# Northeast Secondary Sorting Study

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## Summary

Secondary Material Recovery Facilities (MRFs) aggregate low-volume and difficult-to-sort materials, along with machine yield losses, from a network of existing Primary MRFs. This allows for material to reach the critical mass necessary to justify the types of investments in automated technologies for detailed sorting that may not make sense at the individual MRF level. The Secondary MRF business model is designed to cost-effectively optimize our recycling infrastructure while delivering benefits to all stakeholders within a waste-shed.

After years of stagnant recycling rates in the United States[1], a combination of legislation aimed at reducing plastic pollution and voluntary brand owner commitments[2] to increase the use of post-consumer recycled (PCR) content in packaging and products have provided a catalyst for investment in our domestic recycling infrastructure. With hundreds of thousands of tons of new processing capacity for paper and plastics coming online, access to sufficient supplies of high-quality recyclable commodities and feedstocks is becoming a primary barrier to increasing recycling rates.

Regional Secondary MRFs are poised to tackle this supply challenge by providing a pathway to harmonize and expand recycling programs and by providing a second level of detailed sorting to create new commodity streams and extract additional recyclable materials from otherwise landfill bound residual waste.

The Northeast Secondary Sorting Study collected and analyzed samples from six Primary MRFs that operate within varying municipal recycling programs and collection systems. The study was designed to evaluate the potential increased recovery that could be achieved with the addition of a regional Secondary MRF.

Based on the results of this study, an estimated 52,000 tons per year of additional recyclable materials could be recovered at a regional Secondary MRF servicing the Northeast United States, including approximately 13,700 tons of mixed paper (ISRI PS-54), 9,500 tons of polypropylene (#5 PP), 7,000 tons of polyethylene terephthalate (#1 PET), 5,900 tons of polyethylene (#2 HDPE, #4 LDPE), 4,000 tons of polystyrene (#6 PS), 3,300 tons of corrugated cardboard (ISRI PS-11, OCC), and 3,200 tons of cartons (ISRI PS-52)[3]. The data also support the conclusion that secondary sorting would improve the overall recovery of residential recyclables and reduce greenhouse gas generation by more than 130,000 tons per year $CO_{2eq}$. This is equivalent to taking more than 25,000 cars off the road annually.[4]

[1] United States Environmental Protection Agency. (2020). *Advancing Sustainable Materials Management: 2018 Fact Sheet.*

[2] Ellen MacArthur Foundation, Global Commitment, Signatory Reports. https://ellenmacarthurfoundation.org/global-commitment/signatory-reports

[3] Based on the data obtained during this project and a regional model where MRFs recover 88% of recyclable materials.

[4] According to the Environmental Protection Agency's Greenhouse Gases Equivalencies Calculator

### Key Findings and Takeaways

- The Northeast Secondary Sorting Study showed that a Secondary MRF could recover approximately 50 percent of the landfill bound, end-of-container line residue from the region. This aligns well with typical recovery data from California MRFs and the results of the Pacific Northwest Secondary Sorting Demonstration Project. The average total recoverable materials were 50.7 percent for the Northeast, compared to 49.9 percent for California and 50.7 percent for the Pacific Northwest.
- New domestic processing capacity is coming online and requires access to sufficient supplies of high-quality recyclable commodities and feedstocks. Additional investment in primary and secondary sorting is required to satisfy this demand.
- Some single-stream facilities have been reconfigured as dual-stream facilities and reported decreases in outbound residual waste and inbound recycling material volume. Future studies should evaluate the tradeoffs between single-stream and dual-stream systems.
- Harmonizing and expanding municipal recycling programs could significantly increase the volumes of materials available for recycling. Many of the non-program materials identified in this study could be captured and returned to the circular economy through secondary sorting.
- Secondary MRFs offer a more efficient and cost-effective solution to upgrade our material recovery infrastructure. By providing a multi-material regional sorting solution, they maximize recovery of all materials offered for recycling.
- The Northeast is well-suited to benefit from the addition of a regional Secondary MRF; however, some investment would be required at Primary MRFs to isolate preferred feedstock materials from other waste streams.

## Background

Over the past several years, the combination of shifts away from export markets for recyclable commodities[5] and brand owner commitments to drastically increase post-consumer recycled (PCR) content in packaging and products has led to significant investments in domestic recycling capacity in the United States. To meet the demand as these investments come online, it will be necessary to expand our recycling programs, increase public participation, and improve our ability to sort materials into segregated commodity streams. Secondary MRFs offer a proven, cost-effective solution to this challenge and can be implemented within the timescale necessary to meet demand.

The Northeast Secondary Sorting Study aims to demonstrate how a Secondary MRF in the northeast region could improve recovery of plastics as well as other materials. The study was designed to evaluate the potential increased recovery from a selection of Primary MRFs that operate within a variety recycling systems and programs.

[5] Resource Recycling. (2022). *US scrap plastic exports continue years-long decline.*

## Recycling System & Circular Economy for Plastics

The recycling ecosystem consists of several key elements: design and manufacturing, purchase and use, policy and programs, collection, sorting, and recycling. Residents and businesses offer their recyclable packaging and products for collection, municipalities establish the recycling program that identifies the materials that the system is designed to recover, haulers collect recyclables and deliver them to sorting facilities, material recovery facilities (MRFs) sort the materials by type to meet specifications set by recycling companies, and recyclers clean, purify, and prepare materials for reintroduction into the manufacturing cycle. Manufacturers then incorporate PCR content into new products for sale to consumers.

Traditionally, for plastics, recycling has been accomplished through mechanical processes – sorting, size reduction, purification, and extrusion to form PCR pellets for manufacturing. In the United States, our recycling rate for plastics has plateaued at 9 percent[6] and is primarily accomplished through mechanical recycling. It would be reasonable to assume that the United States could reach a recycling rate of 30 or 40 percent for plastics using traditional means through increased access, participation, and capture rates and further adoption of APR design guidelines[7]. Achieving recycling rates of this level would enable many brands to attain their bold recycled content goals. However, to enable a more complete circular economy for plastics, it will be necessary to commercialize non-mechanical recycling, advanced recycling processes including purification, depolymerization, and conversion technologies (see Figure 1).

As the new capacity spurred by investments becomes activated, it will be critical to have expanded recycling programs and sorting capabilities in place and ready to deliver the required feedstock materials, which can include textiles, durable plastics, and packaging.

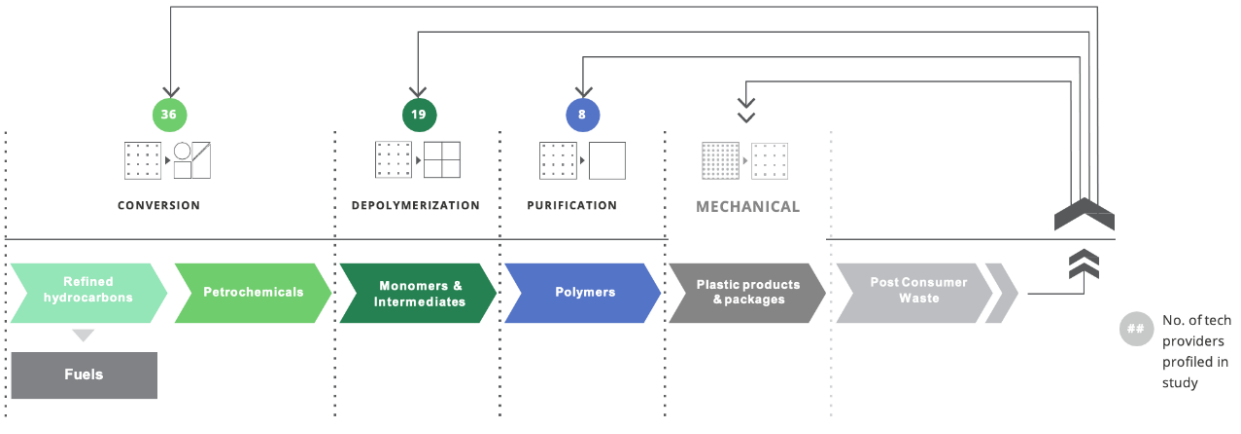



Figure 1. Keep Materials in Play and Grow Markets[8]

[6] United States Environmental Protection Agency. (2018). *National Overview: Facts and Figures on Materials, Wastes and Recycling*.
[7] Association of Plastic Recyclers. *APR Design Guide for Plastics Recyclability*.
[8] Closed Loop Partners, Accelerating Circular Supply Chains for Plastics: A Landscape of Transformational Technologies That Stop Plastic Waste, Keep Materials in Play and Grow Markets

## Municipal Recycling Programs & Collection Systems

Throughout most of the country, municipalities contract with haulers and material recovery facilities to collect and sort recyclable materials from households and businesses and then deliver the recovered commodities to processors who recycle and return the material to the circular economy.

Municipal recycling programs dictate which materials are to be collected curbside for recycling and typically (or in the best case) align with the sorting capabilities of the local MRF infrastructure and the availability of markets for the recovered materials.

Collection systems refer to how recyclable materials are combined or separated for collection and delivery to MRFs. Most of the country currently utilizes single-stream collection which means that all recyclable materials, including fiber, metal, plastic, and glass, are combined for collection and delivery to MRFs. Dual-stream collection generally refers to a system where fiber is collected separately from metal, plastic, and glass. In this case, separate facilities or separate sorting processes within a facility are used to prepare the material for recycling markets. Dual systems are typically used as a measure to prevent one or more streams from contaminating another commodity.

## Primary Material Recovery Facilities

Existing Primary MRFs typically recover 80% to 90% of materials collected for recycling and produce truckload quantities of direct-to-mill commodities that meet industry specifications. Most Primary MRFs can produce high-quality baled products for each of the top nine materials shown in Figure 2, independent of whether the MRF is highly automated or primarily a manual-sorting operation. Technology applied to processing these materials primarily improves efficiency, but not necessarily quality.

