

Final Report

Material Recycling Facility Technology Review

(WDO Project Code OPT-R3-05)

For:

The City of
The logo for the City of Ottawa, featuring a stylized 'O' with three curved lines to its left, followed by the word 'Ottawa' in a serif font.

In Partnership with:



Prepared by:

ENVIROSRIS
knowledge innovation solutions

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1.0 BACKGROUND

In 2000, the City of Ottawa (formerly the Regional Municipality of Ottawa-Carleton) commissioned a study of its curbside collection and processing recycling operations related to commingled containers. The City of Ottawa has been separately collecting and processing a complete range of fibre and containers since 1996. Fibres and commingled containers are processed at two separate private MRFs.

Although markets have been relatively stable over the past two years, the city is considering that it needs better ability to quickly alter the container sorting grades to adapt to market changes in order to capitalize on market revenues. When dealing with manual sorts, the logistics of staff training and meeting specific end market requirements make it difficult to do a quick change in any sort process. It is expected that with the advent of new processing technologies, sorting changes can be easily and economically implemented.

Consequently, the city issued a Request for Proposals for consultants to undertake a review of state of the art sorting technologies that can process the city's current mix of containers and meet end market specifications. Enviro RIS Ltd. was selected for the project and awarded the contract February 26, 2001.

This report presents the findings of the technology review and is the first of two reports dealing with the project. There were two primary objectives of this portion of the study:

1. To identify and characterize sorting technologies and processing equipment that would be suitable for Ottawa's recyclable container mix and
2. To review sorting process flows for commingled container streams to identify common approaches.

The second report, under separate cover, will assess the city's current processing contract, optimization audit and contractors' performance and will review longer-term MRF ownership/operation options.

2.0 THE CURRENT CONTAINER PROCESSING SYSTEM

Halton Recycled Resources Ltd. processes the commingled container stream under contract to the city. Recyclables requested and processed include rigid plastic resins #1 through 7, film bags, glass bottles and jars, metal food and beverage cans, and aseptic and gable top containers. In 2000, the city marketed approximately 12,400 tonnes of these containers.

The contractor uses a combination of traditional manual and automated technologies to process these commingled materials. Incoming material is loaded from the tipping floor onto an inclined conveyor where film bags are removed from the belt. Next, a magnet removes ferrous material. The remaining mixture is then sent through an air classifier where plastics and aluminum are separated from glass. The plastics are sorted by hand into the rigid grades, aluminum is sorted by the eddy current and residue is the final negative sort material in the system. Table 1 presents a breakdown of Ottawa's container materials processed in 2000 and Figure 2.1 is a schematic of the current processing operation.

Table 2.1 – MRF Container Recyclables Marketed in 2000

Material	Tonnes/yr	Tonnes/day ¹	Tonnes/hr ²
Mixed Glass	7,588	30.35	3.80
Flint Glass	0	0	0
Coloured Glass	0	0	0
Steel	2,026	8.10	1.01
Aluminium	574	2.30	0.29
PET (#1)	739	2.96	0.37
HDPE (#2)	62	0.25	0.03
#2-#7 (no 6)	705	2.82	0.35
#3-#7 (no 6)	87	0.35	0.04
LDPE (FILM)	359	1.44	0.18
PS (#6)	17	0.07	0.01
Milk Cartons	230	0.92	0.12
Total	12,386	49.54	6.19

1. assuming 250 working days/yr

2. assuming 8 productive hrs/day

3.0 DATA COLLECTION METHODOLOGY

To identify and characterize appropriate sorting technologies and processing equipment that would be suitable for Ottawa’s recyclable container mix, Enviro RIS:

- searched its in-house resource centre and project files;
- conducted a literature search through “Intellisearch”, a commercial research service at the City of Toronto’s reference library;
- contacted DSD and EcoEmballages officials to assemble research and technology data and operational data, and;
- contacted equipment suppliers to obtain supplementary details such as equipment specifications and costs.

It should be noted that this investigation was not intended to be all encompassing. Traditional sorting techniques and equipment used in many North American are well known, and consequently, were not the subject of this study. This project focused on relatively new, innovative equipment and technologies for sorting commingled container materials that might not yet be well known. While these sorting technologies are now becoming more prevalent in North American MRFs, many originated in Europe and are used extensively in programs such as Germany (DSD) and France (EcoEmballages) where nation-wide packaging stewardship programs are now mature.

4.0 DESCRIPTION OF TECHNOLOGIES

4.1 General

Information gathered on specific equipment was compiled and summarized in Appendix A. Equipment is listed first by function (e.g. size separation) and then by equipment type that performs that function (e.g. trommel, disc screen, etc.). Individual manufacturers are identified in each category so as to give a representative sample of potential suppliers. In some cases, there are many other suppliers that provide similar equipment, and in other cases, these are the only manufacturers.

The following sections review the functions and provide an overview of the particular suitability for Ottawa.

4.2 Bag Breakers

There are a wide variety of bag breakers now on the market, but most can be categorized as one of two types: slitters and augers. Regardless of the type of unit used, there is no mechanical “debagger” on the market today that does an efficient job of breaking the bags and mechanically collecting the plastic. All units require some degree of downstream manual separation of the plastic film.

Most slitters rely on cutting blades rotating in opposite directions. Bags are ripped open as they are forced between the blades, spilling the contents onto a conveyor below. In some machines, rotating wires have been used, most without much success. In most machines, the shafts holding the blades are adjustable to accommodate the most appropriate bag size. Trommels can also be used as bag openers, as described in Section 4.4.1.

Muma Manufacturing Inc. (St. Thomas) manufactures slitter-type breakers. One of these units was installed in the Guelph wet/dry MRF in 1997 and is currently operating at approximately 8 tonnes/hr (capital cost approximately \$110,000¹).

Mayfran also manufactures a bag breaker that is used in the Edmonton blue MRF. This unit processes up to 20 tph at a cost of approximately \$100,000.

BHS is one of the more popular producers of bag breakers in North America. These are designed to break from 20-70 bags per hour with minimal shredding of the bags. Bagged recyclables are gravity fed into the breaker via conveyor to achieve an even material flow rate. Large counter-rotating drums stretch the incoming bags, causing the film to break and the contents to be released. One of these units operates successfully in the Northumberland County MRF to open bagged recyclables (12 tph @ approx \$60,000

¹ All costs are in \$Cdn unless otherwise noted

US). Two sorters then are used to remove the plastic bags from the incoming recyclables mixture after the bag opener.

Auger type bag openers rely on the action of a screw auger rotating in a cylinder. As bags are moved through the cylinder, they are ripped by the action of the auger against the inside wall of the cylinder. These have achieved mixed success with bagged recyclables. Glass breakage is more severe in these breakers. This type of breaker is more popular for use with bagged organics (e.g. as in the Guelph wet composting plant).

Rather than considering the applicability of a bag opener in Ottawa, the city should concentrate its efforts on additional communication and education to convince residents not to bag loose container recyclables.

4.3 Light/Heavy Sort

4.3.1 Air Classifiers

Air classifiers typically use low velocity air to separate lighter materials (e.g. aluminum and plastics) from heavier materials (e.g. glass). This can be accomplished in one of two ways:

- by blowing the lighter materials across and air knife to another conveyor at a conveyor tail pulley (heavier materials drop over the tail pulley), or
- by using suction above a commingled container stream on a conveyor to remove the lighter material (heavier material stays on the conveyor). Once removed, the lighter materials are usually directed to a separate sorting conveyor.

In the vacuum system, air velocities within the pickup unit can be adjusted to create multiple pressure drops. In this manner, heavier items will drop out first and lighter second. Vacuum systems are popular for conveying materials such as film plastic, PET and HDPE containers and aluminum cans from sorting stations to a remote cage or bunker.

The use of an air classifier is now quite common in a container MRF, with most units ranging in throughput capacity from 5 to 10 tonnes/hr. Capital costs are in the order of about \$35,000 US.

