	34%
1991	33%
1992	35%
1993	38%
1994	38%
1995	39%
1996	38%
1997	33%
1998	35%
1999	33%
2000	35%
2001	37%
2002	35%
2003	38%

But what can a closer look at the recycling rate tell us? Examining the trend in the recycling rate shows that the state repeatedly hit a level of about 38% only to drop back a little and then start climbing again. This could be a sign that we have achieved nearly the maximum potential with the current systems, and are "bumping against a glass ceiling" with the recycling rate. At the same time, we know that there are still a lot more recyclable materials left in the garbage, and that there is substantial demand for those resources. Perhaps it is time to try new ideas to help us achieve greater levels of recycling?

In the City of Tacoma, recycling programs have also been stable for the past few years, although the City continues to seek a better solution for the collection of glass. Glass bottles and jars are kept separate in their collection system, but all other materials are commingled. The City collects from all single-family homes, some of the apartment units (participation by apartment buildings is on a sign-up basis), and from small businesses that are on the same routes as residential collections. The City also conducts special collections with one truck to pick up source-sorted glass and other materials from larger commercial generators, and another recycling route that collects cardboard from apartments and businesses.

Tacoma's recyclable materials are brought to a local processor (JMK Recycling) and the city receives the sales revenues minus a processing fee for those materials. In a recent month (March 2005), the City received $55,102 for 1,527 tons of material delivered by city trucks to the processor. The payments for the recyclables varied from a high of $860 per ton of aluminum cans to a low of -$20 per ton (in other words, a fee of $20 per ton) for mixed glass (the price for glass reflects the fact that it is not separated by color). The amount of the processing fee is currently $23.65 per ton for the commingled materials, and $2.00 per ton for the glass. The fee for glass is simply for handling and transferring it, since it is collected and delivered separately by the City of Tacoma, and then JMK Recycling transfers the glass to Fibres International in Seattle for processing.

2. Litter Programs: the Litter Tax was adopted in 1971 as part of the Washington State Model Litter Control and Recycling Act. A tax of fifteen thousandths of one percent (0.015%) is imposed on the gross proceeds of sales by manufacturers, wholesalers and retailers for the items that have been identified as likely contributors to litter (including beverage containers). The product categories are defined in state law (RCW 82.19.020) and shown in the sidebar. In 2003, this program generated $6.4 million in revenues. Funds collected through this tax are placed into a special account within the state treasury known as the Waste Reduction, Recycling, and Litter Control Account. RCW 70.93.180 provides clear direction on how litter account funds are to be allocated:

- 20% is to fund the Community Litter Cleanup Program (CLCP);
- 30% is to help fund waste reduction and recycling efforts; and
- 50% is to fund litter cleanup by Ecology and other state agencies.

Besides funding the Ecology Youth Corps, the 50% dedicated to the state's cleanup efforts also funds litter activities carried out by other agencies (Natural Resources, Corrections, Transportation, Parks, and Revenue). The 20% for CLCP is provided to counties to conduct litter cleanup programs. The 30% used to help recycling pays for the state recycling hotline, some staff and other activities.

The litter cleanup programs are an important part of keeping our environment clean and livable, but picking up pieces of litter is possibly the most expensive method of solid waste management. In 2002, a total of 7,401,004 pounds were picked up from 51,740 miles of road and 4,245 illegal dumps by the various litter cleanup crews. This was done at a cost of $4.4 million, or $1,200 per ton of litter.

Litter Tax Categories:

1. food for humans or pets
2. groceries
3. cigarettes and tobacco
4. soft drinks and carbonated waters
5. beer and other malt beverages
6. wine
7. newspaper and magazines
8. household paper and paper products
9. glass containers
10. metal containers
11. plastic or fiber containers made of synthetic material
12. cleaning agents and toiletries
13. nondrug drugstore sundry products

In 2003, Pierce County ranked second in the state in terms of population (12.0% of the State's total) and also in terms of miles driven on roads in the county (10.6% of State's total), although the county only ranked 10th in terms of total miles of interstate, state and county roads (3.8% of the State's total). In 2003, a total of 164,060 pounds were collected from roads and illegal dumps, of which 14,328 pounds (11.5%) was recycled. In addition to receiving litter grant funds from Ecology, Pierce County also has its own program (Pierce County Responds). Most of this effort is on illegal dumps, and hence is outside of Tacoma city limits (for problems within Tacoma, code enforcement and other methods are usually able to address the problems).

Several surveys and studies have been conducted for litter. The Department of Ecology conducted litter surveys in 1982, 1983, 1985, 1987, 1990, and contracted out for studies in 1999 and 2004. The results of the 2004 study were not available at the time this report was prepared, but the results from the 1999 study are shown in Table 1-2.

Table 1-2
Amount of Cans and Bottles in Litter

	Roads	Interchanges	State and County Parks	Average
Aluminum Cans	4.2	1.6	4.1	4.0
Plastic Bottles	1.6	0.9	1.4	1.5
Glass Bottles	23.7	12.6	16.1	21.2
Totals	**29.5**	**15.1**	**21.6**	**26.7**

All figures are percent by weight. The average is a weighted average based on the amount of litter at each location.

3. Disposal Programs: solid waste collected throughout the state has repeatedly been shown to contain substantial amounts of recyclable beverage containers. Aluminum cans, for instance, have been found in amounts ranging from 0.28% by weight in Seattle to 0.93% in Lewis County (GS 2003a). A recent study done for Clallam County (GS 2003b) provides a breakdown of the glass containers by color and by beverage versus non-beverage (see Table 1-3). Table 1-3 also shows averages of the data from three other studies (for Thurston County, King County and Seattle, all conducted in the year 2000), which provides "best-fit" data for Tacoma, and data from the *Waste Composition Analysis for the State of Washington* (GS 2003a).

Table 1-3
Percent of Cans and Bottles in the Waste Stream

	Clallam County, 2003			Average of Three Counties	Statewide Data
	Residential	Commercial	County-wide Average		
Aluminum Cans	0.85	0.81	0.91	0.40	0.5
PET Bottles	0.86	1.23	1.15	0.41	0.5
HDPE, Natural	0.59	0.32	0.57	0.25	All HDPE =
HDPE, Pigmented	0.67	0.50	0.53	0.31	0.6
Glass Bottles:					
Beverage only;	3.34	3.17	2.73		
Clear	1.52	1.60	1.29		
Brown	1.14	0.95	0.91		
Green	0.68	0.62	0.53		
All bottles & jars;	4.31	3.54	3.30	2.51	2.8
Clear	2.46	1.96	1.84	1.47	1.7
Brown	1.15	0.96	0.92	0.62	0.7
Green	0.70	0.62	0.54	0.43	0.4

All figures are percent by weight.

B. Deposit Programs in Other States

It was not until after World War II that cans began replacing glass bottles in the beer industry. The convenience and disposability of cans helped boost sales at the expense of refillable glass bottles, and by 1960 approximately 47% of beer sold in the U.S. was packaged in cans and no-return bottles. Soft drinks, however, were still sold almost exclusively in refillable glass bottles requiring a deposit. The market share for cans was just 5%. With the centralization of the beverage industry, and a more mobile and convenience-oriented society, the decade of the sixties witnessed a dramatic shift from refillable soft drink "deposit" bottles to "no-deposit, no-return, one-way" bottles and cans.

The gradual demise of refillable beer and soft drink bottles in the fifties and sixties and the rise in one-way, no-deposit cans and bottles resulted in an explosion of beverage container litter. This prompted environmentalists to propose bottle bills in their state legislatures that would place a mandatory refundable deposit on beer and soft drink containers.

The first bottle bill was passed in Vermont in 1953. It merely banned the sale of beer in non-refillable bottles, however, and it did not institute a deposit system. The law subsequently expired four years later after strong lobbying from the beer industry.

By 1970, cans and one-way bottles had increased to 60% of the beer market, and one-way containers had grown from just 5% in 1960 to 47% of the soft drink market. British Columbia enacted the first beverage container recovery system in North America in 1970.

In 1971, Oregon passed the first bottle bill requiring refundable deposits on all beer and soft drink containers. By 1987, ten states (representing over one-quarter of the U.S. population) had enacted some form of beverage container deposit law or bottle bill.

These "bottle bills" were intended not only to reduce beverage container litter, but to conserve natural resources through recycling and reduce the amount of solid waste going to landfills. They proved to be extremely successful in achieving those goals.

Seven states reported a reduction of beverage container litter ranging from 70 to 83%, and a reduction in total litter ranging from 30 to 47% after implementation of the bottle bill. High recycling rates were also achieved.

Today, eleven states and eight Canadian provinces have bottle bills requiring refundable deposits on certain beverage containers. No state bottle bill or deposit law has ever been repealed. In fact, several states and provinces have expanded their laws to cover beverages such as juice and sports drinks, teas and bottled water -- beverages that did not exist when most bottle bills were passed. (The preceding section is excerpted from the Container Recycling Institute's website, http://www.bottlebill.org/).

C. Potential Results of a Deposit System in Washington State

For the purpose of the analysis provided in this report, we are assuming that a 10¢ deposit system in Washington State would recover 90% of the eligible bottles and cans, just as the dime deposit does currently in Michigan. The following analysis illustrates the results of a 90% recovery level, although other sections of this report show the relative impacts of both a 5¢ and 10¢ deposit.

Table 1-4 uses the following data:

- The statewide annual tonnage for 2002 (4,703,879 tons) and recycling tonnages (total and by material) are from the *13th Annual Status Report* (Ecology 2004).
- Recycling tonnages for Tacoma are from reports by their processor plus source-sorted tonnages from the City's recycling center and glass collections. The amount of aluminum includes an estimated 200 tons handled by local buy-back centers. Disposal tonnages for Tacoma are from the City's records for 2002.
- The statewide amounts of each material in the waste stream were calculated using the figures shown in Table 6 (statewide totals) of the *Waste Composition Analysis for the State of Washington* (GS 2003a) and the total waste amount (4,703,879 tons) for 2002. For Tacoma, the amount of each material in the waste stream was calculated using Tacoma's annual waste quantity from 2002 (202,918 tons) and the averages of results from three waste composition studies: Thurston County (2000), King County (2000) and Seattle (2000).
- "Beverage Containers Potentially included in a Deposit" includes all types of beverage containers except milk and dairy products (which are typically not covered by deposits), and foil pouches (for which no data is available).
- Assumptions for the percentages of beverage containers contained in each material category are:
  - aluminum cans are estimated to be 96% beverage cans in both the recycling and waste streams based on previous research conducted for the BEAR report.
  - steel cans (tin cans) are assumed to be 0% for the sake of simplicity, but a very small amount of fruit juice containers can be found in this category.

Table 1-4
Amount of Cans and Bottles Recycled and Disposed

Statewide Amounts								
Type of Container	Tons Recycled (2002)	Tons Disposed (2002)	Beverage Containers Potentially included in Deposit, % by wt.		Total Amount of Containers Generated in 2002 (tons)		Total Tons Recycled at 90% Recovery	Additional Tons Recycled with 10¢ Deposit
			Recycled	Disposed	Deposit Containers	Non-Deposit		
Aluminum Cans	12,718	24,761	96%	96%	35,980	1,499	32,382	20,173
Steel Cans	9,417	49,779	0	0	0	59,196	0	0
PET Bottles	5,886	23,666	90%	75%	23,047	6,505	20,742	15,445
HDPE Bottles	6,029	13,295	5%	5%	966	18,358	870	568
Glass	64,937	131,531	92%	69%	150,499	45,970	135,449	75,707
Milk Cartons, Aseptic	26	13,577	5%	5%	680	12,923	612	611
Total Packaging	99,013, or 27.8%	256,609			211,172	144,450	190,055	112,503
Total, All Materials	2,512,788, or 35%	4,703,879						

City of Tacoma								
Type of Container	Tons Recycled (2002)	Tons Disposed (2002)	Beverage Containers Potentially included in Deposit, % by wt.		Total Amount of Containers Generated in 2002 (tons)		Total Tons Recycled at 90% Recovery	Additional Tons Recycled with 10¢ Deposit
			Recycled	Disposed	Deposit Containers	Non-Deposit		
Aluminum Cans	423	812	96%	96%	1,186	49	1,067	661
Steel Cans	169	1,738	0	0	0	1,907	0	0
PET Bottles	419	825	90%	75%	996	248	896	519
HDPE, Clear	253	506	5%	5%	38	721	34	22
HDPE, Colored	225	620	5%	5%	42	803	38	27
Glass:	1,657	5,093	92%	69%	5,039	1,711	4,535	3,010
Clear	543	2,983	76%	49%	1,874	1,652	1,687	
Brown	636	1,248	98%	98%	1,846	38	1,662	
Green	478	862	98%	98%	1,314	27	1,182	
Milk Cartons, Aseptic	NA	639	5%	5%	NA	NA	NA	NA
Total Packaging	3,146, or 23.5%	10,234					6,571	4,239
Total, All Materials	43,324, or 17.6%	202,918						

  - PET bottles are estimated to be 90% beverage containers in the recycling stream based on a study conducted for NAPCOR, and are estimated to be 75% of the waste stream based on a Seattle waste composition study (Cascadia 2002).
  - HDPE bottles are assumed to not contain many beverage containers once milk is excluded. Personal observations of the recycled materials in Tacoma were the basis for assuming 5% in both the recycling and waste streams.
  - glass bottles are estimated at 92% beverage bottles in the recycling stream based on data from the Seattle study (Cascadia 2002), and 69% based on data from the *Waste Composition Analysis for the State of Washington* (GS 2003a). For Tacoma, the percentage of each color that is beverage bottles comes from the same studies, but the breakdown by color for the total recycled glass tonnage is based on the relative amounts of source-sorted materials received at Tacoma's recycling center.
  - gabletop cartons and aseptic containers are almost entirely milk, and so the amount of non-milk beverages was assumed to be about 5% in both the recycling and waste streams.
  - no data is available from the recycling survey or waste composition studies for the amount of foil pouches currently recycled or disposed in Washington, but CRI estimates that gabletop cartons, aseptic containers and foil pouches altogether are only about 5% of the State's beverage market, excluding dairy (CRI 2005).

- the recovery rate of 90% is hypothetical, and the actual recovery rate will depend on the deposit value and the convenience of the redemption system. In addition, the figures shown in Table 1-4 assume that all beverage containers (except dairy products) would be included in the deposit system. If only carbonated beverages were included in the deposit, then the results would still be 72% of what is shown (in other words, non-carbonated beverages, including wine and distilled spirits, make up about 28% of the total containers).
- the last column, "additional recycling," is calculated based on the 90% recovery figure minus the beverage containers already being recycled.

The last two rows for the statewide and Tacoma columns for the amount of recycling also shows the recycling rate for packaging and for all materials. For Tacoma, this only represents the city's efforts and does not include the large amount of private recycling occurring in the city.

II. Container Deposit Systems

This part of the report provides a general description of how beverage container deposit systems work and what this means for Washington in general and for the City of Tacoma in particular. Since this report was prepared for the City of Tacoma, as an analysis of what a deposit system would mean for its recycling programs, much of the following analysis focuses on the City's programs and impacts to those programs. Much of the initial data, however, is only available on a statewide basis, and so this is where the analysis begins for many of the factors and issues addressed in this report.

A. What are the Possible Approaches to a Container Deposit System?

There are several different deposit systems that are in use or that could be used. The primary factors defining such systems are the point at which deposits are collected and by whom, the manner in which the unredeemed deposits are handled, the amount of deposit and the types of beverages covered by the deposit. One way to look at these variations is to combine them into three categories:

1. *Retail Stores*. Retail stores accept returned containers from consumers and refund their deposits (often called the "traditional" method or the "return to retail" method). This method is currently used in Oregon and several other states.
2. *Redemption Centers*. Consumers redeem containers at staffed "redemption centers." Variations of this system exist in California, Hawaii, Massachusetts, and Maine.
3. *Third-Party Organizations (TPOs)*. The redemption system is operated by third-party organizations (used in Canada and Europe, and proposed change to Oregon system).

There are many different variations possible with these approaches. For instance, deposits can be returned to consumers through the use of automated machines ("reverse-vending machines") in retail settings, redemption centers, and other commercial or public places.

1. Retail Stores for Collecting and Returning Deposits: most of the existing deposit programs use this approach, where the consumer can return containers to a retailer. The containers make their way through a handling and processing system, eventually reaching end markets. Historically, deposit systems relied on manual labor to collect and sort bottles, and redeem deposits to consumers. By 1999, however, an estimated 30% of containers redeemed through traditional deposit systems were redeemed through the use of unattended reverse vending machines (RVMs). These machines return the deposit refund to the consumer and have the capability to sort containers by brand, material type and color. These machines can also reduce volume by compacting, shredding or crushing.

Each party involved in handling and processing empty containers incurs a cost. The mechanics of each deposit system determine the distribution of those system costs.

Under a traditional deposit system, bottlers and distributors are responsible for collecting redeemed bottles and cans from retailers and redemption centers, and transporting them to processing centers for sale to recycling markets, and they incur equipment and labor costs from doing so. These costs can be offset in two ways: by revenue from material sales, and by retaining consumers' unclaimed deposits. Industry representatives argue that materials revenue and unclaimed deposits only partially offset their collection and processing costs, while others argue that unclaimed deposits are a windfall profit for bottlers and distributors amounting to tens of millions of dollars.

