ASTRX
Applying Systems Thinking to Recycling

SUSTAINABLE PACKAGING COALITION®

THE RECYCLING PARTNERSHIP

ASTRX REVIEW OF MATERIAL FLOW AT MRFS AND REPROCESSORS

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Report Appendices

Appendices A-D are **available on the report website**.

Executive Summary

ASTRX (Applying Systems Thinking to Recycling), the joint project of The Recycling Partnership and the Sustainable Packaging Coalition (SPC), collected information about how materials move through two critical pieces of the circular economy by interviewing Materials Recovery Facilities (MRFs) that sort recyclable materials and reprocessors — the next step in the recycling system — that aggregate and convert materials. The objective was to learn whether there are packaging types, materials or contaminants that present significant challenges for MRFs and the different material-type reprocessors, where specifically within the system they cause problems, and why. The information is intended to:

1. Better understand the perspectives of different players across the system, who often only see their part of the supply chain and not the whole system.
2. Identify roadblocks in the system and alert disparate players about materials that are currently problematic for MRFs and/or reprocessors.
3. Determine opportunities for investment and innovation that will improve the overall recycling system.

For this research, the ASTRX team conducted interviews of both reprocessors and MRFs over the summer and fall of 2018. ASTRX interviewed 11 MRFs and 10 reprocessors for this research. The reprocessors included four plastics reclaimers, two glass beneficiators, two paper mills, two aluminum mills and one steel broker.

The team asked both MRFs and reprocessors how each of five broad material categories — plastics, paper, glass, aluminum and steel — fared in their systems. Findings were divided by material category.

Top Takeaways for Brand Owners:

1 Brand owners can help MRFs fund investments in new flexible film recovery technology

Plastic films wreak havoc at MRFs and reprocessors. Brand owners — even those who do not generate a lot of plastic film — can support investment in updated equipment such as vacuum systems, ballistic separators, density-based air separators, robotic film grabbers, and more optical sorters for capturing film and cleaning paper bales. Though targeted at films, such investments would improve outcomes for all packaging types, because a cleaner stream means better value for MRFs and reprocessors and more successful end markets for all materials, including the film itself, which also strongly needs market support.

2 How2Recycle ®

Consider adding a How2Recycle label on packaging to discourage contamination. For example, How2Recycle can help support messaging to discourage recycling products contaminated with food and reiterate the Caps On message for bottles, where caps would otherwise end up as waste at the MRF. Adding a How2Recycle label on film and pouches will help encourage consumers to return films to store drop-off rather than putting them in curbside carts.

3 Create packaging that can successfully navigate the recycling system, which includes being sold into end markets. Designing recyclable packaging helps brands meet goals for recyclability and keeps the recycling system stable. MRFs want brands to consider marketability to end markets at the beginning of the packaging design process. The matrix in appendix C of this report is a helpful tool to assess packaging recyclability.

4 Purchase recycled content for packaging materials and durable goods to the extent possible. This creates a demand pull on the recycling system, helping it to be financially robust and thus able to successfully process discarded materials generated by brands.

5 Be careful with shrink sleeves.

Full-body shrink-sleeve labels on aluminum cans and PET bottles cause problems for both MRFs and reprocessors. It is important to minimize the use of shrink sleeves on aluminum cans. While these may be suitable to small runs while growing a new brand, use of shrink sleeves on cans should not be relied upon indefinitely. When using plastic shrink-sleeve labels for plastic bottles, use those that meet criteria for preferred under APR's Design Guide®.

6 Paper and aluminum design guides are needed,

in the same vein as APR's Design® Guide for plastics. Such guides could tackle how best to handle materials that have the potential to contaminate these valuable material streams. Brands are an important stakeholder in supporting the development of such guides and would benefit from the design guidance they would provide.

Findings by material type:

Summary of Plastics Findings

- MRFs' most preferred plastic materials are polyethylene terephthalate (PET) and high-density polyethylene (HDPE) bottles.
- Polypropylene (PP) and plastics with resin ID code numbers 3-7 can be valuable where regional markets exist, but currently markets are not robust or available for all MRFs. Strong markets are emerging for PP bales, however.
- Films and flexible plastics cause problems in the MRF in both sortation operations and by lowering the value of other bales, notably fiber.
- Reprocessors found labels (particularly full-body shrink sleeve labels), closures with metal components, and oxygen barriers to be problematic.

Summary of Paper Findings

- Cardboard is the preferred material within the paper category, with 11 out of 11 MRFs expressing a preference for it.
- Paper mills expressed concerns with Residential Mixed Paper (RMP), also called mixed paper, because they feel there is not enough recoverable paper and too many contaminants in these bales.
- Mixed paper is less preferred by MRFs because of its current low value in the market in part due to Chinese import restrictions and currently limited domestic capacity.
- Shredded paper was called out both by MRFs and reprocessors as an item of concern because it is sometimes put in plastic bags inside of recycling carts, and it becomes a contaminant to other materials at the reprocessor level, not just paper mills.

Summary of Glass Findings

- Equipment for glass can be installed to clean the material for reprocessing. Where MRFs have invested in that, the acceptability of glass is high, especially when coinciding with strong local markets.
- Glass reprocessors noted that shredded paper in the material mix decreases the value of glass, which impacts the value MRFs see for glass.

Summary of Aluminum Findings

- Some MRFs expressed concern about plastic shrink-sleeved labels on aluminum cans, and both reprocessors expressed concerns about them. Shrink sleeves on aluminum cans cause problems for both MRFs and aluminum mills. It is anticipated that these concerns will grow if shrink sleeves on aluminum cans become more prevalent in the marketplace.
- Some MRFs also expressed concerns about aluminum foil and aluminum trays devaluing the bales of higher-value used beverage containers (UBCs).

Summary of Steel Findings

- In comparison to the other material substrates, steel is relatively easy for both MRFs and reprocessors to handle.
- Both MRFs and steel reprocessors are cautious around aerosol cans, because of the potential safety hazards they pose when not emptied. However, they are accustomed to managing this hazard.

Based on these findings, the ASTRX team recommends:

Design Interventions:

1. Follow the Association of Plastic Recyclers (APR) Design® Guide for Plastics Recyclability.
2. An aluminum design guide is needed.
3. A paper design guide is needed.
4. Use How2Recycle® or other accurate, consistent, and transparent end-of-life labeling consistent with the Federal Trade Commission's Green Guides.
5. Avoid packaging that uses more than one material type.

Infrastructure Interventions:

1. Conduct additional research on infrastructure needs for the recovery of flexible film packaging.
2. Help MRFs invest in infrastructure improvements.
3. Make investments to produce cleaner glass at MRFs by direct investment or by financially supporting the **Glass Recycling Foundation** or similar organizations.

Community Interventions:

1. Make investments to improve community recycling collection, access and capture rates.
2. Discourage consumers from recycling certain impactful contaminants and don't get bogged down with lengthy 'do not recycle' lists of materials that have light impact on the system.
3. Use careful messaging to encourage recycling pizza boxes that do not have excessive grease or food.
4. Reiterate the "Caps On" message for bottles, a message for residents to leave the caps on beverage containers because plastics recyclers want and recycle the material.

Introduction

ASTRX (Applying Systems Thinking to Recycling) is a collaboration between The Recycling Partnership and the Sustainable Packaging Coalition (SPC) that is working to build a roadmap for a stronger American recycling industry. ASTRX set out to explore material recoverability characteristics and challenges at the reprocessing and sortation levels of the recycling system, two links in the material supply chain that lack transparency in much of the existing research.

ASTRX Five Elements of the Recycling System

ASTRX collected information about how materials move through this part of the recycling system by interviewing Materials Recovery Facilities (MRFs) who sort recyclable materials and reprocessors — the next step in the recycling system — who aggregate and convert materials. The objective was to learn whether there are packaging types, materials or contaminants that present significant challenges for MRFs and the different material-type reprocessors, where specifically within the system they cause problems, and why. The information is intended to:

- Better understand the perspectives of different players across the system, who often only see their part of the supply chain and not the whole system.
- Identify roadblocks in the system and alert disparate players about materials that are currently problematic for MRFs and/or reprocessors.
- Determine opportunities for investment and innovation that will improve the overall recycling system.

This research is critical for informing the ongoing conversation on material quality in the U.S. recycling system, especially given changing export regulations on contamination. ASTRX hopes to use this information to support its work to strengthen the U.S. recycling system through research and education.

Background Information on Generation, Market and Pricing Data

This survey of MRFs and reprocessors was undertaken during the most extended challenging market conditions that the recycling industry has felt in almost three decades due to the after-effects of China's scrap ban, sometimes inaccurately referred to as National Sword[1]. The Chinese import ban on scrap materials, announced in July of 2017 and fully enforced on March 1, 2018, had dramatic effects on the

1. The term "National Sword" referred to a customs enforcement action by the Chinese government that inspected and closed hundreds of plastics reclamation facilities across the country and ran from Feb-Nov 2017. A second customs enforcement action – Operation Blue Skies 2018 – ran during the same months a year later.

pricing of all curbside-collected scrap materials, most pointedly on Residential Mixed Paper (RMP). The ban was in response to, in part, poor quality of and high contamination rates in recyclables bales imported into China from other countries, like the U.S. The ban is currently in effect for all mixed paper and mixed plastic exports into China. While some commodities are still exported, there are strict contamination limits.

According to the **Institute of Scrap Recycling Industries (ISRI)**, the effects of the initial scrap ban announcement would put 18% of overall scrap material (both residential and other scrap sources) at risk. While no publicly available data is available on exact-source (post-consumer or -industrial/ commercial) of scrap materials exported, industry consensus is that both mixed paper and mixed plastics bales were reliant on Chinese markets prior to the ban, particularly those served by West Coast ports.

RMP saw a high of almost $140/ton in the summer of 2011 before hitting less than a dollar per ton in the summer of 2018, with many reports of the negative pricing (MRFs paying mills to take material) both for domestic and international, non-Chinese consumers of the material.

Using aggregated data from capture rate and waste composition studies from across the U.S., The Recycling Partnership finds that RMP is 40% of the average composition of recyclables by weight available at residential households (single- and multi-family) in the U.S. (This is what is available to be recycled, not what is actually set out at the curb.)

Composition of Available Materials in Curbside Mix

Material Type	% of Available Material
Residential Mixed Paper	40.0%
Glass Containers	21.3%
Cardboard	13.4%
PET Bottles	6.2%
Other Plastics (Numbers 3-7)	4.4%
Steel Cans	3.1%
Bulky Rigid Plastics	3.0%
Aluminum Cans	2.4%
HDPE Colored Bottles & Jars	2.0%
Non-Bottle PET	1.4%
HDPE Natural, or Non-Colored, Bottles & Jars	1.3%
Aluminum Foil & Trays	0.8%
Aseptic & Gabletop Cartons	0.8%
Total (greater than 100% due to rounding)	**100.1%**

Not all the market price categories are captured separately in the curbside composition data.

As noted in the table above, RMP makes up 40% of what is available at the curb from residential locations.

The combination of low demand and low value for RMP material, plus the fact that it is the highest-volume (by weight) material for the MRF, can be pointed to as a primary cause for the struggles the recycling industry is currently facing from the MRF perspective.

And while the down-market conditions have been felt most acutely by the mixed-paper and plastics commodity bales, the scrap ban and the commodity tariffs enacted as part of the larger U.S.-China trade war have had deleterious effects on other materials as well.

Below, charts detailing historical data of different commodity types lead each commodity section. All pricing data was gathered from RecyclingMarkets.net using the National Average pricing from the first price noted of every available month.

Methodology

For this research, the ASTRX team conducted interviews of both reprocessors and MRFs over the summer and fall of 2018. Names of the individuals and companies interviewed have been kept confidential. During the first part of each interview, the ASTRX team asked open-ended questions without citing any specific packaging concerns, in order to elicit responses on areas of most concern to each interviewee. During the second half of interviews, the ASTRX team asked about any specific packaging concerns identified by the ASTRX team that the interviewee had not raised.

MRF Interviewee Profile

For the purposes of this study, ASTRX interviewed 11 different MRFs between June and November of 2018. Team members conducting the interviews used a standard set of questions for all interviewed facilities designed to explore MRF perspectives on the processing of various forms of packaging materials (see interview format in Appendix A). This research is meant to provide insights on their perspective, however, due to the small sample size, these responses should not be assumed to have any statistical significance.

In an effort to get geographic diversity representative of the U.S., the ASTRX team interviewed MRFs from across the country, including facilities on the West Coast and in the Southeast, Northeast, and Midwest. The MRFs interviewed for the project had annual throughputs ranging from 33,000 to 200,000 tons, with an average of 104,091 tons per facility per year. Four of the MRFs operated on one shift, five operated on two shifts, and two operated on three shifts.

As a group, the MRFs were relatively sophisticated in the combinations of equipment deployed. Whereas some MRFs only have one disc screen and rely heavily on manual sortation, the MRFs interviewed for this project often had numerous fiber screens as well as optical sorters. (For an example of how materials typically flow through a MRF, see Appendix D). All MRFs interviewed had at least one optical sorter, mostly directed to sort out valuable plastic materials and to clean the fiber stream. A smaller subset had optical sorters that can sort other plastics. Most MRFs within our interview set have some glass cleaning equipment, but this rate is higher than the national average, with a recent **NERC study** finding less than half of MRFs surveyed have this type of equipment.