4.3.2 Inclined Conveyors

Bezner introduced the first inclined, heavy/light sorting conveyor system into the North American market at the Rhode Island Johnston MRF. The Bezner technology uses a combination of an inclined conveyor and a series of parallel chain curtains (moving in the same direction as the conveyor) to separate light containers (plastic and aluminum) from heavy containers (primarily glass). The lighter containers, through the motion of both the conveyor and the chain curtains, are directed along the conveyor and discharge off the end. Glass containers, because of their density and shape, are encouraged to slide down the sideslope of the conveyor through the chain curtains. A transfer conveyor at the bottom of the chain curtain system removes the glass to the sorting area. This technology is also used at Toronto's Commissioner

Street MRF. Manufacturers of disc screens such as Bollegraaf and Machinex also produce similar inclined conveyors for separation of containers and miscellaneous fibres.

The Bezner equipment is now distributed by RRT in North America. The inclined conveyor has a throughput capacity of about 10 tonnes/hr at a capital cost of about \$145,000 US.

4.4 Size Separation

4.4.1 Trommel Screens

Trommel screens are rotating, inclined drums that primarily use a combination of rotation and screening to separate materials. The tumbling motion created by the rotation drum shakes loose smaller sized objects (dirt, grit, bottle caps, broken glass, etc.) that exit through holes in the drum. Larger materials work their way through the drum to exit at the downstream end. Trommels can range in diameter from 2 to 16 feet and in length from 8 to 80 feet, depending on the application. Trommels can be designed with a variety of hole diameters, staged in sequence to separate different container sizes. A small trommel (approximately 0.6m x 2.5m) is used at Toronto's Dufferin MRF to remove small debris, broken glass, bottle caps, etc. prior to manual glass sorting.

Trommel screens can also be used as bag breakers. For this application, triangular steel "knives" or spikes are welded to the inside of the drum. As bags containing recyclables or mixed waste tumble in the drum, the bags are ripped open by the knives and the material tumbles out. One disadvantage of trommel screens is pronounced breakage of glass in systems where glass containers are part of the material mix. This is only a disadvantage if it is intended that glass be manually colour sorted and when ceramic content must be reduced.

4.4.2 Trommel/magnets

Several manufacturers now offer a combination trommel screen and ferrous separation. The combination trommel-magnet typically has a stainless steel tube welded to the end of the trommel. A magnetic field is created in the tube to attract ferrous recyclables. Ferrous materials attached to the inside of the tube rise with the rotation of the trommel. At a predetermined point in the rotation, the magnetic field weakens, allowing the ferrous to drop via a chute into a bin or onto a dedicated conveyor.

The trommel-magnet is less expensive than a cross-belt magnet, yields a high ferrous recovery with almost the same purity and also serves to remove fines. These trommel systems handle 4-9 tonnes/hr of commingled containers with prices starting at about \$30,000 for the lower volume models. In addition, this trommel provides some space savings over a conventional trommel and fines screen combination.

4.4.3 Star Screens (Disc Screens)

Star screens have become very popular in recent years in a variety of sorting applications:

- in single stream MRFs they are used to perform an initial separation of fibre and container materials;
- in fibre sorting applications to separate OCC or ONP from other fibre grades;
- in commingled container sorting systems, as an alternative to vibratory screens and trommel screens for removing fines, debris, broken glass, etc. from larger containers, and;
- in commingled container sorting systems, to sort containers from miscellaneous fibre contaminants.

These screens consist of a number of rotating axles, each containing a number of “star” shaped wheels spaced along the axle. The spacing between axles is adjustable, as is the diameter of the “stars”, and spacing between the “stars”, depending on the sorting function. The bed of the screen is typically tilted upward so that as the commingled stream is directed onto the lower end of the screen, oversized material bounces along the top of the screen in the direction of the star rotation and smaller material falls through the open spaces between the stars. In some applications (e.g. separation of containers from miscellaneous fibres), the bed of the star screen is tilted both upward and sideways.

Major suppliers of these screens include Machinex, Bollegraft, CP Manufacturing and Bulk Handling Systems. In most Ontario existing MRF applications, these screens would typically be used on a container sorting line to remove fines, debris, broken glass, etc. from commingled recyclables.

In a single stream (fully commingled mixture of fibres and containers), disc screens used for OCC and ONP separation typically handle up to 23 tonnes/hr and range in cost from about \$125,000 to \$170,000.

4.5 Glass Sorting

Mechanical sorting of glass cullet is relatively new in North American MRFs processing commingled containers. The sorting technologies are more common in larger glass reprocessing facilities where larger throughputs are necessary to justify the capital outlay for the sophisticated equipment. Optical sorters are generally able to work effectively on glass pieces that range in size between 1 and 4 cm. The sorting equipment is typically operated to do one of two sorting operations:

1. to remove ceramics from a mixed glass stream, or;
2. to colour sort a mixed glass stream.

One of the first MRF glass sorting operations was the West Palm Beach, Florida MRF and it is still in operation. This was the first MRF to install the MSS Glass ColorSort™

system. The MSS Glass ColorSort™ requires initial screening, vacuuming and metal removal before the glass cullet can be sorted. The ColorSort™ sorts glass particle sizes from 9-50 mm at a capacity of 20 tonnes per hour when operated in ceramic mode, and 5 tonnes per hour when operated in colour sorting mode. It can sort all shades of green, amber, yellow, blue, and other colored glass such as “Georgia Green” and “Half White”, each in a separate stream. MSS claims that special software algorithms correct for contamination effects and thus improve separation efficiency.

Palm Beach County (Florida) generates as much as 12,000 tons of mixed broken glass per year. Early in 1999, the Waste Authority received a grant to design, install and test an optical sorting system capable of sorting mixed broken cullet. The system was manufactured as a joint effort between MSS Inc. (Nashville) and C.P Manufacturing (California). The system became operational January, 2000 and has a capacity of sorting 5 tonnes per hour with a capital cost of about \$385,000 US. The equipment can be programmed to sort any colour or ceramic material, although it can sort only one colour at a time. The Authority chose to use the equipment to sort flint glass, since it is the largest fraction and has the highest market price. It is projected that the system will sort approximately 3,600 tonnes of flint glass per year from the mix.

SEA International (Bologna, Italy) signed an exclusive North American agreement with Count Recycling Systems (Des Moines, Iowa) to market glass colour sorters. These sorters range in throughput from 5 tons per hour to 20 tonnes per hour, with costs ranging from about \$100,000 to \$200,000 US. These machines can be programmed to detect and eject opaque contaminants such as metal, stones and ceramics. The Rhode Island MRF, which handles on average about 170 tonnes per day of mixed containers, has installed an SEA system. SEA has other glass colour sorting installations in plants in Maryland, New Jersey, Pennsylvania, and Quebec

In Baltimore, Maryland, Partners Recycling Services, a glass processing company with several MRFs, has installed two SEA colour sorting machines to remove ceramic contaminants from glass between 1.3 and 5 cm. A MSS ELPAC System then removes metal contaminates from the glass. The screened, vacuumed mixed broken glass is then sent to a MSS Glass ColorSort™ for colour sorting. The company processes about 10 tonnes of glass per hour. Their new system reportedly doubled their revenue overnight.

According to Count Recycling Systems, the glass sorting equipment supplied by SEA International works well once the prescreening equipment and maintenance personnel are in place. The abrasiveness of the glass is disadvantageous for the ductwork. The optical sorter uses air jets to sort the glass according to color. These air jets can become damaged and worn by the abrasive glass. Therefore the SEA sorting machine requires an above average level of maintenance and expertise compared to other glass sorting technologies.

The particle size and cleanliness of the glass will influence the sorting efficiency. The glass must be pre-sized with screens before being fed to the optical sorter. If the broken glass is too large for the glass sorting equipment, then a glass crusher may be required as a pretreatment. Also paper and other contaminants such as lids and caps should be

removed as much as possible by means of a vacuum system before entering the optical sorter. Paper contaminants disrupt the count of the air jets. Since lightweight paper falls slower than the heavier glass, the air jet has already reacted before the paper contaminant has arrived at the air jet. Thus the paper poses a problem for the sorting efficiency and should be removed as much as possible beforehand.

Count Recycling Systems is no longer affiliated with SEA International. Company representatives site reasons being the unexpected high maintenance and presort and pretreatment requirements of the glass. SEA International is located out of Italy, thus the language barrier and time difference often posed difficulty during times of maintenance and startup. However Count Recycling Systems do verify that the SEA International glass sorting equipment does work well once it is properly installed with the proper presorts and maintenance personnel. Count Recycling Systems are now associated with CP Manufacturing in California.

