Co-Collection of Recyclables and Mixed Waste:

Problems and Opportunities

by Brenda Platt
Jill Zachary

Institute for Local Self-Reliance

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The Institute for Local Self-Reliance (ILSR) is a nonprofit research and educational organization that provides technical assistance and information to city and state government, citizen organizations, and industry.

Since 1974, the ILSR has researched the technical feasibility and commercial viability of environmentally sound, state-of-the-art technologies with a view to strengthening local economies. The Institute works to involve citizens, government, and private enterprise in the development of a comprehensive materials policy oriented towards efficiency, recycling, and maximum utilization of renewable energy sources.

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Introduction

Co-collection—the collection of recyclables and refuse in the same vehicle—provides communities with an alternative to the separate, dedicated approach to residential curbside recycling. Co-collection is a relatively recent development in the recycling field and has grown out of the search for more cost-effective ways to provide curbside recycling services.

There are two different methods of co-collection: the bag method and the bin method. In the bag method, residents commingle recyclables in one bag and set the bags out at curbside with their refuse. Haulers collect the bags of recyclables and the bags of refuse in the same collection vehicle. In the bin method, residents set out their recyclables in rigid containers with their bags of refuse. Haulers collect the recyclables and refuse in collection vehicles that have been retrofitted with recycling bins or trailers. While there are no additional capital collection costs for the bag method of co-collection, there will be added handling and processing costs because bags of recyclables need to be separated from bags of refuse, and recyclables commingled in bags must be sorted. Moreover, when recyclables are commingled in bags and collected with refuse, glass breakage can be a problem, reducing the amount of materials actually recovered and contributing to contamination of other recyclables. Although the bin method of co-collection involves an immediate capital investment for the collection process, it avoids double handling of refuse and does not require as much processing of the recyclables.

In this report, we describe the co-collection systems in 14 communities and present some observations and initial conclusions based on their operating experience. Tables 1-8, pages 13 through 24, provide detailed information on these programs, from demographic information to set-out and collection methods. At the end of this report, we present brief case studies on each of these programs.

Bag Method of Co-collection

There are at least ten communities in the country that co-collect refuse and recyclable materials using a bag system or have done so on a pilot basis:

- Boulder County, Colorado
- Bowdoinham, Maine
- Chicago, Illinois
- Greencastle, Indiana*
- Houston, Texas
- Missoula County, Montana
- Omaha, Nebraska
- Pullman, Washington
- Rochester, Massachusetts
- South St. Louis County, Minnesota

Residents commingle recyclables in one or more bags and set the bags out with their refuse. These programs use a number of different bag types to collect recyclable materials. Appendix A lists some bag vendors. The most popular bags are the Glad 13-gallon 1.5 millimeter and 1.75 millimeter thick blue bag manufactured by First Brands Corp. According to Brent Haney, the Environmental Affairs Officer at First Brands Corp., the 1.5 millimeter bag is used in co-collection programs when glass is not collected and the 1.75 millimeter bag is used in co-collection programs when glass is collected. First Brands has also developed a 1.01 millimeter thick blue bag, which is generally used to collect recyclables in dedicated recycling programs. Houston used 13-gallon 1.5 millimeter thick Glad low-density polyethylene (LDPE) bags manufactured by First Brands Corp. and high-density polyethylene (HDPE) bags used to package groceries in grocery stores. The pilot program in Rochester, Massachusetts used a

*This report does not evaluate Greencastle's program.

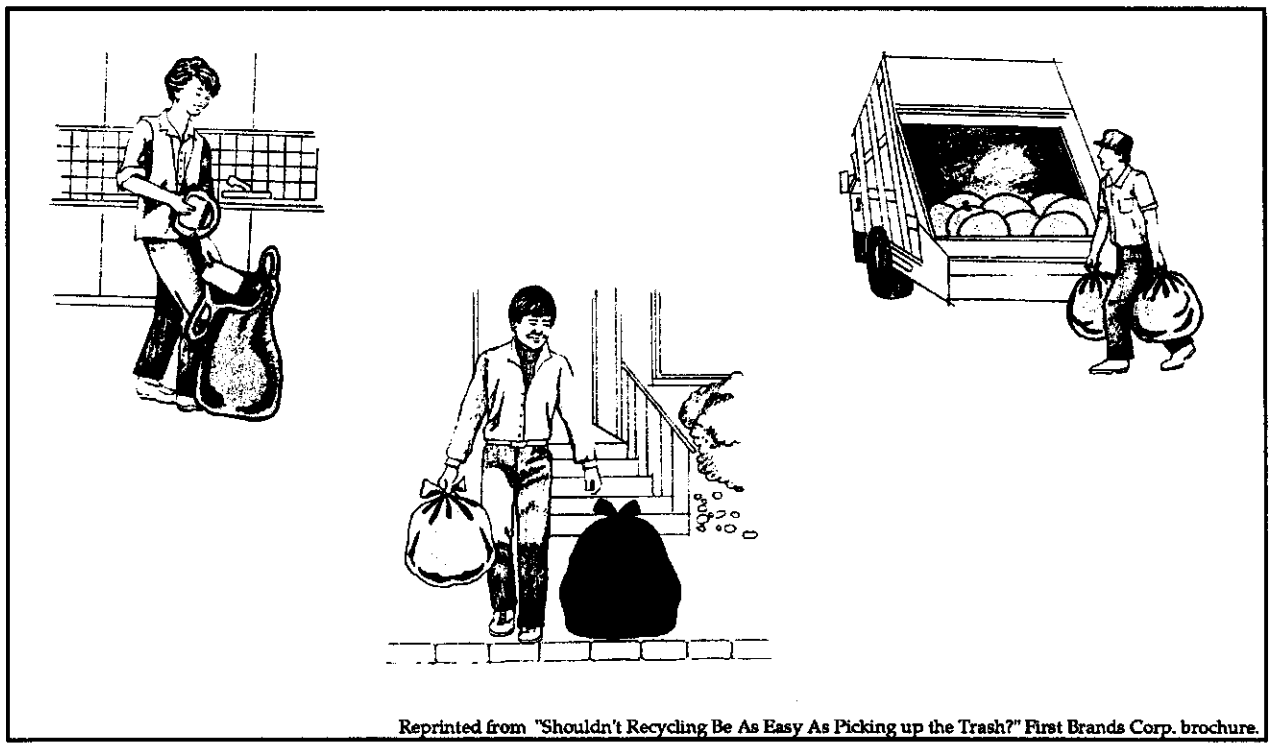
heavy, woven polypropylene "Recycle" bag developed by Exxon. In Bowdoinham, residents set out their recyclables in clear plastic 20-gallon bags. These 1.6 millimeter bags are purchased from Star Paper Co. in Haverhill, Massachusetts. Recycling bags have also been developed by Bagit Systems and Mobil Corporation. In 1988 Bagit Systems developed an 18-gallon polyethylene bag for the collection of recyclables. The bag is reusable and lasts for approximately two years. It comes in three colors (blue, white, and green) and has a handle on the bottom that is used to hold the bag when it is emptied. The top of the bag has a drawstring closure. Bagit bags are used in a number of communities including Jackson County, Florida; Portland, Oregon; Honolulu, Hawaii; and Nantucket, Massachusetts. Mobil Corporation has developed a 1.75 millimeter bag.

There are some variations in collection methods. Haulers in Boulder County, Missoula County, Pullman, and South St. Louis County place the bags containing recyclables on one side of the packer to facilitate the removal of the blue bags at the transfer stations or recycling centers. In most programs, haulers did not change the compaction rate when recyclables were added to the collection program. Compaction rates vary and depend on the size and design of the packer body. More refuse and/or recyclables can be collected at higher compaction rates. Yet the higher compaction rate, the more glass breakage becomes a problem. In some communities, when haulers decreased the compaction rate to accommodate the recyclables, the collection process became less efficient because the truck filled up more quickly, and haulers had to make more trips to the landfill.

While the most significant cost advantage of the bag method of co-collection is the use of existing collection vehicles, a number of vehicle manufacturers have designed packer bodies with two to five compartments for the collection of refuse and recyclables or yard waste. In Houston, BFI tested a prototype 25-cubic-yard packer truck with a split compactor developed by Pak-Mor Manufacturing Company in San Antonio, Texas. Recyclables were placed in the 5-cubic-yard section and refuse in the 20-cubic-yard section of the dual chamber rear loader. Although the BFI program tested the split compactor, it did not change the compaction rate for the recyclables compactor. BFI found that the compartmentalized collection body worked very well, but the number of compartments and the size of each offered some limitations. In certain neighborhoods, 5 cubic yards were not sufficient to store all the blue bags, while in other neighborhoods the blue bag compartment was more than adequate to store the blue bags before the refuse section became full. Additionally, BFI found that as the number of recyclable materials placed in the blue bags increases, the size of the compaction compartments would need to be adjusted. Therefore, BFI concluded that if recyclable materials are bagged, the bags create their own "compartments" and compartmentalized compaction is not necessary; and/or if compartmentalized compaction bodies are used to segregate recyclables from nonrecyclables and yard waste, then bagging the material is not necessary and only adds an additional step (that is, debagging) to the processing system.

G&H Manufacturing and Oshkosh are two other vehicle manufacturers that have developed specialized co-collection vehicles. G&H Manufacturing, Inc. in Arlington, Texas, has developed two to five compartment 20- to 32-cubic-yard rear loaders for about $65,000, which have been tested in Pennsylvania, Virginia, and Toronto, Canada. Oshkosh Truck Corporation has also developed a co-collection vehicle for an estimated cost of $113,000. Its vehicle consists of a 17-cubic-yard side-loading compactor and two 7.5-cubic-yard bins for recyclables (one for glass and metal containers and the other for paper). A plastics compactor is optional.

Other communities use a bag collection system for commingled recyclables in dedicated curbside recycling programs, but do not collect the bags with refuse. These communities include Pittsburgh and Erie, Pennsylvania; Madison, Wisconsin; Concord, New Hampshire; Liberty, Texas; Ft. Myers, Florida; Madison County, New York; Somerset County, New Jersey; and Mobil, Alabama.



Reprinted from "Shouldn't Recycling Be As Easy As Picking up the Trash?" First Brands Corp. brochure.

Blue Bag System: Household Source Separation, Curbside Set-out, and Collection

Bin Method of Co-collection

There are at least five communities that co-collect refuse and recyclable materials using a bin system or have done so on a pilot basis:

- Carroll County, Iowa
- Hamburg, New York
- Loveland, Colorado
- Shaker Heights, Ohio
- Sunnyvale, California

In addition, there are at least seven private haulers that offer co-collection programs in small service areas around the country: Area Refuse in Orange County, New York; Waste Stream Management in Potsdam, New York; Trash Collection Service in Smithfield, North Carolina; Burbridge Trash Service in Telluride, Colorado; Kronmuller Disposal Inc. in Phoenixville, Pennsylvania; American Disposal in Palmyra, Pennsylvania; and Vale Honeywagon in Vale, Colorado.

For the five communities documented in this report with bin co-collection systems, residents set out their recyclables in containers that range in size from 7 to 18 gallons. Recyclables are either segregated or commingled in the containers. In some programs, in addition to the containers, materials are set out separately. For instance, in Shaker Heights, newspaper is set out in paper bags, and plastic is set out in plastic bags next to the recycling containers.

There are two basic bin methods for co-collection. Collection vehicles are either retrofitted with recycling bins or pull trailers with bins.

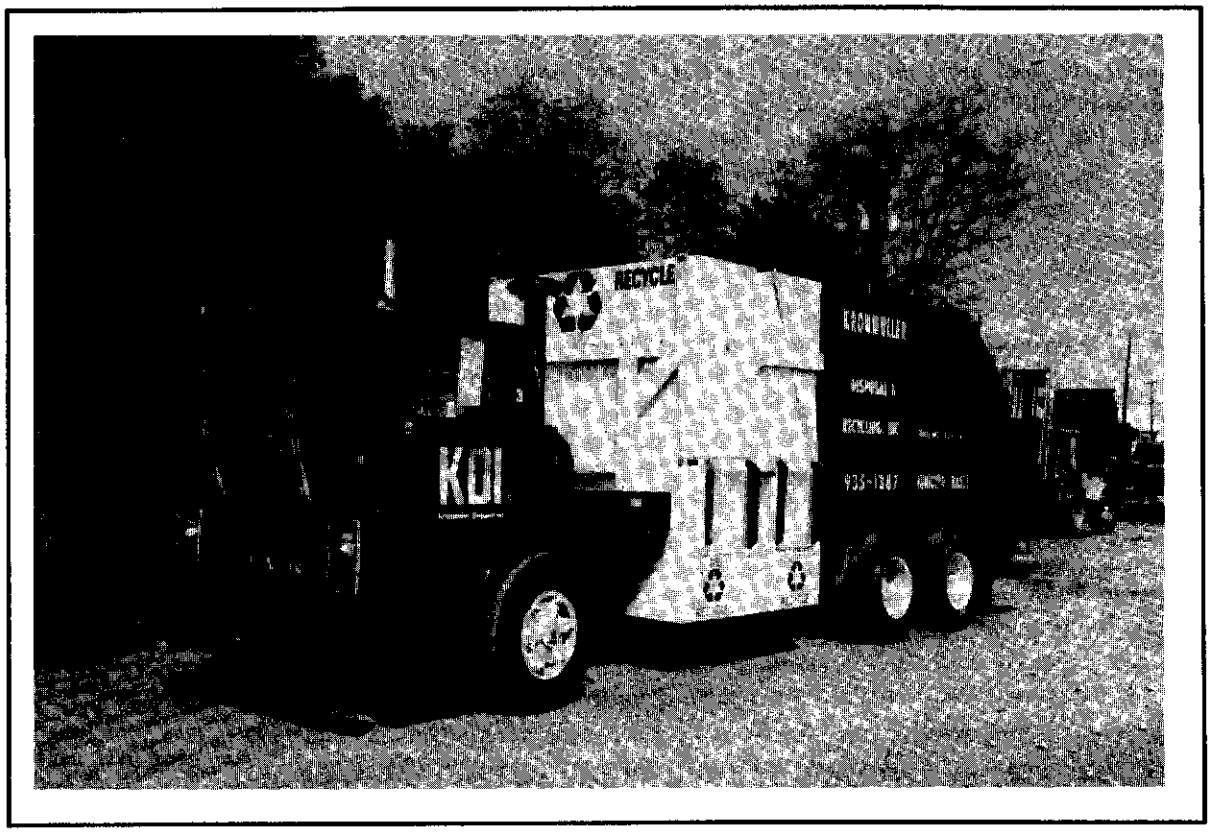
May Manufacturing in Arvada, Colorado, has designed a bin collection system, the Western Curbside Collector, which is being used by a number of communities with co-collection programs. When May Manufacturing retrofits an existing vehicle with its bins, it extends the truck frame and places the bins between the cab and the packer body. Bins are designed to meet the specific recycling volumes of the community. The bins vary in design from a single to a dual or multiple bin system and include one or more compartments. Costs for typical bin systems range from $7,800 to $17,000 depending on the size and the number of compartments (see Appendix B for a cost sheet for the May Manufacturing units and for a diagram of these). According to Jim McMahon at May Manufacturing, it would cost a hauler an estimated total of about $20,000 to convert an existing truck to co-collection (includes cost of bins, extending frame, and reducing packer size). Materials are either separated or commingled in the bins. For example, in Loveland, Colorado, each bin contains two compartments. One compartment is used for newspaper and corrugated cardboard, and the other compartment is used for glass, plastic, and aluminum and ferrous cans.

In Hamburg, New York, recyclables are collected in a trailer that is pulled by a packer truck in which refuse is collected. There are three compartments on each side of the trailer. Newspaper is collected in one, corrugated cardboard in another, and glass and plastic are collected in the third. In Carroll County, Iowa, haulers use both the retrofitted bin system and the trailer system.

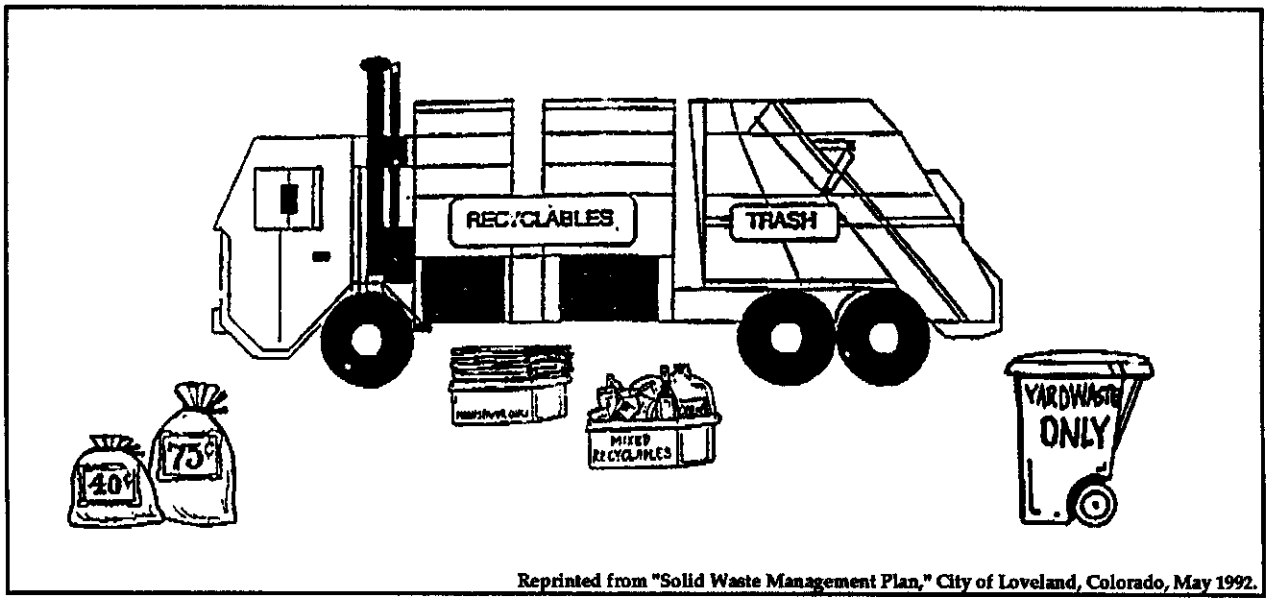
The bin method may introduce problems of volume capacity between the collection bins and the packer; that is, one compartment of one bin may fill up more quickly than the other compartments or the refuse section. (Specialized compartmentalized curbside recycling trucks of course can present the same problem.) If this happens, the collection vehicle becomes less efficient, it must make more trips to the landfill or recycling center, collection costs rise, and wear on the collection vehicles increases.

Moreover, there may be flexibility concerns with the collection bins. If a community needs to maintain a significant degree of separation of the materials, such as in Sunnyvale, California, where glass is color sorted at the curb, it may be difficult to add recyclables to the system once the program has been implemented. If additional recyclable materials are collected, a community may develop volume capacity problems between the collection bins and the packer area. However, some haulers and communities have reported no problems with volume capacities. In Carroll County, Iowa, two haulers who modified their trucks with bins report that their systems are flexible and can handle more recyclables because the bins do not fill up. In Hamburg, New York, the Department of Public Works has been using a trailer attached to its packer trucks to collect recyclables since 1981. Hamburg has experienced no capacity problems and considers its system flexible enough to handle additional items.

The pilot program in Loveland, Colorado initially experienced some difficulty. Since different neighborhoods set out different quantities of refuse and recyclables, the city could not develop accurate volume estimates for its vehicles. The city has addressed this problem by using trucks with compartments large enough to handle slightly over the average set-out for half of each truck's assigned route. Thus, each truck can collect from an average of 425 households before needing to go off-route to unload refuse and recyclables. It will then return to its route, complete another 425 stops and then unload again at the end of the day. Loveland, in other words, designed compartments large enough to handle a little more than half of each truck's assigned daily collections rather than trying to design a truck with compartments that would fill up simultaneously.



Kronmuller Disposal and Recycling Inc.'s (Phoenixville, Pennsylvania) Collection Vehicle Retrofitted with May Manufacturing's Western Curbside Collector



Reprinted from "Solid Waste Management Plan," City of Loveland, Colorado, May 1992.

Schematic of Loveland, Colorado's Collection System: Co-Collection Vehicle, Refuse Bags, Recyclables, and Yard Waste

Comparison of Co-Collection Recycling Systems

Participation Rates

Participation rates in recycling co-collection systems vary widely, from less than 10 percent in Boulder County to 98 percent in Hamburg. See Table 3, page 16. Convenience, legislative requirements, and economic incentives appear to play key roles in increasing citizen participation in recycling programs. Bag costs may reduce participation, mandating participation increases participation, as does distribution of free bags.

While a survey by Rice University of Houston blue bag users found that 73 percent did not consider having to purchase the recycling blue bag a "problem," in practice ongoing bag costs are an economic disincentive and may be an obstacle to high participation rates. Boulder County, Houston, Omaha, and Shaker Heights have the lowest participation rates among the 14 communities documented in this study. Of these, all but Shaker Heights employ or have employed bag co-collection systems in which residents have or had to purchase the bags. The low participation rate (40 percent) in Shaker Heights may be attributed to the inconvenient set-out method required—residents must set out glass in one container, aluminum and ferrous cans in another, newspaper in a paper bag, and plastic in a plastic bag. On the other hand, volume-based refuse rates are a direct economic incentive to participate in recycling no matter what the set-out requirements are. In Bowdoinham, residents are charged $1 per bag of refuse; the 20-gallon clear bag for recyclables costs only 10¢ each (this fee covers bag costs only). Participation in the curbside recycling program is an estimated 95 percent. Loveland's per bag fees for refuse have contributed to its 90 percent participation rate.

Requiring that residents pick up bags at local stores or at a specific office may be another disincentive to recycle. In Rochester residents had to pick up free bags after household distribution was discontinued. As a result of reducing convenience, participation rates dropped from about 70 percent to 50 percent. Boulder County's 10 percent participation rate is the lowest among the programs evaluated in this study. Not only are the bags the most expensive of the bag programs, but residents must pick them up at the hauler's Administrative Office. In most other bag programs, bags are available at local stores.

In Chicago's pilot bag co-collection system, bags were provided for free and distributed; participation by the end of the program was an estimated 84 percent. Bags were also delivered free of charge in Pullman's pilot program; participation rate in this program was an estimated 80 percent.

Participation rates are directly related to convenience factors. In Carroll County, residents are allowed to commingle all their recyclables, with the exception of corrugated cardboard and newspaper, in one 18-gallon bin. Participation in the county's curbside program averages 80 percent. Set-out requirements in Hamburg are similar, but residents can use a container of their choice. The fact that participation in the program is mandatory is an additional incentive. Approximately 98 percent of residents participate in the program.

Materials Targeted and Collection Rates for Recyclables

The number and type of materials targeted for recycling in the co-collection programs studied in this report vary considerably, in both bin and bag systems. See Table 4, page 17. While collection rates for recyclables (the ratio of recyclables collected to the waste generated)* are not available for every program, it appears that they depend largely on the number and type of materials targeted for recycling. Yet, because bag programs have higher reject rates, overall recycling rates will be higher in bin programs than in bag programs that target the same materials.

