FINAL REPORT
1999
Residential Recycling Pilot Projects

Prepared for

Washington County, City of Portland, Clackamas County, Metro

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Executive Summary

Project Overview and Purpose

In November 1998, The City of Portland, Washington County, Clackamas County and Metro contracted with Environmental Practices to study various methods of commingling residential recyclables. The consultant examined the effect of different commingled sorting requirements for residential recycling collection on the quality and quantity of recyclables marketed. The study also looked at the contribution of different collection and processing systems on the quality and quantity of recovered materials. The overall purpose of the project was to observe, document, and clarify the effects of distinct collection and processing methods on the amount and quality of marketable materials.

This study is not a thorough scientific view of the affects of commingling. It monitors one occurrence of each of the chosen scenarios, giving a simplified snapshot of the stream of materials. Therefore, it is not intended that one set of data and observations from a given pilot project be directly compared to those from another for purposes of determining the best approach to commingled residential recycling. There are many circumstances unique to each pilot effort that would make unqualified comparisons inadvisable given the short timeframe of the study. A glossary of terms is included at the end of this report to clarify some terminology used in this text.

The primary focus of this study was glass and old newspapers. By weight, newspapers make up the largest portion of the residential recyclable stream. Negative effects caused by commingling of this material would have a large impact on program recovery rates. The concern with glass in a commingled material mixture is two-fold. First, how does commingling impact the marketability of glass? Second, does collecting glass commingled with other materials contaminate those materials?

Four unique collection systems were chosen for the project involving four different haulers and three processing locations. One day's collection from each of the targeted commingled pilot projects was monitored from collection through processing. The tested collection methods were defined in the following manner as contained in the collection truck:

- **2-Sort:** All fiber combined/All containers combined (implemented in Portland)
- **3-Sort:** Newspaper/Remaining fiber combined/ All containers combined (implemented in Portland)
- **2-Sort:** All fiber and other containers combined/All glass combined (implemented in Washington County)
- **5-Sort:** Newspaper/Remaining fiber combined/ All metal and plastic combined/All clear glass/All colored glass combined (implemented in Clackamas County)

An additional test of off-loaded mixed containers was designed to quantify the effect of increased handling on glass breakage. Multiple residential routes of mixed containers were collected. Each load was off-loaded into a drop box located either on route or at the hauler's yard. This drop box was then transferred to the processor where its handling was monitored by the consultant. In addition, a baseline test for this processing facility was included, monitoring a single collected residential route that was unloaded from the collection truck directly at the processor. The sorting of both of these collections of materials (mixed containers) was monitored and results were measured, with primary attention paid to glass breakage. The tested collection methods were defined in the following manner:

- **Off-loaded drop box:** All containers. Drop box of off-loaded mixed containers from multiple residential loads (implemented in Portland)
- **Single Route:** All containers. Collected as a two-sort on a trough loading truck and processed at same facility that handled the off-loaded drop box (implemented in Portland)

Research involving field observation of collection route operations, site visits to processing facilities, and interviews with market representatives (local, regional, and West Coast) was conducted for each of the commingled pilot projects. This monitoring was done in order to report on the specific materials handling activities characteristic of the different commingled pilots.

The following summary brings together material from the various sections of this report with a priority focus on newspaper, glass and residue. Detailed findings from each of the pilot studies are included in the full report. The report covers collection and processing methodology, as well as material and residue quantification.

Newspaper

Newspaper represents up to 65% by weight of the collected recyclables in the pilot studies. This material also has a consistent local market. These factors contribute to the priority this material received in this study. These are the highlights of the results of this evaluation.

- Source-separated collected newspaper, which still requires some processing, produces a product with marginally lower contamination levels than products produced from commingled fiber collection.
- The newspaper bales produced from the commingled fiber sorts were remarkably consistent in quality, with newsprint making up 93 percent to 95 percent of the bales.
- One materials recovery facility was able to separate out 99% of the newsprint from a commingled fiber stream, which was equivalent to the separation efficiency achieved by source-separated collection of newsprint in the 5-sort pilot.
- Collecting bagged newspaper does not necessarily yield a high separation efficiency, but it did yield the highest quality (lowest contamination) product.
- Newspaper collected with non-glass containers was able to be processed to meet a deink newsprint market.
- At least one Pacific Northwest newsprint mill is designing its feedstock around commingled residential recycling collection programs. Almost one-third to one-half of the newspaper in two of the pilot studies ended up in the mixed waste paper, which was used by this mill in newsprint production. More than 85% of the fiber in these two pilots went into newsprint production. None of the mixed paper is sent to the traditional markets.
- None of the marketed newspaper grades, from either source-separated or commingled fiber pilots, met the strict deinking grade specification that limits contamination to less than 1.25%. However, it should be noted that the non-newspaper materials found in all the tested bales of newspaper were white ledger and junk mail, which are not considered contaminants by newsprint markets. It did not include any brown paper (cardboard or kraft paper) or any gray paper packaging (boxboard), which would be considered major contaminants by newsprint mills.

The following table, Source and Flow for Newspaper, portrays the movement and status of newspaper for each pilot project through collection, processing, and marketing phases. Listed are the percentages that newspaper represents of total collected fiber.

Source and Flow of Newspaper

Sort	Material Processed	Percent of Total Fiber	Percent Newspaper	Sold As	Location of Market	End Use
2-Sort (All Fiber/All containers)						
Mixed Fiber	Newspaper	30.5%	95%	News De-ink Quality	Pacific NW	News
	Mixed Waste Paper	57.5%	45.3%	Mixed Recycled Waste	Pacific NW Overseas	News
3-Sort						
Old Newspaper	Newspaper	35.4%	98.9%	News De-ink Quality	Pacific NW	News
Mixed Fiber	Newspaper	18.1%	93.3%	News De-ink Quality	Pacific NW	News
	Mixed Waste Paper	35.4%	61.3%	Mixed Recycled Waste	Pacific NW Overseas	News
2-Sort (All glass/All fiber & other containers)						
Mixed Fiber & other Containers	Newspaper	72.6%	94.7%	News De-ink Quality	Pacific NW	News
	Mixed Waste Paper	18.9%	4.3%	Mixed Waste Paper	Overseas	N/A
5-Sort						
Old Newspaper & Magazines	Newspaper	69.5%	94.2%	News De-ink Quality	Pacific NW	News
	Mixed Waste Paper	16.9%	10.7%	Mixed Waste Paper	Overseas	N/A

Glass

This material warranted high priority in this study because of market problems with glass breakage. Extra handling results in a greater breakage, decreasing its ability to be sorted. Glass represented between 7.0% and 9.2% of the total recyclable stream in the four pilot studies. The critical points for glass collection, processing and marketing are listed below.

- A local glass container market exists for glass that is collected color-sorted, either in three colors (flint, amber, green) or in two colors (flint, amber-green mix).
- Demand for color-sorted glass is unaffected by the degree of breakage.
- Collection of glass by itself usually results in greater breakage than when glass is collected with mixed containers.
- Commingling glass with other containers creates, after color-sorting, a fourth material called MRF (materials recovery facility) residue glass that has no current market demand by itself without further processing to remove residue and fines (glass < than 3/8”).
- Intermediate processors in California purchase a 3-color mix glass product (no glass removed by color sorting) processed from a commingled container stream, which can include up to 5% residue.
- Commingled collection of all glass, when kept separate from other containers, creates a clean 3-color mix glass that can be marketed without further processing.
- For a given sort, glass collected via trough loading trucks breaks more glass than compactor collection of the same material mix.

- Offloading mixed containers (loading and unloading multiple times) creates substantially higher glass breakage (38% breakage) than direct unloading from a collection vehicle (18%-29% breakage).
- California markets for a 3-color mix glass include containers (especially wine bottles), fiberglass, abrasives, aggregate and fill.

The following chart, Materials Flow for Glass, portrays the movement and status of glass for each pilot project through collection, processing, and marketing phases. The percentages associated with MRF processed glass were directly measured at the processing facility. However, the percentages associated with the flow of MRF residue glass are derived, not calculated. The formula for derivation has been applied equally to the pilots that market this material mix. The intermediate processors reported that screening the MRF residue glass below 3/8 inch results in approximately 25% residue with a 75% recovery rate for this material. Therefore, the percent that was sorted as MRF residue glass was divided; approximately one-fourth of the material is categorized as residue and three-fourths as usable material. For example, in the 2-sort (all fiber/all containers), the MRF residue glass represents 18.2% of the glass processed. Therefore, 4.6% of the glass, or one-quarter of 18.2%, falls in this residue fines classification of material. In the pilot routes that were monitored for this project, between 18.2% and 38.0% of glass ended up as MRF residue glass.

Materials Flow for Glass

Route	Collection Mix	MRF Processed	Intermediate Processing	Market	Location	Percent of Glass	Percent of Total Recyclables
2-sort	Mixed containers	Color sorted, 81.8%	None	Container	Portland	81.8%	7.5%
		MRF residue glass 18.2%	Color-sorted >2”	Container	Seattle	6.1%	0.6%
			3-color Mix A[1]	Wine bottles	California	7.5%	0.7%
			Residue Fines	Beneficial use/Landfill	Seattle	4.6%	0.4%
3-sort	Mixed containers	Color sorted 72.7%	None	Container	Portland	72.7%	5.1%
		MRF residue glass 27.3%	Color- sorted >2”	Container	Seattle	5.7%	0.4%
			3-color Mix A[1]	Wine bottles	California	14.8%	1.0%
			Residue fines	Beneficial use/Landfill	Seattle, Pacific NW	6.8%	0.5%
2-sort	All glass	Color sorted 21.9%	None	Container, Fiberglass & wine bottles	Portland	21.9%	1.8%
		3-color Mix B[1] 78.1%	3-color Mix A[1]	Fiberglass & wine bottles	California	77.1%	6.4%
			Residue Fines	Landfill	California, Pacific NW	<1%	0.1%
5-sort	Color sorted	None	None	Container	Portland	99.0%	8.2%
			Residue Fines	Landfill	Portland	<1.0%	0.1%
Offloaded drop box	Mixed Containers	Color sorted 62% (3-color Mix B)	3-color Mix A[1]	Containers, Fiberglass	California	90.5%	N/A
		MRF residue glass 38% (3-color Mix B)	Residue Fines	Beneficial use/Landfill	California	9.5%	N/A
Single route	Mixed containers	Color sorted 70.6% (3-color Mix B)	3-color Mix A[1]	Containers & Fiberglass	California	92.7%	N/A
		MRF residue glass 29.4% (3-color Mix B)	Residue fines	Beneficial use/Landfill	California	7.3%	N/A

[1] These mix grades (A and B) are defined in the glossary.

Residue

Greater levels of residue are historically associated with commingled recycling collection programs compared to source-separated programs. Therefore, the quantity and sources for residue were monitored closely. Residue sorted out at the MRF and residue, or contamination, levels sampled in selected recycled products were combined to produce a total residue level.

Residue levels varied for each of the pilot routes, depending on a variety of causes. However, in no case did total residue levels exceed 2.1% of incoming recyclables. This study suggests that a commingled program can be designed to produce no more residue than a source-separated program. However, the residue levels do reflect the following points:

- Sampled residue is 2 to 3 times higher in mixed container collections than in sorts with glass kept separate.
- The total residue is 1 to 1.5 times higher in programs that collect mixed containers.

Factors affecting residue levels were:

- The driver for the 2-sort (All glass/all fiber & non-glass containers) collection route rejected all contaminants at the curb, resulting in a cleaner material stream for this pilot.
- Market specifications for residential mixed waste paper generated from the 2-sort (all fiber, all containers) and the 3-sort pilots did not allow milk cartons and drink boxes, which were sorted out at the MRF and landfilled.
- Improper set-outs on all routes accounted for some residue, which included plastic bags, lids on jars, non-recyclable plastic packaging, and motor oil and antifreeze containers. Better education of residents and training for drivers could minimize this contribution.
- Mixed plastic from the 2-sort (all fiber/all containers) and the 3-sort pilots contained rigid plastic packaging other than bottles, which would be classified as residue at the plastics recovery facility. The percentage of this residue was not quantified in this study, but reported at 8 – 12% by the plastics recovery facility.
- The MRF for the 2-sort (all glass/all fiber & non-glass containers) utilized twice the number of sorters of other plants, which in conjunction with a greater level of mechanical processing advantages (e.g., waterfalls, load levelers), resulted in the lowest level of total residue in the study.

The following chart displays the residue findings from the four different pilot project collection and processing operations. The residue is itemized by amount sorted by processor and amount determined in selected sampled materials, which included newspapers, mixed paper and glass. Each column represents the amount of residue in that material stream (e.g., fiber, containers, newspapers, etc) expressed as a percent of total recyclables. Thus the residue levels in each row are additive.

Quantity of Residue after Processing

Sort	Sorted Residue[2]			Sampled and Derived Residue[3]				of Total
	From Fiber	From Containers	Subtotal Sorted	From ONP	From MWP	From Glass	Subtotal Sampled	
2-Sort (All Fiber/All containers)	0.25%	0.25%	0.5%	0.0%	0.6%	0.4%	1.0%	1.5%
3-Sort	0.6%	0.7%	1.3%	0.0%	0.27%	0.5%	0.8%	2.1%
2-Sort (All glass/All fiber & other containers)	0.03%[4]	N/A[5]	0.03%	0.06%	0.18%	<0.1%	<0.3%	<0.4%
5-Sort	0.16%	0.21%	0.4%	0.0%	0.15%	<0.1%	<0.25%	0.65%

[2] Sorted residue is a direct measurement of residue separated from recycables by workers.

[3] Sampled residue is a calculated residue level based on the percentage of residue in a sample of selected material, such as ONP, MWP or mixed glass containers.

[4] Residue measured from fiber, cans, scrap metal and plastic bottles. Containers include only glass.

[5] Glass only collection, residue was minimal. Observed and not weighed.

Introduction

In November 1998, Environmental Practices began a study monitoring various methods of commingling residential recyclables. The City of Portland, Washington County, Clackamas County and Metro contracted with this consulting firm to provide the information that is in this report. The purpose is to evaluate the effects of distinct collection and processing methods on the amount and quality of marketable materials.

Four unique collection systems were chosen for the project involving four different haulers and three processing locations. One day's collection from each of the targeted commingled pilot projects was monitored from collection through processing. The tested collection methods were defined in the following manner as contained in the collection truck:

- **2-Sort:** All fiber combined/All containers combined (implemented in Portland)
- **3-Sort:** Newspaper/Remaining fiber combined/ All containers combined (implemented in Portland)
- **2-Sort:** All fiber and other containers combined/All glass combined (implemented in Washington County)
- **5-Sort:** Newspaper/Remaining fiber combined/ All metal and plastic combined/All clear glass/All colored glass combined (implemented in Clackamas County)

An additional test of off-loaded mixed containers was designed to quantify the affect of increased handling on glass breakage. Multiple residential routes of mixed containers were collected. Each load was off-loaded into a drop box located either on route or at the hauler's yard. This drop box was then transferred to the processor where its handling was monitored by the consultant. In addition, a baseline test for this processing facility was included, monitoring a single collected residential route that was unloaded from the collection truck directly at the processor. The sorting of both of these collections of materials (mixed containers) was monitored and results were measured, with primary attention paid to glass breakage. These tested collection methods are defined in the following manner:

- **Off-loaded drop box:** All containers. Drop box of off-loaded mixed containers from multiple residential loads (implemented in Portland)
- **Single Route:** All containers. Collected via trough loader and processed at same facility that handled off-loaded container (implemented in Portland)

The collected materials were weighed and processed using the material recovery facility's normal method of handling. The materials that were of primary interest, newspaper and glass, were sampled and sorted to determine their marketable grades. Residue from each sorting line was weighed or described either by sorting or by observation.

The processors that participated in this study provided market contacts for each material that is retrieved from the residential recycling stream. These market representatives were contacted for their professional assessments of the current status and trends for recycling markets, especially as they relate to changes in the material supply chain. Thorough interviews were conducted in the glass and fiber markets to more accurately determine the specifications and end products for the two targeted materials in this study.

Research Methodology and Factors Affecting Performance

This report on four pilot projects involving the commingling of residential recyclables, and the effects of different kinds of commingled material mixes on collection, processing and marketing, is based on field observations and industry research conducted from November 1998 to January 1999. Data and information in the report should not be interpreted to apply to any time period other than this one.

Collection operations for each pilot project were observed once by the consultant. Processing operations for each pilot project were observed three times by the consultant. The last visit to the processing facilities was made to verify that materials handling and sorting procedures had not significantly changed from those documented during the initial observations.

The study offers data, information, and observations derived from "snapshots" taken of various elements of the commingled pilots. A long-term, statistically precise assessment that entailed multiple field visits for monitoring collection/processing activities was not performed. The consultant was not directed to provide recommendations for the implementation of one or more commingled program designs. Rather, the documented evidence in the report, and the research methods used during the study, were developed to assist in the decision-making process concerning the possible implementation of one or more types of commingled material combinations for residential recycling.

Some specific circumstances related to the commingled pilot projects that should be identified as part of the context in which the study was prepared are the following:

- The pilots were not all started at the same time.
- While the targeted customers for each pilot were sent a brochure notifying them about how to properly prepare recyclables for participation in the respective projects, the effectiveness of this technique is uncertain.
- The processor for the 5-sort collection route is planning to construct and operate a new facility, so current processing methods and results are not necessarily indicative of what this company may do in the future.

Research involving field observation of collection route operations, site visits to processing facilities, and interviews with market representatives (local, regional, and West Coast) was conducted for each of the commingled pilot projects. This monitoring was done in order to report on the specific materials handling activities characteristic of the different commingled pilots. A summary of the research techniques used in compiling data and making observations about the collection, processing, and marketing aspects of each commingled test project is presented below.

Collection Methodology

- Follow truck on route
- Describe route topography, weather conditions, housing density, other physical features that could impact productivity/efficiency
- Describe collection vehicle type and loading/compaction procedures
- Note proper and improper set-outs based on visual inspection and handling actions of collector

- Record total time to complete a recycling pickup or stop
- Record time collector spends transferring materials from bins at curbside to vehicle
- Obtain total number of customers on route from hauler
- Obtain total number of set-outs collected on route from hauler
- Document other non-collection factors affecting collection such as manual/mechanical compaction, mechanical unloading of temporary holding compartments on sides of truck into main body, traveling between different sections of the route
- Discuss route characteristics and truck operation on informal basis with collector

Processing Methodology

- Observe, describe processing sequence for commingled pilot material, including unloading, storage, placement on in-feed mechanism, movement to conveyor belt/sort line
- Document number, placement of sorters
- Document configuration of sort line, including length, width, speed of conveyor belt/sort line
- Determine which materials are pulled off conveyor belt by sorters versus left on (positive and negative sorts)
- In particular, observe/document processing of newspapers and glass
- Determine which material streams will be sorted (all items categorized and weighed) versus sampled (a portion of the items categorized and weighed as representative of the entire stream)
- Set up work area including sorting/sampling table, scale, tally sheets, containers, other tools
- Verify arrangements with facility operator to deliver materials for sorting/sampling
- For each stream to be sorted/sampled, including residue, separate materials by category, weigh, record weight
- Visually inspect, characterize streams not sorted/sampled
- Obtain samples of residue from glass processing only, if possible

Marketing Methodology

- From processors, obtain material specifications that processing operations are intended to meet
- From processors, obtain names and contacts of markets
- Interview processors regarding contractual or other arrangements with markets
- Discuss with processors any previous problems in meeting specs or controlling contamination
- Focusing on newspaper and glass, contact markets to verify feedback from processors about material quality and quantity
- Review specifications with markets, discuss effects of commingling on material quality
- As feasible, document/check variability of market specs for mixed waste paper (MWP), and allowable quantities of newspaper in MWP
- For glass, determine role (if any) of other specialized processors in additional handling of glass prior to market purchase
- Investigate, document, assess status of other in-state and out-of-state container and non-container markets for glass
- For newspaper and glass, within limits imposed by availability and confidentiality of information, track and verify flow of materials from commingled pilot projects to ultimate end users

Factors Affecting Performance of Commingled Pilot Projects

The equipment and methodology used for both collection and processing of the input streams affect the quality of the output materials. The market specifications mandate the type of material mixes required from this process. Therefore, when evaluating the information presented in the pilot projects and summary, one should consider the following list of factors affecting the quality, quantity and efficiency of the commingled pilots.

Collection

In any residential recycling program the overall and daily collection performance results and efficiency are due to the interaction of various factors, rather than being solely caused by one program design or operations variable. Examples of such factors are listed below:

- topography of route
- number of set-outs collected/participation rate
- number of drivers/collectors per vehicle
- configuration of collection vehicle
- commingling mode/instructions
- weather
- quantity of materials set out
- curbside contamination control actions of collector(s)
- housing density
- material loading procedures
- vehicle capacity, in general and by compartment if applicable
- time spent driving between stops
- time spent off-loading materials mid-route

The collection descriptions for the pilots encompass several of these programmatic and circumstantial factors that distinguish one pilot approach from another, and one pilot project observation period from another. Of the items noted above, many can be measured by objective field observations.

Processing

Another set of variables exists when considering materials processing that interact with each other to produce information indicative of processing performance and efficiency. Examples of such factors follow:

- number of sorters per shift
- placement of sorters along sorting line
- length of sorting line
- width of sorting line
- configuration of sorting line
- positive versus negative sorts
- sorting belt speed
- number and type of commingled materials
- material off-loading procedures
- market specifications
- market demand and pricing arrangements
- density of materials on sorting belt
- number of sorts required for a material to meet specs

- material handling procedures between off-loading and placement on conveyor belt/sort line

As with collection, all of the above-listed variables can be monitored or determined through direct observation or research. The way employees, technology, machinery, and other resources at a processing facility are utilized is variable and is changed in response to the business decisions of the companies operating those facilities. For example, the number of sorters can be modified, the number of shifts can be adjusted, the location of sorters along the line can be altered, sorting belt speeds can change, sorting instructions can change to produce different material mixes and grades, and materials can undergo additional sorting to upgrade the resulting material.

The processing discussions also have information about the number of sorters working during the pilot project observation period, the configuration of the sorting line, what materials were positively and negatively sorted, the sorting belt speed, material off-loading procedures, residue quantities, and the time used for processing specific materials expressed in person-hours/ton.

Pilot Descriptions

The pilot project sections address the following key topics:

Collection

- Route description
- Truck description
- Set-out definition
- Collection timing
- Quantities collected
- Observations

Processing

- Plant description
- Quantities processed
- Sort line descriptions
- Materials flow charts

The four fully-monitored pilots are discussed, followed by the processing of the off-loaded drop box and associated single route. A glossary is attached to define any unfamiliar terms and sort line layouts are pictured in the appendix.

2-sort (All fiber/All container)

Collection

Overview of collection route

This route is located in close-in Northeast Portland and is collected on Wednesdays. This neighborhood is an older, established area of homes on standard urban lots that are close together on fairly narrow streets. The roads are straight, but there is lots of on-street parking, requiring careful maneuvering by the driver. The customers were notified of the commingling pilot project in July 1998 and again in November. The observation date of this route was approximately four weeks after the November notification.

Number of customers	614
Average set-out rate	70%
Miles on route	46 (Including travel to MRF)
Hours required for total route	6
Mid-route off-loading?	Yes
Number of staff required for route	1

Materials collected from the first part of the route were taken to the Material Recovery Facility for processing. The remaining portion (almost half of the total) was taken to a different facility, one that is normally used for materials from this route. Approximately 57% of the total collected material was evaluated for this test.

Truck description:

Collection is done by a 30 cubic yard side-loading split body two-compartment truck. Both compartments are independently compacted when needed on route. The compartments are adjustable, 60/40. This truck is right-hand drive and materials were collected on one side of the street at a time.

Set-out and field description:

Proper set-out was defined as:

Bin 1	Bin 2
• Drink boxes • Magazines • Milk cartons • Telephone books • Scrap paper • Junk mail • Newspapers (bagged in paper) • Corrugated cardboard	• Aerosol cans • Aluminum • Milk jugs • Plastic bottles • Scrap metals • Tin cans • Glass jars and bottles

An improper set-out was defined as any situation that required the driver to take action other than what is required for a proper set-out.

Timing for Collection

The following table portrays information gathered from observing the collection process. *Average stopped time*: the amount of time the collection vehicle was actually stopped at one set-out. *Average handling time*: the time starting when the driver picks up the recyclables from the bin to when he returns the empty bin to the curb. This does not include customer notification for improper set-out.

Set-out type	Number of samples	Average stopped time (seconds)	Average handling time (seconds)	Average time between stops (seconds)
Proper	93	21	13	12
Improper	100	28	20	

Approximately 35% of the set-outs had more than 2 bins.

Pilot Route Statistics

The following findings are from the collection of the single monitored route for the test day. These weights and set-outs represent the entire route. Approximately 57% of this total was evaluated at the processing facility.