CP has developed glass sorting equipment that can mechanically separate glass from other recyclables and debris, so that an operator can clean up the glass. The equipment air-classifies the unders, then optically colour sorts the clear glass, two colours and opaques. The equipment costs \$100,000-\$125,000 US.

A demonstration cullet sorting system was also installed at the Westchester County MRF, a county-owned, 54,000 tonne per year facility, under contract to the County by Trottown Transfer Inc. The optical sorting system was supplied by Binder & Co. (Austria) supplied by their American agent, Tomen America (Charlotte, NC). The facility processes approximately 7,600 tonnes of glass annually, of which mixed broken cullet accounts for about 5,600 tonnes/yr. This was a 3 tph rated system that handles about 2 tph on average. No cost information is available.

The decision to purchase glass sorting equipment should depend on several factors. Several years ago, the high market value of glass made glass sorting equipment a more viable option than today. The local glass market value, transportation costs, tipping fees, amount of glass recovered and equipment cost all play a role in the final purchase decision. Glass sorting technology is available and in operation in MRFs throughout USA. Some manufacturers claim that a MRF must have in excess of 3 tonnes/hr of glass throughput to achieve a payback in a reasonable number of years, although others suggest a volume of at least 9 tonnes per day of glass is necessary.

Ottawa processed approximately 7,600 tonnes of glass in 2000. Assuming 250 operating days a year and an 8 hour processing schedule, the average glass throughput was about 3.8 tonnes/hr. This throughput is considered borderline for consideration of automated glass sorting equipment. Given the proximity of a reliable mixed glass market in Montreal, the need and economics of any colour sorting of glass in an Ottawa MRF is questionable. A thorough economic analysis of all glass sorting options should be conducted if Ottawa proceeds to implement their own MRF and sorting equipment.

4.6 Plastics Sorting

Currently in North America, sorting of plastic containers at a MRF is primarily a manual task. In contrast, in Europe, automation of this process has been implemented more widely because manual labour cost generally is higher. Most automated bottle sorting systems in North America are located at plastics processing facilities and plastic reclaimers where the volume can justify the system costs.

In general, there are two methods of feeding: singulated feed and mass feed. Singulated feed requires objects to be fed to the sensor one-by-one. In most MRFs, the mix of container materials (metals, tetra, trash, etc.) mean that a singulated feed system is not particularly suitable unless plastic containers are first separated from non-plastic containers. These systems require relatively complicated space-intensive feed systems, and they have a feed rate limitation of 570 to 680 kg per hour. Capital cost for these systems including feed and singulation conveyors range from \$200,000 to \$250,000 US. Obviously, these systems are best suited for high volume plastics reprocessors.

The material properties of plastic can be sensed and identified through either transmission or reflection. Transmission identification mode (x-ray, visible light) is used widely to determine resins and colours in plastic reclaiming facilities that have a controlled material stream. It can also be used in some MRFs where the amount of contaminants in the input stream is limited. Reflective near infrared (NIR) sensors are used in dirtier MRF applications where the mixed input material stream does not allow the use of transmission sensor designs.

The mixed container stream is the main reason for the use of reflective NIR sensors. The sensor module can be placed on top of the sorting conveyor and does not come in contact with the material that it is sorting. A limitation of this system is that it is not suitable for multiple sorts unless there are back to back systems, each tasked to separate a particular resin type according to its physical and/or chemical properties. For most efficient plastic sorting, the MRF process should provide for prior removal of oversize objects and film, ferrous and non-ferrous metals and undersize materials. Capital cost for a complete mass feed system is approximately \$170,000 to \$200,000 US.

Germany has the highest level of automation for sorting equipment in MRF facilities. As with all NIR sensors, cost is the major reason for North American MRF operators still hesitating to use the new technologies. Experience in development and operation of plastics separation systems shows proper feeding and preparation of the feed stream as well as the quality of the sensing system are critical to optimal separation efficiency.

MSS has developed a high capacity plastic bottle separator (Alladin) that contains multiple identification and sorting capabilities: it performs two needed tasks – resin and colour identification. This is a mass feed system – no singulation is necessary. The system combines full spectrum colour and NIR detection in one sensor to allow separation of three different fractions. The system has a throughput capacity of 3600-

5500 kg/hr. The first industrial scale machine is due to be installed in a MRF in Pennsylvania in August, 2001. Due to its high throughput capacity and cost (approximately \$170,000 US) this machine is more geared to serving either high volume plastics reprocessors or regional MRFs with high plastics throughput.

The MSS “Saffire” sorting system (approximately \$75,000 US) is targeted for MRFs processing commingled containers. This equipment mechanically sorts a single resin type (1500-3000 kg/hr) and a number of these units must be placed in series to undertake sorts of multiple resin types. There are currently 18 systems installed in MRFs in Germany but none yet in North American MRFs.

TiTech, a Norwegian Company, developed an automated plastics sorting system to separate a single plastic resin from a mixed stream of beverage cartons using near infrared particle detection and selective impulses of compressed air. The system has capacity for up to 4,000 kg/hr depending on the width of conveyor and material to be sorted. This equipment is now distributed in North America. Approximate cost of one unit (one unit is required for each target resin type – multiple resins can be sorted with individual units in series) is about \$90,000 US.

In 2000, Ottawa processed approximately 1,610 tonnes of plastic containers. Assuming 250 operating days a year and an 8 hour processing schedule, the average throughput of plastic containers was about 800 kg/hr. MSS suggested that a throughput of at least 3,000 kg/hr is necessary for justification of automated plastic sorting equipment.

4.7 Eddy Current Separators

Eddy current separators are designed to separate conductive but non-ferrous metals from other lightweight commingled materials. This is a mature technology that is widely used sorting aluminum in MRFs. There are two basic types of separator designs: one uses a rare earth ceramic rotor to separate small, non-ferrous material; the second, which uses a strontium-ferrite-ceramic motor, has less power, but is ideal for separating aluminum cans in MRFs. Consequently, eddy current separators can be smaller and less powerful and still achieve high recovery rates. High speed oscillating magnetic fields are produced, which induce an electric current in the conductive object. The oscillating fields can be adjusted to optimize separation. This electric current generates a magnetic field, which caused the object (e.g. aluminum cans) to be repelled away from the primary magnetic field.

Aluminum cans are typically removed at a point in the sorting process where they are the dominant material, or at least one of only a few on the conveyor. Typically, separators are placed at the end of a sorting process where aluminum is separated from a plastic mix, or after positive sorting of plastics takes place. This ensures that the eddy current separator operates at maximum efficiency and that aluminum cans do not get “buried” under other containers (and that other materials don’t get pulled off with aluminum cans).

Competition among manufacturers is perhaps the primary reason for bringing down the price of the equipment in recent years. Models designed for MRF applications typically cost about \$40,000-\$50,000 US.

A relatively new development in eddy current technology is found in a device manufactured by a company in France, Andrin SA. This machine sorts aluminum based on thickness and is able to differentiate aseptic packages (e.g. tetra boxes) from aluminum cans. The machine senses the thickness of aluminum in a container (using the patented LEAS sensor technology) and through use of air jets at the end of a sorting conveyor, ejects the targeted container over one of two “air knives”. This equipment is now used in several French MRFs, typically at the end of the container sorting conveyor after a positive plastic sort, to sort aseptic cartons, aluminum cans and the remaining residue (broken glass, miscellaneous plastics, etc.). This manufacturer has expressed interest in the North American marketplace. No cost information is available.

5.0 COMMINGLED PROCESSING SEQUENCE

5.1 General

An important consideration in any MRF process design is the sequence in which containers are sorted. An objective of this project was to compile information from a variety of equipment manufacturers and MRF designers as to their recommended sorting sequence for a commingled container stream similar in nature to Ottawa's system and to compare this to Ottawa's current process.

Appendix B contains typical process flow diagrams recommended by the following:

- Count Recycling Systems (now CP Manufacturing)
- Machinex
- RRT
- Van Dyke
- Duales System Deutschland (DSD).

A review of these process flow diagrams shows general consistency for at least the first five steps of the commingled container sorting process:

1. Bag opening (optional)
2. Manual sort - for oversize items, contaminants, and possibly plastic bags
3. Overhead magnet – for ferrous
4. Screen (trommel or disc) – for removal of small debris, broken glass, grit, etc.
5. Air classifier – for separation of light (plastic, aluminum, etc.) from heavy (glass).