Retailers and redemption centers also incur operating costs. Most deposit laws require bottlers and distributors to pay retailers and redemption center owners a handling fee of 1 to 3¢ per container redeemed to offset operating costs.

Figure 2-1
Flow of Containers and Deposits in Traditional System

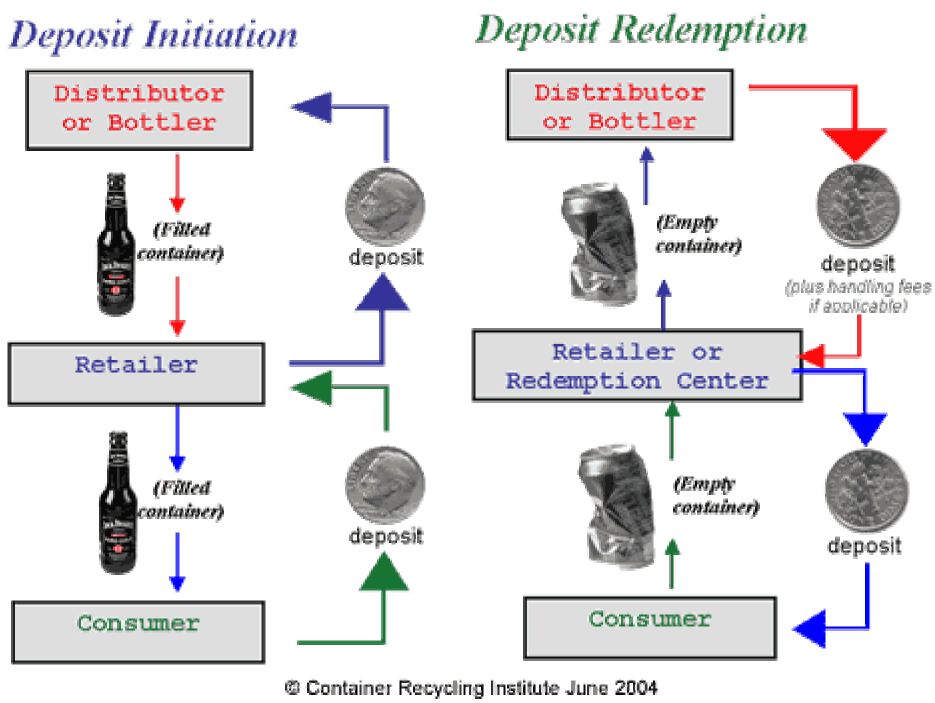


Figure courtesy of Container Recycling Institute, www.container-recycling.org.

Figure 2-1 shows the typical flow of the deposit and handling fees in a traditional deposit system. In some deposit systems, third-party recyclers, redemption centers and retailers share the redemption and handling fees, while in other states there are no third-party recyclers or redemption centers. A recent change in Massachusetts allows redemption center operators to refund only 4¢ of the 5¢ deposit to consumers, but consumers can receive the full refund by returning bottles and cans to a retailer.

In Massachusetts, 100% of the unclaimed deposits, or about $35 million per year, become the property of the state through an "escheat" provision. The funds were originally used for administering the deposit system, promoting recycling, and for other environmental purposes, but since 2004, they have been absorbed by the Commonwealth's General Fund. In Michigan, 25% of the unclaimed deposits are kept by retailers in lieu of a handling fee; 75% are retained by the state and used for environmental programs. Maine has experimented with both approaches.

Containers collected through traditional deposit systems are of high quality and yield the highest market value available, particularly for PET and color-sorted glass.

2. Redemption Centers: this approach is used in California (the "California Redemption System") and Hawaii. The California redemption system has many characteristics that are similar to a traditional deposit system, but some that are fundamentally different. The original law was enacted in 1986 as AB

2020 and has been expanded and modified through legislation several times. The California program differs from the other nine "traditional" deposit programs[1] in several ways:

- The program established the California Redemption Value (CRV). As originally drafted, the CRV was 1¢ per container. The law was later amended to establish a CRV of 2.5¢ for containers under 24 ounces, and 4¢ for containers 24 ounces and greater, and then amended again in 2004 to 4¢ and 8, respectively.
- Deposits are not physically handled by bottlers or distributors. Instead, deposits are handled through a state fund managed by the California Department of Conservation. Deposits are paid to the state by distributors and bottlers, and can be returned to consumers at state-certified redemption centers and programs, including buy-back recycling centers that existed prior to the law (called "old line recyclers," some argue these centers are far less prevalent in other states), and supermarket-based recycling centers (called "convenience zone recyclers," similar to redemption centers operating in some other deposit states). Deposit containers can also be recycled through municipal curbside programs. While consumers do not receive their deposits back directly this way, the curbside programs do receive deposit credit from the state, according to periodic surveys of CRV-container weight in the curbside stream (the audited "commingled rate"). All containers are ultimately handled through certified processors, which cancel the deposit on the container and handle the transfer of funds between the state and recyclers.
- Containers are not required to be segregated by brand. Instead, materials can be collected on a weight basis separated only by material type.
- Manufacturers are responsible for covering the cost of recycling each container type. The state establishes a processing fee based upon the net cost of recycling each container type. Processing fees are paid to the state, which distributes them to all types of recycling programs in the form of processing payments.
- Unredeemed deposits are held by the state and used for various programs, including: program administration, handling fees paid to convenience zone recycling centers, supplemental payments to curbside programs, and grants to local governments and non-profit organizations. Recently, unredeemed deposits have also been used to offset (lower) the processing fees paid by manufacturers.

The California system has generated a significant amount of controversy. It has been critiqued for the large government bureaucracy that administers it, its complexity, its inability to quickly adjust to changing market conditions (since processing fee surveys are conducted only annually), and the steady stream of legislation and litigation it has spawned. In spite of these critiques, however, the system has relatively low costs and yields significant recovery, although not as much as in states with higher deposit refund values.

The first change in California's system took effect in January 2000, and this change expanded the coverage from just carbonated soft drinks, beer and wine coolers to include virtually every beverage packaged in aluminum, glass, plastic or bimetal containers. The only beverages now excluded from the law are milk, wine, and distilled spirits. In the first year of the expanded program, the percentage of redeemed containers collected through curbside increased from seven to 15%, and the redemption rate (all recovery excluding curbside) decreased from 69% to 52%. Some feel this was a matter of a lag in education about the expanded system, but as of 2003 the redemption was still only 54%. Others feel the low redemption rate is to be expected in a state with strong curbside infrastructure and a relatively low deposit amount. Effective January 1, 2004, the CRV was increased to 4¢ for containers under 24 ounces, and 8¢ for containers 24 ounces and larger. As a result of this increase, the redemption rate increased to 65% in the first six months of 2004.

[1] "Traditional programs" include Connecticut, Delaware, Iowa, Maine, Massachusetts, Michigan, New York, Vermont, and Oregon.

3. Third-Party Organizations: a third-party organization ("TPO") is a private, not-for-profit organization that is established to implement and administer programs to recover and manage particular used consumer products for reuse and recycling. A TPO may be formed voluntarily by interested parties or in response to legislation. Membership may be comprised entirely of industry representatives, including manufacturers and retailers, or include other stakeholders, such as non-profit organizations, independent groups, and/or governments. Typically, a TPO's responsibilities include recruiting members; collecting fees and managing program funding; establishing and managing a product collection system; monitoring, evaluating and reporting program results; and program promotion.

Select industries have formed TPOs to assume product stewardship responsibilities. Examples of existing TPOs that illustrate different approaches to collective stewardship programs follow.

Rechargeable Battery Recycling Corporation (RBRC): RBRC was established in 1995 to manage the collection and recycling of nickel-cadmium (Ni-Cad) rechargeable batteries. The rechargeable battery industry voluntarily launched the organization after eight states mandated take-back programs for Ni-Cad batteries. RBRC was formed as an alternative to establishing separate mandated take-back systems in each state, as well as to preempt future legislation in other states.

Licensing fees are used to fund the organization's takeback program. The RBRC licenses its logo to manufacturers of rechargeable batteries and products that contain them. More than 95% of the portable rechargeable power industry in North America participates in the RBRC program. RBRC does not publish any cost or recovery data.

Carpet America Recovery Effort (CARE): in January 2002, members of the carpet industry, governmental agencies, and non-governmental organizations signed a Memorandum of Understanding (MOU) for management of waste carpet. This MOU was the result of a two-year negotiation process, in which participants joined together to implement a product stewardship plan to change how post-consumer carpet is managed in the U.S.

CARE is responsible for achieving an escalating target for diversion of waste carpet from landfills, with the ultimate goal of diverting 40% of post-consumer carpet within 10 years. CARE functions to enhance collection infrastructure for post-consumer carpet by creating demand in the marketplace for products that contain post-consumer recycled content from carpet; serve as a resource for technical assistance; and measure and report on progress toward fulfilling the MOU goals.

CARE is funded by a tiered sponsorship system. Current sponsors include carpet manufacturers, equipment and material suppliers, a professional trade association, and the US EPA. CARE employs an executive director and most likely an administrative assistant. The board consists of volunteers from the carpet industry.

Product Care: Product Care is an industry-sponsored association that manages stewardship programs in British Columbia, Canada for manufacturers of paint, flammable liquids, pesticides, and petroleum products. Developed in response to Canadian provincial stewardship regulations, Product Care partners with local governments, private industry and nonprofit groups to offer a depot collection system where consumers may return leftover paint, flammables, pesticides, and gasoline at no charge. Collectors may be compensated by Product Care for providing collection services at a rate negotiated by both parties, and then Product Care pays for transportation and disposal. The program is funded by a separate "eco fee" which manufacturers remit to Product Care. The eco fee ranges from $0.10 to $2.40 per container, depending on product type and container size. Manufacturers of impacted products have the option to absorb the eco fee or recapture the fee from consumers by adding the fee into the sale price of the product. (Thanks to the Northwest Product Stewardship Council, www.productstewardship.net, for the information on TPOs shown in the above section.)

B. Compatibility with Existing Recycling Programs

Many different recycling programs operate in Washington State to collect paper, cans and bottles from residential and commercial customers. Addressing these in detail would require a lengthy discussion and many assumptions about how these facilities would fit into a deposit system, but some generalizations can be made:

1. Compatibility with Single-Stream Recycling: many programs in the state have recently converted to "single-stream recycling," where all of the recyclable materials are placed into the same container for collection purposes. Materials are sorted after collection at processing facilities equipped with a combination of mechanical and manual methods, but this technology has yet to achieve the same quality of separation as previous source-sorting methods. Glass in particular is a problem, as much of it is broken during collection and then a portion of it is either not recycled or is shipped out with paper or other materials. It is not known what proportions of cans and bottles collected for recycling are being shipped out in paper bales to the wrong market. It is also uncertain what is happening to these containers in China and other foreign markets, but at U.S. paper mills these cans and bottles typically end up in the local landfill after causing numerous problems for the paper mill operations (GS 2003b, AOR 2004).

Single stream programs will lose some revenues from the sale of aluminum cans and PET bottles, but will have lower financial losses associated with handling glass. All in all, these facilities should probably embrace deposits as a method to eliminate at least part of the glass problem, thus reducing their residue stream and increasing the marketability of paper and other materials. If manual picking stations at these facilities can be modified to recover deposit containers, they will be able to offset the loss of market revenues by claiming the deposit for recovered cans and bottles, but only for the glass bottles that remain unbroken and only if the deposit system is designed to allow this redemption method. In a recent study for King County (Green Solutions, unpublished), it was found that about one-third of the glass bottles were crushed during collection.

2. Compatibility with Commingled Programs that Keep Glass Separate: for commingled recycling programs that collect glass separately, collection costs are higher than for fully-commingled (single-stream) programs, but processing costs are lower and the marketability of the collected materials is better. Even with improved marketability of the glass, however, this material is typically handled at a net cost due to the low market value of glass. Removing part of the glass through a deposit system will improve the overall economics of these programs, but it is hard to say at this point how the loss of revenues for aluminum cans and plastic bottles will affect these programs (that is, whether these programs might be able to capture the deposit funds and thus offset any market revenue losses). The aluminum cans for this type of program, as well as for most other types of recycling programs, are an important question because the value of these cans helps to pay for the program and for handling other materials.

This is the approach used by the City of Tacoma for residential and small business customers. Glass is kept separate from other (commingled) recyclables, and the City is paid for the commingled materials by the processing facility that separates those materials for marketing. In their case, diverting part of the glass through a deposit system would make collections more cost-effective (see Section IV.B.4 for a more detailed discussion of this), but in urban areas such as Tacoma there will also be an increase in scavenging of recyclables (deposit containers) from curbside bins, with the subsequent litter problems and complaints. For the rest of Pierce County, where glass is no longer being collected through curbside programs and must instead be taken to a drop-off site, having most of the glass handled through an alternative system (deposits) will greatly increase results and reduce costs.

3. Compatibility with Source-Sorted Programs: programs that require sorting at the source, whether this means 2, 3 or more bins used at the homes and businesses, will fare well with a deposit system if they are allowed to claim the deposit. The greater degree of sorting at the source usually leads to the ability to keep materials clean and not crushed, and thus a higher percentage of the deposit containers would be still eligible for the refund, again assuming these bottles can be kept intact and can be recovered cost-effectively.

4. Compatibility with Drop-Off and Buy-Back Programs: drop-off and buy-back centers usually require the highest level of sorting by the source, and so would be in the best position to claim the deposit, except that their customers will probably take their deposit containers to a redemption site instead if they have to keep them separate and bring them somewhere. If the drop-off and buy-back centers can act as redemption sites, however, they can still capture these materials and also have their handling costs covered, and might experience an increase in other materials.

5. Compatibility with Commercial Programs: commercial programs vary widely in their collection methods, participation rates, and potential impacts due to a deposit system. For businesses generating small amounts of cans and bottles, perhaps through a pop machine in an employee lunch room or through a small cafeteria, it seems safe to assume that the employees will find a way to collect the deposit containers. In general, this will probably represent an improvement over existing conditions, since so many of these types of businesses across the state are not recycling currently. For larger generators of cans and bottles, such as bars and restaurants, it also seems safe to assume that some type of convenient arrangement will be worked out between the business and their suppliers to handle the deposit funds and the containers.

In Tacoma, small businesses are served as part of the residential curbside program. There are also separate collection efforts for some types of businesses. The City collects cardboard separately from many businesses and apartments, and also collects other materials (such as glass) using a special truck. Private companies also collect some recyclables in the City, but their efforts are primarily targeting cardboard and sorted office paper. A deposit system might provide a strong incentive for these companies to offer container recycling at no charge to these business customers as an additional service. The compartmentalized truck used by the City to run a special route to collect source-sorted glass and other materials from bars and restaurants is not the most cost-effective aspect of their operations, and it can be assumed that much of this would go away or could be absorbed by other recycling programs if there was a deposit that included the bottles generated by bars and restaurants.

III. Public Health and Environmental Benefits of Increased Bottle Recovery

Most public health and environmental benefits from increased beverage container recycling come from the substitution of recycled beverage containers for raw materials in the product manufacturing process and the reduced energy requirements for making new beverage containers, as well as other products such as clothing and recycling containers, from recycled rather than virgin raw materials. The existence, if not the extent, of environmental impacts from virgin material and energy resource acquisition and processing is widely acknowledged. Drilling, digging, or cutting and refining, smelting, or pulping creates raw materials to feed our industrial system and, at the same time:

- release chemical substances, carbon dioxide, waste heat and processing residues into air and water and onto land;
- impair the health of people exposed to polluting chemical releases;
- dislocate and destroy habitat for a wide variety of non-human creatures and organisms;
- diminish productivity in natural resource industries that depend on healthy species and ecosystems;
- impair the functioning of ecosystems that clean our air and water and provide nutrients, among other beneficial functions, and, as well, impair the biological diversity in those ecosystems; and
- alter the sights, sound, smells and feelings humans enjoyed in many previously pristine, natural places.

Similarly acknowledged is the existence of environmental impacts resulting from disposal of leftovers from our use and consumption of manufactured products and foodstuffs. Burying these wastes creates a variety of problems, from potential releases into the environment of toxic leachate and landfill gases to noise and traffic impacts on residences and businesses neighboring landfills. Waste incineration creates air and water emissions, as well as potential releases at incinerator ash landfills.

Modern day recycling, e.g., curbside collection from residences, was initiated largely because of a belief that we were running out of landfill space, and because we wanted to reduce the environmental risks associated with waste disposal. Beverage container deposit systems often were put in place largely as a means of reducing litter along our roadways. By now, however, use of recycled materials as substitutes for virgin manufacturing feedstocks is understood as the most significant environmental benefit from curbside recycling and bottle deposits. This chapter provides the scientific background for this understanding, as well as estimates of some of the economic costs of wasting the resources contained in used beverage containers that we currently are throwing in the garbage.

A. What are the Public Health & Environmental Benefits of Increased Bottle Recovery and How Much are they Worth?

In this section we report our estimates of both quantity and economic value for several categories of public health and environmental impacts that are reduced when more beverage containers are recycled rather than wasted by being thrown in the garbage. We also report estimates of the energy savings from recycling beverage containers. Reported results are based on several studies that Sound Resource Management Group (SRMG) conducted recently for the Washington State Department of Ecology and for the San Luis Obispo Integrated Waste Management Authority (SRMG 2005). Those studies calculated public health and environmental benefits of recycling, and conversely the public health and environmental costs of wasting, for a variety of materials including all the common beverage container types.