Materials Total Pounds Collected		Number of Set-outs	Set-out Rate	Pounds Per Set-out
All fiber	10,500			
Mixed containers	2,720			
Total weight	13,220	462	75%	28.6

Observations

The weather on the test day was an asset for speed and efficiency of collection. It was a dry, clear day with temperatures in the mid 30's with little or no wind. Materials were dry.

The driver on this route moved very quickly, but took the needed time to clean up any recyclables that fell out of bin onto the ground. He accepted various types of non-recyclable plastic at curbside and included it with mixed containers on the truck. The collection truck was designed such that the driver could stop with the curbside set-out close to the cab of the truck.

The opening to deposit materials was a large square divided horizontally. The lower opening for mixed containers was shoulder high, the upper opening for mixed fiber was over his head requiring the driver to lift bins and materials up over his head. The truck compartment was divided vertically and both sides were compacted independently. The driver compacted the needed compartment while stopped curbside at a set-out before continuing to the next stop with minimal time interruption. Storage areas for recyclable motor oil were easily accessible from the side.

The materials were dumped from the truck to the concrete floor at the MRF. The emptying of the mixed container compartment caused some glass breakage, but the

presence of plastic bottles offered some cushioning as they fell. Due to the design of the truck there was no cross-contamination during offloading.

Processing

Plant description:

This processing facility has two sort lines. The fiber sort line takes up 22,400 square feet of their 57,850 square feet and the mixed container sort line takes up 5,050 square feet. The scale used for all weighing of trucks, receptacles and drop boxes reads in increments of 20 pounds. Incoming vehicles deposit their materials in areas in the facility that are cordoned off to keep similar streams isolated. When processing begins, these materials are moved via front end loader to the conveyor belt feeding the angled infeed line. The sort lines are elevated with material collection receptacles or drop boxes located below.

Processing Statistics

Approximately 57% of the total collected material was evaluated for this test.

Materials Processed	Material Weight (Lbs.)	Belt Speed (feet/second)	Minutes to Process	Number of Sorters	Person-hours/ton
Fiber	6580	1 foot/second	21	8	0.85
Containers	1020	0.6 feet/second	25	3	2.47

Sort line description – All Fiber: [See Appendix A, Diagram 1]

The input to this sort line was all fiber. The positive sorts were for newspaper, corrugated cardboard and recycled paperboard combined, and contaminants. The negative sort was mixed waste paper, containing scrap paper, phone books, newspaper and magazines. This mixed waste paper included newspaper to upgrade the mixed to a mixed recycled waste sold as a low grade newsprint. Drink boxes and milk cartons were removed and sorted into garbage. The sort line was staffed with 8 sorters all stationed towards the end of the line. Four of the sorters were pulling off newspaper, two were sorting for corrugated cardboard and kraft paper, one was pulling off corrugated cardboard & contaminants, and the last one was pulling contaminants and paperboard. This paperboard was included with the corrugated cardboard.

The horizontal infeed belt is loaded by a front end loader that lifts the material and shakes it onto the belt. This practice loosens and separates the fiber. The infeed belt moves the material to the elevated sort line. All sorters are stationed on platforms above drop boxes, which are used for the collection of the positively sorted recycled materials. Mixed waste paper, the negatively sorted material, falls to the floor to be pushed to the baler for compacting.

Sort line description – Mixed Containers: [See Appendix A, Diagram 2]

The input to this sort line is all containers and scrap metal. Positive sorts are done for plastic milk jugs (HDPE), plastic bottles, green, brown and clear glass, aluminum, scrap metal, tin cans, and contaminants. The negative sort is mixed glass cullet. Three people staffed the line. Receptacles for materials were located directly across the belt line in front of the sorters. The first sorter picked off plastic milk jugs and tossed into the first receptacle and plastic bottles into the second receptacle. When there was a slowdown in plastics, this sorter picked off green glass and tossed into the third receptacle and

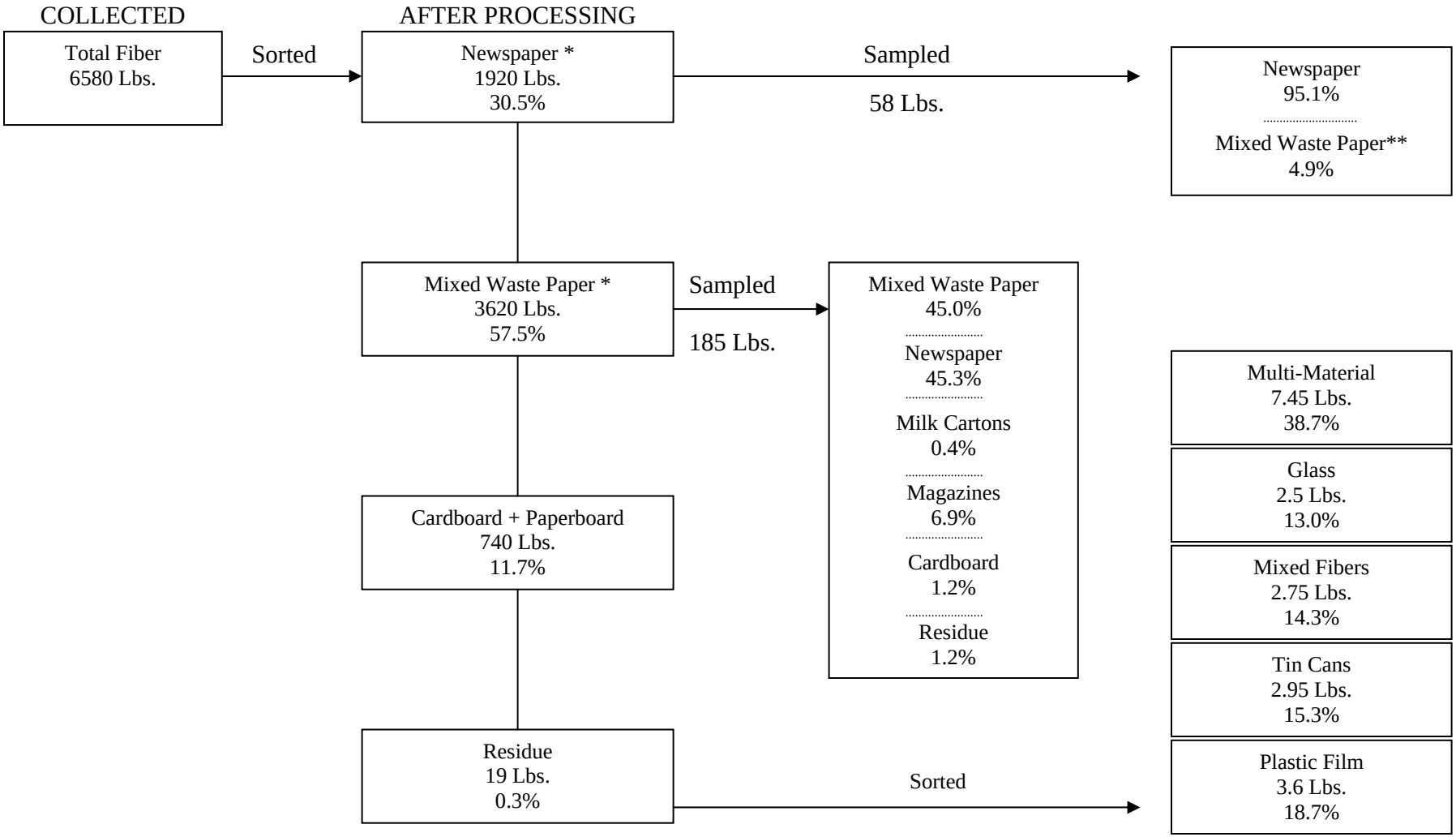
removed contaminants into a roll cart directly behind the sorter. The second sorter picked off green, brown and clear glass into the third, fourth and fifth receptacles. When there was a slowdown in glass, this sorter picked off plastic bottles and contaminants. The third sorter picked off aluminum into the sixth receptacle and scrap metal, which was placed directly beside the sorter. When there was a slowdown in aluminum and scrap metal, this sorter removed clear and brown glass and contaminants. Ferrous metal is removed via a magnetic separator at the end of the line. The residue and MRF residue glass fall off the end of the line approximately 10 feet into a metal dumpster. Some non-recyclable plastics collected curbside were included in plastic bottles.

Normally, the horizontal infeed belt for the mixed container sort line is loaded by a front end loader that pushes the material onto the belt. For the test load, the materials were initially loaded via a front end loader and the remaining material was manually pushed onto the belt with a broom. The infeed belt moves the material to the elevated sort line. All sorters are stationed on a platform across the belt from the drop boxes, which are used for the collection of the positively sorted recycled materials.

The following charts are breakdowns of the tested portions of this load. On each of the two charts, the title “collected” on the left represents the material and associated tonnage as it comes off the truck. The material mix is then processed by the number of sorters listed above for each sorting line. The “after processing” boxes represents the resulting materials and the tonnage of each. All the materials in this column that are noted with an asterisk were sampled or completely sorted by the consultant to further determine the material characterization. The remaining columns of boxes represent these sampled and sorted materials.

NOTE: The scale used for the larger portions registers in increments of 20 pounds. The scale used for smaller amounts of materials registers in 1/100 of a pound. This accounts for the inconsistency of the totals. All weights are in pounds.

2-Sort (All fiber/All containers)
All Fiber

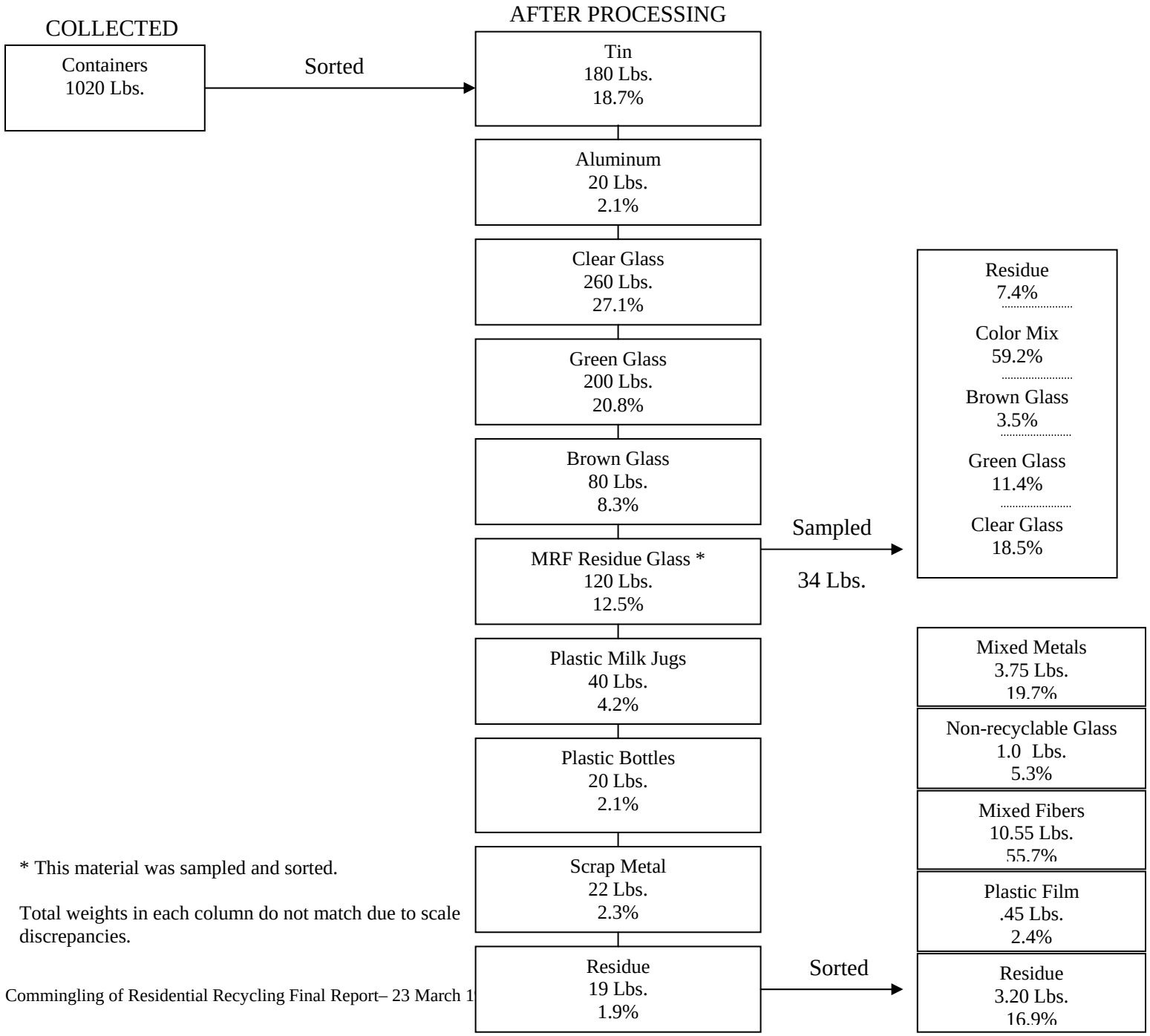


* This material was sampled and sorted.

** Mixed waste paper does not include brown paper.

Total weights in each column do not match due to scale discrepancies.

2-Sort (All fiber/All containers)
Mixed Containers



* This material was sampled and sorted.

Total weights in each column do not match due to scale discrepancies.

Material Flow from Pilot Collection to Market – 2-Sort (All fiber/All containers)

Material Collected	Material Processed[6]	Residue[7]	Sold As	Location of Market
Mixed Fiber (79%)		.3%		
	Newspaper (30.5%)		Deink News	Pacific Northwest
	Mixed Waste Paper (57.5%)		Mixed Recycled Waste	Pacific Northwest Overseas
	Corrugated Cardboard/Paperboard (11.7%)		Old Corrugated Containers	Pacific Northwest
Tin, Aluminum & Glass, Plastic bottles, Scrap Metal (21%)		1.9%		
	Glass			
	Clear (27.1%)		Container Cullet	Pacific Northwest
	Brown (8.3%)		Container Cullet	Pacific Northwest
	Green (20.8%)		Container Cullet	Pacific Northwest
	MRF Residue Glass (12.5%)		MRF Residue Glass	Secondary Processor in Seattle
	Tin Cans (18.7%)		Tin Plated ferrous Cans	Midwest or California
	Plastic			
	HDPE (4.2%)		Natural HDPE	Local Secondary Processor
	Plastic Bottles (2.1%)		Mixed Rigid Plastic Containers	Local Secondary Processor
	Scrap Metal (2.3%)		Ferrous and Non-ferrous	Pacific Northwest
	Aluminum (2.1%)			

[6] Composition of material from collection

[7] Contaminants removed during processing

3-sort (Newspaper/All other fiber/All containers)

Collection

Overview of Collection Route:

This route in Northeast Portland is collected every Friday. The customers were notified of the commingling pilot project in November 1998, approximately four weeks before the pilot observation began. Lot sizes on this route vary between standard urban sized lots and larger suburban ones. The moderate to wide straight streets can accommodate the occasional street parking without slowing down the collection. This route served primarily older established residences, some new single family homes and a few senior care facilities.

Number of customers	1175
Average set-out rate	50%
Miles on route	14
Hours required for total route	8
Mid-route off-loading?	Yes
Number of staff required for route	1

Collection of the first half of the route was observed for this test, taking approximately 5 hours to complete. This included about 2 hours off route to accommodate a mid-route unloading of all 3 compartments at the material recovery facility. The longer-than-average unloading time was due to the maneuvering required to dump at a specific location within the facility. The second half of the collection was not monitored nor included in this test.

Truck description:

Collection is done in a Dempster 37 cubic yard side-loader with 3 compartments as shown below. This right hand drive truck has side troughs for material collection that are hydraulically lifted regularly to empty into the large capacity compartments of the truck. Compartments for recyclable motor oil are collected and stored in space beneath the troughs, requiring the driver to partially lift the troughs to gain access. The material compartments are open to the elements, allowing for continued exposure to weather conditions. This route was covered by one truck staffed by a single driver working one side of the street at a time. The three-sort was a unique collection for the driver. This route is normally a two-sort.

Set-out and field description:

Proper set-out was defined as:

Loose in first bin	Bagged separately in first bin	Loose in second bin
• Drink boxes • Magazines • Milk cartons • Telephone books • Scrap paper • Junk mail • Corrugated cardboard	• Newspaper	• Aerosol cans • Aluminum • Milk jugs • Plastic bottles • Scrap metals • Tin cans • Glass jars & bottles

An improper set-out was defined as any situation that required the driver to take action other than what is required for a proper set-out.

Timing for Collection

The following table portrays information gathered from observing the collection process. *Average stopped time*: the amount of time the collection vehicle was actually stopped at one set-out. *Average handling time*: the time starting when the driver picks up the recyclables from the bin to when he returns the empty bin to the curb. This does not include customer notification for improper set-out.

Set-out type	Number of samples	Average stopped time (seconds)	Average handling time (seconds)	Average time between stops (secs)
Proper	125	24	14	19
Improper	65	39	17	

Pilot Route Statistics

The following findings are from the collection of half of the single monitored route for the test day.

Total Pounds Collected		Number of Set-outs	Set-out Rate	Pounds Per Set-out
Newspaper	1,860			
Other fiber	3,980			
Mixed containers	880			
Total weight	6,720	280	48%	24.0

Observations

This route snaked between two busy streets in an urban area, with set-outs collected on the side streets and the main busy streets. There were few sidewalks in the neighborhood, and many houses were farther apart than standard spacing.

It was raining at the beginning of the route and the temperature was in the mid 40's. Materials were wet. The collection truck was designed such that the driver stopped with the curbside set-outs at the rear of the truck. The three bins on the side of the truck were positioned so they could be filled easily. The side collection compartments located on the trough were hydraulically raised over the truck approximately every 8 stops to empty the contents into the large capacity truck compartments. These large compartments occasionally needed manual compaction. The driver climbed into the compartments to rearrange the material to allow for the addition of more material.

The driver accepted non-recyclable plastic at curbside and included it with the mixed containers on the truck. He was told that all contaminants would be handled at the processing facility.

The driver unloaded each compartment at the material recovery facility. When each section was unloaded, some of the material from that section was caught on the inside of the truck compartment. This residual was usually pushed out by emptying the next compartment, causing some contamination of the mixed fiber (the second section) and the mixed containers (the third section). The last section to be unloaded, mixed containers, dropped to the concrete floor from a height equal to nearly the length of the truck. It needed to be driven forward to shake the remaining material loose and allow space for depositing material on the floor. The glass and metal had shaken to the bottom of the compartment and came tumbling out first with plastic floating on top. This action resulted in glass breakage.

Processing

Plant description:

This is the same processing facility utilized in the 2-sort (all fiber/all containers) pilot. This facility has two sorting areas. The fiber sort line takes up 22,400 square feet of their 57,850 square feet and the container sort line takes up 5050 square feet. The scale used for all weighing of trucks and receptacles or drop boxes reads in increments of 20 pounds. Incoming vehicles deposit their materials in areas in the facility that are cordoned off to keep similar mixes of materials isolated. When processing begins, these materials are moved via front end loader to the conveyor belt feeding the angled infeed line. The sort lines are elevated with material collection containers or drop boxes located below.

Processing Statistics

Total tested collection by truck compartment (Approximately ½ of route)

Materials Processed	Material Weight (Lbs.)	Belt Speed (feet/second)	Minutes to Process	Number of Sorters	Person-hours/ton
Newspaper	1860	1 foot/second	8	7	1.0
Mixed Fiber	3980	1 foot/second	11	7	0.6
Containers	880	0.6 feet/second	25	3	2.47

Sort line description – Newspaper: [See Appendix A, Diagram 3]

When newspaper is being processed, the fiber sort line is staffed with 7 sorters, positively sorting for kraft paper, corrugated cardboard, mixed waste paper and residue, with

cleaned newspaper flowing off the end of the belt. A front end loader is used to move material onto the ground-level infeed belt. The sorters stand on an elevated platform beside the conveyor belt with drop boxes for materials below them.

For this test, the sorters on the newspaper line pulled off materials and put them in small cans that were placed beside them on the sort line.

Sort line description – Other Mixed Fiber: [See Appendix A, Diagram 1]

When mixed fiber is being processed, the fiber sort line has 7 sorters all stationed towards the end of the line. The negative sort was mixed waste paper, containing scrap paper, phone books, newspaper and magazines. This mixed waste paper included newspaper to upgrade the mixed to a mixed recycled waste sold as a low grade newsprint. Three of the sorters pull off newspaper, two sort for corrugated cardboard and kraft paper, and two pull off cardboard and contaminants. Paperboard is included with corrugated cardboard. Drink boxes and milk cartons were removed and sorted into garbage. The fiber sorters pull materials from the belt and put them in drop boxes that are positioned below the belt. The access holes to these boxes are beside the sorters. A front end loader is used to move the fiber to the belt, break it up and loosen it to eliminate clumping.

For this tested portion of the load, the material was wet and the line had to be stopped and restarted to allow for extra handling.

Sort line description – Mixed Containers: [See Appendix A, Diagram 2]

The input to this sort line is all containers and scrap metal. Positive sorts are done for plastic milk jugs (HDPE), plastic bottles, green, brown and clear glass, aluminum, scrap metal, tin cans, and contaminants and the negative sort is mixed glass cullet. Three people staffed the line. Receptacles for materials are located directly across the belt line in front of the sorters. The first sorter picked off plastic milk jugs and tossed into the first receptacle and plastic bottles into the second receptacle. When there was a slowdown in plastic bottles, this sorter picked off green glass and tossed into the third receptacle and removed contaminants into a roll cart directly behind the sorter. The second sorter picked off green, brown and clear glass into the third, fourth and fifth receptacles. When there was a slowdown in glass, this sorter picked off plastic bottles and contaminants. The third sorter picked off aluminum into the sixth receptacle and scrap metal, which was placed directly beside the sorter. When there was a slowdown in aluminum and scrap metal, this sorter removed clear and brown glass and contaminants. Then, ferrous metal is removed via a magnetic separator. The residue (contaminants) and MRF residue glass fall off the end of the line approximately 10 feet into a metal dumpster. Some non-recyclable plastic collected curbside included in plastic bottles.

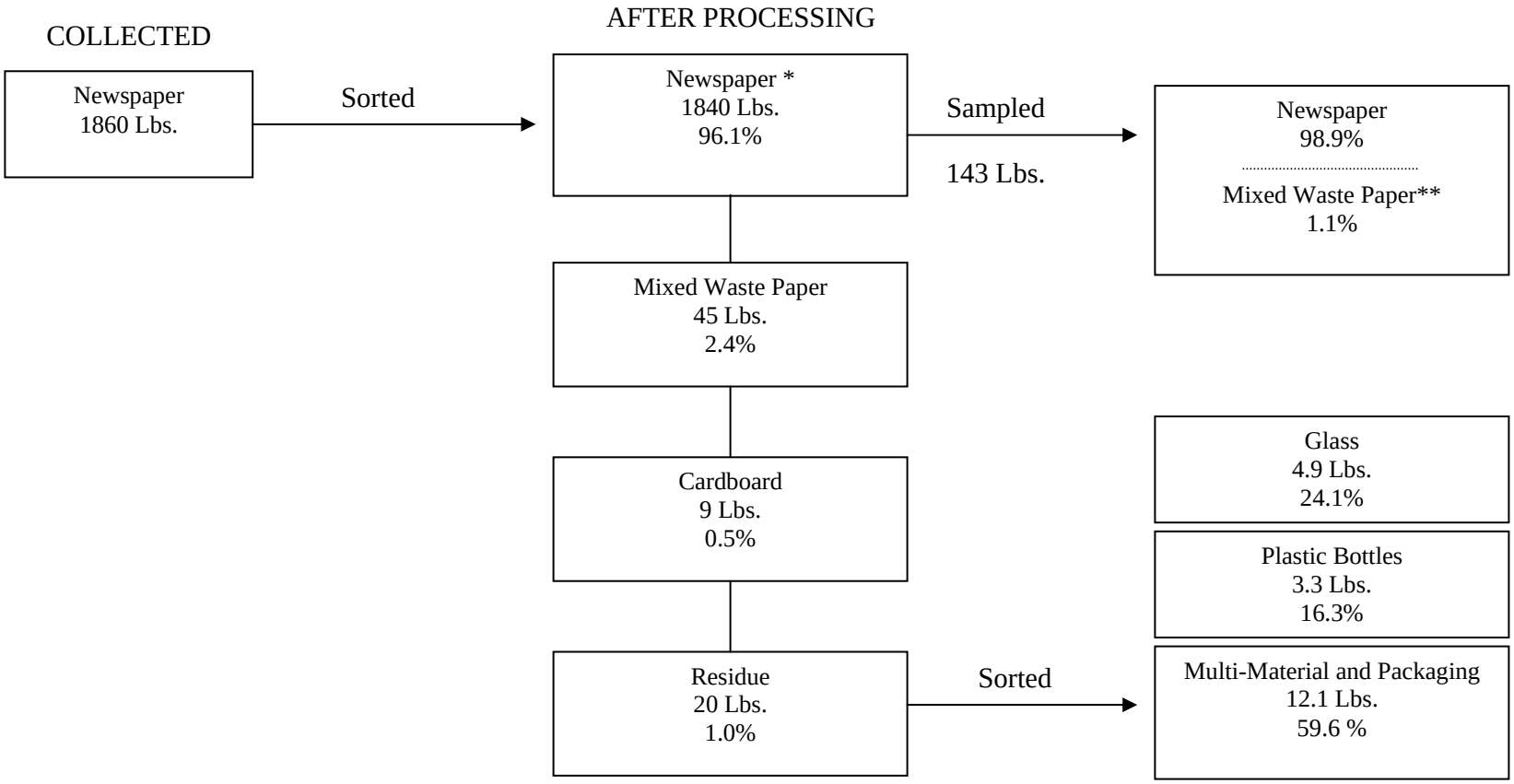
The occasional appearance of containers inside plastic bags slowed down the line for the pilot test. The first sorter on the line controls the speed of the belts.