Providing these five operations alone does not ensure success. Ottawa's current contracted MRF has these five initial processing steps (Figure 1) but still has operational problems. As identified in an earlier project², these problems are primarily due either to the layout of the equipment (lack of space, poor sorting ergonomics), the lack of manual sorting staff to perform the necessary work, or equipment that is operating poorly (air classifier). For instance, if for any reason all of the plastic bags and oversized contaminants are not removed at the initial sorting location, the efficiencies of the overhead magnet and air classifier are significantly reduced, more residue is present on the downstream sorting conveyors, and hence, manual sorting becomes more difficult and also less productive.

One of the major differences in the sorting sequence on the light fraction between the Ottawa MRF and the others is the placement of the eddy current separator. All other process flows recommend the eddy current be positioned at the end of the light sort line. Discussions with equipment manufacturers confirmed that the equipment is most efficient

² Earth Tech Canada and Enviro RIS; Review of the Containers Collection and Processing Operations in the Regional Municipality of Ottawa-Carleton; January, 2001.

when aluminum is the primary container on the conveyor (i.e. after a positive sort of plastics).

In view of the markets for glass in the Ottawa area, the intent of positively sorting contaminants to produce a “clean”, negatively sorted coloured glass mix makes sense. Actual operating problems experienced at the MRF are attributed more to the configuration of the glass sorting conveyor and the lack of space provided to perform a good sort (note that the glass line was recently modified and extended to improve sorting).

5.2 Single Stream Systems

Single stream recycling (fully commingled fibres and containers) is gaining increased interest throughout North America and particularly in the United States. In 1997, there were 3 reported MRFs in the US processing single stream recyclables – in 2001, there are over 75.

While this system offers obvious collection advantages, it also presents processing challenges for the efficient mechanical separation of fibres and container materials. The dramatic growth of these systems in recent years, in large part, has been the result of significant technology advances in the development of “disc” screens.

As part of this study, a summary of selected single stream collection and processing programs has been included in Appendix B to provide more information on these systems.

6.0 SUMMARY

The following findings can be drawn from the review of processing technologies (relative to Ottawa’s commingled container mix):

Bag openers – Technology exists for mechanical bag opening of recyclable containers. If Ottawa continues with its “blue box” approach, there is probably no need in the near future to consider this equipment.

Overhead magnet – standard technology

Screens – any commingled sorting process would benefit from early removal of broken glass, grit, bottle caps, etc. Disc screens are more popular than trommel screens if there is concern about minimizing glass breakage through the sorting operating. This is not an issue with Ottawa’s present end market.

Air classifier – standard technology

Eddy Current - standard technology

Glass sorting - (ceramics or colour) – probably not economically viable for Ottawa at this time. A thorough economic analysis of all glass sorting options should be conducted if Ottawa proceeds to implement their own MRF and sorting equipment.

Plastics sorting – technology is progressing, but not feasible for Ottawa’s plastic throughput.

Aseptic sorting – technology exists for mechanically sorting aseptic packaging (e.g. tetra) from aluminum cans. This material is not currently part of Ottawa’s program and even if it were, anticipated volumes would likely only warrant manual positive sorting (as done at Toronto’s Dufferin MRF).

APPENDIX A

Appendix A - MRF Equipment and Suppliers

Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments
BAG OPENER	Plastic bags from commingled containers	Screw conveyors, bag splitters, etc.	Bulk Handling Systems, (Oregon)	BHS Bag Breaker (several models)	20-70 bags /min	Northumberland County, ON	BB 60 Model (12 tph) \$60,000 US	Installed in over 40 MRFs worldwide, most are in Europe.
			MUMA Manufacturing Inc. (Ont.)	Model 480 Model 600	65 yd ³ /hr 100 yd ³ /hr	Green Lane Environmental London, ON	\$75,000	Company makes other equipment
						Guelph, ON	\$110,000 (1995)	8 tonnes/hr
			Mayfran Canada, Ltd.	Schlitzomat XL	Up to 20 tph	Edmonton, AB	> \$100,000	Distributor for German mfg.

Trommel
(see under "Size" function)

Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments
LIGHT/HEAVY	Plastic & aluminum /glass	Inclined Sorter	RRT /Bezner (NY)	SSM 3000/5000	10 tonnes/hr	Toronto Commissioner's St. MRF Phoenix, AZ	\$145,000 US	Sorts waste into larger, items (cups, cans, bottles, glass) and lighter, smaller flat items (cans, foils, plastic)
		Air Classifier	CP Manufacturing (CA)	AC 78	7 to 8 tph 60% heavy 40% light	> 25 MRFs	\$34,000 US	
				AC 10	7 to 8 tph 60% heavy 40% light	>35 MRFs	\$36,000 US	
		RRT	Custom Airsort				Springfield, MA Boulder, CO Washington, DC	

Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments
			Kongskilde (ON)	MTK MTD Blowers Centrifugal units	800-29,400 cfm 600-7,000 cfm Varies depending on size and density of material being conveyed.	<ul style="list-style-type: none"> ▪ Bluewater ▪ Waterloo (blower for alum) ▪ Guelph ▪ Niagara Recycling (HDPE, PET, Alum sort from glass) ▪ York Region (Miller) 	Depends on type of material, density, throughput and travel distance (eg: aluminum and plastics to travel 50 ft: \$30,000)	
SIZE (SMALL / LARGE)	Broken glass & residue/other Or Small containers/large containers	Screen (vibrating)	RRT /Bezner (NY)	Knuckle Screen BSM 50/2250	10 tph	City of Phoenix, AZ	\$110,000 US	Vibrating screen with large circular, horizontal sifting motion.
		Trommels	Triple S Dynamics, (TX)	Rota screens 5'-12' dia. 20-50' length		Georgia	\$100,000 US to \$250,000	Can be adapted for debuggng

Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments
			The Heil Co. (TN)	6'-12.5' dia 15-70' length	Max 200 tph	Rapid City, SD – 10 tph blue bag	\$50,000 - \$390,000 US	
				Suggest 6-7' x 24-30'	For 100 tpd	C.R. Transfer – three stage trommel with bag opener feature	Varies with size, materials, bag opener	
			McLanahan (PA)	7'-8' dia, 20- 30' length, 2 hole cuts of 2.5" and 6-8" diam	100 tpd	WMI Chicago 4 MRFs (1994) 8 trommels still in operation.	\$175,000 - \$225,000 US	Can be adapted for debagging
			RRT (NY)		10 tph	Springfield, MA	\$30,000 US	
	Disc Screen		Bulk Handling Systems (OR)	Debris Roll Screen (DRS)	8 tph	Tx, Ca, EU. Northumberland Co. MRF	\$16,000 US	More than 500 in operation. Requires belt conveyor feeder 24"-30" wide
			Machinex (PQ)		5 - 15 tph		\$35,000- \$50,000 approx.	

Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments	
NON-FERROUS SEPARATION	Aluminum	Eddy Current	Gantry/ SGM Magnetics (Ohio)	*DIS 100/150 40"-120" width	10 tph	Brussel Recyclage, (Belgium) 1000t/m containers	\$85,000 - \$140,000 US	100 installations in Europe. Looking to open NA market.	
				CP Manufacturing (CA)	ECS-1030 [10" Rotor]	1 to 2 tph	> 30	\$50,000 US	
					ECS-1430 [14" Rotor]	2 to 4 tph	> 20	\$70,000 US	
				RRT (NY)	Eriez 36"	10 tph (after glass, ferrous, plastics sort)	Boulder, CO	\$75,000 US	