Table 1: Equipment Profile of Interviewed MRFs

Facility	Number of Cardboard Screens	Number of Disc Screens	Number of Ballistic Separators	Glass Cleaning Equipment?	Number of Optical Sorters	Purpose of Optical Sorters
MRF 1	2	2	1	YES	2	PET; HDPE
MRF 2	1	2	0	YES	4	PET; cleaning contaminants out of fiber
MRF 3	1	3	0	YES	4	PET; HDPE; Numbers 3-7 Plastics, small paper out of containers
MRF 4	1	2	0	YES	2	PET; Numbers 3-7 Plastics
MRF 5	2	1	0	YES	6	Three for fiber; PET; HDPE; Cleaning for PET
MRF 6	1	3	0	YES	2	PET; Cleaning mixed paper
MRF 7	1	1	0	YES	4	PET; HDPE Natural; HDPE Colored; Mixed Plastic
MRF 8	1	3	0	NO	2	2 for PET
MRF 9	1	6	0	YES	2	PET; Cleaning fiber
MRF 10	1	0	1	NO	2	PET; HDPE
MRF 11	1	0	0	YES	1	PET

The MRFs interviewed did lack some advanced equipment. For example, most lacked ballistic separators, which are better equipped to deal with film plastics since they prevent film wrapping that commonly disrupts equipment at MRFs.

Although the MRFs have a range of mechanized capacity as a group the interviewed MRFs fairly represent the state of MRF infrastructure across the U.S. This is an important point in terms of understanding the capabilities of the national MRF system to manage both the existing and the evolving packaging material stream. It is also important in regards to the consistency of feedback from the interviewed facilities regarding preferred and least preferred materials.

Reprocessor Interviewee Profile

ASTRX interviewed 10 reprocessors for this research, including four plastics reclaimers, two glass beneficiators, two paper mills, two aluminum mills and one steel broker. Together, these reprocessors buy and sell materials from all parts of the U.S., and some purchase from and sell materials to other countries. The reprocessors represent the customers for MRFs for specific materials and most had programs to source some material from MRFs, although some did not source from MRFs due to material quality considerations. These materials represent the major post-consumer material markets in North America and the interviews aimed to capture the similarities and differences reprocessors face across and within material types. For the purposes of anonymity, we will not discuss the throughput capacities or locations of the various reprocessors.

Analysis of MRF & Reprocessor Interviews

Challenges for MRFs and Reprocessors

Both MRFs and reprocessessors cited challenges with certain packaging types and materials. These represent critical areas for system-wide intervention:

1. **Full-body shrink sleeve labels** on aluminum cans and PET bottles cause problems both for MRFs and for reprocessors. As long as full-body shrink sleeve labels continue to be a small part of the waste stream, their impact is tolerable. Frequently, shrink sleeves are used on aluminum cans when brands have small production volumes, for example, for certain craft beers. However, if full-body shrink sleeves become more common, and APR guidelines for the use of these labels are not adhered to, they will pull down the value of the blended ton and reduce the recyclability of two of the most iconic, recyclable items.

2. **Films and flexible packaging** currently wreak havoc at MRFs. Nine of the 11 MRFs expressed concerns about the growing presence of plastic bags and film. Plastic bags and film packaging were also cited as a contaminant to paper reprocessors.

3. **Shredded paper** is a contaminant to multiple MRF commodities as well as a contaminant at glass beneficiators.

4. **Mixed packaging types**, such as plastic lids on aluminum cans, or plastic widgets inside aluminum cans, are challenging for reprocessors but can be managed in small quantities. Plastic bottles that use closures with metal components were also cited by reprocessors as challenging. These mixed material items are also challenging for MRFs since they can impact sortation.

Bottle Bill Results

In addition to citing problematic materials such as those listed above, some reprocessors also noted a policy intervention that consistently produces cleaner streams of material. Many reprocessors for different materials indicated they highly prefer material from states with container deposit legislation in place. It is clear that there is a need for incentives to clean up the stream. Technical assistance and funding interventions, such as cart-tagging contaminated containers, have also been successful in communities as diverse as **Atlanta, Chicago and Denver.**

The MRF's Unique Point of View

MRFs see post-consumer material in its completely unprocessed form, and represent the critical gateway between household recyclables and end markets. As such, they have a unique perspective in the value chain and provide some answers and insights different those of reprocessors.

MRFs are a for-profit business and typically only wish to sort what they can sell. A MRF's financial stability is complicated by how their contracts with local governments are negotiated, written and enforced. Contracts sometimes specify that local governments receive a portion of revenues from the sale of commodities, however, it is important that the MRF's processing costs be covered before revenues are paid to local governments. Otherwise, when market values dip, the MRF may not be able to cover its costs.

An overarching concern by MRFs is the movement towards more complex, "fringe" packaging and away from "core" materials that represent their historic and more reliable sources of income. The core packaging types include: PET (especially bottles), HDPE (especially bottles), cardboard, aluminum cans and steel cans. Our research found some confirmation that where MRFs have invested in glass processing equipment, the acceptability of glass is high, despite its low market value.

In the down market of the past two years, particularly for mixed paper, and with expectations that prices for that grade will not improve substantially in the near term, it is not surprising that MRFs are expressing strong partiality for these core materials. It is noteworthy that this same preference for a common set of core, consistently marketable commodities is being reflected as well amongst waste haulers who also profit from recycling these materials. **However, the packaging market is continually evolving, and eliminating materials that are currently cumbersome to the MRF from the suite of acceptable recyclables prevents the MRF from adapting for emerging material streams. In the meantime, we would lose the opportunity to recover valuable materials while also eroding the public's trust in the recycling system**. Community

recycling programs ultimately bear the costs of sustaining a robust collection mix. Strengthening and supporting community programs is critical to maintaining programs that can recycle packaging.

In general, the MRFs surveyed expressed the most concern over packaging with little value (e.g., mixed paper and numbers 3-7 plastics) and materials that disrupt operations and marketability (e.g., loose film, film-based packaging and shrink-sleeved packages). Some reprocessors also found fringe packaging items to cause challenges, namely add-ons to traditional materials like shrink sleeves on plastic bottles and aluminum cans.

MRF Economics

Flexible packaging represents the fastest growing segment of packaging materials. **It is natural that MRFs, haulers and others may view any threat to that quality or to the operational costs of MRF processing with concern, particularly as brands and consumers generally expect the MRF to be able to adapt to an ever-changing packaging mix.**

A number of MRFs expressed the desire to see brands and packaging companies be more cognizant of MRF challenges and to consider unintended consequences in the recycling world based on their packaging choices. **MRFs want brands to consider marketability to end markets at the beginning of the packaging design process.**

The Reprocessors' Unique Point of View

Reprocessors are the customers of MRFs and are concerned primarily about bale yield and quality of bales they receive from MRFs. Reprocessors interviewed for this research noted the following additional concerning trends to those mentioned above by both MRFs and reprocessors:

- **Lightweighting** in packaging as an overall trend does not seem to be abating, which will lead to continued reduced bale yields.

- Some demand by reprocessors for **smaller market commodities**, like PP or aseptic and gable-top cartons, is not being met by MRFs and therefore risks eventually being removed from collection programs. MRFs do not receive these materials in sufficient volumes to fill trucks quickly, and often lack space to store them for long periods of time, affecting the MRF's ability to move them profitably, which limits markets for reprocessors. MRFs also face added expenses for inserting sortation equipment for these low-volume materials. However, organizations like the Carton Council are working to support markets for cartons and their strength as a commodity is increasing.

Where MRFs and Reprocessors Diverge

While there are many concerns shared by both MRFs and reprocessors, there is also some divergence in perspectives between the two groups. **The economics of the MRF is focused around speed and quantity, while reprocessor economics are more focused on bale quality.**

When MRFs sell reprocessors bales with high contamination rates, the yield that reprocessors are able to achieve is low, costing the reprocessors money. This may happen for a number of reasons, including an increase in contamination entering the MRF or a need to speed up sortation lines to meet demand. In other cases this contamination can be intentional, with so-called "bale dressing" where MRFs hide contaminants inside of bales but from the outside they look acceptable. However, reprocessors do not have the capacity to audit each bale and as a result they may end up paying for bales that are more contaminated than they appear from the outside. Some of our interviewees revealed that oftentimes MRFs have significant power to push back on reprocessors because supply is stagnant and material demand is high.

Bale yields can vary considerably between MRF suppliers and between regions, depending on policy frameworks in place that financially support recycling infrastructure and access to collection. The cost of dealing with contamination for reprocessors is high, as they essentially lose between 14 and 37% of the weight of the material they paid for, depending on the substrate. This amount of contamination has steadily increased over time. These losses contribute significantly to inefficiencies in the U.S. recycling system.

Plastics

Summary of Plastics Findings

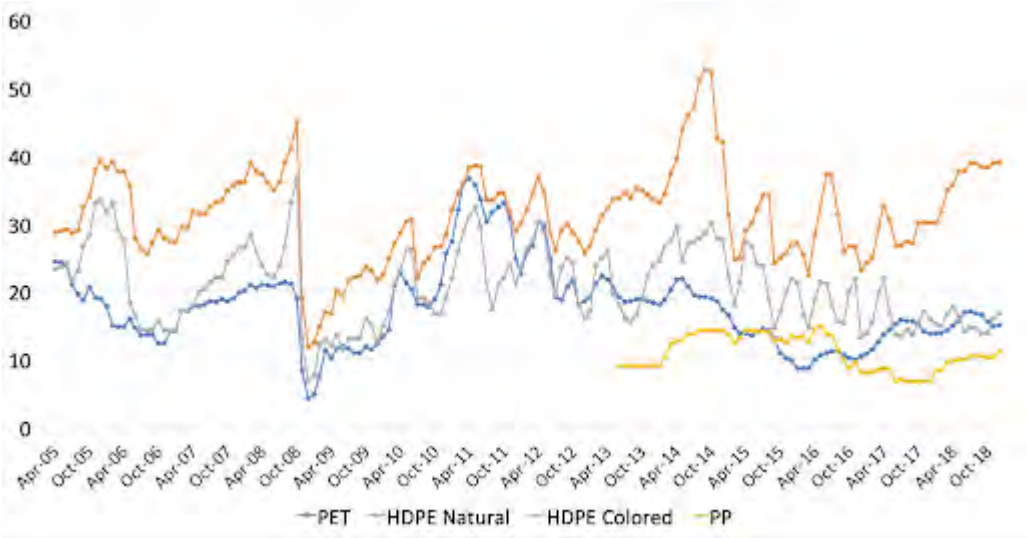
- PET and HDPE bottles are the most preferred plastic materials.
- Numbers 3-7 plastics can be valuable where regional markets exist, especially for PP, for which strong markets are emerging. However, currently markets are not robust or available for all MRFs.
- Films and flexible plastics cause problems in the MRF in both sortation operations and by lowering the value of other bales, notably fiber. Markets for film and flexible plastics need end market support as well.
- Plastics reclaimers found labels (particularly full-body shrink sleeve labels), closures with metal components, and oxygen barriers to be problematic.

Market Characteristics of Plastics

Making up 18.3% of the curbside mix available from U.S. households, plastics is an important and growing part of what residents throw in curbside carts across the country. Almost half (9.5%) of that material has consistent market pricing, with another material, PP, showing similar values, though it is not always sorted into a separate commodity. Looking at the other pricing data, it is shown clearly that the more you sort materials out, the more value those materials have.

The Association of Plastic Recyclers and More Recycling have developed a **Sort for Value Online Calculator** which further details the increase in values the more plastics are sorted by the MRF into individual commodities.

