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Putting quality back into the recovery equation

Research at six MRFs reveals that performance varies significantly and improvements could reduce the landfilling of recyclables.

by Steve Apotheker

It happens every time. Someone asks me what I do, and when I tell them "recycling," the first question out of their mouths is always the same: "Aren't we supposed to have one of the best recycling programs in the country? So, what's with this mixing of paper and containers in our yellow recycling bins? Is recycling still happening?" Although some of this skepticism comes from people not understanding the recycling business, some also stems from a report of commingled recyclables actually being taken to the landfill.

In 2005, the Oregon Department of Environmental Quality (Portland) fined Smurfit-Stone Recycling (Chicago), the largest recycling company in the world, for landfilling recyclables. The Portland plant disposed of its curbside plastic bottles and cans with its processing residue for 18 months because the company claimed it was "uneconomic" to separate them further. In addition to the DEQ fine, Metro (Portland), the regional government responsible for regional solid waste and recycling system planning, required the processor to file an operations plan to show how it would comply with full separation of commingled curbside recyclables.

Although it is easy to dismiss Smurfit-Stone as an extreme, the performance of materials recovery facilities (MRFs) does vary significantly and poor performance can result in unnecessary landfilling of recyclables. For example, MRF X, in another part of the country, reported 30-percent residue from the single-stream curbside recyclables it received from one large urban area. At first blush, such a high residue level would suggest that the community needed to educate residents better; however, the plant operator then audited the residue and found that 50 percent of it was recyclable. Thus, the solution went beyond education and involved both the community and MRF X changing their procedures to prevent 9,000 tons of recyclables from going to the landfill each year.

To address concerns about processing quality expressed by local governments and end users (and to a lesser degree, residents), the region's six MRFs voluntarily agreed to participate in a benchmarking study. Metro conducted sampling at MRFs to see how well they handled their two basic tasks: sorting recyclables into correct commodities and removing prohibitives (i.e., materials that should not have been set out for the generator). MRFs would also report monthly on the amount of residue they disposed.

Background

Residents of the Portland metropolitan region are proud of their recycling program. All 550,000 households and 43,000 businesses have the opportunity to recycle and they pay more than $40 million annually for this service, which is embedded within separate solid waste bills. More than 90 percent of the region's 400,000 households with curbside garbage service set-out recyclables.

In order to reach the region's goal of 62-percent waste reduction by 2005 however, more paper from households and businesses needs to be recovered. Despite a regional paper recycling rate already 25-percent higher than the national rate, commingling was seen as a strategy that could increase the recovery of paper and containers.

Mixing recyclables, particularly containers with paper, seems counter to decades of education. People were taught that separating materials by type at the curb was necessary so that high-quality recyclables could be delivered to end-use markets. Now more than ever, successful recycling is a team effort that involves not only the households and haulers, but also the MRFs and mills. The MRF is the point at which prohibitives are removed and this recycling mixture is turned into separate commodities.

In 1998, local governments were interested in moving to a system of collecting commingled recyclables from households. At the request of local governments, Metro con-

Steve Apotheker is a senior recycling planner for Metro (Portland, Oregon). He can be reached at apothekers@metro.dst.or.us.

ducted a field study that looked at how effectively MRFs were able to process different mixes, using the quality of the existing source-separated five-sort mix as a control. At the time, sorting of commingled recyclables was entirely manual (i.e., no disc screens), except for magnets that removed ferrous scrap and a trommel used by one MRF for mixed-container separation.

The results of the study found that:

- Old newspapers (ONP) sorted from a commingled, two-sort collection (i.e., either paper/containers or paper-plastic-metal/glass) had a quality almost equal to source-separated ONP from a five-sort collection. Both grades had five-percent other paper by weight, such as magazines or junk mail. There was no brown fiber in either sample. The only difference was that recyclable containers comprised 0.1 percent in the two-sort ONP.
- Glass could be color-mixed, but it had to be kept separate from other recyclables in order to be shipped to California where an intermediate processor would prepare it for fiberglass manufacturers.

With those assurances, commingled recycling collection began in 2000. The resulting program was a success. Households still put out their recyclables using their existing two 14-gallon bins, but they could commingle the paper, metal and plastic bottles. Glass was kept separate. In the first full year of commingling, curbside recyclables sent to end-markets jumped 21 percent to 127,000 tons.