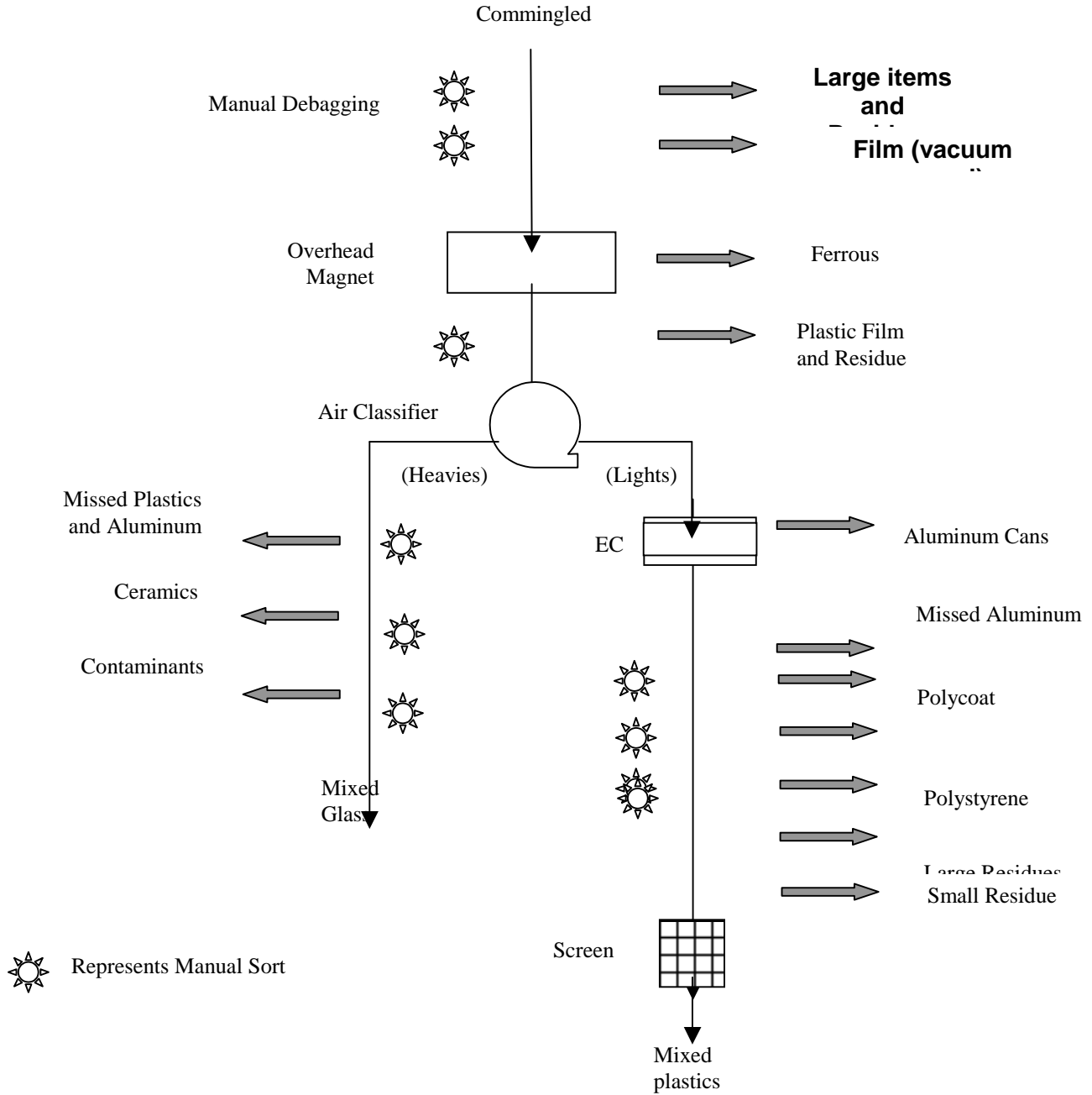
Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments
	Asseptics (e.g. Tetra)	Eddy Current	Andrin SA, (France)	LEAS-Trialu sort device	15,000 tpy: (11,000 tpy residential)	Ecosita at Roche Condy, France. Very new, several in operation in Europe		Sorts aluminum based on thickness. Can differentiate asceptic from alum cans. Adjustable speeds
	Aluminum and Aseptic Packaging	Eddy Current	MSS (TN)	MRF- ELPAC	Plastic Shred Feedrate of EL-8: 900 kg/hr Glass Cullet Feedrate EL-8: 12 tph	ETL, BC: Glass Cullet 20 tph Glass Recyclers, USA Glass Cullet 20 tons/h Illinois, 2 tph mixed recyclables	\$50,000- \$60,000 US for aluminum can removal. \$100,000 US for more precise metal removal such as aluminum can tabs.	Uses a series of eddy-current detectors spaced across a falling feedstream to identify and separate non- ferrous objects by means of precision air jets.
GLASS SORT	Colour sort	Optical NIR Sorters with air jets	MSS (TN)	Glass ColorSort	5-7 tph	West Palm Beach, FL	\$110 000 US	Programmable - in ceramic mode, sorts both ceramics

Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments
						Partners Recycling Baltimore, MD, Ceramics, brown and green from flint glass - 5 tph		and colored glass, 20 tph. Sorts all glass colours.
MAGNETIC SEPARATION	Ferrous	Trom-Mag™	CP Manufacturing, (CA)	TM 78 TM 10	7 to 8 tph 60% heavy 40% light	20 –25 units	\$42,000 - \$46,000 US	CP designs commingled sort systems, especially involving paper sorting. Works in conjunction with MSS.
PLASTIC SORT	Various resin types	Optical Sorters	TiTech, (Norway)	AutoSort KT PE PP PET PPK GT	Up to 6 tph input of plastics (100,000 bottles/h) 1.4 –4 tph	200+ installations Eco Emballages (France), DSD(Germany) and Japan.	\$75,000 - \$175,000 US (for each unit)	Singularization not required. Used in series – for each plastic type. Five units in US by summer, 2001 Beverage carton sorting

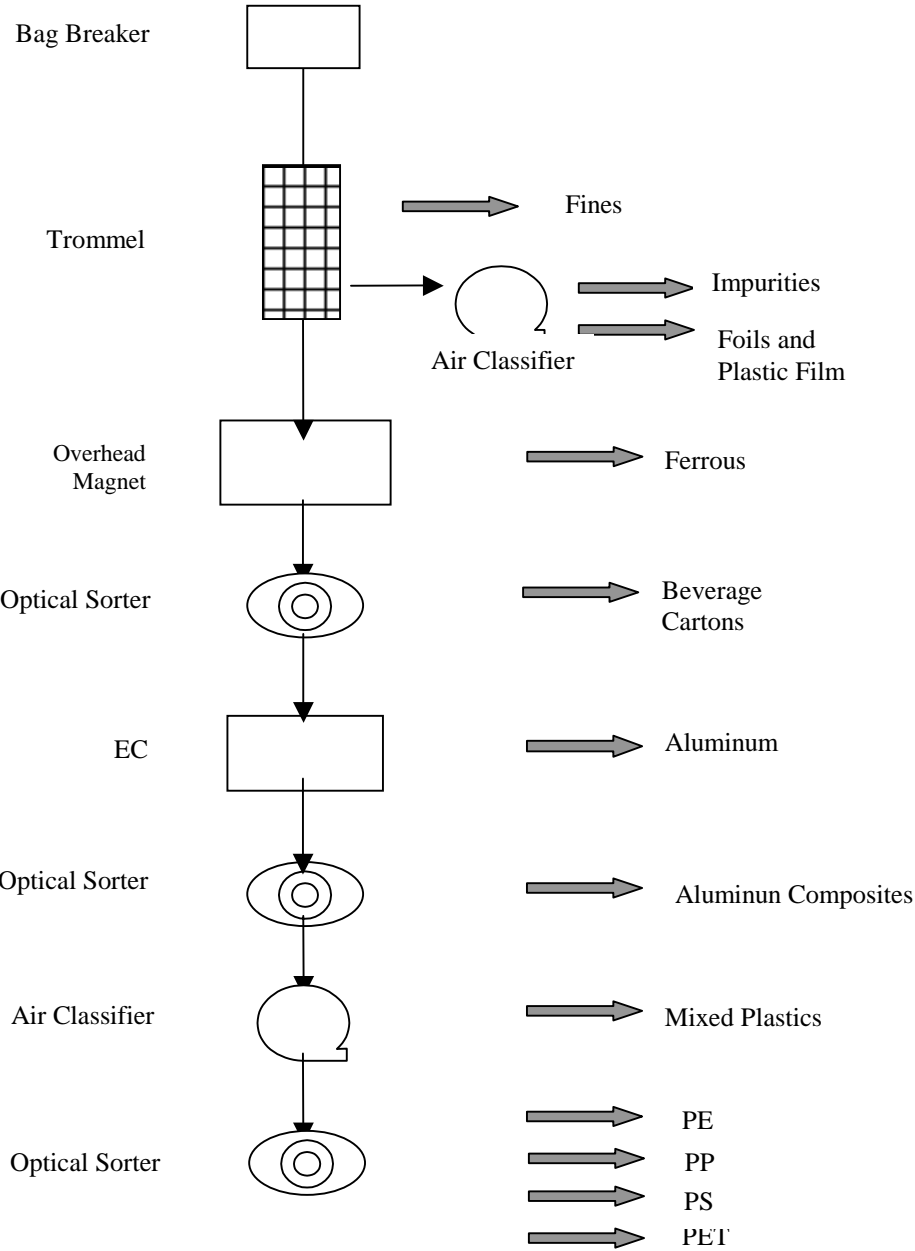
Function	Materials Separated	Equipment	Company	Type or Model	Capacity	MRF Installations	Capital Cost	Comments
			PELLENC SA, (France)	TVB (Trieuse Visuelle a Bulles)	Up to 2.5 tph input of plastics	Paris MRF and a few other intallations in France - very new. No installations in North America.		Used by Eco Emballages. Air Jet visual PET sorter
			MSS (TN)	Binary BottleSort® system – Mass Feed	1.1 and 2.2 tph	Merlin Plastics, BC - PVC from PET: 2.2 tph (1998)	\$80,000 - \$120,000 US	Sorts PET and HDPE, PVC, PEN, Cartons
				B64 Model		FixCorp, Ohio, Natural from	\$95,000 US for 2 tph	
				B128 Model		mixed color HDPE 4.4 tph	\$75,000 US for 1 tph	