Most of the bag programs target newspapers and food and beverage containers (aluminum and ferrous cans, and glass and plastic containers). In Houston, BFI excluded glass, which it directed to buy-back and drop-off centers. Plastics are or were picked up in all programs except Boulder County. In

*Collection rates do not exclude any material rejected as nonrecyclable.

Rochester, newsprint was excluded. Corrugated cardboard is accepted in the bag programs in Bowdoinham, Omaha, and South St. Louis County.

Some of the bag programs target other materials. In addition to the materials mentioned above, South St. Louis County accepts magazines, brown paper bags, small scrap metal, high-grade paper, textiles, and all types of plastics. The recyclables collected from January to September 1991 represent 14 percent by weight of the waste generated from the 3,000 households served.

Bowdoinham picks up the widest range of materials—in addition to newsprint, corrugated cardboard, and food and beverage containers, haulers collect high-grade and mixed paper (junk mail, paperboard, magazines, paper towels, and wrapping paper), small scrap metal, rags, and all types of plastic including polystyrene. Its bag program is unique in that residents must sort these materials into five different bags. As a result of targeting so many materials, the town's recycling rate in fiscal year 1990 was 43 percent by weight.

For the programs that just target newspaper, and food and beverage containers, collection rates for recyclables are low. Consider Houston's 6 percent collection rate, Missoula County's less than 1 percent rate, and Omaha's 3 percent rate. Chicago, which also targeted magazines in its pilot program, reported a 7 percent collection rate for recyclables.

Materials targeted for recycling in the bin systems and collection rates vary from program to program. Two of the programs, Hamburg and Sunnyvale, accept used motor oil. Three out of the five bin recycling programs collect corrugated cardboard.

Bag Breakage, Reject Rate, and Contamination Issues

The main disadvantages of the bag co-collection method include glass breakage and material contamination. Glass breakage, in particular, compromises the quality of the materials collected. Broken glass shreds the bags and contaminates newsprint and other materials. Communities with bag programs report that from 10 to 25 percent by weight of the collected glass breaks. The concern over glass breakage has led communities to develop methods to insure the integrity of the materials. Some communities attempt to protect the newspaper by placing it in a separate bag either inside or outside the recyclables bag, by collecting glass separately, or by excluding glass from the co-collection program. Not only does broken glass compromise the collection system, it becomes a health and operational issue at the processing and manufacturing stage. Glass fragments are potentially harmful to workers who sort and process the material. (This problem of course is not unique to co-collection systems.)

At the beginning of Pullman's bag co-collection, the compactor blade in the collection vehicle used by the hauler, Pullman Disposal, shredded all the blue bags. The first day of the program, not one bag was retrieved from the vehicle. Glass in the bags compounded the problem. To reduce bag breakage, glass is now both set out and collected separated from other recyclables. Residents place glass in a separate bag, which they set out with their blue bag and refuse bag in their trash can. The hauler then places the glass in a side rack on the collection vehicle. A reduced compaction rate and the exclusion of glass from the blue bags has increased the recovery rate from an average of 30 percent to 80 percent. To further reduce bag breakage, Pullman Disposal is planning to switch from 1.5 millimeter First Brand Glad blue bags to a sturdier 1.75 millimeter bag developed by Mobil.

In Houston, 8 to 10 percent of the bags collected by BFI during the pilot program were rejected due to poor preparation by residents (residents sometimes set out refuse in the bags) and as a result of collection and processing activities. Like Pullman, BFI used the 13-gallon 1.5 millimeter Glad blue bags. Yet, BFI excluded glass altogether in order to avoid breakage during collection and material contamination. (Residents were encouraged to recycle their glass at drop-off and buy-back centers.)

In Missoula County, BFI uses the same Glad blue bags as it does in Houston and also excludes glass. (When residents include glass, BFI will recycle it.) Of the materials collected for recycling, 14 percent by weight was nonrecyclable residue, which included blue bags containing only refuse, blue bags of recyclables contaminated with refuse, and broken bags.

In Chicago's pilot program, the city instructed residents to place old newspapers in a grocery bag before putting them in the 13-gallon 1.75 millimeter Glad blue bags. Of the materials collected for recycling, 10.9 percent was nonrecyclable residue. In addition, 9 percent of the blue bags was lost as a

result of repeated loading and unloading—during collection, at the transfer station, and again at the sorting facility.

Omaha's program is similar to Chicago's pilot in that newspaper is separated from the other recyclables by being placed in a separate bag altogether. The city encourages residents to place their newspaper in HDPE grocery bags. Residents place their other recyclables in either 13- or 33-gallon 1.35 millimeter LDPE blue bags manufactured by Pitt Plastics. About 19 percent of collected materials are rejected as nonrecyclable; residue includes broken glass, magazines, disposable diapers, other plastics aside from polyethylene terephthalate (PET) and HDPE, pizza boxes and other mixed paper. Approximately 15 percent of the glass breaks during collection. A dedicated blue bag pilot recycling program in Concord, New Hampshire, includes both glass containers and paper, but in separate bags to reduce contamination.

In Rochester, the hauler offering the co-collection service, SEMASS Recycling Management Corp., chose to exclude newsprint altogether. One reason for this was concern that broken glass would contaminate the paper. Glass breakage was a significant problem in the Rochester pilot program. Of the total glass collected, 15 to 25 percent by weight broke during collection and processing activities. The front-end loader at the sorting site, which was used to separate bags of recyclables from bags of refuse, broke many of the bags and glass. SEMASS Recycling Management Corp. used a heavy, woven polypropylene bag designed by Exxon.

In Greencastle, Indiana's pilot program, 20 percent of glass collected broke. This was attributed to tossing the bags into the collection vehicles. The local hauler, Refuse Handling Services, did not compact the bags of refuse and the bags of recyclables. As a result, bag breakage has not been a problem.

In the Pittsburgh, Pennsylvania dedicated blue bag recycling program, nonrecyclable residue usually totals 5 percent; most of this is broken glass. Glass and plastic containers and aluminum and steel cans have been collected since the inception of this program in September 1990. Steel aerosol cans and newsprint were recently added. According to Doug Scott, operations manager at the Chambers Development processing facility, the amount of glass breakage depends on how much compaction the driver uses. Normally, drivers in the Pittsburgh program use less than half the compaction they would use for garbage. Erie, Pennsylvania's dedicated blue bag recycling program excludes newsprint and uses a very light compaction to reduce glass breakage, which averages less than 2 percent. In Mobil, Alabama's dedicated blue bag recycling program, glass is excluded altogether. A dedicated blue bag recycling pilot program in Concord, New Hampshire, is recycling more than 20 percent of the residential waste stream in the pilot service area. In this program, residents place mixed paper in one bag and glass, metal and plastic containers in a second. Browning Ferris Industries performs collection in standard rear-loading packer trucks, using a light compaction setting. Glass breakage and contamination of materials has reportedly been low. However, about 15 percent of the bags have been breaking in the truck or at the sorting plant. This problem has been attributed to the thinness of the bags, which are only 1.01 millimeter thick. In the Liberty, Texas dedicated blue bag recycling system, a two-bag system is used (one for newspaper and another for metal and plastic containers) to make sure the newspaper remains dry.

Only three of the bag co-collection programs reported virtually no problems with glass breakage: Boulder County, South St. Louis County, and Bowdoinham. In Boulder, few bags are collected; perhaps refuse bags provide a cushioning effect. Interestingly, both the other programs target the widest range of materials for recycling including mixed paper grades and all types of plastics. In South St. Louis County and Bowdoinham these materials likely cushion the glass. In addition, in South St. Louis, glass is placed in a separate bag within the blue bags. As a result, less than 1 percent of the glass breaks during the collection. In Bowdoinham, the fact that the bags are collected uncompacted in dump trucks has a lot to do with the low level of breakage (less than 1 percent of the glass breaks).

The bin method of co-collection has some advantages over the bag method. Materials are less likely to become contaminated during the collection process because materials are more likely to be set out and collected separated. Carroll County reports an average residue rate of 6 percent by weight of the material collected in its bin program; this includes broken glass and types of plastic not targeted for recycling. Some communities such as Hamburg, Sunnyvale, and Shaker Heights, report no residue rejected as nonrecyclable. In contrast, the bag programs documented in this study experienced residue

rates ranging from 5 to 19 percent. In the two of these programs with residue rates below 10 percent, glass was either collected separately or not at all.

In an ILSR study for the U.S. EPA, which documented in detail the recycling and composting programs of 30 communities,* those programs with commingled collection and sorting had significantly higher residue rates than those using more segregated collection systems that required minimal processing. Residue rates in the commingled systems were typically 7 to 14 percent. Residue rates for the segregated systems were typically 1 to 5 percent.

Costs

For communities that are interested in curbside recycling but do not want to make a substantial capital investment in a program, co-collection may provide a simple, low-cost approach to the curbside collection of recyclables. Many of the communities included in this study chose to co-collect for economic reasons. In rural areas such as Missoula County, Montana, and South St. Louis County, Minnesota, co-collection is the only cost-effective option for a curbside program because collection routes are long and the distance between households is too great to warrant a separate collection vehicle. Moreover, in rural communities such as Missoula County and Rochester, avoided solid waste disposal costs are not the driving force behind recycling programs; curbside recycling is offered to residents as a convenient alternative to drop-off areas. Pullman chose a bag co-collection program because it is largely a transient student community and the county did not want to continue to invest in residential collection containers.

The development of specialized refuse/recycling collection vehicles with split compactors provides communities with an alternative bag method of co-collection. While the capital cost of these vehicles negates the collection cost advantages of using existing collection vehicles for curbside recycling, these vehicles may prove more cost-effective than operating two trucks—one for recyclables and one for refuse. The Pak-Mor Dual Chamber Rear Loader body costs approximately $40,000 to $45,000. With the addition of a new truck, the total cost of the vehicle may be as high as $95,000 to $100,000. The Recycling Rear Loader body developed by G&H Manufacturing is similar in cost to the Pak-Mor design. Costs range from $30,000 to $45,000 depending on the size of the packer (from 20 cubic yards to 32 cubic yards) and whether there are two or three compartments. Although a split compactor may reduce material contamination because the refuse and recyclables are in separate compartments and compaction rates can be adjusted, there are no data to support this assumption. When BFI in Houston used the Pak-Mor Dual Chamber Rear Loader, it did not compare the quality of material from the blue bags in the separate compactor to the quality of materials from the blue bags that were collected with the bags of refuse. Communities considering the purchase of new collection vehicles and implementing curbside recycling, might wish to consider the split compactor. However, the split compactor has yet to be tested widely.

Similar to the bag method of co-collection, the bin method of co-collection offers communities the advantage of collecting recyclables with refuse in existing collection vehicles. However, the bin method involves an initial capital investment for the purchase and installation of the collection bins. The cost of retrofitting vehicles varies from community to community. For example, one hauler in Carroll County retrofitted his vehicle with a hydraulic lift and four compartments for approximately $9,000. Another hauler in the same county spent $19,300 for a retrofitted vehicle. For approximately $21,000, the city of Loveland, Colorado, retrofitted a 20-cubic-yard Leach collection vehicle with a two-bin dual side-loading unit manufactured by May Manufacturing. The city of Shaker Heights rebuilt six collection vehicles with collection bins and new packers for $320,000 (an average of $53,000 per vehicle). This latter cost is probably not typical for communities looking at adding bins to their trucks. According to Jim McMahon at May Manufacturing, it would cost a hauler an estimated total of about $20,000 to convert an existing truck to co-collection (includes cost of bins, extending frame, and reducing packer size). The initial capital investment to retrofit existing trucks with bins is small in comparison to the costs of new recycling vehicles needed for dedicated curbside recycling programs.

*Brenda Platt, et al., *In-Depth Studies of Recycling and Composting Programs: Designs, Costs, and Results*, Institute for Local Self-Reliance, Washington, DC, 1992.

Whether co-collection systems are cheaper than dedicated curbside recycling systems is not yet clear, and they may add to the costs of refuse collection. Bag co-collection systems in which the bags are not compacted, will reduce the operating efficiency of collection. For instance, in Greencastle, Indiana, where no compaction is used, the local hauler makes four trips to the transfer station a day. Prior to co-collection, when refuse was hydraulically compacted, it made one to two trips. Depending on trip distances, a loss in vehicle volume capacity can significantly increase costs. A number of haulers who have tried bag co-collection systems report no added collection costs with the addition of bags of recyclables as compared to just refuse collection. BFI reported no additional costs during its pilot program in Houston. Dave Kronmuller, owner of Kronmuller Disposal Inc. in Phoenixville, Pennsylvania, claims he is able to offer recycling service at no additional cost with his 13 cubic-yard truck retrofitted with bins. He services 200 households a day with newspapers, glass, aluminum, tin, PET, and HDPE recycling service.

Adding recyclables to the refuse collection program may make the collection method more labor intensive. Mark Frisone, the Assistant Service Director for Shaker Heights, estimates that with the addition of curbside recycling, collection personnel spend an additional 45 minutes to one hour on the collection route. Yet, these extra labor costs may be less than those that would be incurred through a dedicated curbside recycling program. A decisive factor in determining whether co-collection systems will be more cost-effective than dedicated recycling systems is the crew size for each vehicle and the number of daily collection routes for refuse and recycling. For instance, in Sunnyvale, a preliminary cost analysis indicated that co-collection would cost 20 percent more than a separate recycling collection program, primarily because two-person crews were needed for co-collection and only one-person crews were needed for the separate systems.

The cost analysis developed by Chicago's Department of Streets and Sanitation for the Blue Bag/Materials Recycling and Recovery Facility (MRRF) program has been criticized by local recyclers and community groups. The city estimates that the net system cost for the program in 1992 will be $12 million (capital burden of four MRRFs, operating and maintenance costs, and education minus the diversion value of 10 percent of the solid waste stream). Moreover, the city estimates that program costs would continue to decrease over a decade as the diversion rate increases (see Appendix C). The city's figures show that a blue bag/MRRF program will save the city $9.7 million in 1992 and $288 million over a decade over the separate collection program. However, according to community activists and recyclers, in order to support its own conclusions, the city underestimated its potential collection rates and overestimated costs for the dedicated system. The Chicago Recycling Coalition points out that the city of Chicago excluded the cost of the blue bags ($1.6 million per year) and significantly underestimated processing cost by assuming this will be $10 per ton. It further points out that dedicated recycling trucks are cheaper than specialized packer trucks, and that packer trucks should be saved for the specialized function for which they are designed: compacting and hauling garbage. Moreover, as recycling rates increase, specialized recycling vehicles will replace some refuse collection vehicles. Recycling trucks typically cost about $65,000 each, compactor trucks about $110,000. Recycling trucks also use less fuel than compactor vehicles.

Unfortunately limited economic data on operating co-collection programs are available (see Table 8, page 24). Collection costs are available for only three of the fourteen communities studied in this report. These collection costs range from $31 in Omaha to $63 per ton in Hamburg—not unlike traditional refuse collection costs. (Loveland estimates that its co-collection program, including collection, processing, and disposal, costs $79 per ton.) We have no separate data on the costs to separate refuse from recyclables in the bag systems, which necessitate double handling of refuse. Processing costs for recyclables are available for eight communities; these ranged widely from $18 to $269 per ton. Costs at processing centers around the country that handle recyclables from dedicated curbside programs also vary widely.

The cost of processing recyclables depends on a number of factors including scale, level of technology and automation, extent of sorting needed, and labor requirements. Capital and operating costs vary significantly from one processing operation to another. The 1992-93 *Materials Recovery and Recycling Yearbook*, which provides a detailed review of all planned and operation processing centers in the

United States, reports that capital costs range from $2,700 to $20,000,000 and operating costs from $7 to $189 per ton at facilities reporting this information.*

Low-tech facilities have lower capital costs than high-tech facilities, as do smaller operations. High-tech facilities tend to process commingled recyclables and to be large scale—above 100 tons per day. Such facilities are operating in Seattle, Washington; Providence, Rhode Island; and Islip, New York. Rabanco Recycling Company's processing center in Seattle cost about $7 million in capital equipment and has a capacity of 600 tons per day. Rhode Island's 120 ton-per-day facility cost $6 million. The Islip, New York processing center cost about $7 million and has a design capacity of 1,500 tons of commingled recyclables per week (300 tons per day). While capital costs may be high, operating costs tend to be relatively low at these facilities. Operating costs at Rhode Island's processing facility, for example, are only $32 per ton. Automation reduces the amount of manual sorting needed and the scale of these facilities reduces per ton costs.

On the other hand, low-tech and small-scale processing centers are often less capital intensive but have higher per ton operating costs due to the level of manual sorting needed and low tonnage throughput. Bowdoinham, Maine, and South St. Louis, Minnesota, for example, incurred $88 per ton and $269 per ton respectively for processing under 2 tons per day of commingled recyclables. Requiring residents to keep recyclables segregated or having curbside crews undertake some of the sorting can reduce operating costs at small-scale processing facilities. At the processing centers in Carroll County, Iowa; Hamburg, New York; and Shaker Heights, Ohio—all of which process under 15 tons per day of largely segregated recyclables—operating costs are under $70 per ton.

The costs of collecting and processing recyclables whether in a co-collection system or in a dedicated curbside system depend on a variety of factors—scale, distances traveled, crew size, level of processing needed and technology used, amount of materials targeted for recycling, compaction—some of which are discussed above. The trade-offs in costs are between collection and processing. Operating and maintenance costs for collecting recyclables in a co-collection system will likely be cheaper than in separate collection systems, but processing recyclables may be more expensive, especially for bag systems. Bags of recyclables must be sorted from the bags of refuse and then sorted by material. In all the bag systems currently operating, bags of recyclables are manually sorted from bags of refuse. For systems with minimal recycling, handling costs may be low. However, in communities that plan to maximize recycling, the extra cost of double-handling bags of refuse and recyclables on sorting floors may be extremely high. (Communities that use transfer stations already incur double-handling costs for refuse. While they may be well suited for bag co-collection systems for this reason, separating bags of recyclables from bags of refuse will add an additional step to the transfer process.) The processing stage for bagged recyclables is either labor intensive or capital intensive, depending on whether sorting is done primarily by hand or by machine. On the other hand, separate collection of recyclables using the bin method or dedicated recycling trucks may require much less sorting and material preparation depending on the level of en route sorting. Yet, these latter systems will take more time and labor at the collection step. Regardless of how recyclables are collected, they need some level of processing to meet end user specifications. The extent and level of processing required very much depends on the collection system in place.

Processors for most, if not all, bag programs split open bags of recyclables manually. At the Chambers sorting facility in Pittsburgh, workers wearing heavy gloves slice bags open with utility knives. Lummus Development Corp. of Columbus, Georgia has developed an automatic debagging system, which can open 60 13-gallon bags per minute (about 10 tons per hour). The machine sells for $90,000 to $95,000 and can now process bags containing glass, aluminum, ferrous cans, and HDPE and PET plastics. Lummus is currently in the process of designing a machine that can handle bags containing paper too and expects this version to be available in 1992.

In Omaha, Waste Management, Inc. (WMI), the city's contracted processor, raised its processing fees April 1992 for bags of recyclables from less than $20 per ton to $95.56 per ton. The company cites the labor-intensive nature of processing bags of commingled recyclables as the primary reason for the

*Governmental Advisory Associates, Inc., *1992-93 Materials Recovery and Recycling Yearbook*, New York, New York, 1992, pp. 52-58.

increased costs. The city's share of the revenues has also increased from 50 percent to 60 percent, and it is guaranteed minimum net revenues from the sale of each specific material (for example, $35 per ton for newspaper and $600 per ton for aluminum). The new contract requires that the process for separating the blue bags from the refuse be mechanized to improve efficiency and lessen the possibility for personnel injuries. According to city officials, separating the blue bags from the rest of the refuse under the initial contract was inefficient and strenuous work, although not "back breaking." (At the same time WMI increased the cost of recycling, it reduced the fee it charges for refuse handling from about $20 per ton to about $6 per ton. Under the previous contract, WMI paid the disposal costs for refuse; under the new contract the city of Omaha pays for these.)

High participation rates are critical to high recycling rates and, in turn, lower per ton costs for recycling. Participation rates for those programs requiring residents to buy bags at local stores can be expected to be lower than those programs providing recycling containers. One in-depth study of the communities with the higher recycling rates in the country, showed that those programs that collect more tonnage per household had the lowest per ton costs.* Thus, high participation rates and high recycling rates can be critical to keeping per ton costs down.

Based on the limited data available and the operating experience of the programs documented in this study, we believe that co-collection will be cost-effective if (1) high participation rates are achieved, (2) tonnage of recyclables collected per household is maximized, (3) refuse handling is minimized, and (4) glass is collected segregated in side bins to enable normal compaction settings to be used on refuse and other recyclables. In this way, communities can avoid incurring costs to operate a separate fleet of vehicles for recycling and help keep per ton costs for recycling low. We believe that the bin method of co-collection offers the best way to reduce the need to double handle refuse. The question of whether commingled systems are more cost-effective than segregated systems has no easy answer. Small communities that will have to undertake processing themselves in small-scale facilities could reduce their processing costs by collecting more segregated materials. Larger communities may benefit from economies of scale and be able to afford automated high-tech processing centers to handle commingled material. Both types of systems in the communities documented in this report have produced marketable materials (average per ton revenues range from $13 to $37). Although 19 percent of the material it collected was rejected, WMI in Omaha has not had any problems marketing recyclables collected commingled in the city's blue bag system. (Contamination has not been a problem because the sorting and preparation process is conducted under strict controls.) BFI received numerous letters from materials brokers and end users attesting to the high quality of the recyclables it processed from Houston's pilot blue bag program. Communities looking at implementing co-collection systems need to evaluate the trade-offs closely and keep in mind that producing high-quality recyclables will become increasingly important in these times of tight markets.

Conclusion

To date, there is very little hard data on the comparative costs for the two methods of co-collection. Co-collection has yet to reach a stage of development where program characteristics can be analyzed and conclusive observations made. Each method offers advantages and disadvantages that become less or more important with each community's program goals and design characteristics. Table 9, page 25, presents some of the trade-offs between co-collection systems and separate collection systems for refuse and recyclables.

In rural areas, co-collection may be the only economically feasible option for curbside recycling because the costs of a separate recycling program may be prohibitive. In a more urban setting, the trade-off of the low capital collection cost of a bag program may be offset by higher processing and refuse handling costs and a reduction in materials recovered due to high reject rates. There is no

*Brenda Platt, et al., *Beyond 40 Percent: Record-Setting Recycling and Composting Programs*, Institute for Local Self-Reliance, Washington, DC, August 1990.

accurate data yet on urban bag programs. Omaha has not fully evaluated its program, and its refuse disposal and recyclables processing costs were renegotiated earlier this year. Chicago has yet to implement its bag program citywide and has only completed a theoretical cost analysis, which has been greatly criticized.

Pullman, Washington's co-collection program, in which glass is collected in a side rack on the trucks and refuse and other recyclables are compacted (5:1), may be the best bag co-collection system operating. Bag programs in which residents must purchase bags at local stores have lower participation rates than programs that provide bags or containers. Making recycling mandatory and instituting volume-based refuse rates can increase participation in recycling. To reduce contamination in bag programs, glass and paper should be kept segregated. To reduce glass and bag breakage, compaction settings in packer trucks should be light, or glass should be collected separately as in Pullman's program. The latter may be preferable as lighter compaction will reduce the overall efficiency of the collection system.