The following charts are breakdowns of the tested portions of this load. On each of the three charts, the title “collected” on the left represents the material and associated tonnage as it comes off the truck. The material mix is then processed by the number of sorters listed above for each sorting line. The “after processing” boxes represents the resulting materials and the tonnage of each. All the materials in this column that are noted with an asterisk were sampled or completely sorted by the consultant to further determine the

material characterization. The remaining columns of boxes represent these sampled and sorted materials.

NOTE: The scale used for the larger portions registers in increments of 20 pounds. The scale used for smaller amounts of materials registers in 1/100 of a pound. This accounts for the inconsistency of the totals. All weights are in pounds.

3-Sort
Newspaper

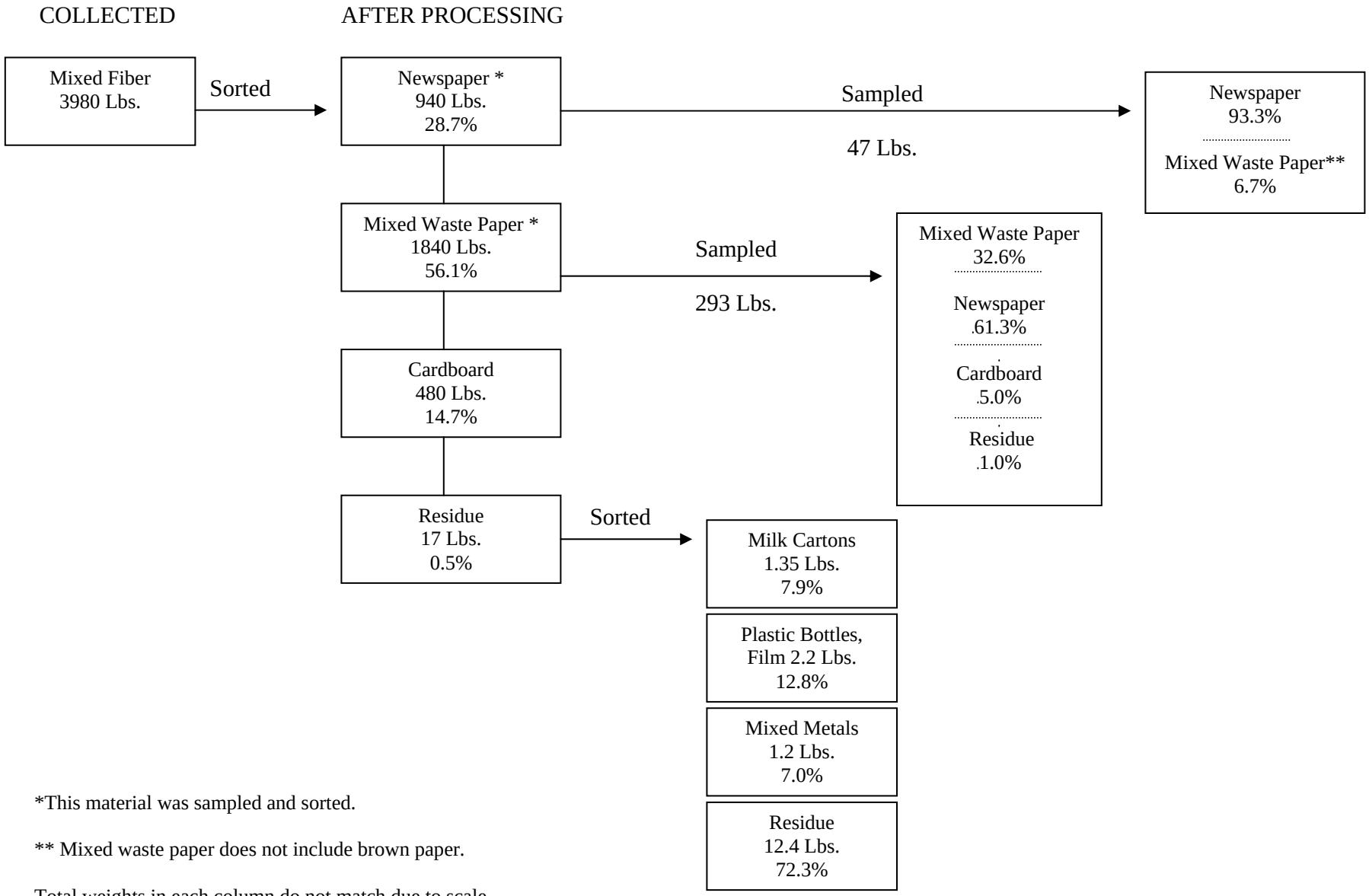


* This material was sampled and sorted.

** Mixed waste paper does not include brown paper.

Total weights in each column do not match due to scale discrepancies.

3-Sort
Mixed Fiber

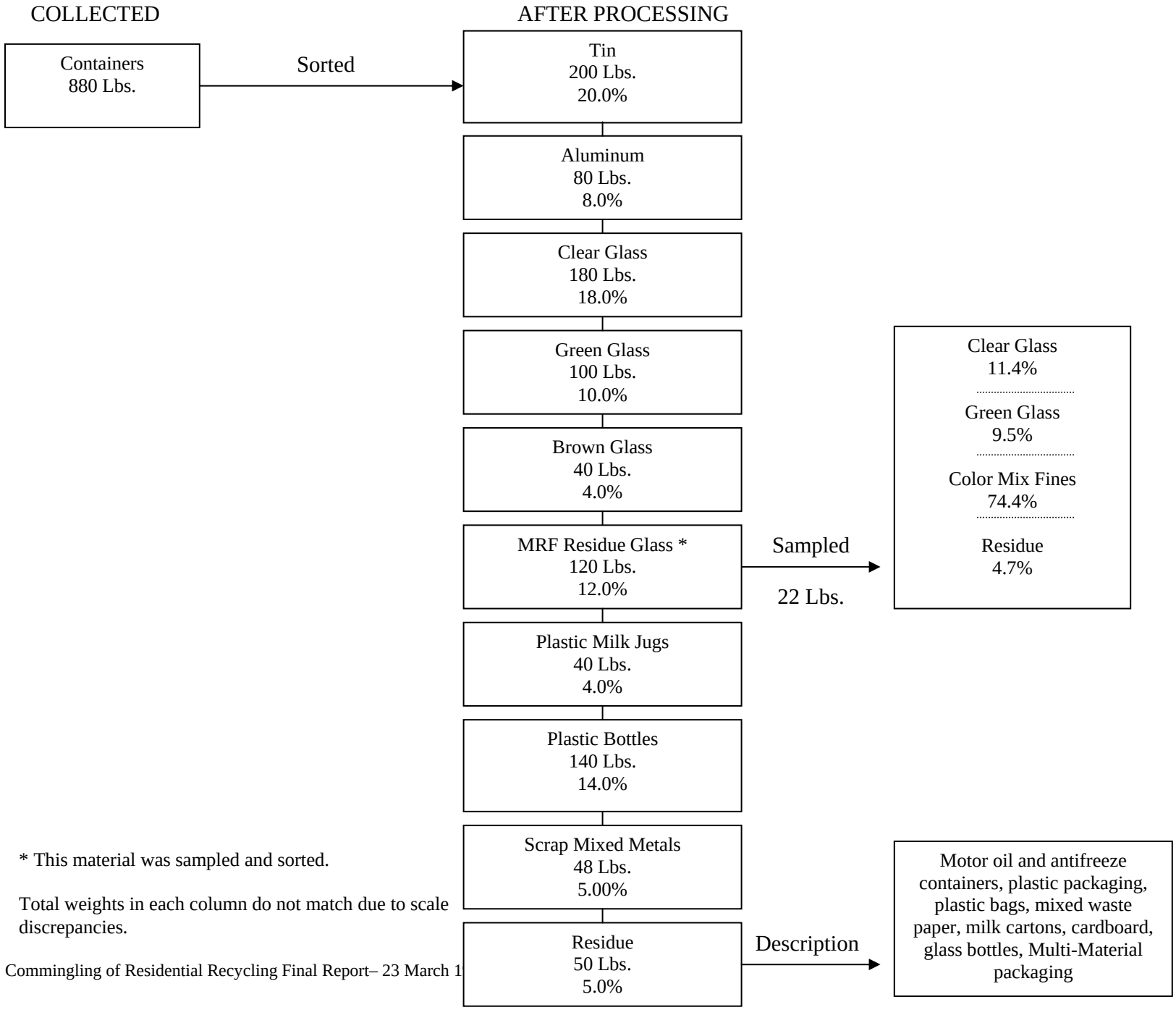


*This material was sampled and sorted.

** Mixed waste paper does not include brown paper.

Total weights in each column do not match due to scale discrepancies.

3-Sort
Mixed Containers



* This material was sampled and sorted.

Total weights in each column do not match due to scale discrepancies.

Material Flow from Pilot Collection to Market – 3 Sort

Material Collected	Material Processed[8]	Residue[9]	Sold As	Location of Market
Old Newspaper		1.0%		
	Newspaper (96.1%)		Deink News	Pacific Northwest
	Mixed Waste Paper (2.4%)		Mixed Recycled Waste	Pacific Northwest Overseas
	Corrugated Cardboard/ Paperboard (0.5%)			
Mixed Waste Paper		0.5%		
	Mixed Waste Paper (56.1%)		Mixed Recycled Waste	Pacific Northwest Overseas
	Newspaper (28.7%)		Deink News	Pacific Northwest
	Corrugated Cardboard/Paperboard (14.7 %)		Old Corrugated Containers	Pacific Northwest
Tin, Aluminum & Glass		5%		
	Glass			
	Clear (18%)		Container Cullet	Pacific Northwest
	Brown (4%)		Container Cullet	Pacific Northwest
	Green (10%)		Container Cullet	Pacific Northwest
	MRF Residue Glass (12%)		MRF Residue Glass	Secondary Processor in Seattle
	Tin Cans (20%)		Tin Plated Ferrous Cans	Midwest or California
	Plastic			
	HDPE (4%)		Natural HDPE	Local Secondary Processor
	Plastic Bottles (14%)		Mixed Rigid Plastic Containers	Local Secondary Processor
	Aluminum (8%)		UBC	
	Scrap Metal (5%)		Ferrous and Non-ferrous	Pacific Northwest

[8] Composition of material from collection

[9] Contaminants removed during processing

2-sort (All glass/All fiber & other containers)

Collection

Overview of collection route:

This route is collected on Mondays in urban Washington County outside the city limits of Tigard. The customers were notified of the commingling pilot project during the week of November 9, approximately four weeks before this pilot test began.

Number of customers	900
Average set-out rate	60%
Miles on route	28
Hours required for total route	7
Mid-route off-loading?	Yes
Number of staff required for route	1

This route varied between a suburban and rural setting with a larger-than-average distance between homes. Roads within the route were winding, sometimes narrow cul-de-sacs, requiring precise maneuvering by the driver.

Truck description:

Collection is done in a two-compartment, right hand drive, Freightliner SL70. It has one 14 cubic yard, side-loading, compaction compartment at the rear of the truck. An additional 4 foot two-compartment Kann trough loader behind the cab is a non-compaction compartment for mixed-color glass.

Set-out and field description:

Proper set-out was defined as:

Bin 1	Bin 2
Magazines Scrap paper Junk mail Newspapers (bagged in paper) Corrugated cardboard	Aerosol cans Aluminum Milk jugs Plastic bottles Scrap metals Tin cans All glass jars, bottles (bagged together in paper)

An improper set-out was defined as any situation that required the driver to take action other than what is required for a proper set-out. All fiber and non-glass containers are collected in the 14 yard compactor. Bags of commingled glass are emptied into the 4-foot side compartment behind the cab of the truck and the paper bags are added to the compartment containing fiber.

Timing for Collection

The following table portrays information gathered from observing the collection process. *Average stopped time:* the amount of time the collection vehicle was actually stopped at one set-out. *Average handling time*: the time starting when the driver picks up the recyclables from the bin to when he returns the empty bin to the curb. This does not include customer notification for improper set-out.

Set-out type	Number of samples	Average stopped time (seconds)	Average handling time (seconds)	Average time between stops (seconds)
Proper	65	26	14	23
Improper	114	29	17	

Pilot Route Statistics

The following findings are from the collection of the single monitored route for the test day.

Total Pounds Collected		Number of Set-outs	Set-out Rate	Pounds Per Set-out
All fiber & containers	13,420			
Mixed glass	1,020			
Total weight	14,440	462	51%	31.3

Observations

The entire route took approximately 8 ½ hours to complete. This included offloading only the compacted compartment of fiber and non-glass containers once at the hauler's yard during mid-route. Both the fiber/container compartment and the glass collection were emptied at the end of the day. The time spent off route unloading in the mid-route was approximately 55 minutes.

It was raining the day of monitoring the pilot route and had been for most of the night. Temperatures were in the low 40's. The driver was instructed to manage the contaminants at the curb. He was careful to reject any non-compliant material and to empty plastic bags of recyclables, leaving the plastic bags behind.

The rain was a major factor in the difficulty of collection on this route. Glass was required to be set out in a separate paper bag. However, the wet bag did not hold up when lifted into the truck, adding material handling time even at properly set-out stops. The rain also added weight to the fiber collection. Newspapers were required to be bagged but the bags did not hold up under these conditions, spilling newspapers all over the road. The driver cleaned up all problems quickly, but this requirement added considerable time to the otherwise efficient collection system.

The collection truck was designed such that the driver could stop with the curbside set-out close to the cab of the truck. The driver could pick up the bins and deposit the materials

easily into the compartments because their openings were very close behind the cab of the truck. The motions required were easily enacted; bins never needed to be lifted higher than just above the waist.
The driver compacted the compartment containing the fiber/tin/plastic mix while stopped curbside before continuing to the next site with minimal time interruption. Mid-route the driver offloaded the compacted compartment of fiber and non-glass containers into a drop box at the hauler's yard. At the end of the route he offloaded the remaining fiber and non-glass containers into the same drop box. Then offloaded all of the glass into another drop box for storage. The hauler delivered the fiber and non-glass containers to the processor.

Processing

Plant description:

This facility consists of one sort line to handle the mixed fiber and non-glass containers collected curbside. Both residential and commercial loads are tipped at various locations throughout the covered 63,000 square foot facility. Mixed glass is handled at a separate processing facility. Incoming vehicles deposit their materials in areas at the facility that are cordoned off to keep similar mixes of materials isolated. When processing begins, these materials are moved via front end loader to the conveyor belt feeding the angled infeed line. The sort line is elevated with material collection receptacles or drop boxes located below.

Processing Statistics

Materials Processed	Material Weight (Lbs.)	Belt Speed (feet/second)	Minutes to Process	Number of Sorters	Person-hours/ton
Mixed Fiber & Containers	13,420	2 feet/second	24	15	0.9
Mixed Glass*	10,515	N/A	29	3	0.3

*The mixed glass was collected from the pilot route for 8 days, then processed.

Sort line description: Fiber and non-glass containers [See Appendix A, Diagram 4]

The sort line consists of a 20 foot long feed pit, a 35 foot long incline belt, a "load leveler", and a 5 foot wide 63 foot long sort line with 19 stations. This consists of an initial sort belt with an overhead crossbelt magnet; a 7 foot long connection belt, a 4 foot by 15 foot four-station sort belt; a magnetic head pulley, 4 foot by 18 foot four-station sort belt, and a 19 foot long takeaway belt.

Eight sorters were staffing the sort line when it began, and an additional seven arrived very quickly. Positive sorts are done for mixed waste paper, corrugated cardboard, plastic, mixed office paper, magazines, and aluminum. Ferrous metals are removed via mechanical means. The negative sort is newspaper. The first two sorters (one on each side of the belt) pull off corrugated cardboard. One of these sorters controls the belt speed. The next two sorters pull off magazines, mixed waste paper, plastic bottles and office pack. The remainder of the sorters pull off aluminum, plastic bottles, mixed waste paper and contaminants.

The material was damp due to the fact that it had not been moved around as much as a normal load would have been. This caused it to clump together, making it more difficult

to separate. All aluminum aerosol cans were removed as residue. Steel aerosol cans are included with other tin cans.

Sort line description: Mixed glass [See Appendix A, Diagram 5]

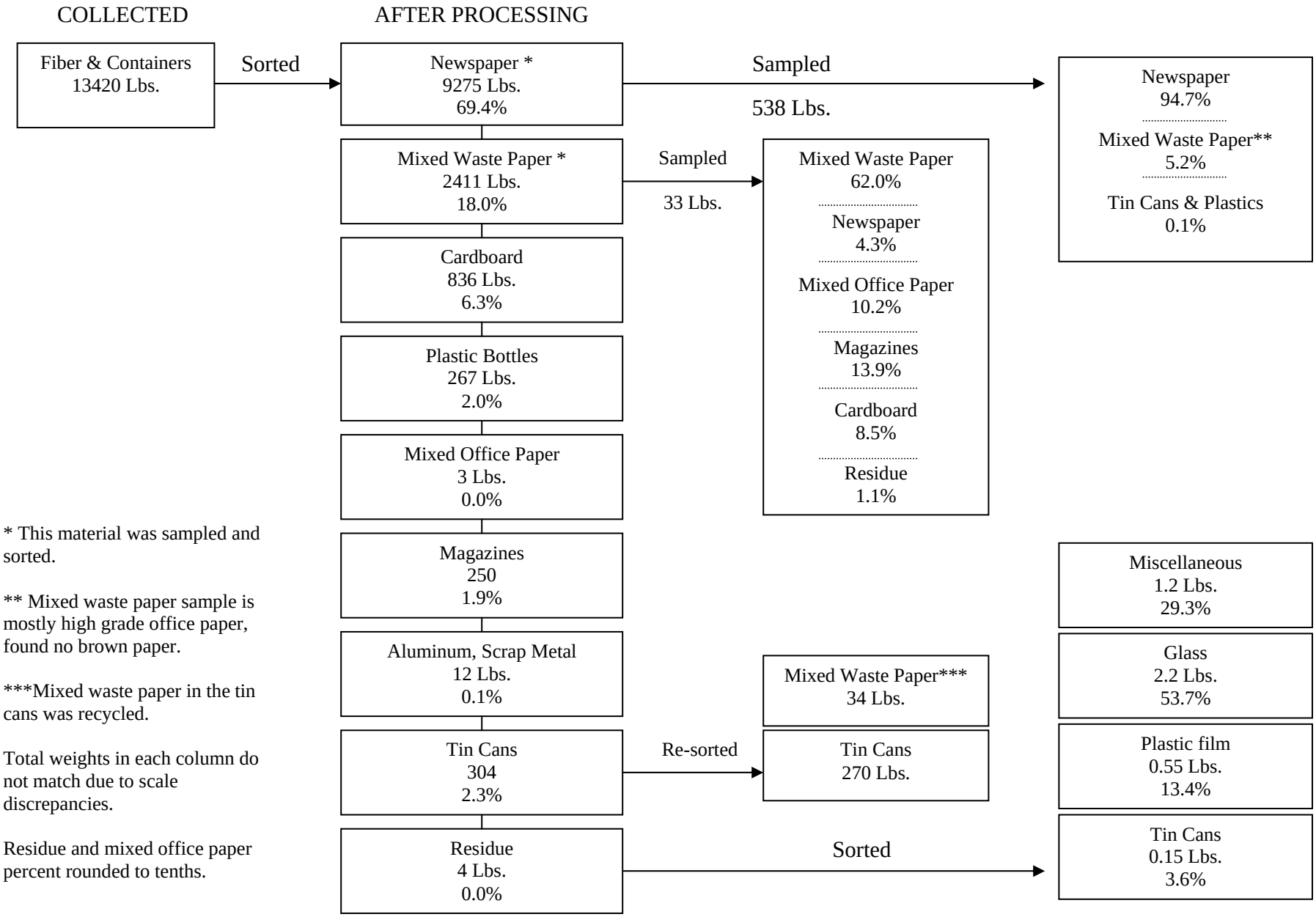
The mixed glass collected on the pilot route was offloaded each week into a drop box and stockpiled at the hauler's yard over an 8 week period. Normally the glass is source separated into clear and colored, offloaded into separate receptacles, then sent to a local market for processing as container cullet. This unique mix of mixed glass was processed locally. The focus of this test was the effects of offloading on glass. Residue was observed and not measured. The attached chart referring to the glass processing is the result of sorting this drop box of mixed glass. The fiber & non glass container mix was tested once by the consultant.

The following charts show a breakdown of the complete load. Tin cans that have been separated during the initial processing are stockpiled and reprocessed once at the end of the week to remove any attached mixed waste paper. By applying the average recovery percentages to this load, this secondary processing would result in approximately 270 pounds of tin cans and 34 pounds of mixed waste paper from the 304 pounds that were extracted from this commingled stream.

The color-mixed glass was processed at a different facility than the remaining materials. The following charts are breakdowns of the tested portions of this load. On each of the two charts, the title "collected" on the left represents the material and associated tonnage as it comes off the truck. The material mix is then processed by the number of sorters listed above for each sorting line. The "after processing" boxes represents the resulting materials and the tonnage of each. All the materials in this column that are noted with an asterisk were sampled or completely sorted by the consultant to further determine the material characterization. The remaining columns of boxes represent these sampled and sorted materials.

NOTE: Inconsistency of weights are accounted for by the differences in scales used at this facility.

2-Sort (All glass/All fiber & Other containers)
All fiber and other containers



* This material was sampled and sorted.

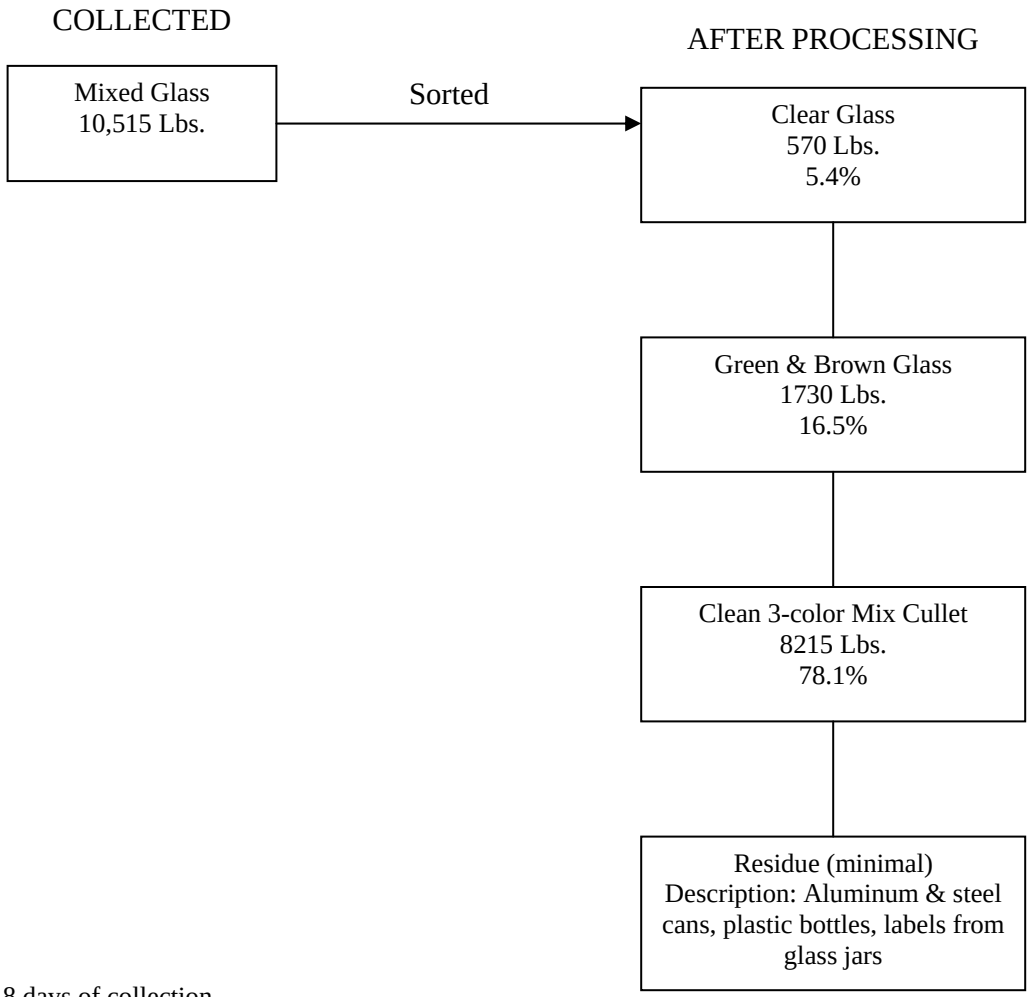
** Mixed waste paper sample is mostly high grade office paper, found no brown paper.