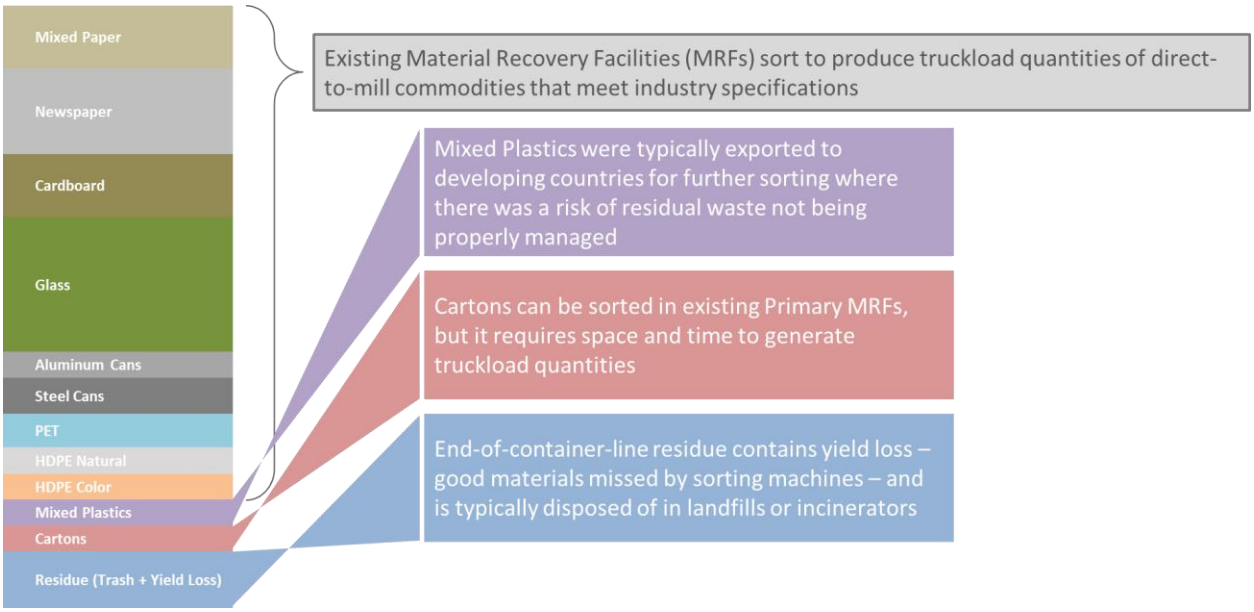



Figure 2. Typical Commodities Recovered at Primary MRFs and Opportunities for Secondary Sorting

## Plastics Recovery Facilities

Plastics Recovery Facilities (PRFs) are a type of secondary sorting process that are designed to sort mixed plastics and then continue with the recycling process to produce a flake or pelletized resin product for one or more of the sorted commodities. PRFs typically require a large waste-shed from which to source enough material to reach capacity and achieve the economies of scale necessary for efficient operation.

## Secondary Material Recovery Facilities

Secondary MRFs are another type of secondary sorting process but differ from PRFs in a few distinct ways. Secondary MRFs source a wider range of materials, including mixed plastics, end-of-container-line residue, and other low-volume materials such as cartons, and produce baled commodities sorted by material type. This difference allows Secondary MRFs to recover a larger portion of the recycling stream and reduce the size of the waste-shed necessary to fill the capacity of a regional sorting facility.

The concept of a Secondary MRF is less about advanced sorting technologies and more about a business model that can achieve economies of scale for sorting all materials by type within a regional waste-shed, such as the Northeast. The equipment and technologies utilized at Secondary MRFs are much like those found at modern Primary MRFs, but they are employed to refine the recycling stream to recover low-volume and difficult-to-sort materials along with machine yield losses (see Figure 3). The key is to concentrate these materials in the feedstock to a Secondary MRF by sorting out most of the high-volume and easy-to-sort materials at Primary MRFs, and then to aggregate the remaining mixed materials from a network of existing Primary MRFs within the region to reach the critical mass necessary to justify investments in automated technologies for a second level of sorting by material type.

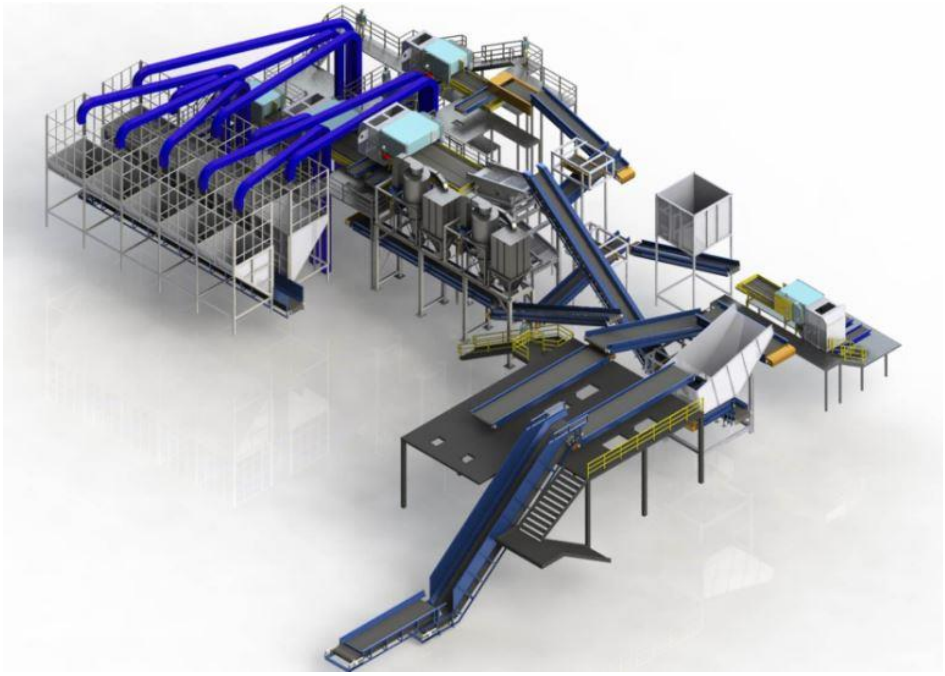


Figure 3. Example of a Full-Scale Secondary MRF

Secondary MRFs are designed to work with our existing recycling system and increase material recovery with the most efficient use of capital. One Secondary MRF can extend the capabilities of all Primary MRFs within a region, as shown in Figure 4.

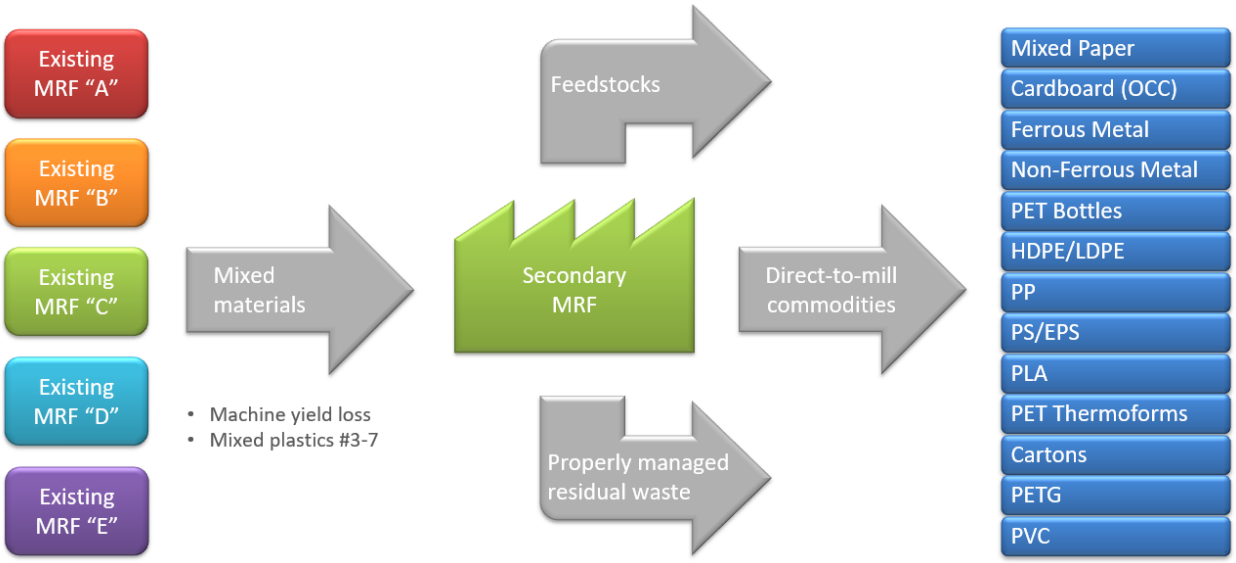



Figure 4. Secondary MRF Process Flow

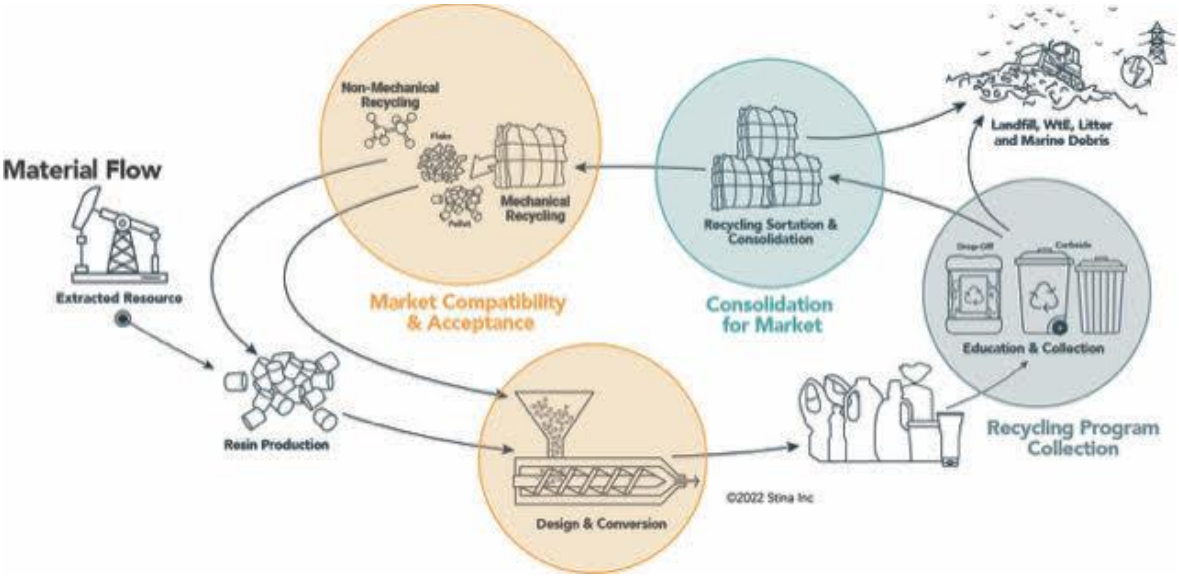
In addition to increasing regional recycling rates, Secondary MRFs are more easily adaptable to changing packaging and sorting technologies, extend the capabilities of the existing MRF infrastructure, and deliver benefits to a wider range of recycling stakeholders.

Perhaps most important, secondary sorting can be implemented within a timescale more likely to meet the increased demand from new processing capacity coming online domestically. Secondary MRFs will help brand owners and other signatories meet their New Plastics Economy Global Commitments to drastically increase usage of PCR content – an initiative of the Ellen MacArthur Foundation[9].