If communities are willing to make a capital investment in collection bins, the bin system may provide a viable alternative to dedicated recycling trucks. The cost to retrofit a truck is generally less than the cost to purchase a recycling truck. Yet, the viability of this type of co-collection program depends on adequate volume capacities for refuse and recyclables. Loveland is one community that has worked this out to meet its needs. In fact, the results of Loveland's pilot program have been impressive. Trash set-outs decreased nearly 62 percent by weight, participation in the program is more than 90 percent, and an estimated 54 percent of the pilot households' waste stream is being recovered. The city of Loveland is planning to implement its co-collection system citywide by early 1993. Adding a trailer for collection of recyclables, as Hamburg, New York has done, may be the most successful type of co-collection, in terms of system flexibility, maintaining material quality, avoiding double-handling of refuse, and keeping rejects to a minimum. Trailers, however, may not be suited to some urban environments.

Based on the data presented in this report and on our ongoing research on state-of-the-art recycling programs, our initial findings on co-collection systems are as follows:

- Co-collection can be cost-effective if designed properly.
- Co-collection systems (both bin and bag) can achieve high recovery and participation rates if designed properly.
- Charging residents for bags in which to set out recyclables will decrease participation in recycling.
- Requiring residents to pick up bags (for their recyclables) at inconvenient locations will decrease participation in recycling.
- Volume-based refuse fees and mandating participation will increase participation in recycling.
- Commingled collection of recyclables versus more segregated collection of recyclables will decrease the amount of materials marketed as a result of higher reject rates.
- Glass breakage is a problem in bag co-collection systems; therefore, it is better to collect glass at curbside segregated from other recyclables.
- Bag co-collection systems should try to use normal compaction rates to maintain collection efficiency. Collecting glass separately will enable this.
- Double handling of refuse in bag co-collection systems can add to costs and thus should be minimized. Bin co-collection systems do not have this problem.
- Volume capacity ratios of bins have presented problems in some bin co-collection programs. Other programs have overcome these.

Since little cost and operating data are actually available to date on co-collection systems, communities should approach implementation of such a system slowly. We recommend several pilot programs—both bag and bin systems, targeting a wide range of materials, experimenting with several bags, and performing a detailed cost analysis of the trade-offs between collection, processing, marketing, and recycling rates.

Table 1
Demographic Information

Community	Jurisdiction	Population 1990	Total Number of Households 1990	Number of Single-Family Households 1990	Area (square miles)	Population Density (per square mile)
BAG PROGRAMS:						
Boulder County, CO	rural	225,339	88,402	54,375	742	303
Bowdoinham, ME	small town	2,189	880	850	23	38
Chicago, IL	large city	2,783,726	1,133,218	298,474	228.5	4,959
Houston, TX	large city	1,630,553	616,877	387,600	540	3,019
Missoula County, MT	rural	78,000	30,500	NA	2,582	30
Omaha, NE	city	335,795	133,842	84,579	104.5	3,213
Pullman, WA	rural	23,478	7,384	3,194	6.7	3,504
Rochester, MA	rural	3,921	1,288	1,088	34	115
South St. Louis Co., MN	rural	7,178	3,617	NA	1,080	7
BIN PROGRAMS:						
Carroll County, IA	rural	21,423	8,372	7,859	576	37
Hamburg, NY	small town	10,442	4,035	2,853	2.5	4,177
Loveland, CO	city	37,352	14,049	10,342	21	1,745
Shaker Heights, OH	suburban	30,831	8,389	7,059	6.2	4,973
Sunnyvale, CA	city	117,229	48,296	29,346	22	5,329

Table 2
General Program Characteristics

Community	Pilot/ Full-scale	Start-up Date	Duration of Program (months)	Mandatory Recycling	Economic Incentives	Public/ Private/ Contract [a]	Service Provider
BAG PROGRAMS:							
Boulder County, CO	full-scale	1989	ongoing	no	var. can/bag rate	contract	Western Disposal Service
Bowdoinham, ME	full-scale	4/89	ongoing	no	refuse bag fees	private	1 private hauler
Chicago, IL	pilot	3/27/91	2.5	no	none	public	City of Chicago
Houston, TX	pilot	8/1/90	11	no	none	private	Browning-Ferris Industries
Missoula County, MT	full-scale	1/91	ongoing	no	none	private	Browning-Ferris Industries
Omaha, NE	full-scale	3/25/91	ongoing	no	none	contract	Watts Trucking of Nebraska
Pullman, WA	full-scale	9/91	ongoing	no	none	contract	Pullman Disposal Company
Rochester, MA	pilot	10/89	24	no	none	contr./public	ABC Disposal/ DPW
South St. Louis Co., MN	full-scale	8/90	ongoing	no	none	private	4 private haulers
BIN PROGRAMS:							
Carroll County, IA	full-scale	11/5/90	ongoing	no	none	contract	9 private haulers
Hamburg, NY	full-scale	11/1/81	ongoing	yes	none	public	Village of Hamburg
Loveland, CO	pilot [b]	8/1/91	ongoing	no	refuse bag fees	public	City of Loveland
Shaker Heights, OH	full-scale	2/90 [c]	ongoing	no	none	public	City of Shaker Heights
Sunnyvale, CA	pilot	7/91	3	no	none	contract	Specialty Solid Waste & Recycling, Inc.

[a] Public = city or county government provides service
Contract = city or county contracts with one or more providers
Private = private haulers service the area independent of a contract

[b] Based on results of pilot, the city plans to implement a full-scale citywide co-collection program by early 1993.

[c] Pilot program began February 1990, full-scale program implemented by August1991.

Table 3
Households Served and Participation Rate

Community	Households Served with Co-collection	% Total Households Served	% Single Households Served	Type of Households Served	Weekly Set-Out Rate %	Overall Participation Rate %
BAG PROGRAMS:						
Boulder County, CO	3,000	3	NA	single and duplex	NA	7-10
Bowdoinham, ME	290	33	33	single and four businesses	NA	95 [a]
Chicago, IL	2,849	<1	1	single	42	84
Houston, TX	18,300	3	5	single	21	57
Missoula County, MT	14,000	46	NA	single and multi-unit	NA	NA
Omaha, NE	100,000	75 [b]	100	single and 2- to 4-units	47	NA
Pullman, WA	5,000	68	NA	single and multi-unit	NA	80 [c]
Rochester, MA	1,300	100	100	single and multi-unit	NA	50-70 [d]
South St. Louis Co., MN	3,000	82	NA	single and multi-unit	22	50-90
BIN PROGRAMS:						
Carroll County, IA	5,000	60	NA	single and multi-unit	50	80
Hamburg, NY	3,391	84	NA	single and up to 2-story multi-units	98	98
Loveland, CO	2,000	14	19	single and up to six-plexes	33	90+ [e]
Shaker Heights, OH	8,264	87	100	single and 2-family units	60	NA
Sunnyvale, CA	2,250	5	NA	single to 3-units	30-33	NA

NA = not available

[a] David Berry, the Solid Waste Manager, estimates that 95 percent of the residents served with co-collection service participated in 1990.

[b] Omaha contracts with Watts Trucking, Inc. to service 100,000 households in buildings with 1 to 4 units. 100% of households served with public sector sponsored refuse collection are served with the co-collection system. All other multi-units have a separate collection system that does not include co-collection.

[c] After four months of the pilot program, 80 percent of the residents were participating in the program.

[d] Angelo Hazifotis, the General Manager of SEMASS Recycling Management Corp., estimates that overall participation was 50 to 70%.

[e] Mick Mercer, the Solid Waste Manager, estimates that over 90 percent of the residents participate in the pilot program.

Table 4
Materials Collected and Recycling Rate

Community	Recyclable Materials Collected	Collection Rate for Recyclables [a]
BAG PROGRAMS:		
Boulder County, CO	ONP, G, A, F	NA
Bowdoinham, ME	ONP, OCC, MAG, G, A, F, MP, M, T, MPlastic, O [b]	43 [c]
Chicago, IL	ONP, G, P, A, MAG, F	7.3
Houston, TX	ONP, P, A, F	6
Missoula County, MT	ONP, A, F, (OCC, G, P) [d]	<1
Omaha, NE	ONP, G, A, F, P	3 [e]
Pullman, WA	ONP, G, A, F, P	1-2
Rochester, MA	G, A, F, P	NA
South St. Louis Co., MN	ONP, OCC, G, A, F, M, HP, MP, T, MPlastic, Plastic film	14 [f]
BIN PROGRAMS:		
Carroll County, IA	ONP, OCC, G, A, P, T, Foil	10 [g]
Hamburg, NY	ONP, OCC, G, P, A, F, O	19
Loveland, CO	ONP, OCC, G, A, P, F [h]	NA [i]
Shaker Heights, OH	ONP, G, A, F, P [j]	7
Sunnyvale, CA	ONP, OCC, G, A, P, F, O	NA

Key:

A = Aluminum
F = Ferrous cans
G = Glass
GP = Glossy paper
HP = High-grade paper
M = Small scrap metal
MAG = Magazines
MP = Mixed Paper
MPlastic = Mixed Plastic
O = Waste oil
OCC = Corrugated cardboard
ONP = Newspaper
P = Plastic
T = Textiles

[a] Collection rate = total tons of recyclables collected, divided by sums of total tons of refuse collected + total tons of recyclables collected

[b] Oil is collected at drop-off sites.

[c] Includes collection from four businesses and two drop-off sites. Although this figure does not represent just the co-collection program, 12% of recyclables were collected through the co-collection service.

[d] BFI targetted ONP, A, and F for the program, residents began to add OCC, G, and P

[e] Includes recyclables collected through drop boxes; 64% of recyclables were collected through co-collection. This figure excludes yard waste. In the 1st year of the program's operation Omaha recovered about 16% of its total MSW through recycling and composting (based on an average of 1,578 tons composted per month).

[f] Includes recyclables collected through four Cash for Trash sites; 28% of recyclables were collected through co-collection.

[g] Includes drop boxes and commercial recycling.

[h] Motor oil, used paint, and vehicle batteries are accepted in a free drop-off program.

[i] City reports a 54% recovery rate, including materials reused and composted as well as those recycled.

[j] White goods are picked up by separate trucks and sold to a scrap dealer for recycling.

Table 5
Set-out Method

Community	Set-out Method for Refuse	Set-out Method for Segregated Recyclables	Set-out Method for Commingled Recyclables	Price per Bag or Bin
BAG PROGRAMS:				
Boulder County, CO	bags and cans	---	1 yellow bag for all recyclables	$0.24
Bowdoinham, ME	20-gal. bag with yellow tag	4 bags: 1- ONP, 1- OCC; 1- MAG;1- MP	1 bag for G, P, A, F, T, M, polystyrene	$0.10
Chicago, IL	bags in refuse carts	---	13-gallon GLAD blue bag; cans & plastics flattened; ONP in a bag	free for pilot
Houston, TX	bags	---	13-gallon GLAD blue bag	free for pilot
Missoula County, MT	cans	---	13-gallon GLAD blue bag	free
Omaha, NE	bags	1 bag for ONP	9-gallon HDPE bag; 13- and 30-gallon LDPE bags	free; $0.15; $0.22
Pullman, WA	bags	1 bag for G	13-gallon GLAD blue bag	varies $0.16-$0.22
Rochester, MA	cans or bags	---	Recycle Bag	free
South St. Louis Co., MN	bags	---	13-gallon GLAD blue bag	$0.18
BIN PROGRAMS:				
Carroll County, IA	cans and bags	ONP, OCC separate from bin	1 18-gallon bin for G, A, P, T, Foil	some HH pay deposit
Hamburg, NY	cans and bags	---	1 container for G, P, A, F; 1 5-qt. container for oil	5-qt container free
Loveland, CO	13- and 30-gal. bags	OCC placed flat under bins; 1 12-gallon bin for ONP	1 15-gallon bin for G, P, A, F	free
Shaker Heights, OH	cans	ONP in paper bags, P in plastic bags	1 7-gallon bin for G; another for A, F	in collection fee
Sunnyvale, CA	64-,96-,104-gal containers	ONP & OCC bundeled separately, O in a sealed container	1 14-gallon bin for G; another for A, F, P	in collection fee

Key:

A = Aluminum	MP = Mixed Paper	--- = not applicable
F = Ferrous cans	O = Waste oil	
G = Glass	OCC = Corrugated cardboard	
HP = High-grade paper	ONP = Newspaper	
M = Small scrap metal	P=Plastic	
MAG = Magazines	T = Textiles	

Table 6
Collection Vehicles and Method

Community	Co-collection Vehicles	New/ Retrofitted/ Existing	Compaction Setting
BAG PROGRAMS:			
Boulder County, CO	20-cy vehicles (Ford, International, Heil)	existing	NA
Bowdoinham, ME	2 1-ton, 15-cy dump trucks, 1 with a divider in truck bed	existing/retrofitted	uncompacted
Chicago, IL	2 20-cy Leach 2R Packers	existing	3:1 (500 lb/cy)
Houston, TX	4 Pak-Mor 20-cy packers, 1 Pak-Mor 25-cy split compactor	existing/new	6:1 (1000 lb/cy)
Missoula County, MT	10 25-cy Heil Packers	existing	unchanged (800 lb/cy)
Omaha, NE	25 30-cy Heil Packers	existing	full (567 lb/cy)
Pullman, WA	2 25-cy Heil Packers, 2 International	existing	varies
Rochester, MA	NA	existing	NA
South St. Louis Co., MN	16- to 18-cy packer	existing	normal (3:1)
BIN PROGRAMS:			
Carroll County, IA	16-cy vehicles: Leach; Pak-Mor; Glenwood, 2 pick-ups w/ stock racks	retrofitted	varies
Hamburg, NY	2 20-cy packers: 1 Diamond-Rio and 1 White, 2 spare packers	retrofitted	NA
Loveland, CO	5 28-cy vehicles: 10-cy E-Z Pack Apollo and May Unit with 6.4-cy and 11.3-cy bins	retrofitted/new [a]	5:1
Shaker Heights, OH	6 33,000 GVW Chassis, 1.0-cy plasic compactor, 2 5.5-cy side bins; 12 scooters	retrofitted	NA
Sunnyvale, CA	1 18-cy Demster packer with May Unit	retrofitted	NA

Key:
cy = cubic yard
NA = not available
Retrofitted = Either a bin is installed behind the cab or a trailer is pulled behind the vehicle.
Existing = Compactor vehicle already in use for refuse collection.

[a] In its pilot program, Loveland retrofitted a 20-cy Leach vehicle with a May Unit. The City plans to use the custom-designed co-collection vehicles listed above when its program goes citywide.

Table 6 (cont'd)

Community	Number of Collection Routes	Crew Size/ Vehicle	Collection Frequency	Co-collection Method
BAG PROGRAMS:				
Boulder County, CO	NA	2	weekly	bags with recyclables placed on one side of the packer, refuse bags on other
Bowdoinham, ME	2	1	weekly	hauler stores recyclables towards the back of the truck
Chicago, IL	2	3	weekly	blue bags with recyclables collected with refuse bags
Houston, TX	13	2	weekly	blue bags with recyclables collected with refuse bags; 1 packer with separate compartment
Missoula County, MT	10	2-3	weekly	blue bags with recyclables collected with refuse bags; blue bags are set on one side of packer
Omaha, NE	23	1	weekly	LDPE and HDPE bags with recyclables collected with refuse bags
Pullman, WA	NA	2	weekly	blue bags placed on one side of packer, refuse bags on other side, side rack for glass
Rochester, MA	NA	3	weekly	bags with recyclables collected together with refuse bags
South St. Louis Co., MN	NA	1	weekly	blue bags with recyclables collected with refuse bags; blue bags are set on one side of packer
BIN PROGRAMS:				
Carroll County, IA	15	1-3	weekly	2 compartments in either bins or trailers: 1 for ONP and OCC; 1 for other materials
Hamburg, NY	10	2-3	weekly	3 bins on each side of trailer: 1 for ONP; 1 for OCC; 1 for G and P
Loveland, CO	5	2	weekly	2 compartments: 1 for ONP and OCC; 1 for G, A, F, P
Shaker Heights, OH	4	3	weekly	5 bins: glass color sorted into 3 bins at curb, plastics compacted, ONP in 1 bin, A and F in another
Sunnyvale, CA	5	2	weekly	4 bins: glass sorted at curb into clear and colored bins; ONP in one bin; and P, A and F in another

Key:

A = Aluminum
F = Ferrous cans
G = Glass
OCC = Old corrugated cardboard
ONP = Newspaper
NA = not available

Table 7
Processing Centers and Costs

Community	Processing Center	Public/ Private	Owner	Operator	Start-up Date	Design Capacity (TPD)	Thru-put (TPD)
BAG PROGRAMS:							
Bowdoinham, ME	Renovated poultry barn	Public	Private [a]	Town of Bowdoinham	1989	3-5	1.4
Chicago, IL	Chicago Recycling Works (CRW)	Private	CRW	CRW	NA	NA	NA
Houston, TX	Temporary facility	Private	BFI	BFI	8/1/90	180 [b]	87 [b]
Missoula Co., MO	NA	Private	Montana Recycling	Montana Recycling	NA	NA	NA
Omaha, NE	2-story IPC and transfer station	Private [c]	City	WMI	3/25/91	30	20
Pullman, WA	Processing and mixed waste sorting at landfill	Public	County	Whitman County	1/1991	6	3-5
South St. Louis Co., MN	Recycling Center	Public	DAC [d]	South St. Louis SWC	5/1990	NA	NA
BIN PROGRAMS:							
Carroll County, IA	County IPC with loading dock	Public	County	County SWC	11/5/90	30	13-14
Hamburg, NY	Recycling Center	Public	Village	DPW/ARC	1970s	---	2-4
Loveland, CO	Larimer County landfill	Public	County	Larimer County	7/91	3 [e]	3
Shaker Heights, OH	Service Center & Transfer Station	Public	City	Service Department	1972 [f]	---	
Sunnyvale, CA	Sunnyvale Recycling Center	Public	City	Scavengers, WMI Sub.	1982	NA	27

Key:

ARC = Association of Retarded Children
DPW = Department of Public Works
MRRF = Materials Recycling and Recovery Facility
NA = Not Available
SWC = Solid Waste Commission
--- = Not Applicable

[a] The building is owned by David Berry, the Town's Solid Waste Manager.
[b] Refuse and recyclables
[c] In Omaha, the city owns the building and some equipment, but contracts with Waste Management to operate the facility.
[d] The Commission rents a building and a forklift.
[e] The new IPC, scheduled to come on-line by early 1993, will have the capacity to handle 70 tons per per day, and will serve Larimer County and some other counties.
[f] The Center began accepting recyclables in 1984.

Note: Boulder County, Colorado, and Rochester, Massachusetts are excluded from this table due to the limited data. In Boulder, CO, bags are pulled and sorted by hand at the transfer station. In Rochester, 15 to 25% of the glass collected broke, in large part from the front-end loader used to separate refuse bags from recyclables

Table 7 (cont'd)

Community	Tonnage Delivered by Community (TPD)	Tipping Fee per Ton ($)	Materials Accepted	Commingled (Yes/No)	Reject Rate (% by wt.)	Glass Breakage (% by wt.)
BAG PROGRAMS:						
Bowdoinham, ME	1.4	---	ONP, OCC, MAG, MP, G, P, T, M, O, A, F, PS	Some	5	<1
Chicago, IL	NA	NA	ONP, G, A, P, MP	Yes	10.9	NA
Houston, TX	87	$0 [g]	ONP, A, P, F	Yes	8-10 [h]	--- [i]
Missoula Co., MO	NA	$0	NA	Yes	14	NA
Omaha, NE	20	$20	ONP, OCC, G, P, A, F	Yes	19	15
Pullman, WA	3-5	$50	ONP, G, A, F, P	Yes	5-10	negligible
South St. Louis Co., MN	NA	---	ONP, OCC, MP, A, M, F, G, P, HP	Yes	NA	<1
BIN PROGRAMS:						
Carroll County, IA	9	$0 [j]	ONP, OCC, G, A, P, T, Foil, F, M	Yes [k]	6	NA
Hamburg, NY	NA	---	ONP, OCC, G, P, A, O	No	negligible	NA
Loveland, CO	2	$0	ONP, OCC, G, A, P, F	Yes	NA	NA
Shaker Heights, OH	42	$0	ONP, G, P, A, F, White Goods	No	negligible	NA
Sunnyvale, CA	2.3 [l]	$0	ONP, G, P, A, F	No	negligible	NA

Key:

A = Aluminum
F = Ferrous cans
G = Glass
HP = High-grade paper
M = Small scrap metal
MAG = Magazines
MP = Mixed Paper
NA = Not Available
O = Waste oil
OCC = Corrugated cardboard
ONP = Newspaper
P = Plastic
PS = polystyrene
T = Textiles
--- = Not Applicable

[g] No tipping fee was charged during the pilot program.
[h] Eight to ten percent of bags were rejected due to poor preparation by residents.
[i] Glass was not collected in the pilot program
[j] Haulers serving Carroll County pay no tipping fee, but haulers serving three other counties pay $30 per ton.
[k] Food and beverage containers are commingled, ONP and OCC are segregated by haulers.
[l] Does not include OCC or oil.

Table 7 (cont'd)

Community	Total No. of Employees	Technology	Capital Costs (Building and Equipment)	Cost/TPD of Capacity
BAG PROGRAMS:				
Bowdoinham, ME	1-2	Manual sorting from a conveyor, shredding, baling	$23,161 [m]	NA
Chicago, IL	10	Loaded by front-end loader to conveyor, manual sorting from conveyor, crushing, baling	$145,000	---
Houston, TX	9	Manual sorting of commingled materials from a conveyor	NA	NA
Missoula Co., MO	NA	NA (taken to private facility)	NA	NA
Omaha, NE	32	Manual sorting of commingled materials from a conveyor, baling, flattening	$476,200 [n]	$15,900
Pullman, WA	6-7	Manual sorting of commingled materials from a conveyor	Over $200,000	≈$33,300
South St. Louis Co., MN	2	Manual sorting of commingled materials, baling, and storing in trailers		NA
BIN PROGRAMS:				
Carroll County, IA	10-14	Manual sorting of commingled materials from a conveyor, magnetic separator, baling	$674,883	$22,500
Hamburg, NY	4	Manual sorting of commingled materials, and storing in bins	$4,200 [o]	NA
Loveland, CO	2-3	Manual sorting of commingled materials into roll-off containers	$0 [p]	NA
Shaker Heights, OH	1-2	Unloading sorted materials into bays	NA	---
Sunnyvale, CA	3	Sorted materials dumped separately, stored in roll-off containers	NA	NA

[m] Bowdoinham leases the sorting conveyor and pallet boxes from The Sagadahoc Recycling Company.
[n] The City leases the building free of charge; the building has been assessed at $1.8 million.
[o] Capital costs incurred from 1981-1989. The building was donated.
[p] The roll-offs are rented.