APPENDIX B

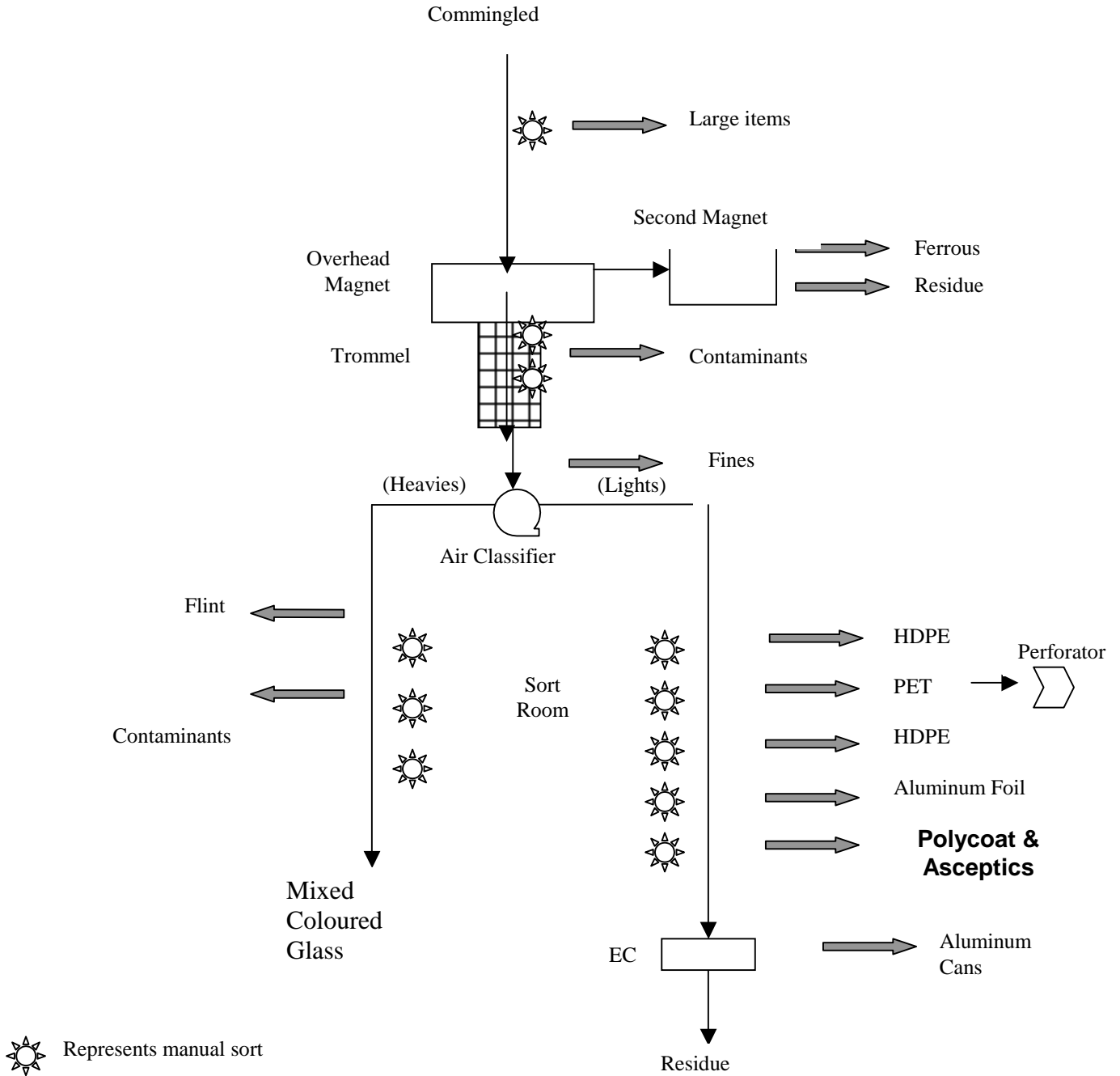
**Figure 2.1
Ottawa (HRR) Commingled Sort Sequence**



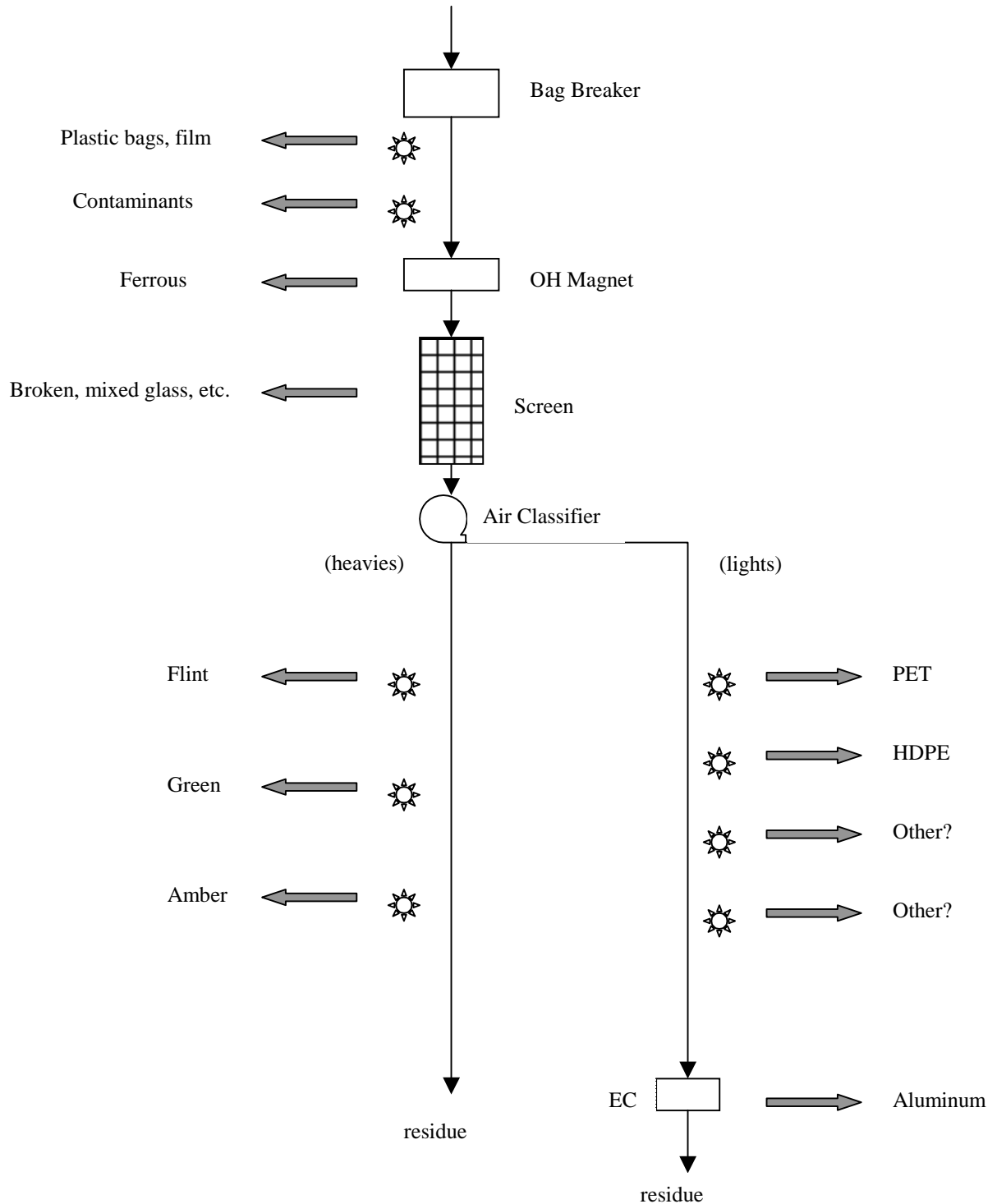
Duales System Deutschland AG (DSD) A.R.T. Sortieranlage – Sort Equipment