## Secondary MRF Contributions to Recyclability

While many materials are technically recyclable, to fully achieve recyclability, several barriers with the supply chain must be overcome (see Figure 5). Secondary MRFs play a key role, especially for low-volume materials, in overcoming these barriers. Regional Secondary MRFs are the simplest and most cost-efficient way to provide a path for harmonizing and expanding recycling programs to include low-volume materials and are designed to consolidate these materials regionally to provide truckload quantities to the marketplace.

[9] https://www.newplasticseconomy.org/




*Source: Stina Inc.*

Figure 5. Elements of Recyclability

## Secondary MRF Contributions to Recycling Rates

Overall recycling rates are a combination of access, participation, capture, sorting recovery, and processor recovery rates. Secondary MRFs are uniquely positioned to improve all these and deliver increased overall recycling rates.

Access rates refer to the availability of recycling programs, collection systems, and recycling facilities for a given material. The Federal Trade Commission allows unqualified claims of recyclability "when recycling facilities are available to a substantial majority of consumers or communities where the item is sold," where the term "substantial majority" means at least 60 percent.[10] Secondary MRFs can dramatically increase access rates for materials throughout a regional waste-shed through recycling program harmonization and expansion. For example, recycling programs could be harmonized and expanded to include all rigid plastics if they can flow through the Primary MRF infrastructure and then be captured by a regional Secondary MRF.

Recycling system harmonization and expansion can also simplify recycling program messaging and decrease confusion among participants which is expected to improve participation and capture rates, much like access to single-stream recycling has done.

Primary MRF recovery rates for target materials can be as high as 90 to 96 percent when facilities are optimized, well-maintained, and operated within their design capacities. Secondary MRFs offer a second level of sorting, and with the same sorting efficiency can drive recovery rates to greater than 99 percent.

Secondary MRFs also play a significant role in processor recovery rates by re-sorting byproducts from processors and re-distributing the sorted materials to the appropriate recycling facilities.

[10] Federal Trade Commission. *Part 260 – Guides for the use of Environmental Marketing Claims*.

## Purpose of the Northeast Secondary Sorting Study

The primary purpose of the Northeast Secondary Sorting Study is to determine how a Secondary MRF in this multi-state region could improve the recovery of plastics as well as other materials. Information from this study could also help to inform where investments in sorting could be made, on a regional scale or an individual facility basis, to help improve recovery. This study could also show how municipal recycling programs could be expanded to add new materials as new recycling capacity comes online and how they could be harmonized within a region to improve community outreach and education efforts. And finally, this study could show what additional recyclable commodities could be recovered to meet the demand of the growing domestic recycling industry.

## Sample Collection

Samples were collected from six MRFs in the Northeast U.S. and included facilities that varied in ownership (public vs. private), collection system (single stream vs. dual stream), facility size, level of automation, sorting strategy, recycling programs, and producer responsibility programs. All samples were collected in a manner to assure that they were representative of the end-of-container line residue plus mixed plastics being generated during the sample period. Sample size was two super sacks per facility, and most were collected over several hours from end-of-container line conveyor outfalls. Sampling from one facility was completed all at once because the infeed and presort operations had to stop during sampling and another sample was a series of grab samples from the container line residual bunker because the dual stream facility had shifted to processing fiber during the sampling window. Samples were collected during June 2021. The sampling strategy was not designed to capture variability at the MRFs associated with route schedules, seasons, or holidays.

The Primary MRFs that participated in this study included:

- Mazza Recycling in Tinton Falls, NJ
- Winter Bros. in Yaphank, NY
- Westchester County MRF in Yonkers, NY
- Madison County ARC Recycling Center in Canastota, NY
- Waste Management in Billerica, MA
- Ecomaine in Portland, ME.


Figure 6. Map of Material Recovery Facility Locations

This study includes three publicly owned and three privately owned MRFs. Three facilities operate within single stream collection systems and three operate within dual stream collection systems. Facility sizes range from 333 TPM to 10,000 TPM and level of automation varies from mostly manual sorting to highly automated systems.

The recycling programs that identify which materials are accepted for recycling varied throughout the region and are provided in Appendix A. All of the programs accepted corrugated cardboard, mixed paper, metal cans, and foil. Glass was accepted in all but one program. Cartons were accepted in some programs but not others. Accepted plastics ranged from #1 PET and #2 HDPE bottles only in some programs and all plastic containers in other programs. One program specifically excluded black plastics due to the difficulty sorting this material at downstream processors. Plastic thermoforms (clamshells, take out containers, etc.) were also excluded from certain programs.

Four of the MRFs included in this study operate in New York or Massachusetts, bottle bill states with a $0.05 deposit value. New York's program applies to 78% of beverage containers sold and had a 64% redemption rate in 2020. Massachusetts' program applies to 42% of beverage containers sold and had a 43% redemption rate in 2020.[11]

[11] TOMRA. (2021, September 8). *Bottle bill states and how then work*. https://newsroom.tomra.com/bottle-bill-states/

| Material Recovery Facility | Ownership | Collection System | Bottle Bill | Capacity (TPM) | Automation |
|---|---|---|---|---|---|
| Mazza Recycling | Private | Single Stream | No | 10,000 | Optical sorters for fiber, PET, HDPE, and PP |
| Winter Bros. | Private | Dual Stream | Yes | 1,600 | Optical sorters for PET, HDPE, and PP |
| Westchester County | Public | Dual Stream | Yes | 7,700 | Optical sorters for PET, HDPE, and #3-7. |
| Madison County | Public | Dual Stream | Yes | 333 | Manual sorting except for metals |
| Waste Management Billerica | Private | Single Stream | Yes | 10,000[12] | Optical sorters for PET, HDPE, and PP |
| Ecomaine | Public | Single Stream | No | 3,200[13] | Optical sorters for PET only. |

[12] Waste Management. *WM Billerica MRF hosts municipal officials*. https://www.wm.com/about/wm-monday/billerica.jsp

[13] Resource Recycling. (2009, October). *MRF of the Month – ecomaine Recycling Facility*. https://resource-recycling.com/images/MRF/MRF_1009.pdf

## Mazza Recycling

Mazza Recycling is a privately owned MRF located in Tinton Falls, NJ and operates within a single stream collection system. The highly automated facility was recently upgraded to a VanDyke system with TOMRA optical sorters and has a capacity of 10,000 tons per month. The MRF design is well aligned with the municipal recycling program with optical sorters for fiber commodities as well as PET, HDPE, and PP. The dedicated optical sorter for PP was made possible by a PP Coalition Grant from The Recycling Partnership. The recycling program targets PET bottles, HDPE bottles, and PP containers. Cartons are excluded from the program.

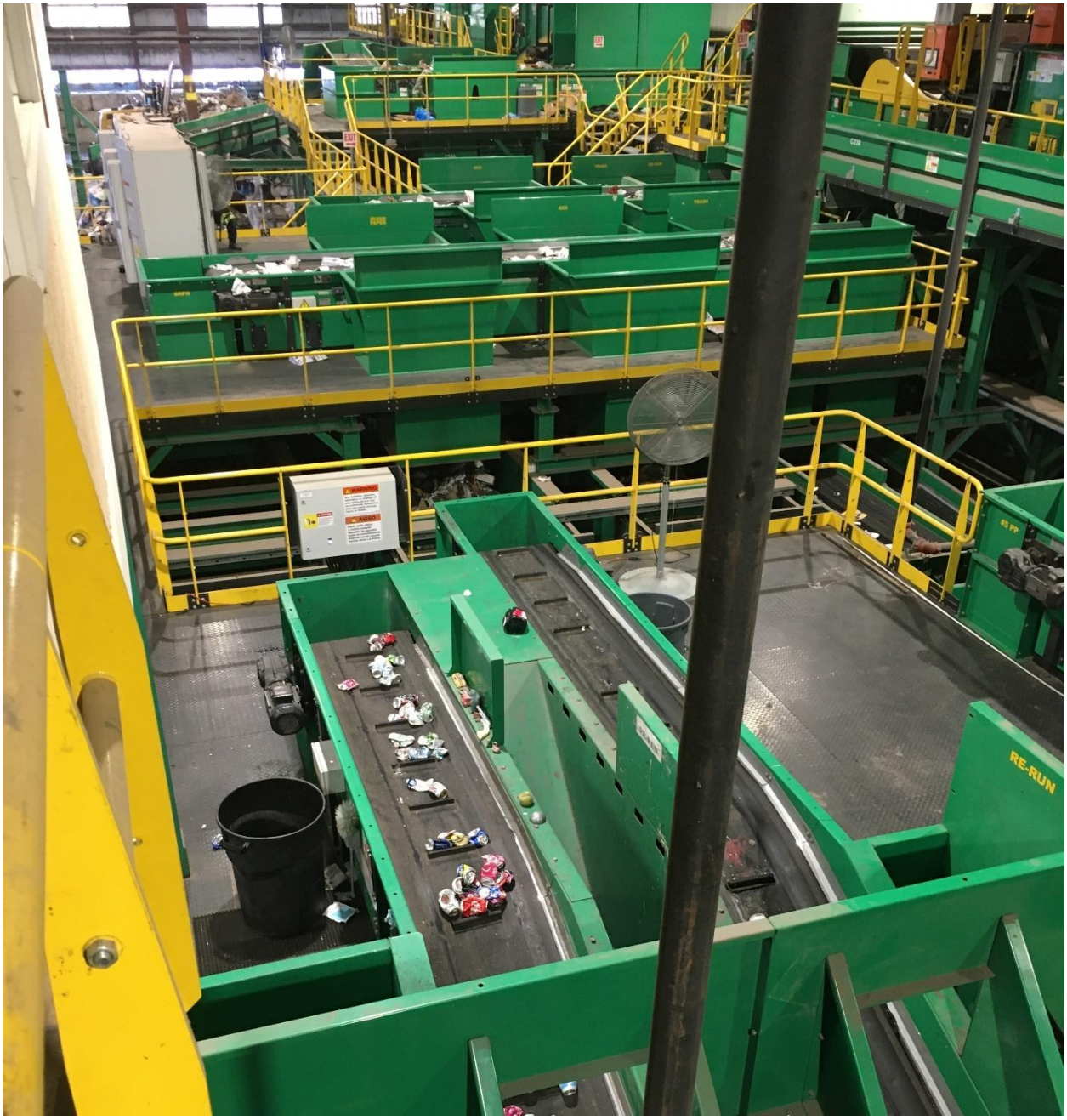



Figure 7. Mazza Recycling

## Winters Bros.

Winters Bros. is a privately owned MRF located on Long Island in Yaphank, NY and was recently converted to process materials from a dual stream collection system that excludes glass. The facility is highly automated with Green Machine optical sorters and has a capacity of 1,600 tons per month. The municipal recycling program limits plastics to PET and HDPE bottles, however the facility is also equipped to optically sort PP.