In 2002, Metro and local governments revisited the issue of the MRFs' capacity and capability to handle more commingled paper and containers. Metro wanted to be assured that MRFs had the ability to process the additional 100,000 tons of paper and containers to be recovered from businesses. In particular, quality concerns resulted in the question of setting performance standards on material quality. Reasons behind these quality concerns were:

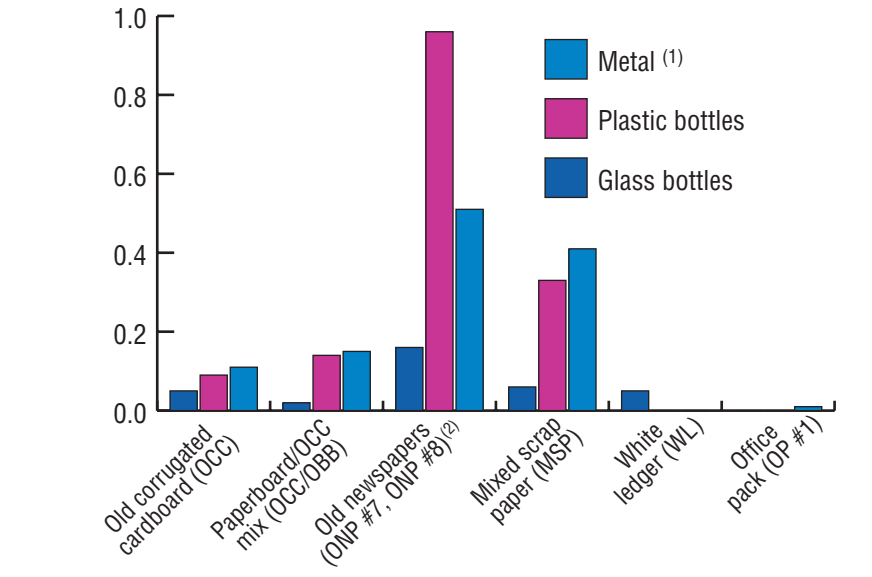
- Paper mills were reporting declining quality of scrap paper, particularly contamination from the presence of broken glass and plastic bags.
- Some haulers had moved to single-stream collection for businesses.
- MRFs had shifted from manual sorting to mechanical screening.

The MRFs proposed a benchmarking field study to see how effectively they were handling commingled materials and to determine whether they could handle increased volumes. The 2002 field study focused on commingled recyclables from businesses because most of the increased paper would come from this sector.

This study targeted MRFs that handled any commingled material and sampled plastic bottles and all major paper grades, including two grades of ONP, two grades of corrugated cardboard, mixed paper and white ledger. This study's approach was repeated in 2003. The major findings from two years of sampling were:

- Commingled paper and containers were a challenge for MRFs to sort correctly, while commingled paper mixes had little contamination.
- The negatively sorted paper grade had six times the contamination from recyclable containers as the positively sorted grades (see Figure 1). For MRFs that accepted commingled paper and containers, ONP was negatively sorted. For MRFs that took only commingled paper, mixed paper was the negative sort.
- Reloads between MRFs were common, but sampling them would overestimate contamination. Reloads took place when capital-intensive MRFs would run commingled commercial paper quickly to separate the corrugated cardboard and then would ship the remaining mixed office paper to a labor-intensive plant where it was more cost-effective to sort out white ledger and produce an office pack. Since the second sort also removes contamination, reload grades were identified and were not included in future sampling efforts.

Figure 1 **Percentage of recyclable containers and prohibitives in paper after sorting**



(1) Includes cans and scrap metal.
(2) Contribution of samples from Processors B and C calculated using weighted averages, which reduces contamination levels. Averages for other ONP samples and other commodities are not weighted.
Source: Metro Commingled Recyclables Processing and Quality, 2004.

Current study

Based on this previous fieldwork, the current, ongoing field-sorting program targets only the six MRFs that handle commingled paper and containers from curbside collectors. In addition, the number of paper grades sampled was trimmed to just ONP. Hand-sorted plastic bottles and residue continued to be sampled.

At the suggestion of the MRF operators, the pre-scheduled sorts became "surprise visits," with notification being given at 8 a.m. on the day of the sort. In addition, sample sizes were increased from the 150 pounds in the previous study to 300 pounds, which matched the same size samples being taken by some paper mills in their quality-sort monitoring of suppliers.

To look at a MRF's ability to perform in a variety of conditions, each plant is visited at least four times over a six-month period that spans wet and dry weather. Each MRF provides 24 samples, or eight samples per material. Over the course of six months, more than 21 tons of commodities and residue were sampled. Each visit records how many sorters are working compared to a full crew (not loaders, spotters or rovers) and if the equipment is working correctly.