1. Life Cycle Analysis and Public Health/Environmental Impact Categories: there has been extensive research over the past fifteen years on identifying and quantifying the public health and environmental benefits of recycling versus disposal. This research is based on the rapidly developing field of life cycle analysis. Some of this research involved summarizing the types of emissions that cause particular environmental impacts such as global warming, acid rain, and ozone layer depletion, and particular public health impacts such as increased disabilities and deaths from diseases caused by air pollution. That research has focused on learning which particular emissions cause a particular impact, and then indexing those emissions by potency.

For example, researchers thus far have identified the following atmospheric emissions as greenhouse gases that cause global warming:

- carbon dioxide (1)
- methyl bromide (5)
- methylene chloride (10)
- methyl chloride (16)
- methane (23)
- chloroform (30)
- trichloroethane (140)
- nitrous oxide (296)
- HCFC 22 (1,700)
- carbon tetrafluoride (5,700)
- Halon 1301 (6,900)
- CFC 12 (10,600)

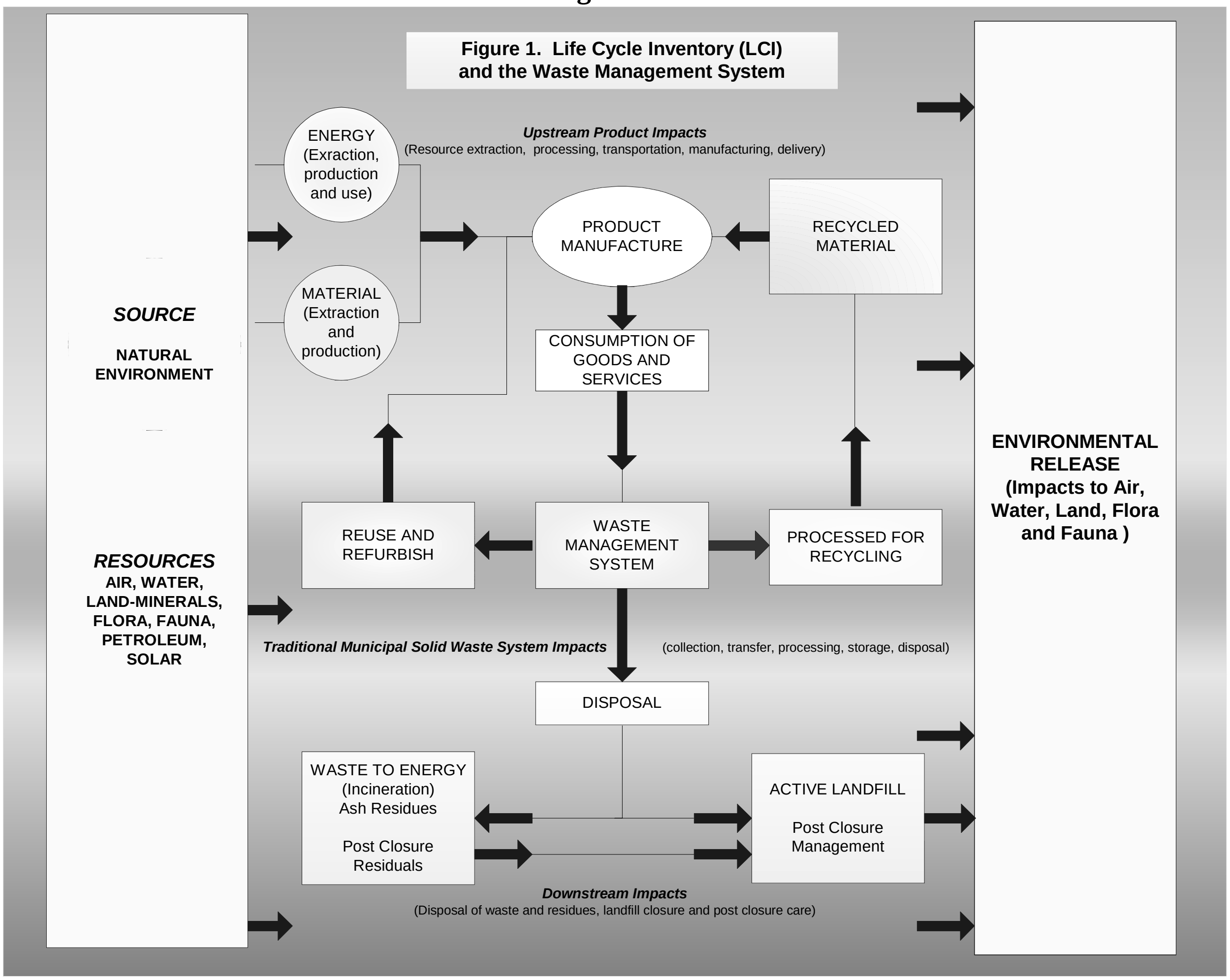
The number in parenthesis after each of these twelve atmospheric pollutants indicates their global warming potential relative to carbon dioxide. These numbers allow us to add up the various pollutants as a common denominator, in the case of greenhouse gases in either carbon dioxide or carbon equivalents. This is similar to the way we add up all the disparate products and services produced in the economy in terms of the common denominator of dollars to calculate gross domestic product (GDP). In the case of environmental impacts, we add up all the disparate pollutants in terms of a common denominator so that it is possible to quantitatively compare the environmental impact of one course of action versus another.

For comparing the recycling life cycle against the disposal life cycle we make use of a database developed by the US Environmental Protection Agency (EPA) over the course of a nearly ten-year project managed by Research Triangle Institute (RTI 1999). That project involved stakeholder consultation and review followed by peer review of emissions and energy usage data from life cycle studies conducted over the years since the first energy crisis in 1974.

Figure 3-1, Life Cycle Inventory (LCI) and the Waste Management System, is a graphic from the Washington State Department of Ecology (Ecology 2002) study that illustrates the material flows and environmental releases associated with the life cycle of used products that end up in our waste management systems. These environmental releases cause public health and environmental costs that are imposed indirectly on society at large rather than being directly internalized in the costs of the products whose manufacture creates those emissions. These are the external costs of product manufacturing and, as we demonstrate in this report, these external costs are much larger for virgin-content products than they are for products made from recycled materials.

For the solid waste management system there is enough information on releases of various types of pollutants to calculate the life cycle impacts for energy and six categories of public health or environmental impacts. These categories, as well as a number of other impact categories, were laid out in several recent scientific reports. Impact categories are based on the Environmental Problems approach to impact assessment as developed in the early 1990s within the Society for Environmental Toxicology and Chemistry (SETAC). This approach is codified in the National Institute of Standards and

Figure 3-1



Technology's Building for Environmental and Economic Sustainability (BEES) 3.0 model, and supported by US EPA Office of Research and Development's recent development of TRACI (Tool for the Reduction and Assessment of Chemical and other environmental Impacts).[2]

The six impact categories, as described in the BEES model (Lippiatt 2002), and current estimates of the economic cost of these public health and environmental impacts are as follows:

a. ***Global Warming Potential:*** this index characterizes the increase in the greenhouse effect due to emissions generated by humankind. Life Cycle Analyses (LCAs) often use a 100-year time horizon to delineate which type emissions of greenhouse gases have a global warming potential. Carbon dioxide (CO2) from burning of fossil fuels to generate energy is the most common source of greenhouse gases. Methane from anaerobic decomposition of organic material is another large source of greenhouse gases. Estimates of the dollar cost of a ton of greenhouse gases, measured as CO2 equivalents, range between about $1 per ton CO2, which is a current spot market price for

[2] TRACI is a set of state-of-the-art, peer-reviewed US life cycle impact assessment methods. See US Environmental Protection Agency Office of Research and Development (2002): *Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI): User's Guide and System Documentation*, EPA/600/R-02/052. The weights for assembling pollutant emissions into impact categories are given in the BEES 3.0 manual (Lippiatt 2002).

emissions permits traded under voluntary greenhouse gas emission limitation agreements, and $36 per ton, which is Seattle City Light's impact cost estimate used in long range planning. Recent spot market trades of CO2 emissions permits under the European Union's compulsory system have been at about $11 per ton. For this evaluation we used $36 as the long run cost of greenhouse gas emissions.

b. ***Acidification Potential:*** this index characterizes the release of acidifying compounds from human sources, principally fossil fuel and biomass combustion, which affect trees, soil, buildings, animals and humans. The main pollutants involved in acidification are sulfur and nitrogen compounds (sulfur oxides, sulfuric acid, nitrogen oxides and ammonia) and hydrochloric acid (HCl).

For purposes of evaluating the economic benefit of recycling in terms of the resulting reductions in releases of acidifying compounds (due to decreased reliance on virgin materials in manufacturing products), we denominated the acidification potential index in tons of sulfur dioxide (SO2) equivalents. One estimate of the impact cost of releases of acidifying compounds is provided by the spot market price for SO2 emissions permit trading under the Clean Air Act's cap and trade program. EPA's March 2004 spot market auction for emissions permits resulted in a clearing price of $260 per ton of SO2.

c. ***Eutrophication Potential:*** this index characterizes the addition of mineral nutrients to the soil or water. In both media, the addition of large quantities of mineral nutrients, such as nitrogen and phosphorous, results in generally undesirable shifts in the number of species in ecosystems and a reduction in ecological diversity. In water, it tends to increase algae growth, which can lead to lack of oxygen and therefore death of species such as fish.

For purposes of evaluating the economic benefit of recycling in terms of the resulting reductions in releases of nutrifying compounds (due to decreased reliance on virgin materials in manufacturing products), we denominated the eutrophication potential index in tons of nitrogen (N) equivalents. Our estimate of the impact cost of releases of nutrifying compounds is based on EPA's cost-effectiveness analysis for the NPDES regulation on effluent discharges from concentrated animal feeding operations. That analysis estimated that costs up to $4 per ton of nitrogen removed from wastewater effluents were economically advantageous (EPA 2002).

d. ***Disability-Adjusted Life Year (DALY) Losses:*** criteria air pollutants are solid and liquid particles commonly found in the air, including coarse particles known to aggravate respiratory conditions such as asthma and fine particles that can lead to more serious respiratory symptoms and diseases such as lung cancer. In particular, air emissions included in the criteria air pollutants category that cause these human health effects are nitrogen oxides, sulfur oxides, and particulates. Disability-adjusted life years, or DALYs, have been developed to measure health losses from these air pollutants. They account for years of life lost and years lived with disability, adjusted for the severity of the associated unfavorable health conditions.

One of the economic benefits of recycling due to manufacturing products with recycled rather than virgin materials is a reduction in DALY losses. We measured the economic value of that benefit by the Seattle-Tacoma-Bellevue Metropolitan Statistical Area's average wage per job in 2002 of $44,050 (Bureau of Economic Analysis, U.S. Department of Commerce, Table CA34: Average wage per job for 2002.) Inflating this value to 2004 yields our dollar value for a DALY of $45,771.

e. ***Human Toxicity Potential:*** EPA in its TRACI software (*Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts*) developed toxicity equivalency potentials for a number of chemical compounds that measure the relative health concern associated with various chemicals from the perspective of a generic individual in the U.S.

For purposes of evaluating the economic benefit of recycling in terms of the resulting reductions in releases of compounds toxic to humans (due to decreased reliance on virgin materials in manufacturing products), we denominated the human toxicity potential index in tons of lead (Pb) air emissions equivalents rather than the toluene equivalents used in TRACI. This was so that we could use a Minnesota Public Utilities Commission quantification of the externalized environmental costs of criteria air pollutant emissions, in particular lead, associated with electricity generation to measure the human health costs of toxics. The Commission's cost estimates, developed under direction of the Minnesota legislature, were challenged in court, but were affirmed by the Minnesota Court of Appeals, and then Minnesota's Supreme Court in 1998 denied a requested review of the Appeals Court's affirmation. The MN PUC's externalized cost for lead in urban areas was $3,500 per ton in 1995 dollars. Inflating this estimate to 2004 dollars yields our economic benefit value of $4,293 per ton for reductions in air emissions of lead.

f. ***Ecological Toxicity Potential:*** EPA's TRACI software also developed toxicity equivalency potentials for a number of chemical compounds that measure the relative potential for chemicals released into the environment to harm terrestrial and aquatic ecosystems.

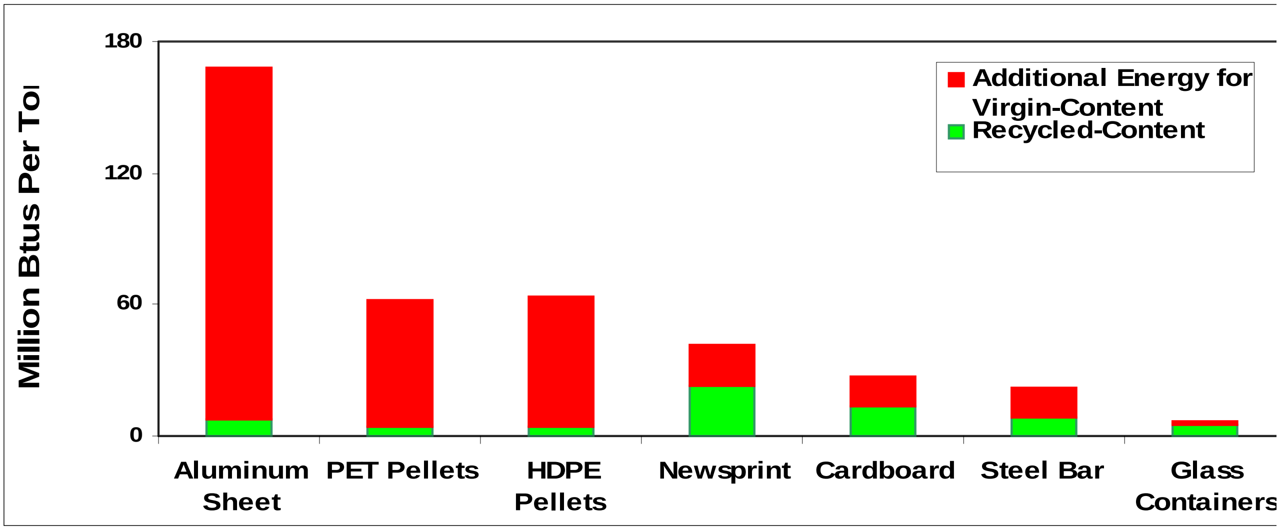
For purposes of evaluating the economic benefit of recycling in terms of the resulting reductions in releases of compounds toxic to terrestrial and aquatic ecosystems (due to decreased reliance on virgin materials in manufacturing products), the ecological toxicity potential is expressed in terms of tons of 2,4-D. The toxicity cost to plants and wildlife from the application of a ton of 2,4-D herbicide is estimated at $2,900. This estimate is based on research work by Joe Kovach, Integrated Pest Management Program, Ohio State University (J. Kovach, *et al*, A Method to Measure the Environmental Impact of Pesticides, available through Online Publications of the New York State Integrated Pest Management Program at www.nysipm.cornell.edu/publications/EIQ.html#table2).

2. The Importance of Upstream Impacts Relative to Collection and Processing Impacts: one of the frequent criticisms of recycling is that it puts extra trucks on the road, incurs high collection and processing costs, and then ships processed materials long distances to recycled-content manufacturing establishments. This subsection displays results from SRMG research that puts the public health and environmental impacts of recycling systems into real world perspective. These results are consistent with a number of other studies on the life cycle of used products that can either be thrown away in the garbage or recycled into further beneficial uses. These studies all demonstrate that the upstream public health and environmental impacts caused by extraction, refining and manufacturing products with virgin materials so substantially outweigh the impacts of manufacturing products from recycled materials that they overwhelm the public health and environmental impacts of recycling. In other words the impacts of recycling trucks and processing facilities, which to be sure do exist, are insignificant compared with the pollution prevention and resource conservation reductions that result from making products out of recycled rather than virgin raw materials.

The following five graphs illustrate this conclusion for energy use, greenhouse gas emissions, and human toxicity. Figure 2, Comparative Energy Usage for Recycled- vs. Virgin-Content Products, shows energy savings for several closed-loop, recycled-content products which can use recycled beverage containers as feedstocks. The graph also shows comparative energy usage for two important paper industry products, newsprint and cardboard. These two products do not typically use beverage containers for recycled-content production, but the fiber from recycled gabletop and aseptic beverage containers yields a high quality recycled fiber that can be used in a variety of paper industry products.

As indicated in Figure 3-2, recycled-content products require much less energy than virgin-content products. This is due to their reduction or elimination of demands for virgin raw materials. Recycled-content aluminum sheet and plastic pellets require only between 5% and 7% of the energy needed to make these items from virgin raw materials. Recycled-content steel requires about 37% of the energy

Figure 3-2
Comparative Energy Usage for Recycled- vs. Virgin-Content Products



required for virgin steel. Glass containers only require 65% of the energy needed to produce virgin-content glass jars. The magnitude of these energy savings foreshadows the conclusion that the recycling life cycle has far less impact on public health and the environment than does the disposal life cycle, whether disposal is via landfill with or without recovery of energy from landfill gases, or via waste-to-energy incineration.