## Westchester County

The Westchester County MRF in Yonkers, NY is publicly owned and operates within a dual stream collection system. The facility is equipped with a highly automated CP system with optical sorters for positive sorting of PET and HDPE, and negative sorting of mixed plastics (3-7s). A final optical sorter is used to scavenge yield loss for reprocessing.

## Madison County

The Madison County ARC Recycling Center is a publicly owned MRF located in rural Canastota, NY and operates within a dual stream collection system. The facility utilizes manual sorting except for metals and operates at 4,000 tons per year (333 tons per month). All materials, including residues, are positively sorted except for colored glass. The collection program limits plastics to non-black bottles, jugs, and tubs, and does not include cartons.

Figure 8. Manual sort line at Madison County ARC Recycling Center

## Waste Management – Billerica

The Waste Management MRF in Billerica, MA is a privately owned facility that operates within a single stream collection system. The facility processes more than 450 TPD (~10,000 TPM) and utilizes optical sorters to recover PET, HDPE, and PP.

## Ecomaine

Ecomaine is a non-profit, quasi-publicly owned MRF located in Portland, ME that was upgraded and converted to a single stream operation in 2007. The current facility utilizes Bollegraaf equipment and has a design capacity of 15-18 tons per hour (~3,200 tons per month).[14] The MRF design is outlined below and accepts a comprehensive list of program materials; however, it is overdue for an upgrade and currently requires running containers through the line twice to maximize recovery. For this study, containers were only run through the line one time to demonstrate how secondary sorting can provide a service to aging facilities.

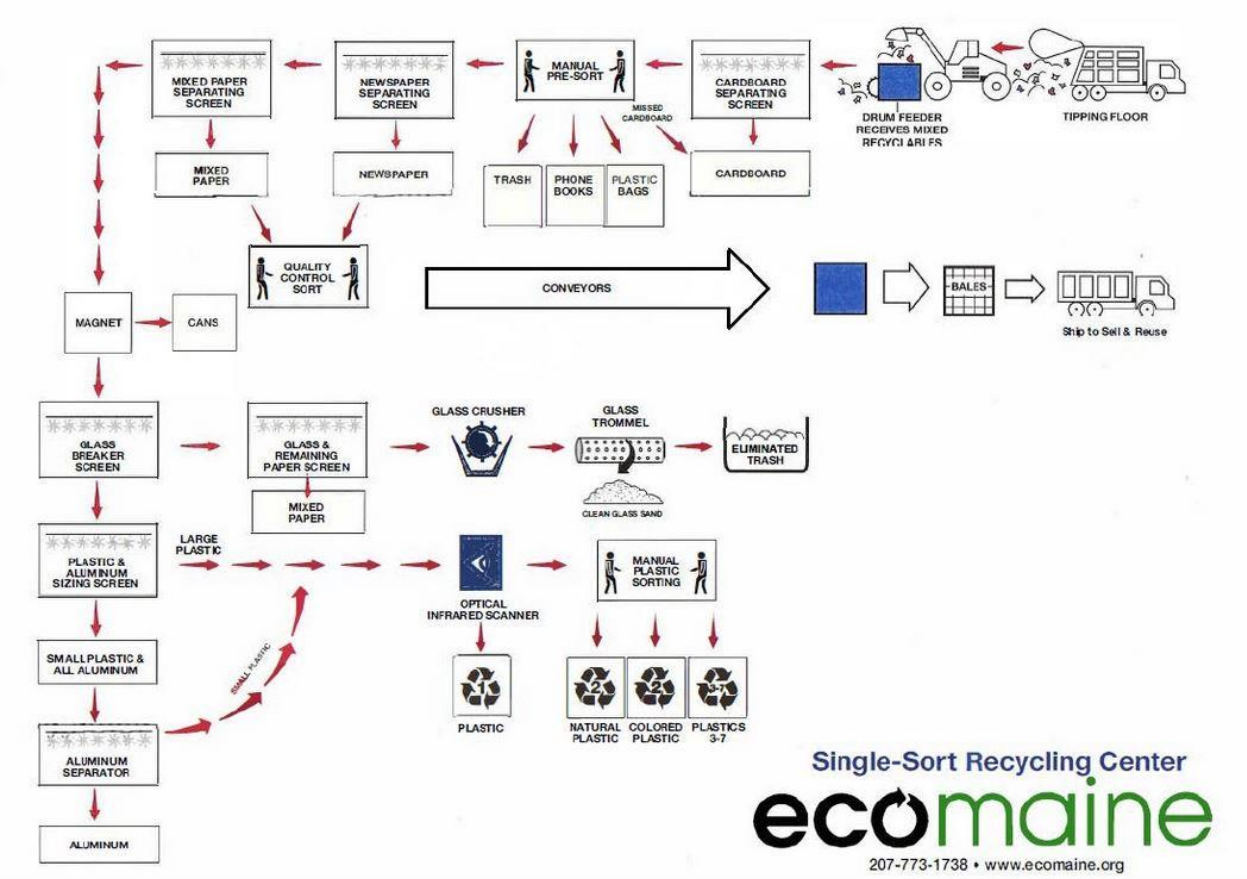



Figure 9. Ecomaine Single-Sort Recycling Center Process Flow Diagram

[14] Resource Recycling. (2009, October). *MRF of the Month – ecomaine Recycling Facility*. https://resource-recycling.com/images/MRF/MRF_1009.pdf

## Sample Characterization & Data Analysis

Sample characterization and data analysis was completed in multiple phases. First, the basic material characterization was accomplished by manual sorting materials into the following categories: Corrugated Cardboard (ISRI PS-11, OCC), Mixed Paper (ISRI PS-54), Cartons (ISRI PS-52), Non-Ferrous Metal (Aluminum UBC), Non-Ferrous Metal (other), Ferrous Metal, Glass, Plastic (rigid), Plastic (film), Plastic (foam), Trash (including wood, aggregate, rubber, etc.), and Fines (<2”). Next, the detailed plastics characterization was accomplished by manual sorting based on Resin Identification Codes (RIC) and by near-infrared (NIR) spectroscopy where RICs were not available or not visible.

To provide a clearer picture of the markets for recovered materials, some materials were further sorted to match common grades of recyclable commodities, such as #2 HDPE natural and mixed color grades.

To better understand the impacts of recycling programs and the behaviors of their participants, the plastics fractions were further sorted by common packaging and product types that are often used to describe materials that are accepted or not accepted in recycling programs. For example, some programs allow #1 PET bottles but don’t allow #1 PET thermoforms.

And finally, the plastics fractions were further sorted by design to better understand the likelihood that a given product or package would be able to be efficiently sorted for recycling. Resin color and label design were considered. Specifically, black plastic packaging and products were analyzed separately because the typical applications use a variety of resins so they can’t be manually sorted and NIR sorting systems can’t identify black plastics. Similarly, packaging with full-shrink or similar non-compliant labels were analyzed separately because they are often challenging to identify with NIR sorting systems.

## Samples of Container Line Residue

Figures 10 through 13 provide examples of the samples of container line residue collected during this study.

Figure 10. Sample of Container Line Residue

Figure 11. Sample of Container Line Residue

Figure 12. Sample of Container Line Residue

Figure 13. Sample of Container Line Residue

## Recovered Commodities

Figures 14 through 30 provide examples of the commodities recovered during the NE Secondary Sorting Study. Most of the commodities are equivalent or like materials typically recovered at Primary MRFs and represent typical yield loss. Some of the commodities are less commonly recovered at Primary MRFs due to the economics of sorting low-volume materials such as cartons, PP, and PLA. Secondary MRFs compliment Primary MRFs by recovering the yield loss plus the low-volume materials that are concentrated in container line residue and aggregated from a regional waste-shed.

Figure 14. Corrugated Cardboard (ISRI PS-11, OCC)

Figure 15. Mixed Paper (ISRI PS-54)

Figure 16. Cartons (ISRI PS-52)

Figure 17. Glass

Figure 18. Non-Ferrous, Aluminum UBC

Figure 19. Non-Ferrous, Aluminum Other

Figure 20. Ferrous, Tin Cans

Figure 21. PET Bottles, Clear

Figure 22. PET Bottles, Color

Figure 23. PET Thermoforms

Figure 24. HDPE Natural

Figure 25. HDPE Color

Figure 26. PP

Figure 28. PLA


Figure 29. Polystyrene, Foam (EPS and XPS)

Figure 30. Polystyrene, Rigid

## Difficult-to-Sort Packaging and Products

Certain packaging and products are difficult to sort at Primary and Secondary MRFs. Two common problematic groups of materials are packaging with full coverage labels and black plastics. Full coverage labels make it difficult for near infrared (NIR) optical sorting systems to see the underlying resin and black plastics don't provide enough reflectance because they absorb much of the NIR energy.


Figure 31. Full Coverage Labels – Difficult to Sort

Figure 32. Black Plastics – Difficult to Sort

## Non-Recoverable Commodities

Figures 33 through 35 provide examples of non-recoverable commodities due to contamination or entrapment within other materials.


Figure 33. Heavily Contaminated – Non-Recoverable Commodities

Figure 34. Entrapped – Non-Recoverable


Figure 35. Entrapped – Non-Recoverable

# Results & Discussion

## Average Northeast MRF Residual Composition

The Northeast Secondary Sorting Study found that the average MRF end-of-container line residual composition for the six Northeast MRFs aligned well with typical recovery data from California MRFs and the results of the Pacific Northwest Secondary Sorting Demonstration Project. The average total recoverable materials were 50.7 percent for the Northeast, compared to 49.9 percent for California and 50.7 percent for the Pacific Northwest.

The total recoverable commodities in end-of-container line residue varied significantly and ranged from 33.2 to 67.9 percent for the samples collected and characterized for this study. Factors that influenced the percent recoverable commodities included the type of collection system, alignment of the recycling program materials with the capabilities of the corresponding MRF, and the age of the sorting line. Actual throughput versus design capacity can also impact the amount of recoverable commodities in this waste stream, however, none of the facilities included in this study reported that they were operating significantly above or below design capacity.

The average total fiber content was lower for the Northeast MRFs due to including several dual stream facilities in the study. Aluminum and plastic content offset the lower fiber content with significant contributions from all primary resin categories including PET, HDPE/LDPE, PP, and PS/EPS.