Table 8
Operating and Maintenance Costs

Community	Dates of Collection	Collection Cost	Tons of Refuse and Recyclables Co-collected	Per Ton Cost for Collection	Processing Cost	Tons of Recyclables Processed	Per Ton Cost for Processing	Materials Revenues	Per Ton Materials Revenues	Refuse Disposal Costs
BAG PROGRAMS:										
Bowdoinham, ME	7/89-6/90	NA	NA	NA	$19,400	220	$88 [a]	$2,900 [b]	$13	$8/cy
Chicago, IL	NA	NA	NA	- - -	NA	NA	$18	---	---	NA
Houston, TX	8/90-6/91	NA	22,771	$40 [c]	NA	811	$20 [c]	$18,880	$23	$5.07/cy
Missoula Co., MO	1/91-6/91	NA [d]	25,018	NA	NA	18	NA	NA	NA	$4/cy
Omaha, NE	3/91-2/92	NA	119,190	$31	NA	4,182 [e]	$42.40 [f]	$50,031 [g]	$15	$18.95/ton
Pullman, WA	NA	NA	NA	NA	NA	NA	$50 [h]	NA	NA	$50/ton [h]
South St. Louis, MN	1/91-2/92	NA	1,441	NA	$59,801[i]	222 [j]	$269	$8,238 [k]	$37	$58.75/ton
BIN PROGRAMS:										
Carroll County, IA	11/90-7/91	NA	15,592	NA	$74,405	1,223 [l]	$61	$39,497	$32	$34.75/ton
Hamburg, NY	11/90-10/91	$300,000	4,743	$63	$37,525	921	$41	$13,585	$15	$45/ton
Loveland, CO	8/91-7/92	NA	750	$79 [m]	NA	302	NA [n]	$0 [n]	$0	$2/cy
Shaker Heights, OH	1/91-12/91	NA [o]	15,412	NA	$58,147	1,311 [p]	$69	$24,000	$18	$40/ton [q]
Sunnyvale, CA	7/91-10/91	NA	12 TPD	NA	NA	2.3 TPD	NA	NA	NA	$30/ton

Key:
cy = cubic yard
NA = Not available
- - - = Not applicable

[a] Includes drop-off
[b] Includes revenues from drop-off materials
[c] These represent approximate costs. The $20/ton processing cost covers refuse and recyclables including transfer costs but excluding residual disposal costs. Refuse collection alone costs BFI about $40 per ton; collecting recyclables did not add to the cost.
[d] Besides some extra labor for blue bag sorting and a small investment in advertising, BFI has not made a substantial investment in the program. BFI does not consider the program an added cost.
[e] Includes 1,223 tons of recyclables collected at drop-off boxes and unmarketed material.
[f] Estimated based on a flat fee of $469 for up to 30 tons of recyclables per day, plus the $18.95/ton fee for handling bags. The city renegotiated its contract with WMI in 1992. The city's processing costs have increased to $95.56/ton. Its share of revenues has also increased. See case study.
[g] Based on the City's average net revenue of $14.70 per ton from March 1992 through December 1991.
[h] Pullman Disposal pays a tipping fee of $50 per ton for refuse disposal and processing recyclables.
[i] Includes Cash for Trash program. See Appendix D.
[j] Includes 160 tons collected from four Cash for Trash sites.
[k] Revenues for all 222 tons recycled.
[l] Cost and tonnage figures include drop boxes and co-collection.
[m] Estimated cost to collect, process, and dispose of refuse and recyclables for a citywide program, including all new equipment needed.
[n] Larimer County performed the processing. Loveland received no revenues.
[o] Total cost for collecting, processing, and disposal of refuse and recyclables was $124/ton in 1991.
[p] Total recyclables collected, includes drop-off site
[q] [illegible] hauled from transfer station and disposed. Contract fee is now $46 per ton.

Table 9
Trade-Offs Between Co-Collection Systems and Dedicated Collection Systems for Refuse and Recyclables

	Co-Collection	Separate Refuse and Recyclables Collection
Collection Costs	*Bag System*: no additional cost for collection besides bags if normal compaction is used. If compaction is lighter than normal, collection efficiency may decrease, and costs will increase. *Bin System*: costs for retrofitting truck with bins or trailers are cheaper than costs for new dedicated recycling vehicles. Whether and how much operating and maintenance cost will increase depends on level of en route curbside sorting. Higher labor costs than in bag systems.	Costs for dedicated recycling vehicles incurred unless existing trucks are used. Operating costs for separate recycling crews incurred, but these may be offset by lower refuse collection costs. Operating costs for collecting recyclables depends on level of en route sorting, materials targeted, and crew size.
Recycling Processing Costs	Processing costs similar to dedicated recycling systems; removing recyclables from bags may add to cost. *Bag System*: requires sorting of materials; higher level of processing needed than in bin systems. *Bin System*: Low level of processing could be required if some materials sorted en route or set out already segregated.	Some processing of recyclables usually required. Costs depend on scale, level of sorting needed, equipment utilized, and labor requirements. High-tech systems designed to sort commingled materials have higher capital costs but lower operating costs than low-tech systems relying on manual labor.
Refuse Handling Costs	*Bag System*: Bags of refuse need to be manually sorted from bags of recyclables. Double handling refuse could be expensive and inefficient. *Bin System*: Refuse and recyclables already segregated. No extra handling of refuse required than in traditional collection systems, although refuse may have to travel to processing center before being disposed.	Refuse and recyclables collected segregated. No extra handling or transportation of refuse required. (Collection costs may decrease as the tonnage of recyclables increases.)
Reject Rate for Collected Recyclables	*Bag System*: Relatively high (5-19%) — due to bag and glass breakage and contamination *Bin System*: Relatively low (negligible-6%) — due to material segregation	Depends on type of collection and processing systems in place and the materials targeted for recycling. Rates vary widely across the country, from 0.2% to 47%, with an average of 7%.* 1-5% typical for segregated collection and processing systems 7-14% typical for commingled collection and processing systems**
System Flexibility	*Bag System*: Adding more types of materials for recycling can be done, but more sorting is required and reject rates may increase. Several bag co-collection programs have excluded glass and newsprint because of contamination problems. *Bin System*: Inflexible volume capacities of bins can be a problem in modified trucks, decreasing collection efficiencies. The one trailer system in operation has not had these problems.	Inflexible volume capacities of specialized compartmentalized recycling vehicles can be a problem, decreasing collection efficiency. Ability to adjust volumes and/or combine materials in compartments can help alleviate this problem. A variety of flexible dedicated recycling systems exist.
Participation Rate in Recycling	Can be high, depending on pick-up frequency, set-out convenience, and economic incentives. Can be low when residents must pay for bags or pick up bags at certain locations.	Can be high, depending on pick-up frequency, set-out convenience, and economic incentives.
Recovery Rates	Depends on participation, materials targeted, and reject rates. Glass breakage has been a problem in bags systems unless separated effectively and not compacted.	Depends on participation, materials targeted, and reject rates.

*Governmental Advisory Associates, Inc., *1992-93 Materials Recovery and Recycling Yearbook*, New York, New York, 1992, pp. 29-30.

**Brenda Platt, et al., *In-Depth Studies of Recycling and Composting Programs: Designs, Costs, and Results*, Institute for Local Self-Reliance, Washington, DC, 1992.

Bag Co-collection Programs

Boulder County, Colorado

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In 1989 Western Disposal Service, the primary private hauler in Boulder County, began servicing 3,000 rural households (single and duplex) with a bag co-collection system. These households are not included in the Boulder County recycling program. According to Glen Overture, the Operations Manager, Western Disposal chose the bag co-collection system because it was a cost-effective way to provide recycling collection service to rural customers. Western Disposal did not want to make a great investment in the program because few residents wanted to participate in the program.

Of the 3,000 households that are offered the service, only 200 to 300 households participate in the program. Newspaper, glass, aluminum and ferrous cans are commingled in yellow plastic bags. Residents purchase a box of 35 bags for $8.50 at the Administration Office of Western Disposal. Bags are collected on a weekly basis with refuse in 20-cubic-yard packer trucks. The yellow bags are placed on one side of the compactor. The addition of the yellow bags to the collection system has not changed the collection method significantly because only a few bags are set out on a regular basis. Total waste collected has not increased.

Glen Overture does not track the tonnage of the materials collected and does not have data on participation rates. However, he estimates that participation is quite low because very few yellow bags are collected each week. Besides the low participation rate, the co-collection program has not experienced any significant problems. Co-collection is an additional service for residents that would otherwise not receive curbside collection. Western Disposal does not charge a collection fee for the recyclables, and residents only pay for the bags. Only four materials are collected and although glass is included in the bag with the other materials, there are few problems with glass breakage. Glen Overture is more concerned with worker injuries from broken glass than material contamination.

Most of the costs incurred by Western Disposal are for processing the materials. Bags are pulled and sorted by hand at the transfer station. If the program expanded to include more households, Glen Overture estimates that the labor costs for processing the material would increase. For the moment, the program is too small to have a significant impact on either the collection or the processing systems.

Bowdoinham, Maine

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The co-collection program in Bowdoinham is very different from the other bag programs. The scale is smaller, and some recyclables are kept segregated from each other in several bags rather than all being commingled in one bag. Of the 880 households in the town, 290 single-family homes receive curbside co-collection service for a $2 weekly fee. (Other residents self-haul their refuse to the municipal landfill and recyclables to two drop-off locations.) In January 1989, a 10-week curbside recycling pilot sponsored by a community group, The Sagadahoc Recycling Company, revealed the feasibility of a curbside collection program. In April 1989, after the pilot program ended, two private haulers, Hollis Temple and Richard Plummer began the co-collection service. Hollis Temple has since retired, and Richard Plummer has taken over his route.

A number of materials are collected in 20-gallon clear plastic bags. These 1.6 millimeter bags are purchased from Star Paper Co. in Haverhill, Massachusetts. Residents sort materials into five separate bag categories: (1) corrugated cardboard, (2) newspaper, (3) magazines, (4) glass, plastic, textiles, polystyrene (including food trays and packaging), aluminum and ferrous cans, and scrap metal, and (5) mixed paper (high-grade paper, junk mail, paperboard, and paper towels). Residents purchase the bags for $0.10 from either the Town Office or the Bowdoinham Country Store. Both haulers pick up the material in 1-ton, 15-cubic-yard dump trucks. Hollis Temple divided the truck body into two sections, one for recyclables and one for refuse. Richard Plummer did not put a divider in his vehicle but places the recyclables towards the back and refuse towards the front of the truck.

In 1990 an estimated 106 tons were recovered from both residents and businesses (there are four businesses that participate in the program) through the curbside program. David Berry, the Solid Waste Manager, estimates that 95 percent of the residents served with co-collection participated in the recycling program in 1990. Residents have an economic incentive to recycle. They pay volume-based fees for refuse disposal, but do not pay for the recyclable materials that are taken to the processing center. Residents and businesses must place a yellow town refuse tag, which is sold at the Town Office for $1, on each bag of refuse.

Since most of the materials are not commingled in one bag and the bags are not compacted, material contamination and glass breakage is not a problem. Richard Plummer delivers recyclables free of charge to the town's Recycling Barn for sorting and marketing. The Barn, a 12,000-square-foot, 3-story converted poultry barn, contains about $23,000 worth of processing equipment including a baler, a shredder, a sorting conveyor, five 6-cubic-yard rolling storage bins, and sixty 1.25-cubic-yard pallet boxes. All processing is done by hand. Three part-time employees work at the Barn. Richard Plummer delivers separated bags of recyclables to the first floor of the Barn. Magazines and catalogues are collected loose in pallet boxes. Mixed paper was baled until 1991, when the town began shredding it for composting. Corrugated cardboard is baled and stored on the first floor. Newspaper was baled until 1991, when a local farmer began to haul it away in pallet boxes to be shredded for animal bedding. Commingled materials, including glass, aluminum and ferrous cans, plastics, and rags are brought to the third floor by freight elevator. These materials are dumped into a hopper that feeds a converted hay conveyor set up on the second floor for sorting. Employees hand-sort approximately 2 tons of commingled recyclables each week. They drop the plastics and tin cans down chutes into pallet boxes on the first floor and separate the glass, aluminum, and rags into drums on the second floor, where they can be dumped directly into the Town's truck for delivery. Materials are eventually sorted into 12 or 13 different categories. An estimated 5 percent by weight of recyclable materials processed at the Barn is landfilled as residue. Less than 1 percent of the glass breaks in the process, which is attributed to the cushioning effect of less rigid recyclable materials such as newspaper. The Barn has the capacity to process an estimated 3 to 5 tons of recyclables per day.

In fiscal year 1990, the town spent $19,400 to process 220 tons of recyclables ($88 per ton), excluding its $7,800 annual fee to lease the Barn. Operating and maintenance costs for the curbside program are not available from the town's two private haulers. The tipping fee at the Bowdoinham municipal landfill is $8 per cubic yard. From July 1989 to June 1990, 43 percent by weight of Bowdoinham's municipal solid waste was recycled (about 7 percent as a result of the state's bottle bill, 12 percent from co-collection, and 24 percent through the drop-off center).

Chicago, Illinois

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The city of Chicago Department of Streets and Sanitation developed a recycling plan that includes a blue bag co-collection program. Although the city has been conducting a separate recyclables collection pilot program, which serves 64,000 households, the city favors the blue bag co-collection system because special recycling vehicles are not needed and it does not have to adjust its collection practices. A theoretical cost analysis completed by the city judged co-collection to be a more cost-effective program for the city. Local recyclers have criticized the city's cost analysis, pointing out its many flaws. In preparation for the 1992 citywide implementation of the program, the city undertook four pilot collection programs.

In the city's first test of the blue bag collection, a one-day test done in June 1990, 24 percent of the bags were broken, and their contents had to be disposed in a landfill or incinerator. This was a controlled test to determine the performance of different bags. The second test, conducted in September, was a three-week test involving 1,000 households. Five different types of bags were tested. On average, the retrieval rate for the bags was 90 percent. However, only 73 percent of the bags collected survived intact. Of the bags retrieved, 18 percent was mistakenly used for garbage and an additional 7.5 percent of the material taken to the processing center was refuse. In the city's preliminary test, approximately 30 percent of the newspaper was wet or soiled and thus nonrecyclable. Also, some waste paper mills refuse to accept newsprint collected through this approach because of the risk of glass getting mixed in with the paper and damaging the machinery. Taken together, the city's figures for the first test indicate that the loss through broken bags, glass breakage, and contamination of newsprint would result in the recycling of only 56.3 percent of total recyclables set out by residents.

The most recent program ran for 10 weeks from March 27, 1991 to June 4, 1991. The city conducted this pilot to address program viability issues such as bag and glass breakage, material marketability, and participation rates in the program.

For the 10-week pilot program, the city targeted 2,849 single-family households that had previously been served under the city's separate recycling collection pilot program in the fall of 1989. These households, in the 7th and 41st wards, represent less than one percent of the total households in the city. Residents received starter kits of 20 First Brands 1.75 millimeter thick, 13-gallon blue bags and instructions on how to use the blue bag, and were asked to suspend use of the city-issued recycling bins for the duration of the demonstration. Approximately one half of the bags had drawstring closures; the remaining had tie-handle closures. Newspaper, magazines, aluminum, tin and steel cans, glass, and plastic were collected. To increase the capacity of the bag and to reduce material contamination, residents were instructed to rinse and flatten cans and plastic containers, and to place newspaper in a grocery bag before putting them into the blue bag. The city also requested that residents securely tie the filled blue bags and place them inside their city trash carts for collection with the regular refuse collection. This request was made to protect the contents from pilferage and bad weather and to ensure that blue bags were loaded into the refuse vehicles in a consistent manner. For the two collection routes, the city used two Leach 2R 20-cubic-yard compactor vehicles with a semi-automated assist, which facilitates the collection of refuse and recyclables from the carts set out by residents. The blue bags were collected with refuse bags in the packer. The City's normal 3:1 compaction rate for refuse was used in the co-collection trucks. The crews consisted of three collection personnel: a driver and two laborers.

Collected refuse and recyclables were weighed and unloaded onto the concrete floor of the city's 34th Street Transfer Station. Blue bags and refuse bags were loaded from the concrete tipping floor onto a 30-foot conveyor using a small front-end loader. Once on the conveyor, laborers separated blue bags from refuse. After blue bags were removed from the conveyor, they were loaded into transport vehicles, weighed, and sent to Chicago Recycling Works, an independent recycling processing facility.

At Chicago Recycling Works (CRW), the bagged recyclables were again unloaded onto a concrete floor and loaded onto a conveyor by a front-end loader. Ten full-time workers sorted the bags manually from a conveyor. CRW used more labor to sort the commingled recyclables than it does to sort segregated recyclables. CRW did not incur any capital costs and used existing equipment to process the recyclables from the pilot program. The equipment included a conveyor system ($50,000), an aluminum crusher ($45,000), a baler, and a truck scale ($50,000). Sorted recyclables were again weighed. According to Rick Aardma, the Plant Manager, the average cost to process the recyclables from the pilot program was $18 per ton. Rick Aardma claims that the quality and marketability of the materials were good and that commingled recyclables collection is a viable alternative to separate collection.

Of the 14,522 blue bags collected during the 10-week program, 826 or 5.7 percent, contained refuse. "The unsophisticated materials handling and processing operations" at the 34th Street Transfer Station led to a 9.1 percent loss of blue bags before the bags were delivered to Chicago Recycling Works. Of the materials delivered to the Chicago Recycling Works, newspaper represented 59.4 percent, magazines represented 3.1 percent, all colors of glass represented 13.2 percent, cans 6.2 percent, plastic 5.5 percent, blue bags 1.5 percent, other bags 0.2 percent, and residue 10.9 percent. The city estimates that residue, which does not include materials contaminated by the blue bag collection process, was a result of repeated loading and unloading of the blue bags. Recyclables collected during the program (and forwarded to Chicago Recycling Works) represented 7.3 percent of the total waste collected in the co-collection service area.

The city considered the material quality of the recyclables collected during the blue bag pilot to have a comparable quality with recyclables that are collected in separate collection systems. For example, "Co-collected newsprint often had significant advantages over paper collected separately, in that the bagging procedures kept the fiber cleaner and drier." However, the city has been criticized for misrepresenting the data on material quality. David Moberg, in his article in the September 1991 *Reader*, claims that the blue bag program will produce materials inferior in quality to materials collected in dedicated programs. Inferior quality material will lead to reduced revenues if the material can be marketed or it will end up in a landfill. Moreover, in the article, Vanessa Surney, the supervisor of the sorting operation at Chicago Recycling Works, comments on the quality of the material received during the pilot program. "It's poor, real poor...There's so much contamination. They might as well just put it in the garbage if they're going to send it to us in this condition."

Weekly and overall participation rates varied between the two wards. While the average weekly set-out rate for all 10 weeks was 42 percent, the set-out rate for Ward 7 was 32 percent, and the set-out rate for Ward 41 was 53 percent. Participation rates increased as the program progressed. Overall participation rate in the program was 84 percent.

Chicago contracted the B-Tel Marketing Management Group and Richard Day Research, Inc., to conduct two independent surveys of the residents who participated in the demonstration project. During the program 756 residents were reached for the survey (all the households were targeted). After the program ended, 580 residents were reached out of a total 1,500 households targeted. The city used the results of the surveys to further evaluate the program. Surveyed residents found that the blue bag was cleaner, easier to handle, and it held more recyclables than the bins. Residents preferred the drawstring closures to the tie-handle closures. Fifty-five percent of the residents found the blue bags convenient. However, residents disliked having to clean and crush the recyclables. Residents expressed a preference for the blue bag over the bin method of recycling when they were asked to choose between increased property taxes for a separate bin collection program or the purchase of blue bags for 0.18¢.

The development of Materials Recycling and Recovery Facilities (MRRFs) are an integral part of Chicago's city recycling plan and cost analysis. The city plans to update its city-owned transfer stations into MRRFs that will process the entire solid waste stream—recyclables, yard waste, and mixed waste—when the program is implemented citywide. The pilot program did not include the collection of yard waste or the processing of mixed waste. When the program is implemented, yard waste in kraft paper bags will be collected in packer trucks with the bags of recyclables and bags of refuse. In October 1990, the city issued a Request for Proposals (RFP) for processing facilities with the capacity to receive approximately 1,500 tons per day of mixed recyclables, yard waste, and refuse. The city plans to contract with firms to process the refuse to recover additional materials for recycling (at least 25 percent). On March 18, 1991, the city received bids from eight firms and is in the process of negotiating with two of the proposers, Ogden Projects, Inc. (Fairfield, New Jersey), and Waste Management, Inc. (Oak Brook, Illinois). The city estimates that the net system cost for 1992 (including capital burden for MRRFs) will be $11,854,250 and the cost will decrease each year as the tonnage diverted increases (see Appendix C).

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In August 1990, BFI began an 11-month pilot co-collection program for the city of Houston. BFI offered the program free of charge to the city for the 11-month period. While BFI carried out the pilot project, the city carried out a dedicated recyclables collection program servicing 27,000 households. BFI chose the blue bag system because it wanted to offer curbside collection without incurring costs for dedicated recycling trucks or additional labor. At the end of the pilot, BFI proposed a 1-year contract

that was rejected by the city in favor of the separate collection system. According to Ed Chen, the Recycling Coordinator for the city, the city did not contract with BFI to continue the program because the costs for the co-collection program would be higher than for the city's separate collection program. Ed Chen would not provide specific cost data on either the BFI program or the city's program. Michael Meagher, BFI's manager of recycling systems, Southwest Region, maintains that BFI offered a "permanent" program cost to the city that was well below estimated "full costing" prices for dedicated recycling programs. The city has taken over the collection routes from BFI and although the blue bags are still collected, the city plans to replace the bags with rigid recycling containers in the spring. Moreover, the city recycling center cannot handle the blue bag system because it does not have the sorting capacity.

Co-collection services were offered to 18,300 single-family households of the 30,000 households served with refuse collection by BFI. During the program, newspaper, aluminum, ferrous cans, and plastic were collected in 13-gallon 1.5 millimeter First Brands Glad blue bags. BFI opted to exclude glass from curbside collection in order to avoid breakage during collection and material contamination. Instead, glass was directed to drop-off or buy-back centers. BFI and First Brands donated the initial promotional starter kit that included 10 bags and informational brochures, and First Brands held in-store demonstrations of the blue bag. After the residents used the starter kit, they purchased a box of 10 bags in local stores for $1.75.

BFI used four existing 20-cubic-yard Pak-Mor vehicles and one 25-cubic-yard Pak-Mor Dual Chamber Rear Loader. The Dual Chamber Rear Loader is a split compactor designed with two compartments to separate recyclables or yard waste from refuse. BFI maintained compaction rates of 6:1 (1,000 lbs per cubic yard) for the five vehicles including the recyclables compactor on the prototype vehicle. Michael Meagher claims that in the pilot program the addition of the blue bags had no impact on the collection system. The bags were just another bag to throw into the truck and BFI used existing collection routes. Thirteen collection routes were covered four days a week by five vehicles, each with two collection personnel. There were 1,100 to 1,400 stops per route, which took 8 to 10 hours to complete—no additional time as compared to BFI's normal solid waste collection.