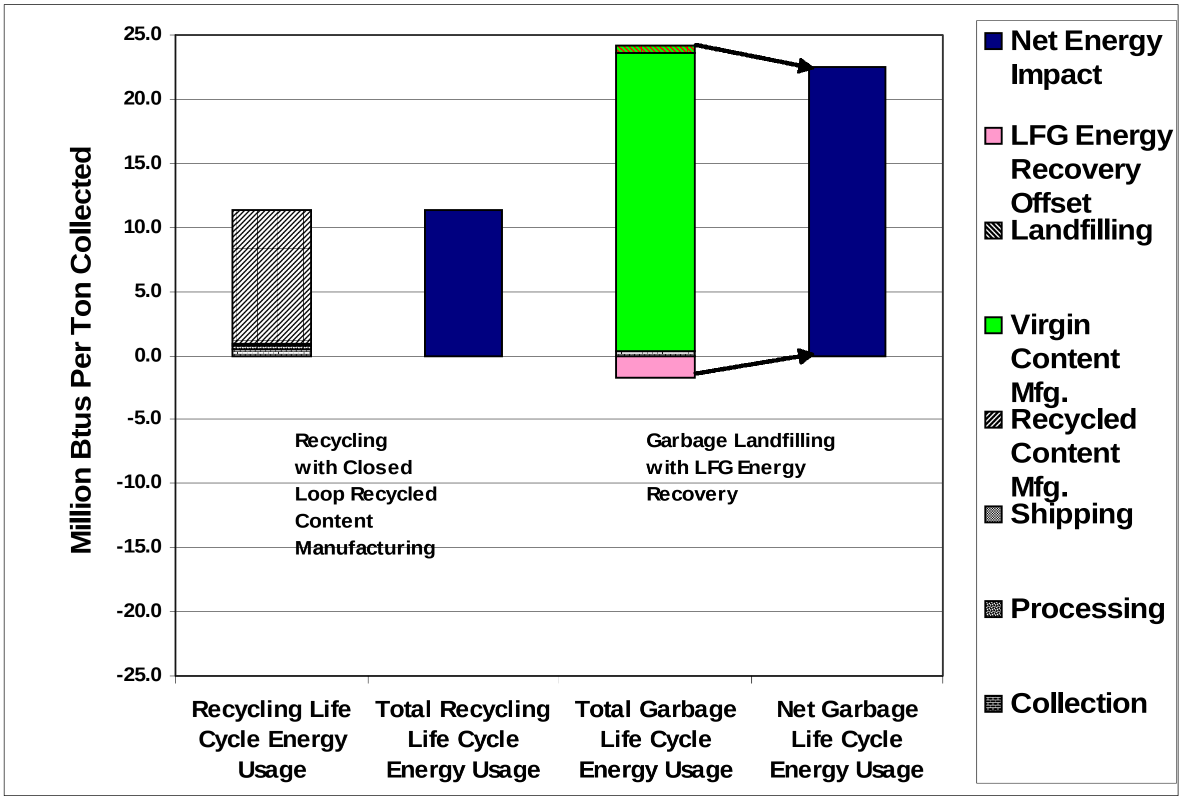
Figure 3-3, Total Energy Usage for Recycling vs. Disposal Life Cycle, shows energy usage for materials recycled in San Luis Obispo County, California, and used to produce new products. The figure also shows the comparative energy usage for collecting those same materials in garbage and replacing them with virgin materials for the next round of product use. The garbage life cycle shown on the right hand side of Figure 3-3 includes an offset (negative or below the zero line portion of the stacked bar) for the energy produced from collecting and burning landfill gases.

As indicated in Figure 3-3, the recycling life cycle's total energy usage is just 45% of the garbage life cycle's energy usage. Figure 3-3 also shows the relatively small amounts of energy usage associated with the collection, processing and shipping to market of recycled materials.

Figure 3-4, Net Energy Usage for Recycling vs. Landfilling with Energy Recovery – The Energy Savings from Recycling, is the same as Figure 3-3 except that the bar showing energy usage for extraction, refining and manufacturing products from virgin materials is now shown as an offset to the energy uses for the recycling life cycle. The second bar from the left shows that the recycling life cycle actually saves energy when account is taken of the energy saved by making recycled- rather than virgin-content products. This is what is meant by the oft-repeated statement that recycling saves energy. As indicated, the energy savings from recycling is much greater than the energy savings from landfilling materials and turning the resultant landfill gases into energy. A similar result holds for recycling versus waste-to-energy incineration of recyclable materials.

Figure 3-5, Net Greenhouse Gas Reductions for Recycling vs. Landfilling with Energy Recovery, shows the extent to which recycling reduces pollution from releases of greenhouse gases. In fact, as indicated

Figure 3-3
Total Energy Usage for Recycling vs. Disposal Life Cycle



by the two solid dark blue color bars, recycling reduces emissions of greenhouse gases by 74% compared with manufacturing products from virgin materials. Furthermore, the greenhouse gas reductions from recovering landfill gases produced from decaying materials in the landfill is de minimus in comparison to the greenhouse gas reductions from recycling.

Finally, Figure 3-6, Net Human Toxicity Reductions for Recycling vs. Waste-to-Energy Incineration, shows the impact of the recycling life cycle on releases of compounds that are toxic to humans compared with the impact on human toxicity of incineration with recovery of energy from the destroyed materials. As indicated, recycling reduces the release of toxic substances by 65%, while incineration actually increases releases to the atmosphere of those toxics. This despite the reduction in releases of toxics from conventional means of energy generation that is credited to incineration for the energy generated from the recyclable materials that incineration destroys.

3. Estimates of Magnitude and Value for Six Public Health & Environmental Benefits of Increased Beverage Container Recycling: based on the San Luis Obispo County and Washington Department of Ecology studies previously discussed, and our estimates of beverage container recycling and wasting in the state of Washington and the City of Tacoma, we estimated the amount of public health and environmental protection attained by current levels of beverage container recycling and the amount of public health and environmental damages caused by current levels of beverage container wasting. Table 3-1 shows these estimates for Washington and Table 3-2 shows the estimates for Tacoma. Both tables also show energy conservation achieved by our current beverage container recycling efforts, and energy wastage from current levels of beverage container disposal.

Figure 3-4
Net Energy Usage for Recycling vs. Landfilling with Energy Recovery – The Energy Savings from Recycling

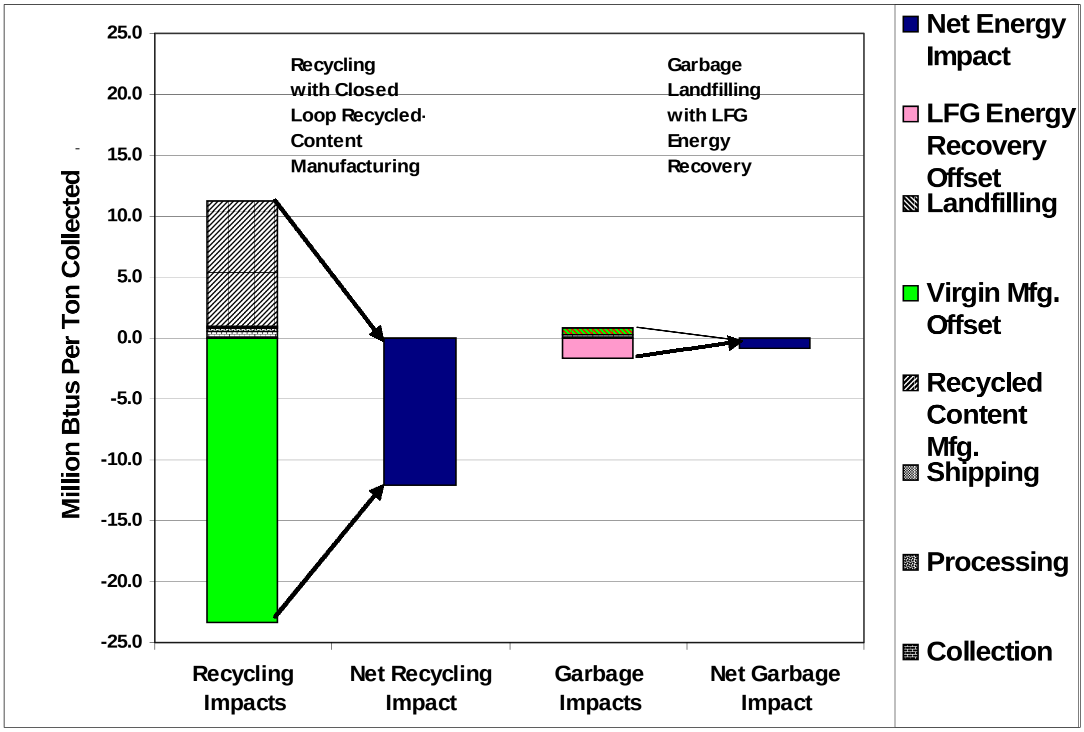


Figure 3-5
Net Greenhouse Gas Reductions for Recycling vs. Landfilling with Energy Recovery

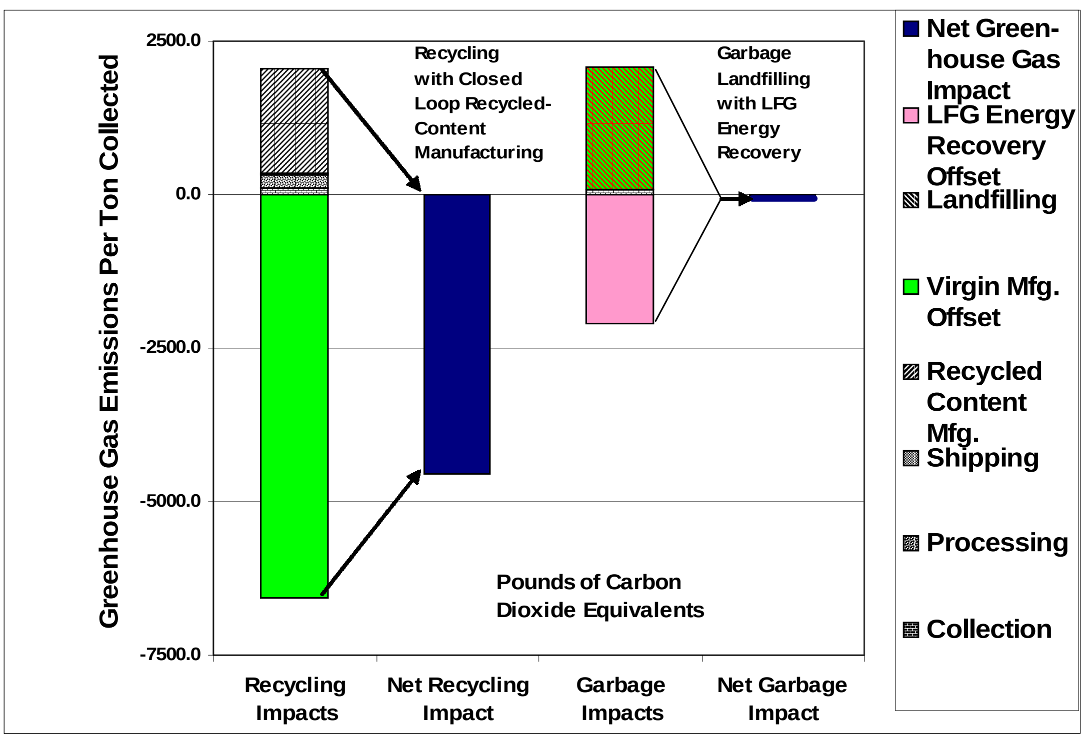
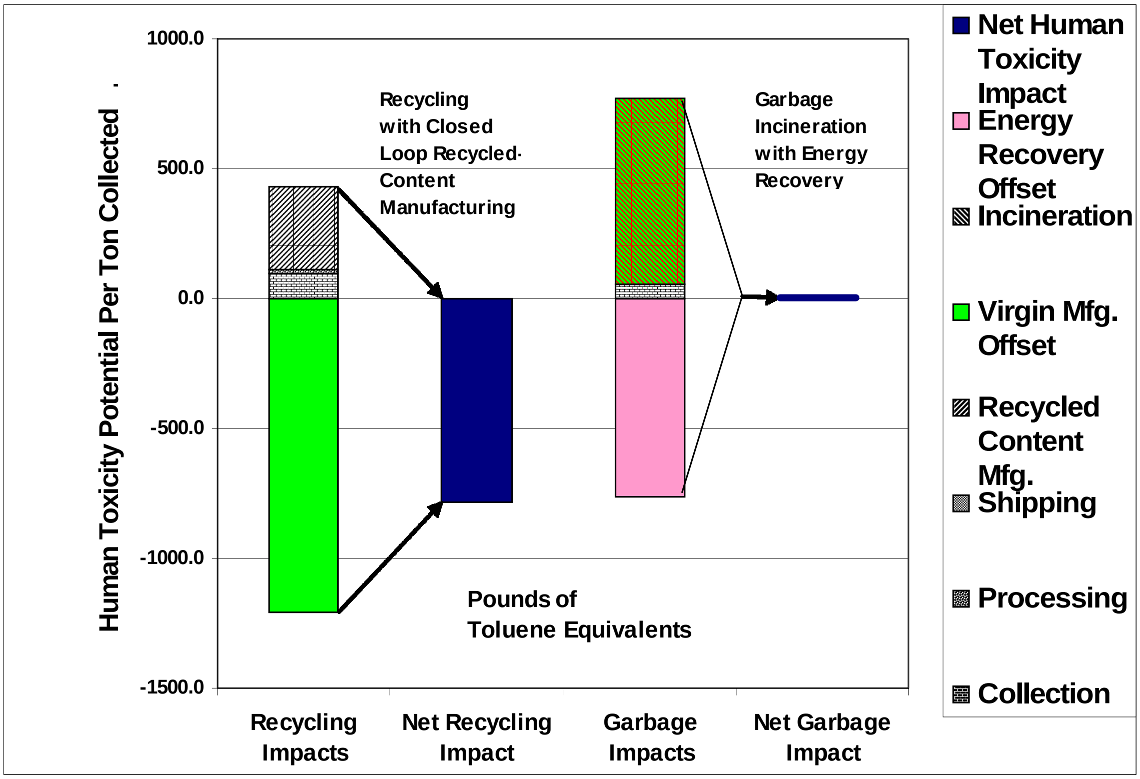


Figure 3-6
Net Human Toxicity Reductions for Recycling vs. Waste-to-Energy Incineration



Both tables indicate that damages from beverage containers still being thrown in the garbage are greater for all six public health and environmental impact categories we examined than are the levels of environmental protection provided by current levels for beverage container recycling. For example, beverage container wasting in Washington currently results in release of at least 313,000 tons of greenhouse gases each year, nearly double the amount of greenhouse gas reductions currently being achieved by beverage container recycling efforts in the state. In the City of Tacoma, greenhouse gas releases caused by beverage container wasting is 90% greater than greenhouse gas reductions from current recycling levels in Tacoma. The results for the other public health and environmental impacts shown in the two tables are similar.

In other words, while current beverage container recycling efforts in our state do achieve significant environmental benefits, we continue to create more environmental damages through our beverage container wasting. We could readily more than double the environmental benefits attained from beverage container recycling by capturing for recycling a significant additional portion of the used beverage containers currently being put in our garbage.

What are these levels of wasting for used beverage containers costing us? Using the estimates listed in Subsection A.1 of this chapter for the costs of releases of pollutants in each of the six public health or environmental impact categories, we can estimate the current cost levels associated with 2002 levels of beverage container wasting in Tacoma and Washington. These estimates are reported in Table 3-3, Estimated Cost of Public Health and Environmental Impacts from Used Beverage Container Wasting. As Table 3-3 shows, beverage container wasting in Washington State costs over $19 million, $650 thousand for the City of Tacoma alone, in terms of costs to public health and the environment for increases in global warming, acidification, eutrophication, disabilities and deaths, human toxicity and ecological toxicity. As discussed later in this chapter, these quantifiable costs are likely just the tip of the iceberg in public health and environmental impact costs associated with used beverage container wasting.

B. Additional Public Health and Environmental Cost Savings

The previous section developed estimates of the public health and environmental benefits from reducing the quantity of beverage containers thrown away in garbage. Those estimates quantified the benefits of reduced impacts for six categories of public health and environmental impacts as a result of substituting used containers for virgin raw materials in manufacturing new beverage containers and other products. In addition to these upstream benefits from recycling used beverage containers there are other benefits from increased beverage container recycling that we address in this section.

1. Downstream Public Health & Environmental Benefits from Reducing Disposal of Used Beverage Containers: in their four-year study of the social costs of packaging materials, recycling and packaging alternatives, Tellus Institute conducted a life cycle inventory of the emissions of nearly 200 chemical substances associated with the production and disposal of packaging materials, including emissions from acquisition and processing of raw materials used to manufacture packaging (Tellus 1992). In the study on beverage container recycling that SRMG conducted for Massachusetts Public Interest Research Group (SRMG 1998), we used the Tellus study to estimate the public health costs for collection and disposal of used beverage containers at a dollar per ton for disposal via landfill and $2 per ton for disposal in a waste-to-energy incinerator.

These estimates suggest that current levels of beverage container wasting in Washington State cost between $200 and $400 thousand annually in public health and environmental costs from collecting and disposing of beverage containers in the garbage stream. These costs are in addition to the $19.2 million in upstream costs discussed in the previous section of our report.

2. Public Health & Environmental Benefits of Reducing Litter: in SRMG's study for MASSPIRG we used another Tellus Institute study (Tellus 1997) to estimate some of the costs from roadside littering of used beverage containers. One significant cost investigated and quantified by Tellus for the State of Massachusetts involved hospital emergency room visits to deal with cuts from littered glass (Tellus 1997). Based on the proportion of glass beverage containers being wasted we estimate that each additional ton of beverage containers recovered for recycling saves about $7 in avoided hospital visits to deal with littered glass cuts. This amounts to a potential savings of $1.4 million in Washington, with nearly $50 thousand of this in Tacoma alone, should all the used beverage containers currently being wasted in Washington State get recycled.