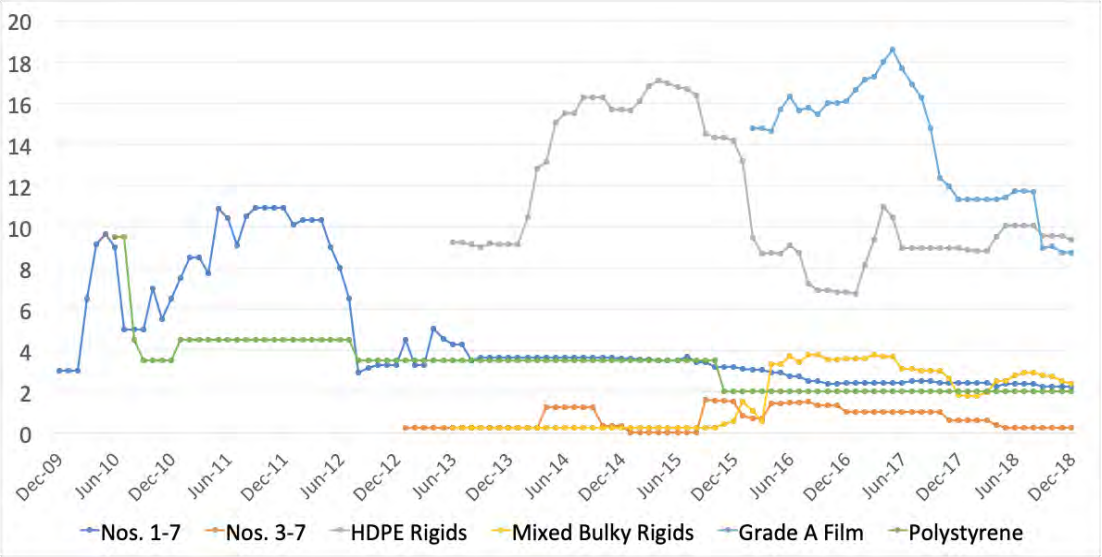
Figure A: Price of Higher Value Plastics in Cents/Pound Over Time



Data provided by RecyclingMarkets.net

***Figure A**: PET, HDPE (Natural and Colored) and PP pricing charts show the primary packaging types of plastics in the curbside mix. Much of the cyclical nature of commodity pricing for all recovered materials (the crash felt most acutely during the peak of the Great Recession in the fall of 2008, the recovery in 2011) is represented in the price fluctuations shown by this chart. The price spike for HDPE in the fall of 2014 was generally cited as being connected to higher virgin ethylene pricing at that time.*

Figure B: Price of Lower Value Plastics in Cents/Pound Over Time



Data provided by RecyclingMarkets.net

***Figure B**: Numbers 1-7, Numbers 3-7, HDPE Rigids, Mixed Bulky Rigids, Grade A Film and Polystyrene all show a bit less price variability than the above Figure A, but some of that may be due to the relatively low value of some of the materials (i.e., there are likely fewer data points for the pricing, as there are fewer buyers of the identified bales).*

Plastics at the MRF

ASTRX asked the interviewed MRFs about the kinds of packaging and other materials they prefer to process. The following table indicates the preferences expressed by the MRFs for plastics.

Table 2: Preferred Plastic Materials

Material	Frequency of Preference	Reasons for Preference
PET	9 out of 11 MRFs expressed a preference for PET packaging, in particular PET bottles	Market value; sortability with optical sorters
HDPE	9 out of 11 MRFs expressed a preference for HDPE packaging, in particular HDPE bottles	Market value; stable demand; sortability
Polypropylene	2 out of 11 MRFs called out this material as preferential	Good markets, although food contamination can be an issue.
Plastic bottles and jugs	1 out of 11 MRFs framed their plastic preference around container shape	Ease of recovery and sorting; stable markets
Numbers 3-7 plastics	1 out of 11 MRFs called out this material as preferential	Strong local market for mixed plastics bale.

ASTRX asked the MRFs to also identify the types of packaging and other materials they least prefer to process. The following table indicates the frequency and reasons for concerns.

Table 3: Least Preferred Plastic Materials

Material	Frequency of Least Preference	Reasons for Least Preference
Film – bags, wraps, other loose film	6 out of 11 MRFs expressed explicit concerns over film in the form of bags, wrap and other loose film	Operational issues within the MRF and resulting costs for handling these issues
Film packaging – pouches, multi-layer packaging	5 out of 11 MRFs expressed explicit concerns over film-based packaging	Contamination of other plastics and other materials; lack of markets; sortability issues
Numbers 3-7 plastics	5 out of 11 MRFs expressed explicit concerns over #3-7s plastics as a specific grade	Lack of value and markets
Shrink-sleeved plastic containers	5 out of 11 MRFs expressed explicit concerns over shrink-sleeved plastic containers	Degradation of value of PET and HDPE bales; sortation issues in MRF
PET thermoforms	3 out of 11 MRFs expressed explicit concerns over PET thermoforms	Negative effects on specifications and value of PET bottle bales; marketability issues; sortability issues due to lightweight nature
Pigmented PET and PETG	2 out of 11 MRFs expressed explicit concerns over pigmented PET and PETG	Negative effects on specifications and value for PET bottle bales; marketability issues; sortability issues
Composite packages – e.g., plastic body with metal ends	1 out of 11 MRFs expressed explicit concerns over plastic packaging combined with other materials	Lack of marketability; degradation of value of plastic bales
Small format plastics	1 out of 11 MRFs expressed explicit concerns over small format plastics	Operational and sortability issues; cross-contamination of other materials
Degradable plastics	1 out of 11 MRFs expressed explicit concerns over degradable plastics	Degradation of value of plastic bales; identifiability in MRF processes

The small minority of MRFs expressing concern over issues such as degradable plastics, composites, small format plastics or pigmented PET, as noted in the table above, does not imply broader acceptance of those materials by the majority of MRFs. A single MRF found each of these contaminants to be problematic, however, currently there does not appear to be widespread concerns for these items. If those materials were more prevalent in the broad array of plastics received at MRFs, additional concerns might be expressed.

"The entire recycling industry is shrouded in secrecy. Transparency is better for the entire industry but how difficult is that based on the current state of relationships? Everyone knows it's a limited supply of material because of low recycling rates."

- Plastics Reprocessor

Plastics at the Reprocessor

ASTRX interviewed four plastics reprocessors, or as they are called by the plastics recycling industry, reclaimers. These reclaimers primarily work with PET, HDPE and PP resins, the resins that are traditional commodities produced from material sourced from MRFs. Together, these reclaimers produce resins that are used in both packaging and in other products.

The team asked the reclaimers to identify the types of products that are challenging for them to process and why they are challenging, as well as products that most commonly show up as contaminants in their reprocessing facilities.

Table 4: Problematic Materials for Plastics Reclaimers

Item	Frequency Mentioned as Problematic	Reasons Item is Problematic
Labels	3 out of 4 reclaimers expressed explicit concerns over presence of labels in general	Sortability issues: lead to rejects and missortation; ease of recovery/ difficult to remove; contamination of bales
Closures on plastic bottles with metal components, particularly aluminum caps	3 out of 4 reclaimers expressed explicit concerns over closures with metal components	Sortability issues: can't be magnetized out; contamination of bales
Oxygen or nylon barriers	3 out of 4 reclaimers expressed explicit concerns over these barriers	Sortability issues: cannot be seen with detectors; degrades market value of bales since they can cause discoloration when recycled; currently a small part of the stream but if it grows will be a problem
Polypropylene (PP) caps	2 out of 4 reclaimers expressed explicit concerns about the presence of caps in PET bales and one expressed a preference for PE caps on PET bottles	Reduces bale yields, small market value for PP; PE caps are preferred by one reclaimer since they have better markets
Cross-resin contamination (the wrong type of plastic in bales)	2 out of 4 reclaimers expressed explicit concerns about cross-resin contamination	Contamination of different plastic bales by other plastics, i.e. PET can end up in the PP stream or opaque non-HDPE bottles that looks like HDPE can end up in HDPE bales
Full-body shrink sleeve labels	2 out of 4 reclaimers expressed explicit concerns about full-body shrink sleeve labels	Contamination in plastic bales that decreases bale yield; operational issues with de-labeler equipment requiring a lot of maintenance; sortation issues: the sorter sees the label and thinks it's opaque and rejects the bottle

CONTINUED

Item	Frequency Mentioned as Problematic	Reasons Item is Problematic
Metals, especially, pump rods, screws and springs inside containers	2 out of 4 reclaimers expressed explicit concerns about metal contamination	Sortation issues: magnet won't move the metal outside the container; operational issues: metal can break the shredders
Paper, specifically small pieces of paper or newspaper	2 out of 4 reclaimers expressed explicit concerns about paper contamination	Sortation issues — torn sheets of loose or wet paper (newspaper and cardboard) ends up in the stream; operational issues: the paper fine loads become saturated, which shuts down the float-sink tank because of shrouded water
Paper labels or cellulose in labels	2 out of 4 reclaimers expressed explicit concerns about paper or cellulose in labels	Ease of recovery: these labels come off easily in heat since many are thermoset, typically large labels with lots of glue, and require more use of water to remove. One reprocessor noted plastic labels are preferable

One reclaimer estimated that about 5% of the PET bottles they receive are rejected and not recycled because of barriers, full-body shrink sleeve labels or closures with metal components.

"I can't stand the polypropylene multi-layer full-shrink sleeve label metallized cap bottle... Sometimes it's identified as PET and sometimes HDPE."
- Plastics Reclaimer

Table 5: Additional Reclaimer Concerns About Plastics

Colored PET	1 out of 4 reclaimers called out colored PET	Low market demand and value
Opaque PET	1 out of 4 reclaimers called out opaque PET	Sortation issues - sorters think it is HDPE so it ends up in the HDPE bale as a contaminant; low market demand and value
Metalized labels	1 out of 4 reclaimers mentioned metalized labels	Sortation issues - the MRF cannot magnetize out these labels
Bags	1 out of 4 reclaimers mentioned bags from MRFs	Contamination - decrease in bale yield and cost to dispose
Black plastic	1 out of 4 reclaimers mentioned black plastics	Little market value
Excess colorant in caps, particularly dark shades	1 out of 4 reclaimers mentioned excess colorant in caps	Causes discoloration when extruded, degrading the value of the bale. Natural colored caps are preferable
Hot melt adhesive in labels	1 out of 4 reclaimers mentioned hot melt adhesives	Degrades value so can't go into higher end markets
PLA (in thermoforms particularly)	1 out of 4 reclaimers mentioned PLA in thermoforms	Operational issues - causes problems in float-sink tank since it acts like PET. Not currently a lot in the stream, but if increased would be problematic
PVC labels or products	1 out of 4 reclaimers mentioned PVC	Degradation of value - leads to a discolored end product
Trash	1 out of 4 reclaimers mentioned trash	Contamination - decreases bale yields and costs money to dispose of trash
Wood	1 out of 4 reclaimers mentioned wood	Contamination - decreases bale yields and costs money to dispose of trash

"I get more and more frustrated with colored PET. No one wants it, and people think it's HDPE so they salt and pepper it into our bales. Nobody wants to buy it." - Plastics Reclaimer

Plastics reclaimers mentioned a few specific packages that are particularly challenging to process. These included:

- PP microwavable bowls. One reason cited is because it looks like HDPE but HDPE reclaimers do not want PP containers.
- Thermoforms. One reason cited is that thermoform producers' label practices are not as conducive to the recycling process as bottle makers' label practices.
- Materials that have been left outside or that have a lot of ground glass from being processed with glass containers or sand in them.
- Plastic containers with metal closures, for example Monster brand plastic cans (a container also noted by one of the interviewed MRFs as problematic), small liquor bottles with metal lids, and the new Snapple bottle, were all found to be problematic because of their metal lids.

Additional challenges that were mentioned by the reclaimers we interviewed were:

- In general, dirtier bales due to single-stream recycling.
- Lower bale yields from lightweighting packages.
- Moisture from residual product which decreases bale yields.
- Intentionally diluting bales with small amounts of less valuable materials, such as colored PET, in a bale of more valuable materials, in response to Chinese import restrictions.

Improvements for Plastics Reprocessing

Reclaimers were also asked what they wish they could do to improve the bales they receive and how they are working to improve their bale quality. Three reclaimers noted that they have a system in place to communicate feedback to MRFs about the qualities of bales they receive from them. In some cases, bad quality bales means visiting the MRFs to perform audits or conduct training. In other cases it can mean no longer sourcing from that MRF. One reclaimer noted that MRFs have the power to push back because supply is stagnant and demand is high.

Interviewees were asked if there were any infrastructure investments that would help them reprocess more material. Answers varied widely and there does not appear to be a perceived need for specific infrastructure investments across the board. Some needs that were noted include capital investment for de-labelers, flake sorting systems to better remove barriers, and adjustments on separators to deal with thin bottles, as well as additional magnets or other demetalizing technologies. Some reclaimers had already invested in multi-million-dollar facilities. Reclaimers also suggested improvements outside of their facilities, including virgin resin markers, to allow sortation equipment to identify resins more easily, and policy tools like container deposit laws.

Major Changes Anticipated for Plastics

Interviewees were asked what major changes they expected to see in the next three to five years for plastics. The most commonly cited concerns were related to the market conditions following National Sword and China's attendant scrap ban. Reclaimers either expected some changes as a result of the China scrap ban, but were not sure what those changes would be, or expected to receive lower quality bales in the future due to the scrap ban. Some reclaimers thought that in the future there might be an increase in numbers 3-7 bales being sold in the U.S., even more lightweighting of packages, and increased commitments to using PCR.