Sorting residue

Average annual residue reported by the six MRFs ranged from one percent to two percent, which does not appear to be a great amount compared to some MRFs that report double-digit residue. However, when Metro looked at the composition of the residue from the local MRFs in 2002, it found that 44 percent consisted of recyclable paper and containers, which was similar to the 50 percent of recyclables that MRF X found in an audit

of its residue.

The lesson learned is that a MRF's residue level, whether a low two percent of the local MRFs or the higher 30 percent of MRF X, does not tell you anything about the MRF's effectiveness. Only an audit of the percentage of recyclables in residue indicates how effective the MRF is in doing its job.

Figure 2 shows the progress MRFs have made since the 2002 study, reducing recyclables in residue to 20 percent. An average, however, can hide a wide range of performance. Figure 3 shows that the best local MRF in 2004-05 had less than five-percent recyclables in its residue, whereas several other MRFs saw more than 30-percent recyclables in their residue. Only one MRF consistently did a great job keeping recyclable paper out of residue.

Some of the improvement is due to increased communication with the MRFs. In the 2002 study, one MRF was disposing of all its scrap metal in residue because it did not know this was a curbside recyclable that had to be sorted out by law. In addition, scrap metal prices were low, so the MRF was not motivated to market this material instead of disposing it.

With the knowledge that scrap metal was a curbside recyclable, it is now doing a better job of sorting scrap metal. In addition, when Metro does its residue sampling at a MRF, the plant supervisors can see the results of the sort and get immediate feedback on what is being mistakenly thrown away.

Sorting plastic bottles

Plastics are the major prohibitive found in curbside recyclables, up to 30 percent by weight of prohibitives in residue. However, the export market's specification for mixed-bottle bales has been widening to accept a larger percentage of rigid plastic containers.

Up to 20 percent of a mixed plastic bottle bale can be rigid plastic. If a MRF has to sort these rigid plastics out of the paper, then it would much rather receive revenue of $150 per ton from a plastic market than pay $100 per ton to have them picked up and disposed of in a landfill.

In order to fully characterize the type and amount of plastic prohibitives and track the changing nature of the export market, Metro decided to sample plastic bottles. MRFs have made progress lowering the contamination of non-plastic recyclables and prohibitives in plastic bottles. Although performance among processors varies, between the 2003 and the 2004-05 study, contamination was cut by almost two-thirds, from 9.0 percent to 3.5 percent.

Sorting old newspapers

Metro's sampling of ONP found the composition shown in Figure 4. Acceptable paper accounts for 90 percent; however, of the 10 percent contamination, most (80 percent) is recyclable cardboard and containers that has not been separated out by the MRFs.

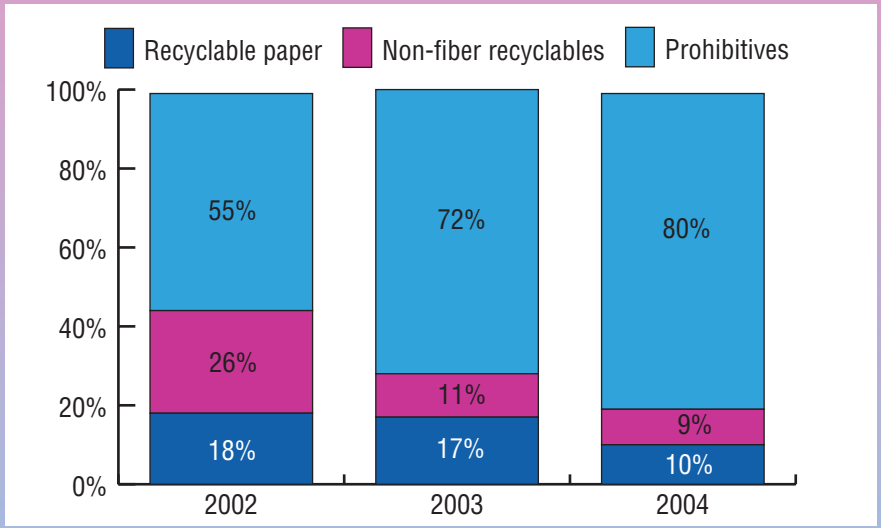
Metro's experience is supported by a study by the North Pacific (NORPAC) newsprint mill in Longview, Washington published in the January 2006 *TAPPI Journal*. The average NORPAC supplier of ONP from single-stream curbside recyclables averaged contamination of 15 percent, compared to less than 0.5 percent in ONP produced from source-separated materials. The mill noted that pulper rejects increased every time a supplier switched to commingled collection. By the first quarter of 2005, pulper rejects were at 10 percent.