Although at this point we have no quantified estimate of their economic costs, other costs from used beverage container litter are likely of greater economic import than cuts from littered glass. These include litter on public beaches[3], bicycle and other vehicle tire punctures from broken glass bottles on the roadways, equipment and livestock damage and crop contamination from beverage containers thrown onto farmlands from passing vehicles[4], and degraded aesthetics along our nation's highways.

---

[3] According to the Center for Marine Conservation's 1995 International Coastal Cleanup, beach cleanup in Texas, a non-bottle bill state, yielded 2,461 pounds of litter per mile of beach, while cleanup efforts in two bottle bill states, Maine and Michigan, yielded, respectively, just 152 and 35 pounds of litter per mile of beach.

[4] For a personal account see Ed Fielder' testimony before US Senate Committee on Commerce, Science, and Transportation, hearing to consider *Beverage Container and Recycling Act*, 5 Nov. 1981 (Y4.C73/7.97-83). For a quantified assessment see Daniel B. Taylor and John B. Hodges, "Impacts of Beverage Container Litter on Virginia Farms," *Virginia Agricultural Economics*, September-October 1985.

Table 3-1
Public Health and Environmental Impacts from Used Beverage Containers in Washington State in 2002

2002 Washington State Beverage Container Environmental Impacts

Environmental Protection from Recycling of Beverage Continers

	Energy	Greenhouse Gases	Acidification	Eutrophication	DALYs	Human Toxicity	Ecological Toxicity
	Btus (million Btus)	Carbon Dioxide (pounds)	Sulfur Dioxide (pounds)	Nitrogen (pounds)	(life years)	Lead (pounds)	2,4-D (pounds)
Aluminum Cans	1,824,780	248,453,283	3,500,021	35,648	28.9	882	803,409
Steel Cans	0	0	0	0	0.0	0	0
PET	266,037	18,937,354	446,356	9,204	2.1	85,938	38,660
HDPE	15,451	848,269	7,101	196	0.0	1,231	912
Glass Bottles	145,479	47,644,903	343,061	3,651	10.0	192	21,507
Gable-top Cartons/Aseptic Boxes	16	8,688	16	1	0.0	0	1
Foil Pouches	*	*	*	*	*	*	*
Total All Materials	2,251,763	315,892,496	4,296,555	48,700	41	88,244	864,489

Environmental Damages from Disposal of Beverage Containers

	Energy	Greenhouse Gases	Acidification	Eutrophication	DALYs	Human Toxicity	Ecological Toxicity
	Btus (million Btus)	Carbon Dioxide (pounds)	Sulfur Dioxide (pounds)	Nitrogen (pounds)	(life years lost)	Lead (pounds)	2,4-D (pounds)
Aluminum Cans	3,552,711	483,720,062	6,814,281	69,405	56	1,718	1,564,178
Steel Cans	0	0	0	0	0	0	0
PET	891,384	63,451,610	1,495,562	30,840	7	287,943	129,533
HDPE	34,072	1,870,580	15,659	432	0	2,715	2,012
Glass Bottles	221,003	72,379,172	521,157	5,547	15	292	32,673
Gable-top Cartons/Aseptic Boxes	8,502	4,536,746	8,374	311	0	0	322
Foil Pouches	*	*	*	*	*	*	*
Total All Materials	4,707,672	625,958,171	8,855,033	106,533	79	292,669	1,728,717

Sources for environmental impacts per ton of virgin- or recycled-content

1. Research Triangle Institute, Franklin Associates, and Roy F. Weston, Data Sets for the Manufacturing of Virgin and Recycled Aluminum, Glass, Paper, Plastic and Steel Products, ES UPA, Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, March 2000.
2. Research Triangle Institute, Municipal Solid Waste Life-Cycle Database, US EPA, National Risk Management Research Laboratory, Atmospheric Protection Branch, Version 1.0, 2003.
3. Swiss Federal Agency for the Environment, Forests and Landscape, Life Cycle Inventories for Packaging, Environmental Series No. 250/11, 1996.
4. US EPA, Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks, May 2002.
5. Morris, Jeffrey, Comparative LCAs for curbside recycling versus either landfilling or incineration with energy recovery, International Journal of Life Cycle Analysis (Online First, forthcoming in print in 2005).

Table 3-2
Public Health and Environmental Impacts from Used Beverage Containers in the City of Tacoma in 2002

2002 Tacoma Beverage Container Environmental Impacts

Environmental Protection from Recycling of Beverage Continers

	Energy	Greenhouse Gases	Acidification	Eutrophication	DALYs	Human Toxicity	Ecological Toxicity
	Btus (million Btus)	Carbon Dioxide (pounds)	Sulfur Dioxide (pounds)	Nitrogen (pounds)	(life years)	Lead (pounds)	2,4-D (pounds)
Aluminum Cans	60,692	8,263,543	116,411	1,186	1.0	29	26,721
Steel Cans	0	0	0	0	0.0	0	0
PET	18,938	1,348,072	31,774	655	0.2	6,118	2,752
HDPE	6,351	348,650	2,919	80	0.0	506	375
Glass Bottles	3,712	1,215,757	8,754	93	0.3	5	549
Gable-top Cartons/Aseptic Boxes	0	0	0	0	0.0	0	0
Foil Pouches	*	*	*	*	*	*	*
Total All Materials	89,693	11,176,021	159,857	2,015	1	6,658	30,397

Environmental Damages from Disposal of Beverage Containers

	Energy	Greenhouse Gases	Acidification	Eutrophication	DALYs	Human Toxicity	Ecological Toxicity
	Btus (million Btus)	Carbon Dioxide (pounds)	Sulfur Dioxide (pounds)	Nitrogen (pounds)	(life years lost)	Lead (pounds)	2,4-D (pounds)
Aluminum Cans	116,506	15,862,877	223,464	2,276	2	56	51,295
Steel Cans	0	0	0	0	0	0	0
PET	31,074	2,211,932	52,135	1,075	0	10,038	4,516
HDPE	2,886	158,426	1,326	37	0	230	170
Glass Bottles	8,557	2,802,587	20,180	215	1	11	1,265
Gable-top Cartons/Aseptic Boxes	400	213,521	394	15	0	0	15
Foil Pouches	*	*	*	*	*	*	*
Total All Materials	159,423	21,249,343	297,500	3,617	3	10,335	57,261

Sources for environmental impacts per ton of virgin- or recycled-content

1. Research Triangle Institute, Franklin Associates, and Roy F. Weston, Data Sets for the Manufacturing of Virgin and Recycled Aluminum, Glass, Paper, Plastic and Steel Products, ES UPA, Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, March 2000.
2. Research Triangle Institute, Municipal Solid Waste Life-Cycle Database, US EPA, National Risk Management Research Laboratory, Atmospheric Protection Branch, Version 1.0, 2003.
3. Swiss Federal Agency for the Environment, Forests and Landscape, Life Cycle Inventories for Packaging, Environmental Series No. 250/11, 1996.
4. US EPA, Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks, May 2002.
5. Morris, Jeffrey, Comparative LCAs for curbside recycling versus either landfilling or incineration with energy recovery, International Journal of Life Cycle Analysis (Online First, forthcoming in print in 2005).

Table 3-3
Estimated Cost of Public Health and Environmental Impacts from Used Beverage Container Wasting

	Units	Unit Costs	Total Cost of Wasting: Washington (millions)	Total Cost of Wasting: Tacoma (millions)
Global Warming	lbs CO2	$0.018	$11.3	$0.4
Acidification	lbs SO2	$0.130	$1.2	$0.0
Eutrophication	lbs N	$0.002	$0.0	$0.0
DALYs	DALYs	$45,771	$3.6	$0.1
Human Toxicity	lbs Pb	$2.147	$0.6	$0.0
Ecological Toxicity	lbs 2,4-D	$1.450	$2.5	$0.1
Total Cost			$19.2	$0.6

Note: $0.0 shown in the table means that the estimated cost is less than $50,000.

3. Benefits from Reducing Energy Use: acquiring raw materials from nature and transforming them into materials suitable for use in manufacturing containers requires intensive applications of energy. Substantially less energy is required to transform recycled containers into materials that can be used in manufacturing new containers, as well as other products. These points were portrayed in Figure 3-2 in the previous section of this report.

At electricity prices of $0.04 to $0.08 per kilowatt hour, each ton of used beverage containers recycled back into recycled-content products provides energy savings worth $45 to $90 in electricity purchases. This represents an energy savings of nearly $0.02 per beverage container recovered and used as a manufacturing feedstock.

These energy savings are reflected in part in market prices for recycled materials, one of the economic benefits of increased container recovery that is discussed in the following chapter. Here we note that subsidies to energy production and energy use reduce energy prices and cause some of the energy benefits of recycling to be unrecovered through sales of recycled materials.

This, of course, reduces the competitiveness of recycled materials relative to virgin feedstocks. One study of federal energy subsidies to virgin aluminum producers estimated that these subsidies amounted to between 5 and 13% of primary aluminum prices in 1989 (Koplow 1994). If virgin ingot prices were to be increased to cover this subsidy and recycled aluminum prices followed, prices for recycled aluminum cans would be $80 to $210 higher than they currently are.

The quantitative impact on virgin prices from the sum total of federal subsidies has not been examined to any great extent. Studies that have been done tend to measure potential price impacts as a function of the percent of total costs represented by subsidies. This methodology overlooks the equally important impact of subsidies on profits and resultant industry growth. In addition, the nature and extent of state and local or foreign government subsidies has not been investigated at all. Since most virgin commodities trade on international markets, foreign subsidies are also an important factor in low virgin material prices.

Suffice it to note for this report that governmental subsidies and regulatory exemptions of all kinds, as well as externalized public health and environmental costs, contribute significant unearned benefits to virgin materials producers and users, and uncompensated costs to the public and the environment. A corollary result is prices for virgin materials that most likely are substantially lower than they would be in the absence of these unearned benefits.

This is significant for evaluating waste material recovery programs that would reduce used beverage container wasting, because it means that revenues from selling recovered materials will be much lower than they would be in the absence of subsidies. Net costs of the recovery program, thus, will appear higher than they should, which may lead to unwarranted rejection of a program that is beneficial from a society-wide point of view.

4. Benefits from Reducing Ecosystem Impacts: a 1997 article in *Nature* magazine (Costanza 1997) and the Paul Hawken and Amory Lovins book *Natural Capitalism: Creating the Next Industrial Revolution* (1999) brought mainstream recognition for the important role that ecosystems and natural capital play in creating and maintaining life, health and wealth for humans. A 2002 publication in the journal *Ecological Economics* (de Groot 2002) refined the concept of ecosystem services; provided a categorization of ecosystem functions, goods and services; and catalogued the economic valuation estimates obtained from studies in the scientific and professional literature on valuation.

We had neither the time nor the budget to attempt to fully estimate the negative impacts on ecosystems and ecosystem services caused by wasting used beverage containers and therefore having to make new containers from virgin materials for every used container thrown in the garbage can. There are, however, a few pollutants that are toxic to ecosystems whose emissions are quantified in the RTI/EPA database. We used those emissions factors to estimate the ecological toxicity costs of beverage container wasting shown in Table 3-3.

Because so few ecosystem toxins are measured in the RTI/EPA database, we believe that the $2.5 million estimated annual cost for the negative impacts on ecosystems from toxic emissions substantially underestimates the full cost of used beverage container wasting. Furthermore, the Costanza study and subsequent work in the field of ecological economics suggest that direct human health costs from environmental externalities caused by the production of virgin-content beverage containers are likely dwarfed by costs from impacts on ecosystem functions as a result of the use of virgin materials and fuels in beverage container production and disposal.

Expenditures for clean up at abandoned mine sites[5], remediation of old dumps, containment and clean up of oil spills, and other attempts to mitigate or repair ecosystems damaged by our use of virgin materials and energy resources provide concrete examples of the value of ecosystems and what we have to pay to maintain them. Until they are damaged, the role of ecosystems in supporting human activities often goes unnoticed.

In conclusion, when ecosystems are damaged, clean up and mitigation costs often are borne by taxpayers and, thus, not directly included in prices we pay for materials, fuels and electrical power. Virgin materials prices set an upper bound on prices for recovered materials. Anytime that an environmental cost of virgin materials acquisition and processing is not charged directly to virgin material producers, the probable result is that a virgin material's price is lower than it would otherwise be. In turn this means lower prices paid by manufacturers to buy recovered materials for use in making recycled-content products. Thus, ecosystem services that the virgin producer uses free of charge and clean up costs that

[5] Estimated by Mineral Policy Center in its recent publication *Golden Dreams, Poisoned Streams* to total $32 - $72 billion in taxpayer absorbed costs for 557,000 abandoned mine sites in just the US alone.

are funded by government programs impair the financial viability of recycling and recovery programs implemented to reduce the wasting of used beverage containers.

C. Public Health & Environmental Benefits of Increased Beverage Container Recovery that have not yet been Quantified

A 1987 review by the Conservation Foundation (CF 1987) revealed that the Toxic Substances Control Act (TSCA) inventory listed over 63,000 chemical substances used commercially since 1975, with nearly 1,500 additions to the inventory occurring each year. Some of these substances are not toxic under normal usage - e.g., that inventory even included water because people can drown in it.

In 1992 the National Research Council reported that,

> "About 70,000 chemicals are used in commerce, of which several hundred are known to be neurotoxicants. However, except for pharmaceuticals, less than 10% of all chemicals in commerce have been tested at all for neurotoxicity, and only a handful have been evaluated thoroughly" (NRC 1992).

The Toxics Release Inventory provisions of the Emergency Planning and Community Right to Know Act of 1986 require certain industrial facilities to annually disclose large releases to air, land and water for a list of some 654 chemicals. In 1995, EPA added 280 more chemical substances to the required reporting list. In addition, seven non-manufacturing industries -- metal mines, coal processors, waste disposal, solvent recyclers, oil- and coal-fired utilities, chemical wholesalers and petroleum bulk storage -- are required to report annual releases starting with 1998.

The estimates for human health impacts from virgin container production that have been discussed in this report cover only a handful of chemical substances. These relatively few chemical substances may be the ones that cause significant impacts during the production of beverage containers, but this supposition remains unproven until releases from all chemicals are measured and evaluated through life cycle inventories similar to those that yielded the RTI/EPA database used for the impact quantity and cost estimates from beverage container wasting shown in Tables 3-1, 3-2 and 3-3.

Data presented in this chapter cover several of the public health and environmental benefits that would result from expanded recovery and reduced wasting of used beverage containers. Numerous other potential benefits have not been addressed because they have not been adequately studied and quantified as of yet. Omissions include:

- Direct human health impacts from releases of currently unregulated substances or substances that have been overlooked in available studies;
- Human health and other environmental impacts from currently unregulated on-site disposal or impoundment of a wide variety of processing and manufacturing wastes, and
- Valuation of ecosystem impairments caused by exploration and harvesting of material and energy resources necessary for virgin-content beverage container production.

From this we conclude that this chapter's estimate of over $20 million in public health and environmental costs from current levels of used beverage container wasting in Washington is actually a substantial underestimate of the total costs to public health and the environment from throwing used beverage containers in the garbage can.

IV. Economic Benefits of Increased Bottle Recovery

Direct economics benefits from increased bottle recovery include revenues earned from selling recovered containers on recycled commodity markets, savings in garbage collection and disposal expenditures, savings in litter control costs, and new jobs processing and marketing recovered containers, as well as new manufacturing jobs in businesses that make recycled-content products. Offsetting these direct benefits is the potential for job and income losses in garbage collection and disposal, as well as in virgin materials manufacturing.

Indirect benefits include additional income and jobs created via the multiplier or ripple effects from recovered container sales revenue and net job and income creation.

A. Deposit Dollars

1. Total Deposits: deposits are generally paid by consumers and then held temporarily by retailers or others, and so by themselves are not an economic gain or loss. The total deposits paid are shown here, however, as a first step in showing the amount of unredeemed deposits.

The total deposits collected will depend on two factors:

- the types of beverages included in the deposit system, and
- the amount of deposit per container (5¢, 10¢ or other amount).

The following table (see Table 4-1) addresses all beverage containers that could potentially be included in a deposit system, including:

- **carbonated,** such as pop, carbonated water, and beer.
- **non-carbonated, non-alcoholic**, including fruit juices but excluding milk.
- **non-carbonated, alcoholic**, such as wine and liquor.
- **carbonated alcoholic**, such as wine coolers, sparkling wines and champagne.

None of these categories include milk containers. The non-carbonated, non-alcoholic beverage containers represent about 25% of the total number of containers, and non-carbonated, alcoholic beverage containers (for wine and distilled spirits) are about another 3%. In other words, if a deposit system were adopted in the state that only included carbonated beverages (as some states have done), that would still include 72% of the total number of containers.

2. Unredeemed Deposits: for all of the possible deposit systems, a percentage of the containers are not returned for the deposit. Most of these are probably disposed along with wastes, but a small amount are probably also littered (in locations where they are not recovered), or broken or otherwise damaged to the point the container is no longer eligible for a deposit. The amount of unredeemed deposits will depend on:

- the amount of the deposit itself (10¢ provides more incentives for returns than 5¢).
- the type of deposit and return system.
- the convenience of return centers.