Paper

Summary of Paper Findings

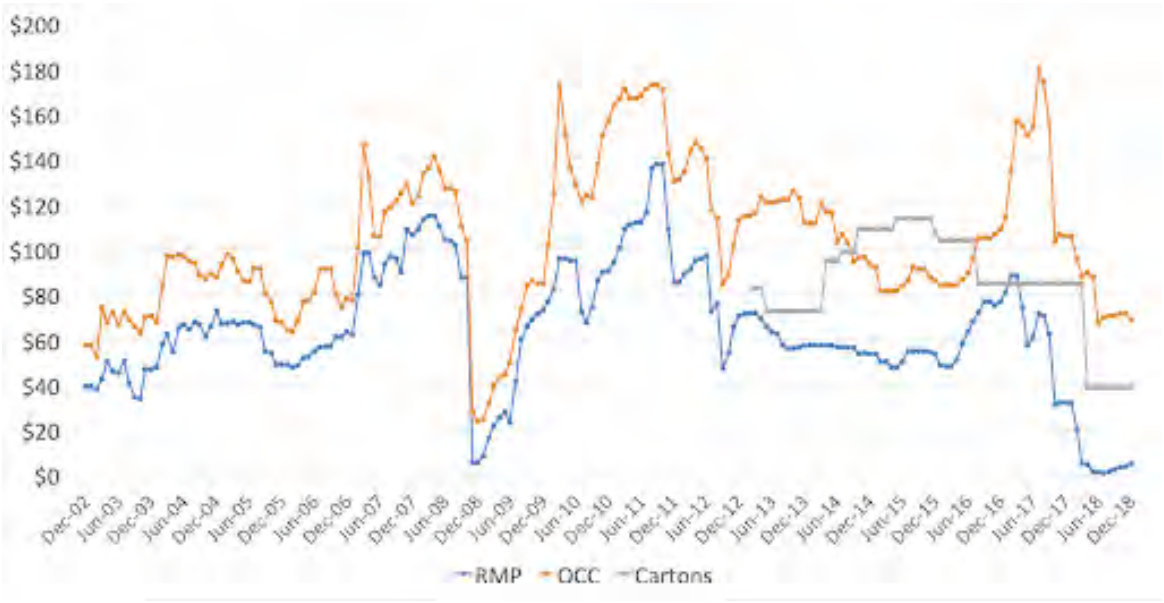
- Old corrugated cardboard (OCC) is the preferred material within the paper category, with 11 out of 11 MRFs expressing a preference for it;
- Mixed paper is less preferred by MRFs because of its current low value in the market;
- Paper mills also expressed concerns with Residential Mixed Paper (RMP), also known as mixed paper, because they feel there is not enough recoverable paper and too many contaminants in these bales;
- Aseptic and gable-top cartons were not preferred because markets for this product are not as robust as other grades (although markets for cartons are on the rise, due in large part to the work of the Carton Council);
- Shredded paper was called out both by MRFs and reprocessors as an item of concern because it is sometimes put in plastic bags inside of recycling carts, and it becomes a contaminant to other materials at the reprocessor level, not just paper mills.

Market Characteristics of Paper

Recovered fiber products make up the majority (54.2%) of recyclables available from households with mixed paper making up 40%, OCC making up 13.4% and aseptic and gable-top cartons making up 0.8%. Mixed paper pricing has dragged down the recovered fiber markets in general, but OCC pricing and cartons, while off historic highs, do bring value.

There are numerous other grades of fiber consumed by paper mills, but those from the residential stream are typically of lower value than from the post-commercial side, where commodities are not generally aggregated and then sorted. For example, cardboard coming from the retail sector is clean and not mixed from other materials, whereas the curbside cardboard has to be sorted out from the other mixed paper stream.

Figure C: Paper Pricing in $/Short Ton Over Time



Data provided by RecyclingMarkets.net

***Figure C**: Historical recovered fiber pricing has the greatest impact on the economics of the MRF, because it is such a large portion of the materials collected and processed. There is a fair amount of volatility in the recovered fiber market, as the above chart shows. At the end of 2008, at the peak of the commodities crisis that was connected to the Great Recession, there is a dip in pricing. Another dip can be seen at the beginning of the impacts of Green Fence, a customs enforcement action launched at the beginning of 2013. The impact of China's Scrap Ban has been severe as shown at the end of the chart, especially for RMP. If sorted, the other commodities shown, OCC and Cartons, have value.*

Paper at the MRF

ASTRX asked the interviewed MRFs about the kinds of packaging (and other) material they prefer to process. The following table indicates the preferences expressed by the MRFs for paper.

Table 6: Preferred Paper Materials

Material	Frequency of Preference	Reasons for Preference
Corrugated Cardboard (recycling market name: OCC)	11 out of 11 MRFs expressed a strong preference for processing cardboard	Market stability and value; sortability
Newspaper (recycling market name: ONP)	Though not a packaging material, this fiber type was mentioned as a preferred paper material by 5 out of 11 MRFs	Sortability; steady value
Sorted Office Paper (recycling market name: SOP)	Though not a packaging material, this fiber type was mentioned as a preferred paper material by 3 out of 11 MRFs	Market value

ASTRX asked the MRFs to identify the types of packaging and other materials they least prefer to process. The following table indicates the frequency and reasons for concerns about those packaging and material types for paper.

Table 7: Least Preferred Paper Materials

Material	Frequency of Least Preference	Reasons for Least Preference
Plastic-lined or coated paper packaging, fast-food paper packaging	5 out of 11 MRFs expressed explicit concerns about coated papers	Degradation of value of paper bales; market concerns; sortability issues as dimensional items could sort with plastic
Cartons (aseptics and gable-top cartons)	4 out of 11 MRFs expressed explicit concerns about cartons/aseptics	Weak end markets
Mixed paper (can include non-packaging material such as junk mail and writing paper, but also includes cartons, paperboard and other fiber-based packaging)	3 out of 11 MRFs explicitly named mixed paper as least preferred	Lack of market value
Molded pulp	1 out of 11 MRFs expressed explicit concerns about molded pulp	Weak markets; degradation of value of paper bales

Although 5 of 11 MRFs cited plastic-lined or coated paper packaging and/or fast-food paper packaging as problematic, there are some recent changes in the industry that may improve outcomes for these products. **WestRock announced** in September 2018 (after the majority of interviews for this research had already been conducted) that it would begin accepting mixed paper bales that include food service packaging at its 100% recycled paperboard mills in the U.S. This will impact markets for these materials moving forward. In addition, there are now newer coatings available for fiber-based packaging that aim to repulp at paper mills more easily than traditional poly-coated packaging. These changes are likely not recognized by the MRFs interviewed for this research because they are cutting edge for the recycling industry.

Additional Challenges Mentioned at MRFs

- **Pizza Boxes:** The consistent message about pizza boxes is general acceptability as long as food and excessively greasy boxes are excluded. Again, the very small amount of pizza boxes in the overall stream helps MRFs tolerate the material, but any curbside program that includes pizza boxes in its collection mix should strongly message to residents to exclude food.
- **Shredded Paper**: Although not a packaging material, shredded paper has been a generally collected material despite its ability to contaminate glass and its tendency to arrive at MRFs in plastic bags. Nine of the 11 interviewed facilities expressed concerns about the material, indicating that the acceptability of shredded paper in community recycling programs should be reconsidered.

The Unique Case of Cartons

The addition of cartons to the recycling stream has been the largest success story to date of moving a material that was once considered not commonly recyclable in curbside systems into a situation where cartons have achieved wide access in the recycling system (meaning over 60% of U.S. households now have access to recycle this item). **The Carton Council**, a nonprofit organization dedicated to improving carton recycling in the U.S., should be commended for their methodological work in adding cartons to the recycling stream. They have helped local recycling programs with communications to residents, assisted in financing equipment to improve sortation of the product at the MRF, and identified and bolstered end markets for the material.

Markets for cartons have been consistently strong for the half-dozen years that they have been tracked by **Recyclingmarkets.net**, generally following the trends for recovered fiber over that same time. Markets have dipped with the beginning of the impact of National Sword and China's scrap ban, but cartons were still seeing prices of over $38 per ton at the end of 2018, compared to just under $5 per ton for residential mixed paper.

Cartons have shown consistent value when MRFs develop systems to intentionally sort cartons into their own bale (otherwise known as sorting positively for cartons). However, some MRFs are configured and operated in such a way that they do not effectively sort cartons into the container line, where they are more easily aggregated into a separate commodity. Also, some MRFs choose not to configure optical sorters to separate out cartons as a commodity, instead going after higher-volume portions of the material stream, such as PET or HDPE. The same decision is sometimes made with staffing, directing positive-sorting workers — those workers tasked with trying to capture specific commodities on the container line — to sort for materials other than cartons.

When MRFs do not sort cartons positively, they end up in mixed paper bales which, in the past, was

acceptable for many mills in China. Some domestic mills also are able to tolerate cartons in residential mixed paper bales, and are able to effectively separate the non-fiber portions of cartons out to capture the fiber.

Some overseas mills still consume cartons (South Korea is often mentioned as a presently consuming market as of May 2019), as do other mills around the country. Additionally, nascent domestic markets like the company Continuus Materials, which makes insulating and building products from cartons, find the multilayer materials in the product category to be desirable for its insulative properties.

The mills that do consume cartons value the long, high-grade fibers that are in cartons. These fibers are a valuable resource because shorter fibers are used in some other packaging materials.

Other markets are coming online in the coming months, including the $52 million **Ecomelida facility in Orangeburg, South Carolina**, which will reportedly produce 72,000 tons of plastic pellets and 36,000 metric tons of pulp annually from of cartons and other materials.

Cartons are made up primarily of paper with a thin layer of polyethylene and an additional layer of aluminum in shelf-stable cartons. Refrigerated cartons, such as milk cartons, do not contain aluminum. Because cartons are mostly paper

and because most MRFs consider them to be a paper product, in designing the interviews for this research, the ASTRX Team included cartons in the section on Paper.

Paper at the Reprocessor

ASTRX interviewed three paper mills. The team asked these mills to identify the types of products that are challenging for them to process, specify why they are challenging, and identify products that most commonly show up as contaminants in their reprocessing facilities.

The paper mills we interviewed noted a general decline in bale quality over the years. One mill noted, "In mixed paper you've got bottles and metal cans...It's only 1 or 2 % but even that can be an issue for a cleaning system that's not one of the more modern systems." This mill specified that they thought the decline in paper bale quality had influenced China's import ban, saying, "China took the majority of the mixed paper and they have the most modern cleaning systems in the world. They'd been taking it for 15 or 20 years and it had built up to where it was even a problem for their cleaning systems."

Because China is no longer importing lower quality bales, U.S. mills report a decrease in the quality of bales that they receive, including an increase in plastics, glass and metal contamination in bales and less fiber per bale. Mills also noted that there has been an increase in contamination such as staples and plastic blister packs over the last decade.

These mills most frequently reported that metals and plastics, including bottles, films and polystyrene, were contaminants in their systems. Paper mills also experienced contamination from glass. The specific contaminants of concern for paper mills are summarized in the table below.

Table 8: Problematic Materials for Paper Mills

Item	Frequency Mentioned as Problematic	Reasons Problematic
Metals	3 out of 3 paper mills expressed explicit concerns about metal	Contamination by metals, including metal cans and pieces, leads to a decrease in bale yields
Film	2 out of 3 paper mills expressed explicit concerns about plastic films	Contamination by films leads to a decrease in bale yields; operational issues: film blinds screens during reprocessing, because it acts like two-dimensional paper.
Plastic attachments to paper, for example blister packaging	1 out of 3 paper mills expressed explicit concerns about plastic attachments to paper	Contamination by plastics leads to a decrease in bale yields. Some mills have seen an increase in the amount of plastic contamination in bales in recent years, taxing the ability of their equipment to remove it all and reducing the amount of paper in bales
Plastic packaging, such as bottles and polystyrene but excluding plastic film (listed above)	1 out of 3 paper mills expressed explicit concerns about plastic packaging	Contamination by plastics leads to a decrease in bale yields. Some mills have seen an increase in the amount of plastic contamination in bales in recent years, taxing the ability of their equipment to remove it all and reducing the amount of paper in bales

CONTINUED

Polycoated paper	1 out of 3 paper mills expressed explicit concerns about polycoated paper	Polycoating sticks to the dryers and creates a lower grade of paper for which they do not have buyers
Glass	1 out of 3 paper mills expressed explicit concerns about glass	Contamination by glass fragments sticking to other materials leads to a decrease in bale yields
Expanded Polystyrene (EPS)	1 out of 3 paper mills expressed explicit concerns about EPS	Contamination by EPS leads to a decrease in bale yields
Wax-coated paper, glue and stickies (tacky substances such as those attaching a faux credit card to an application)	1 out of 3 paper mills expressed explicit concerns about coated or waxed paper, glue and stickies	Operational issues - sticks to the dryers and may shut down operations to clean the dryers; creates an off-grade paper that causes marketability issues

"Consumers think film is recyclable and it is [at store drop-off sites], but it is the number-one enemy to the MRFs as well as the paper mills. They're not automated to the point to remove film."

- Paper Mill

Improvements for Paper Reprocessing

Mills try to work with MRFs to help them understand how much contamination the mill can handle. Some mills schedule periodic reviews with suppliers as well as meetings when a load is of particularly low quality. One paper mill also highlighted the need to educate consumers, in order to reduce contamination going into the recycling cart in the first place.

"I think the industry in the last year has done a decent job of cleaning up the materials from MRFs versus a year ago, but the U.S. specification specific to paper is 2% [contamination]. And there's still a long ways to go from the 2% prohibitive spec."