Toronto's Dufferin MRF Commingled Sort Sequence

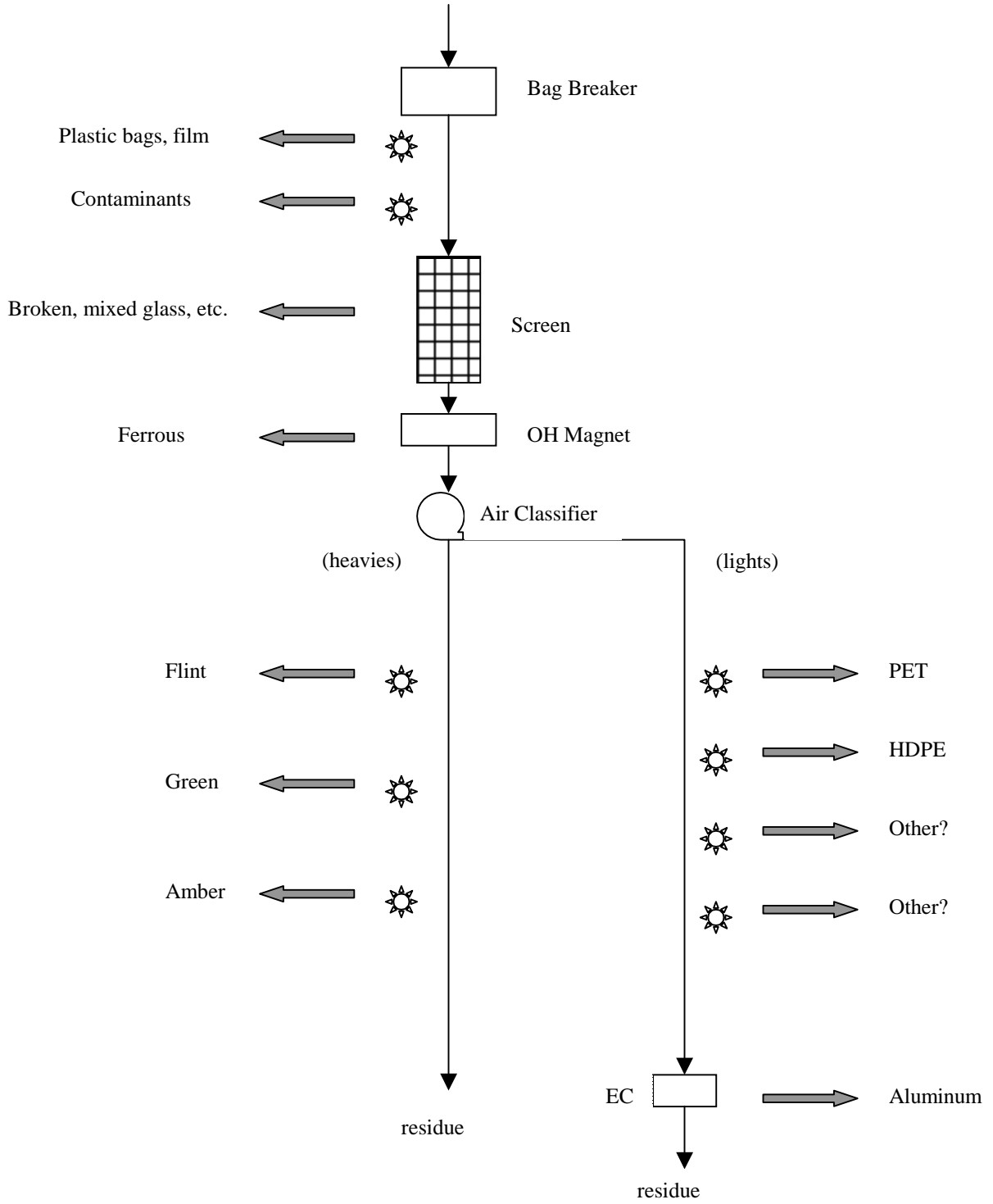



Van Dyke Suggested Commingled Sort Sequence



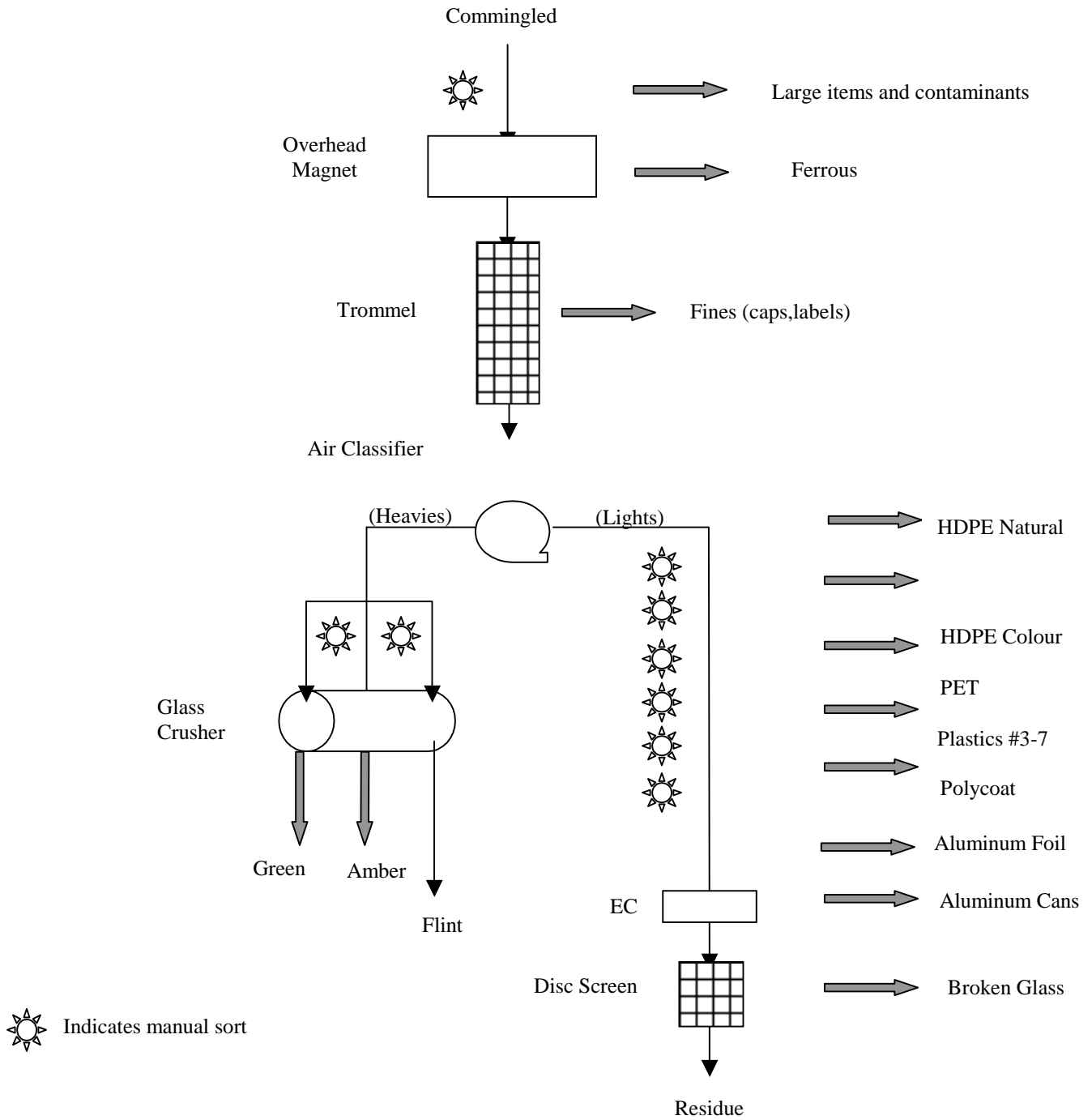
 Represents manual sort

Machinex Suggested Commingled Sort Sequence



 Represents manual sort

RRT Suggested Commingled Process (Springfield, Mass.)