The use of the 25-cubic-yard Pak-Mor Dual Chamber Rear Loader in the Houston pilot program was a joint venture between BFI and Pak-Mor. BFI received the vehicle three to four months into the pilot program. Pak-Mor has designed a 20-cubic-yard and a 25-cubic-yard dual chamber rear loader. The 20-cubic-yard packer has a 5-cubic-yard chamber for recyclables and a 14-cubic-yard chamber for refuse. The 25-cubic-yard packer has an 8-cubic-yard and a 16-cubic-yard chamber. BFI purchased the 25-cubic-yard packer body for approximately $40,000 to $50,000, and had the packer installed on a Ford truck. The total cost of the collection vehicle was approximately $95,000 (the packer body and the truck). The Dual Chamber is similar in operation to a regular rear loader; the hopper is one piece and the slide blade is common to both compactor areas. However, each chamber has a separate sweep blade and a separate ejector panel. During the collection process, bags of refuse and bags of recyclables are put in the hopper together. When the hopper is full, the sweep blade for each chamber cleans the hopper and pushes the bags into the truck. The slide blade pulls all of the material further into the truck at the same time. When the vehicle unloads the bags, material from the chambers is dumped separately because each chamber has its own ejector panel. However, because the hopper is one piece, when it is opened, and the material from one chamber is dumped, between 10 and 15 bags from the other chamber (either bags of refuse or bags of recyclables depending on which chamber is emptied first) fall out of the hopper. These bags are usually the last ones picked up on the route. Jeff Cecil, the Assistant District Manager for BFI, claims that BFI had few volume capacity problems with the Dual Chamber. While the recyclables area never filled up before the refuse area, sometimes the refuse area filled up before the recyclables area. Although the vehicle performed well during the pilot program, Michael Meagher has some reservations about the vehicle's overall performance and prefers to use a regular rear loader to collect bags of refuse and bags of recyclables together. For instance, Michael Meagher believes that a separate compactor could introduce the problem of different refuse-to-recyclable volume ratios in different residential neighborhoods. One packer area may fill up more quickly than the other in some neighborhoods while it does not in others. Moreover, if yard waste is included in the co-collection system, a seasonal fluctuation in the volume of yard waste may change the volume ratios and lead to a decrease in the system's efficiency. Despite potential volume capacity issues, the split

compactor may reduce material contamination during the collection process. BFI did not monitor material quality from the split compactor vehicle and does not report reduced contamination of the materials in the separate chamber. Michael Meagher points out that if a vehicle has a separate compartment for recyclables and refuse, he would not have the recyclables bagged. Since the pilot program was discontinued, BFI uses the vehicle as a spare and a show piece for interested individuals.

The cost for collecting refuse and recyclables during the pilot program was approximately $40 per ton. Processing refuse and recyclables, including transfer costs, costs approximately $20 per ton.

The weekly set-out rate during the program varied from 12 to 32 percent and averaged 21 percent. According to a Rice University survey, which BFI commissioned, participation in the pilot program was 57 percent. Residents generally set out one bag of recyclables for every five to seven bags of refuse. Of the materials in the bags, 86 percent was newspaper, 1.4 percent was aluminum, 8.3 percent was tin, and 4.4 percent was plastic. From August 1990 to July 1991, recyclables represented an estimated 6 percent of the total waste collected (811 tons of recyclables and 13,746 tons of refuse were collected). Eleven percent of the bags was rejected due to poor preparation by residents and breakage during collection and processing. BFI was pleased with the overall performance of the blue bags. Michael Meagher points out that some bag breakage is to be expected because the collection and sorting process is tough on the bags. (There are no data available on the amount of residue due to mispreparation by the residents versus failure of the bags in the collection process.) Moreover, BFI discovered that when bags were given to residents, a greater number of them were set out full of refuse rather than recyclables. For instance, during the first two months of the program when blue bags were provided to the residents, 17 to 18 percent of the bags were used for refuse. By the eighth and ninth week of the program, only 7 percent of the bags had refuse in them.

For the pilot program, BFI set up a temporary processing facility in a refurbished building at the McCarty Road Landfill. Because the facility was set up to serve a pilot program, BFI minimized its capital investment. On Monday, Tuesday, Thursday, and Friday, the days BFI provided the co-collection service, bags of refuse and recyclables were unloaded onto a hydraulic walking floor at the front end of the processing area. The walking floor moved the materials from the tipping area to a conveyor system, which took the material to the back of the building. Blue bags of recyclables were pulled off and stored in three to four roll-off containers. The bags of refuse were sent out to a transfer trailer that went up to the working face of the landfill. On Wednesday and Saturday, the blue bags from the roll-off containers were manually opened and dumped back onto the walking floor and then the conveyor system. The blue bags were pulled off, leaving the recyclables on the conveyor belt from where they were then manually sorted into containers. BFI marketed the aluminum and tin directly but sent the newspaper and plastic to a BFI facility to be baled. BFI employed nine people for the processing operation: an equipment foreman, a mechanic, a labor supervisor, and six laborers. Michael Meagher estimates that 87 tons of refuse and recyclables were sorted each day and the facility had the capacity to sort 180 tons per day. The net revenues from the sale of 811 tons of processed recyclables were $18,880. BFI did not weigh incoming material; tipping fees were based on cubic yards. The tipping fee for refuse is $5.07 per cubic yard. BFI did not have any trouble marketing the materials collected during the pilot program. In fact, Michael Meagher claimed that during March and February 1991 when Houston had a lot of rain, the newsprint collected in the blue bags stayed dry while the newsprint collected in the separate collection program was wet and virtually unmarketable. Michael Meagher did not share cost data for the temporary facility or the additional labor costs for sorting the material. However, he estimated that it would cost approximately $20 per ton to process bags of recyclables at a transfer station, including the cost to transfer any residues. After the program ended, BFI dismantled the facility. Since completing this research and development project, BFI has been an active bidder/proposer on co-collection system bids and RFPs.

Missoula County, Montana

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In rural Missoula County, BFI began to offer blue bag co-collection service to 14,000 county households in January 1991. According to Jim Leiter, the BFI Landfill Manager, BFI chose the blue bag co-collection approach because it wanted to offer a curbside recycling service to a rural community without incurring additional collection costs. BFI does not charge customers for recyclables collection and considers the program a "value added service." Montana Recycling processes the materials collected. All revenues (after materials processing costs) are donated to a local organization, Keep Missoula County Clean.

The majority of the households served by the program are single-family, but the program includes multi-unit complexes such as senior citizen homes. In fact, Jim Leiter claims that the highest participation rate comes from the senior citizen homes. The program uses the 13-gallon 1.5 millimeter thick First Brands Glad blue bag. During the program start-up, BFI distributed 10,000 free bags to residents. After the initial 10,000, residents purchased a box of 10 bags for $1.79 in local stores. At the beginning of the program, only newspaper and aluminum and steel cans were targeted for collection. When residents began to include in their bags other materials that were not actually targeted for recycling, such as corrugated cardboard, glass, and plastic, Montana Recycling processed these materials as well. Tonnages of plastic collected are not tracked and the tonnages for corrugated cardboard and glass are not reliable. From January 1991 through June 1991, BFI collected 18 tons of recyclables and 25,000 tons of refuse. Recyclables represented less than one percent of the total waste collected. Of the materials collected, newspaper represented 70 percent, corrugated cardboard 3 percent, glass 5 percent, aluminum cans 4 percent, ferrous cans 3 percent, and residue 14 percent. Residue included blue bags containing only refuse, blue bags of recyclables contaminated by refuse, and broken bags. These bags were landfilled. Jim Leiter would prefer a thicker bag, perhaps one that combines the materials used in Bagit Systems' bag with those in Glad's blue bag. Missoula County experienced some problems with bag thickness because the tensile strength seems to weaken under cold weather exposure.

BFI uses 10 25-cubic-yard Heil packer trucks with two to three collection personnel for 10 collection routes a week. As in other blue bag programs, the bags of recyclables are collected weekly with the bags of refuse. BFI does not change the compaction rate of the packer truck, which is about 800 pounds per cubic yard. While some blue bags are placed on one side of the packer, most are placed in front of the blade where they are not compacted. There is space for 50 bags in front of the blade. The addition of blue bags to the collection system has not greatly changed the collection process. Bags are unloaded at the landfill before the refuse is tipped and stored in roll-off containers provided by Montana Recycling. If there are more blue bags than will fit in the non-compacted section, they are manually separated from the refuse bags. According to Jim Leiter, this does not pose a problem because there are so few bags that end up mixed with the refuse bags. Montana Recycling picks up the blue bags twice a week at no charge and takes them to its intermediate processing facility. The tipping fee for refuse is $4 per cubic yard.

It is difficult to itemize or estimate the costs for the blue bag program because neither BFI nor Montana Recycling consider the program an added cost. Jim Leiter points out that besides some extra labor for the sorting of the blue bags and a small investment in advertising, BFI has not made a substantial investment in the program. BFI does not want to make a financial investment in the program because some organizations in the community collect recyclables for revenue. For instance, BFI does not want to compete for the revenues from the sale of aluminum cans. Moreover, Montana Recycling, an organization with small processing areas around the state, has yet to process a significant amount of material from the Missoula County program.

Jim Leiter thinks that separating bags of recyclables from bags of refuse on a larger scale and with increased recyclables will be problematic. First he pointed out that bags break more frequently when refuse and recyclables are compacted together. Second, he thinks separating a large quantity of blue bags from refuse bags would place workers at long and high exposure to refuse, which could pose health problems.

Omaha, Nebraska

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In January 1990, the city of Omaha contracted with Refuse Resource Recovery Systems (RRRS) to operate a mixed waste sorting facility. During the awarding process, the City Council and some citizens expressed a desire for residents to be more involved in the recycling program. Public Works staff and RRRS were directed to develop a system that allowed citizens to participate by presorting their recyclables. The blue bag system was developed as a result. RRRS began operation, solely as a mixed solid waste sorting facility on July 9, 1990. The blue bag portion of the program was announced on November 30, 1990. The city paid RRRS a contracting fee of $8.70 per ton. RRRS underestimated its operating costs and went out of business in December 1990. The city, shortly after that, declared RRRS in default of the contract and began looking for a way to continue a recycling program. Omaha then contracted with Waste Management of Nebraska, Inc. (WMI) to process the bagged recyclables, but dropped the mixed waste sort stage. The city resumed citywide co-collection on March 25, 1991. The city chose the co-collection bag system because under its current contract with Watts Trucking of Nebraska, it could not start a separate collection system until 1996. Moreover, before the city started the first co-collection program, it received bids on separate dedicated recycling collection. The lowest bid received by the city was $158 per ton. The cost per ton for blue bag co-collection is $31.

The co-collection program serves 100,000 households, which range from one- to four-family units. The 100,000 households represent 100 percent of the population served with public sector sponsored refuse collection (or 75 percent of the total households). The other 25 percent of the households have separate collection agreements with private haulers. Recyclables are collected weekly in three different bags: HDPE grocery bags, 13-gallon 1.35 millimeter LDPE blue bags, and 33-gallon 1.75 millimeter LDPE blue bags. The LDPE bags are manufactured by Pitt Plastics in Pittsburgh, Kansas and distributed by Industrial Chemical Laboratories. Two bag sizes are offered to give residents more flexibility. Residents purchase the 13- and 33-gallon LDPE bags in retail stores for 15¢ and 22¢ respectively. According to Lou Tomsu, the city's Recycling Programs Supervisor, Omaha chose the LDPE bags because they represented a good balance between bag strength and cost. The city could have chosen thicker bags, but it would have increased the cost to the residents. Materials collected for

recycling include newspaper, corrugated cardboard, glass, plastic, and aluminum and ferrous cans. The glass, plastic, and aluminum and ferrous cans are commingled in one bag, and the newspaper is separated and set out in a different bag. Residents are encouraged to put their newspaper in HDPE grocery bags. Watts Trucking uses 25 existing front-loading 30-cubic-yard Heil packer trucks, each operated by a one-person crew. There are 23 collection routes. The vehicles are commonly called Heil Half-Packs because the packer does not begin compacting until the vehicle is half full. (Full compaction rates are used.) When the vehicle is full, the compaction rate is approximately 567 lbs per cubic yard. According to Lou Tomsu, yard waste in refuse bags contributed more to bag breakage than vehicle compaction rate. The sticks in yard waste tended to put holes in the bags; in addition, yard waste increased the weight of the refuse bags. The blue bags are collected with refuse bags in packer trucks. Omaha pays Watts Trucking a contract fee of $31.22 per ton for the collection of refuse and recyclables.

The city has a 5-year contract with Watts Trucking to collect and compost yard waste. Yard waste is collected in a separate vehicle on the same day refuse and recyclables are collected. Residents are allowed to set out their yard waste in any type of bag but they are instructed to place the bags of yard waste on the opposite side of their driveway so they are not confused with the bags of refuse. Yard waste is collected in older refuse collection vehicles. Yard waste collection began on April 8, 1991; approximately 14,201 tons were collected from April 8, 1991 to December 20, 1991. Lou Tomsu does not know the number of residents that participate in the program but he estimates that only 20 percent of the available yard waste was collected. It is difficult to monitor the ratio of yard waste produced to the yard waste collected because Omaha's composting program focuses more on backyard composting and tries to influence residents to leave their grass clippings on their lawn. Yard waste collected with the refuse and recyclables is landfilled. Omaha pays Watts $30.34 per ton in collection fees and $16.50 per ton in tipping fees. Moreover, Omaha has set up an incentive system where in 1991 the city will pay Watts an additional $5 for each ton collected after 5,000 tons have been collected. In 1992 the city will pay an extra $5 for each ton after 10,000 tons; in 1993, it will pay an extra $5 per ton after 15,000 tons; in 1994 after 20,000 tons and in 1995, after 25,000 tons. Watts operates the compost site located in Iowa.

Participation rates in the co-collection program have increased with the program's development. At the beginning of the program, the participation rate was 23 to 24 percent. Dan Slattery, the Recycling Coordinator for the city, attributes this initially low participation rate to a degree of disillusionment among residents after the first program failed and the three-month period before the new program began when recyclables collection was not offered. Dan Slattery estimates that the weekly set-out rate for the bag program reached 47 percent during the week ending October 4, 1991. The city has not calculated the overall participation rate in the program. From March 25, 1991 to February 17, 1992, a total of 3,385 tons of recyclables (not including the residuals) were collected in 47 weeks, of which 2,162 tons (or 64 percent by weight) were collected in the blue bag program and 1,223 tons were collected at the drop-off boxes. During the same period, a total of 116,232 tons of refuse were collected. Three percent of the solid waste stream excluding yard waste was collected as recyclables. Omaha's actual materials recovery rate (through recycling and composting) during this time period was about 16 percent (based on an average of 1,578 tons of yard waste composted per month in the first 9 months of 1991).

Recyclable materials are processed at a facility owned by the city of Omaha. The facility was a solid waste incinerator until 1976 when it was demolished, and a refuse baling plant was constructed on the property. Omaha operated the baling plant from 1976 to 1986 when it disposed of its refuse in a "bale fill." When the City Council closed the bale fill after public pressure, the city landfilled refuse at the county landfill. Subsequently, the city closed the baling facility because the county landfill did not reduce the tipping fee for baled refuse, and baling refuse cost the city $15 to $20. From 1986 to 1989, the facility remained empty. Before the co-collection program began, the city assessed the 58,000-square-foot building at $1.8 million dollars. Omaha now leases the facility to Waste Management free of charge as part of its contract with Waste Management to operate the facility as a transfer station and process the recyclables from both the co-collection program and the drop-off boxes. However, the contract stipulates that Waste Management can only accept solid waste from the city of Omaha. If

Waste Management wanted to accept waste from other communities, it would have to pay to lease the facility.

The facility, which processes 20 tons per day of recyclables in blue bags and 500 to 550 tons per day of refuse, began operation March 25, 1991, and operates 5 days a week. Waste Management employs 32 full-time people (16 handle refuse and 16 handle the recyclables) who work on the tipping floor, the baling area, and the sort-lines. The facility has the following equipment, purchased by WMI:

Portable Ptarmigan Conveyor System	$75,000
Multipurpose Balemaster	$250,000
Blower/Flattener (for cans)	supplied by Alcoa
3 Loaders (F-E Bucket)	$150,000 each
Portable Scale	$1,200
Truck Scale	came with building

Refuse is tipped from trucks onto the top floor of a two-story 58,000-square-foot building. Front-end loaders pick up commingled refuse and blue bags and lay them out in a thin layer on 12,000 to 15,000 square feet of the tipping floor. From there laborers pick out the blue bags and place them in one of three storage areas in the periphery of the floor. Loaders then push remaining refuse out of a window into a transfer vehicle on the lower floor. Loader operators are notified by sorters through a red-light/green-light mechanism when sorters need more blue bags. When the green light is on, the loader operator tips blue bags down a chute to the sort-line (the portable ptarmigan) below. Eight to ten sorters work on the sort-line, which is a "positive" picking line (one in which recyclables are picked off and contaminants are left to drop into a 20-cubic-yard container at the end of the line). The first two positions on either side of the line debag the bags. Then three pickers separate old newspapers which are dropped into 2-cubic-yard bins below (picking line is elevated about 8 feet off the ground). On the other side of the line, laborers pick PET containers, HDPE milk jugs and detergent containers, and all other plastics. PET is tipped into one bin, HDPE is tipped into two other bins, and the mixed plastics are tipped into another bin (four 2-cubic-yard bins altogether). At the end of the sort-line is a picker for mixed brown and green glass on one side, and a picker for clear glass and corrugated cardboard on the other side. These are also workers responsible for collecting miscellaneous other materials that were missed earlier in the line (mainly old newspapers). Residue (food waste, diapers, needles), which gets carried off the conveyor, is estimated at 15 to 20 percent by weight of the material that comes in through blue bags. Lou Tomsu believes that contamination is due to poor sorting procedures, rather than collecting methods. Refuse and residue are conveyed into 100-cubic-yard walking floor transfer trucks.

Under the 1-year interim program (March 3, 1991 to March 29, 1992), Omaha has paid Waste Management a flat fee of $469 for up to 30 tons of recyclables a day ($15.63 per ton if 30 tons are collected). The contract required a fee of $13.25 for each ton in excess of 30 tons per day (this charge did not occur during 1991). This fee included opening of the bags, sorting the contents into specific categories, processing the recyclables for shipment, and marketing the recyclables. Omaha also paid Waste Management a blanket tip fee of $20.15 ($18.95 before October 1, 1991) per ton for the receipt and sorting of the bags of refuse and recyclables at the facility, the loading of refuse onto the transfer trucks, the transportation and unloading of the refuse at the Douglas County Landfill, and payment of the landfill tip fee of $12.45 per ton ($11.25 before October 1, 1991). Revenues from the marketing of materials were divided between the city and Waste Management. The city received 50 percent of the net revenues. As of December 10, 1991, a total of 2,029 tons of recyclables were marketed, resulting in $29,898 in revenues for the city of Omaha. The average net revenue from the sale of recyclables was $29.46 per ton. Waste Management has not had any trouble marketing the recyclables. According to Lou Tomsu, WMI has not experienced any marketing problems because the sorting and preparation process is conducted under strict controls. During 1991 a total of 3,630 tons of material were sorted, of which 2,932 tons were recyclable. The other 698 tons (19 percent of materials processed) were classified as residual or nonrecyclable material. Dan Slattery estimates that residue includes broken glass and materials that are not targeted for recycling, such as magazines, disposable diapers, dirt, mixed plastics (the program only collects HDPE and PET, and the blue bags), pizza boxes, and mixed paper. Approximately 15 percent of the glass breaks during collection. All residue is landfilled. Omaha plans to market the LDPE blue bags and the HDPE grocery bags when it has accumulated a truckload. The city has letters of agreement with three plastic bag recycling companies. Two of the three companies would use the

bags to produce mixed plastic products. The third company would separate the LDPE and the HDPE bags, clean them, and manufacture recycled plastic bags.

Omaha issued a Request for Proposals (RFP) for a 3-year and 9-month contract (from March 30, 1992 to December 31, 1995) to process 1,000 tons per day of refuse and 80 tons per day of recyclables. In December of 1991 the contract was awarded to Waste Management, Inc. Under the new contract, the city of Omaha pays Waste Management $5.64 per ton for receipt and separation of co-collected solid waste and loading the remaining garbage on 110-cubic-yard trailers, $2.90 per ton for transportation to the landfill (city pays tipping fees), and $95.56 per ton for processing recyclables collected in blue bags and from drop-off centers. The city receives 60 percent of the net revenues from the sale of recyclables and is guaranteed the following minimum net revenues from the sale of recyclables :

Newspaper: $35/ton
HDPE Plastic: $100/ton
PET Plastic: $100/ton
Aluminum (UBC): $600/ton
Steel Cans (Tin Cans): $40/ton
Glass (all 3 colors): $65/ton
Blue Plastic Bags: $60/ton
Old Corrugated Cardboard: $20/ton
Kraft Paper: $30/ton

Under the new contract, the refuse and blue bags are separated via a conveyor on the top floor. A larger permanent conveyor on the lower (recyclables) sort-line can accommodate up to 80 tons per day of recyclables. The contract requires that the process for separating the blue bags from the refuse be mechanized to improve efficiency and lessen the possibility of personnel injuries.

In addition, the city is setting up all its collection and processing contracts for refuse, recyclables, and yard waste so that they will all come due at the same time—December 31, 1995. At that time, Omaha plans to put together a unified set of specifications to cover all of its solid waste management programs. The city will allow different portions of the programs to be awarded to different bidders if it finds that most cost-effective and efficient.

Pullman, Washington

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Pullman, Washington, located in rural Whitman County, has a population of 23,478, of which approximately 17,000 are students at Washington State University. In January 1991, the county targeted 1,200 households, in an area called Military Hill, for a pilot co-collection program. In September 1991, the program expanded to 5,000 single and multi-unit households; these represent 68 percent of the total number of households in Pullman. Cliff Cooper, the Solid Waste Manager for Whitman County, explained that co-collection was chosen so the hauler, Pullman Disposal, would not incur additional costs for labor or equipment. Pullman also estimated that a separate recycling collection system would have greater costs for the town—the town would have to continue to replace rigid containers for recyclables because of the transient nature of the town's residents. Moreover, the bag system of collection is compatible with the county's solid waste program.

When the program began, residents received start-up kits of bags and instructions on how to prepare the bags. Volunteers from various civic organizations went from door to door to deliver the start-up kits. Residents now purchase a box of 10 bags for $1.60 to $2.20 in local stores. Newspaper, glass, and

aluminum and ferrous cans are collected. Residents commingle all the materials except glass in the 13-gallon 1.5 millimeter First Brands Glad blue bags. Glass is placed in a separate bag and set out in trash cans with blue bags and refuse bags. The blue bags are collected with refuse. Pullman Disposal uses four 25-cubic-yard collection vehicles: two International Dempster packers and two Peterbuilt Heil 5000 packers. Glass is collected in a side rack on the truck. The rack has an approximate capacity of 2/3 cubic yards and was built by Pullman Disposal for $200. There are two collection personnel for each vehicle. Blue bags are loaded on one side of the packer.