- Paper Mill

Some mills are investing in new equipment to remove more ink, while others have not made such investments. Some plants will have many screens and flotation tanks to remove inks, but this requires considerable investment and not many mills have made these investments. One mill noted the high cost of new technology, saying investments in paper mills would be "millions and millions of dollars," and that such costs have to be weighed against the return on investment. De-inking technology removes contaminants but does not create white fiber, for which there is a greater demand in the market while at the same time is harder to find as our use of writing paper declines. Some mills noted that ideally, MRFs could share the burden for investing in technology to remove contamination in the stream. Some integrated MRF/mill operators are making investments on both sides, and there is anecdotal evidence that more hauler-owned and independent MRFs are making paper cleaning investments.

All that noted, more than $1.6 billion of investments have been announced to improve mills around the U.S. to be able to take more curbside collected fiber, such as mixed paper and cartons.

Major Changes Anticipated for Paper

The changes that paper reprocessors are expecting to see in the next three to five years are a continuing decline in the volume of printing and writing paper as well as mixed office paper in general. One mill noted that because the sales price for mixed paper has essentially dropped to zero, and there is a cost to sort the material, MRFs are not making money on mixed paper. Because of this, the mill anticipates seeing more local governments having to pay for processing of curbside collected recyclables, whereas in the past they were receiving some revenues from the sale of recyclables. There is strong evidence of a trend in this direction — communities across the country are now receiving processing charges from MRFs. Another possible outcome is that more programs decide to make changes to their list of recyclable items, potentially dropping numbers 3-7 plastics or glass or both.

"The sales price, especially mixed, has gone to basically zero and then it costs to sort and that's significant and then it's a negative equation on process. We're going to see municipalities getting charged for their residential recycling programs whereas a couple years ago they were getting [some revenue]."

- Paper Mill

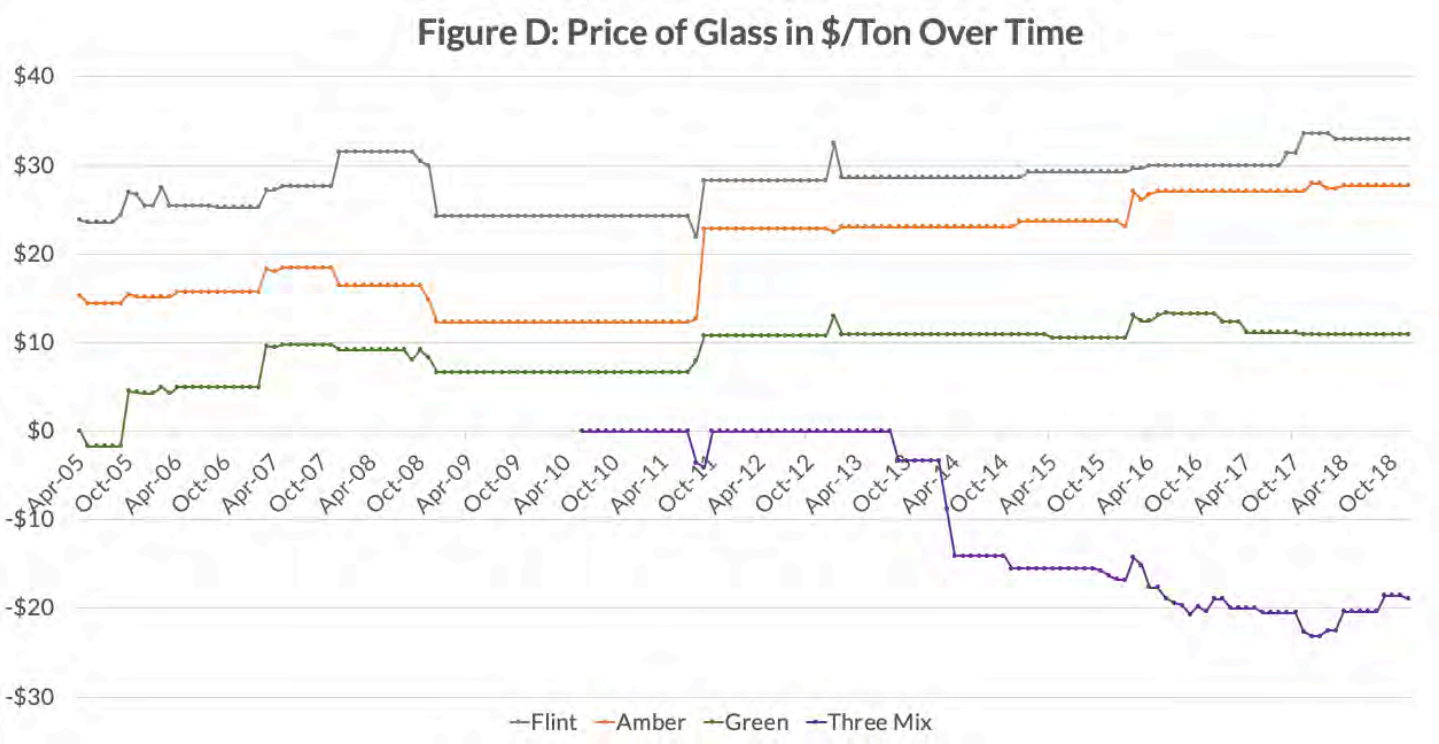
Glass

Summary of Glass Findings

- Equipment for glass can be installed to clean the material for reprocessing. Where MRFs have invested in that, the acceptability of glass is high, especially when coinciding with strong local markets.
- Glass reprocessors noted that shredded paper in the material mix contaminates glass, which negatively impacts the value MRFs receive for glass.

Market Characteristics of Glass

Although it is thought of as an iconic recyclable, in the last few years some MRFs have struggled to make a profit from recycling glass and some communities have been dropping glass as a result. Data on the pricing of glass over time is shown in Figure D below.



Data provided by RecyclingMarkets.net

Figure D: *Prices for sorted glass, as shown above, are consistent, but low. The prices paid for MRF-generated Three Mix have been at zero or negatively priced since being tracked in 2010. The decline in glass is due to the increase in contamination of the glass coming from MRFs. But, when processed properly with available equipment, with nearby end markets, glass can be a consistent source of revenue for MRFs.*

Glass at the MRF

MRFs use a variety of sorting techniques to separate glass from other recyclable commodities. How MRFs separate glass can have impacts on the wear and tear to equipment at the facilities. Separating glass out at the beginning of the process can help reduce some of those impacts, though the means by which that separation occurs can impact other materials.

Glass typically is broken at the beginning of the process in an attempt to remove it from materials, but depending on what material is being processed at the time, and the moisture level of all of the materials, broken glass can stick to other materials, such as PET bottles or OCC, or other materials can stick to the broken glass, most deleteriously, shredded paper.

In addition to equipment used to separate glass from other materials, some MRFs also use cleaning equipment to help prepare glass for reprocessing. Furnace-ready recycled glass generally has a low value compared to other recyclable commodities, however, there is demand for clean recycled glass, and MRFs that produce cleaner glass can expect a better return than MRFs that do not clean glass.

A 2018 survey by the Glass Recycling Coalition (GRC) found that of 82 MRFs surveyed, 27% have glass cleaning equipment. Glass cleaning equipment is not standard in all MRFs but is useful for removing contamination on glass that is a result of commingled recyclables mixing during curbside set-out and hauling. The GRC's report found that the most common glass cleaning equipment in the 27% of MRFs that do have it is air separation units, vacuums or blowers designed to remove paper and organics. Ten percent of MRFs in the survey said they had considered glass cleaning equipment but found it to be too costly. (**GRC**)

Of the 11 MRFs that ASTRX surveyed for this report, only two lacked any glass cleaning equipment. However, the remaining nine MRFs had a wide variety of types of glass cleaning equipment, including glass breakers, trommels, cyclonic separators, and additional screens.

ASTRX asked MRFs about the kinds of packaging and other materials they prefer and least prefer to process. The following tables indicate the preferences expressed by the MRFs for glass.

Table 9: Preferred Glass Materials

Material	Frequency of Preference	Reasons for Preference
Glass bottles and jars	6 out of 11 MRFs expressed a preference for this material	Only readily marketable type of glass

Table 10: Least Preferred Glass Materials

Material	Frequency of Least Preference	Reasons for Least Preference
Shrink-sleeved glass bottles	1 out of 11 MRFs expressed explicit concerns over the shrink-sleeving of glass bottles	Further complicates reduction of contaminants in processed glass


Credit: Strategic Materials

One MRF out of the 11 interviewed did not accept glass at its facility and one additional facility explicitly noted the difficult value proposition and operational challenges of glass in the single-stream mix. The information provided in the interviews provides some confirmation that where MRFs have invested in glass processing equipment, the acceptability of glass is high, despite its low market value.

Glass at the Reprocessor

Glass reprocessing starts with a glass beneficiator — this is a specialized facility that removes contaminants and sorts glass by color and size. Glass containers collected for recycling in commingled residential programs typically undergo beneficiation following preliminary sortation at a MRF. For this project, the ASTRX team interviewed two glass beneficiators. Those two beneficiators said that the three biggest contaminants were ceramics, paper and aluminum.

One beneficiator said ceramics can be 2 to 4% of the glass stream and saw shredded paper as an especially difficult contaminant. Shredded paper mixes into glass at the MRF because MRFs deliberately break glass to sort it out from larger fiber and containers as a small item — thereby sending other small items, such as shredded paper, along with it. Shredded paper was noted as problematic because as more and more consumers acquire shredders for use at home, these machines cut paper into even smaller pieces than commercial shredders and there is thus an increase in tiny pieces of paper that become contamination in the recycling stream.

Other Comments by Glass Beneficiators

Overall contamination is a big issue: Glass beneficiators felt that contamination in general was their greatest challenge, noting that it impacts throughput, specifications for their customers, labor costs and landfill costs. One said, "If we had 100% glass, that would be very profitable and costs would be more competitive with virgin material."

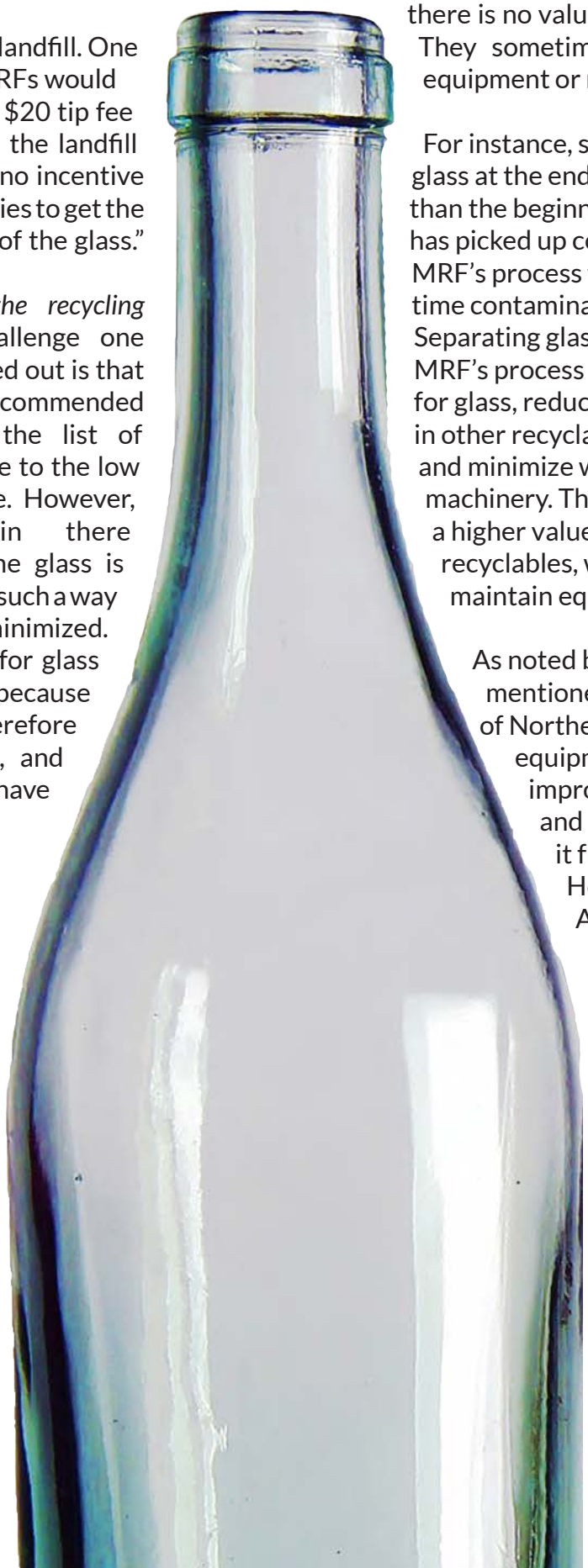
Another beneficiator noted that the week we conducted the interview, they received a load of glass with a six-foot piece of aluminum and a car tire in it. While these particular materials may not show up in every load, it is common to find

large pieces of contamination that are not glass. This beneficiator felt that MRFs do not have an incentive to clean up the glass stream because it is cheaper for them to send glass to a glass beneficiator than it is to pay a tip fee for it at a landfill. One beneficiator said that MRFs would "rather pay me a $15 to $20 tip fee than take their trash to the landfill and pay $50. So there's no incentive for the recycling companies to get the paper and ceramics out of the glass."