Although MRFs in the Metro region have made progress in removing recyclables from residue and in reducing plastic bottle contamination, the contamination in ONP has risen. Between the 2003 and the 2004-05 studies, the percentage of recyclable containers and prohibitives increased one percentage point to four percent.

Contamination varies almost two-fold between the best and the worst MRFs, at six percent and 11 percent, respectively. The biggest contributor to contamination, and the one with the greatest variation among the MRFs, is the amount of brown fiber from corrugated cardboard and old boxboard, such as cereal boxes. Paper mills would like to see the amount of brown fiber lowered, and some MRFs have experimented with adding 25-percent more sorters.

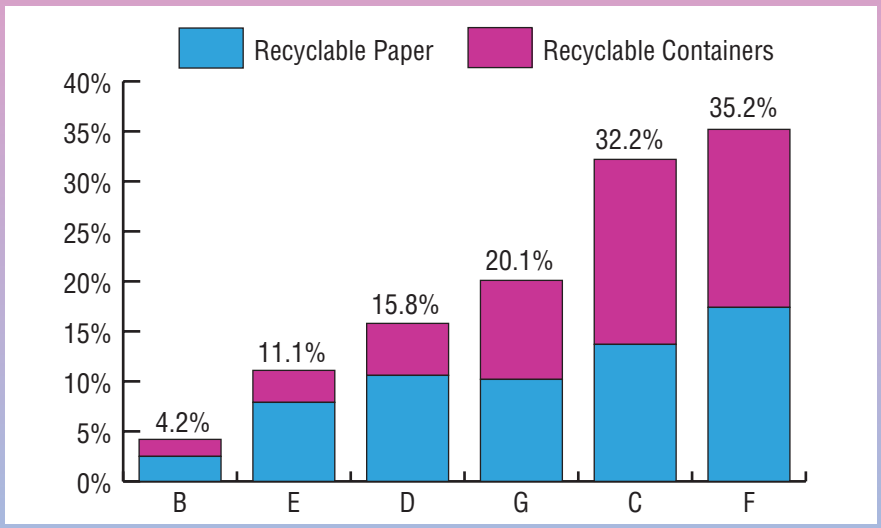
However, additional sorters cannot always

Figure 2 **Residue composition in sampling studies**



Source: Metro Commingled Recyclables Processing and Quality, 2004.

Figure 3 **Recyclables in residue by processor**



Source: Metro Commingled Recyclables Processing and Quality, March 2004.

deal with the brown fiber contamination. Three weeks of daily rain recently resulted in soggy brown bags, because the majority of the region's curbside recyclables are collected from open bins. The brown bags were mushed up going across the star screens, causing greater than usual contamination. As a result, some MRFs have resorted to additional hand-sorting of ONP or moving the fiber as mixed paper to an export market. At times like this, roll carts with lids appear more attractive because they would have kept the paper dry.

The six MRFs in the Metro study averaged 0.34-percent glass contamination, which was double that of the previous year. Although this contamination level is very small, the NORPAC mill found that glass contamination of 0.5 percent was enough to shut the mill down, sometimes for a few days. It can have a major effect on mill process and repair-and-maintenance costs, estimated at several million dollars annually.

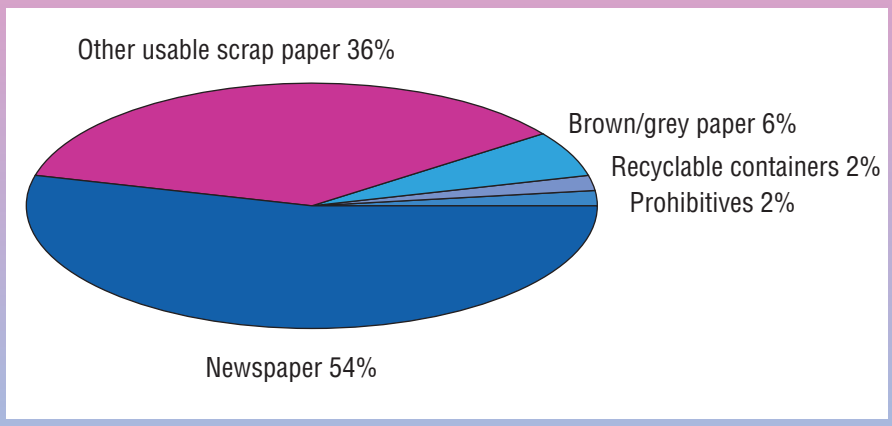
There is room for improvement. Two MRFs saw a decrease in glass contamination, with the greatest decrease at the MRF located in a county that targeted residents with a "keep glass separate" mailer. Three MRFs saw glass contamination increase substantially, with one MRF averaging one-percent broken glass in its ONP samples. One MRF saw its level unchanged.