For the purposes of calculating the amount of unredeemed deposits (containers that are still thrown out with garbage or otherwise lost from the system), this analysis assumes an 80% return rate for 5¢ deposit systems and 90% for 10¢ deposits. These figures are consistent with the experience of existing deposit systems. Coincidentally, the amount of unredeemed deposits are the same in both cases (5¢ deposit and 80% returns versus 10¢ deposit and 90% returns), since twice as many containers are not returned in the 5¢ system, which only collects half as much funds in the first place.

Table 4-1
Amount of Deposit Funds Collected

STATEWIDE FIGURES								
Material	**Tons per Year (2002)**	**Containers per Ton**	**Millions of Containers**	**Deposit Paid, in millions**		**Deposits Returned, in millions**		**Unredeemed Deposits, in millions**
				5¢	**10¢**	**5¢**	**10¢**	
Aluminum cans	35,980	67,500	2,428.6	121.4	242.9	97.2	218.6	24.3
Steel Cans	0	11,430	0	0	0	0	0	0
PET	23.050	25,500	587.7	29.4	58.8	23.5	52.9	5.9
HDPE	970	25,500	24.6	1.2	2.5	1.0	2.2	0.25
Glass Bottles	150,500	4,000	602	30.1	60.2	24.1	54.2	6.0
Gabletop Cartons	680	16,000	NA	NA	NA	NA	NA	NA
Aseptic Boxes	NA	56,800	NA	NA	NA	NA	NA	NA
Total	**211,170**		**3,643**	**182**	**364**	**145.7**	**327.9**	**36.4**
TACOMA FIGURES								
Aluminum cans	1,186	67,500	80.0	4.0	8.0	3.2	7.2	0.8
Steel Cans	0	11,430	0	0	0	0	0	0
PET	1,000	25,500	25.4	1.3	2.5	1.0	2.3	0.25
HDPE	80	25,500	2.05	0.1	0.2	0.08	0.18	0.02
Glass Bottles	5,040	4,000	20.2	1.01	2.02	0.81	1.81	0.2
Gabletop Cartons	NA	16,000	NA	NA	NA	NA	NA	NA
Aseptic Boxes	NA	56,800	NA	NA	NA	NA	NA	NA
Total	**7,306**		**128**	**6.4**	**12.8**	**5.1**	**11.49**	**1.28**

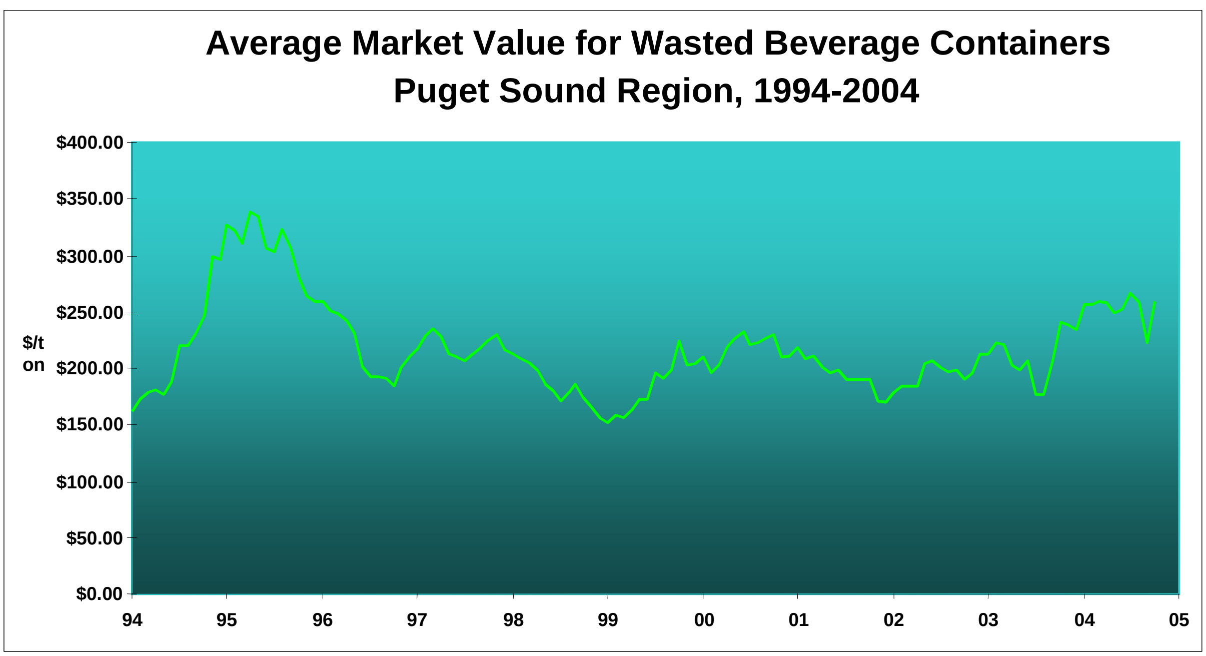
B. Economic Benefits

1. Recovered Materials Sales Revenue: revenues from selling the used beverage containers that are currently being wasted in Washington and Tacoma will provide significant economic benefits. As shown in Figure 4-1, Average Market Value for Wasted Beverage Containers, prices paid over the past eleven years for a ton of recycled beverage containers, processed and packaged to end-user specification, where the ton contains the same average mix of container types as are currently being wasted in Washington State.

The prices used to calculate the average price graph shown in Figure 4-1 are end-user prices (net of transportation costs – i.e., FOB at a material recovery facility) paid for used beverage containers that have been collected by Puget Sound area curbside recycling programs. Market values for glass bottles are based on market prices for color-sorted, whole glass containers, although many programs are mixing and breaking bottles during collection. Thus, market revenues for glass containers collected curbside are in reality near or below zero due to the quantities of broken, mixed-color glass needing to be sold. The kind of product stewardship program that would recover most of the wasted beverage containers would likely result in much lower levels of broken bottles and mixing of colors, and therefore attain market revenues for glass in the neighborhood of a current combined weighted average price of $7.50 per ton for the three colors. A deposit-refund beverage container recovery system would also likely increase the market values for recycled PET and HDPE bottles due to easier separation by color, but the market prices shown in Figure 4-1 do not included any adjustment for this upgrade in quality of the collected plastic bottles.

Based on recent market trends as shown in Figure 4-1 we would expect market prices for used beverage containers collected through deposit systems to average more than $250 per ton for the mix of beverage container types currently thrown in the garbage in Washington State.

Figure 4-1



2. Decreased Garbage Collection Costs: another benefit that would accrue from a container deposit system would be the increased efficiencies during the garbage collection process from fewer containers in the waste stream.

The City of Tacoma does not have current waste composition data so we have utilized the averages from three Western Washington urban waste sorts; King County, City of Seattle and Thurston County. Data from these three studies were used to determine the amount of containers subject to a deposit that are still in the waste stream. Using this data along with estimates of the percentage of each type of container that would be covered under a deposit system (see Table 1-4), density figures for each material and operational data from the City's garbage collection operations, we were able to estimate the garbage volume reduction that would result from a deposit system. The density figures used were an average of data from the American Plastics Council (APC 1995), the Business Recycling Cost Model (GS 1997) and the National Solid Waste Management Association (Miller, various dates). The results of this analysis are presented in Table 4-2.

Table 4-2
Garbage Collection Cost Savings

Current Garbage Collection Operations for the City of Tacoma					
Date	**Number of Trucks/Day**	**Tons Collected**	**Ave. Tons /Truck/Day**	**Ave. Stops /Truck**	**Pounds /Stop**
2-21-05	16.5	290.5	17.6	750	47.0
2-22-05	16.5	301.3	18.3	750	48.7
2-23-05	16.5	285.2	17.3	750	46.1
2-24-05	16.5	302.1	18.3	750	48.8
2-25-05	16.5	308.2	18.7	750	49.8
Averages	**16.5**	**297.4**	**18.0**	**750**	**48.1**

Reduction in Volume due to Deposit Containers							
Material	**Density, lb/cy**	**Amt. in Waste, % by wt**	**% Deposit Containers**	**90% Redeemed**	**Pounds per Load**	**Cubic Yards (cy) per Load**	**After Compaction, cy per load**
Aluminum	62	0.40%	96%	90%	62.3	1.00	0.25
PET	34	0.41%	75%	90%	49.9	1.47	0.37
HDPE, nat.	23	0.25%	5%	90%	2.0	0.09	0.02
HDPE, pigm.	44	0.31%	5%	90%	2.5	0.06	0.01
Glass	515	2.51%	69%	90%	281.0	0.55	0.27
Milk, Aseptic	51	0.32%	5%	90%	2.6	0.05	0.01
Totals					**400**	**3.22**	**0.94**
Savings				Cubic Yards per Day (for 33 loads)			**31.0**
				Equivalent Number of Trucks per Day			**0.57**
				Savings: Driver (unit cost = $109,750) Truck Repair, Maint. and Replacement (unit cost = $26,254) **Total Savings**			 $63,064 $15,086 **$78,149**

The analysis shown in Table 4.2 begins with actual data from a recent week of garbage collections in Tacoma. The City uses 27 cubic yard automated trucks for the collection of garbage. The truck routes consist of approximately 750 stops and each truck collects two loads per day from that route. The average weight per load for the week was nine tons (18 tons per truck per day). Based on typical performance, we have assumed a compaction rate of 4:1 for all materials other than glass. Glass is calculated at a 2:1 compaction rate (i.e., some but not all of the bottles are broken during collection).

We estimate the City will save almost one cubic yard per load per day with 90% of the deposit containers taken out. For 16.5 trucks and two loads per day, that is equal to 31.0 cubic yards per day, or the equivalent of 0.57 trucks per day (at 54 cubic yards collected per truck per day). At current wage rates for the drivers and maintenance rates for the garbage trucks, this translates to an annual savings to the City of $78,149. This is a conservative estimate, since the data used to develop this cost figure is from a period of the year when waste volumes are typically at their lowest.

3. Decreased Disposal Costs: in addition to reduced collection expenses, less garbage also means reduced disposal costs. The City of Tacoma currently has a contract with LRI to dispose of garbage at the LRI Landfill located at South 304th and Meridian in Pierce County. That contract provides for a sliding scale of fees based on the amount of waste delivered by the City of Tacoma to the landfill. For the tonnages that the City has been delivering to the landfill in the past few years, the average cost is $26 per ton. If the deposit system eliminates 4,239 tons per year (see Table 1-4), that is the equivalent of $110,214 in disposal savings.

In addition to reductions in the disposal charges, there would also be a reduction in the cost of transporting the waste from Tacoma to the landfill. This is done by City employees, at a cost of about $9.50 per ton. For 4,239 tons per year, the transportation savings would be $40,271, for a total disposal savings of $150,485 per year.

4. Decreased Recycling Collection Costs: the same approach that was used to analyze the decreased garbage costs can be used to estimate decreased recycling collection costs. In this case, the average mix of the City's curbside recyclables is provided by the monthly reports from the materials processor. These reports give the percentage breakdown of each commodity in the recycling stream. The percentage of these containers that are assumed to be from beverages changes slightly from the garbage collection analysis because studies have shown that beverage containers are recycled more often than food containers for these two materials. The City's recycling trucks are also 27 cubic yard capacity for the most part although there are a few 18 cubic yard rear loaders that are still used when needed. For purposes of this report, we have not taken these smaller trucks into consideration. Had we done so, the operational savings would be even greater than what we show below.

Collection is semi-automated with the glass set out and collected separately from the rest of the commingled recyclables. The average recycling route has 368 stops and each stop averages 30 pounds of material. On a typical day, Tacoma sends out 12 recycling trucks and each truck collects two loads. With the current mix of containers in the recycling stream, we estimate that a deposit system would save approximately 1.24 cubic yards of space on each recycling load. We used a 4 to 1 compaction rate on all materials except glass which we estimated at 2 to 1. This space savings on each load translates to 29.54 less cubic yards per day, or the equivalent of 0.55 trucks per day. This represents a savings of $60,035 in driver's salary and benefits and $ 14,361 in truck maintenance and depreciation for a total collection savings of $74,396 (see Table 4-3).

5. Decreased Litter Control Costs: as mentioned earlier in this report, a total of 7,401,004 pounds of litter were picked up in 2002 at a cost of $4.4 million, which is the equivalent of $1,200 per ton of litter. As shown in Table 1-2, 26.8% of this litter was aluminum cans, plastic bottles and glass bottles. According to the definitions used by the 1999 litter study, all of these materials were beverage

Table 4-3
Recycling Collection Cost Savings

Current Recycling Collection Operations for the City of Tacoma						
Date	**Number of Trucks/Day**	**Tons Collected**	**Ave. Tons /Truck/Day**	**Total Number of Stops**	**Ave, Stops /Truck**	**Pounds /Stop**
3-14-05	12	73.8	6.2	5,151	429	28.7
3-15-05	12	65.5	5.5	4,347	362	30.1
3-16-05	12	67.9	5.7	4,746	395	28.6
3-17-05	12	59.2	4.9	4,011	334	29.5
3-18-05	14	76.4	5.5	5,025	359	30.4
3-21-05	11	72.1	6.6	4,231	385	34.1
3-22-05	11	59.9	5.5	4,066	370	29.5
3-23-05	11	50.0	4.6	3,696	336	27.1
3-24-05	12	73.0	6.1	4,378	364	33.4
3-25-05	12	58.7	4.9	4,103	342	28.6
Averages	**11.9**	**65.7**	**5.5**	**4,375**	**368**	**30.0**

Reduction in Volume due to Deposit Containers							
Material	**Density, lb/cy**	**Amt. in Recy. Mtl, % by wt**	**% Deposit Containers**	**90% Redeemed**	**Pounds per Load**	**Cubic Yards (cy) per Load**	**After Compaction, cy per day**
Aluminum	62	1.00%	96%	90%	47.7	0.77	0.19
PET	34	1.55%	90%	90%	69.3	2.04	0.51
HDPE, nat.	23	1.32%	5%	90%	3.3	0.14	0.04
HDPE, pigm.	44	1.57%	5%	90%	3.9	0.09	0.02
Glass	515	8.11%	92%	90%	370.6	0.72	0.36
Milk, Aseptic	51	1.75%	5%	90%	4.3	0.08	0.02
Totals					**500**	**3.84**	**1.14**
Savings			Cubic Yards per Day (for 24 loads)				**27.4**
			Equivalent Number of Trucks per Day				**0.51**
			Savings: Driver (unit cost = $109,750) Truck Repair, Maint. and Replacement (unit cost = $26,254) **Total Savings**				 $55,973 $13,390 **$69,362**

containers, and so would potentially be included in the deposit system. The savings from eliminating 90% of these bottles and cans from the litter would be 24.1% of the total cost, or $1,071,245 per year.

This analysis ignores the fact that part of the litter control costs may be fixed expenses that do not vary according to the amount of litter, but there is no information available as to the proportion of fixed and variable expenses for the litter control programs. This analysis also ignores the very small, presumably insignificant, number of milk containers that might be included in the plastic or glass bottle categories for the litter composition study. This analysis also does not, however, include the other types of containers (such as gabletop cartons and foil pouches) that would contribute to the amount beverage containers and hence increase the savings. More importantly, previous research has found that deposit systems not only reduce the amount of beverage containers that end up as litter but also reduce other litter by up to 47% (CRI 2004).

6. Increased Jobs: a report for the Arizona Department of Commerce estimates that 4.1 new jobs in recyclables processing and recycled-content manufacturing are created for every 1,000 additional tons recovered, without regard to type of recycled material (RW Beck 1996). We are projecting an additional recovery of over 112,000 tons of beverage containers, which could yield 460 new processing and manufacturing jobs. Based on data from The Institute for Local Self-Reliance presented in the MASSPIRG report (SRMG 1998), we expect at least half of these jobs to be in processing and pre-manufacturing.

We did not have the time or budgetary resources to accurately determine the extent of job losses in virgin materials industries that might occur in Washington as a result of increased beverage container recycling. However, three beverage container material types account for virtually all of the increased recycling – glass containers, aluminum cans, and PET bottles. We do not believe that there would be significant job losses in virgin aluminum manufacturing in the state because most virgin aluminum manufacturing here appears to be devoted to materials other than can sheet. For glass, we would expect the increased use of recycled glass to offset any reductions in virgin-content glass container manufacturing. Due to the current shortage of recycled PET in the US, the large offshore demand for it, and the lack of much recycled content in PET beverage containers, we would not expect the additional volume of recycled PET bottles to have any serious consequences for virgin PET production activities that may presently be occurring in Washington State. In conclusion, we do not expect to see many job losses in virgin-content product manufacturing as a result of increased beverage container recycling.

One could posit an impact on garbage and recycling truck operator jobs as a result of such a significant increase in beverage container recovery as well as a switch from recovery through curbside as a result of implementation of some sort of container deposit refund recycling system. Indeed we expect certain garbage and recycling collection route and recyclables processing efficiencies, as discussed in the sections on decreased garbage and recycling collection costs. However, we would not expect the institution of a deposit-refund system to result in any actual collection truck operator lay offs. Rather the change would most likely mean a delay in new hires to cover population growth in the state, but not a decrease in current employment levels.