Removing glass from the recycling stream: The other challenge one glass beneficiator pointed out is that some MRFs have recommended removing glass from the list of acceptable materials due to the low value the MRFs receive. However, beneficiators maintain there is value in glass, if the glass is processed at the MRF in such a way that contamination is minimized. The value proposition for glass may also vary by region, because glass is heavy and therefore expensive to transport, and some MRFs do not have beneficiators nearby.

Improvements for Glass Reprocessing

Beneficiators feel that infrastructure investments for glass are most needed at the MRF level. One noted that sometimes MRFs do not set up existing equipment in the optimal way for glass recovery, or they lack equipment that would help them produce cleaner glass. Beneficiators feel that MRFs are hesitant to make infrastructure investments, even when options such as grants or loans are available. One said that MRFs "think glass has no value but there is no value because of contamination. They sometimes use the wrong sorting equipment or not in the best process flow."



For instance, some MRFs may separate glass at the end of the MRF process rather than the beginning, which means that glass has picked up contamination all along the MRF's process flow while at the same time contaminating other recyclables. Separating glass at the beginning of the MRF's process can reduce contamination for glass, reduce glass contamination in other recyclable commodities, and minimize wear and tear on MRF machinery. This can help MRFs maintain a higher value for both glass and other recyclables, while reducing costs to maintain equipment.

As noted by the NERC study mentioned previously, less than half of Northeast U.S. MRFs have glass cleaning equipment, which can help improve the value of glass above and beyond simply separating it from other recyclables. However, of the 11 MRFs ASTRX spoke with for this research, nine of them had glass cleaning equipment, and only one of those nine have concerns about processing glass. One of these MRFs even noted that they saw "strong demand and some revenue" for the glass they process. This indicates that where MRFs invest in glass cleaning equipment, they see value in processing glass.

Table 11: Problematic Materials for Glass Beneficiators

Item	Frequency Mentioned as Problematic	Reasons Problematic
Ceramics	2 out of 2 glass beneficiators expressed explicit concerns about ceramics	Contamination, primarily dinner plates, mugs, cups, etc., resulting in a decrease in glass yields and damaging to the resulting new containers
Paper, especially shredded paper	2 out of 2 glass beneficiators expressed explicit concerns about paper	Contamination, resulting in a decrease in glass yields; shredded paper affects ease of recovery because it falls through half inch screens.
Aluminum cans and aluminum scrap	2 out of 2 glass beneficiators expressed explicit concerns about aluminum	Contamination, resulting in a decrease in glass yields; however, one beneficiator noted they can sometimes pull out aluminum and sell it.
Batteries	1 out of 2 glass beneficiators expressed explicit concerns about batteries	Operational issues: batteries can explode (beneficiator did not know why they had become a problem as of late)
Caps	1 out of 2 glass beneficiators expressed explicit concerns about caps	Contamination, resulting in a decrease in glass yields
Hazardous or corrosive material	1 out of 2 glass beneficiators expressed explicit concerns about hazardous/corrosive material	Contamination, resulting in a decrease in glass yields; cost to dispose; operational risks
Radioactive material	1 out of 2 glass beneficiators expressed explicit concerns about radioactive material	Contamination, resulting in a decrease in glass yields; cost to dispose; operational risks
Leaded glass (a type of glass in which lead oxide is used, also called crystal)	1 out of 2 glass beneficiators expressed explicit concerns about leaded glass	Contamination, resulting in a decrease in glass yields; cost to dispose; operational risks
Medical waste	1 out of 2 glass beneficiators expressed explicit concerns about medical waste	Contamination, resulting in a decrease in glass yields; cost to dispose; operational risks
Plastic labels	1 out of 2 glass beneficiators expressed explicit concerns about plastic labels on bottles	Ease of recovery - hard to remove, sticks to the glass when crushed and loses glass lowering yields; creates “off emissions” in furnace; paper and direct print labels are easier to manage.

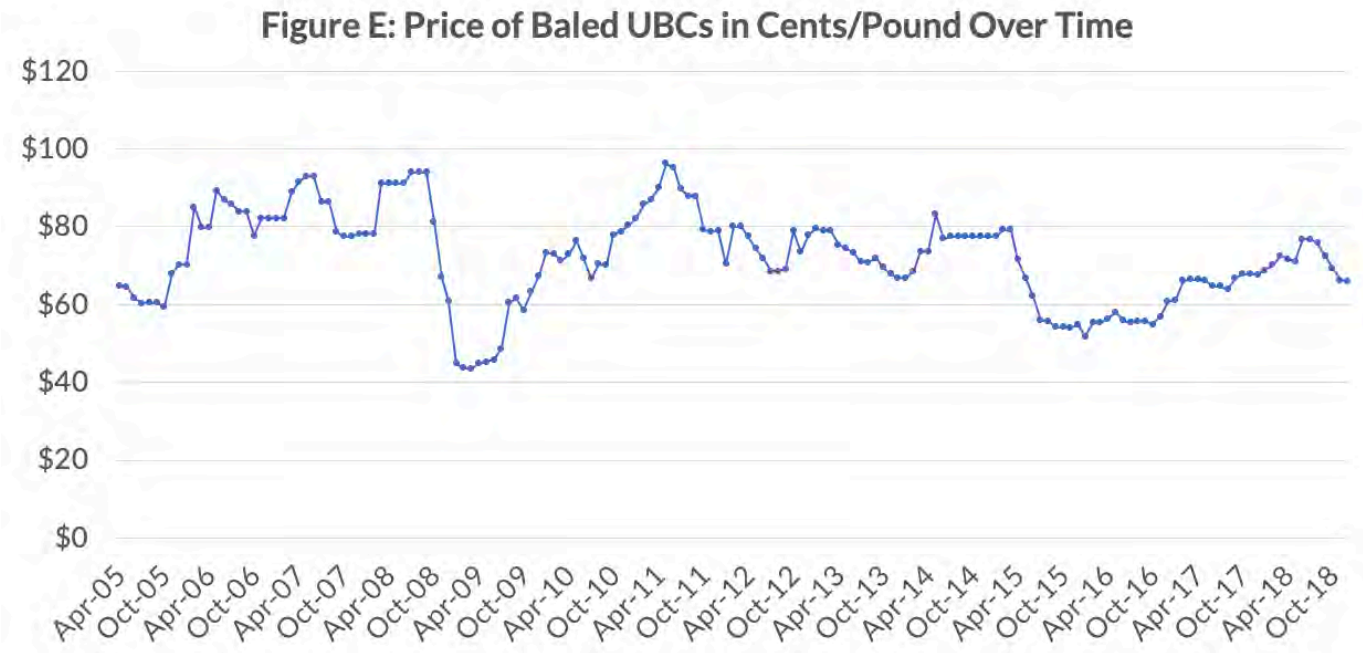
Aluminum

Summary of Aluminum Findings

- Some MRFs expressed concern about shrink-sleeved aluminum cans, and both reprocessors interviewed expressed concerns about them. MRFs reported that they are a contaminant for their consuming mills, and that the MRFs have no way to separate them from the used beverage container (UBC) stream. Clearly, shrink sleeves on aluminum cans cause problems for both MRFs and aluminum mills. It is anticipated that these concerns will grow if shrink sleeves on aluminum cans become more prevalent in the marketplace.
- Some MRFs also expressed concerns about aluminum foil and aluminum trays. One MRF reported that foil is difficult to recover, has limited markets, and has to be hand picked out of the UBC stream.

Market Characteristics of Aluminum

Aluminum provides a consistent source of revenue for MRFs. Although the material is not immune to price changes, its price has remained relatively steady over time in comparison to more volatile commodities in the recycling system.



Data provided by RecyclingMarkets.net

Figure E: *Markets for UBC bales are the most consistent and highest amongst commodities produced by MRFs. Even at the peak of the 2008 crash, bales were still commanding prices far above counterparts that hovered at or around zero.*

Aluminum at the MRF

ASTRX asked MRFs about the kinds of packaging (and other) material they prefer to process. The following table indicates the preferences expressed by the MRFs for aluminum.

Table 12: Preferred Aluminum Materials

Item	Frequency of Preference	Reasons for Preference
Aluminum beverage cans	10 out of 11 MRFs expressed a strong preference for this material	High value; consistent markets; easily sorted

ASTRX asked the MRFs to identify the types of packaging and other materials they least prefer to process. The following table indicates the frequency and reasons for concerns about those packaging and material types for aluminum.

Table 13: Least Preferred Aluminum Materials

Item	Frequency of Least Preference	Reasons for Least Preference
Aluminum foil/trays	5 out of 11 MRFs expressed explicit concerns about aluminum foil and trays	Difficult to separate; limited value; can have food contamination; degradation of value and quality of can bales
Aluminum aerosol cans	1 out of 11 MRFs expressed explicit concerns about aerosol cans (see more on aerosol cans below), when specifically asked about the behavior of the cans, 4 other MRFs expressed concern	Degradation of value and quality of can bales; potential fire hazard if cans are not emptied by consumer
Shrink-sleeved aluminum cans	3 out of 11 MRFs expressed explicit concerns about shrink-sleeved aluminum cans; Note: concern may rise with more market penetration of this package	Degradation of value and quality of can bales
Cat food cans	1 out of 11 MRFs expressed explicit concern about aluminum cat food cans	Hard to distinguish in bales and becomes an outthrow at consuming mills

Aerosol Cans

This packaging material comes in two substrates: aluminum and steel. Most MRFs were accepting of the material while expressing caution about the potential for fires and other hazards caused by cans that are not fully emptied. One MRF reported having had baler fires because of unemptied aerosol cans, and another MRF said the market does not want them. One reprocessor noted that if an unemptied aerosol

can made it to the molten metal bath, there is a chance for an explosion. The relative low volume of aerosols in the overall material mix mitigates some of the concern, but there seems to still be some baseline wariness about these cans.

Aluminum at the Reprocessor

ASTRX interviewed two aluminum can sheet mills that consume UBC bales as part of their recycling facility and asked them to identify the types of products that are challenging for them to process and why they are challenging, as well as products that most commonly show up as contaminants in their reprocessing facilities.

One mill reported that what they target for contamination in aluminum bales coming from MRFs is upwards of 12%, meaning they recover less than 88% of the bale as UBCs. The 12% contamination can include lacquer or coating on or in the cans, residual organics in the cans, or other types of contamination.

Sometimes, there is sufficient contamination in bales that they are pre-sorted at a facility between the MRF and the reprocessor. While a range of contaminants were discussed, the top contaminants are full-body shrink sleeves, widgets like the plastic ball in a can of Guinness beer designed to make it taste like draught beer, and plastic lids on cans. These are summarized in the following table (page **37**).

The challenges with shrink sleeves, stickers and widgets encourages involvement in design for recyclability. Mills generally prefer lacquered cans, such as big-brand soda or beer cans. Because of

"Shrink wrap on aluminum cans, stickers are absolutely terrible, the resealable can technology where you have plastic on top, liners, the widgets like in Guinness cans, all of those things reduce the recovery of those UBCs so that when you get those in a bale you get lower than expected recovery. If a large portion of the market moves to things like shrink wraps and widgets, it will gradually increase the losses to our system. Our position is, I don't mind if this is an easy way to get into the can, but once you get to a certain mass, you ought to be converting to lacquer."

- Aluminum Mill

lack of scale and smaller orders, many craft beer cans use stickers and shrink sleeves as opposed to lacquered designs.

Dirty UBC bales, along with bales of other scrap aluminum such as aluminum foil or trays, can be sent for secondary processing and melted into ingots called recycled scrap ingot (RSI) or remelt sheeting.

"MRF cans are not assumed to recover at 88%, they're assumed to be of a lower quality."

- Aluminum Mill

Improvements for Aluminum Reprocessing

Infrastructure improvements for aluminum mills are possible but come at a cost. As an example, one reprocessor interviewed said that their new facility cost $200 million. Because it is a substantial investment, this person said, "So if you want people to build the infrastructure to take these materials, there's got to be a predictable quality, there's got to be good infrastructure behind them. It's great that the package is sustainable and we're doing that for our customers because they're demanding it, but we're also doing it because it makes financial sense. Otherwise you move into other materials."

Major Changes Anticipated for Aluminum

One aluminum mill interviewed for this report expects to see more lightweighting and more attempts to design a resealable aluminum package. Additional design innovations with aluminum cans that could cause challenges for mills, like raised printing, are also expected.