Analysis of MRF results

The MRF sorting results were used to evaluate how effective MRFs were in removing prohibitives from commodities and sorting commodities correctly. About 60 percent of prohibitives are correctly sorted by the MRFs into either disposed residue or marketed in film or plastic bottle bales, but 40 percent of the prohibitives stay in the ONP (primarily) and other recyclables. Adding up the different prohibitive streams, one can estimate that prohibitives comprise about four percent of incoming recyclables. The best MRF diverts about 75 percent of incoming prohibitives.

This incoming contamination level agrees with the findings of the Oregon Department of Environmental Quality, which sorted recycling setouts in bins and roll carts. It found prohibitive levels between 2.5 percent and 10 percent, respectively. As more local governments move to roll carts (see side bar), with their higher contamination levels, MRFs will see higher contamination levels in delivered loads. MRFs will see costs increase if they have to add more workers, run more slowly or add more equipment to process more highly contaminated roll cart material to the current level of quality. The alternative is for communities and haulers to reduce the amount of prohibitives in roll carts.

Figure 4 **Old newspaper commodity composition, in percent**



Source: Metro Commingled Recyclables Processing and Quality, 2004.

A similar material flow analysis could look at incorrectly prepared materials. In the Metro region, glass is supposed to be set out separately from other recyclables so it is not mixed with the paper going to the MRF. Sampling of selected MRFs indicates that between 20 percent and 25 percent of the glass bottles end up in the commingled recyclables because households mix them with other recyclables or haulers incorrectly collect them together. If the incorrectly prepared glass were included in the above analysis, the average effectiveness of MRFs to remove prohibitive materials would increase to just over 70 percent.

Table 1's material recovery rate figures answer the second question on the MRFs' ability to sort recyclables correctly. The good news is that 99 percent of newspapers and bleached scrap paper correctly ends up in the ONP grade shipped to the newsprint mills. Very little ONP, less than one percent, is sorted out incorrectly and ends up in disposed residue, cardboard or container commodities. By contrast, only about 95 percent of the cardboard and old boxboard is recovered, with most of the five-percent loss occurring in the ONP.

Finally, the recovery of plastic bottles and metal averages about 80 percent. The 20 percent of lost containers end up mixed with the ONP. Because the amount of ONP is ten times larger than the collected bottles and cans, every one-percentage-point of containers in ONP translates into a 10-percent loss in collected recyclable containers. Individual MRFs saw non-fiber recyclables range from one percent to almost four percent in ONP, which corresponds to a loss of 10 percent to 40 percent of incoming containers.

By material, the 20 percent of non-fiber recyclables landfilled by the newsprint mill or MRF translate into a loss of:

- Plastic bottles, 24 percent of collected bottles.
- Aluminum and steel cans, and scrap metal, 18 percent of collected metal.
- Glass bottles, 3 percent of collected glass.

MRFs saw non-fiber recyclables range from one percent to almost four percent in ONP, which corresponds to a loss of 10 percent to 40 percent of incoming containers.

Roll carts: Pro versus con

Although roll carts definitely have more contamination, they have increased the amount of collected recyclables in the Metro region by 10 percent to 15 percent or more after contamination and population growth are netted out. Roll carts also provide drier recyclables, which allows a star screen to effectively sort year-long with minimal adjustments.

Sort data of prohibitives in roll carts suggest the additional contamination is from bagged waste, textiles, wood, organics and inerts, which are heavier and larger than the average bin contamination and thus easier to remove. Finally, glass contamination in the commingled recyclables from roll carts appears to be less than half that coming into the MRFs from bin collection programs.

This landfilling of 20 percent of non-fiber recyclables, mostly by newsprint mills, is equivalent to disposing of the recyclables generated by 80,000 households in one year. Thus, the current operation of the six MRFs is disposing of recyclable containers in an amount four times greater than the amount of containers deliberately landfilled by Smurfit-Stone in one year. To put this loss in another perspective, the amount of curbside recyclable containers sent to end-use markets has remained flat with the implementation of commingled collection, so even though households have set out 20-percent more recyclable containers, these additional containers have ended up in the landfill and their substantial environmental benefits have not been realized.