The county processes all the materials from the blue bag program at the county landfill, 6 miles northwest of Pullman. Pullman Disposal pays a tipping fee of $50 per ton for refuse and recyclables at this facility. The county sorting facility cost about $200,000 (for separation conveyor and building addition) and has a capacity of 6 tons per day. About 3 to 5 tons per day of recyclables are sorted from the bags. Six to seven workers process recyclables. The same workforce handles the refuse. Trucks unload bags onto a tipping floor from where bags are loaded onto a baling conveyor. The blue bags are separated out and put in separate containers along with the blue bags of glass collected in the side racks. From there, the recyclables are unloaded onto a separation conveyor where they are manually sorted into their own containers. An estimated 5 to 10 percent of recyclables are rejected as nonrecyclable. Very little glass breaks and is rejected. The county reports no problems marketing recyclables. Aluminum is baled and hauled to Ismat in Post Falls, Idaho. Newspaper, cardboard, and plastics are sold to Spokane Recycling. Glass is crushed and shipped to Portland by Pullman Disposal. All refuse is baled. Only refuse bags with high recyclable materials content are processed through the separation conveyor.

The county has very little data on the pilot program. When the starter-kits were handed out at the beginning of the program, 60 percent of the residents were at home and 97 percent agreed to participate in the program. For four months, from January 1991 to April 1991, collection personnel picked up the bags and replaced a full bag with an empty one. There were some bag distribution problems in the multi-unit complexes because building managers did not distribute the bags to residents on a regular basis. Four months into the program a telephone survey indicated that 80 percent of the households were still participating in the program. Those who had stopped claimed they hadn't received the blue bags. Cliff Cooper estimates that during the pilot program, only 1 to 2 percent of the waste stream from the households included in the program, was diverted. The county has yet to start collecting data on the expanded collection program. There are plans to survey participants by telephone. Since the program only recently expanded, the county has not set a goal for recovery rates. The county plans to analyze the expanded program in 1992 after hiring a recycling coordinator.

Although the bag co-collection program in Pullman is still in the developmental stage, some operational issues have arisen. For example, at the beginning of the program, the collection vehicle used by Pullman Disposal shredded all the blue bags. The design of the compactor blade creates a shearing force that destroys the bags. The first day of the program, not one bag was retrieved from the vehicle. Glass in the bags compounded the problem. A reduced compaction rate and the exclusion of the glass from the bags has increased the recovery rate for the bags from an average of 30 percent to 80 percent. While bag breakage is not an ideal aspect of the program, broken bags can be recovered since Whitman County sorts mixed waste. To reduce bag breakage, Cliff Cooper wants to switch to a sturdier 1.75 millimeter bag developed by Mobil. Information on Pullman Disposal's average per ton cost for the collection of refuse and recyclables is not available.

Rochester, Massachusetts

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Rochester, a small rural community with a population of 3,921 and 1,300 households, is the host community for a SEMASS waste incineration plant operated by Energy Answers, Corp. In October 1989, the SEMASS Recycling Management Corp., a subsidiary of Energy Answers, began a pilot co-collection program to test a heavy, woven polypropylene bag called the "Recycle Bag" designed by Exxon. Residents did not pay for either the bags or for the collection service. Moreover, because Rochester is the host community for the SEMASS plant, residents do not pay for refuse disposal. Energy Answers ended the program in October 1991 because the expansion plans for the SEMASS facility reduced the processing area for the recyclables.

During the pilot program, only glass, plastic, and aluminum and ferrous cans were collected. Newspaper was not collected for two reasons. Energy Answers could not compete with a local paper company that pays $10 per ton for newsprint, and there was some concern that broken glass would contaminate the paper. Residents commingled the recyclables in the Recycle Bag and set them out with their refuse. A private hauler, ABC Disposal, and the Rochester Department of Public Works provided the co-collection service. At the beginning of the program, Energy Answers provided the bags and paid the haulers to distribute them. Haulers attached the bags to the side of the collection vehicle and dropped off empty bags when they picked up full ones. Problems with bag distribution led SEMASS to discontinue distribution and require residents to pick up the bags from SEMASS. Angelo Hazifotis, the general manager of SEMASS Recycling Management Corp., explained that distribution problems arose when haulers could not find a place to secure the empty bags and when bad weather prevented haulers from distributing the bags.

Angelo Hazifotis estimates that participation rates dropped from 70 to 50 percent once residents had to pick up the bags. Tonnage information for the materials collected is not available. Glass breakage was a significant problem. It ranged from 15 to 25 percent of the total glass collected. Glass breakage occurred in both the collection and sorting stages. The bags and glass broke if haulers did not set the bags in the trucks carefully. The front-end loader at the processing area broke many of the bags and glass when it sorted them from the refuse. SEMASS has yet to compile all of the data on the program. Even though SEMASS ended the program with the expansion of the energy facility, it maintains a drop box for recyclables and has plans to develop a 300-ton-per-day processing facility in Avon, Massachusetts.

South St. Louis County, Minnesota

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South St. Louis County is one of seven service areas in St. Louis County, Minnesota. The South St. Louis County Solid Waste Service Area includes 3 cities and 25 townships. The solid waste and

recycling programs are administered by the South St. Louis Solid Waste Commission, a nonprofit, municipal corporation. The Commission also operates the four Cash for Trash sites in the area.

The pilot blue bag co-collection program, which began in August 1990, targeted 1,000 households. In October 1990, the program expanded to districtwide service. The Commission chose the blue bag co-collection method because it was a cost-effective way to offer recycling service in its service area, which is very rural. The Commission wanted to offer the program to all residents. Of the 3,617 households, approximately 3,000 are served by the program (approximately 700 households are summer cabins). While most of the service area consists of single-family households, it does include four apartment buildings, which are serviced with the co-collection system. Materials collected include newspaper, corrugated cardboard, glass, plastic (types 1 through 7), aluminum and steel cans, small scrap metal, high-grade paper, mixed paper (magazines and brown paper bags), textiles (rags, flannel shirts, and blankets), and mixed plastic (plastic film and plastic bags). Magazines were added in June 1991, and rags and office paper were added in July 1991. All recyclable materials are commingled in the blue bags. Glass, however, is placed in a paper or a plastic bag before it is commingled with other materials in the blue bag. The 1.5 millimeter thick 35-gallon Glad blue bags with tie handles are delivered to residents every four months. Bags are essentially free to residents. The Commission covers bag costs ($0.18 per bag or $10.80 per household per year) and other recycling service costs through a special assessment fee on property taxes. Residents have the added convenience of delivery; volunteers are paid $1.00 for each household to which they deliver bags. Four private haulers collect the blue bags and refuse in existing one-person collection vehicles which range in size from 16 to 18 cubic yards. The haulers collect the blue bags with refuse bags but place the blue bags on one side of the compactor with the bag handles facing out to facilitate their removal at the transfer station. Haulers use normal compaction settings, which Ron Daigle, the Commission Chairman, guesses is about 3:1; the trucks are quite old and are apparently not very good at compacting.

From January 1991 to September 1991, 222 tons of recyclables were collected from the blue bag program and the four Cash for Trash sites. Of the 222 tons, 62 tons of recyclables were collected from the blue bag program. During the same period, 1,379 tons of refuse were collected. The collection rate for recyclables in the blue bag program was 4 percent while the total collection rate for recyclables from the blue bag and the Cash for Trash programs was 14 percent. Material contamination from glass is not a significant problem. Ron Daigle claims that less than 1 percent of the glass breaks during the collection process. Approximately 10 percent by weight of collected recyclables are rejected as nonrecyclable. On average, 22 percent of the households served set out a blue bag each week. Monthly participation rates vary between 50 and 90 percent. The Cash for Trash sites are popular because about 50 percent of all the county's residents self-haul their refuse and recyclables. The set-out rate for co-collected recyclables at curbside has been steadily increasing. Ron Daigle thinks it will especially increase with more education.

Collection vehicles tip the bags onto the floor of the transfer station. The blue bags are then manually pulled out with a hook and placed on a sorting table, where workers open them with utility knives. The recyclables are then hand sorted from the table into Gaylord boxes before further processing at the Commission's 5,000-square-foot small-scale processing center. The processing center has two full-time employees. One employee bales the material and one crushes the glass. When materials are ready for market, they are stored in two semi-tractor trailers.

For the fiscal year 1991, the Commission budgeted $100,620 for recycling operations. By September 1991, it had spent $85,618 ($386 per ton). See Appendix D for a breakdown of these costs. From January 1991 to September 1991, it cost $9,917 to transport the recyclables from the transfer station to the recycling center and then to market. The Commission contracts with haulers to market the material. Materials revenues for the same period were $8,238 (the Commission received $18,285 for the materials when marketed but paid out $10,047 through the Cash for Trash programs). Collection costs are not available because four private haulers provide the co-collection service. Tipping fees for refuse are $58.75 per ton.

Bin Methods of Co-collection

Carroll County, Iowa

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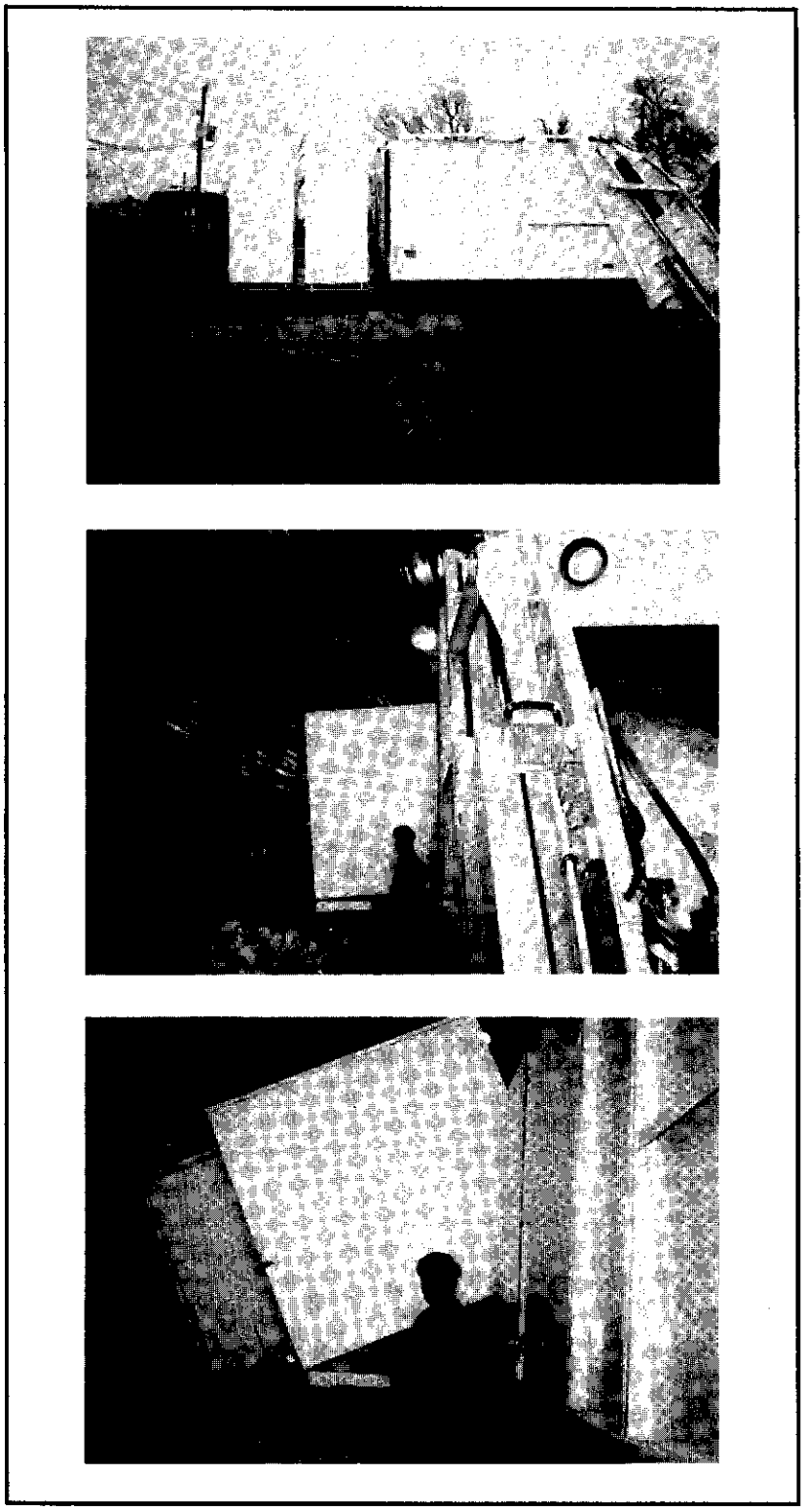
In 1989 the Carroll County Solid Waste Management Commission and New Hope Village were awarded a Solid Waste Landfill Alternative Grant from the Iowa Department of Natural Resources to develop a curbside and drop-box recycling collection program in Carroll County. The Commission contracted with Gershman, Brickner and Bratton (GBB), a solid waste consulting firm, to develop the recycling plan for the county. GBB recommended a curbside recycling program, and the Commission requested that haulers collect recyclables on the same day as refuse. The Commission also specified that recyclables could not be collected with refuse (such as the bag method of co-collection), but allowed haulers to develop their own collection systems. Nine of the twelve haulers in the County chose the co-collection method of curbside recycling. The Carroll County recycling collection program began in November 1990. In Carroll County, collection services for recyclables must be offered to all residents.

Of the 8,372 households in the county, 5,000 single- and multi-unit households are serviced with co-collection. Materials collected include newspaper, corrugated cardboard, glass, aluminum, plastic, textiles, and foil. Residents commingle all the recyclables in one 18-gallon container except newspaper and corrugated cardboard, which are placed next to the bin. When materials are collected, newspaper and corrugated cardboard are commingled in one compartment and the other materials are commingled in a second compartment. Approximately 6 percent of the material collected is landfilled as residue. The residue is either broken glass or types of plastic that the county does not recycle (the county only recycles HDPE and PET plastic).

There are 12 different haulers that contract privately with each service area. The collection vehicles used by haulers in Carroll County have capacities of 16 cubic yards; packer body manufacturers include Leach, Pak-Mor, and Glenwood. Two haulers use pick-up trucks that have stock racks. The haulers that chose to retrofit their vehicles include B.J.'s Refuse, Cady's Trucking, Carroll Refuse, D&L Refuse, Hilbert Stiffes, John's Refuse, Lanesboro city hauler, and Ray's Refuse. Co-collection is the most cost-effective method of collecting recyclables because some collection routes are as long as 25 to 30 miles one way. Haulers chose a variety of ways to retrofit their vehicles. Of the twelve, three haulers chose to retrofit their vehicles with bin systems similar to the unit developed by May Manufacturing.

Jerry Schumacher of B.J.'s Refuse designed and manufactured his own bin system with hydraulic lifts to dump the recyclables at the recycling center. Photos of his retrofitted vehicle are shown on the next page. In his prototype unit the recycling compartments slide out 5 feet before unloading the material, so that they are placed in the proper area. Unloading time is approximately 2 minutes, and after 18 months in operation no maintenance costs have been incurred. Jerry Schumacher estimates it cost $1,200 to extend the frame of his truck and $7,000 to $8,000 to build a unit with four compartments.



B.J.'s Refuse Retrofitted Co-collection Vehicle, Carroll County, Iowa

Larry Cady, the owner of Cady's Trucking, had Dave Schroeder, a local person, design and build his bin system. The retrofit consists of two compartments and a rack under the truck. The rack under the truck is used for yard waste while the first compartment is used for newspaper and corrugated cardboard and the second compartment is used for glass plastic, aluminum and tin cans. The total cost to retrofit his vehicle was $19,300. The bins cost $3,300, and Larry Cady had to buy a longer truck for $16,000 (cost after trading in old truck) to accommodate the bins.

Neither Jerry Schumacher nor Larry Cady have experienced volume capacity problems with their bins. According to Larry Cady, the system is flexible and can handle more recyclables because the bins do not fill up. Jerry Schumacher serves approximately 930 households and some commercial businesses. He estimates that 90 percent of the households participate in the program. Larry Cady picks up refuse and recyclables from 718 households.

Six of the haulers pull trailers behind the collection vehicles. There are three additional haulers that do not co-collect but pick up recyclables in a different vehicle. These haulers only service approximately 30 households each. There are approximately 15 collection routes, and collection crew sizes vary between one and three. Residents pay an average of $10.50 per month for weekly recyclables and refuse collection. The tipping fee for refuse at the Carroll County Landfill is $34.75 per ton. There is a separate collection program for yard waste.

Sara Bixby, the Carroll County Solid Waste Management Commission Recycling Coordinator, estimates a weekly set-out rate of 50 percent and an 80 percent overall participation rate in the program. The county tracks tonnages for the entire recycling program but does not track separate tonnages or collection rates for the co-collection program. From January 1991 to the end of September 1991, 14,032 tons of solid waste and 1,560 tons of recyclables were collected. The tonnages for recyclables include curbside and drop boxes. About 11 percent of the waste stream was recycled. Both the residential and the commercial sector use the drop boxes. Sara Bixby estimates that 60 to 70 percent of the recyclables collected is from residential households and 30 to 40 percent is from commercial businesses. The Commission promotes commercial business recycling and has set a goal of 100 percent participation. Approximately half of the businesses in the County already participate in the program.

The Commission constructed an intermediate processing center (IPC) to prepare the county's recyclables for end users. Construction of the facility began in June 1990 and was completed in November 1990. Total construction costs were $383,765, and total equipment costs were $291,118 (see Appendix E). The IPC is a 18,200-square-foot building with a loading dock and has a 30-ton-per-day design capacity. The Commission contracts for labor with New Hope Village, a facility for the housing and rehabilitation of disabled individuals. The County employs 10 to 14 people at the facility: 6 to 10 disabled people who, for the most part, hand-pick materials from a conveyor, 1 full-time supervisor, and 3 Commission employees. The IPC receives 9 tons per day from the curbside and drop-off recycling programs in the county. Haulers empty commingled recyclables on one side of the receiving area and newspaper on the other side; they place corrugated cardboard on a baler. The newspaper is stored in an outer lean-to area. The commingled recyclables are pushed into a pit hopper, which feeds a conveyor. Approximately six New Hope Village employees sort the material on the conveyor. HDPE and PET plastic are pulled off and separated into carts, a magnetic separator removes the tin cans (collected from drop-off sites), aluminum is hand sorted, and glass is removed from the conveyor to be sorted by color. There are three stations for the final stage of glass sorting, one for each color. A smaller conveyor feeds the glass into a crusher and out into a lean-to area for storage. Tin is baled in a horizontal baler, HDPE plastic is separated by color (white, natural, and colored) before it is put into a plastics granulator, and corrugated cardboard is fed into an automatic baler and then stored in a trailer off the loading dock. PET plastic is baled in a vertical baler. The Commission has not collected enough PET plastic to market it. Metal cans are baled and stored in a semi-trailer. In the outer lean-to area, newsprint is conveyed to a roto chopper, shredded, and then baled in a farm baler. All the newsprint is used for animal bedding. Foil is baled in the aluminum baler and textiles are baled in a vertical baler. All the materials except the PET plastic are marketed. Since Carroll County is a rural farming area, the animal bedding is in high demand. From November 1990 to July 1991, the total cost for processing 1,223 tons of recyclables collected at curbside and from drop-off areas was $74,405. The Commission incurred an average per ton processing cost of $61 and received $39,497 in materials revenues. In October 1991, the Commission expanded the operation of the facility to include recyclables collected from three

surrounding counties: Audubon, Crawford, and Shelby. The Commission does not charge a tip fee for materials collected in Carroll County but it charges a $30 per ton tip fee for the three counties. With the addition of the three counties, the facility processes approximately 13 to 14 tons per day.

Hamburg, New York

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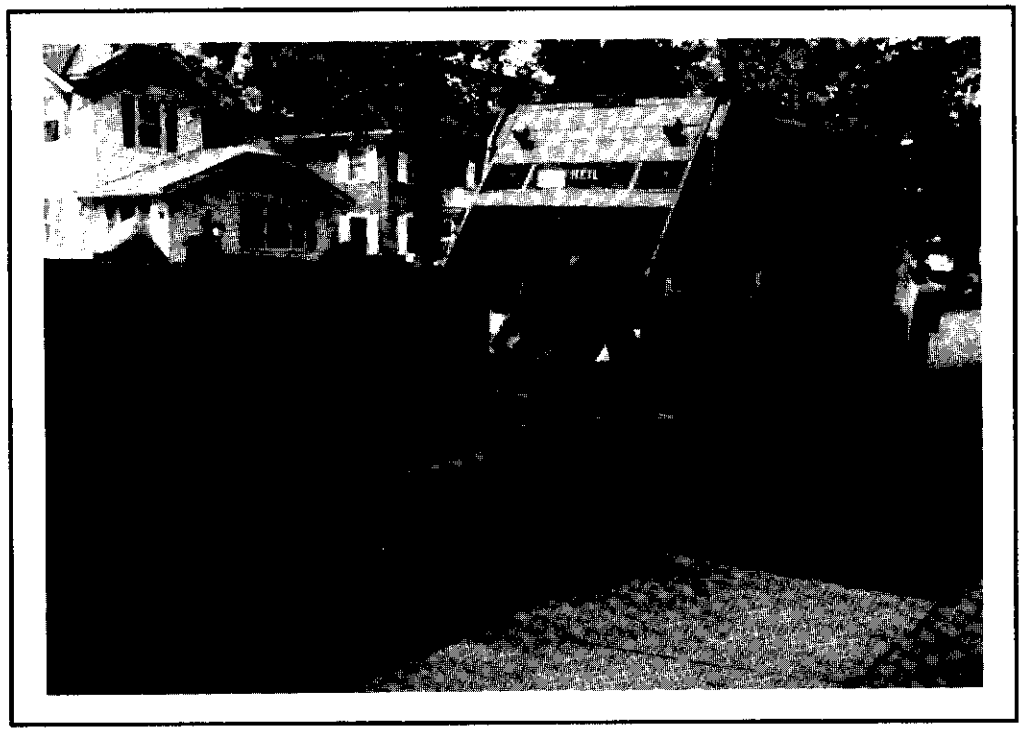
The village of Hamburg is the only community using a co-collection system that has a mandatory recycling program. The Village Board passed a law in 1981 requiring residents to separate their refuse and place it at the curb. The village chose co-collection because it was convenient to retrofit its existing collection vehicles with bins and specially designed recycling trailers by Power Pack (now out of business).

The Village Sanitation Division collects recyclables from 3,391 households in Hamburg. Materials collected include newspaper, corrugated cardboard, glass, waste oil, plastic (PET and HDPE beverage and detergent containers), and aluminum and bi-metal cans. Residents set out their recyclables in a container of their choice and receive a 5-quart container for waste oil. The three-person collection crew sorts the material at the curb. The trailer has six compartments, three on each side. Newspaper is sorted into one, corrugated cardboard into a second, and glass and plastics into the third. Waste oil is stored at the front of the trailer, where the trailer attaches to the collection vehicle.



Village of Hamburg, New York, Collection Vehicle for Refuse and Trailer for Recyclables

Anne Kankolenski, the Village DPW Secretary, considers the collection system flexible enough to handle additional items. The 1991 operating and maintenance cost for collecting refuse and recyclables was about $63 per ton. There is a $45 per ton tipping fee at the landfill. Refuse disposal costs for 3,822 tons of refuse were $172,000 in 1991.