APPENDIX C

Appendix C - Selected Single Stream Collection/Processing Programs

Location /Municipality Served:	Edmonton, AB	Seattle, WA	Phoenix, AZ (southern and central regions)	Fairborn, OH (and 3-4 counties)	San Diego, CA (north part of the city)	Greensboro, NC (and the County of Guildford)	Chicago, IL
Contact	<p>Terry Manziak City's Admin at the plant 780-496-6682</p> <p>Wayne Charney Maintenance Manager Canadian Waste Operator at Plant. 780-472-0121</p> <p>Fong Chong 780-496-6680</p> <p>Ross Boutillier 780-496-6689</p>	<p>Rabanco 54 South Dawson Seattle WA 98134 Phone: (206) 763 – 2700 Fax: (206) 764 – 1234</p> <p>Rabanco Recycling & Transfer Station 2733 Third Ave South #B Seattle WA 98134 206-652-8802 (FAX) 206-624-2991</p> <p>www.rabanco.com</p>	<p>Carl Smith Solid Waste Admin Analyst City Of Phoenix Public Works Dept. Ph. 602-256-5600 Fax: 602-534-1766</p>		<p>Gary McGrath or Mike Thometz Allan Company Phone: 858-578-9300 Fax: 858-578-9942 6733 Consolidated Way San Diego CA 92126 gmcgrath@allancompany.com</p> <p>Stephen Greeley San Diego Dept. of Environment (858) 573-1275</p>	<p>Steve Rich or Dick White FCR Greensboro, Inc. 706 Patton Avenue Greensboro, N.C. 27406 (336) 272-9669</p> <p>Monday -Thursday 7:30 a.m. - 4:00 p.m. Friday 7:30 - 2:00 p.m.</p>	<p>Shellie Riedle 312-742-2203</p> <p>City of Chicago Dept. Of Environment</p> <p>General Info 312-744-7606</p> <p>Public Info /Media 312-744-5716</p>

Location /Municipality Served:	Edmonton, AB	Seattle, WA	Phoenix, AZ (southern and central regions)	Fairborn, OH (and 3-4 counties)	San Diego, CA (north part of the city)	Greensboro, NC (and the County of Guildford)	Chicago, IL
Materials Collected:	Fibre: newsprint, RMP, books, OTD, OCC, boxboard, gable top, aseptics. Metal: tin, alum, aerosol, small metal pieces Glass: jars, bottles Plastics: all containers, shopping bags	Fibre: newsprint, high grade, low grade, ONP, OCC Metal: Tin, steel, alum cans Glass: (sorted at truck) Plastics: HDPE, PET, no bags	Fibre: newsprint, ONP, OCC, boxboard, high grade, low grade paper, gable top, OTD or books to be added this year. Metal: Tin, steel, alum cans, foil and plates Glass: jars, bottles Plastics: HDPE, PET, PS (6) to be dropped this year, no bags	Fibre: ONP, OCC, RMP (no books), OMG, OTD, gable top containers Metal: UBC (including foil and plates), Tin, Steel cans, Aerosol Cans, Aseptic containers Glass: jars and bottles, including coloured glass. Plastics: PET, HDPE, Polystyrene, no bags	Fibre: ONP, OCC, RMP= (residential mixed paper ?), OMG, OTD Metal: UBC, Steel cans Glass: jars and bottles, including coloured glass. Plastics: PET, HDPE	Fibre: ONP, OCC, RMP, OMG, OTD Metal: UBC, Steel cans Glass: jars and bottles, including coloured glass. Plastics: PET, HDPE	Fibre: newsprint, ONP, OCC, boxboard, high grade, low grade paper Metal: Tin, steel, alum cans Glass: jars, bottles Plastics: HDPE, PET
Collection Container Type	Blue bags for all single family units. (used blue boxes formerly) Will start multi family units in the fall 2001.	90 US gallon "Toter" cart and 18 gallon box for glass (to keep glass out of fibre)	Blue recycling container - two 100 gallon roll out carts, one for recyclables and one for refuse.	Green recycling box	36, 60, 90 gallon carts. Households have a choice - can have up to two carts for free.	Majority use 90 US gallon carts	Three blue bags for fibres, containers and yard waste - tied and all collected in single compartment rear packer

Location /Municipality Served:	Edmonton, AB	Seattle, WA	Phoenix, AZ (southern and central regions)	Fairborn, OH (and 3-4 counties)	San Diego, CA (north part of the city)	Greensboro, NC (and the County of Guildford)	Chicago, IL
Collection Vehicle Type	Side loader for single family. Front-end loader for multi family when they start.	Rear packer with separate bins for glass. (glass is colour sorted by operators at the curb)	Side Loaders	Using side, rear and front loaders.	Rear loader loader used with cart lifter.	Rear loader loader used with cart lifter. Trucks are owned by the city.	Rear loader used with cart lifter.
Number of Households served:	City Pop: 636,000 Single family units: 160,000 (include some mf units that have blue bag programs).	Serves 200,000 residential and also commercial customers. Half of the hhlds are served by Rabanco MRF, the other half by the WM MRF.	Phoenix pop: 2,122,100 214,500 households served This MRF serves 66% of the houses. A second solid waste mgmt facility serves the Northern region.	# N/A The population of Fairborn is approximately 31,300. The approximate number of families is 13,288. MRF Serves: Residential Commercial Industrial	135,000 residential homes served 270,000 total in the city - roughly half are served by each MRF. Phasing in single stream, still adding households.	60,000 households 70 % Residential 30% Commercial	750,000 single family households including up to 4 unit multi-family households. This is the total number served by the four MRFS.
Collection Frequency	Weekly Apr-Oct Bi-weekly Nov – Mar	monthly	Weekly for both recyclables and refuse	Weekly with the trash	Bi-weekly	Weekly	Weekly

Location /Municipality Served:	Edmonton, AB	Seattle, WA	Phoenix, AZ (southern and central regions)	Fairborn, OH (and 3-4 counties)	San Diego, CA (north part of the city)	Greensboro, NC (and the County of Guildford)	Chicago, IL
MRF Location:	Edmonton Waste Management Centre in East Edmonton	Rabanco Recycling Centre, South Seattle industrial district	27 th Avenue Solid waste Management Facility, Phoenix	Fairborn	Northern San Diego	Greensboro	4 MRFS, generally located in the NE, NW, SE, SW parts of the city.
MRF Owner:	City of Edmonton	Rabanco (Owned by Allied Waste Systems Inc.)	City of Phoenix	Waste Management Inc.	Allan Company	FCR Inc.	City of Chicago
MRF Operator:	Canadian Waste Systems	Rabanco	Private Company under contract.	Koogler- Suburban (division of WM)	Allan company	FCR Inc.	Waste Management
MRF Key Equipment Supplier:	Built by BFI (Browning Ferris Industries) using a variety of suppliers – facility is now being modified by CWS and Machinex	Eddy Current (Count Recycling) Conveyors (Krause) Curbside Waste Containers (Toter) 3 Balers (Harris WM Group) Recyclone (Recycle Systems, Rabanco, Bellevue, WA)	Bezner Mfg. Co. (Ravensberg, Germany) Balers (Bollegraaf Inc, Holland)	Bulk Handling Systems	CP Manufacturing CP also supplied the other MRF owned & operated by IMS.	Mayfran Manual sorting line	Mayfran debagger Mayfran conveyors Hustler conveyors McLanahan Trommels Eriez eddy-currents Eriez magnets Dings magnets Harris Balers All the MFS have the same equipment. Layouts may be unique to location.