***Mixed waste paper in the tin cans was recycled.

Total weights in each column do not match due to scale discrepancies.

Residue and mixed office paper percent rounded to tenths.

2-Sort (All glass/All fiber & Other containers)
Mixed Glass



This mixed glass represents 8 days of collection.
The focus of this test was the effects of offloading on glass. Residue was observed and not measure.

Material Flow from Pilot Collection to Market – 2-Sort (All glass/All fiber & Other containers)

Material Collected	Material Processed[10]	Residue[11]	Sold As	Location of Market
Mixed Fiber & Containers		0.0%[7]		
	Newspaper (69.4%)		Special News Deink Quality	Pacific Northwest
	Mixed Waste Paper (18%)		Mixed Waste Paper	Overseas
	Corrugated Cardboard (6.3%)		Old Corrugated Containers	Pacific Northwest
	Tin Cans (2.3%)		Tin Plated Ferrous Cans	Midwest or California
	Plastic Bottles (2%)		Mixed Rigid Plastic Containers	Local Secondary Processor
	Magazines (1.9%)		Magazines	Pacific Northwest
	Aluminum, Scrap Metal (0.1%)		Ferrous and Non-ferrous	Pacific Northwest
	Mixed Office Paper (0.0%)[12]		Mixed Office Paper	Pacific Northwest

Composition of Mixed Glass Collected Over Eight Weeks From Pilot Route

Material Collected	Material Processed[13]	Sold As	Location of Primary Market
Mixed Glass	Clear (5.4%)	3-color Mix	Intermediate Processor
	Brown & Green (16.5%)		
	MRF Residue Glass (78.1%)		

[10] Composition of material from collection

[11] Contaminants removed during processing

[12] Percent is rounded to tenths

[13] Material was sorted for percent of glass only

5-sort (Newspaper/All other fiber/Clear glass/Colored glass/Tin & Plastic)

Collection

Overview of collection route:

This route, collected on Tuesdays in Clackamas County, serves neighborhoods that are on standard city lots on moderate to wide streets. The subdivisions consist of many cul-de-sacs, requiring the driver to make several turns to negotiate. The route is several neighborhoods linked together by busy streets, consisting of a mix of newer and established single family homes. The customers were notified of the commingling pilot project in November 1998, approximately four weeks prior to this pilot observation.

Number of customers	800
Average set-out rate	55 - 65%
Miles on route	18
Hours required for total route	4
Mid-route off-loading?	No
Number of staff required for route	2 (2 trucks, running simultaneously)

Truck description:

Collection is done in a 40 cubic yard dual sided trough-loader with 5 compartments and right-hand drive. It has an additional small compactor section immediately behind the cab used for plastic bottles. The side troughs are hydraulically lifted, emptying the materials into non-compacted compartments. These hold (1)tin/plastic combined, (2)clear glass, (3)green/brown glass, (4)newspaper, and (5)phone books/mixed waste paper/cardboard combined, in that order from front to rear.

Set-out and field description:

Proper set-out was defined as:

Bagged in Bin 1	Bagged in Bin 1	Loose in Bin 2	Bagged in Bin 2	Bagged in Bin 2
• Drink boxes • Milk cartons • Scrap paper • Junk mail	• Newspapers • Magazines • Corrugate cardboard (loose in bin)	• Aerosol cans • Aluminum • Milk jugs • Plastic bottles • Scrap metals • Tin cans	• Clear glass jars & bottles	• Colored glass jars & bottles

An improper set-out was defined as any situation that required the driver to take action other than what is required for a proper set-out.

Timing for Collection

The following table portrays information gathered from observing the collection process. *Average stopped time:* the amount of time the collection vehicle was actually stopped at one set-out. *Average handling time*: the time starting when the driver picks up the recyclables from the bin to when he returns the empty bin to the curb. This does not include customer notification for improper set-out.

Set-out type	Number of samples	Average stopped time (seconds)	Average handling time (seconds)	Average time between stops (seconds)
Proper	42	32	21	16
Improper	168	36	25	

Pilot Route Statistics

The following findings are from the collection of the single monitored route for the test day.

Total Pounds Collected		Number of Set-outs	Set-out Rate	Pounds Per Set-out
Newspaper & magazines	3,720			
Other fiber & cardboard	1,230			
Tin & plastic bottles	190			
Clear glass	220			
Colored glass	260			
Plastic bottles	120			
Total weight	5,740	257	64%	22

We observed one of the two trucks that covered the route. The driver collected from both sides of the street at each stop. Note: plastic bottles were collected both separately and mixed with tin.

Observations:

The weather on the observed day was clear and dry with temperatures ranging from 32 to 45 degrees. The collected materials were dry.

The driver stopped with the curbside set-outs at the front of the truck requiring the driver to walk the entire length of the truck to deposit materials. The 5 compartment bins on the side of the truck were positioned so they could be filled easily. The hatchway to the plastic compactor was elevated somewhat, but not difficult to access. The side bins had to be hydraulically raised over the truck approximately every 11 stops to deposit the materials into the large compartments on the truck. These side loading compartments also were raised to collect recyclable motor oil. The driver stopped occasionally to manually compact the materials and to rearrange the corrugated cardboard to accommodate additional material. This required the driver to climb into the material compartment. The

driver on this route checks for contaminants and leaves some materials at the curb along with notes for the customer. The additional time required for this continuous feedback to the generator creates a cleaner recycling stream at the processor.

Processing

Plant description:

This processing facility has 2 sort lines inside a covered warehouse area and another mechanical/manual sort area outside for tin/aluminum/plastic extraction. The enclosed facility is 18,000 square feet. Glass is stored outdoors. This plant will be replaced within a year or two by a new, higher capacity, more mechanized facility.

Processing Statistics

Materials Processed	Material Weight (Lbs.)	Belt Speed (feet/second)	Minutes to Process	Number of Sorters	Person-hours/ton
Newspaper & magazines	3,720	2 feet/second	8	10	0.7

Sort line description: Newspapers and magazines[See Appendix A, Diagram 6]

The sort belt for the newspaper was 4 feet wide and approximately 40 feet long. The upper section was about 25 feet long and the lower section was about 15 feet long, divided by a water fall. This was an elevated line fed at ground level by a front end loader. A team of 10 sorters processed the newspaper/magazine fiber mix. One person was stationed at the base of the infeed belt to remove bulky contaminants, which included paper sacks. The other 9 sorters were removing mixed waste paper and phone books. This line did a negative sort for newspaper. The last sorter on the line controlled the speed of the belt. The sorters handling newspaper and magazines face the moving belt and throw the sorted material, mixed waste paper, through chutes beside them. This is collected on the floor below and pushed with a front end loader onto a baling infeed line. The material arrived on the sort line in clumps without any mechanical separation earlier in the process line. The belt was stopped occasionally to disperse clumped material, slowing the line and decreasing the efficiency. Phone books were removed and stacked behind the sorters.

Sort description: Mixed Waste Paper

Normally the mixed waste paper is offloaded near the bailer. Mixed waste paper is then pushed onto the infeed belt with a front end loader. Corrugated cardboard and contaminants are removed. The remaining mixed waste paper is fed into the baler. Milk cartons and drink boxes are included in this mix. For this pilot, mixed waste paper was isolated. Sorters removed corrugated cardboard leaving the remaining material on the ground. A sample of the remaining mixed waste paper was sorted and weighed by consultants.

Sort description: Tin/Aluminum/Plastic

The sorting of the tin/aluminum/plastics mix was being done manually for this pilot test. This was deemed as the only feasible method to handle the materials and continue to keep this stream isolated from the rest of the materials flowing through this processor. This mixed material was spread on the ground and sorters separated the plastics into roll carts leaving the remaining material for the consultants to sort. Normally plastics are removed from the tin/aluminum mix by sorters before the remaining material is

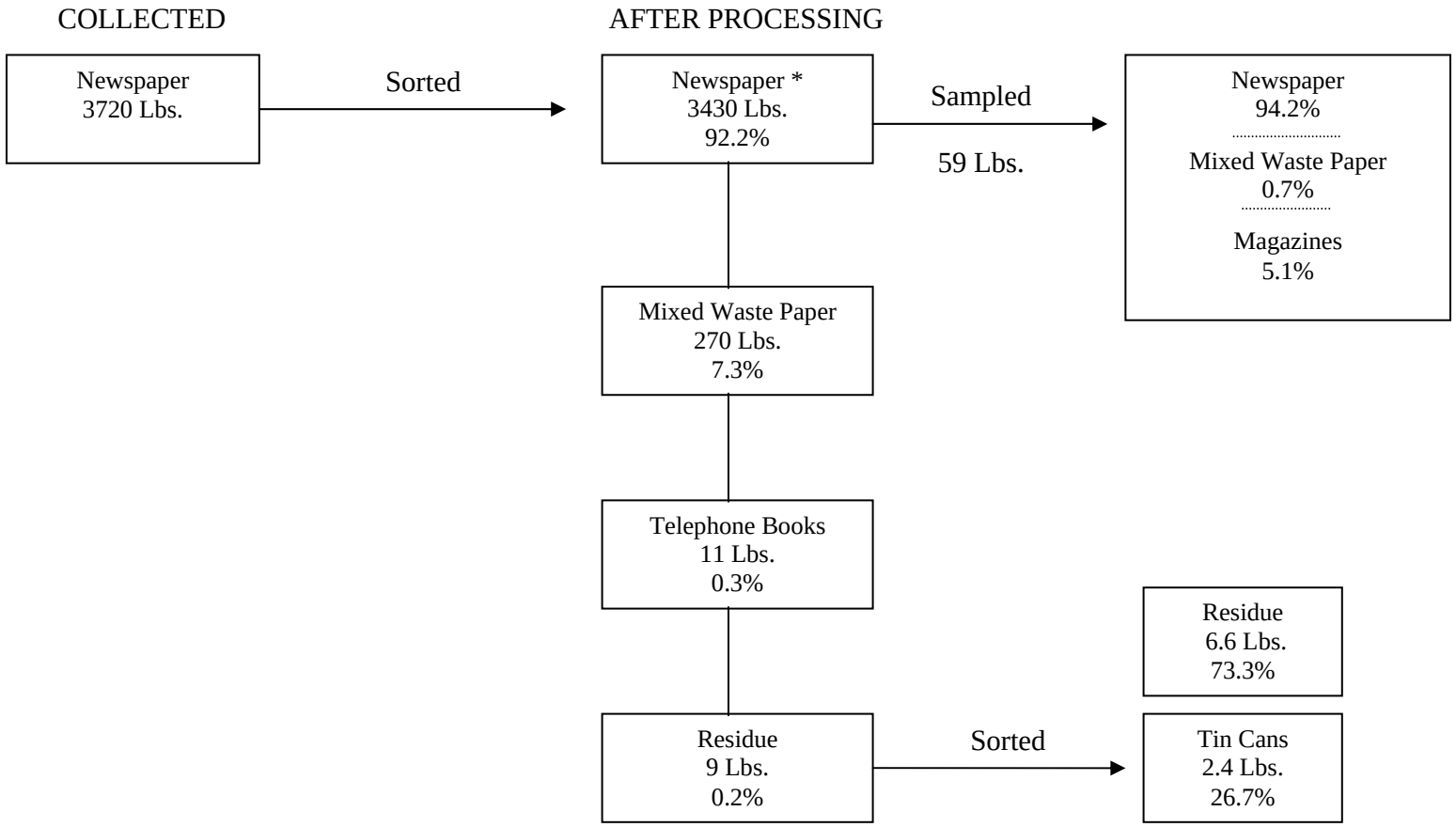
mechanically separated. All aluminum aerosol cans are removed as residue due to safety issues in the smelting process. Steel aerosol cans are included with other tin cans.

Sort description: Glass

Normally glass is delivered source separated as clear or brown/green mix at this facility. However, further cleaning is required prior to shipment due to outside storage in open bunkers. A sorter removes any contaminants found in the glass before sending to market. For this study glass was offloaded in front of the cordoned off area for clear and green/brown glass. A visual observation determined that there was relatively low contamination in the glass at this stage.

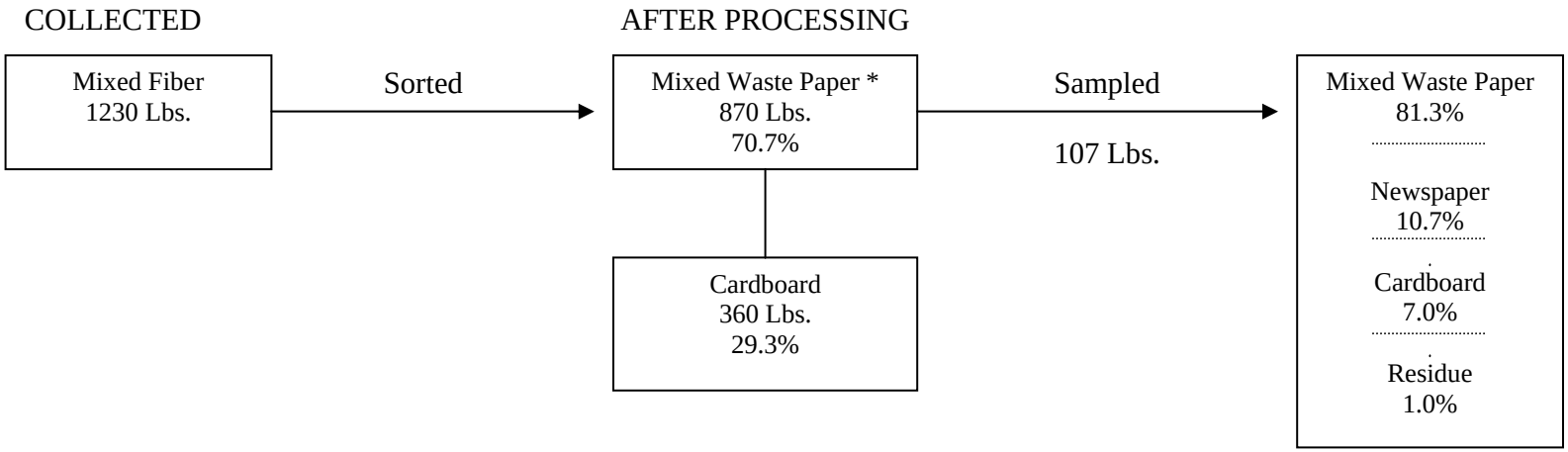
The following charts are breakdowns of the tested portions of this load. On each of the four charts, the title “collected” on the left represents the material and associated tonnage as it comes off the truck. The material mix is then processed by the number of sorters listed above for each sorting line. The “after processing” boxes represents the resulting materials and the tonnage of each. All the materials in this column that are noted with an asterisk were sampled or completely sorted by the consultant to further determine the material characterization. The remaining columns of boxes represent these sampled and sorted materials.

5-Sort
Newspaper/Magazines



* This material was sampled and sorted.

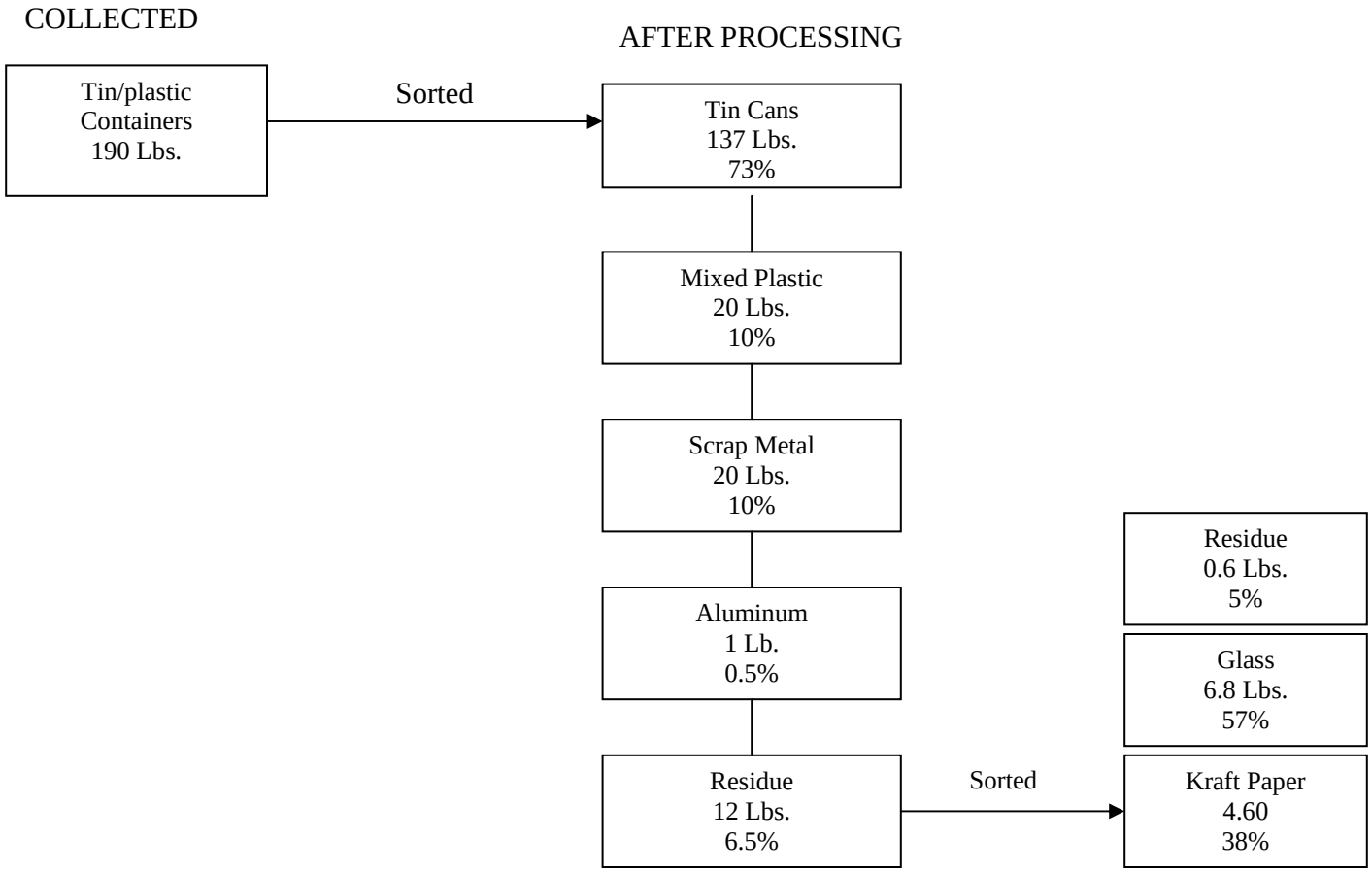
5-Sort
Mixed Fiber



*This material was sampled and sorted.

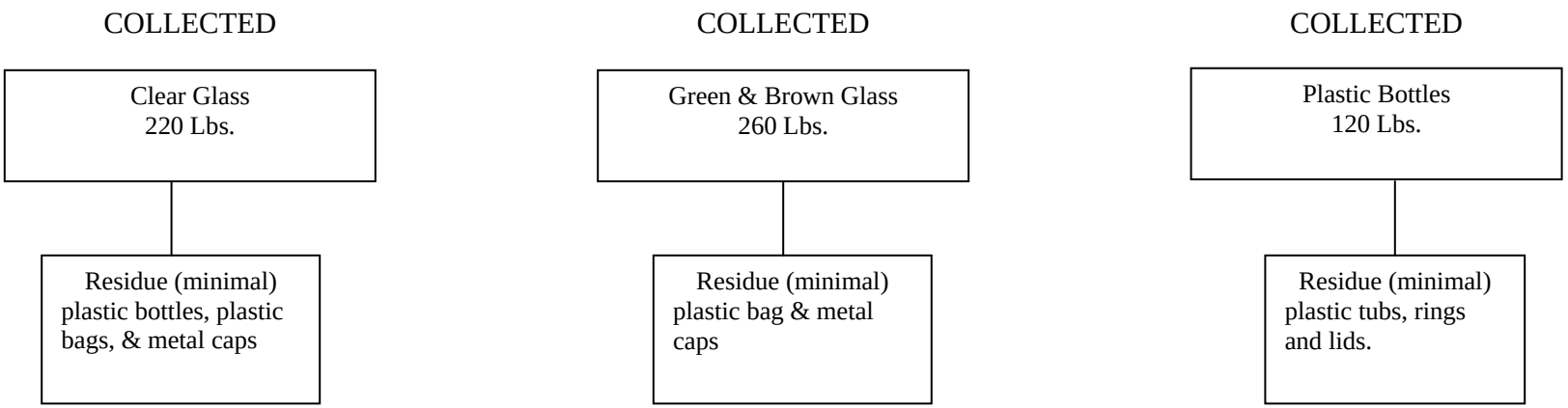
Corrugated Cardboard was removed from the mixed fiber by sorters. No residue was remove during this process. The consultant team sampled the remaining mixed waste paper.

5-Sort
Tin & Plastic



Plastic containers were removed by sorters from the tin/plastic container mix. No residue was removed during this process. The consultant team sorted the remaining material.

5-Sort
Source Separated Materials



Plastic bottles were not processed, therefore no residue was measured.

Green & brown glass had no residue.

Material Flow from Pilot Collection to Market – 5-Sort

Material Collected	Material Processed[14]	Residue[15]	Sold As	Location of Market
Old Newspaper & Magazines		0.2%		
	Newspaper (92.2%)		Deink News	Pacific Northwest
	Mixed Waste Paper (7.3%)		Mixed Waste Paper	Overseas
	Phone Books (0.3%)			
Mixed Waste Paper		1.0%*[16]		
	Mixed Waste Paper (70.7%)		Mixed Waste Paper	Overseas
	Corrugated Cardboard (29.3%)		Old Corrugated Containers	Pacific Northwest
Glass Clear	Material not processed		Container Cullet	Pacific Northwest
Glass Brown & Green	Material not processed		Container Cullet	Pacific Northwest
Plastic Bottles[17]	Material not processed			Local Secondary Processor
Tin cans, Aluminum & Plastic		6.5%[18]		
	Tin Cans (73%)		Tin Plated Ferrous Cans	Midwest or California
	Plastic Bottles (10%)		Mixed Rigid Plastic Containers	Local Secondary Processor
	Scrap Metal (10%)		Ferrous and Non-ferrous	Pacific Northwest
	Aluminum (0.5%)		UBC	

[14] Composition of material from collection

[15] Contaminants removed during processing.

[16] Percentage based on sampling of mixed waste paper.

[17] Plastic bottles were stored on the truck separately as well as stored with other containers.

[18] Included in the residue are cross-contaminants which were recycled.

Off-loaded drop box and single route

Collection

Route description:

Two styles of collection were tested at this processing facility. One method was a two-sort commingled residential load, the other was a drop box of mixed containers that had been offloaded from multiple residential routes. The collection process was not monitored for either of these material streams. For this project, the focus was on the ability to retrieve color separated glass from these 2 sources, with close attention to the effect of commingled, off-loaded materials on glass breakage. Therefore, the only processing evaluated was the handling of the mixed containers. The truck used to collect the single route that was tested was a dual compartment trough loader.

Processing

Plant description:

This processing facility has two sort lines, one for fiber and one for mixed containers. The full facility has been on line since mid-1997. Of the 45,000 square feet of space, approximately 2/3 of the space is used for processing fiber and the remainder is for handling containers. The plant processes on average 140 tons of residential materials per day.

Processing Statistics

Materials Processed	Material Weight (Lbs.)	Belt Speed (feet/second)	Minutes to Process	Number of Sorters	Person-hours/ton
Mixed containers (offloaded)	3,239	N/A	5	36	1.85
Mixed containers (single route)	1435	N/A	5	24	2.78

Sort line description: Mixed Containers [See Appendix A, Diagram 5]

The container sort line consists of an inclined feeder, a rotating perforated drum, a magnet, an air separator system, and two sort lines. The inclined feeder, made from a soft rubber, is fed via front end loader. The rotating drum removes two inch pieces of glass or smaller and other small contaminants. The air separator divides the light weight material from the heavy. The sort line for the light weight materials contains plastics and aluminum. Magnets remove the ferrous metals, leaving color mixed glass on the heavy container line. The infeed system has a unique mechanical re-routing mechanism to feed heavy materials through again that accidentally end up on the light side.