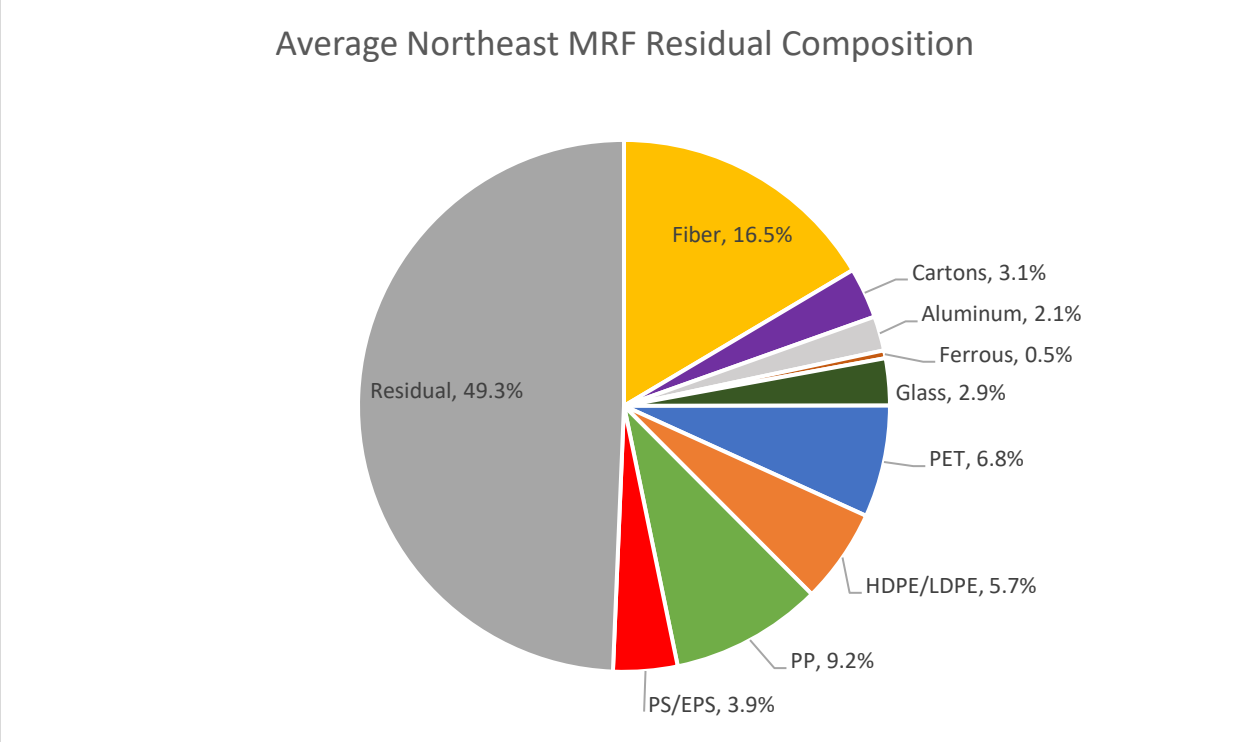



Figure 36. Average Northeast MRF Residual Composition

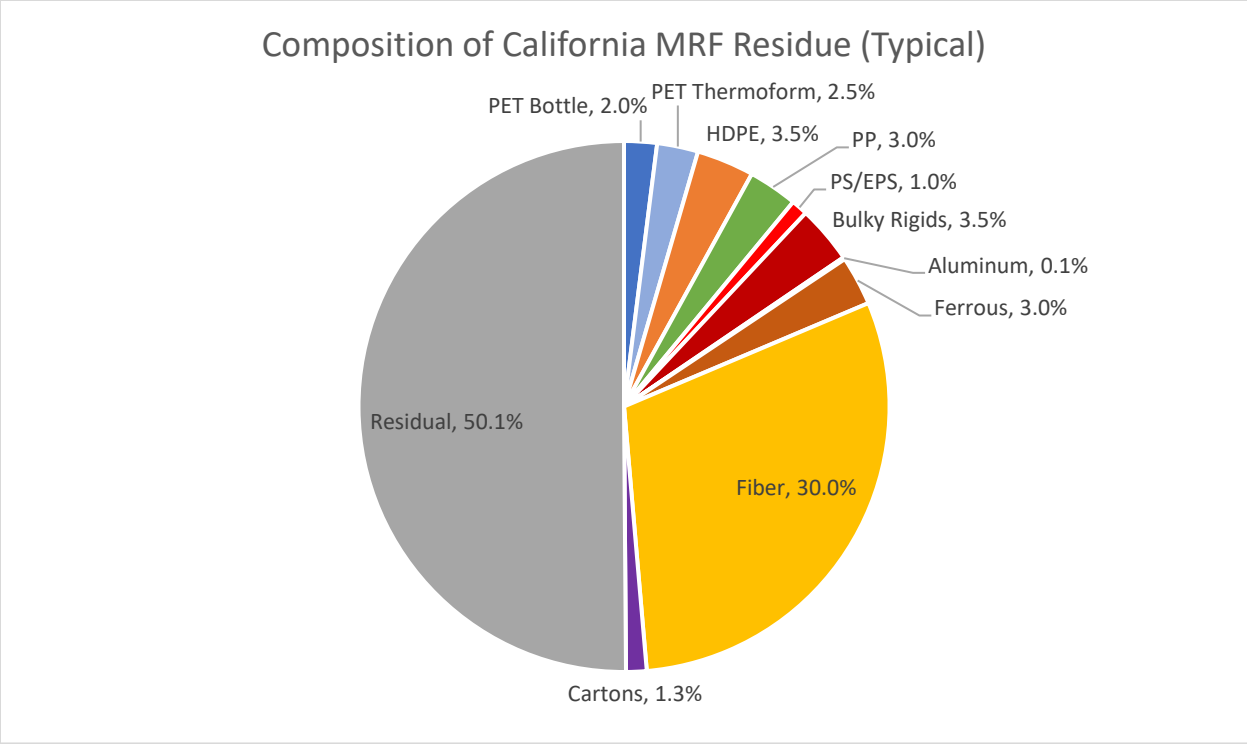



Figure 37. Composition of California MRF Residue (Typical)

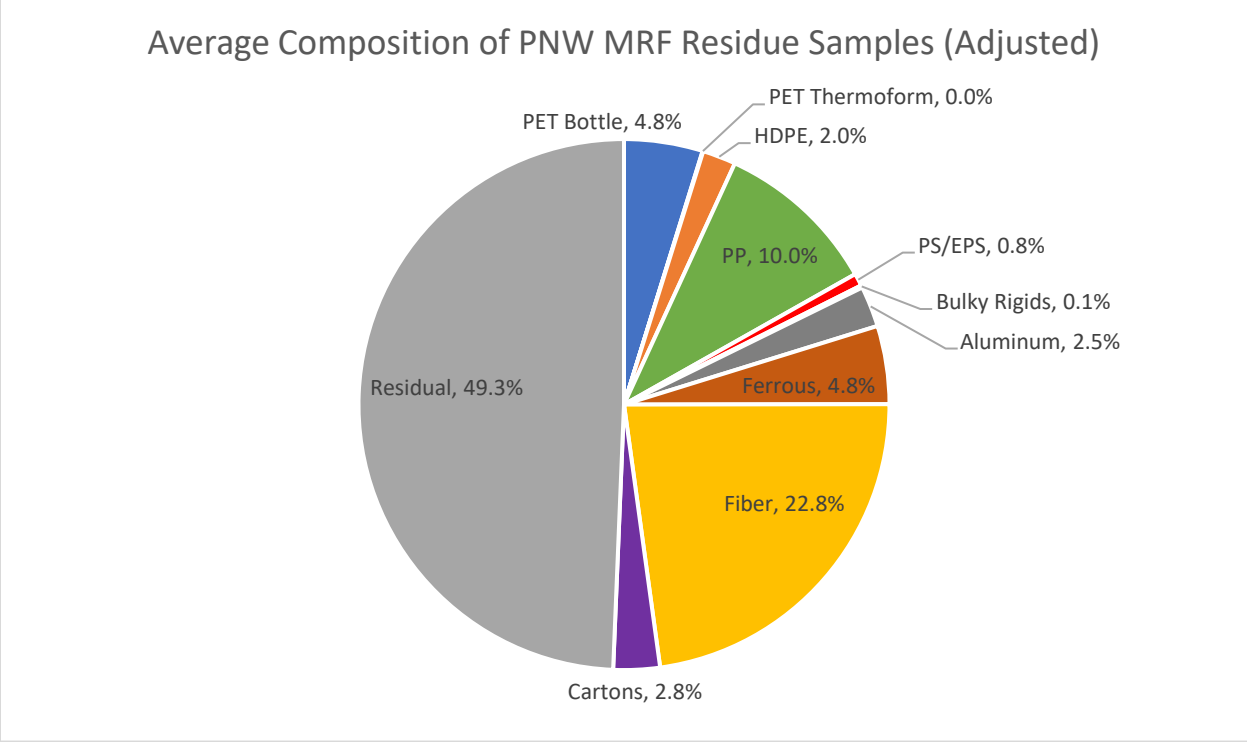



Figure 38. Average Composition of PNW MRF Residue Samples (Adjusted)

## Single Stream vs. Dual Stream Composition

As expected, potential recovery through secondary sorting was greater for single stream MRFs (53.9 percent recoverable commodities) when compared to dual stream MRFs (47.5 percent recoverable commodities). An important factor is that the challenges of sorting are greatly reduced when fiber is collected and processed separately from containers.

Lower fiber content in the container line residual was the primary cause for the lower potential for secondary recovery from dual stream facilities. A common issue with single stream MRFs is small format fiber reporting to the container line where it typically becomes a component of the end-of-container line residual waste. While fiber in MRF residue of a single stream facility is regarded as yield loss, fiber in MRF residue of a dual stream facility is a contaminant with limited means for recovery if it is collected and processed with containers.

One facility included in this study had recently converted from a single-stream system to dual-stream and reported decreases in outbound residual waste percentage and inbound recycling material volume. Future studies should evaluate the tradeoffs between single-stream and dual-stream systems.