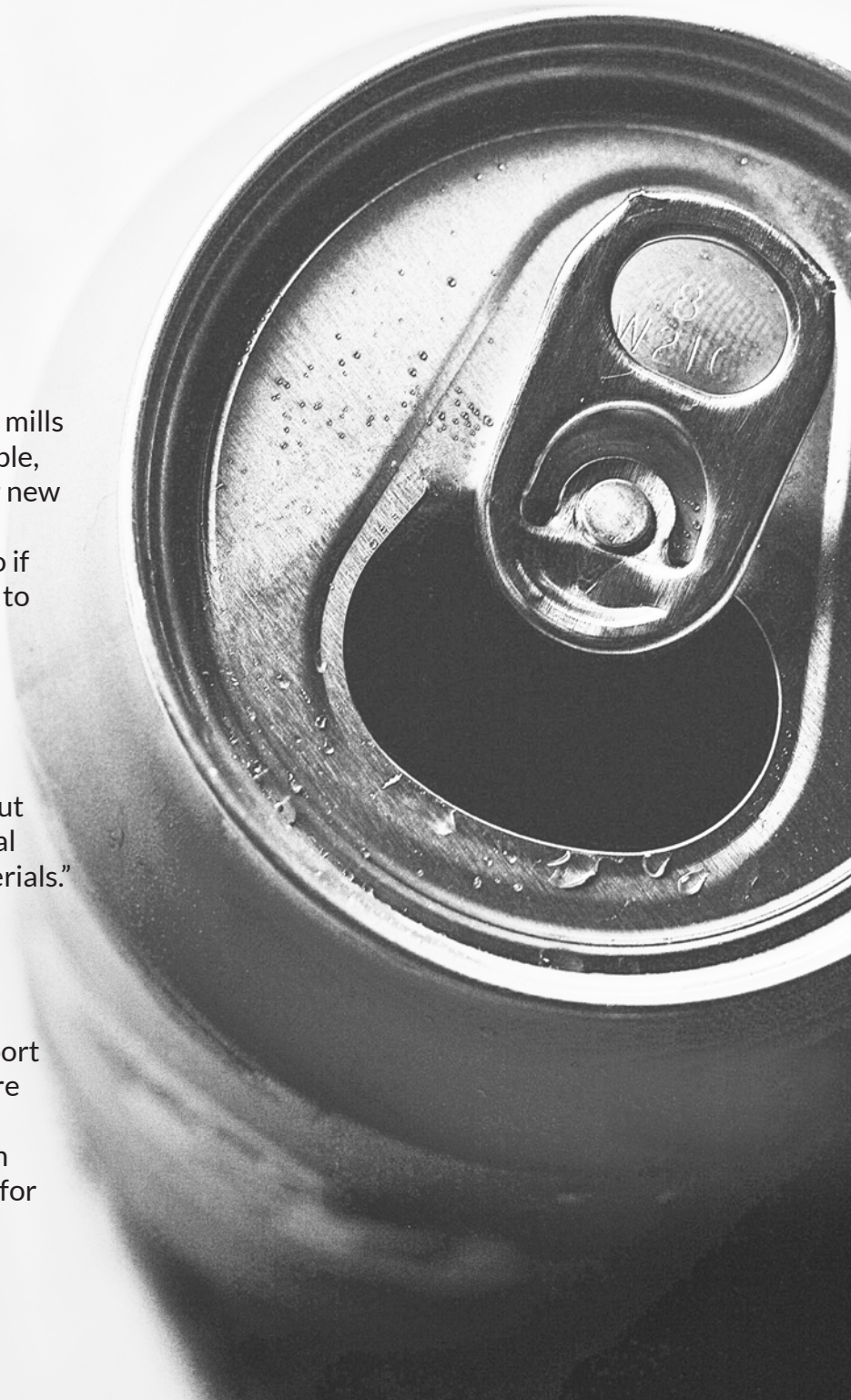


Table 14: Problematic Materials for Aluminum Mills

Item	Frequency Mentioned as Problematic	Reasons Problematic
Full-body shrink sleeves	2 out of 2 aluminum mills expressed explicit concerns about full-body shrink sleeves	Operational issues: when shredded, shrink sleeves get tangled together and gum up the equipment. The shrink sleeves are then burned, which increases the risk for fires and causes impurities in the kiln which must be scraped off and sent out for external processing; separation issues: one of the separation processes might separate aluminum based on the shrink sleeve and not the aluminum, so the aluminum itself is lost, reducing yields; in the kiln, shrink sleeves can burn up, which increases dross creation, anything that is not aluminum creates dross.
Plastic widgets	2 out of 2 mills expressed explicit concerns about widgets	Operational issues: the introduction of plastic impacts the ability to control furnace temperature and requires the mill to operate at a slower pace. This will be a problem if these products increase in use.
Plastic lids on aluminum cans, like resealable cans	1 out of 2 mills expressed explicit concerns about plastic lids	Operational issues: the introduction of plastic impacts the ability to control furnace temperature and requires the mill to operate at a slower pace. This will be a problem if these products increase in use. The mill can tolerate 1-2% of the can's weight in plastic but greater than 10% causes an issue, which can be a concern with some resealable lids.
Plastics mixed into the bale	1 out of 2 mills expressed explicit concerns about plastics	A fluctuating amount of gas is needed to control the furnace when plastics are mixed into the bale - the mill's controls are not dynamic enough to handle the change from a small amount of plastic. Melting plastic also impacts the exhaust stream.
Stickers	1 out of 2 mills expressed explicit concerns about stickers	Operational issues: when stickers are burned in the process of separation it increases the risk for fires and causes impurities in the kiln which must be scraped off and sent out for external processing; separation issues: aluminum attached to the stickers is lost, which decreases yields.
Aerosol cans	1 out of 2 mills expressed explicit concerns about aerosol cans	Aerosol cans present a safety issue. The shredder should empty aerosols, but if does not break open and the aerosol enters the bath, it could explode.

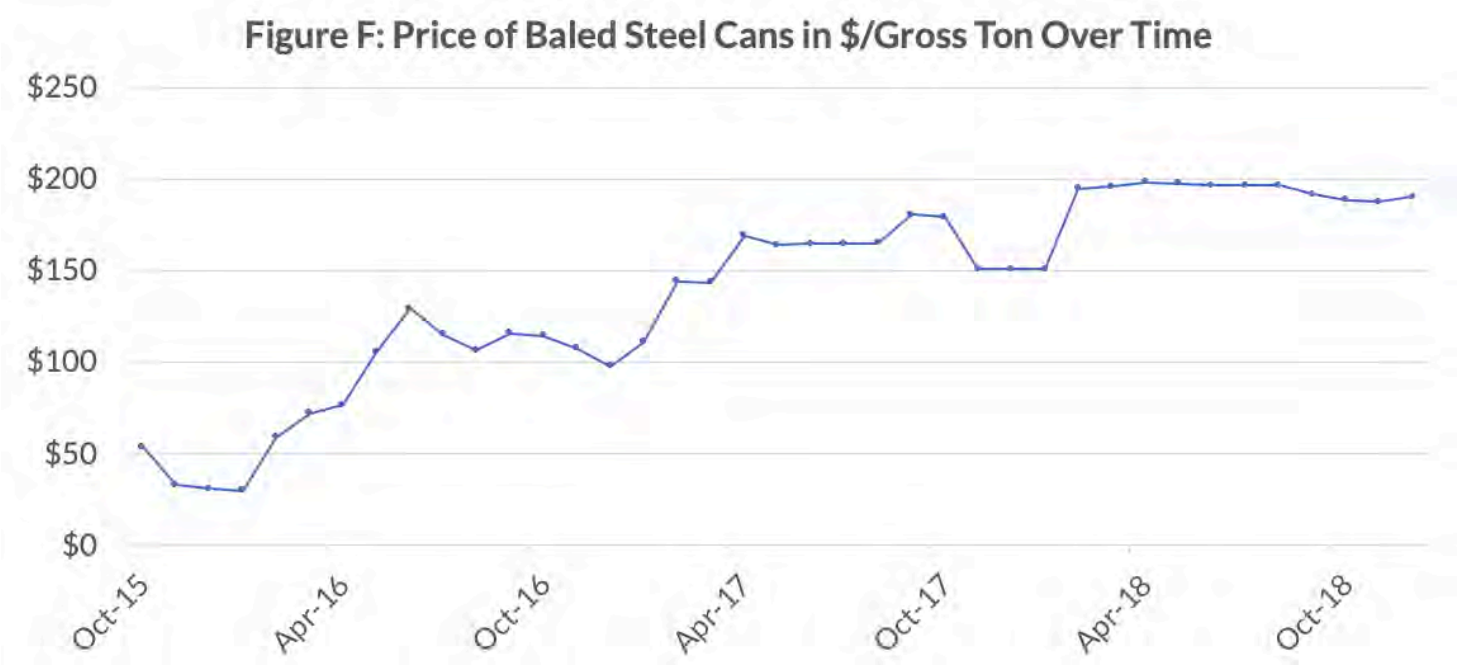
Steel

Summary of Steel Findings

- In comparison to the other material substrates, steel is relatively easy for both the MRF and reprocessor to handle.
- Both MRFs and steel reprocessors are cautious around aerosol cans, because of the potential safety hazards they pose when not emptied. However, they are accustomed to watching out for this hazard.

Market Characteristics of Steel

While steel is a small part of the material mix, it generally fetches a high price per ton. Data on pricing of steel over time is shown below.



Data provided by RecyclingMarkets.net
Figure F: *Prices for baled steel from the MRF have been fairly consistent over the last several months, in part due to impacts from U.S. tariffs for imported scrap steel.*

Steel at the MRF

ASTRX asked the interviewed MRFs about the kinds of packaging (and other) material they prefer to process. The following table indicates the preferences expressed by the MRFs for steel.

Table 15: Preferred Steel Materials

Item	Frequency of Preference	Reasons for Preference
Steel cans	10 out of 11 MRFs expressed a strong preference for this material	Easy sortation; decent markets and value

ASTRX asked the MRF facilities to also identify the types of packaging and other materials they least prefer to process. The following table indicates the frequency and reasons for concerns about those packaging and material types for steel.

Table 16: Least Preferred Steel Materials

Item	Frequency of Least Preference	Reasons for Least Preference
Aerosols	1 out of 11 MRFs expressed an explicit concern about steel-based aerosol cans	Effects on steel can bales; safety issues
Metal scrap, like pots and pans or large scrap	4 out of 11 MRFs expressed a concern about steel scrap	Scrap can be difficult to remove and can potentially jam or damage systems

Steel at the Reprocessor

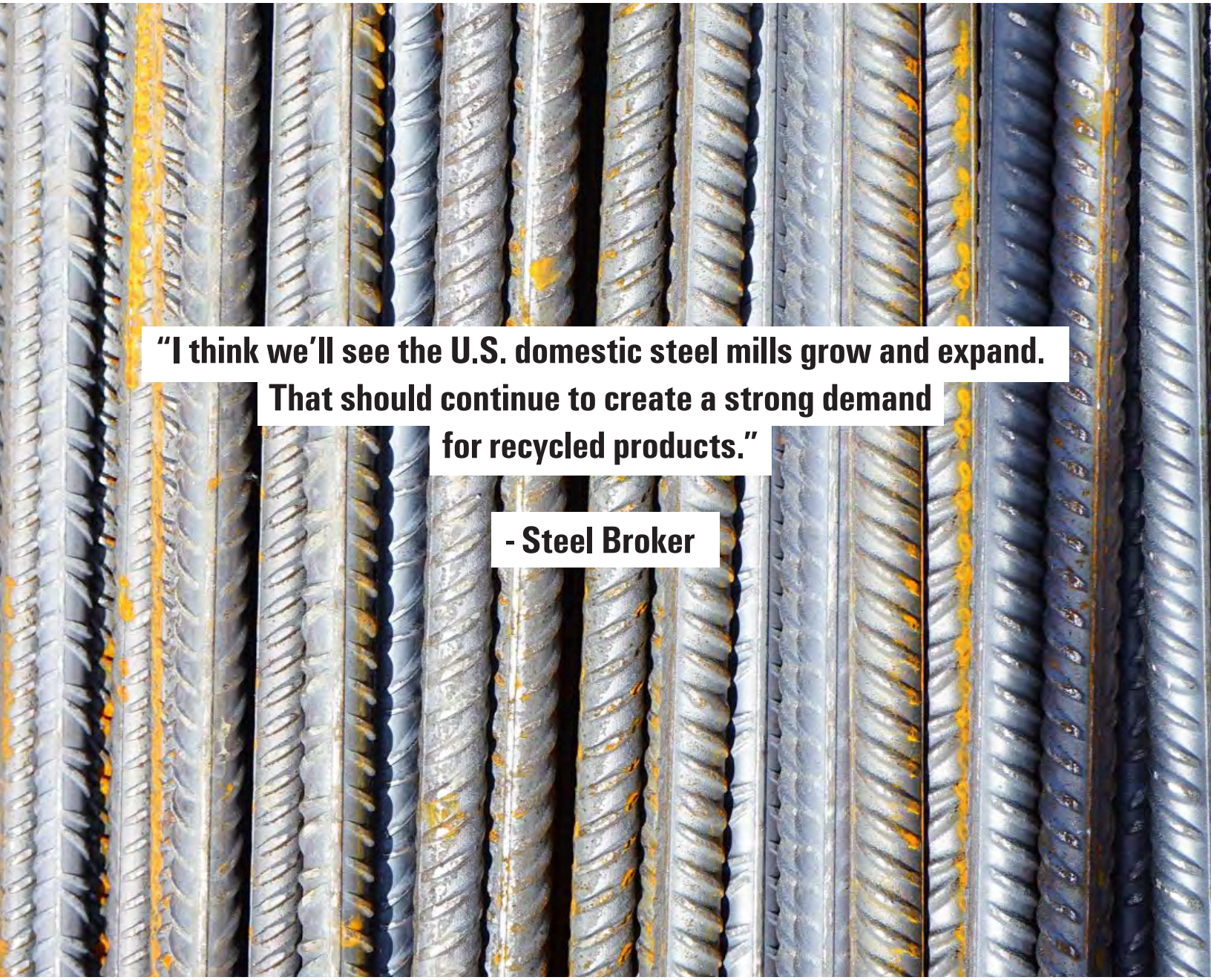
The ASTRX team interviewed one steel broker. While food contamination at scrap yards can be a health and safety issue, the steel broker interviewed for this report felt that steel coming from MRFs had low contamination rates, in part because MRFs generally do a good job educating consumers to rinse out steel cans. Occasional issues with MRFs are solved by having direct conversations with MRF operators.