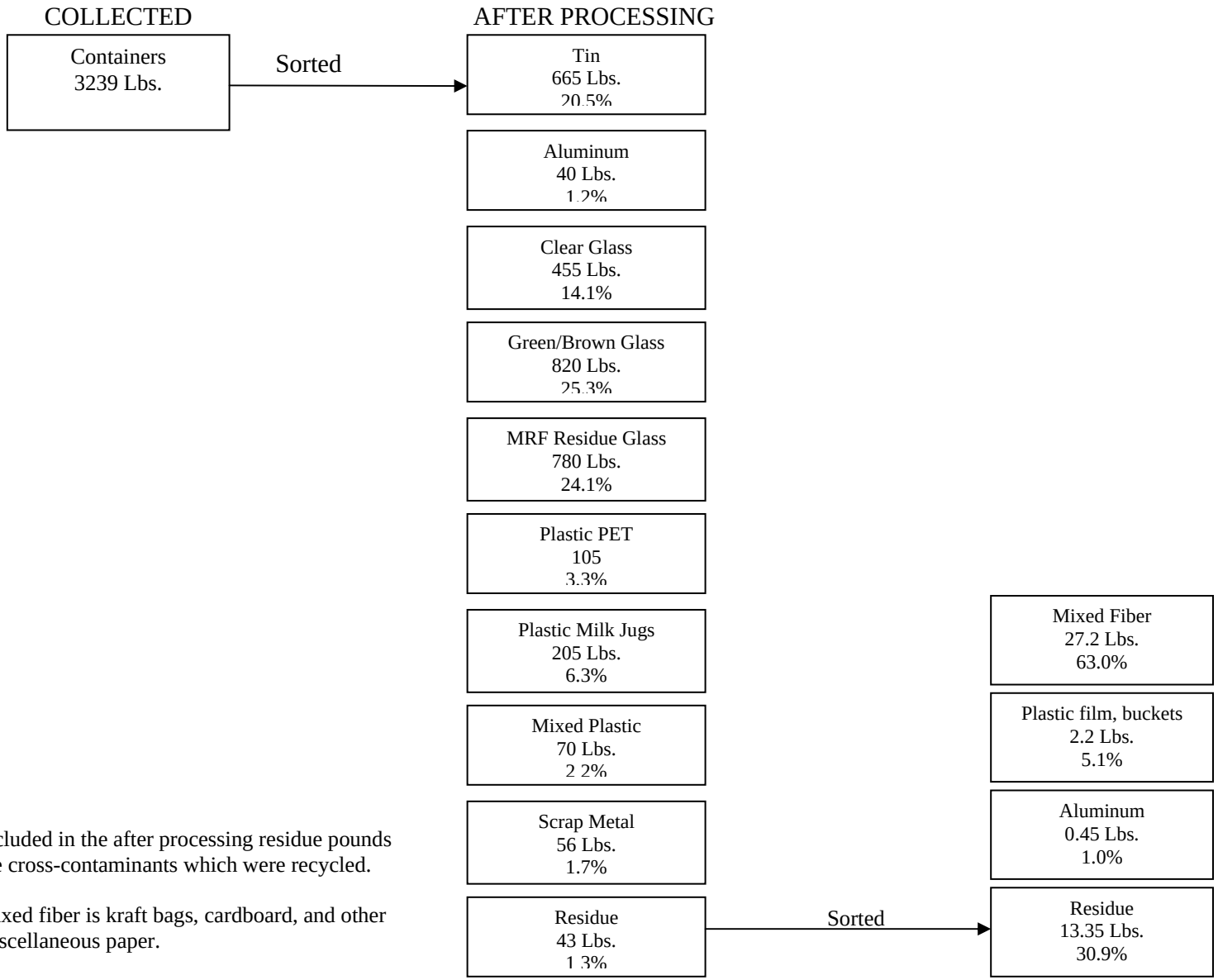
Incoming vehicles deposit their materials in areas in the facility that are cordoned off to keep similar mixes of materials isolated. When processing begins, these materials are moved via front end loader to the conveyor belt feeding the angled infeed line. The sort lines are elevated with material collection receptacles or drop boxes located below. Most

of the bulkier contaminants were removed at the infeed station by staff loading the belt. The sorters on the elevated platform handled the remaining residue. The container line sorters face the moving belt and push the materials off the belt into metal dumpsters. The slightly angled edges of the belt (rather than sharp, vertical sides) make this action easy and efficient. The only lifting required for the materials was in handling the contaminants – fibers, aluminum foil, and tin from the light materials line and plastic and scrap metal from the heavy materials line. Each of these contaminants was removed from the stream and separated into receptacles for recycling. This resulted in a residue stream that was relatively free of usable materials. The MRF Residue Glass may not represent a typical MRF Residue Glass mix due to an unusual amount of sheet metal shavings collected on route.

The following charts are breakdowns of the tested portions of this load. On each of the charts, the title “collected” on the left represents the material and associated tonnage as it comes off the truck. The material mix is then processed by the number of sorters listed above for each sorting line. The “after processing” boxes represents the resulting materials and the tonnage of each. All the materials in this column that are noted with an asterisk were sampled or completely sorted by the consultant to further determine the material characterization. The remaining columns of boxes represent these sampled and sorted materials.

NOTE: The outside scale was frozen due to the unusually cold weather. Weights for the incoming stream is a sum of processed materials. All weights are in pounds.

Off-loaded Route
Mixed Containers



Included in the after processing residue pounds are cross-contaminants which were recycled.

Mixed fiber is kraft bags, cardboard, and other miscellaneous paper.

Material Flow from Pilot Collection to Market – Off-loaded Route

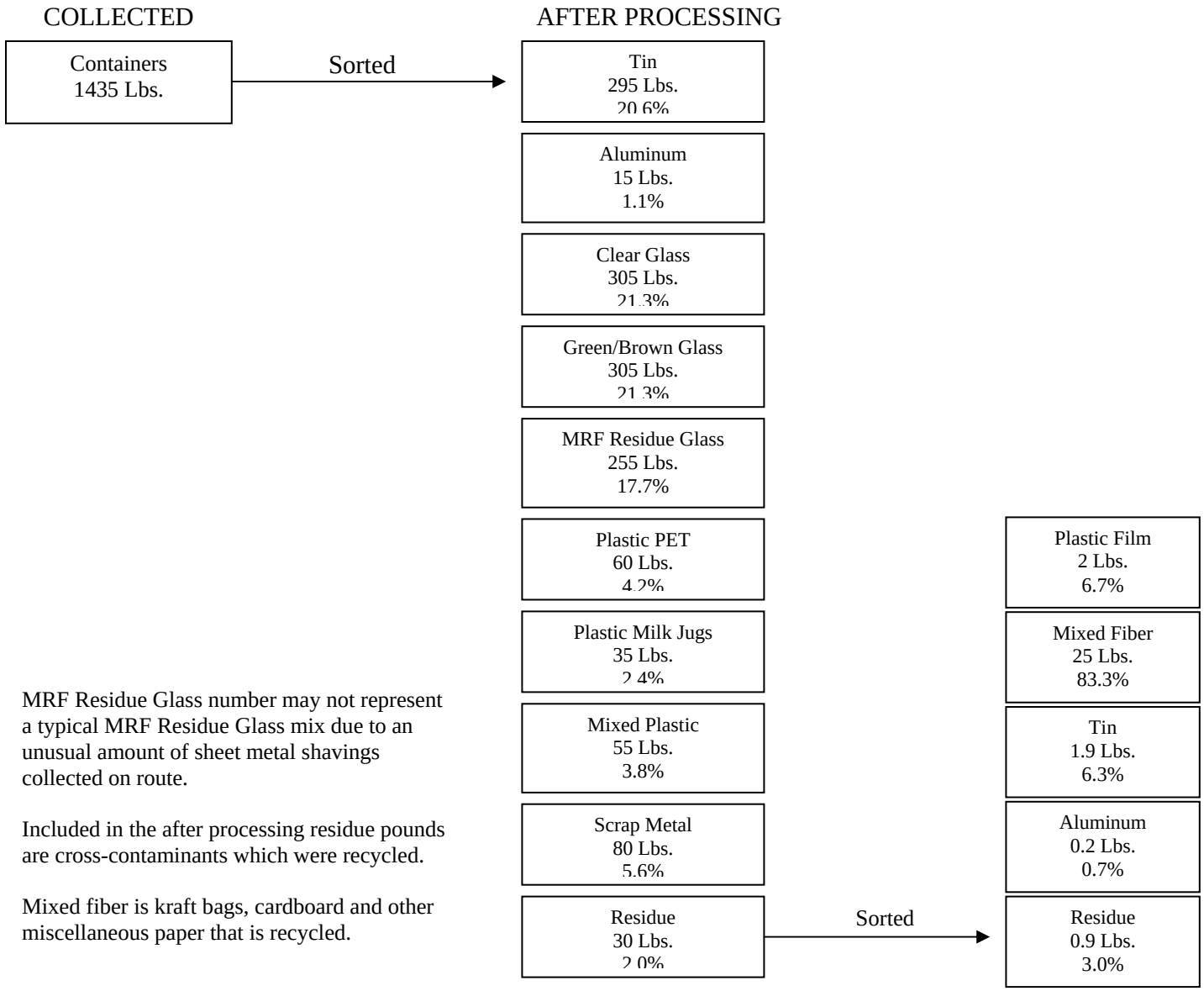
Material Collected	Material Processed[19]	Residue[20]	Sold As	Location of Market
Containers		1.3%[21]		
	Tin Cans (20.5%)		Tin Plated Ferrous Cans	Midwest or California
	Glass			
	Clear (14.1%)		3-color Mix	Intermediate Processor in California
	Brown & Green (25.3%)		3-color Mix	Intermediate Processor in California
	MRF Residue Glass (24.1%)		3-color Mix	Intermediate Processor in California
	Plastics			
	HDPE (6.3%)		HDPE	
	PET (3.3%)		PET	
	Mixed Containers (2.2%)		Mixed Rigid Plastic Containers	
	Scrap Metal (1.7%)		Ferrous and Non-ferrous	Pacific Northwest
	Aluminum (1.2%)		UBC	

[19] Composition of material from collection

[20] Contaminants removed during processing.

[21] Included in the residue are cross-contaminants which were recycled.

Single Route
Mixed Containers



MRF Residue Glass number may not represent a typical MRF Residue Glass mix due to an unusual amount of sheet metal shavings collected on route.

Included in the after processing residue pounds are cross-contaminants which were recycled.

Mixed fiber is kraft bags, cardboard and other miscellaneous paper that is recycled.

Material Flow from Pilot Collection to Market – Single Route

Material Collected	Material Processed[22]	Residue[23]	Sold As	Location of Market
Containers		2.0%[24]		
	Tin Cans (20.6%)		Tin Plated Ferrous Cans	Midwest or California
	Glass			
	Clear (21.3%)		Container Cullet	Secondary Processor in California
	Brown & Green (21.3%)		Container Cullet	Secondary Processor in California
	MRF Residue Glass (17.7%)		MRF Residue Glass	Secondary Processor in California
	Plastics			
	HDPE (2.4%)		HDPE	
	PET (4.2%)		PET	
	Mixed Containers (3.8%)		Mixed Rigid Plastic Containers	
	Scrap Metal (5.6%)		Ferrous and Non-ferrous	Pacific Northwest
	Aluminum (1.1%)		UBC	

[22] Composition of material from collection

[23] Contaminants removed during processing.

[24] Included in the residue are cross-contaminants which were recycled.

Markets

This section focuses on two key materials, the marketability of which are most affected by commingled collection – glass and old newspapers (ONP). Other grades of recycled fiber, specifically mixed waste paper (MWP) and old corrugated containers (OCC) are discussed in the section of fiber, primarily in the context of ONP recycling. In addition a short discussion of tin cans and plastics is provided.

Market representatives from both recycled glass and fiber sectors were asked in telephone interviews for their professional assessments of the current status and trends for recycling markets, especially as they relate to changes in the material supply chain. Details and supporting data are presented in the two sections on glass and fiber. It became clear that these market representatives are observing and, to different degrees, responding to an increase in commingled collection throughout their supply region.

They define several forces that are at odds in recycling markets:

- An increasingly mixed feedstock, including different material grades and contaminants, is being delivered while the demands for quality products by their customers are ever higher.
- Market prices for their products are in many cases depressed, while the costs of processing to meet quality demands are rising.
- Though materials that are unusable by existing markets are increasing in quantity, new users are appearing that target these “bottom-of-the-food-chain” supplies.

There are several countervailing forces at play in the evolution of recyclables collection, processing and markets, as noted in the discussion of “Market Trends, Barriers and Opportunities” especially for Glass and Newspaper. This study can provide no definitive prognosis of how incremental decisions made by recycling collectors and local jurisdictions will sort out in the marketplace. Clearly, however, incremental decisions are defining the course for the long-term viability of recycling markets.

This chapter is intended to present facts and viewpoints from each market sector based on personal interviews. Much of the data and viewpoints provided in the interviews was offered confidentially. This report is cautious about specific attribution, while still reflecting the findings. Interviewees are listed at the end of each section. In addition, some information was provided by the Project Officer based on interviews that he conducted with market representatives.

Recycled Glass Markets

SUMMARY

Recycled glass markets are in a state of transition, in which the entire West Coast is entangled as a region. Public policy and business strategies are interacting dynamically. The

potential fate of material generated in Portland cannot be understood without considering previous and potential future actions taken by processors and by government in California.

California is a net importer of recycled glass containers, and currently California markets are seeking new supplies. However, their demand is driven at least in part by the recycled content legal requirements for new glass containers and fiberglass. At the same time, several forces, among them, competition with virgin materials, recycled content requirements, and the California bottle redemption law, drive prices for recycled cullet. These forces have driven some traditional color-sorted markets to utilize three-color mixed cullet.

There is therefore a strong demand at present for three-color mixed glass. But one principle appears clear in today's glass recycling market. The lower the quality of material that you are selling, the more you are subject to uncertain political and market forces.

It is important to distinguish the different grades of glass cullet that are being marketed, for the markets and prices are different for each. The three-color mix grades are not used formally by glass markets, however, they represent grades that local processors are producing and selling to markets.:

- Color-Sorted
  - Flint
  - Amber
  - Green
- Three-Color Mix
  - Unprocessed, all glass containers included
  - Processed, 3/8" – 2" size[25]
  - MRF Residue, <2" size
  - MRF Fines, <3/8" size

Color-sorted glass cullet will find a high-value home, at least until the day we drink our wine and beer out of plastic, or perhaps when Oregon policy-makers lower content requirements for glass containers. In contrast, the markets for the lower quality three-color mix grades, especially the fine material, are dependent on California content requirements, on sourcing and political strategies by a few large California consumers, and on the development of a handful of prospective new applications.

In brief, color-sorted glass now stays in Oregon and mixed-color glass is predominately consumed in California. The largest market for MRF residue glass is the Gallo wine company bottle plant in Modesto, CA. Gallo is currently in need of additional cullet supply due to being out of compliance with the California mandatory content law. However, they purchase 2" minus cullet and have recently adopted specifications that leave 3/8 inch minus cullet without a reliable home. The full reverberations of these changes - both in processing costs

[25] Prices paid for this grade may differ depending on whether or not whole bottles have been color-sorted from the mix.

and material flow – are still being sorted out. At the present, Portland processors are finding opportunities to sell into California, although, at a cost or only a minimal dollar return for three-color mix cullet.

Meanwhile, some other outlets hold some promise for three-color mix. A new fiberglass plant is going into Northern California. In addition, a prospective new use as an abrasive is being developed in the Pacific Northwest.

Three tables follow that are intended to present views of the flow of recycled glass to markets. The options are complex.

Table M-1 depicts the grades of glass produced from five collection scenarios studied in this report.

Table M-2 discusses the glass container market grades on the West Coast:

- Color-sorted container glass.
- Three-color mix, including several different informal grades that are produced by local processors.

Table M-1 Grades of Glass

TABLE M-1 GRADES OF GLASS PRODUCED FROM COLLECTION SCENARIOS						
Collection	**Glass Sort**	**MRF Processor Glass Grades**		**Market Destination**	**Location**	**Percent of Total Glass**
		Portland	**Seattle[26]**			
2-Sort	Mixed Containers	Flint	N/A	Container Manufacturer	Portland	39.4%
		Amber				12.1%
		Green				30.3%
		MRF Residue Glass	3-Mix A[27]	Wine Bottle Manufacturer	West Coast	18.2%[28]
			Residue Fines	Beneficial Use[29]/Landfill	PNW	
3-Sort	Mixed Containers	Flint	N/A	Container Manufacturer	Portland	40.9%
		Amber				9.1%
		Green				22.7%
		MRF Residue Glass	3-Mix A[27]	Wine Bottle Manufacturer	West Coast	27.3%[30]
			Residue Fines	Beneficial Use/Landfill	PNW	
2-Sort	All Glass	Color-Sorted	N/A	Container Manufacturer	Portland	22%
		3-Mix B[27]	N/A	Intermediate Processor	West Coast	78%
5-Sort	Clear Glass	Flint	N/A	Container Manufacturer	Portland	45.8%
	Colored Glass[31]	Green				44.2%
Single route	Mixed Containers	3-Mix B	N/A	Intermediate Processor	West Coast	100%
Offloaded drop box						

[26] Intermediate processor, same ownership as Portland processor.
[27] These grades of glass (A and B) are defined in Table M-2 and in the glossary.
[28] Represents the percentage of MRF Residue Glass shipped to a sister MRF in Seattle for additional process and sale.
[29] Seattle MRF reports this grade is used as an on-site pothole patch.
[30] Prices paid for this grade depending on whether or not whole bottles have been sorted from the mix.
[31] A mixture of amber and green glass, which in a bottle bill state meets the specification for green cullet.

Table M-2, Glass Container Market Grades

TABLE M-2 GLASS CONTAINER MARKET GRADES ON THE WEST COAST									
Grade	**Specification**	**Residue** [32]	**Current Price**[33]	**Price History**	**Market Destination**	**Location**	**Current Demand**	**Forecast** [34]	**Current End Use**
Color Sorted									
Flint	>95% flint, <5% other colors[35]	<1%	$40/ton	Stable 4 yrs.	Container	Portland	Exceeds NW supply	Strong	Containers
Amber	>90% amber, <10% other colors	<1%	$25/ton[36]	Stable 4 yrs.	Container	Portland	Exceeds NW supply	Strong	Containers
Green	>70% green, <30% other colors	<1%	$5/ton	Stable 4 yrs.	Container	Portland	1/3-1/2 used in O-B amber	Strong	Containers
						California	½ -2/3 shipped to CA	Strong	Containers
Three Color Mix[37]									
A	3/8”-2”	<1%	$20/ton	New, Stable 1 yr.	Wine Bottle Manufacturer	California	Strong	Depends on pending CA legislation	Wine Bottles
B	Un-processed, all glass	1-5%	$0-$15/ ton	New grade	Intermediate Processor	California	Good - Strong	Good	Containers/ Fiberglass
MRF Residue Glass	<2”	5-15%	None[38]	Unstable	Intermediate Processor	California	Only from CA suppliers	Uncertain	Stockpiled
Residue Fines	<3/8”	20-30%	-$65/ton to $0	New grade	Intermediate Processor	California	None	Depends on R&D	Stockpiled/ Landfilled

[32] Residue is a total amount of non-glass material removed from cullet to make it furnace-ready. It is not part of most market specifications. For color-sorted glass, it averages 0.75% across all colors, with flint residue being the highest at 1.0%.
[33] All price information comes from market interviews. Prices are as of March 1999, FOB Portland. Rail freight from Portland to San Francisco is $18 to $20 per ton.
[34] Estimated demand for next three years.
[35] Maximum content of ceramic materials:

>8 mesh (1/8”)	0 particles in 50 lbs.
Between 8 &20 mesh	1 particle in 50 lbs.
Between 20 &40 mesh	40 particles in 50 lbs.

[36] For amber only Owens pays a freight subsidy of $5 per ton for shipments from 150 miles or greater.
[37] These grades are not used by glass markets to purchase cullet. However, they reflect distinctly different types of cullet, ranging from scrap of the highest value and price to material with the lowest value and price.
[38] Grade is not currently purchased out of Portland. Typical value was no charge delivered to California.

Perspectives on Individual Markets

When recovered glass cullet leaves a processor in Portland, sometimes it goes directly to an end-use market, and in other cases it is delivered to an out-of-state intermediate processor. To capture both these situations, intermediate processors of three-color mixed cullet are discussed first, then end-use markets that produce container glass, fiberglass, abrasive and aggregate/fill/filtration.

Three-Color Mixed Cullet

Intermediate Processors of Glass from Pilot Programs

- Strategic Materials, San Leandro, California processes mixed glass for container and fiberglass markets. They produce a beneficiated fine-grind cullet for fiberglass manufacturers and a three-color mixed cullet for Gallo (which does its own beneficiation). They have developed a purchase agreement with a Portland processor for three-color mix to include the full three-color. They prefer and pay more for three-color mix if it still includes all the glass collected, because it contains a higher ratio of usable glass to residue (consisting of fines and garbage).
- Recycle America in Seattle processes mixed glass from Waste Management's Pacific Northwest facilities for sale of color-sorted cullet, and sale of three-color mix to a mixed-color container market. They state that they have committed their three-color mix to a long-term contract, though the contract is still being finalized. Presumably, most of the Portland material goes to the three-color mix market since it has already had whole bottles removed for sale locally.

Material Quality Processes

Strategic Materials performs a quality inspection on all loads received. They have a negotiated price, but will charge a service fee for loads that contain large amounts of non-glass items. They grade loads on a 1 to 4 scale. 1 is reserved for pre-consumer material.2-3 is color-sorted material and 3-4 is three-color mix. 4 can be a rejectable load.

Market Trends, Barriers, and Opportunities

Intermediate processors are dependent on end-use markets, and their long-term viability is effected by changes in those markets. Neither of our intermediate processor contacts were optimistic about the long-term viability of any current markets for three-color mix. They both have markets now, and are both seeking more material. However, they are very reserved in their prognoses. They report that the future of markets for three-color mix are dependent on a whole variety of factors that are out of their control, including:

- Politics, i.e., California content legislation.
- Corporate sourcing decisions.
- New technologies, e.g., abrasive manufacturers, optical color sorting.
- Not-yet-built plants, e.g., the Knauf fiberglass plant.
- The trends in market share by glass food and beverage containers versus plastic and metal.

According to several sources in California, recent changes in specifications for three-color mix have caused the fine material (particle size <3/8”) to be very difficult to market. Most of these fines are now being stockpiled or landfilled. See the discussion of Gallo below.

In Southern California, Container Recovery Alliance is investing over $1 million in development of glass processing capacity, including three optical sorting machines. This could potentially flow more material to the color-separated market, leaving less from California for the three-color market.

Market Views of the Trend to Commingling
Interviewees were asked their views of the trend to more commingling and the impact on markets. These responses are reported as anecdotal.

A view was repeatedly expressed that the reason to do commingling is to avoid collection cost and that it is detrimental on the material marketing end. The market for commingled glass, factoring in costs of processing, transportation and revenues, is a cost-avoidance market versus a revenue-generating market. What the sources mean by this is that the net value for commingled glass generally does not exceed the costs.

Southern California, especially, is seeing a growth of single-stream commingling, which is producing a very low quality product. This is significant to Oregon programs, because Oregon processors sell into California-based intermediate processors and markets, and are therefore affected by these trends.

Container Glass

End-Use Markets for Glass from Pilot Programs

- Owens-Brockway in Portland purchases only color-separated cullet from various Portland sources, according to the following specifications:
  - Flint: >95% flint, <5% total of all other colors
  - Amber: >90% amber, <10% total of all other colors
  - Green: >70% green, <30% total of all other colors.
- Ball Glass in Seattle purchases color-separated material from Fibers International, which beneficiates their cullet, and which purchases material that may include some Portland-generated glass. They were not contacted for their specifications.
- There are eight glass container plants in California.
- Gallo Glass Company in Modesto purchases three-color mix from Strategic Materials and from a Pacific Northwest source, including Portland-generated material. Specifications include:
  - Size between 3/8 and 2 inches
  - <2% ceramics
  - <40% amber and <40% green.

Material Quality Processes

Owens-Brockway:

Owens conducts a visual inspection after offloading. They perform a random sample on about 10% of loads, providing reports to the supplier. They use a 1 to 10 grading system; with grade 7-8 being typical. Loads are rejected at grade 2. This occurs approximately once every couple of months. On occasion, they will audit a supplier if repeated problems arise.

Owens does their own beneficiation, while Fibers International does beneficiation for Ball Glass in Seattle. Owens states that they may have less than 1/2% residue by weight from the material received, including labels, caps, ceramics, plastics, etc.

Gallo:

Gallo first visually inspects all loads, and then they pull a 5-pound bucket of material to sort for ceramics. Though they have no grading system, charts on ceramic contaminants are provided back to suppliers.

They reject loads for several causes:

- More than 20 pieces of ceramics (approximately 1-2%) in the 5 pound sample
- Out of size range
- Too much organics (sources of carbon) or other contaminants.