The village uses the following equipment for its curbside recycling program:

3 Trailers	$ 7,500	(bought 1981/82)
Skidsteer Loader	$12,738	(bought 1981/82)
1.25-cubic-yard bins	$ 7,068	(bought 1981/82)
Waste oil containers	$ 3,500	(bought 1983)
18 1.25-cubic-yard replacement bins	$ 8,766	(bought 1988)
18 1.25-cubic-yard replacement bins	$ 11,565	(bought 1989)

Participation in the program, at 98 percent, is very high because residents are required by law to separate their refuse. If refuse is not separated correctly, it is left at the curb. Residents are required to set out all materials for recycling except waste oil. In 1990, 888 tons of recyclables were collected. Of this, newspaper represented 63 percent by weight, corrugated cardboard 13 percent, glass 16 percent, plastic 2 percent, aluminum less than 1 percent , tin 5 percent, and waste oil 1 percent. In 1991, 921 tons of recyclables were collected.

Recyclables are delivered to the Recycling Center. The Center is operated and staffed by the Association of Retarded Children (ARC) under the supervision of the Department of Public Works. Processing equipment includes a sorting table ($200, incurred in 1981) and 12 bins ($3,969, incurred in 1981/82). There are four full-time employees. Glass is separated into clear and colored, cans into aluminum and tin, plastic into PET and HDPE, and paper into newspaper and cardboard. Anne Kankolenski reports that there is no residue from collection and processing. The materials are stored in bins or 40-foot trailers until they are picked up by purchasers. Integrated Waste in Buffalo takes the newspaper and cardboard, Safety Clean picks up the waste oil, Eddie Arnold picks up the tin, and glass is hauled to Ball, Inc. In 1991 operating and maintenance costs for the Recycling Center were $37,525 ($41 per ton) and materials revenues were $13,585 ($14.75 per ton).

Loveland, Colorado

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The city of Loveland began a pilot co-collection program in August 1991. The city targeted 2,000 households (single and up to six-plexes). According to Mick Mercer, the Streets and Refuse Superintendent for Loveland, the city chose to test the co-collection method of curbside service after it estimated potential cost savings of $95,000 a year in labor, equipment, and operating and maintenance costs (this savings considered only expenditures not revenues). The pilot program was an opportunity to troubleshoot volume capacity needs for the recyclables bins and refuse packer. Loveland also began a separate pilot yard waste collection program.

The 2,000 households included lower-, middle-, and high-income households in five different areas of the city. Residents were provided with two containers for the recyclables. Newspaper was set out in one 12-gallon blue container, and glass, plastic, and aluminum and ferrous cans were set out in a second 15-gallon green container. Residents were instructed to only set out the containers when they were full and to protect the newspaper from wind and rain by stacking the commingled recyclables container on top of the newspaper container. Corrugated cardboard was flattened and placed under the containers. Residents received the bins free of charge (the cost to the city was $3.33 per bin). To give residents an

incentive to recycle, the city changed the flat fee structure for refuse collection to a much lower flat monthly collection fee plus a per-bag fee. Before the program, residents paid a flat monthly fee of $5.75 for refuse collection. For the pilot program, residents paid a flat monthly fee of $3.40 for refuse and recyclables collection and a 40¢ fee for a small 13-gallon bag of refuse, or 75¢ for a 30-gallon bag of refuse. Residents purchased 33-gallon white bags for refuse and special tags for large items (such as furniture) for 75¢ each at local stores. At the beginning of the program, in addition to the containers, residents received three free refuse bags, three free tags, and instructions on how to set out the containers and bags of refuse.

For approximately $21,000, the city of Loveland retrofitted a 20-cubic-yard Leach collection vehicle with a two-bin dual-side-loading unit, manufactured by May Manufacturing in Arvada, Colorado. Loveland did not cut down the size of the packer body. One bin (5.5 cubic yards) is used for newspaper and corrugated cardboard, and the other (also 5.5 cubic yards) is used for glass, plastic, and tin and aluminum cans. The May unit has hydraulic scoops that dump the materials into the respective compartments once the scoops are full.

Recyclables and refuse are taken to the Larimer County landfill located 10 miles from the city. The landfill tipping fee for refuse is $2 per cubic yard. Recyclables are sorted (but glass is not color-sorted) into 30-cubic-yard roll-off containers, which are rented. Reject rates are about 10 percent. Waste Management, Inc. has a contract to pick up and market all the recyclables. This 3 ton-per-day processing facility is temporary only and is very limited. It consists of a concrete pad surrounded by roll-off boxes for materials. Two to three laborers sort and toss materials into the appropriate roll-offs. Larimer County is in the process of building an intermediate processing center (IPC) at the landfill. The project was sent out to bid for a 20-year contract, and the county has awarded a contract to New England CRInc. New England CRInc. will operate the IPC and market the recyclables. Revenues from the marketing of the materials will be divided between Larimer County and New England CRInc. The new IPC, which will handle 70 tons per day in one 8-hour shift, will serve Larimer County and probably several adjoining counties.

In the first months of the co-collection pilot program, the city had problems with developing volume capacities relative to the disposal habits of the different neighborhoods. For example, in two of the three neighborhoods, residents set out similar volumes of refuse and recyclables, and the recycling area of the truck filled up more quickly than the refuse area. On average, the recyclables area filled up four times faster than the packer area for refuse. However, in the third, more wealthy neighborhood, residents set out much more refuse and fewer recyclables than the other neighborhoods, and the packer area filled up more quickly than the recycling area. As a result, the city was at first concerned about being unable to predict how many different volume ratios would exist once the program became citywide. The city has addressed this problem by designing trucks with compartments large enough to handle slightly over the average set-out for half of each truck's assigned route. Thus, each truck can collect from an average of 425 households before needing to go off-route to unload refuse and recyclables. It will then return to its route, complete another 425 stops and then unload again at the end of the day. Loveland, in other words, designed compartments large enough to handle a little more than half of each truck's assigned daily collections rather than trying to design a truck with compartments that would fill up simultaneously. The final design of the co-collection vehicle Loveland plans to use with citywide implementation is shown on the next page.

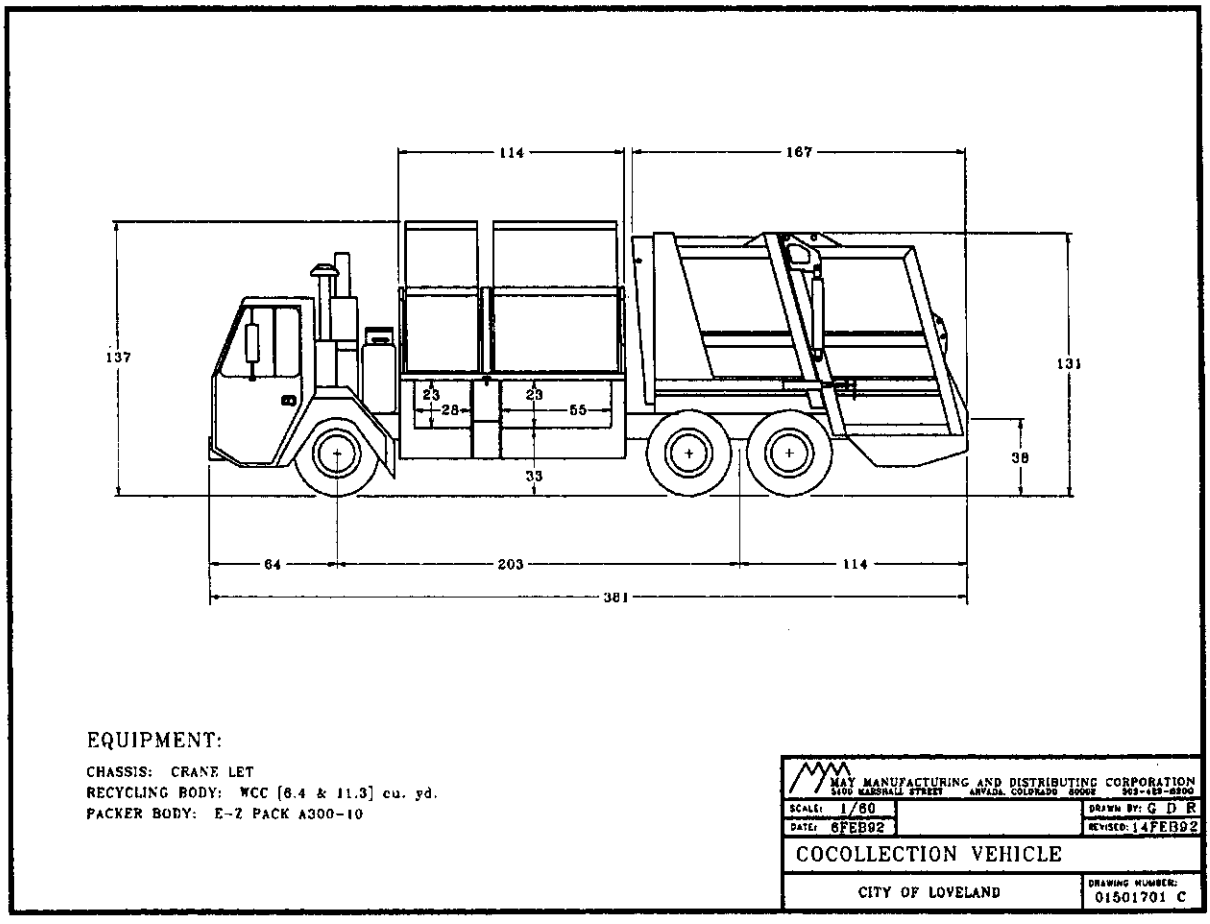
The city also found that the size and weight of the co-collection truck increased wear on the vehicle and maintenance costs. Jim McMahon at May Manufacturing thinks this may have a lot to do with the fact that the city did not cut down the size of its packer body. The May units are designed to be added to existing vehicles whose packer bodies are reduced in size.

The city has evaluated four options for a citywide recycling program: co-collection vehicles with the May unit, co-collection with two-person compartmentalized rear loaders, separate collection vehicles, and separate collection vehicles with the one co-collection vehicle used in the pilot program. As a result of this evaluation and its pilot program, the city of Loveland has decided to implement a citywide co-collection program (with two-person crews) as soon as the new intermediate processing center is operational, which is expected by early 1993. In its full-scale co-collection program, the city will use five custom-designed trucks. These trucks will have a low-entry, dual drive Crane Carrier Chassis with a 10-cubic-yard E-Z Pack rear loader and a divided 18-cubic-yard recycling compartment

located between the cab and packer. The recycling compartment is an automated side-loading system, built by May Manufacturing of Arvada, Colorado.

The city's estimated cost for co-collecting and disposal of refuse and recyclables is $79 per ton with two-person crews per vehicle. The cost for separate collection of recyclables is estimated to be $104 per ton. If the co-collection program proves successful, the city estimates it will save $300,000 over the next 5 years as compared to a separate collection program.

To give residents the flexibility of using their own bags, minimize the number of overweight set-outs, and at the same time save $65,000 per year in the cost of supplying the bags, Loveland is considering substituting a tag-only program for the current bag-based program. An opinion poll, to which 600 pilot program participants responded, showed that 83 percent support curbside recycling, 79 percent support volume-based rates, 85 percent say they always recycle (compared to 26 percent prior to the program), the weekly trash set out rates are down 40 percent (the actual figure is 62 percent), 68 percent find the curbside recycling convenient, and there is an 8 percent average reduction in total monthly disposal costs per each household, even though an additional service was added. The monthly household curbside recycling participation rate is now over 90 percent, and 54 percent of the waste stream is reportedly being recycled and composted. Trash set-outs in the pilot neighborhoods have been reduced by nearly 62 percent. Prior to the new plan, households set out an average of 45.7 pounds of trash per week. Under the new program, the average weekly trash set-out has been about one trash bag, which weighs an average of 17.5 pounds.



Design Loveland Plans to Use for Its Co-collection Vehicles

Shaker Heights, Ohio

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The city of Shaker Heights began a co-collection pilot program in February 1990 and gradually expanded the program to include the entire city by August 1991. The city chose the bin method of co-collection because it was easier to integrate it into the existing refuse collection system. Shaker Heights has a labor-intensive collection service in which refuse and recyclables are collected from residents' backyards rather than at the curbside. Collection personnel use motorized scooters to collect the materials.

The Shaker Heights Service Department serves 8,264 single- and two-family households with weekly curbside collection. Newspaper, glass, plastic, and aluminum and ferrous cans are collected. Residents set out the recyclables in two 7-gallon containers and in plastic or paper bags. They place glass in one container, aluminum and ferrous cans in another, newspaper in a paper bag, and plastic in a plastic bag. In addition to the co-collection program, Shaker Heights has a separate collection program for white goods and yard waste.

The city of Shaker Heights Service Center operates the co-collection program. It employs approximately 20 full-time employees. Of the six vehicles and twelve scooters that the city retrofitted, four vehicles and eight scooters are used in the co-collection program. Each of the four vehicles used in the co-collection program has three collection personnel: one vehicle driver and two scooter drivers. Each vehicle has two scooters that pick up the refuse and recyclables from residents' backyards. Refuse is stored in the back of the scooter and the recyclables are stored in four 18-gallon pails on the side. When the scooters are full (after four to six houses), they unload into the collection vehicle. Shaker Heights rebuilt its vehicles with two-bin single-side-loading, multi-compartment Western Curbside Collector bins (manufactured by May Manufacturing) and 16-cubic-yard packer bodies. There are five separate compartments in the bins and a 1-cubic-yard plastics compactor on the back of the cab. A local company, Plastic Pack, manufactures the plastics compactor. Glass is color sorted at the curb and is manually loaded into three separate compartments under the cans and newspaper. One compartment is used for newspaper and the fifth compartment is used for cans. A hydraulic lift dumps newspaper and cans into their respective compartments. Plastic is compacted in the plastics compactor. The city retrofitted six vehicles with the bins for a total cost of $320,000 (includes the cost of the bins, new packers for the collection vehicles, and an additional axle for each truck; a breakdown for each is not available). The cost to retrofit the 12 scooters was estimated at $5,000. When the trucks were retrofitted, the packer area was cut down from 20 cubic yards to 16 cubic yards. In 1990 Shaker Heights received a state grant for $125,000 to help cover the retrofit costs.

Although the city has tracked 1991 tonnages for each collection route, it is difficult to estimate recycling rates for recyclables because the routes came on-line at different times. From July 8 to September 27, 1991, the Service Department collected 2,743 tons of solid waste from the four routes. Of the 2,743 tons, 195 tons were recyclables (or 7 percent of the total waste collected). Set-out rates vary from week to week, but the average set-out rate was 56 percent for the four collection routes. Mark Frisone, the Assistant Service Director, estimates that very little material is lost due to contamination. Actual reject rates are not available.

In 1991, a total of 1,311 tons of recyclables were collected from the curbside and drop-off programs and 14,101 tons of refuse were collected. The average set-out rate for the year was 60 percent.

Recyclables are taken to the Shaker Heights Service Center. Before the co-collection program began, the area served as a transfer station for refuse and a drop-off center for recyclables. The drop-off area is still open on Saturday. Residents in multi-family complexes do not have curbside collection

and are encouraged to take their recyclables to the Service Center. Recyclables from the co-collection program are sorted into individual bays and sold directly to purchasers. Materials in the collection vehicles are dumped directly from the collection bins into the bays. The city only employs one full-time worker for the service area but at times uses additional seasonal labor. The one full-time worker transfers all recyclable materials to the lower level storage area. The materials are not baled or crushed before they are sold to a purchaser. Purchasers include Louisiana Pacific Corp. for newspaper, Alcoa Recycling Corp. for aluminum, and BFI for glass and plastic.

In 1991 the total cost of recycling and refuse collection, processing, and disposal was $1,905,175 or $124 per ton (excluding costs for additions and improvements such as the vehicle retrofits). See Appendix F. Processing costs in 1991 were $58,147, $69 per ton. Shaker Heights received $24,000 in revenues from the sale of recyclables. The city plans to expand the Service Center and begin processing the material with a grant for $77,000 from the State of Ohio. The city wants to purchase a baler, a glass crusher, and a front-end loader and plans to hire additional personnel. With the new processing equipment, the city will be able to store more materials on site and increase the material marketability.

Refuse is landfilled at the Bedford Landfill after being transferred to transfer trailers at the transfer station. The 1991 contract cost to haul and dispose of refuse was $39.96 per ton. This increased to $46 per ton in 1992 and will increase to $52 per ton in 1993.

Mark Frisone points out that co-collection with the Western Curbside Collector is the most feasible option for Shaker Heights. Shaker Heights is a wealthy suburb of Cleveland and residents expect and receive specialized services. The Service Department has an annual budget of $6 million of which $2 million is for the operating and maintenance costs of refuse collection and disposal. Shaker Heights is pleased with the May unit. Mark Frisone is not concerned with volume capacity issues even though the system is not completely efficient because the refuse packer fills up before the bins of recyclables.

Sunnyvale, California

Contacts

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Project Manager
SCS Engineers
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Long Beach, California 90807
Phone (213) 426-9544

Sunnyvale has had a dedicated curbside recycling program since 1982. The city uses nine two-person rear-loading collection vehicles for refuse collection and five recycling trucks for recyclables collection. The recycling trucks are redesigned Gruman trucks with Midway trailers. However, according to Richard Gurney, the Recycling Coordinator for the city of Sunnyvale, the trucks need to be replaced to increase the program's efficiency. Specialty Solid Waste and Recycling, Inc. received the 20-year franchise for refuse and recyclables collection. Specialty proposed a co-collection project, which ran from July 1991 to September 1991. The pilot was carried out by Specialty and monitored by SCS Engineers. While Specialty ran the co-collection program, the city tested a one-person front-loader and compared it to its existing two-person rear-loader vehicles. The contract with Specialty includes the purchase of new refuse and recycling vehicles in 1992.

Approximately 2,250 one- to three-unit households were included in the pilot. Newspaper, corrugated cardboard, waste oil, glass, plastic, and aluminum and tin cans were collected weekly. Residents received two 14-gallon containers for the recyclables. The cost of the bins was included in the collection fee. They set out glass in one container; plastic and aluminum and tin cans in the second; and bundled newspaper and containerized oil next to the containers. The weekly set-out rate during the program ranged from 30 to 33 percent. For the pilot program, Specialty retrofitted an 18-cubic-yard Dempster vehicle with a two-bin dual-side-loading May Manufacturing Western Curbside Collector. It

reduced the size of packer body but did not extend the truck frame. The collection crew consisted of two laborers; there were five collection routes. Specialty divided each bin in the May unit into two compartments because Sunnyvale requires glass to be sorted at the curb. A false bottom was placed in each bin to divide it into two compartments. Clear glass was stored in the bottom compartment of one bin, and newspaper was stored in the top compartment. Color glass was placed in the bottom compartment of the second bin and plastic and aluminum and tin cans were placed in the top compartment. Residents set out refuse in 64-, 96-, or 104-gallon containers.

Recyclables are taken to the Sunnyvale Recycling Center, located next to the landfill. There the recyclables are separated, stored in roll-off containers, and picked up by the purchaser. The city of Sunnyvale operates the recycling center and does not charge a tip fee for the recyclables. Recyclables collected in the May unit system were dumped separately by material. For instance, after the compartment of newspaper was dumped, the pins that kept the false floor in place were removed so the glass would fall out. Newspaper and plastic go to Smurfit in San Jose, aluminum to Reynolds Aluminum in Fremont, and glass to CIRCO in Fremont. Richard Gurney reports that all of the materials are marketed and there is no residue from the collection or sorting process. In fact, in July 1991 before the pilot co-collection program began, due to the lack of markets for mixed glass, Sunnyvale required the separation of glass by color at the curb. The landfill is owned by the city, but Oakland Scavengers, a subsidiary of Waste Management, Inc., has the operation contract. Refuse is landfilled for $30 per ton.

The final report and analysis of the co-collection project is not publicly available. However, Richard Gurney, the Recycling Coordinator for the city of Sunnyvale, explained that the preliminary results of the pilot are not favorable. Despite the addition of false floors to the bins in the May unit, volume capacity problems arose during the program. Sometimes the packer area filled up before the recyclables area, and at other times, the compartment for newspaper filled up before the packer or the other compartments. Sunnyvale requires a significant amount of source separation. Richard Gurney concedes that if Sunnyvale did not require such a high degree of material segregation, and one bin was used for newspaper, while the other was used for commingled materials, the system may have been more successful. Moreover, the pilot program was hampered by the collection vehicle. There were frequent breakdowns on route because Specialty retrofitted the oldest vehicle in its fleet. According to Jim McMahon of May Manufacturing, the pilot program in Sunnyvale was well conceived but poorly executed. Mr. McMahon believes that the units being compared were not given equal parameters and that the results were likely predetermined from the outset.

According to Richard Gurney, a preliminary cost analysis indicates that co-collection costs would be 20 percent greater than refuse and recyclables collection costs for separate collection programs. The city analyzed three refuse and recyclables collection systems for annual labor and equipment costs. The analysis excluded management, overhead, and disposal costs, and materials revenues. The estimated cost of the co-collection program was $3.1 million annually. The estimated annual cost for the one-person front loader and separate recyclables collection vehicles was $2.6 million and the estimated annual cost for two-person rear loaders and separate collection vehicles was $2.7 million. The labor costs are based on the crew size for each vehicle and the number of daily collection routes for refuse and recycling. Although the co-collection program would have 18 total routes per day, it requires two crew members per vehicle for a total of 36 personnel. The one-person front loader and separate recycling collection system would have 17 daily refuse routes and 6 daily recyclables collection routes for a total of 23 collection personnel. The two-person rear loader and separate recycling collection system would require 12 daily refuse routes and 6 daily recyclables collection routes for a total of 30 collection personnel. For collection efficiency and reduced labor costs, SCS Engineers recommended that Sunnyvale choose the one-person front loader and separate recycling vehicles.

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Appendix A
Bag and Vehicle Equipment Vendors

Bags

First Brands Corp.
Glad Bag-Based System
83 Wooster Heights Rd.
P.O. Box 1911
Danbury, CT 06813
Brent Haney
Manager, Solid-Waste Issues Management
(203) 731-2300

The Bag Connection, Inc.
Bagit System
P.O. Box 817
Newberg, OR 97132
Bob Bunn
(800) 628-3630

Mobil Chemical Corp.
Technical System
Macedon, NY 14502
Tom Higgins
(315) 986-5302

Pitt Plastics
P.O. Box 356
Pittsburgh, KA 66762
Wayne Russell
Plant Foreman
(316) 231-4030

Vehicles

Pak-Mor Manufacturing Co.
1123 S.E. Military Dr.
P.O. Box 14147
San Antonio, TX 78214
Carter Thurmond
(512) 923-4317

G&H Manufacturing, Inc.
1015 Commercial Blvd., South
Arlington, TX 76017
(817) 467-9883
(800) 533-8458
or
1843 Tucker Street
Rock Hill, SC 29730
(800) 654-5291

Haul-All Equipment Systems
4115 18th Avenue North
Lethbridge, Alberta
Canada T1H 5G1
(403) 328-7719

May Manufacturing and Distributing Corp.
5400 Marshall
Arvada, Colorado 80002
Jim McMahon
Marketing Director
(303) 423-6200

Waste Stream Management, Inc.
145 Outer Maple Street
Box 5195
Potsdam, NY 13676
(315) 265-3860

Oshkosh Truck Corporation
P.O. Box 2566
Oshkosh, WI 54903-2566
(414) 265-3860

Appendix B
May Manufacturing Cost Sheets and Truck Design

Source: Jim McMahon, Marketing Director, May Manufacturing and Distributing Corp., Arvada, Colorado, (303) 423-6200.