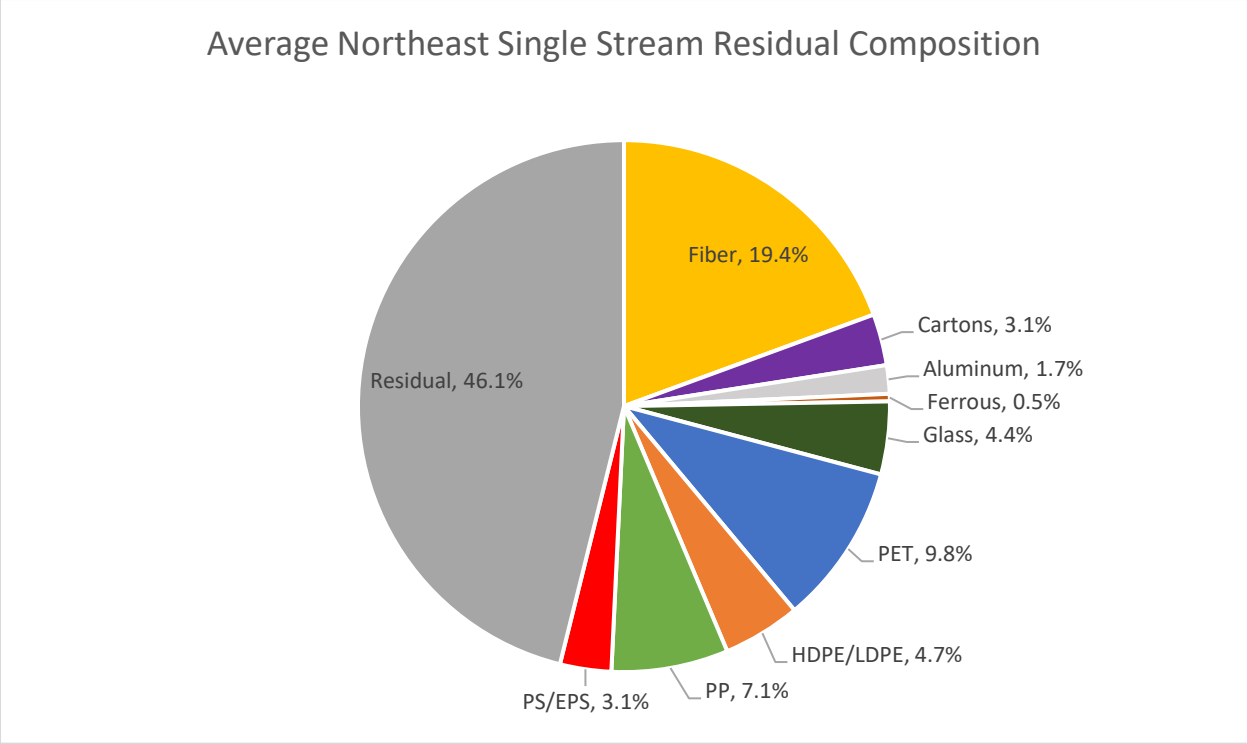



Figure 39. Average Northeast Single Stream Residual Composition

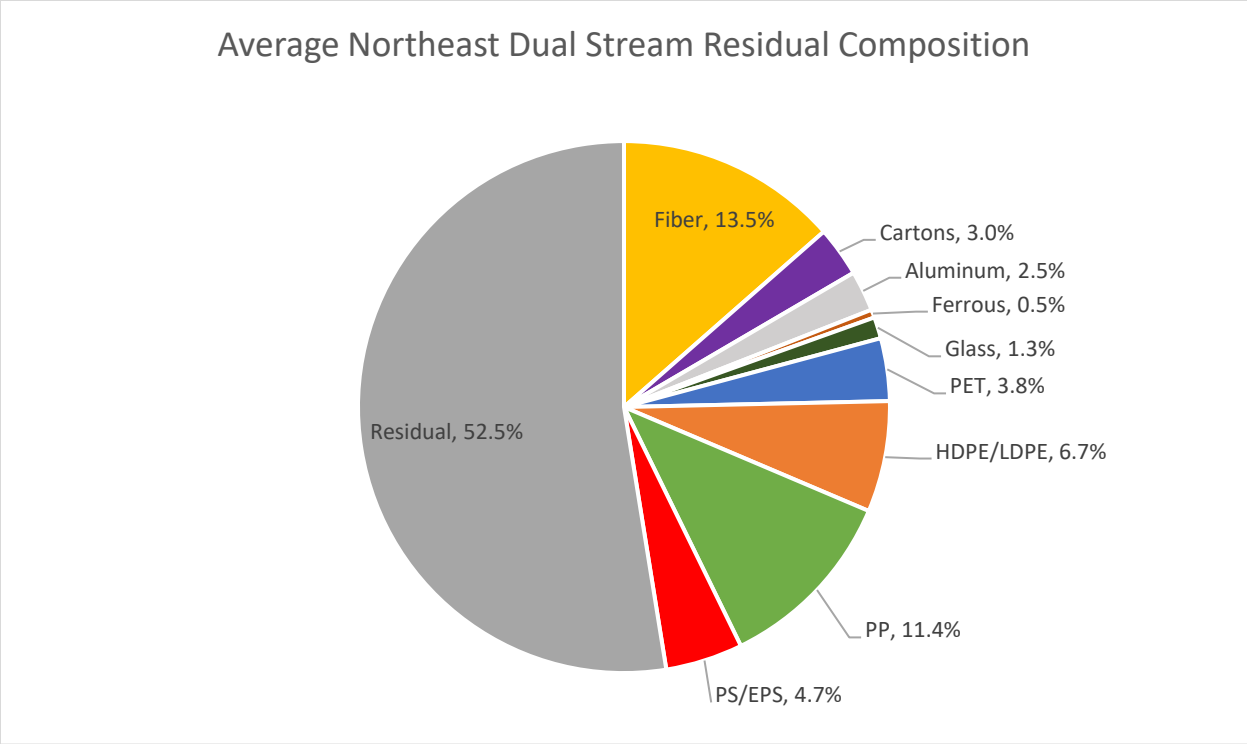



Figure 40. Average Northeast Dual Stream Residual Composition

## Program vs. Non-Program Materials in MRF Residue

An evaluation of MRF residue content compared to the municipal recycling programs associated with each facility highlights the opportunities for additional recovery.

Recovered yield loss represents the program materials that were missed by the sorting systems utilized at each facility. Modern, well-maintained optical sorting machines can reliably capture about 95 to 96 percent of target materials when positively ejected in the upward direction or about 90 to 92 percent of target materials when positively ejected in the downward direction on dual-sort machines. Secondary sorting with equivalent capture rates allows the overall recovery of target program materials to improve to greater than 99 percent. This ensures that nearly all program materials that are recycled by residents can be captured for recycling.

Non-program recovered commodities represent the minimum potential for additional recovery of common commodities, such as cartons, #5 PP or #6 PS, that may not be included in municipal recycling programs because they are difficult to manually sort and/or are not present in sufficient volumes to justify the cost of automated optical sorting systems. The materials enter the curbside program either due to consumer confusion about what is recyclable, or due to “wish-cycling”, where residents hope materials can be recycled despite not being including in the accepted materials list. Based on the recycling program guidelines, they are technically considered a contaminant to Primary MRFs because the facilities would likely not be designed to recover these materials and may not be able to generate enough volume to

produce and provide truckload quantities to the marketplace. However, if a regional Secondary MRF was available and these materials could flow through the Primary MRFs without issue, they could be added to the recycling program and significantly increase the amount of material captured for recycling and diverted from landfill. This would also allow municipalities within a region to harmonize their recycling programs and simplify their communications related to outreach and education.

Non-program recovered feedstocks provide additional potential recovery of value from otherwise landfill bound waste. These materials include various mixtures of fiber and/or plastics with specifications designed to meet the requirements for pyrolysis or gasification conversion technologies or for energy recovery, depending on the specific markets available within a given region.

The sum of program and non-program commodities appears to be slightly inflated when compared to the commodity recovery potential shown in Figure 41. This is due to fact that some program materials, such as black plastics, are not necessarily captured by Secondary MRFs as a commodity and would instead be captured as a feedstock for conversion or energy recovery technologies.

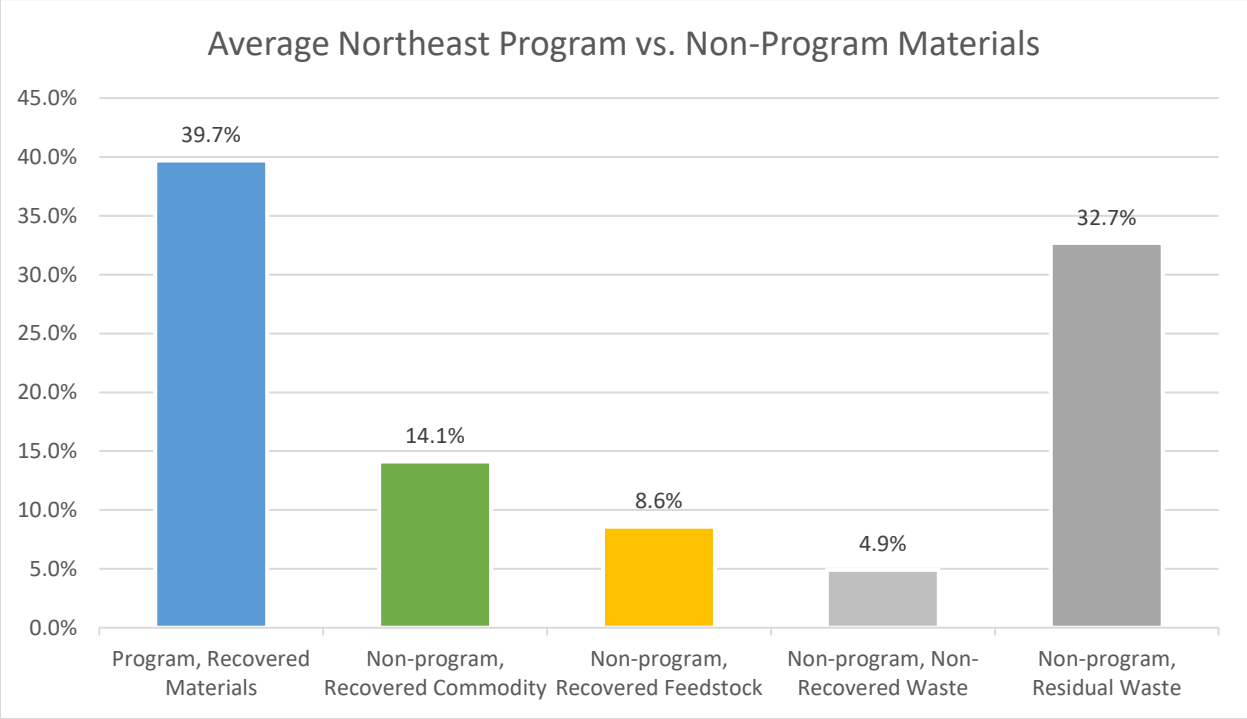



Figure 41. Average Northeast Program vs. Non-Program Materials

### Markets for Recovered Commodities and Feedstock Materials

Titus MRF Services was provided space for sample characterization at Agri-Plas, Inc. in Brooks, Oregon – an agricultural plastics recycler that has been servicing the Pacific Northwest agricultural community for almost 30 years. To highlight the value of the commodities and feedstock materials that were recovered as part of this study and the availability of markets, Titus sought to deliver these materials to local recycling markets in the Pacific Northwest as much as possible. Some materials were delivered to emerging or niche markets in other regions.