When they reject loads, they pay for the freight to Gallo, and the supplier covers the return freight, except for loads rejected for size, then Gallo pays no freight charges.

Gallo does their own beneficiation. They developed the technology to grind cullet into 12-mesh size for furnace feed, which makes the furnace more tolerant of some ceramics content.

Market Trends, Barriers and Opportunities

Color-sorted glass cullet has had the least volatile pricing of all post-consumer recyclables. The demand for cullet by the container industry in Oregon exceeds the supply from Oregon. The same is true for California. Owens-Brockway's flint glass is now 48-50% recycled cullet. Their goal is 75%+.

The California demand for cullet has several uncertain and destabilizing forces. Demand is largely driven by the content law, which now stands at 35% for containers (and 30% for fiberglass). Two years ago, the requirements were capped at the 35% rate; they previously were on a ramp up to 65%.

Bills have been introduced to lower the content rate. One bill, SB 322, is currently under consideration that would reduce the content rate to 25% for facilities that use mixed-color cullet. This provision would effect primarily Gallo. It was passed last year, but the bill of which it was part was vetoed by the Governor. Even if adopted, the demand for recycled glass containers, even mixed-color cullet, should remain strong.

Gallo pioneered the use of three-color-mix for wine bottles to meet the content law using less expensive mixed-color cullet. There has been a shortage of usable material and Gallo has sourced out of Mexico and Arizona. Recently, several curbside programs have converted to single stream, resulting in a much dirtier three-color mix. In 1997, Gallo experienced furnace upsets, and traced it to the presence of organics, with carbon upsetting the furnace chemistry. They responded by tightening their quality specifications to reduce contamination. They now do not accept 3/8" minus material, which serves to exclude most organics.

Upon changing the spec, they increased their price from $35/ton to $40/ton. However, this more rigorous spec has added costs to processors and created a glut of fines in California.

Last year, the California Department of Conservation (DOC) fined Gallo for failing to meet the 35% content requirement. The case is now being contested. Gallo intends to begin purchasing color-sorted flint in February (at $70/ton versus $40 for three-color mix).

Gallo claims to be seeking three-color mix wherever it can be found. They are now purchasing a considerable amount of material from the Pacific Northwest.

Gallo states the need for 170,000 tons annually with 5 furnaces now operating. The most they have purchased is 110,000 tons, including sources that they no longer have. They have been working down a stockpile. The gap for future sourcing appears to be at least 60,000 tons per year.

Their need to find additional supply may lead them to source further afield and/or to revise their specifications. In addition, more color sorting capacity in Southern California may direct three-color cullet away from Gallo. Since the dirty condition of LA single-stream material has presented some of the major problems for Gallo, this could increase their demand for material from the north.

Gallo claimed that earlier they had attempted to source from Portland, however, none of the Portland processors were able to meet their specifications (2-inch minus material).

Several factors make the prognosis for three-color mix markets in California uncertain:

- The fate of content requirements. Some have made the case that California could reduce their requirements if meeting them requires out-of-state sourcing.
- Gallo's response to the DOC lawsuit.
- Gallo's uncertain future specifications and sourcing strategies.

In addition, a new fiberglass plant is going into Northern California in the next year. This plant is expected to draw three-color mix material (apparently primarily through Strategic Materials) from the Pacific Northwest.

At present, there is a strong demand for three-color mix that local processors could take advantage of.

Market Views of the Trend to Commingle

Interviewees were asked their views of the trend to more commingling and the impact on markets. These responses are reported as anecdotal.

- The supply of flint is reported to be decreasing relative to other colors. It has been estimated that 10% of the flint is lost due to commingling. Generally, the future supply of color-sorted cullet is a worry to glass container markets because commingling, at the best, reduces the supply by 15-40%, and at the worst diverts it all to a color-mixed use.
- Several stated that they believe commingling decreases the quantity and quality of the cullet supply. Even color-mix consumers are concerned about degrading quality and the uncertain status of consumers of the low-grade materials.

Fiberglass

Since Portland material was not reported to be sold directly to fiberglass manufacturers, none were interviewed directly. The following information therefore has come indirectly.

End Users

- There are three consuming plants in California – Johns Manville in Willows, Owens Corning in Santa Clara, and Certainteed in Chowchilla.
- A new plant by Knauf is in the permit phase near Redding, California. Supply lines for this plant are not clear, but it is expected to increase demand from the Pacific Northwest.
- A plant in Alberta has only rarely taken material from Oregon.

Material Quality Issues

Fiberglass manufacturing is somewhat less tolerant of contaminants than container manufacturing. Generally, it competes for material comparable to the Gallo three-color mix. However, it is less tolerant for amber cullet. Furnace-ready material must be quite clean.

Market Trends, Barriers and Opportunities

California content requirements currently stand at 30% for fiberglass, so all California plants are using secondary cullet. Most fiberglass plants use 3rd-party beneficiation. Strategic Materials performs beneficiation for some plants. This includes grinding material to a 12-mesh size, essentially the size of sand.

The continued demand for secondary cullet by fiberglass manufacturers would be expected to continue as long as the content requirements are held up. Last year one fiberglass manufacturer, Johns Manville in Willow, California, was cited for failure to meet the content specification. The citation is currently being negotiated. If Gallo is able to receive from the legislature a lowered content requirement to 25% for use of mixed cullet, then it is conceivable that fiberglass manufacturers could ask for the same.

Abrasives

Since none of the Portland processors reported direct sales to abrasive markets, they were not pursued aggressively. However, we were referred to one company, which at some future time may play a role in the region.

End Users

Only one user was referenced by the Portland processors - TriVitro in Seattle, which is now in developmental mode, taking only 200-300 tpm, apparently none directly from Portland, though some may pass through Recycle America.

Market Trends, Barriers and Opportunities

Sandblasting grit must meet high-quality specifications, and processing costs can be $40-50/ton. However, the grit competes with $80-120/ton virgin materials. Glass has been demonstrated by studies to have good abrasive qualities. It has superior performance over sand relative to worker safety. During sandblasting, sand sheds silicon into the air, which can cause silicosis, while in glass the silicon is not volatile.

TriVitro reports that a much larger potential market remains to be tapped for recycled glass as an abrasive grit. However, its plan for expansion faces the traditional resistance to a new recycled product.

The price they pay for three-color mixed cullet is now $0.

Market Views of the Trend to Commingle

Commingling produces a dirtier mix, increasing processing costs to meet very high product specifications. Meeting high-end product specifications is more difficult and costly from a dirtier feedstock than from a cleaner feedstock, because more processing is required.

Aggregate/Fill/Filtration

None of these uses were reported for Portland material. However, the option exists and most likely some mixed cullet has been, or is being, used for fill or aggregate. After shipping to an intermediate processor, it is likely that some Portland material is being thus used.

INTERVIEWEES

1. Eric Kinstler, Owens-Brockway
2. Mike Centers, Strategic Materials
3. Don Zimmerman, Recycle America
4. Fred Miller, TriVitro
5. Bob Kirby, Clean Washington Center
6. Steve Storable, California Integrated Waste Management Board
7. Bernie Meyerson, California recyclables marketing consultant
8. Jim Hill, Recycling Specialist, California Department of Conservation
9. Larry Martin, VP Govt. Affairs, Gallo
10. Steve Nicolai, Purchasing Manager, Gallo

Recycled Fiber Markets

SUMMARY

This section discusses both old newspapers (ONP) and mixed waste paper (MWP), since the issues for the two grades are similar and, in fact, increasingly intertwined. As with glass, the processors and end users are facing increasing commingling and a dirtier feedstock. This affects the quality of the final product, in particular the brightness, sheet integrity and dirt count of the newsprint. Of course, many other factors effect final product quality, especially the capabilities of the technology used by the mill.

In response to the dirtier feedstock, mills are:

- Tightening quality control systems
- Adjusting their processes, and/or
- Adjusting their specifications to accept a mixed material.

Most of the traditional mills are very concerned what the impact might be on their operations if Seattle and Portland areas convert to commingled collections. Some, however, have stepped into the breach to position themselves squarely to take advantage of these changes. Since the Pacific Northwest is traditionally a market for #8 recycled old newspapers, drawing material from well outside the region, we are at the heart of the transition.

In fiber, processors have a greater ability than in glass to upgrade material without a substantial loss to low-value uses. Here it is a matter of making the investment to do so. However, since the newsprint market is flat, that is, demand is not growing, such investments are slow to be made.

In the meantime, end users are developing new alternatives for use of mixed residential fiber in newsprint manufacturing. The Abitibi mill in Steilacoom, Washington has done so, and overseas mills are apparently in the process of doing so.

The basis for grading recycled paper is the “Scrap Specifications Circular 1998”, published annually by Paper Stock Industries, a National Chapter of the Institute of Scrap Recycling Industries (ISRI). The definitions for grades of significance to this study are summarized below. The definition for #8 deink quality ONP is quite strict, allowing less than ¼ of 1% outthrows. Outthrows include anything that is not delivered with the newspaper. However, it is reported that in practice, not all outthrows are equal. For example, the presence of brown grades may be enforced more strictly than white paper. Also, different mills are reported to exercise different degrees of strictness in enforcing the specifications.

In addition, some mills establish their own grade specifications. These are business and operational decisions.

Table M-3, Fiber Marketability

TABLE M-3 FIBER MARKETABILITY ISSUES					
Material	**Current Price**	**Price Stability**	**Location of Buyers**	**Reported Demand**	**Market Vulnerability**
#8 ONP	$40-45/ton (OBM 12/26), but an upward trend and now more like $50-60	Very volatile – in past 5 years has ranged from $10 to $225	5 Pacific Northwest mills	Demand in Pacific Northwest exceeds supply	Solid local consumers
#6 ONP	$15-20/ton (OBM 12/26), also has trended upward	Very volatile, generally parallel to #8 ONP price	Some Pacific Northwest buyers, most sold overseas	Varies according to overseas demand and price of #8 ONP	Dependent on overseas markets and specialty uses, therefore unreliable
Mixed Recycled Waste[39]	Approximately 50% of #8 ONP price, also adjusted according to export prices.	Generally parallel to #8 ONP price	Steilacoom, WA	One mill only in Pacific Northwest	Recently established, but apparently reliable local demand; growth opportunities possible for this grade
Mixed Waste Paper	$10-15/ton (OBM 12/26), but has trended upward to $25-30 dockside	Variable with export demand and prices	Brokerage into overseas markets	Variable but growing	Dependent on overseas markets and specialty uses, therefore unreliable

[39] This is a mill grade specified by Abitibi, Steilacoom, WA.

PERSPECTIVES ON INDIVIDUAL MARKETS

ONP Grades

The following grades are defined according to Institute of Scrap Recycling Industries specifications.

- #8: Processed old news containing what is received in delivered newspaper (i.e., including inserts), deink quality, allowing no prohibitives and less than ¼ of 1% outthrows.
- #7: Similar to the definition for #8, but including magazines
- #6: Curbside quality but without mixed paper, allowing 1% prohibitives and 5% outthrows.

Following is an Abitibi mill-defined grade.

- Mixed Recycled Waste (MRW): ONP off a curbside route containing mixed paper, but 2% or less brown grades and 1% or less outthrows. The grade does not accept gable top cartons, old telephone directories or books with glue bindings.

End Users of ONP and Mixed Paper Identified by the Pilot Programs

- Jefferson Smurfit mills in Oregon City and Newberg
  - Purchase: #8 ONP
  - Product: Variable recycled content newsprint
- Weyerhaeuser Quality Sort Center in Portland, which is an aggregation point for the Weyerhaeuser Longview mill
  - Purchase: #8 ONP
  - Product: Variable recycled content newsprint
- Daishowa in Port Angeles, WA
  - Purchase: #8 ONP
  - Product: 50% recycled content directory paper
- Abitibi in Steilacoom, WA
  - Purchase: Mixed Recycled Waste (MRW)
  - Product: 40% recycled content newsprint and specialty papers, e.g., construction grades, inserts, colored writing papers
- Recycle America in Seattle (formerly staff of PRI)
  - Purchase: #8, #6 & Mixed Recycled Waste ONP
  - Export to Asia
- American Chung-Nam
  - Purchase: #9 (over-issue), #8 & #6 ONP
  - Export to Asia

Material Quality Issues

Several interviewees report that the quality of their supply has been decreasing in recent years, because collection systems are digging deeper into the waste stream. One buyer even

claimed that the material he receives out of Portland is amongst the dirtiest. At the same time, the mill's customer demands for quality, especially brightness, dirt count and sheet integrity, have been increasing. Overall newsprint demand is flat, making it difficult to invest in new cleaning equipment. Therefore, the mills are finding it increasingly difficult to bridge the quality gap.

Different mills use very different quality control systems. They range from breaking open one or two bales on every load and sampling, to load inspections on an "as needed" basis. Some use an A/B/C grading system. For example, one mill would break and sort a bale[40] from each load, assigning grades as follows:

- A = <8 pounds of prohibitives and outthrows.
- B = 8 to 30 pounds of prohibitives and outthrows.
- C = >30 pounds of prohibitives and outthrows, with a deduction of $5/ton.

Others stated that they consider a grading system counterproductive. They generally provide verbal or quantitative feedback, however. Notably, increased contamination in loads is driving most to tighten their standards and adopt more rigorous quality inspection systems.

Most buyers have programs where they work with their suppliers to improve quality. This often includes supplier audits. They commonly cut off or blacklist suppliers who, following repeated efforts to get improvement, cannot meet their specifications.

Some buyers reject loads, while others downgrade or deduct a fee. None do a significant amount of manual sorting. The only reported processing that is done at the mill to improve material quality was at Abitibi.

All buyers concur that glass in the fiber is the most significant problem. However, this is primarily a problem arising from single-stream material. None of the Portland-area programs propose to mix glass with the fiber stream. The problem applies equally to mixed paper as to ONP, since overseas mills often manually high grade the material, creating a safety hazard if glass is present.

Market Trends, Barriers and Opportunities

Demand growth for newsprint in North America is expected to be minimal or negative for the foreseeable future. Generally, additional newsprint capacity is not expected to be built in the near term. However, conversion to consumption of new or different grades is a possible trend.

Most Pacific Northwest mills rely on #8 ONP. This high-quality grade of ONP minimizes the mills' costs and enhances product quality. They often target customer markets that are very demanding of high quality. However, grade flexibility occurs when price or availability so dictates.

Mills and mill suppliers have reported that they are under increasing pressure to produce an every higher quality product in the global trading system. For example, traditionally newssheet standards for brightness have been higher in the East than West, a historical result of differences in virgin feedstocks. However, newspapers that are distributed nationally, but

[40] Bale weights vary considerably, from 1000 to over 1700 lbs., depending on the baler and other conditions. Therefore it is difficult to translate these weights into percentages as defined in grade specifications. But in any case they appear to exceed the specifications for #8.

printed on separate coasts, are applying pressure to increase brightness in the Western sheet. These types of factors place pressure on mills to tighten their purchasing quality specifications.

The Abitibi mill in Steilacoom, Washington has been consuming a mixed recycled waste (MRW) grade of ONP (defined on prior page) for two years. It specifically designed its process to consume material as it is coming out of residential collection programs, with certain exclusions, and to provide the most efficiently handled stream from curb to pulper.

Their mill is designed to take the full residential mixed fiber stream, with the exception of brown grades, polycoated gable tops, and glue bound book grades. They do some pre-processing of the material to remove fines and other contaminants.

When an ONP grade is produced for Abitibi, chipboard and boxboard must be removed to below the 2% specification. This brown material is often pulled and included with old corrugated cardboard (OCC), though it reduces the quality of that material. Sellers of OCC must know the content of their pack so that they can sell into the appropriate mill. Depending on the mill's end product, different OCC mills are more or less tolerant of other brown grades.

Alternatively, overseas buyers of ONP are generally more tolerant of the presence of brown grades. Overseas mills, especially in China, are actively buying different grades of mixed waste paper, providing considerable flexibility for processors. They have recently tightened down on the presence of garbage in the paper bales, however, following incidents of medical waste being shipped to China. But, with sophisticated mill technology and manual sorting operations, they are able to consume many of the mixed grades that cannot be sold domestically.

The presence of polycoated paperboard in the mixed paper can present a problem, since it is not welcome in the Abitibi grade, nor in OCC. Markets for this grade are very limited, and storage at the processing facility to generate a full truck load can present a problem.

There is also some advance in cleaning operations in Korea to upgrade #6, or possibly other mixed grades, to #8 for deink newsprint. The Asian market is expected to be strong for consumption of deink newsprint and mixed grades. At present, offshore deink prices (recently rising to $70/ton on the pier) are pushing on domestic prices. But, of course, here in the Pacific Northwest with disadvantageous shipping costs and a strong local demand, domestic consumers will be the mainstay.

The question seems to break down to two issues that will affect the viability of marketing fiber locally that is collected in a commingled form:

1) The added cost of cleaning up commingled fiber streams. Can savings in the costs of collection cover these costs? Will they be borne by the market? In good times, possibly, but prices now do not support additional investments. Or will an added cost get charged back to the generator through higher service fees?

2) The ability of mixed ONP fiber consumption capacity to expand parallel with the expansion of commingled collection systems, while meeting demanding customer requirements. Such changes are slow to be realized, but substantial movement seems to be happening both in technology and new mind-sets.

The other side of this issue is that in-place mill technology is, in some cases, not adequate to handle the contamination being delivered, and the quality of the product has been degraded. This can put in doubt the viability of a mill that relies on older technology.

Market Views of the Trend to Commingling

- Commingled recycling is frequently pointed to as a cause of the declining quality of ONP supply. Indeed as single-stream and other aggressively commingled systems are expanded, a new and poorer grade of ONP is being delivered to mills. However, a primary concern expressed by #8 ONP consumers is the quality of processing to produce their grade. Problems with suppliers are generally believed to arise from processing factors (e.g., too few sorters, belt load too deep, or belt speed too fast) rather than the collection mode.
- There is increasing recognition that commingling is here to stay, and that, like it or not, mills will have to live with it. With good processing, a good quality product can be produced. The exception is if glass were to be mixed with paper during collection, not a likely factor for the collections systems studied here.
- Abitibi, and apparently some overseas deink consumers, have recognized the market reality of commingled curbside recycling and are working to demonstrate the feasibility of newsprint production from a nearly-off-the-truck mixed residential fiber stream.

INTERVIEWEES

1. Les Joel, Deink Plant Superintendent, Smurfit Newsprint Corp., Oregon City
2. Ray Peterson, Daishowa
3. Andy Rivinus, Manager, Quality Sort Center, Weyerhaeuser
4. Craig Fletcher, Fiber and Transportation Procurement Manager, Abitibi Consolidated Sales
5. Robes Nelson, VP, Pacific Forest Resources
6. Heidi Zimmerman, Recycle America
7. Susan Huang, American Chung-Nam

Other Recycled Material Markets

SUMMARY

Two other primary curbside materials – plastics and tin-plated cans - were looked at briefly to identify potential marketability issues from commingling.

PERSPECTIVES ON INDIVIDUAL MARKETS

Plastics

Processing and marketing mixed plastics revolves around milk jugs, since natural HDPE is the primary source of revenue from scrap plastics. The material out of Portland area curbside programs consists of approximately 70% natural HDPE, 20% PET and 10% colored HDPE, called a 70/20/10 mix.

The plastics recycling facility (PRF) at Garten Services was established to use optical sorting technology to separate the different resins from a mixed-resin material collected primarily in curbside programs. Some of the local processors sell their 70/20/10 material directly overseas, others separate off some milk jugs for sale, and others send the whole mix through Garten. Garten's prices vary according to the amount of natural HDPE that is in the load, but they generally involve a tip fee for delivered material. Recycled resin prices are at an all-time low. Garten grades loads based on the processed weights of each plastic resin.

Out of the processing system, they have about an 8-12% reject rate, though they are installing a new system with the intent of reducing that to 6-7%. They handle each load separately, screen off the small-sized material, and manually sort off garbage.

The desire to recycle several plastic grades at the curb, beyond the more traditional milk jug-only program, nearly necessitates commingling of plastics. It was in response to the growth of this commingled plastic stream that the Garten PRF was built.

Tin-Plated Steel Cans

Though different systems process ferrous metals differently, no substantial problems arise due to the mode of collection. Magnetic separation systems are able to produce a clean material from a commingled stream. However, some processors produce a material that is less clean than others, and in some cases, loads are rejected. This is apparently more directly a function of processing systems than of the collection mode.

Though tin cans are no longer processed in the Pacific Northwest, ferrous metals are commonly transported long distances. AMG buys the material from the Portland processing facilities, and bales are transloaded for shipping to Lathrop or Gary, Indiana.

INTERVIEWEES

1. Jack Force, AMG
2. John Matthews, Garten Foundation

Summary

Introduction

In this section, information and observations on the collection, processing and marketing aspects of the four commingled residential recycling pilot projects are integrated and summarized. The summary brings together material from the previous sections of this report, with a priority focus on newspaper and glass. By weight, newspaper is the largest portion of the material stream picked up curbside. Glass received extra emphasis throughout the study because of concerns about how various forms of commingling would impact its marketability.

The summary is organized around six questions that define the scope and objectives of this study:

1. How is the market quality of recyclables, especially glass and old newspapers, affected by different sorting requirements for curbside recycling collection programs?
2. What is the level of cross-contamination during collection and after processing (amount of recyclable material that is in the wrong place)?
3. What are the effects of handling and equipment during collection and processing on separation efficiency and quality of recycled materials?
4. What is the separation efficiency of the recyclables (percentage of an incoming recyclable that is sorted out on the processing line and marketed as that specific material)?
5. What is the quantity and composition of residue from the different operations?
6. What are the productivity measures for collection and processing of the different commingled sorts?

The six issues explore various facets of the study's central purpose---to examine and document the impact of different approaches to commingling on materials marketability. The discussion of each issue is presented through narrative text and tables/charts.

It is not intended that one set of data, information and observations from a given pilot project be directly compared to those from another for purposes of determining the best approach to commingled residential recycling. As noted in numerous places throughout the report, there are many circumstances and conditions unique to each pilot effort that, given the short time frame of the study, would make unqualified comparisons difficult and inadvisable. These distinct circumstances and conditions are present in the collection, processing, and marketing phases of all the pilots.

Given such operational variables, the information summary does put forth a snapshot picture of the separate pilots. It shows their performance within a brief observation period relative to the issues of handling, equipment, productivity and efficiency in both collection and processing, and includes residue levels, cross-contamination and material quality.

The following tables give a material characterization of each of the four pilot sorts and the two mixed-container loads that were processed and tested. The percentages refer to the total collected materials from the single route.

Composition of Pilot Project Recyclables After Processing

Route	ONP	MWP	OCC	Mags	Tin Cans	Alum inum	Clear Glass	Green Glass	Brown Glass	MRF Residue Glass	Plastic	Scrap Metal	Residue	Total
2 Sort (All fiber/All containers)	26.5%	50.0%	10.2%		2.5%	0.3%	3.6%	2.8%	1.1%	1.7%	0.8%	0.3%	0.2%	100%
3 Sort	44.9%	30.6%	7.9%		3.2%	1.3%	2.9%	1.6%	0.6%	1.9%	2.9%	0.8%	1.4%	100%
2 Sort (All glass/All Fiber & other containers)	64.6%	16.8%	5.8%	1.7%	1.9%	0.1%	0.4%	1.2%[41]	0.0%	5.6%	1.9%	Other fiber 1.8%	0.03%	100%
5 sort	59.8%	20.0%	6.3%		2.4%	.02%	3.8%	4.5%[41]	0.0%	0.0%	2.4%	0.4%	0.4%	100%

Composition of Off-loaded Drop Box and Single Route

Route	Tin Cans	Alumin um	Clear Glass	Green Glass	Brown Glass	MRF Residue Glass	Plastic	Scrap Metal	Residue	Total
Off-loaded Drop Box	20.5%	1.2%	14.1%	25.3%[41]	0.0%	24.1%	11.7%	1.7%	1.3%	100%
Single Route	20.6%	0.7%	21.3%	21.3%[41]	0.0%	17.7%	10.4%	5.6%	0.2%	100%

NOTICE: These percentages represent the total containers collected, not including fiber.

[41] This glass is a green/brown mix.

Summary Issues

1. How is the market quality of recyclables, especially glass and old newspapers, affected by different sorting requirements for curbside recycling collection programs?

Glass

Color-separated glass, regardless of degree of breakage, has a local container market. If a goal of a collection and processing system is to attain as much color-separated glass as possible, then the information here can help determine the methodology. The act of commingling glass creates additional material streams, either MRF residue glass or clean 3-color mixed cullet. These names denote the materials that are left over after larger pieces of glass have been color-separated. MRF residue glass results from processing a mixed container input stream. Clean 3-color mixed cullet is the small pieces of glass that result from processing a mixed-glass only collection. The following information shows that these materials also have regional and California markets - container, fiberglass, aggregate or beneficial fill.