In summary, then, we would expect to see significant new employment opportunities in recyclables processing and recycled-content manufacturing as a result of implementation of a beverage container deposit-refund system in this state. The reader should note that our minimum estimate of over 200 net new jobs in the state does not include any jobs that might be created as part of the infrastructure put in place to collect deposits, refund deposits and handle the beverage containers returned for deposit refund and shipment to recycled container processing centers. We treat these jobs as costs of the deposit-refund system rather than increased job benefits, but such jobs would also provide gainful employment for those who got and held them. It would be legitimate, however, to apply an economic multiplier effect to these jobs as well as to the recycling jobs created as a direct result of container deposit legislation. Based on information from the Office of Financial Management (OFM 2004, see www.ofm.wa.gov/economy/io/), the indirect job gains factor would be about 2.74. Hence, a net gain of 200 jobs would also result in an additional 348 jobs due to ripple effects.

V. Cost of Deposit System

This part of the report addresses the increased costs associated with deposit systems. There are two primary costs: 1) the administrative/handling expense for the companies or organizations that need to handle the deposits and the returned containers and 2) the loss of market revenues from existing recycling programs.

A. Administrative and Handling Costs for Deposit Systems

The following is an analysis of the additional handling and other overhead expenses associated with the three main types of deposit systems. This analysis is by necessity based on existing experiences in other states and organizations, but this provides a "reality check" that other approaches to cost estimating might lack. On the other hand, it also requires several built-in assumptions about what a deposit system in Washington might look like.

1. Retail Stores for Collecting and Returning Deposits: much of the following analysis of costs for this approach (and for the next approach, on redemption centers, as well) is taken from the BEAR report (RW Beck 2002). As shown in that report, the costs vary among the nine traditional deposit systems, and the factors leading to those differences include:

- Labor rates paid to employees who handle returned containers at retail stores and at distributors, and the cost per square foot attributed to the space to recycle.
- The extent to which redemptions occur through retailers, redemption centers, third-party recyclers, old-line recyclers or reverse vending machines. Reverse vending machines (RVMs) and "old-line recyclers" generally have the lowest costs (RVM costs are discussed separately below).
- Although documentation is scarce, the sorting of containers by brand name, which most traditional deposit systems require, adds a cost compared to systems in which brand sorting is not required.

Revenue sources also vary. Factors affecting revenue include:

- The deposit amount and redemption rate.
- The existence of a state "escheat" law (which determines whether unredeemed deposits are available to offset system costs).
- The existence and basis of handling fees (which transfer costs from retailers and redemption centers to bottlers and/or producers).
- Differences in market value resulting from regional market conditions, the mix of containers redeemed and/or the business relationships of the program operators. Deposit systems yield the highest quality materials and, especially for glass and plastic, are often are sold at higher values than materials collected in curbside programs.

There is a wide range in the availability and quality of cost data on the nine traditional deposit systems, partly because the systems are largely private sector-based. Due to concerns over differing methodologies, the BEAR report based its estimates of typical program costs on a detailed study that had been performed by Franklin Associates Ltd. for a confidential client. That study only examined one traditional deposit system but those estimates are adjusted as appropriate in the BEAR report. Some of the key assumptions in the Franklin study include:

- *Covered beverage containers.* In this cost model, Franklin Associates, Ltd. assumed the covered beverages to be soft drink and beer, the types most frequently covered by traditional deposit systems.

- *Redemption Rate.* Based on redemption rates for the three states with the best documentation (which happen to be the three most populous traditional deposit states – New York, Massachusetts and Michigan), a 1999 average redemption rate of 78% was used.
- *Study Year.* The deposit system cost model uses 1999 data.
- *Redemption Only.* The cost model addresses only the costs and revenues associated with redemption of covered beverage containers. Additional recycling occurring in deposit states through curbside and other programs was not addressed.
- *Fraudulent Redemption.* Container redemption fraud through containers being transported across state lines from a non-deposit state to a deposit state is accounted for in the model, since it considers average redemption rates (presumably including some degree of fraudulent redemption). A study prepared for the Michigan Great Lakes Protection Fund in July 2000 estimated statewide fraud at 2.5% of the containers redeemed in Michigan, although Michigan's deposit is 10¢ per container or twice the national average for states with deposit laws. Fraudulent return rates are likely higher for those communities located on the border of a state that does not have deposit/redemption legislation.
- *Flow of containers.* Consumers redeem used containers at either retailers or redemption centers, which return the containers to either the distributor or a third-party recycler. Most distributors process the redeemed containers for sale to scrap markets. In this analysis, 72% of the redeemed containers are assumed to be processed by distributors and sold directly to markets. The remaining 28% are assumed to flow first to an intermediate processor and are then marketed.
- *Percentage of Containers Handled by Each Party.* The BEAR report makes specific assumptions about the relative amounts of containers that are handled by the retailers, redemption centers, distributors, third-party recyclers, and intermediate processors. These assumptions in particular are likely to vary significantly by state depending on the deposit system in place.
- *Container Mix Handled by Each Party.* The container mix (aluminum, glass and plastic) will also differ for each party involved in the system, and this mix will vary from state to state depending on the deposit system in place.
- *Handling Fee.* Handling fees help offset retailer and/or redemption center program costs. Handling fees do not reduce or increase the overall system costs, but only shift the cost burden. In the BEAR report, distributors are assumed to pay 2¢ per container handling fee to the retailers or the redemption centers, and third-party recyclers receive the handling fee from the retailer. Seven of the nine traditional deposit states have similar handling fees, ranging from 1¢ per container in Iowa to 3¢ in Maine and Vermont. Legislation in Michigan and Oregon do not provide for a handling fee, although Michigan does return 25% of the escheat fund to retailers to offset their costs.
- *Processing Costs.* The BEAR report assumes that the processing costs for deposit containers would be similar to those estimated for a curbside sort or drop-off program in which containers are completely source separated. Processing costs may sometimes be less than this, since the materials collected through a deposit system are generally cleaner and better separated than other recycling programs.
- *Market Value.* Finally, the BEAR report assumes that market values for recovered materials in the deposit system are the same as those used in the curbside and drop-off collection program analyses, which understates deposit revenues in relation to curbside and drop-off programs. In this report, we used market revenues for glass based on the sales value for color-sorted glass containers instead.

Typical costs are shown in the BEAR report for each party involved in the deposit system, and are expressed in terms of dollars per ton of material (aluminum, glass, and plastic) as well as cents per container. The figure for cents per container is used here because it avoids the need to convert from the number of containers based on assumptions about container weights and material densities. This figure is used in Table 5-1 to calculate the cost of a deposit system.

Table 5-1
Costs for Administrating and Handling Deposit Containers

	Retail Stores	Redemption Centers	Third-Party Organizations	Average
Statewide:				
Millions of Containers	3,643	3,643	3,643	3,643
Cost per Container	$0.0407	$0.0162	$0.0221	$0.0263
Total Cost	$148,270,000	$59,020,000	$80,510,000	$95,811,000
Tacoma Only:				
Millions of Containers	107	107	107	107
Cost per Container	$0.0407	$0.0162	$0.0221	$0.0263
Total Cost	$4,355,000	$1,733,000	$2,365,000	$2,814,000

The costs shown in Table 5-1 are not "net costs" (do not take into account material revenues, for instance). The net cost for a deposit system is borne ultimately by the consumer, but costs are incurred initially at several different levels:

- *Consumers.* Consumers pay the deposit on covered beverages at the time of purchase. If the container is not returned to the retailer or redemption center, the consumer absorbs the cost of the deposit. If the consumer redeems the container, there is a cost associated with transporting the container back for the redemption, which is borne by the consumer. In this analysis, it was assumed that most consumers combine travel for returning containers with other objectives such as grocery shopping and therefore this cost impact is negligible.
- *Retailers.* Retailers include grocery stores, convenience stores, specialized markets, and other locations that sell deposit beverages. Retailer costs include allocating floor space to recycling activities, investment in equipment and supplies, daily operation and labor. Labor expenses include sorting, cashier, accounting and management work related to handling deposit containers, refunds, handling fees, etc.

  The average hourly retail wage rate assumed in the BEAR report, $9.50, was developed from previously administered industry surveys. Each job classification wage rate for employees involved in handling redeemed containers was weighted according to the amount of time spent handling the containers. For example, the salary range for employees in the redemption area and sorting and storage areas ranged from $7.50 to $11.50 per hour. The cashier and accounting pay range was $8.00 to $12.00 and management was over $15.00 per hour. Since over 80% of the labor was assumed at the redemption, sorting and storage areas, the average labor rate reflects these entry-level positions. Operational costs included items like pest control, additional cleaning, storage boxes, etc. Investments such as building modification and equipment were included. Space set aside for handling containers, such as sorting, storage and redemption areas, was included in the model as well.
- *Redemption Centers.* The labor costs to redemption centers are associated with sorting the beverage containers and collecting the deposit and handling fees. Redemption centers also incur investment costs for buildings and equipment and the cost of providing space for sorting and handling operations.

- *Distributors.* The labor costs to distributors involve collecting the beverage containers and processing them for recycling markets. Distributors also incur investment costs for buildings and equipment, the cost of providing space for operations, and the costs of any handling fees and the management of those fees.
- *Third-Party Recyclers.* The cost of handling deposit containers through third-party recyclers was estimated similarly to the other entities. Labor costs involve some sorting and processing of the beverage containers. Third-party recyclers also incur investment costs for buildings and equipment and the cost of providing space for sorting and handling operations.

1b. Reverse Vending Machines: the above cost analysis assumes that all collection and processing is done by hand. A potentially less expensive alternative is the use of reverse vending machines (RVMs). In traditional deposit systems, labor accounts for about 76% of the retailer costs and 82% of the redemption center costs. The use of RVMs in some bottle redemption states has reduced labor costs associated with redeeming containers.

RVMs are typically located in supermarkets or recycling centers. The machine identifies the container and brand owner by the barcode marking. It sorts containers by material type, then compacts or shreds the containers in order to destroy the barcode, increase storage capacity, and reduce transportation costs. RVMs can accept aluminum cans, glass and plastic bottles, and steel cans.

The cost of using an RVM is estimated by the BEAR report to be $0.0253 per container (versus manual sorting methods at $0.0407 per container).

2. Redemption Centers: this approach has been used in California for the past few years and is also the system recently implemented in Hawaii. Some of the differences between this system and traditional deposit systems, which affect costs and revenues, are:

- Unlike traditional deposit systems, distributors and retailers do not handle containers.
- Unlike traditional deposit systems, redeemed containers are not sorted or shipped by brand.

The California system has an on-going comprehensive audit and documentation reporting system compiled annually by the California Department of Conservation, Division of Recycling (DOC). This is possible because all funds flow directly into the DOC and are dispersed from the DOC to other entities. The California Redemption System cost analysis shown in the BEAR report is based on data for 1999 as provided by the California DOC.

In the California system, containers are returned by consumers to one of three parties (figures shown are the percentage of returned containers that each handled in 1999):

1) “old-line recyclers” (67%);
2) convenience zone recyclers located close to retail stores (24%); or
3) curbside programs (7%).

In addition, a very small percentage of containers are recycled at other locations such as office or venue recycling programs.

The BEAR report shows gross system costs of 1.62¢ per container, while the net cost is of course lower due to the offsetting material revenues. Unredeemed deposits are used to help finance the system plus pay for grants and other recycling promotion programs.

The Convenience Zones receive both a processing fee and a handling fee for glass and PET containers, but not for aluminum containers. In aggregate, the Convenience Zone recyclers, which account for 24% of the recovery of beverage containers, have revenue exclusive of scrap value (processing fees +

administrative fees + handling fees) amounting to $279 per ton of materials recovered. By contrast, old-line recyclers, which handle 67% of returned containers, receive revenue from the same sources amounting to $93 per ton of materials recovered. The contrast there shows how much the old-line recyclers benefit the redemption program, again partly because of the way the California system works, and partly because pre-existing infrastructure benefits the system from a cost standpoint.

3. Third-Party Organizations: TPO operating costs are difficult to determine because they are relatively new organizations and since they are mostly voluntarily funded by private business, cost information is usually not available. Some observations, however, can be made from published data.

In its 2003 annual report, the Carpet Industry TPO, CARE lists 15 sponsoring members. Based on the published membership schedule for CARE, these 15 organizations contribute approximately $300,000 per year. For 2003, they reported 43,300 tons of carpet recycled for a per ton cost of $6.92 for the TPO.

TPOs have been established in many Canadian provinces to handle not only containers but packaging and many other products. In 2002, the Ontario Waste Diversion Act (WDA) established Waste Diversion Ontario (WDO), a permanent, non-governmental corporation whose mandate is to oversee the development of waste diversion programs for specific wastes as requested by the Minister of the Environment. The Act specifies the composition of the WDO and its responsibilities.

The WDA authorizes and charges the WDO with establishing Industry Funding Organizations (IFO) for each designated material. The IFOs are a second tier of producer responsibility organizations. The WDA outlines the roles and responsibilities of the WDO and the industry funding organizations.

The materials are not designated in statute. The Minister is able to designate materials through "minister's regulations," which do not have to be approved by the provincial legislature. There is a consultation process between the affected parties and local governments and then the Minister files the regulation and it becomes law. The actual process consists of the following steps:

- The Minister of the Environment designates a waste material, and requires WDO to develop a diversion program for the material.
- WDO creates an IFO, or works with an existing one. WDO establishes an agreement with the IFO, and together they develop a program, which will include an industry fee structure to pay for the program, performance targets and implementation details.
- The WDO submits the agreement and program to the Minister for approval.
- The Minister approves the agreement and program.
- The IFO begins implementing the program, and may make rules, as authorized in statute, to designate stewards (stewards are usually brand owners and first importers) of the specified waste material, and set the amount of the fee to be paid by the stewards.
- The IFO submits an annual report to the WDO, which submits an annual report to the Ministry of Environment.

Ontario not only requires that the IFO's cover the cost of collecting their materials through a takeback network, they require that the fees cover 50% of the cost of the municipal recycling programs. The current fee structure for the blue box (curbside recycling) program is shown in Table 5-2. Note the negative value for aluminum packaging for food and beverage cans. The municipality actually pays the manufacturer to use aluminum cans which is indicative of their high market value and recyclability.

Glass weighs 0.5 pounds per bottle and 33 plastic bottles or aluminum cans equal a pound. Hence, the cost to the producer for 33 plastic bottles is $0.19 per bottle and for a glass bottle producer $0.85 to $1.00 per bottle depending on color. The Ontario system shows how a Product Stewardship system transfers the cost of collecting packaging materials from the ratepayers of a recycling system to the manufacturer and ultimately the consumer of the product being manufactured.

Table 5-2
Table of Fees for Ontario Blue Box Recycling Program (2005)

Category	Material	Annualized Fee
Aluminum packaging	Food and beverage cans	- 0.37 ¢/lb
	Foil and other aluminum packaging	1.88 ¢/lb
Glass packaging	Clear	1.28 ¢/lb
	Colored	1.51 ¢/lb
Other Packaging	Paper based packaging	2.69 ¢/lb
	Plastic packaging	4.74 ¢/lb
	Steel packaging	1.62 ¢/lb
Printed Paper	Newspaper CNA/ OCNA Members	0.09 ¢/lb
	Newspaper Non CNA/OCNA	0.27 ¢/lb
	Magazine and Catalogs	0.29 ¢/lb
	Telephone Directories	0.44 ¢/lb
	Other Printed Paper	3.08 ¢/lb

Figures in the above table have been converted from Canadian currency to U.S. Dollars based on an exchange rate of $0.75 U.S. to $1.00 Canadian.

Finally, a report from Clarissa Morawski of CM Consulting (CMC 2003) identifies system costs for most of the Provincial container deposit programs. For provinces in the report with TPOs and with available cost data (British Columbia, Alberta, and Saskatchewan), the costs of the system ranged from 2.5¢ to 3.4¢ per unit without the unredeemed container revenue as an offset, and from 0.83¢ to 1.8¢ per unit with the unredeemed deposits as system cost offsets. For 2.5¢ to 3.4¢ per unit in Canadian dollars, at a current exchange rate of 75¢ Canadian to $1.00 USD, this is the equivalent of 1.9 to 2.6¢ per container or an average of 2.21¢ per container in U.S. dollars.

B. Loss of Market Revenues for Residential and Commercial Recycling Programs

If that portion of the beverage containers that are currently being recycled were instead handled through a deposit system, existing recycling programs will lose the revenues that they are currently receiving for those containers. The existing recycling programs might also retain that portion (and more) of their revenues if they were part of the system for returning deposits to consumers (such as is done in California), but that benefit is discussed in Section IV.B.1 (market revenues would benefit someone in the system, if not the existing recyclers, assuming the containers were recycled).

Even if existing recyclers were not part of the container redemption system, they could potentially benefit from deposit containers that are still recycled through the traditional recycling programs (i.e., deposit containers that are set out for curbside recycling, etc.), but only if:

- existing recycling systems can be modified to recover intact deposit containers (see discussion in Section II.B).
- existing recyclers are allowed to redeem the recovered containers. In Oregon, for instance, few recyclers can redeem containers for the deposit due to the structure of their deposit system.

Preliminary data from a study being conducted in Oregon (Spendelow 2005) indicates that about 5% of the deposit containers are being received by curbside and drop-off recycling programs. If the deposit were 10¢ instead of 5¢ (as it is in Oregon), then this figure may be higher or lower. It could be lower than 5% due to people having a greater incentive to bring the containers back to a location where the deposit is reimbursed, or the figure could be higher due to an overall higher recycling rate. For the purposes of this analysis, it is assumed that existing recyclers would receive 5% of the deposit containers in either case.