Standard Oregon program materials including corrugated cardboard, mixed paper, aluminum cans and foil, tin cans, and plastic bottles, jars, and tubs were delivered to WestRock Recycling Solutions in Portland, Oregon for aggregation and delivery to recycling markets.

Rigid and foam polystyrene, which have limited mechanical recycling markets, were delivered to Regenyx in Tigard, Oregon – a joint venture between Agilyx and America Styrenics that utilizes a proprietary pyrolysis process to deconstruct the polymer so that it can be purified and then repolymerized to create virgin-equivalent, post-consumer recycled polystyrene.

Clear PET thermoforms were delivered to James Recycling in Portland, Oregon for aggregation and delivery to recycling markets. James Recycling is a weekly recycling service that complements local municipal recycling programs and allows participants to recycle additional materials that are not currently included in curbside programs.

Color and black PET thermoforms, which are not recycled today, will be shipped to Eastman Chemical Company in Kingsport, Tennessee for processing through their methanolysis process which deconstructs the polymer to create the raw materials for virgin-equivalent, post-consumer recycled polyester resins.

Recovered polylactic acid (PLA) plastics were delivered to Closed Loop Plastics in Southern California for mechanical recycling to produce 100 percent post-consumer recycled 3D printer filament. This is a niche market that can operate at low production volumes due to the high value of their finished product.

## Conclusions & Recommendations

With growing demand for recycled feedstock to meet fast approaching 2025 goals and minimum recycled content legislation, industry needs solutions that will quickly enhance the existing domestic recycling capabilities. Meeting this growing demand will require investment in several areas, including in primary and secondary sorting. Through aggregation, regional secondary sorting can enhance the capabilities of a network of existing Primary MRFs and create the economies of scale for recovering low-volume and difficult-to-sort packaging and products. Secondary sorting also allows harmonization and expansion of municipal recycling programs which is expected to significantly increase the volume and types of commodities recovered for recycling.

The Northeast would benefit from the addition of a regional Secondary MRF to process mixed plastics and other low-volume materials such as cartons along with end-of-container-line residue in order to recover

feedstock for new and existing reclaimers and for emerging recycling and recovery technologies. Among the many benefits, it is estimated that a Secondary MRF would generate 46 green jobs, increase material recovery or landfill diversion by more than 52,000 tons per year with the current recycling system (not accounting for future potential increases in recycling access or expanded diversity of materials collected), reduce the generation of greenhouse gases by more than 130,000 tons per year $CO_{2eq}$, and provide enhanced recovery and traceability for all materials offered for recycling.

To move forward with an effective and viable project to build a Secondary MRF in the Northeast, establishment of long-term supply agreements between existing Primary MRFs and the regional Secondary MRF could be considered as a means to drive business certainty and support. It may also be necessary to consider funding for modifications to the Primary MRFs to facilitate the production of suitable feedstock materials for the Secondary MRF.

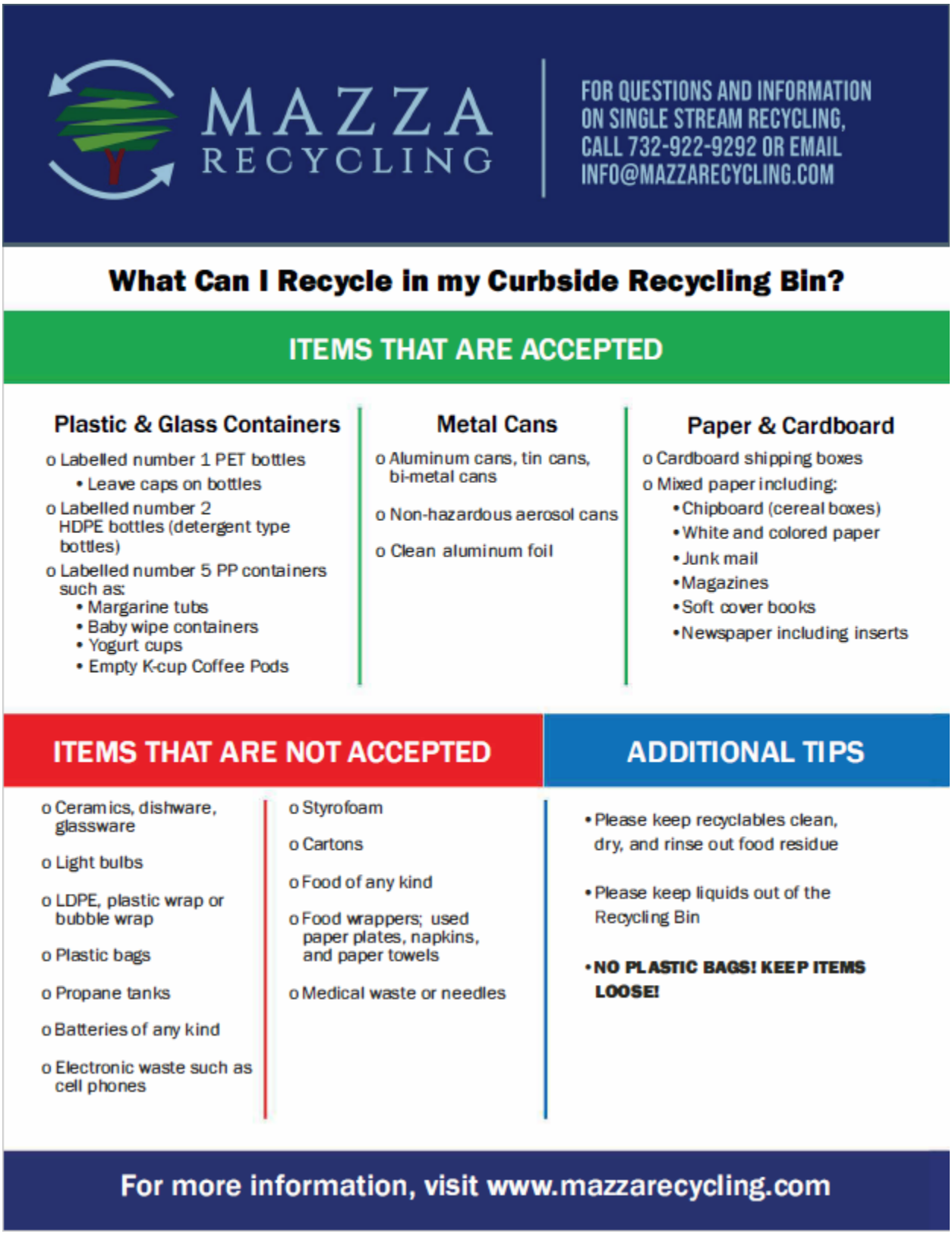
A Secondary MRF would also help to expand and harmonize recycling collection programs across recycling jurisdictions. This can reduce confusion for consumers as to what materials are accepted in recycling programs across the region, reducing contamination and increasing participation. Investments in recycling system improvements, such as secondary sorting capabilities, could be supported by producer responsibility systems, and help brands meet their recycling obligations.

In the Northeast, given the size of the states and populations, a multi-state regional approach to secondary sorting will be important to capture enough volume to reach the economies of scale to justify the investment in a Secondary MRF. For this reason, it will also be important to implement coordinated recycling policies and programs between participating states.

There is also a possibility that some additional cost to the system might need to be considered if the difference between the Secondary MRF's processing fee and the Primary MRFs' landfill disposal cost avoidance are not sufficiently covered by the revenue sharing from commodity sales. Any increase in rates would of course come with an increased level of service as measured by improved recycling rates and an expanded list of program materials.

The conditions that would make secondary sorting successful in the Northeast would be similar for other metropolitan areas across the country. There will be a long-term need to aggregate lower-volume materials in order achieve the economies of scale necessary to sort by material type and produce products in truckload quantities for recycling markets. The addition of secondary sorting capability to the system has the potential to help further extract value from our material streams, offering benefits for all stakeholders.

## Appendix



MAZZA RECYCLING

FOR QUESTIONS AND INFORMATION ON SINGLE STREAM RECYCLING, CALL 732-922-9292 OR EMAIL INFO@MAZZARECYCLING.COM

**What Can I Recycle in my Curbside Recycling Bin?**

**ITEMS THAT ARE ACCEPTED**

**Plastic & Glass Containers**

- o Labelled number 1 PET bottles
  - • Leave caps on bottles
- o Labelled number 2 HDPE bottles (detergent type bottles)
- o Labelled number 5 PP containers such as:
  - • Margarine tubs
  - • Baby wipe containers
  - • Yogurt cups
  - • Empty K-cup Coffee Pods

**Metal Cans**

- o Aluminum cans, tin cans, bi-metal cans
- o Non-hazardous aerosol cans
- o Clean aluminum foil

**Paper & Cardboard**

- o Cardboard shipping boxes
- o Mixed paper including:
  - • Chipboard (cereal boxes)
  - • White and colored paper
  - • Junk mail
  - • Magazines
  - • Soft cover books
  - • Newspaper including inserts

**ITEMS THAT ARE NOT ACCEPTED**

- o Ceramics, dishware, glassware
- o Light bulbs
- o LDPE, plastic wrap or bubble wrap
- o Plastic bags
- o Propane tanks
- o Batteries of any kind
- o Electronic waste such as cell phones
- o Styrofoam
- o Cartons
- o Food of any kind
- o Food wrappers; used paper plates, napkins, and paper towels
- o Medical waste or needles

**ADDITIONAL TIPS**

- • Please keep recyclables clean, dry, and rinse out food residue
- • Please keep liquids out of the Recycling Bin
- • **NO PLASTIC BAGS! KEEP ITEMS LOOSE!**

**For more information, visit www.mazzarecycling.com**

Pay My Bill Online

WINTERS BROS. WASTE SYSTEMS

Call us: 631-491-4923 or 516-937-0900

RESIDENTIAL COMMERCIAL DUMPSTER RENTAL EAST END RECYCLING SECURE SHREDDING OUR COMMUNITY

## What to recycle:

Recycle today for a better tomorrow...

Plastic Bottles, Milk Jugs & Detergent Bottles
(Plastic ♳ & ♴)

Metal Cans, Aluminum Containers & Foil
(Rinse & Clean)

Paper, Newspaper, Magazines & Junk Mail
(No Need to Tie or Bundle)

Cardboard, Paper Containers & Cartons

## How to recycle:

Before you toss it in the recycling container...