Commingling glass with other containers creates, after color-sorting, another material called MRF (materials recovery facility) residue glass. This material has no current market demand by itself without further processing to remove residue and fines (glass < than 3/8 inch). The percentages associated with MRF processed glass were directly measured at the processing facility. However, the percentages associated with the flow of MRF residue glass are derived, not calculated. The formula for derivation has been applied equally to the pilots that market this material mix. The processors reported that screening the MRF residue glass below 3/8 inch results in approximately 25% residue with a 75% recovery rate for this material. Therefore, the percent that was sorted as residue was divided; approximately one-fourth of the material is categorized as residue and three-fourths as usable material. For example, in the 2-sort (all fiber/all containers), the MRF residue glass represents 18.2% of the glass processed. Therefore, 4.6% of the glass, or one-quarter of 18.2%, falls in this residue fines classification of material. In the pilot routes that were monitored for this project, between 18.2% and 38.0% of glass ended up as MRF residue glass.

The data for the 2-sort (All glass/All fiber & other containers) collection of mixed-color glass were calculated from 8 days of collection of the pilot route. The glass-only collection created more broken glass than the mixed container collections. The presence of other containers within the mix offers some cushioning effect during loading and unloading. However, the all-glass collection generates a cleaner mixed-glass cullet after processing. The market information available on the recovery rate for a clean 3-color mixed cullet indicates that almost all of it could be marketable as containers or fiberglass. The percentages used in the table below reflect this assumption.

The 5-sort route that was studied collected glass in a two-color stream. These materials required no color-sorting before going to market. One sorter removed minimal contamination from the collected material. Therefore, these products went directly to the local container market. This market reports that 99.5% of the incoming material is usable.

Off-loading mixed containers (loading and unloading multiple times) creates substantially higher glass breakage (38%) than direct unloading from a collection vehicle (18% - 29%). This material stream from a mixed container collection is a 3-color mix glass product with no glass removed by color sorting. It can include up to 5% residue.

The following is a percentage breakdown of total glass collected and the path it takes to markets. The percentage delineation for MRF residue glass is defined above and is based on the market averages listed in the Markets section on Table M-1.

Materials Flow for Glass

Route	Collection Mix	MRF Processed	Intermediate Processing	Market	Location	Percent of Glass	Percent of Total Recyclables
2-sort	Mixed containers	Color sorted, 81.8%	None	Container	Portland	81.8%	7.5%
		MRF residue glass 18.2%	Color-sorted >2”	Container	Seattle	6.1%	0.6%
			3-color Mix A[42]	Wine bottles	California	7.5%	0.7%
			Residue Fines	Beneficial use/Landfill	Seattle	4.6%	0.4%
3-sort	Mixed containers	Color sorted 72.7%	None	Container	Portland	72.7%	5.1%
		MRF residue glass 27.3%	Color- sorted >2”	Container	Seattle	5.7%	0.4%
			3-color Mix A[42]	Wine bottles	California	14.8%	1.0%
			Residue fines	Beneficial use/Landfill	Seattle, Pacific NW	6.8%	0.5%
2-sort	All glass	Color sorted 21.9%	None	Container, Fiberglass & wine bottles	Portland	21.9%	1.8%
		3-color Mix B[42] 78.1%	3-color Mix A[42]	Fiberglass & wine bottles	California	77.1%	6.4%
			Residue Fines	Landfill	California, Pacific NW	<1%	0.1%
5-sort	Color sorted	None	None	Container	Portland	99.0%	8.2%
			Residue Fines	Landfill	Portland	<1.0%	0.1%
Offloaded drop box	Mixed Containers	Color sorted 62% / MRF residue glass 38% — 3-color Mix B[42]	3-color Mix A[42]	Containers, Fiberglass	California	90.5%	N/A
			Residue Fines	Beneficial use/Landfill	California	9.5%	N/A
Single route	Mixed containers	Color sorted 70.6% / MRF residue glass 29.4% — 3-color Mix B[42]	3-color Mix A[42]	Containers & Fiberglass	California	92.7%	N/A
			Residue fines	Beneficial use/Landfill	California	7.3%	N/A

Newspaper

Some of the tested pilot sorts in this project collected newspaper separate from other fibers. This did not eliminate the need for processing the material, but did improve the quality of the resulting material. Separating newspaper in the collection process can increase the purity of the newspaper by approximately 4 percentage points. The 2-sort (All fiber/all containers) and the 3-sort have a high percentage of newspaper in the mixed waste paper due to unique market specifications. None of the marketed newspaper grades, from either source-separated

[42] These mix grades (A and B) are defined in the glossary.

or commingled fiber pilots, met the strict deinking grade specification that limits contamination to less than 1.25%. However, it should be noted that the non-newspaper fiber found in all of these tests did not include any brown paper (cardboard or kraft paper) nor any gray paper packaging (boxboard), which would be considered major contaminants by newsprint mills.

This table tracks newspaper from the pilot routes through processing to markets. Listed are the percentages that newspaper represents of total collected fiber. The processed streams of fiber were sampled and tested to determine the percent of newspaper contained in the outgoing material stream.

Source and Flow of Newspaper

Sort	Material Processed	Percent of Total Fiber	Percent Newspaper	Sold As	Location of Market	End Use
2-Sort (All Fiber/All containers)						
Mixed Fiber	Newspaper	30.5%	95%	Deink News	Pacific NW	News
	Mixed Waste Paper	57.5%	45.3%	Mixed Recycled Waste	Pacific NW Overseas	News
3-Sort						
Old Newspaper	Newspaper	35.4%	98.9%	Deink News	Pacific NW	News
Mixed Fiber	Newspaper	18.1%	93.3%	Deink News	Pacific NW	News
	Mixed Waste Paper	35.4%	61.3%	Mixed Recycled Waste	Pacific NW Overseas	News
2-Sort (All glass/All fiber & other containers)						
Mixed Fiber & other Containers	Newspaper	72.6%	94.7%	Deink News	Pacific NW	News
	Mixed Waste Paper	18.9%	4.3%	Mixed Waste Paper	Overseas	N/A
5-Sort						
Old Newspaper & Magazines	Newspaper	69.5%	94.2%	Deink News	Pacific NW	News
	Mixed Waste Paper	16.9%	10.7%	Mixed Waste Paper	Overseas	N/A

2. What is the level of cross-contamination during collection and after processing (amount of recyclable material that is in the wrong place)?

Cross-contamination totals were calculated by finding all recyclable materials within a given stream that were in the wrong place. For example, in a 2-sort that required all containers to be collected in a single compartment on the truck, any tin cans that were found in the fiber sorting process would be listed as cross-contamination. In one pilot study, the design of the truck was a source of cross-contamination. The 3-sort route was collected in a trough loader. When each of the three sections was unloaded at the processing facility, some of the material was caught on the inside of the truck compartment. This residual was pushed out by emptying the next compartment, causing some contamination of the mixed fiber (the second compartment) and the mixed containers (the third compartment).

In the following chart, each collected material stream has a cross-contamination level based on how much recyclable material is found in the wrong compartment on the truck. With the exception of the 3-sort mixed fiber compartment, cross-contamination was minimal. There

are many possible reasons for the high newspaper content in the mixed fibers with the 3-sort. For example, the markets used for this processor allow for a high percentage of newspaper in with mixed paper. The driver would use discretion for placement of fiber in the truck on route.

Cross-contamination After Collection

Route	Collected Mix	Percent Cross contamination	Contents
2-Sort (All fiber/All containers)			
	Fiber	0.4%	Tin cans
	Containers	1.0%	Mixed fiber
3-Sort(ONP/Mixed fiber/All containers)			
	ONP	4.0%	Plastic bottles, glass, MWP
	Mixed fiber	50.4%	ONP, plastic bottles
	Containers	0.1%	OCC
2-Sort (All glass/All fiber & other containers)			
	All fiber & other containers	0.09%	Glass
	Glass	N/A	
5-Sort			
	ONP	8.0%	MWP, Tin cans
	Mixed fiber	7.1%	ONP
	Tin/plastic	6.0%	Glass, Kraft paper

Levels of contamination were calculated again after processing. Cross-contamination percentages are listed below by pilot sort. The numbers are based on samples taken of the newspaper (ONP) and the mixed waste paper (MWP) after they were processed. The 3-sort pilot has two numbers listed for cross-contamination in ONP. The first of these numbers comes from the test of the processed newspaper from the all-newspaper stream. The second one comes from the processed newspaper from the mixed fiber stream. It should be noted that the mixed waste paper found in the newspaper samples did not include any brown paper (cardboard or kraft paper) nor any gray (boxboard).

Cross-contamination After Processing

Route	Percent Cross-contamination in ONP	Contents	Percent Cross-contamination in MWP	Contents
2-Sort (All fiber/All containers)	4.9%	MWP	46.5%	ONP & OCC
3-Sort	1.1% & 6.7%	MWP	66.3%	ONP & OCC
2-Sort (All glass/All fiber & other containers)	5.3%	MWP	23%	Office pack, ONP, OCC
5-Sort	0.7%	MWP	17.7%	ONP & OCC

3. What are the effects of handling and equipment during collection and processing on separation efficiency and quality of recycled materials?

Glass

Increased handling of glass causes breakage. However, types of handling have varying degrees of impact. Trough loaders dump the side troughs into the truck compartment when any one of the material troughs is full. The truck used to collect the 3-sort route emptied the troughs on average about every 8 stops on the monitored route. This act of pouring mixed

containers on top of other mixed containers results in a higher percentage of glass breakage than compacting similar loads of mixed containers. The 2-Sort (All fiber/all container) and the 3-sort collections mixed the containers identically curbside and were processed at the same facility. The percentage of MRF residue glass is significantly higher with the load collected in the trough loader than with the compacted sort. These numbers are noted in the above table, Materials Flow for Glass. Glass breakage also occurred during unloading of the trough loader. The containers are collected in the compartment closest to the cab of the truck. Therefore, when the truck is raised for unloading, the three-compartment trough loader dumped mixed containers from a height nearly equal to the length of the truck. Glass and metal fell out of the truck first onto the facility floor and plastic came out on top. Nothing offered a cushion to the cascading glass. The compactor truck used for the 2-sort (all fiber/all containers) stored materials in two compartments that each ran the length of the truck. Therefore, unloading a compactor releases material close to the ground. Enough metal and plastic comes out early in the unloading process to offer a bit of cushioning for the remaining material.

Collecting isolated but mixed-color glass and dumping this into drop boxes increases the amount of total glass breakage. This was the tested collection for the 2-sort (all glass/all fiber & non-glass containers) mix. This glass collection was done in a small trough loader. There are no materials in the box to cushion each load of glass as it is deposited. The material in the trough was unloaded regularly during the route. At the end of the route, the compartment was unloaded at the facility. Then, other similar loads were unloaded on top of it throughout the weeks of collection causing additional breakage. Glass breakage also occurred at the processing facility during offloading. The monitored load contained minimal contaminants and residue. These numbers are listed in the chart above, Materials Flow for Glass.

Fiber

Water content causes problems and delays in processing all kinds of fiber. Collecting materials in an enclosed truck, such as a compactor, can minimize additional water content. However, compacting already wet fiber can increase clumping of the material. A variety of techniques are used to break clumped fiber apart. Some processing facilities have a long sorting belt with waterfalls, others shake and separate material with a front-end loader as it feeds the belt, and others stop the belt to manually separate clumps. All of these methods resulted in similar levels of purity for bales of newspaper.

In general, positively sorted materials are cleaner than negatively sorted materials. However, a processor can choose to invest in technology and manpower to obtain a quality material stream. For example, the 2-sort (all fiber and non-glass container) mix processed newspaper as a negative sort and met or exceeded the market specifications. This same example shows that separating newspaper at collection is not a necessary condition for high-grade output. Markets help determine the investment a processor will make.

See the chart above, Source and Flow of Newspaper, for material tracking information.

4. What is the separation efficiency of the recyclables (percentage of an incoming recyclable that is sorted out on the processing line and marketed as that specific material)?

The following chart tracks the amount of newspaper that is collected on each pilot route and the percentage of that material that is marketed as such. It should be noted, as highlighted in the Table M-3 above, that the market used by the processor for the 2-sort (All fiber/all containers) and for the 3-sort has specifications for a mixed waste paper grade that includes a high percentage of newspaper. This resulting material mix goes to a newsprint market.

Overview of Processing Results for Newspaper

Route	Commingled definition	Percent Newspaper marketed as Newspaper	Percent Newspaper marketed as Mixed waste paper	Percent as residue	Person hours/ton to process
2-Sort	(1)All Fiber (2)All Containers	52.7%	47.3%[43]	0%	0.85 Hrs
3-Sort	(1)Newspaper (2)Other Fiber (3)All Containers	70.5%	29.5%[43]	0%	1.00 Hrs
2-Sort	(1)All Fiber & non glass containers (2)Mixed Glass	98.8%	1.2%	0%	0.90 Hrs
5-Sort	(1)Newspaper (2)Other Fiber (3)Tin/plastic (4)Clear Glass (5)Other Glass	97.2%	2.8%	0%	0.72 Hrs

[43] This material is marketed as Mixed Recycled Waste, which is used by the mill in newsprint production.

The second chart tracks the amount of glass that flows from curbside collection to market. This chart summarizes the amount of incoming glass that is processed into color-separated streams and sent to a container market. It also lists the amount of glass that ends up as MRF residue glass and the amount that is disposed as residue.

Overview of Processing Results for Glass

Route	Commingled definition	% marketed as Color separated	% marketed as MRF residue glass	% as residue	Person hours/ton to process
2-Sort	(1)All Fiber (2)All Containers	81.8%	13.6%	4.6%	2.47 Hrs
3-Sort	(1)Newspaper (2)Other Fiber (3)All Containers	72.7%	20.5%	6.8%	2.84 Hrs
2-Sort	(1)All Fiber & non glass containers (2)Mixed Glass	21.9%	77.1%	<1%	0.27 Hrs
5-sort	(1)Newspaper (2)Other Fiber (3)Tin/plastic (4)Clear Glass (5)Other Glass	99.0%	0%	<1.0%	0
Offloaded drop box	(1)All Containers	62.0%	28.5%	9.5%	1.85 Hrs
Single route	(1)All Containers	70.5%	22.1%	7.3%	2.78 Hrs

5. What is the quantity and composition of residue from the different operations?

Residue levels varied for each of the pilot routes, depending on a variety of causes. However, in no case did total residue levels exceed 2% of incoming recyclables. This study suggests that a commingled program can be designed to produce no more residue than a source-separated program.

Improper set-outs account for a portion of this residue total. Some residents set out materials in plastic bags or improperly mix materials in bags. Some included a variety of non-recyclable plastic packaging in their curbside collections. Plastic motor oil and antifreeze containers were found in curbside bins. Occasionally, lids were still on glass jars or plastic bottles.

Market specifications for residential mixed waste paper generated from the 2-sort (all fiber, all containers) and the 3-sort pilots did not allow milk cartons and drink boxes, which were sorted at the MRF and landfilled.

The MRF for the 2-sort (all glass/all fiber & non-glass containers) utilized twice the number of sorters of other plants, which in conjunction with a greater level of mechanical processing advantages (e.g., waterfalls, load levelers), resulted in the lowest level of total residue in the study.

The next phase of the residue stream is the collection. Some of the drivers on the pilot routes took everything that was set out curbside. Others were careful to reject the improper items. All of the drivers were acting based on instructions from their company. One driver emptied the contents of all plastic bags into the proper compartment on the truck and returned the bags to the bin curbside. If any other item was rejected, a note was left for the residents. This action resulted in a low residue level for this route (2-sort, all glass/all fiber & other containers).

The Plastics Recovery Facility that receives plastics from some of the processors reports an 8 – 12% residue level. The practice of accepting various unrecyclable rigid plastic packaging curbside and including it in the mixed plastic stream was observed in some of these pilots. The plastics processed from the 2-sort (All fiber/all containers) and the 3-sort contained some of this packaging.

The following chart quantifies and describes the residue found in each of the collected material streams of the studied routes. The percentages of residue represent the portion of that incoming stream of materials.

Quantity and Composition of Residue from collection, sorted at MRF

Route	Collected Mix	% Residue of mix	Description
2-sort	All fiber	0.3%	Plastic film, Tin cans, Fiber, textiles, Glass Multi-material
	Mixed containers	1.9%	Mixed metals, Glass, Mixed fiber, Plastic film, Other
3-sort	Newspaper Mixed fiber	1.0% 0.5%	Glass, Plastic bottles, Multi-material packaging Mixed metals, Plastic bottles, Milk cartons, Other
	Mixed Containers	5.0%	Motor oil bottles, Plastic packaging, Milk cartons, Fiber, Multi-material packaging
2-sort	All fiber & other containers	0.03%	Glass, Tin cans, Plastic film, Multi-material packaging
	All glass	Minimal	Small pill bottles, aluminum & tin cans, Labels from jars
5-sort	Newspaper/ magazines	0.2%	Tin Cans, Textiles, plastic bags, other
	Mixed fiber	0.7%	Plastic film, multi-material packaging
	Tin/plastic	6.5%	Kraft paper, Glass, Other
	Clear glass	Minimal	Plastic film and bottles, Metal lids
	Green/brown glass	Minimal	Plastic film, Metal lids
	Plastic bottles	Observed	Plastic tubs & lids
Offloaded drop box	Mixed containers	1.3%	Plastic film & buckets, Mixed fiber, Aluminum foil, Other
Single route	Mixed containers	2.0%	Plastic film, Mixed fiber, Tin, Aluminum foil, Other

After each material mix was processed, samples were taken of the resulting newspaper and mixed waste paper to determine market quality. The following chart lists the source of the material and the after-processing residue level.

Field Observation of Quantity and Composition of Residue after Processing

Sort	Sorted Residue[44]			Sampled Residue[45]				Total
	From Fiber	From Containers	Subtotal Sorted	From ONP	From MWP	From Glass	Subtotal Sampled	
2-Sort (All Fiber/All containers)	0.25%	0.25%	0.5%	0.0%	0.6%	0.4%	1.0%	1.5%
3-Sort	0.6%	0.7%	1.3%	0.0%	0.27%	0.5%	0.8%	2.1%
2-Sort (All glass/All fiber & other containers)	0.03%[46]	N/A[47]	0.03%	0.06%	0.18%	Minimal	0.2%	0.3%
5-Sort	0.16%	0.21%	0.4%	0.0%	0.15%	Minimal	0.15%	0.5%

6. What are the productivity measures for collection and processing of the different commingled sorts?

The table below presents information about key pilot project operating conditions, design elements and performance results for materials collection. The operating conditions are considered to be topography and the total number of customers that could be served on the route. The design elements are the truck type and total capacity in cubic yards. The set-outs are the actual number of stops or recycling pickups completed. Set-outs are not a measure of collection performance, but rather of customer participation. Stop time is the average time spent at each collection. Handling time is the average time spent handling the recyclables and placing them into the truck. As measured in the field, handling time is part of the stop time.

The time between stops is influenced by the route configuration/layout and other conditions that are unrelated to commingling, such as weather, street width, distance between residences, presence of cul-de-sacs, traffic, parked vehicles and truck maneuverability. Employee attitude, where materials are placed on the truck, and how close the truck can get to the curb will impact productivity. In some cases, trucks could pull right to the curb and in others they had to stop in the middle of the street due to parked cars.

Even considering these impacts, the data support a very clear correlation between the handling time of proper set-outs and the method for commingling. Clearly, a collection that involves several individual material categories that must be picked up, carried to the truck and emptied into separate compartments will take longer to accomplish than one that doesn't.

Observations of pilot project collection activities provided additional quantitative and qualitative evidence that clarified the role of several factors in determining productivity and efficiency. This evidence is summarized below, substantiated by examples from the field observations:

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[44] Sorted residue is a direct measurement of residue separated from recycables by workers.

[45] Sampled residue is a calculated residue level based on the percentage of residue in a sample of selected material, such as ONP, MWP or mixed glass containers.

[46] Residue measured from fiber, cans, scrap metal and plastic bottles. Containers include only glass.

[47] Glass only collection, residue was minimal. Observed and not weighed.

Contamination control by collector: Checking for and removing contaminants on the route has an impact on collection productivity/efficiency. Part of the timing difference between the 2-sorts can be attributed to this factor. The residue levels found after processing of each load bears this out. Both the 2-Sort (all glass/all fibers & other containers) and 5-Sort checked for contaminants.

Compaction: Compaction extends truck capacity, but compacting "fiber only" material, especially when wet, can cause it to clump together, which makes processing more difficult. This was not observed in the 2-sort (all glass/all fiber & other containers), where non-glass containers were mixed with fiber, thus allowing compaction but not excessive densification of the material.

Truck size: While large capacity gives a bigger payload, a big truck can be difficult to maneuver in tight residential locations, thus increasing the time between stops (3-Sort).

Weather: Set-outs with materials in paper bags can present handling problems for collectors during rainy periods. When wet, the bags break, or must be carried and unloaded carefully, thus consuming more time (3-sort and 2-sort all glass/all fiber & other containers). The time required to collect the 2-sort requiring all glass to be bagged separately was increased by the wet weather.

Vehicle design: Some side-loaders use temporary holding compartments or "troughs" that are mechanically lifted and unloaded into the main truck body. The truck cannot be moving when this procedure is performed, thus lengthening the overall time on route. Both 3-sort and 5-sort pilot routes have a trough loader and no compaction. During the route the drivers had to periodically stop the truck, climb into the main body area, and manually compact material by jumping up and down on it. While not directly impacting set-out handling time, these actions lengthen the collection day.

Collection Route Parameters and Productivity Issues

Route	Stop Time Proper	Handling Time Proper	Time Between Stops	Average Lbs. Per Set-out	Truck Type	Truck Volume Cubic Yards	Condition of Recyclables
2-sort (All fiber/All Containers)	21	13	12	28.6 Lbs.	Compaction	30	Dry
3-sort	24	14	19	24.0 Lbs.	Trough	37	Wet
2-sort (All glass/All Fiber & other containers)	26	14	23	31.3 Lbs.	Compaction	14	Wet
5-sort	32	21	16	22.0 Lbs.	Trough	40	Dry

Processing Productivity/Efficiency

Observations of pilot project processing activities provided additional quantitative and qualitative evidence that clarified the role of several factors in determining productivity and efficiency. This evidence is summarized below, substantiated by examples from the field observations:

Configuration of conveyor belt/sort line: Changes in levels along the belt line of between one to three feet help break up or "de-clump" materials, making them less dense and easier to separate. This is particularly applicable to commingled fiber streams which, especially when wet, tend to bunch up. Such a phenomenon was not observed with 2-sort (all glass/all fiber & other containers.)

Paper and plastic bags: Materials cling to the sides and bottoms of paper and plastic bags making removal difficult and time consuming.

Placement and number of sorters along conveyor belt/sort line: Three MRFs placed at least two sorters (one on each side of the belt) at the point where materials leave the in-feed line and enter the conveyor belt. They spread material out, remove obvious contaminants and pull off larger accumulations of recyclable fiber. All these actions help sorting efficiency by providing the remaining sorters with an easily viewed and available material stream. Remaining sorters were generally placed at even intervals along both sides of the conveyor belt/sort line at each MRF.

Speed at which conveyor belt/sort line moves: The respective conveyor belt speeds for fiber processing at the three primary MRFs were as follows:

5-sort MRF--2 feet/second
2-sort (all fiber with non-glass containers/mixed glass) MRF--2 feet/second
3-sort and other 2-sort (all fiber/all containers) MRF--1 foot/second

The 2-sort(All glass/All fiber & other containers) had the longest and widest sort line with the largest number of waterfalls and sorters. Due to this concentration of physical and human resources, the MRF could run its sort line at the higher speed of two feet per second without losing efficiency.

The 5-sort MRF had fewer sorters, but also operated the sort line at two feet per second. It achieved a high news-to-contaminant ratio because the incoming stream was news only. This conveyor belt contained one waterfall. Thus, the resource allocation did not need to be as intense as with the MRF handling commingled fibers and non-glass containers.

Finally, the MRF receiving the 3-sort mixture with newspaper separated had the fewest number of sorters (8), no waterfalls in its conveyor belt/sort line, operated at the slowest speed (one foot per second), and had a market that willingly accepted large quantities of newspaper as part of mixed waste paper bales. The result from this combination of conditions is logical: 81% news-to-news conversion when newspaper comes in separated, 51% news-to-news conversion when it comes in commingled with other fibers.

Density of materials on conveyor belt/sort line: High materials density can hinder processing efficiency, especially for commingled fiber streams. Material density can be reduced by positioning sorters near the beginning of the conveyor belt to rearrange and redistribute materials; by having waterfalls break up the flow of materials; by insuring that sorters are evenly spaced along the entire length of the belt; and by having a belt that is wide enough and long enough so materials can be spread out and made easily visible and recoverable.

Material density affects a mixed-container processing line also. The processing facility that handled the mixed containers from the offloaded routes incorporated multiple mechanical separating and sorting devices into the line before the material arrived at the manned sorting area. The small materials were removed via trommel, the ferrous metals were removed by magnet, and the heavy and light materials were separated through air currents, all before arriving in front of the sort personnel. This resulted in a low-density material stream, easing the staff's responsibility.