Due to the wide range of market prices received by recyclers across the state, plus concerns about transportation costs and other factors, it is nearly impossible to accurately project what the loss of market revenues means on a statewide basis. The best that can be done within the scope of this report is to calculate the impact for the City of Tacoma's system and then project that to the entire state. Needless to say, this approach has a number of drawbacks and so the statewide figure should only be taken as an indication of the order of magnitude of the impact on a statewide basis.

Table 5-3 shows the impact to the City of Tacoma in terms of loss of market revenues for beverage containers that are instead handled through a deposit system, minus the increase in revenues from the recovery of deposit containers that are still in their recycling program. This table uses the following data:

- Lost market revenues are based on the city's recycled tonnages, taking into account only that portion that is contributed by beverage containers (see Table 1-4). In this case, 100% of the amount of beverage containers in each material category is assumed to be lost (although we add back in 5% in the next step), because the assumption is that the portion of containers that is not recycled or redeemed (20% loss with a nickel deposit and 10% with a dime) is instead landfilled or otherwise gone. These tonnages are multiplied by the current value per ton (as of March 2005) received by Tacoma for each material, minus the current processing fee (see Section I.A.1 for a more detailed description of Tacoma's existing recycling system). The amount of aluminum was also adjusted by removing the estimated 200 tons handled by local buy-back centers (since those tons aren't assessed a processing fee, etc.) that had been added in for Table 1-4.
- The statewide figure for the net revenue loss is calculated by working backwards from Tacoma's net figure per ton.
- For the figures for recovery of deposit containers, colored HDPE is not shown for the statewide figures because a breakdown is not available for the amount of natural versus pigmented HDPE that is recycled statewide. In other words, for the statewide figures, all HDPE bottles (natural and pigmented) are shown under natural HDPE.

C. Other Potential Costs

1. Loss of Litter Funds: a potential concern for enacting a bottle bill in Washington State is the loss of litter funds. Originally, the litter tax was proposed and adopted in Washington as an alternative to a bottle bill being considered at about the same time that Oregon's law was adopted. Should a bottle bill be enacted in this state, some may argue for relief from the litter tax, at least for beverage containers. Only a portion of the litter tax is paid for beverage containers (see list in Chapter 1), however, and it would unreasonable at this point to argue for a complete cancellation of the litter fund on this basis. Furthermore, the litter funds are already at risk and a portion of the funds may not be available in the future because Governor Gregoire is proposing to shift $2 million out of this fund and put it into the general revenues for other programs.

Table 5-3
Lost Market Revenues for Existing Recycling Programs

	City of Tacoma			Statewide		
Commingled Materials:	Tons	Value per ton	Market Value			
Aluminum Cans	214	$860	$184,352			
PET Bottles	377	$220	$82,955			
HDPE, Natural	13	$200	$2,530			
HDPE, Pigmented	11	$40	$450			
Total Commingled Tons	615					
Lost Market Revenue			$270,287			
Lost Market Revenue			$270,287			
Processing Fee ($23.65/ton)			- $14,545			
Net Loss for Commingled Mtl.			$255,742			
Glass Bottles:						
Tons	1,524					
Value (Cost) per ton		($20)				
Total Value (Cost)			($30,480)			
Handling Fee ($2/ton)			+ ($3,048)			
Net Revenue (Cost) from Glass			($33,528)			
Net Revenue Loss		$222,214				
Total Tons		2,140				
Net Loss per Ton		$103.84				
Net Loss per Ton				Assumed to be same as Tacoma		
Total Tons				77,550		
Net Revenue Loss				$8,052,800		
Deposits Redeemed through Recovered Containers:	Millions of Containers	Value at 5¢	Value at 10¢	Millions of Containers	Value at 5¢	Value at 10¢
Aluminum Cans	0.72	$36,174	$72,348	41.21	$2,060,320	$4,120,632
PET Bottles	0.48	$24,038	$48,076	6.75	$337,710	$675,419
HDPE, Natural	0.02	$806	$1,613	0.38	$19,220	$38,435
HDPE, Pigmented	0.01	$717	$1,424	NA	NA	NA
Glass Bottles	0.30	$15,245	$30,491	11.95	$597,420	$1,194,840
	1.54	$76,981	$153,961	60.29	$3,014,660	$6,029,330
Net Loss (lost revenues minus redeemed deposits)	$68,250 – $145,230			$2,023,470 – $5,038,140		

VI. Conclusions

A. Summary of Environmental and Economic Costs and Benefits

Table 6-1 shows a summary of the direct and indirect costs and benefits for Washington State and the City of Tacoma. These figures are explained in the previous chapters of this report but the primary assumptions made to allocate these costs are also shown below:

- the costs associated with public health and environmental impacts are explained in Chapter 3, and most of these figures were first calculated for Washington State and then prorated to Tacoma based on the city's share of the total population (3.2%).
- the reverse approach was used for many of the economic benefit figures, where costs and revenues for the City of Tacoma were first calculated and then scaled up to the rest of Washington State. This approach was necessitated by the lack of comprehensive statewide data for garbage and recycling costs. To scale up from Tacoma to the rest of the state, figures were prorated based on the number of tons disposed (a factor of 23.2) or recycled (a factor of 58).
- figures for "reduced disposal impacts" were calculated as a range and so the average value is shown in Table 6-1 for simplicity.
- no figure is shown for Tacoma for unredeemed deposits because the city would not collect these.
- material sales is based on the additional amount of recycling (see Table 1-4) and an average value for beverage containers of $250 per ton (see Figure 4-1).
- there should be a net increase in jobs for Washington State and Tacoma, but a figure for the value of these jobs is beyond the scope of this report.
- for the cost of the deposit system, we show the range of costs for the three different approaches in Table 6-1. Note that the costs for two of the three deposit systems are in the neighborhood of $60 million, which results in a net gain for a deposit system. Only the retail store based system has costs that result in a negative bottom line.
- loss of market revenues (see Table 5-3) was calculated based on both a 5¢ or 10¢ deposit amount, but only the value for 10¢ is shown in Table 6-1.

B. Next Steps

An important next step in considering a container deposit system for Washington State is to provide a better definition of the ideal system, since there are several different approaches that could be used. This would perhaps be best accomplished through a facilitated, consensus-based process, involving the key stakeholders in such a system, to define how a deposit system could work best in Washington. Once a proposed system had been developed, the details could be distributed to a larger group for review and comment. The list of possible stakeholders includes:

- private and public recyclers.
- cities, towns and counties.
- non-governmental organizations (NGO's) and others who would be likely proponents.
- NGO's and others who would be likely opponents.
- Washington State Soft Drink Association and various retail groups.
- Washington State Recycling Association (WSRA) and Washington Refuse and Recycling Association (WRRA).
- many others, including the Washington Citizens for Resource Conservation (WCRC), the State Solid Waste Advisory Committee (SWAC), Eastern Washington and Western Washington Recycling Coordinators, Washington State Association of Counties (WSAC), Association of Washington Cities (AWC), and other environmental and business organizations.

Table 6-1
Summary of Costs and Benefits

Cost or Benefit	State of Washington	City of Tacoma
Benefits from Reduced Public Health and Environmental Impacts of Beverage Container Disposal		
Reduced Greenhouse Gases	$11,300,000	$400,000
Avoided Acidification	$1,200,000	$39,000
Avoided Eutrophication	less than $500	less than $500
Reduced DALY	$3,600,000	$100,000
Reduced Human Toxicity	$600,000	$22,000
Reduced Ecological Toxicity	$2,500,000	$100,000
Reduced Disposal Impacts	$300,000 (ave.)	$9,600
Public Health Benefits from Reduced Litter	$1,400,000	$45,000
Subtotal, Environmental Benefits	$20,900,000	$707,000
Economic Benefits of Increased Beverage Container Recovery		
Unredeemed Deposits	$36,400,000	NA
Increased Material Sales	$28,126,000	$1,063,000
Decreased Garbage Coll. Costs	$1,813,100	$78,150
Decreased Disposal Costs	$3,491,400	$150,500
Decreased Recycling Collection Costs	$4,023,000	$69,400
Decreased Litter Costs	$1,071,000	$34,300
Increased Jobs	Net benefit	Net benefit
Subtotal, Economic Benefits	$72,361,000	$1,400,400
Total Environmental and Economic Benefits	**$92,969,000**	**$2,102,400**
Cost of Deposit System		
Administrative Costs**	$59,020,000 to $148,270,000	$1,733,000 to $4,355,000
Loss of Market Revenues for Recycling Programs	$2,023,500	$68,300
Total Costs	**$61,043,500 to $150,293,500**	**$1,801,300 to $4,423,300**
Total* **	**Total impact ranges from a net gain of $31,925,500 to a net cost of $57,324,500**	**Total impact ranges from a net gain of $301,100 to a net cost of $2,320,900**

*   DALY = Disability Adjusted Life Years.

** Redemption centers and third-party organizations are both at the low end of the range. Retail takeback is the high number of the range.

*** Both redemption centers and TPOs show a net gain for the State, and the redemption center approach shows a net gain of $301,000 for the City. Only the retail takeback option shows a net cost in all cases.

Glossary

The following definitions are for terms used in this report.

BEAR stands for Businesses and Environmentalists Allied for Recycling.
Beverage Containers are the primary container types used to package beverages for shipment from manufacturers or wholesalers to consumers. This report addresses aluminum, glass, PET and HDPE beverage containers. Transport and secondary packaging are not considered beverage containers.
Buy-Back Center refers to mainly privately operated centers that accept beverage containers (primarily aluminum cans) for recycling and pay consumers a portion of the material's market value.
California Redemption System is the unique deposit system adopted by California in 1987.
Convenience Zone Recycler is the term for a type of redemption center in the California redemption system.
Curbside Programs operated by municipal governments and private haulers collect recyclable materials primarily from residences.
Deposit System is the generic term for any recycling program that includes a deposit on beverage containers paid by the consumer, some or all of which can be recouped through participation in a qualified recycling program. Types of deposit programs include traditional U.S. deposit systems, the California Redemption System, several distinctive variations adopted by Canadian provinces and Northern European states and the deposit programs traditionally operated voluntarily by industry.
Discarded means used beverage containers (of all material types) that a consumer has returned for recycling or reuse through a recovery program, placed in a container for ultimate disposal at a landfill or incinerator facility, thrown away as litter or otherwise disposed (legally or illegally).
Disposed means discarded beverage containers that have been placed in a container for transport to a landfill or incinerator, or otherwise thrown away (legally or illegally).
Downstream refers to those impacts that occur after a product or packaging is disposed.
Drop-Off Programs means a facility or (unstaffed) containers where people can leave material to be recycled.
Escheat is a provision of two traditional deposit systems (in Michigan and Massachusetts) that allows the state to obtain unredeemed deposits. (California also retains unredeemed deposits but no escheat is necessary since the bottlers pay the state directly.)
Fraudulent Redemption refers to beverage containers from out-of-state that are illegally redeemed in a state's deposit program.
Handling Fee refers to per container payments paid by bottlers to retailers to offset their costs to redeem beverage containers in a traditional deposit system.
HDPE means High-Density Polyethylene, which is a type of plastic often used to produce water and milk jugs, among other products.
Intermediate Processing refers to cleaning, sorting and size reduction performed prior to shipping recovered beverage containers to a beneficiator, reclaimer or manufacturer for recycling.
MRF means Material Recovery Facility.
Old-Line Recycler refers to recycling centers in California that were in operation before the advent of the 1987 California Redemption Center. Old-line recyclers usually operate as buy-back centers and are certified by the state to redeem deposits to consumers.
PET means Polyethylene Terephthalate, which is a type of plastic used to make soda pop bottles and a growing list of other beverages and food products.

Recovery means the collection of discarded beverage containers for the purpose of recycling or reuse.
Recycling means using recovered beverage containers as a raw material to manufacture a new product or package.
Redemption Center is a location where consumers may redeem deposits on covered beverage containers.
Reverse Vending Machine (RVM) are automated devices that return the deposit refund to the consumer and that may have the capability to sort containers into refillable and nonrefillable containers and direct them to appropriate bottlers or processors.
Source-Sorted refers to materials that have sorted by the generator into the different materials, or at least into basic categories, for recycling purposes.
TPO means Third-Party Organization.
Third-Party Recycler refers to recycling processing companies that contract with bottlers to undertake their assigned recycling operations.
Traditional Deposit System refers to the type of deposit program adopted in nine U.S. states. In traditional deposit programs, beverage containers are typically returned to a retailer or redemption center, sorted by brand, shipped to the bottler or a contracted third-party recycler and processed for sale to an end-use market.
Unredeemed Deposits are the funds resulting from the fact that not all beverage containers for which deposits are paid are redeemed. Unredeemed deposits may be used to offset bottler costs or may flow to states through an escheat provision.
Upstream refers to those impacts that occur due to the production process for a product or packaging.

References

AOR 2004. Association of Oregon Recyclers newsletter. *Tour of the Month – NORPAC, Longview, WA*, August 2004.

APC 1995. American Plastics Council. *How to Collect Plastics for Recycling*, 1995.

Cascadia 2002. Cascadia Consulting Group. *Residential Recycling Composition Study*, prepared for Seattle Public Utilities, October 2002.

CF 1987. The Conservation Foundation, *State of the Environment: A View toward the Nineties*, 1987.

CMC 2003. CM Consulting. *Who Pays What-An Analysis of Beverage Container Recovery and Costs in Canada*, 2003.

Costanza 1997. Robert Costanza, et al. "T*he value of the world's ecosystem services and natural capital*," Nature, Vol. 387, 15 May 1997.

CRI 2004. Container Recycling Institute. *The 10¢ Incentive to Recycle*, 2004.

CRI 2005. Container Recycling Institute. *Washington State Beverage Container Market Data Analysis*, prepared for the City of Tacoma, April 2005.

deGroot 2002. Rudolf S. de Groot, et al, "*A typology for the classification, description and valuation of ecosystem functions, goods and services*," Ecological Economics, Vol. 41, 2002, pp. 393-408.

Ecology 2002. Washington State Department of Ecology. *Beyond Waste, Washington State Solid Waste Plan Issue Paper 10: Solid Waste Costs and Barriers to Recycling*, Publ. No. 02/07-030, December 2002.

Ecology 2004. Washington State Department of Ecology. *Thirteenth Annual Status Report*, December 2004.

EPA 2002. Environmental Protection Agency. *Economic Analysis of the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations*, EPA-812-R-03-002, December 2002.

GS 1997. Green Solutions. *The Business Recycling Cost Model*, 1997.

GS 2003a. Green Solutions. *Waste Composition Analysis for the State of Washington*, prepared for Washington Department of Ecology, June 2003.

GS 2003b. Green Solutions. *Solid Waste Composition Study*, prepared for Clallam County, Washington, June 2003.

Koplow 1994. Douglas Koplow. *Federal Energy Subsidies and Recycling: A Case Study*, Resource Recycling, November 1994.

Lippiatt (2002). Lippiatt B. *BEES 3.0 Building for Environmental and Economic Sustainability, Technical Manual and User Guide*, Office of Applied Economics, Building and Fire Research Laboratory, National Institute of Standards and Technology, Technology Administration, US Department of Commerce, October 2002.

Miller, various. Chaz Miller, National Solid Wastes Management Association. *Profiles in Garbage*, articles highlighting specific materials, Waste Age magazine, various dates of publication.

NRC 1992. National Research Council, *Environmental Neurotoxicology,* National Academy Press, 1992.

OFM 2004. Washington State Office of Financial Management. *1997 Washington Input-Output Model*, revised July 2004.

RTI 1999. Research Triangle Institute. *A Decision Support Tool for Assessing the Cost and Environmental Performance of Integrated Municipal Solid Waste Management Strategies: Users Manual, Draft*, prepared for the US Environmental Protection Agency, 1999, and *Application of Life-Cycle Management to Evaluate Integrated Municipal Solid Waste Management Strategies, Draft*, US Environmental Protection Agency, 1999.

RW Beck 1996. R.W. Beck. *Arizona Recycling Market Development Study: Economic Impact of Recycling in Arizona*, prepared for Arizona Department of Commerce, December 1996.

RW Beck 2002. R.W. Beck, Franklin Associates, Sound Resource Management Group, and Tellus Institute. *Understanding Beverage Container Recycling*, prepared for Businesses and Environmentalists Allied for Recycling, January 16, 2002.

Spendelow 2005. Personal communication with Peter Spendelow about preliminary results of Oregon study.

SRMG 1998. Sound Resource Management Group. *Economic & Environmental Benefits of Updating Massachusetts' Bottle Bill*, prepared for Massachusetts Public Interest Research Group, March 1998.

SRMG 2005. Sound Resource Management Group. *Comparative LCAs for Curbside Recycling versus either Landfilling or Incineration with Energy Recovery*," article printed in International Journal of Life Cycle Analysis (Online First 2004; forthcoming in print summer 2005).

Tellus 1992. Tellus Institute. *CSG/Tellus Packaging Study*, prepared for The Council of State Governments, US Environmental Protection Agency, and New Jersey Department of Environmental Protection and Energy, May 1992.

Tellus 1997. Tellus Institute. *An Analysis of the Costs and Benefits of Expanding the Scope of the Bottle Bill in Massachusetts*, prepared for Massachusetts Department of Environmental Protection, June 1997.