Empty It!

Clean It!

Dry It!

## What NOT to place in curbside recycling containers:

- Glass (bottles, jars, windows, mirrors)
- Cat litter
- Chemicals
- Household hazardous waste
- Contaminated paper products
- Dry cleaning bags
- Food waste
- Garbage
- Light bulbs
- Needles/syringes/sharp items
- Paint and paint cans
- Plates (plastic and ceramic)
- Plastic (♳, ♴, ♵, ♶ or ♷)
- Plastic shopping bags
- Plastic utensils
- Styrofoam
- Waxed paper
- Yard waste
- Drinking glasses

Please check with your local hauler or your municipality for the rules and guidelines for recycling in your community.

## Do your part. Be a good recycler!

# WESTCHESTER RECYCLES

Sorting your paper, cardboard and other recyclables is quick and easy. Just focus on tossing all mixed paper into one bin and plastic, glass, and metal into another. Please **EMPTY** and **RINSE** all containers and flatten and break down cardboard boxes.





## TIPS FOR RECYCLING RIGHT!

- Keep it Loose! Don't bag your recyclables.
- All containers are empty, rinsed, & dry
- Place shredded paper in paper bags.
- Cardboard is flattened & broken down

**Please *DO NOT* place items listed below in your recycling bin**

### PLASTIC BAGS

**INSTEAD**: Recycle your bags at a participating grocery or retail store.

### RECYCLABLES SOILED WITH FOOD

**INSTEAD**: Dispose of soiled recyclables that can't be cleaned in the trash

### HAZARDOUS & ELECTRONIC WASTE

**INSTEAD**: Bring items to the Household Hazardous Waste Facility in Valhalla

### SHARPS WASTE

**INSTEAD**: Find safe & secure disposal information at environment.westchestergov.com

Westchester County Department of Environmental Facilities, Division of Solid Waste 270 North Ave. 6th Floor, New Rochelle, NY 10801
Westchester County Recycling HelpLine: (914) 813-5425

# CURBSIDE RECYCLING

Madison County has a two-bin recycling system where paper products are placed into one bin and containers go into another bin.

**DO NOT PUT RECYCLABLES IN PLASTIC BAGS.**

**ALL RECYCLABLES MUST BE EMPTY, CLEAN & DRY.**

## PAPER RECYCLABLES:


- ✓ Newspaper & Inserts
- ✓ Cardboard (flattened)
- ✓ Paper & Magazines
- ✓ Mail & Envelopes
- ✓ Cereal Boxes

**NOT ACCEPTED:**

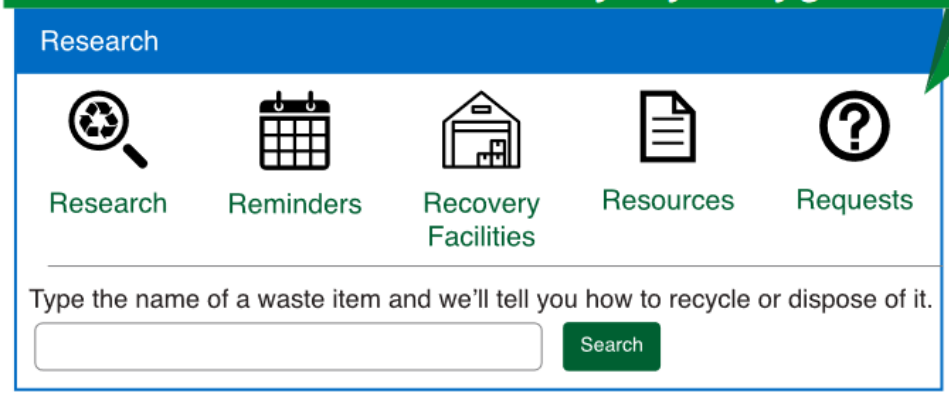
Refrigerated boxes, coffee cups, paper egg cartons, clothing or linens

## CONTAINER RECYCLABLES:


- ✓ Plastic Bottles
- ✓ Plastic Jugs *(soap & detergent bottles)*
- ✓ Plastic Dairy Tubs
- ✓ Metal Containers
- ✓ Aluminum Foil
- ✓ Empty Aerosol Cans
- ✓ Glass Bottles & Jars

**NOT ACCEPTED:** Plastic clamshell and take-out containers, plastic bags, black plastic, plastic cups, pots & pans

**To learn more about our services, where to recycle & more, visit us online at MadisonCountyRecycles.ny.gov.**




mixed
recycling
RHODE ISLAND RESOURCE RECOVERY CORPORATION
paper, cardboard (flattened) and cartons only
metal cans, lids and foil only
glass bottles and jars only
plastic containers only
empty at a minimum, rinsed whenever possible
NOT FOR USE AS A LABEL: Rhode Island's official mixed recycling container labels are copyright and trademark protected by Recycle Across America®. Public and private entities should contact Resource Recovery for labels.
These items do not belong in your recycling bin or cart
no plastic bags, bags of bags, or recycling inside of bags
no more than a trace of food or beverage residue
no fiber that isn't paper, cardboard or cartons (e.g. textiles or wood)
no paper shreds, napkins, tissues, or paper towels
no metal that isn't a can, lid, or foil (e.g. pans)
no glass that isn't a bottle or jar (e.g. drinking glasses)
no plastic that isn't a container (e.g. hangers)
no foam containers
no containers from flammable materials or oily chemicals
Containers for mixed recycling in Rhode Island vary in color and size. If you're unsure of which container to use, ask your city or town's Department of Public Works, property owner, or property manager.
Follow these guidelines and you'll be a great recycler! If you want to be a SUPER recycler, get more details at RecycleTogetherRI.org.
For information on recycling, composting, or disposal of other items, visit RIRRC.org.
Date of Publication: August 2017

**Massachusetts Smart Recycling Guide: In the Bin**

| Material | Item | Special Instructions |
|---|---|---|
| Metal | Aluminum baking tray (disposable) | Rinse or wipe clean all food or other residue |
| | Aluminum foil | Rinse or wipe clean all food or other residue |
| | Aluminum pie plate | Rinse or wipe clean all food or other residue |
| | Beer can | Empty and rinse. |
| | Beverage can (metal) | Empty and rinse. |
| | Food can & lid (metal) | Rinse or wipe clean all food/residue. Replace lid. |
| Plastic | Jars (plastic) | Rinse or wipe clean all food/residue. Replace lid. |
| | Jugs (plastic) | Rinse or wipe clean all food/residue. Replace lid. |
| | Plastic bottle | Empty and replace cap. |
| | Plastic detergent bottle | Empty and rinse. Replace cap. |
| | Plastic milk jug | Empty and rinse. Replace cap. |
| | Plastic sauce bottle | Empty and rinse. Replace cap. |
| | Plastic soap bottle | Empty and rinse. Replace cap. |
| | Plastic soda bottle | Empty and replace cap. |
| | Plastic tubs & lids | Rinse or wipe clean all food or other residue. Replace lid. |
| | Plastic water bottle | Empty and replace cap. |
| | Clear plastic deli & fruit container | Rinse or wipe clean all food or other residue. Replace lid. |
| | Egg carton (plastic) | |
| | Yogurt Container | Empty and rise. Put foil tops in the trash. |
| Glass | Beer bottle | Empty and rinse. Place cap in the trash. |
| | Glass bottles | Rinse or wipe clean all food/residue. |
| | Jar (glass) | Rinse or wipe clean all food/residue. Replace lid. |
| | Liquor container | Rinse and replace cap. |
| | Wine bottle | Empty and rinse. Put wine cork in trash. |
| Paper & Cardboard | Paperback book | |
| | Cardboard | Flatten. Remove all foam, bubble wrap, air pillows. |
| | Catalogue | |
| | Colored paper | Staples, paper clips, spirals OK. |
| | Dry food boxes | |
| | Egg carton (paper) | |
| | Envelope | |
| | Envelope (with plastic window) | |
| | File folder | |
| | Junk mail | Remove free samples. |
| | Magazine | |
| | Newspaper | |
| | Office paper | Staples and paper clips are okay. |
| | Paper bag | |
| | Paperboard | Flatten/nest when possible. |
| | Paper towel roll | |
| | Phone book | Remove from wrap/bag. Remove free samples. |
| | Pizza box (empty, no food) | Empty of all food residue. Liner should go in the trash. |
| | Toilet paper roll | |
| | White paper | Staples, paper clips, spirals OK. |

# ECOMAINE'S LIST OF RECYCLING DO'S AND DON'TS

## DO RECYCLE

### PAPER

- All clean cardboard, paperboard, & pizza boxes (NO FOOD)
- Newspaper & inserts
- Magazines
- Mail & catalogs
- Paper bags
- Office paper, envelopes, & window envelopes
- Wrapping paper
- Phone books
- Books
- Paper plates (clean)
- Milk & juice cartons
- Drink boxes & aseptic containers ("Tetra Paks")
- Shredded paper (put in clear plastic bags)

### PLASTIC

- Water bottles
- Milk jugs
- Detergent bottles
- All rigid containers marked #1-7 (except Styrofoam)

### METAL

- Tin cans
- Aerosol cans (empty)
- Aluminum cans & foil
- Pots & pans

### GLASS (ALL COLORS)

- All glass bottles & jars

**All rigid containers must be EMPTY (not perfectly clean)**

# ECOMAINE'S LIST OF RECYCLING DO'S AND DON'TS

## DON'T RECYCLE

### PLASTIC BAGS & WRAP

- Trash & shopping bags (empty or full)
- Plastic wrap or film
- Bubble wrap or mailers
- Tyvek or plastic envelopes
- Bread bags
- Potato chip & snack bags
- Sandwich baggies
- Animal food bags
- Frozen vegetable bags
- Pellet bags
- Newspaper bags
- Boat wrap or tarps

### BATTERIES

- alkaline
- button-cell
- rechargeable & lithium-ion

- Styrofoam (even if it's #6)
- Paper towels, napkins, or tissue
- Needles & sharps
- Large metal parts (car, boat, truck, etc.)
- Gas tanks (propane, helium, oxygen, etc.)
- Wood & lumber
- Pipes (metal or plastic)
- Clothing & shoes
- Bedding & pillows
- Furniture
- Light bulbs (any type)
- Garden hoses
- Hangers (metal or plastic)
- Diapers (baby or adult)
- Food or plants (compost these)
- Kitty litter
- Knives & blades
- Toys
- Vinyl siding
- Wax-coated paper & boxes
- Rope, string, chain