In addition to the cost of the Western Curbside Collector, the cost to convert an existing trash truck to co-collect refuse and recyclables is estimated by Jim McMahon as follows:

Stretch frame	$1,800
Cut down packer body	1,200
Adjust PTO and pump	300
Reseal ejection cylinder	250
Paint body	600
Subtotal	$4,150

MAY MANUFACTURING
& DISTRIBUTING CORP.
5400 MARSHALL • ARVADA, COLORADO 80002 • 303-423-6200

PRICING FOR WESTERN CURBSIDE COLLECTOR
PRICES EFFECTIVE OCTOBER 1, 1991

SINGLE_BIN_SYSTEM

	BIN_SIZE			
LENGTH(in)	30"	36"	42"	61"
HEIGHT(in)	96	96	88/96	96
VOLUME(yd)	5.5	6.5	6/7.5	11
CHASSIS REQUIREMENTS	46"	52"	58"	77"
SINGLE BIN ONE SIDELOAD LIST	$ 9750	$ 10375	$ 9800/11000	$ 12000
SINGLE BIN ONE SIDELOAD LIST TWO COMPARTMENT	$ 10688	$ 11313	$ 11000/11938	$ 13438
SINGLE BIN ONE SIDELOAD LIST THREE COMPARTMENT	$ 11000	$ 11625	$ 11312/12250	$ 13750
SINGLE BIN ONE SIDELOAD LIST FOUR COMPARTMENT	N/A	N/A	$ 11625/12653	$ 14063
FOR LOADING SCOOP ON BOTH SIDES LIST	$ 1250	$ 1312	$ 1375	$ 1875
MESH TARP LIST	$ 156	$ 166	$ 175	$ 438
MOUNTING LIST	$ 875	$ 940	$ 1000	$ 1250

DUAL BIN SYSTEM

		BIN SIZE		
BIN CONFIG.	LENGTH(in)	30/30	30/42	42/42
	HEIGHT(in)	88/96	96	96
	VOLUME(yd)	9/11	13	15
CHASSIS REQUIREMENTS		80"	92"	104"
DUAL BIN ONE SIDELOAD	DEALER LIST	12375/14250	15500	16750

ADD FOR MULTIPLE COMPARTMENTS - PRICE PER BIN IS

TWO COMPT	LIST	$ 938	$ 938	$ 938
THREE COMPT	LIST	$ 1250	$ 1250	$ 1250
FOUR COMPT	LIST	N/A	42"/1563	$ 1563
FOR LOADING SCOOP ON EACH SIDE	LIST	$ 1875	$ 2188	$ 2500
MESH TARP PER BIN/ADD	LIST	$ 156	$ 175	$ 175
MOUNTING	LIST	$ 1313	$ 1563	$ 1875

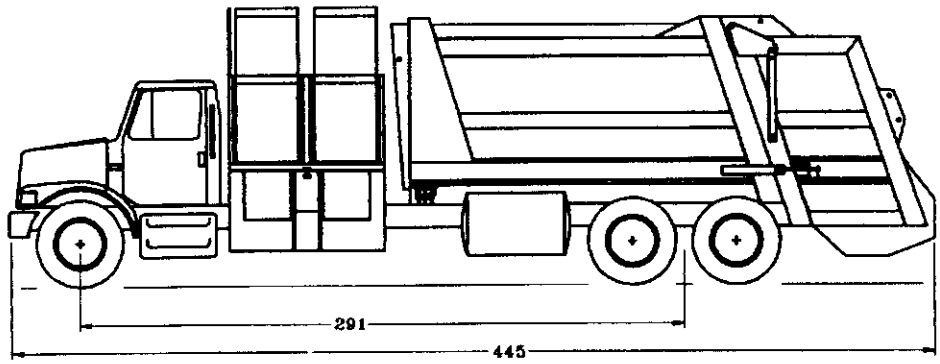
OPTIONS:

Cart tipper attachment available on 42" bin or larger.	$300.00 each
Automotive finish--includes surface preparation, sand blast, finished seams and automotive enamel (requires an additional 3-7 days)	$750.00

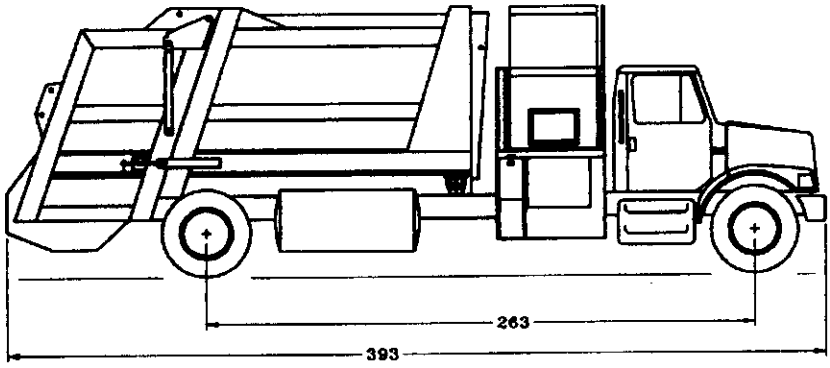
WESTERN CURBSIDE COLLECTOR

Typical Mounting Arrangements

Collect
Recyclables
And Trash
With The Same
Vehicle

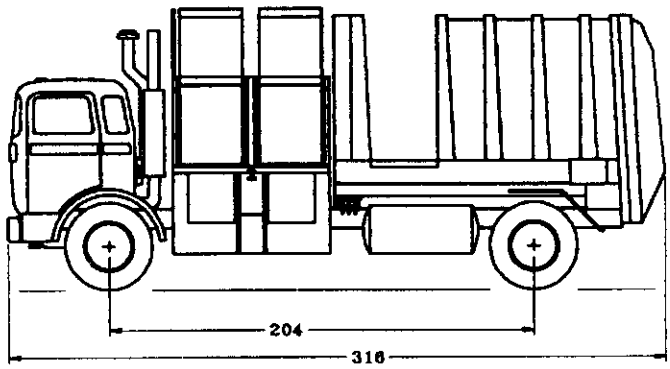


EQUIPMENT:
Chassis: International 4900 6X4
Recycling Body: Standard WCC
Packer Body: E-Z Pack A300-20



EQUIPMENT:
Chassis: International 4900
Recycling Body: Single Divided Bin WCC
Packer Body: E-Z Pack A300-16

EQUIPMENT:
Chassis: Mack MS 300P
Recycling Body: Standard WCC
Packer Body: Peerless PRT 10



Options:

* Dual Side Loading
* Multiple Compartments
* Cart Dumper
* Manual Tarp Covers
* Hand Load System
* Complete Recycling Vehicle

Distributed By:

Patent No. 4,978,271

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& DISTRIBUTING CORP.
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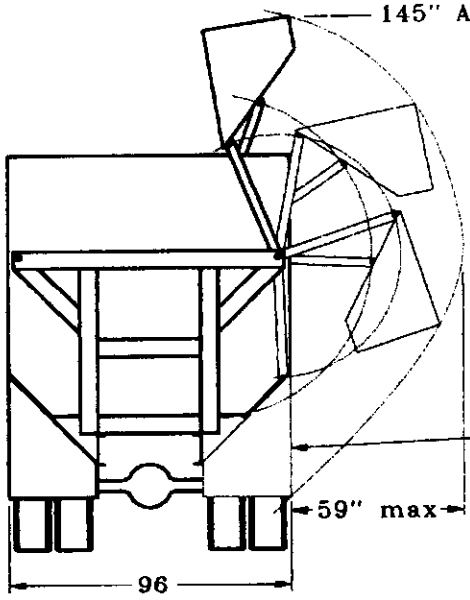
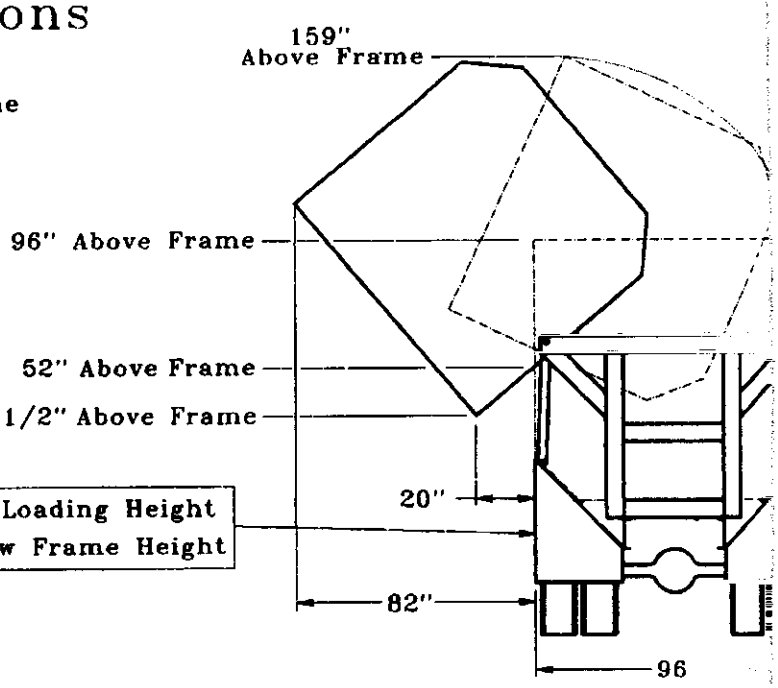
WATS: 1-800-292-7968 FAX: 303-423-6213

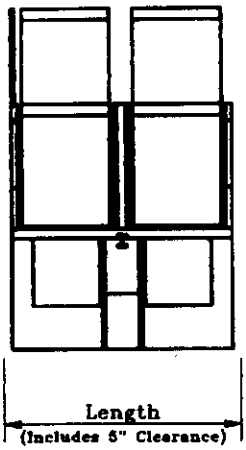
Technical Specifications



Power Loading From Both Sides

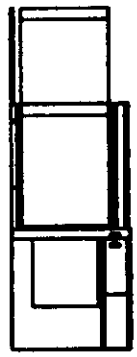


Side Unloading Into 30yd Roll



Double Bin Systems:

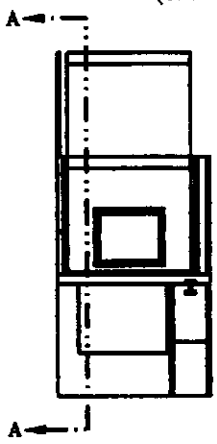
Capacity (cu. yds.)	Length (inches)	Weight (Pounds)
10.6	80"	5000
11.7	86"	5108
12.8	92"	5216
13.9	98"	5324
15.0	104"	5433
16.1	110"	5591
17.2	116"	5749
18.3	122"	5907
19.4	128"	6066
20.5	134"	6224
21.6	140"	6382

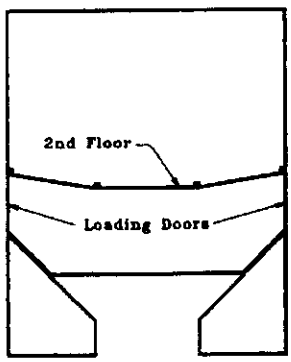


Single Bin Systems

Capacity (cu. yds.)	Length (inches)	Weig (Pou
5.3	45"	28
6.4	51"	25
7.5	57"	30
8.6	69"	36
9.7	75"	43
10.8	81"	50

Multiple Compartments
(Many Varieties Available)





DETAIL A-A

SPECIFICATIONS

1. Scoops: Fabricated from 3/16 and 12ga A569 Steel with 2 - .4 cubic yard and 1 - .2 cubic yard compartments per side.
2. Bins: Fabricated from 1/4 and 14ga A569 Steel with structural reinforcements. Volume per bin (Standard): 5.3 cubic yards. Weight capacity (Standard): 4500 pounds per bin. Larger sizes available, see above.
3. Bearings: All bronze bushed with grease fittings. Pins: 1026 Steel.
4. Hydraulics: Scoop cylinder; 2 - 3.5" x 16"; Bin cylinder; 2 - 5" x 16"; 1 single spool valve and 1 three spool valve with pressure relief; and 1 gear type flow divider; all hoses and fittings included.

Appendix C
Fiscal Analysis of Chicago's Co-collection Program

Source: City of Chicago Department of Street and Sanitation, *Blue Bag/MRRF Recycling Demonstration Project, Final Report*, September 1991.

BLUE BAG/MRRF - COALITION COLLECTION SYSTEMS COMPARISON

SYSTEMWIDE DATA	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	DECADE TOTAL/AVG
Tonnage Collected	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	11,000,000
Base Disposal Fee/Ton	$38.33	$40.24	$42.25	$44.37	$55.46	$61.00	$67.10	$73.81	$81.20	$89.31	
BLUE BAG/MRRF	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**DECADE TOTAL/AVG**
Capital Burden	$4,320,000	$4,320,000	$4,320,000	$4,320,000	$4,320,000	$4,320,000	$4,320,000	$432,000	$432,000	$432,000	$31,536,000
O & M Fees	11,000,000	11,550,000	12,127,500	12,127,500	12,127,500	12,127,500	12,127,500	12,127,500	12,127,500	12,127,500	119,570,000
Less O & M Fees for Transfer	(550,000)	(577,500)	(606,375)	(606,375)	(606,375)	(606,375)	(606,375)	(606,375)	(606,375)	(606,375)	(5,978,500)
Public Education	1,300,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	10,300,000
Total System Costs	$16,070,000	$16,292,500	$16,841,125	$16,841,125	$16,841,125	$16,841,125	$16,841,125	$12,953,125	$12,953,125	$12,953,125	$155,427,500
Less Diversion Value	$4,215,750	$6,639,806	$9,295,729	$12,200,644	$16,470,869	$19,460,027	$22,882,308	$25,982,491	$29,473,889	$33,403,741	$180,025,254
Net System Cost	$11,854,250	$9,652,694	$7,545,396	$4,640,481	$370,256	($2,618,902)	($6,041,183)	($13,029,366)	($16,520,764)	($20,450,616)	($24,597,754)
Monthly Cost Per Household	$1.52	$1.24	$0.97	$0.59	$0.05	($0.34)	($0.77)	($1.67)	($2.11)	($2.62)	($0.31)
Solid Waste Diversion	10.00%	15.00%	20.00%	25.00%	27.00%	29.00%	31.00%	32.00%	33.00%	34.00%	25.60%
Tons Diverted	110,000	165,000	220,000	275,000	297,000	319,000	341,000	352,000	363,000	374,000	2,816,000
Diversion Value	$4,215,750	$6,639,806	$9,295,729	$12,200,644	$16,470,869	$19,460,027	$22,882,308	$25,982,491	$29,473,889	$33,403,741	$180,025,254
CRC BLUE BIN RECYCLING MODEL	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**DECADE TOTAL/AVG**
Capital Costs	$1,171,800	$1,367,100	$1,562,400	$585,900	$585,900	$585,900	$585,900	$585,900	$585,900	$585,900	$8,202,600
Recycling Service Fee	10,000,000	20,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	270,000,000
Yard Waste Service Fee	11,900,000	11,900,000	11,900,000	11,900,000	11,900,000	11,900,000	11,900,000	11,900,000	11,900,000	11,900,000	119,000,000
Market Development	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,500,000
Public Education	1,300,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	10,300,000
Total System Costs	$24,621,800	$34,517,100	$44,712,400	$43,735,900	$43,735,900	$43,735,900	$43,735,900	$43,735,900	$43,735,900	$43,735,900	$410,002,600
Less Diversion Value	$2,951,025	$5,311,845	$7,436,583	$9,760,515	$15,250,805	$16,775,885	$18,453,474	$20,298,821	$22,328,704	$24,561,574	$143,129,232
Less Collection Savings	$112,461	$192,309	$255,771	$318,914	$416,444	$437,266	$459,129	$482,086	$506,190	$531,500	$3,712,070
Net System Cost	$21,558,314	$29,012,946	$37,020,046	$33,656,471	$28,068,651	$26,522,748	$24,823,296	$22,954,993	$20,901,006	$18,642,826	$263,161,298
Monthly Cost Per Household	$8.28	$5.57	$4.74	$4.31	$3.59	$3.40	$3.18	$2.94	$2.68	$2.39	$3.74
Recycling Diversion	3.00%	5.00%	7.00%	9.00%	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%	20.50%
Yard Waste Diversion	4.00%	7.00%	9.00%	11.00%	14.00%	14.00%	14.00%	14.00%	14.00%	14.00%	
Tons Diverted	77,000	132,000	176,000	220,000	275,000	275,000	275,000	275,000	275,000	275,000	2,255,000
Diversion Value	$2,951,025	$5,311,845	$7,436,583	$9,760,515	$15,250,805	$16,775,885	$18,453,474	$20,298,821	$22,328,704	$24,561,574	$143,129,232

COST COMPARISON	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	DECADE TOTAL/AVG
CURBSIDE NET COSTS	$21,558,314	$29,012,946	$37,020,046	$33,656,471	$28,068,651	$26,522,748	$24,823,296	$22,954,993	$20,901,006	$18,642,826	$263,161,298
BLUE BAG/MRRF NET COSTS	$11,854,250	$9,652,694	$7,545,396	$4,640,481	$370,256	($2,618,902)	($6,041,183)	($13,029,366)	($16,520,764)	($20,450,616)	($24,597,754)
BLUE BAG/MRRF SAVINGS	$9,704,064	$19,360,252	$29,474,650	$29,015,990	$27,698,395	$29,141,650	$30,864,479	$35,984,359	$37,421,770	$39,093,442	$287,759,052

Appendix D
South St. Louis County 1991 Costs

Source: "Budget and Financial Report South St. Louis County Solid-Waste Commissions: Recycling Operations, September 1991," County Solid Waste Commission, Culver, Minnesota.

South St. Louis County 1991 Budget and Report for Recycling Operations

Expense	Budget	Expenses (Jan. - Sept. 1991)
Employee Wages	$16,200	$17,521
Payroll Taxes	2,500	1,333.52
Insurance	4,800	0.00
Office Supplies	0	153.37
Postage	600	0.00
Telephone	720	907.47
Printing/Education	600	1,958.59
Rent and Rental (Building & Forklift)	3,900	4,448.73
Utilities	3,840	2,282.73
Repair & Maintenance (Building & Equipment)	600	5,517.44
Cash for Trash (payment)	23,000	12,252.47
Blue Bags & Delivery	28,600	25,816.67
Material Transport to Center & Market	9,600	9,917.00
Contract Services (rental space & labor)	5,400	3,407.45
Miscellaneous	260	101.60
Total Expense	**$100,620**	**$85,618**

Appendix E
Carroll County, Iowa, Capital Costs for Processing

Source: Carroll County Solid Waste Management Commission and Carroll Enterprise Systems, *Iowa Department of Natural Resources Solid Waste Landfill Abatement Grant Recycling Operation, Final Report*, Carroll, Iowa, August 1991.

BUILDING AND EQUIPMENT

Commission officials examined several local buildings but determined none of them were suitable for use as a MRF so planning was initiated for the construction of a building on Commission-owned land near the landfill.

The original building constructed was 60 by 140 feet, with a 20 by 120 foot lean-to on the south edge for storage. As the program evolved, the overhanging lean-to area was enclosed, a new 60 by 70 foot storage room was attached to the west and a 20 by 26 foot tipping floor expansion with a 30 foot roof was built on the east. (Attachment 4).

Total construction costs for the MRF facilities were $383,765 (Attachment 5). Construction was begun in June 1990 and finished in November 1990.

Equipment installation began in September 1990 and was completed by December 1990.

RECYCLING EQUIPMENT

EQUIPMENT	MANUFACTURER	COST
Commingled sorting line with floor hopper and feeder conveyor, three glass crushers	Recycling Equipment Manufacturing; Spokane WA	$ 68,436
Horizontal baler with floor hopper, feeder conveyor, fluffer and automatic tie	Recovery Systems; Hopkins, MN	$125,234
Plastics granulator	Rome Inc.; Sheldon, IA	$ 7,850
Animal Bedding Line - Valby shredder and John Deere baler	Elliott Equipment; Davenport, IA	$27,280
Feeder conveyor for Valby lin	Recovery Systems.	$ 3,200
Sorting containers	Gregory Manufacturing North Texas Casters Storage Concepts	$13,411
Home storage containers	Rehrig Pacific Company; Gurnee, IL	$29,079
70' truck scale (50% recycling use; split with landfill)	Smith Scale Co.	$16,628.50 (actual total cost was $33,257)
TOTAL		$291,118.50

Appendix F
Shaker Heights, Ohio,
Cost Summary for Solid Waste Disposal and Recycling

Source: Randall E. DeVaul, Department of Public Service, *Shaker Heights Integrated Recycling Plan,* Shaker Heights, Ohio, April 1992.

EXHIBIT II

CITY OF SHAKER HEIGHTS

COST SUMMARY FOR SOLID WASTE DISPOSAL AND RECYCLING

	********** RUBBISH **********			********** RECYCLING **********			GRASSCYCLING	
	1990	1991	1992*	1990	1991	1992*	1991	1992*
PERSONAL SERVICES								
SALARIES & WAGES	$618,000	$633,500	$665,175	$46,439	$61,200	$48,700	$31,000	$53,000
PERSONAL BENEFITS	$160,680	$221,725	$246,115	$14,773	$83,000	$18,200	$11,160	$19,080
TOTAL PERSONAL SERVICES	$778,680	$855,225	$911,290	$61,212	$144,200	$66,900	$42,160	$72,080
CONTRACTUAL SERVICES								
RENTS & LEASES	$84,443	$92,560	$97,188	$2,823	$145	$0	$0	$0
SPECIAL SERVICES	$632,650	$564,040	$668,885	$7,780	$9,200	$10,000	$12,000	$24,300
VEHICULAR MAINT.	$97,326	$106,640	$111,972	$1,123	$125	$300	$5,000	$6,000
TOTAL CONTRACTURAL SERVICES	$814,420	$763,240	$878,045	$11,726	$9,470	$10,300	$17,000	$30,300
MATERIALS & SUPPLIES	$82,261	$103,440	$108,612	$11,007	$29,600	$19,500	$18,000	$19,800
ADDITIONS & IMPROVEMENTS	$92,356	$44,500	$45,000	$13,700	$322,000	$134,500	$0	$0
TOTAL EXPENDITURES	$1,767,716	$1,766,405	$1,942,947	$97,645	$505,270	$231,200	$77,160	$122,180
REVENUES	$6,111	$65,700	$70,000	$8,129	$24,000	$25,000	$47,000	$60,000
GRANTS					$125,000	$77,500		
NET AMOUNT	$1,761,605	$1,700,705	$1,872,947	$89,516	$356,270	$128,700	$30,160	$62,180
TOTAL HOUSEHOLDS	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500
COST/HOUSEHOLD/MONTH	$15.45	$14.92	$16.43	$0.79	$3.13	$1.13	$0.26	$0.55
SOLID WASTE/RECYCLABLES (TONS)	17,726	14,101	14,500	1,025	1,311	1,500	2,300	2,500
SOLID WASTE DISPOSAL COST ($/TON)	$35.69	$39.96	$46.13	$35.69	$39.96	$46.13	$39.96	$46.13
COST AVOIDANCE				$36,582	$52,388	$69,195	$91,908	$115,325