One consequence of the contamination in ONP is that Metro's true recovery becomes exaggerated. Because almost half of the region's recovered paper is shipped to newsprint mills, the 10-percent contamination is equivalent to overstating regional paper recovery by 23,000 tons or one percentage point in the recovery rate. Similarly, state and national paper recovery rates will increasingly overstate true paper recovery as commingled recycling collection and contamination rates increase.

Do it right

Metro, local governments, haulers, processors and end users have worked together through the field sort program to understand how the current recycling system is working and to identify ways in which each partner can help improve the system.

First, it is the responsibility of local governments working with haulers to educate households about prohibitive materials and to keep glass separate. This will allow MRFs to focus their resources on the important job of sorting out commodities correctly.

Metro will spend $170,000 on a residential outreach campaign asking households to keep glass separate at the curb and keep loose plastic bags out of curbside entirely. The MRFs and newsprint mills identified these issues as among their largest problems.

Second, MRFs have voluntarily made changes that should improve their effectiveness in removing prohibitives and correctly sorting recyclables, especially ONP. These changes include:

- *More workers*. Three MRFs have increased the number of sorters by 25 percent or more to remove more brown fiber and non-fiber recyclables; this enables the MRFs to absorb absenteeism and turnover without sacrificing quality.
- *Adjusted conveyor speed*. One MRF slowed down its infeed conveyor by 10 percent. Other MRFs are experimenting with increasing the speed of takeaway conveyors to reduce burden depth and make more visible those items to be sorted.
- *Better training of workers*. One MRF did not know scrap metal was recyclable.
- *Better expectations*. One MRF has started a program to monitor how many "picks" per minute are made, which can range from 15 to 60. Pick rates at the lower end indicate a need to adjust the worker's targeted materials or to identify a worker who is not sorting effectively. This approach has been useful at plants that have high worker turnover.
- *Equipment searches*. MRFs are looking for screens or other technology to better separate containers from paper. Five of the six MRFs have processing systems that are less than five years old.

Lastly, the field sort program suggests quality benchmarks that MRFs could strive to reach. The two best MRFs are averaging six percent to eight percent ONP contamination. However, the other four MRFs have levels half-again higher, in the 10-percent range. Clearly, substantial gains in quality could be realized if all MRFs performed at the same level as the best ones.

MRF X had a goal to have less than four-percent contamination in its ONP. It found that contamination levels in the ONP from the large urban single-stream curbside program ranged from five percent to eight percent, which fluctuated as MRF X's throughput increased from 20 tons per hour to 35 tons per hour. The MRF is working with an equipment vendor to design a new, more automated system with additional screens and optical sorting for removal of brown fiber and plastic containers, but with half the labor. The MRF has asked the equipment vendor to guarantee no more than two-percent contamination in the ONP when the MRF is fully staffed.

As the nexus between collection and end use, MRFs are the linchpin to ensuring that recyclables end up at the right market. Working with MRFs and mills, government can identify benchmarks that can help MRFs improve their performance so that environmental benefits are fully realized and costs are reduced. Although Metro wants more recovery, it also wants it "done right" through the entire system, so residents can remain confident that their investment actually realizes those environmental benefits. **RR**

Table 1 Material recovery in tons

Materials	Collected	Loss	Recovery rate
Newspaper	70,349	650	99%
Cardboard	15,015	804	95%
Metal	3,456	611	82%
Plastic bottles	3,496	839	76%

Source: Metro Commingled Recyclables Processing and Quality, 2004.

The biggest contributor to contamination in ONP, and the one with the greatest variation among the MRFs, is the amount of brown fiber from corrugated cardboard and old boxboard.

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Four quality benchmarks for communities and MRFs

These benchmarks should result in material recovery rates of more than 98 percent for all paper grades and 95 percent of recyclable containers. These benchmarks were all met or exceeded with source-separation curbside programs with bins.

1. Community – Prohibitives should be two percent or less of delivered recyclables.
2. MRF – Recyclables in residue less than five percent.
3. MRF – Contamination(1) in ONP less than four percent.
4. MRF – Prohibitive removal from delivered recyclables greater than 90 percent.

(1) Contamination is brown and gray paper, recyclable containers and prohibitives.