Improvements for Steel Reprocessors

No infrastructure needs were cited for steel.

Major Changes Anticipated for Steel

In March 2018, **the Trump Administration imposed** tariffs of 25% on all imported steel, with the exception of steel from Australia and Argentina. Because of the tariffs, there was an expectation that demand for domestic recycled steel will increase. In 2019, the Trump Administration lifted the tariff on metals from Canada and Mexico.



Recommendations: Design Interventions

1 Follow the Association of Plastic Recyclers Design ® Guide for Plastics Recyclability

Brands and suppliers should use only shrink-sleeve labels for plastic bottles that meet criteria for preferred under APR's Design® Guide.

2 An Aluminum Design Guide is Needed

Brands and suppliers should invest in the development of a design guide for aluminum cans, similar to APR's Design® Guide. This guide should offer suggestions on what types of shrink sleeves are acceptable for the sortation and reprocessing of aluminum cans. Shrink-sleeve labels cause problems in both the sortation and reprocessing areas of the recycling system when the label material is different than the primary package material, and will be more easily resolved through design changes than intervention at the MRF or reprocessor level. Potential design guidelines and associated outreach and training should be focused on sectors that are more likely to use shrink sleeves due to low production volumes.

3 A Paper Design Guide is Needed

While a number of facilities are available that are able to test for repulpability of different types of fiber, there is not a single guide that is able to communicate cleanly to packaging and fiber goods producers what is acceptable and not acceptable for paper mills to turn a fiber product into a new fiber product. There is an opportunity for the various fiber trade associations, along with available testing facilities, to collaborate on a document that can guide brands and packaging designers. Such a guide was released in February 2019 in the UK by the Confederation of Paper Industries (CPI) in conjunction with WRAP (Waste & Resources Action Programme). The guidelines were "developed after broad consultation with the packaging supply chain and are intended to give clarity for retailers and specifiers about what the UK Paper Industry considers readily recyclable" (**CPI**). This guide could be used as a foundation for the development of a similar guide geared towards U.S. supply chains.

4 Use How2Recycle or Other Accurate, Consistent and Transparent End-of-Life Labeling Consistent with the FTC

Clear labeling for the consumer to recycle correctly is an important way brands can contribute to improving the recycling system's efficiency and reduce contamination. While the How2Recycle tool is valuable for all packaging, so that consumers understand what to do with their packaging at its end of life (including to not recycle it), it is especially critical for packaging that uses shrink-sleeve labels. This will help customers determine whether a label should be removed before recycling, or, critically, if it should not be recycled at all.

5 Avoid Packaging that Uses More than One Material Type

Brands and suppliers should avoid where possible or minimize reliance on mixed-material packaging types, such as plastic lids on aluminum cans, or plastic bottles with metal lids, which were cited as problematic by both reprocessors and MRFs during our study.

Recommendations: Infrastructure Interventions

1 Conduct Additional Research on Infrastructure Needs for the Recovery of Flexible Film Packaging

Both MRFs and reprocessors cited films and flexible packaging as a cause for concern. For MRFs, this type of packaging causes sortation issues, which translates upstream to reprocessors, as a source of contamination and reduced bale yield. This problem area represents a key example of the general transition from core to fringe packaging, as society is increasingly moving towards lighter-weight, flexible packaging overall. While complex packaging and flexible plastic packaging might be currently burdensome to MRFs, it will be difficult to reverse these trends altogether, as there are considerable efficiency and greenhouse gas benefits for brands using this type of packaging. For this reason, this is a critical intervention area for U.S. recycling infrastructure. By and large, the current recycling system in the U.S. cannot handle flexible packaging and so at present, this material is not suitable for recovery at the MRF level, with some possible exceptions in a few communities where this material is accepted curbside and MRFs have robust film equipment.

It is unclear whether in the long term films should be more widely recovered at the MRF or at store drop-off sites. In either case, films continue to enter and impact MRFs at significant rates and better infrastructure is needed to manage films in MRFs whether or not a community includes them on a list of acceptable materials. There are existing projects to address these challenges, including **Materials Recovery for the Future** and various chemical recycling initiatives, however, additional research is needed to understand how best to recover the material in MRFs and prevent it from disrupting recycling systems.

2 Help MRFs Invest in Infrastructure Improvements

Some investments can be made to improve how MRFs respond to flexible films such as vacuum systems, ballistic separators, density-based air separators, robotic film grabbers, and more optical sorters for both the capture of film and cleaning of paper bales. These investments would mean less disruption from film in MRFs and less contamination for reprocessors. Even in locations with bag bans, or where film is not accepted in curbside collection, film materials in MRFs are still an oft-cited problem. This trend is likely to continue, meriting increased investment to better manage films in U.S. MRFs. The responsibility to make such investments should not fall solely on MRFs. These types of changes benefit the end of life of all packaging, by increasing the operational efficiency of MRFs, and should therefore be a shared investment by everyone along the supply chain. Packaging companies that perpetuate challenging packaging, like multi-material packages and flexible packaging with difficult to recycle inks and adhesives, should be encouraged in particular to invest in better sortation equipment at MRFs.

3 Make Investments to Produce Cleaner Glass at MRFs

Glass represents another key area for infrastructure investment. Less than half of U.S. MRFs have glass cleaning equipment, but our research found that where this equipment exists and is paired with robust local end markets, demand for glass is steady. Beneficiators largely feel that MRFs are hesitant to make infrastructure investments for glass since there is little market value for this material, even when options such as grants or loans are available. On the other hand, there is a demand for relatively clean glass. In addition, glass can also contaminate other materials. Brands and suppliers should help MRFs make improvements to produce cleaner glass, either by **direct investment or** financially supporting the **Glass Recycling Foundation** and/or others in the glass value **chain who can fund such investments.**

Recommendations: Community Interventions

1 Make Investments to Improve Community Recycling Collection, Access and Capture Rates

Community recycling programs bear the brunt of the financial burden for managing the ever-changing mix of recyclable packaging and other materials. As with many local government programs, recycling programs may not have all the funds they need for communicating with residents. Given the recent down market, these community programs are losing more funding as MRFs change from a model of paying local governments for recyclable materials to charging processing fees. To maintain programs that provide quality recyclable commodities to the market, local governments must invest in communication and outreach to residents. Next-wave packaging, like flexible pouches, will not find a home in the recycling system if technical and financial support of the programs does not grow over time. Smart capital interventions could help bridge the widening gap between the trend of MRFs and communities simplifying the recycling stream and the trend of brands and suppliers of complicating the stream.

2 Discourage Consumers from Recycling Certain Impactful Contaminants and Don't Get Bogged Down in Lengthy "Do Not Recycle" Lists That Have Light Impact on the System.

The How2Recycle Not Yet Recycled label tells consumers exactly when an item should not be recycled, and more brands should consider using the label to help fight contamination. **Clear communication about what are the top, impactful contaminants is critical, and there is strong agreement as to what those contaminants are.** Communities with recycling programs and organizations that work with communities, like The Recycling Partnership, should consider their messaging around contaminants cited by both MRFs and reprocessors as troublesome. It's important to highlight to residents the need to exclude materials from the recycling stream that cause the most damage, such as shredded paper and plastic bags. However, don't message on an exhaustive list of every material that should be excluded, as the message becomes diluted and less effective.

3 Encourage Recycling Pizza Boxes

The study confirms that pizza boxes are generally considered acceptable for communities to collect as long as food and excessively greasy boxes are excluded. Curbside programs should strongly message to residents about excluding food and greasy components.

4 Reiterate the Caps-On Message

The large majority of MRFs did not mention caps on bottles as an issue, indicating widespread acceptance of this policy. Caps are typically polypropylene, which is still a growing market. The caps-on-bottles initiative helps boost supply of this material since otherwise, caps are typically too small to be captured in MRFs. For this reason, it is recommended that communities advertise this practice in their recycling programs. This is complemented by clear labeling for the consumer on recycling bins and packages.

Glossary

Ballistic Separators: sortation equipment used in some Materials Recovery Facilities to separate 2-D materials from 3-D materials. The separators move long, graded paddles elliptically, separating materials without getting dangled by plastic film and bags. This is typically used instead of traditional star screens, which use spinning shafts with rubbers discs on them to separate materials. Flexible materials, such as plastic bags and wraps, can tangle easily on star screens.

Bulky Rigid Plastic: a term used to describe bulky plastic-based items, such as five-gallon buckets, milk crates, laundry baskets or lawn furniture.

Contamination: materials that are included in the recycling system that are either currently non-recyclable or cannot effectively flow through the recycling system as it is currently configured. Examples include: food waste; clothing or textiles; tanglers such as extension cords or holiday lights; batteries or electronics; propane tanks; or needles or other medical waste.

Cullet: recycled broken or waste glass used in making new glass products. To prepare cullet for a container furnace, a specialized facility called a glass beneficiator removes contaminants and sorts glass by color and size, creating furnace-ready cullet. Glass containers collected for recycling in commingled residential programs typically undergo beneficiation following preliminary sortation, and potentially some cleaning, at a MRF.

Curbside Mix: the combination of recyclable materials that appears in recycling collection containers. This mix of materials can vary based on what types of packaging are collected for recycling in different regions.

Dual- or Multi-Stream Collection: a method of collecting recyclables where materials are collected in different bins or containers, typically with fiber in one bin and containers in another.

Eddy Current: eddy current separation is used to remove aluminum from other materials at a MRF. The eddy current creates a magnetic field around non-ferrous material. This field reacts with the magnetic field of the rotor, resulting in a combined driving and repelling force, which ejects the aluminum from the stream of mixed materials.

Fiber: packaging or other recyclable materials made of paper, such as old corrugated containers, paperboard or mixed paper.

Glass Beneficiator: a specialized facility that receives used glass from MRFs and other sources and then removes contaminants from the glass and sorts it by color and size.

Lightweighting: redesigning a product, such as a PET water bottle, to use less material and lower its weight.

Materials Recovery Facility (MRF): a facility that sorts, processes and bales different types of recyclables for sale to a reprocessor. All of the MRFs in this report accept residential, curbside collected materials.

Old Corrugated Containers (OCC): a type of fiber packaging that contains a wavy middle layer, commonly referred to as cardboard. Mills use old corrugated containers to make new recycled content shipping boxes.

Paperboard: a type of fiber packaging that is thicker than paper and does not have a wavy middle layer, for example, cereal boxes.

Polycoating: the process of coating a product with a thin layer of plastic for aesthetic or protective purposes. This includes hot and cold beverage cups and freezer boxes.

Reprocessor: any facility that consumes materials from a MRF and processes it into a commodity-ready material. Examples include plastics reclaimers, paper mills, aluminum mills, steel mills or glass beneficiators.

Residential Mixed Paper (RMP): the fiber portion of the curbside mix that includes everything but separated OCC. This includes paperboard, magazines, office and scrap paper and catalogs. Mills use mixed paper to make paperboard and tissue, as a secondary fiber in the production of new paper, or as a raw material in a non-paper product such as gypsum wallboard, chipboard, roofing felt, cellulose insulation, and molded pulp products such as egg cartons. Also used for production of medium used in corrugated containers.

Single-Stream Collection: method of collecting mixed recyclable materials in a single container, typically in a wheeled, lidded cart larger than 32 gallons.

Stickies: classified as any glue- or ink-based materials that are used in making paper products that when recycled turn into tiny tacky particles. Typical sources of stickies are envelope glues, stamps, magazine/paperback bookbindings, credit card promotional mailings, etc.

Stream: see "Curbside Mix" above.

UBCs: Used Beverage Containers, the industry term for used aluminum cans.

Widgets: a device usually made of plastic and added to beer containers to control characteristics of the beer and mimic the taste of draft beer. Widgets can be spherical or elongated.[2]

Yield Loss: loss of material in converting the recyclable material from the baled or aggregated form to its ready-for-use product by its reprocessor. Examples include lacquer or paint on an aluminum beverage container or labels and adhesive on an HDPE container.

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2. Calderone, Julia. "Guinness cans hide a weird plastic ball." Business Insider. March 16, 2018. https://www.businessinsider.com/guinness-plastic-smoothifier-widget-adds-nitrogen-2016-3

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Applying Systems Thinking to Recycling

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