Glossary

Amber: Brown glass containers.

Average handling time: The time spent by a recyclables collection vehicle driver (or other crew member) handling materials at the curb, calculated from when the person touches the first recycling bin to when the last bin is returned empty to the curb. This includes clean-up time.

Average stopped time: The amount of time a recycling collection vehicle was actually stopped at one house for purposes of picking up recyclable materials. This includes any compaction activity as well as unloading troughs.

Beneficiation: The preparation of recovered glass containers (broken or whole) into furnace-ready cullet. To reach this condition the glass is processed through several steps to remove contaminants such as ceramics, rocks, metal caps/rings, labels, and other adhesives. The purpose of processing is to produce a feedstock with uniform characteristics. Processing may include some or all of the following: magnetic removal of ferrous metals, eddy current separation of aluminum, screening to remove over-sized items, manual sorting to remove a variety of contaminants, vacuum removal of light materials, optical sorting into two or three separate colors, optical detection and removal of rocks and ceramics, and grinding to a small and consistent particle size.

Collection efficiency: Average handling time, as defined above, is often considered a standard indicator of recycling collection efficiency and productivity. Other indicators are average number of households collected per hour, total time to complete a route, and average quantity of recyclables handled per crew member per hour.

Color-separated cullet: Recovered glass containers that have been sorted into either three colors (clear, brown, green) or two colors (generally clear and brown/green).

Commingling: Generators setting out two or more recyclables into one bin for collection. For example, mixing together three colors of glass jars and bottles; mixing together tin, aluminum, glass, and plastic containers; mixing together newspaper, cardboard, and mixed waste paper; or putting all these materials together into one bin for subsequent pickup and processing.

Contaminant: Any item defined by markets that degrades a stream of recyclable material.

Conveyor belt: A continuously rotating loop that moves horizontally by virtue of being attached to a series of wheels or other similar devices. The belt, usually somewhat flexible but still sturdy, is used for moving materials between a start and end point so that manual removal of contaminants and manual sorting of material into categories may be accomplished.

End use market: Usually refers to the last destination for recyclable materials where they are manufactured into products that are either new, or similar to their original form. For example, a paper mill or glass container manufacturing plant.

Fiber: A broad term generally intended to encompass a variety of paper grades that are collected for recycling.

Flint: Clear glass containers.

Garten Services, Inc.: Garten Services is a non-profit institution located in Salem that performs a variety of social service, education, and employment functions including a recyclables processing operation for residential and commercial materials. This is the location of the region's Plastic Recycling Facility.

Glass cullet: Broken glass that has gone through preliminary processing and is ready for additional processing (see ***Beneficiation*** above) to make it "furnace ready".

Glass grade A: A processed three-color mix glass cullet ranging in size from 3/8"-2" with less than 1% residue level.

Glass grade B: An unprocessed three-color mix glass cullet varying in size with 1 - 5% residue level.

Grading of loads: The practice by end use markets of assigning quality ratings or levels to different types of processed recyclables they purchase.

In-feed line: Usually one or more conveyor belts, often segmented or partitioned by rubber or metal strips, that are inclined or angled to carry and direct materials from the floor of a processing facility to an elevated sorting line.

Intermediate processor: A business engaged in the sorting, separation, upgrading, consolidation, and packaging of recyclable materials before their sale to an end use market.

ISRI specifications: ISRI is the Institute of Scrap Recycling Industries, a national trade organization primarily composed of processors and markets for recyclable paper and metals. ISRI publishes definitions and descriptions of various types and grades of materials ("specifications"). These specifications also include what kinds and levels of contaminants, outthrows, and prohibitives are associated with each identified material grade.

Kraft paper: Generally refers to brown paper bags.

Material characterization: Studying or analyzing the composition, by volume and/or weight, of the various component materials of a given waste stream or material stream.

Material recovery facility (MRF): a processing plant that receives either mixed waste, commingled recyclables, source separated recyclables, or all three kinds of material streams, and then manually and mechanically retrieves reusable and/or recyclable materials for market.

Mixed waste paper: An all-purpose grade of recyclable waste paper composed of multiple other grades. The precise specifications can vary from mill to mill depending on what end product is being created from the feedstock as well as the particular type of technology in place at the mill.

MRF residue/glass: Either a glass container mix that is left after sortable containers are removed or the small pieces of material (usually broken glass) resulting from using a screen or trommel in a processing line with a 5-15% residue level.

Negative sort: The material that flows off the end of the conveyor belt after other materials have been removed during the sort process.

Outthrows: All papers that are manufactured or treated, or are in such a form, as to be unsuitable for consumption as the grade specified. It is not unusual for the maximum quantity of outthrows indicated in connection with many paper grade definitions to be considered as the total of both outthrows and prohibitive materials (see ***Prohibitives*** as defined below).

Paperboard: A lower grade of waste paper with a high recycled content that is used in making small containers that do not require high strength properties (such as for holding tissue paper, crackers, or breakfast cereal) or for secondary, supportive purposes and not for direct use as paper (such as the bottom portion of a paper tablet).

Positive sort: The materials that are deliberately removed by the sorters from the conveyor belt during processing.

PRF: Plastics Recovery Facility, a plastics processing operation that receives mixed plastic bottles and packaging, separates it by resin types, and markets the results. Garten Services, Inc. Is the regional PRF located in Salem, Oregon.

Processing: An all-inclusive term covering numerous manual and mechanical operations for sorting, separating, de-contaminating, upgrading, consolidating, aggregating, and baling recyclable materials.

Prohibitives: These are materials which, by their presence in a bale or other type of paper stock load (such as loose in a drop-box), in excess of the amount allowed by a particular market, will make the load of paper unacceptable and unusable as the grade originally specified by the supplier and/or requested by the market. Prohibitives are also typically considered to be material that may be damaging to equipment in a paper mill.

Recycling markets: See ***End use market*** above; in addition, for firms that perform recyclables collection services, their material markets can be both end use markets or material recovery facilities/intermediate processors. A market is, broadly speaking, the company that purchases recyclables from another company. The market may, or may not, be an end user.

Residue: Material for disposal left over after other materials have been recovered for recycling.

Residue fines: A processed three-color mix glass cullet that is less than 3/8" with a 20-30% residue level.

Runnability: Another terms for runnability is "sheet integrity", namely the ability of a manufactured sheet of paper to run through printing presses without tearing or causing other production/equipment problems and breakdowns.

Sampled: In the context of this report, "sampled" or "sampling" means extracting a smaller portion of a larger quantity of waste or recyclables and then sorting and weighing a pre-determined number and type of items to determine the composition of the bigger material stream from which the sample was drawn.

Set-out rate: The percentage of residences that set out one or more designated recyclable materials for collection on a per visit basis.

Set-outs: One or more recyclables placed curbside for collection at one customer site.

Side-loader: A refuse or recycling collection truck that accepts materials through an open area on the side of the vehicle.

Sorted: A material stream that has been separated into component material categories.

Sorting line: Generally a conveyor belt carrying materials in front of people who are standing on one or both sides of the belt, picking off specific materials.

Sourcing strategies: A term used in the paper-making industry to cover the diversity of formal and informal business terms between mills and companies supplying them with recyclable paper.

TAG: Tin, aluminum, and glass containers. In this region (Northwest Oregon), a TAG container mix also includes plastic.

Three-color mix: Recyclable glass containers, whole and/or broken that include clear, green and brown glass mixed together.

Trough loader: A type of side-loading recyclables collection truck with one or more small holding compartments attached to one or both sides of the vehicle. These compartments are filled multiple times during a route collection, then are mechanically lifted and unloaded into the main body of the vehicle.

Waterfall: The elevation change or drop off on a conveyor belt sorting line that helps break up bundles of material, particularly fiber.

Appendices 1 – 6

Diagrams of Processing Lines

Diagram 1: Processing line for 2-Sort (All fiber/All container) and 3-Sort

Mixed Fiber

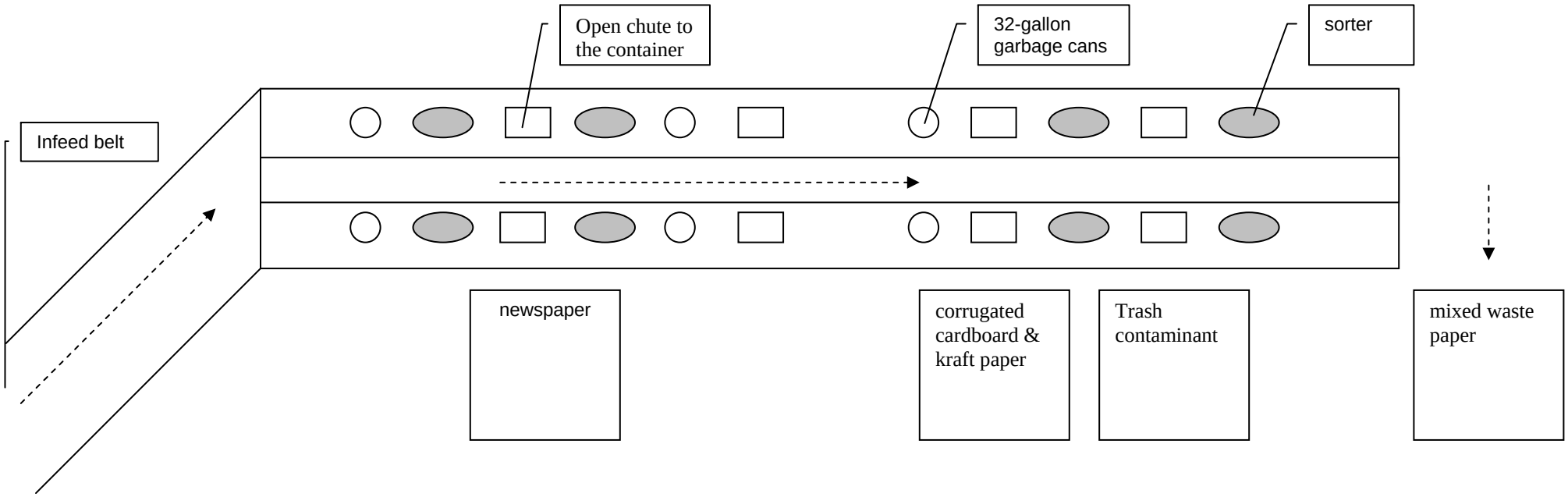


Diagram 2: Processing line for 2-Sort (All fiber/All container) and 3-Sort

Mixed Container Line

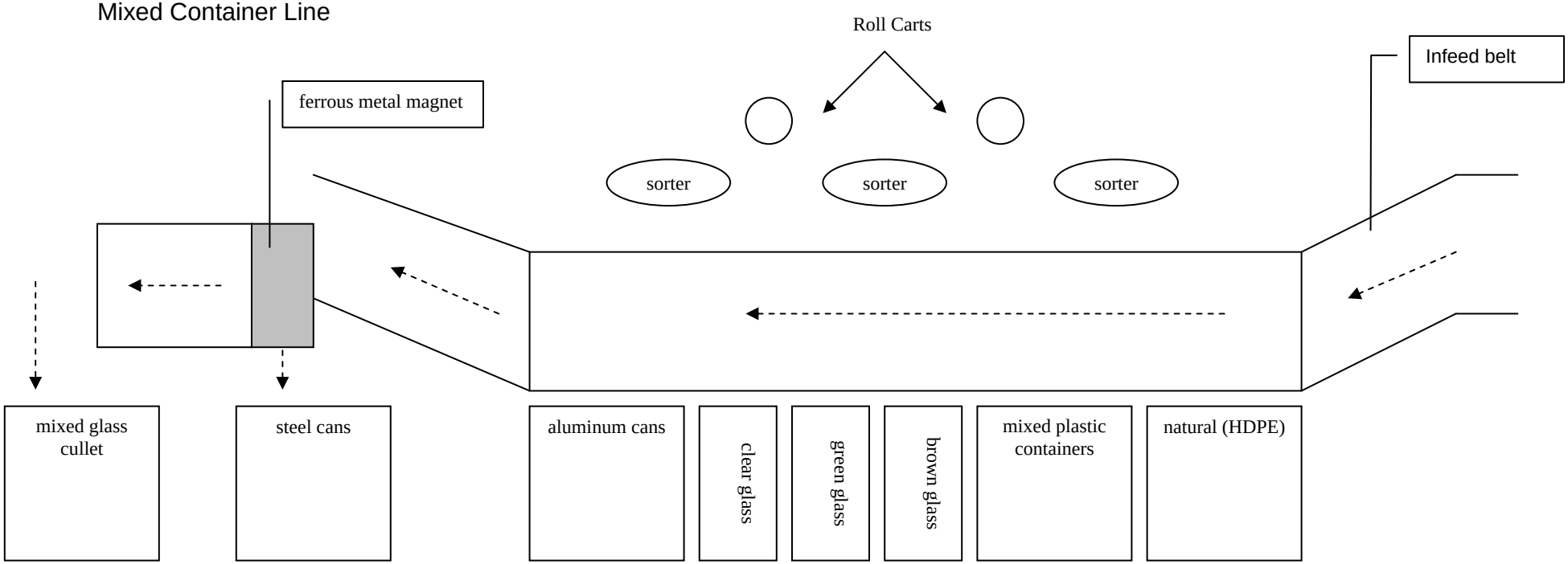


Diagram 3: Processing line for 3-Sort

Newspaper

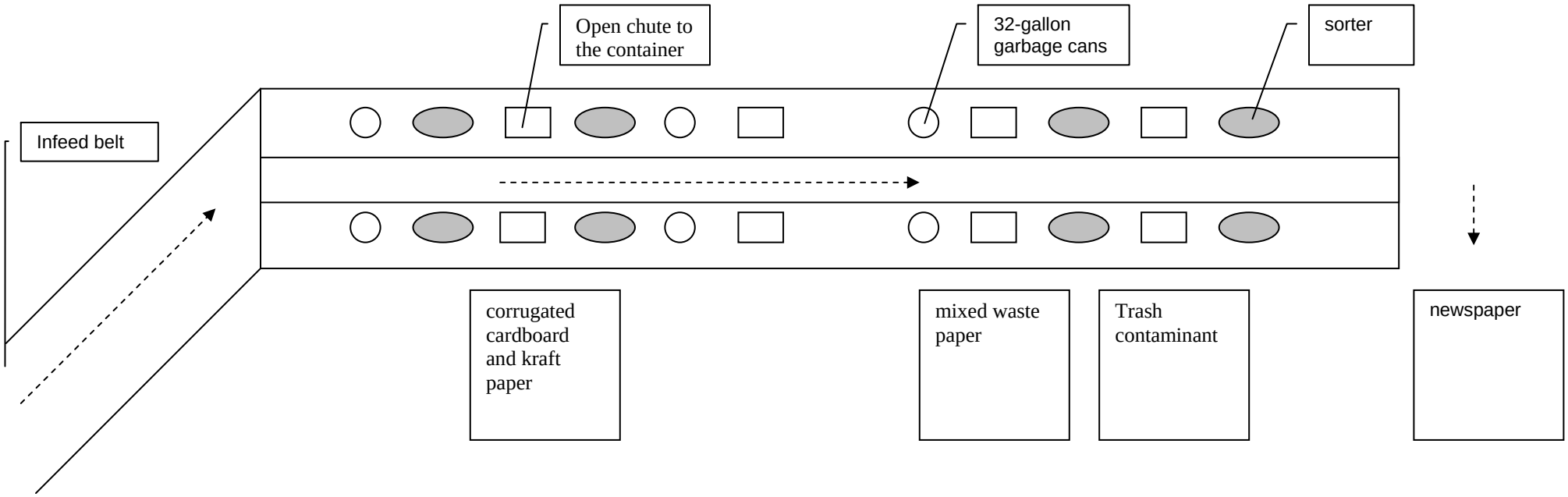


Diagram 4: Processing line for 2-Sort (All glass/All fiber & other containers)

Mixed Fiber and Non-Glass Containers

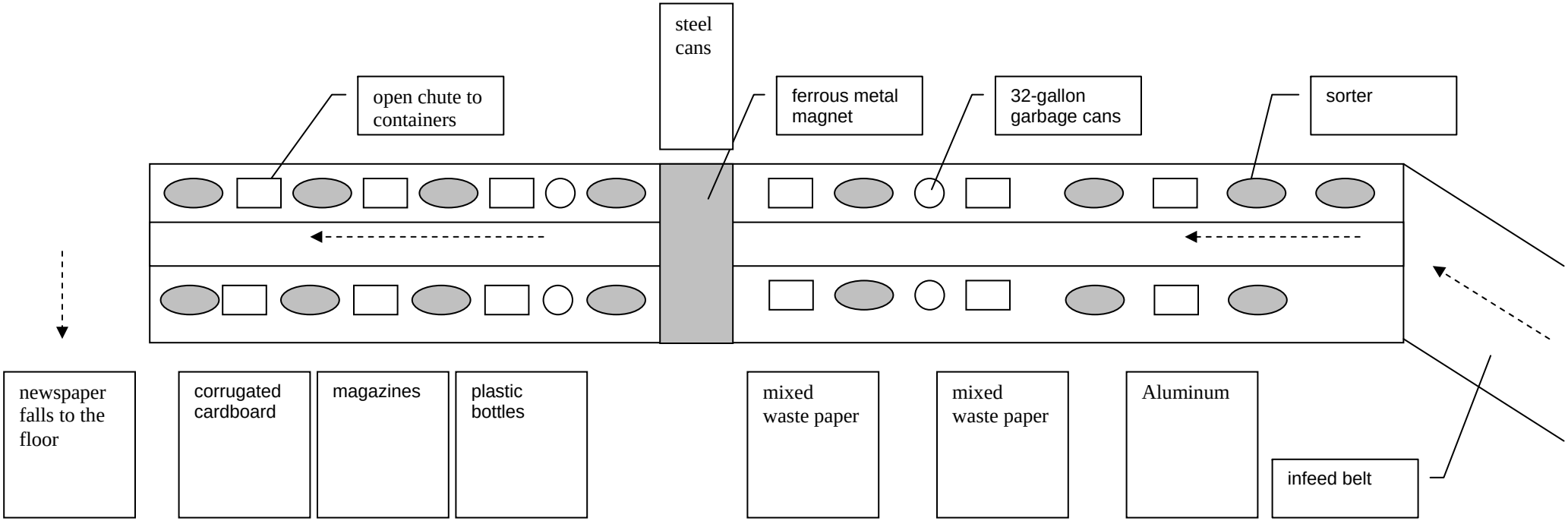


Diagram 5: Processing line for 2-Sort (All glass/All fiber & other containers), Off-load drop box and single route

Mixed Container Line

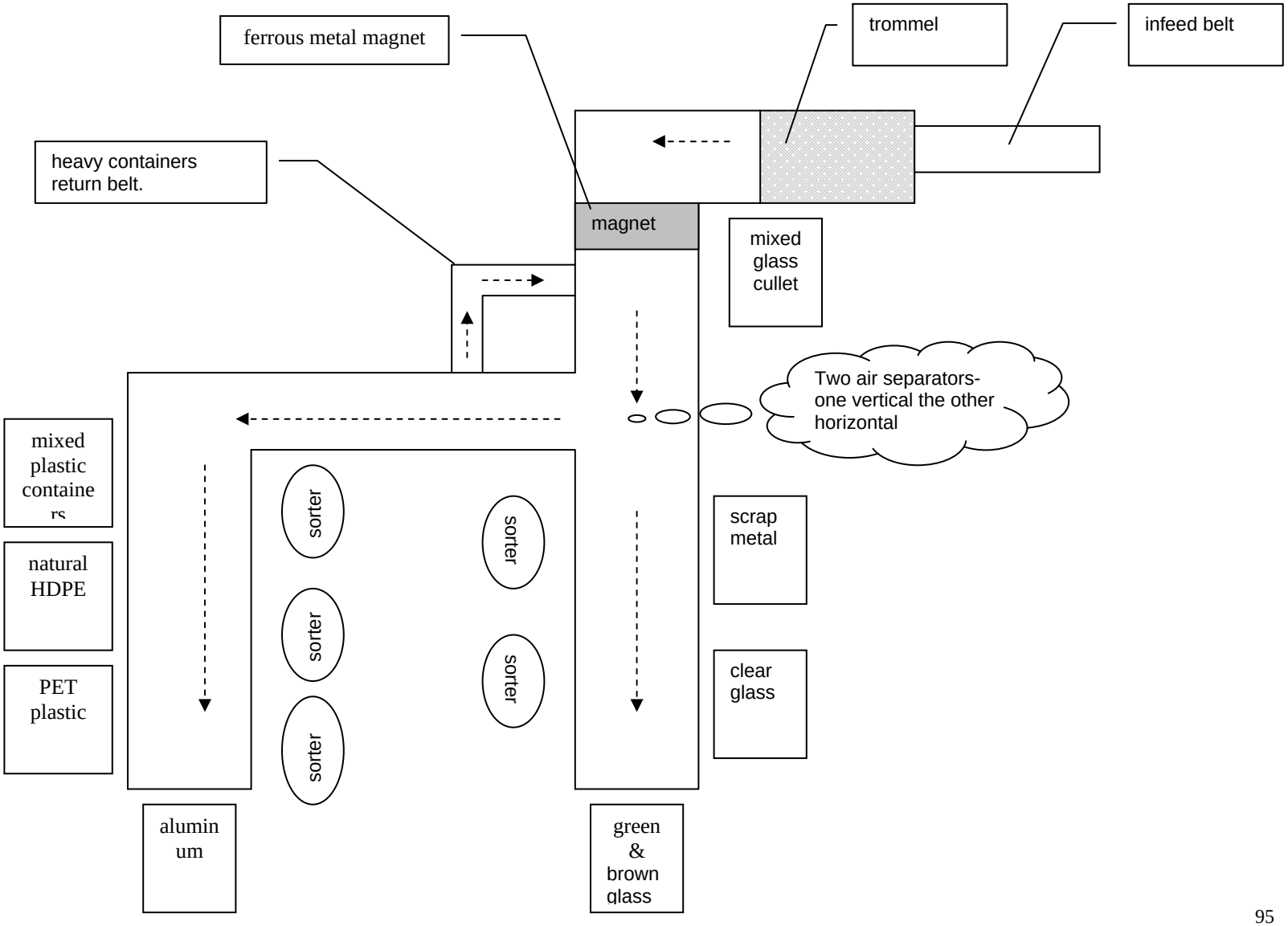
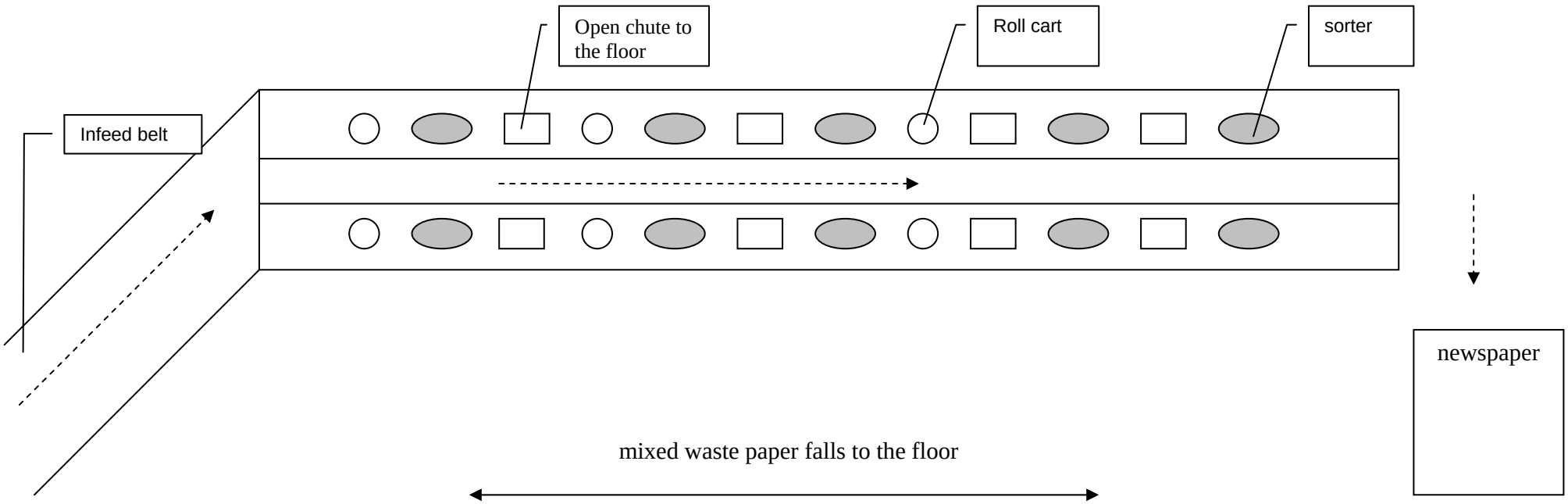


Diagram 6: Processing line for 5-Sort

Newspaper/Magazines Sort Line