Chicago Secondary Sort Demonstration Project

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Prepared for: Circular Great Lakes
FORGING A FUTURE WITHOUT WASTE
POWERED BY COUNCIL OF THE GREAT LAKES REGION
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EXECUTIVE SUMMARY

The Challenge – To Capture More Recyclable Material and Reduce Landfill Inflow

According to a materials management gap analysis conducted by Resource Recycling Systems (“RRS”) for the CGLR Foundation that assessed the Great Lakes region’s performance in six key areas (collection, processing, end-markets, consumer education and engagement, supportive policies, and investment), it was found that over 88 million tons per year (all tons are US tons unless noted), of material is landfilled across the eight Great Lakes states and the Canadian provinces of Ontario and Quebec each year. Approximately 40% of this material, or 35 million tons per year, is considered recyclable based on landfill audit data trends in the United States. Of this recyclable material, 14.5% (approximately 12.8 million tons per year) is rigid and flexible plastics worth US $1.7 billion/yr (CA $2.1 billion per year) in the commodities market.

As a result of the findings from the gap analysis, the CGLR Foundation launched the Circular Great Lakes initiative with business, government, NGO, and academic partners to forge a future without plastic waste and litter by facilitating the cross-sector collaborations necessary to achieve a 50% recycling rate in the region by 2030, which is consistent with the US EPA’s National Recycling Strategy and similar zero plastic waste efforts in Canada. The long-term aim is to close the loop within a decade.

To achieve the national circular economy ambitions of both countries in the transnational Great Lakes region, North America’s economic engine, an additional three million tons of plastics would need to be recovered and recycled each year, which would save close to US$200 million/yr from avoided landfill and would reduce annual GHG emissions by 2.6 million MTCO2e. This target can be met in two ways. First, individuals put more core recyclable plastics in the recycle bin instead of depositing it in their garbage. Second, more types of rigid and film plastics are accepted in the recycle bin in local recycling programs.

However, while there are over 200 primary MRFs in the Great Lakes region, the gap analysis prepared for the CGLR Foundation concluded that for the region to process an additional three million tons of plastics each year, the region’s material processing capacity would need to increase by 60%. But, because most of the region’s primary MRFs are unable to sort today’s light weight plastic packaging formats, such as flexible plastic packaging, due to aging equipment, lack of re-investment, and insufficient economies of scale in preparing and supplying this material as post-consumer recycled (PCR) feedstock to existing and new end markets, other processing methods will need to be built across the region if we are to achieve a 50% recycling rate and a Great Lakes circular economy.

Our Study to Address the Challenge

Therefore, to increase plastics processing capacity and diversion in the Great Lakes region, as well as meet growing demands for recycled feedstock, a hub-and-spoke approach for plastics collection, sortation, and processing is proposed using a network of secondary MRFs that would work alongside, and in collaboration with, the region’s primary MRFs and emerging chemical recycling assets.

To validate the secondary MRF business model and its potential application in the transnational Great Lakes region, the CGLR Foundation partnered with Titus, thanks to funding from the Alliance to End Plastic Waste (AEPW) and The Recycling Partnership (TRP), to deploy a portable secondary MRF to Chicago to demonstrate how extra value can be extracted from end-of-container-line, fiber line post sort contaminants as well as residue and/or mixed plastics from primary MRFs.

Our Findings

Based on data from a previous recycling market study conducted by SWALCO/SWANCC,[1] we believe up to 85,000 tons per year of MRF residual could be sent to a regional secondary MRF for reprocessing. Using the percentage of material sorted during the Chicago project, we estimate that 80% of the 85,000 tons, or 67,901 tons/yr, could be positively sorted for end-markets, 42% for traditional commodity markets and 38% for emerging advanced recycling or chemical recycling systems and other end markets.

Material	Tons per Year
Targeted MRF Residual Greater Chicago Region	85,000
Mixed paper (ISRI PS-54)	24,183
Polypropylene Rigids (#5 PP)	3,927
Polyethylene terephthalate (#1 PET)	2,171
Polyethylene Rigids (#2 HDPE)	2,644
Polystyrene (#6 PS)	472
Aluminum cans	617
Cartons (ISRI PS-52) [2]	411
Polylactic acid (PLA)	791
Metal	564
Total sorted for existing markets	35,780
Chemical or advanced recycling to include sorted film[3]	32,121
Total tons removed from landfill via a secondary MRF	67,901

Other key findings and takeaways are:

- Moving 35,780 tons per year of this material from landfill to a traditional recycling end-use will reduce greenhouse gas emissions by more than 103,141 MTCO2E per year. [4]

[1] *MRF and Recycling Markets Evaluation December 2019 SWALCO and SWANCC*

[2] *Based on the data obtained during this project and a regional model where MRFs recovered 84% of recyclable materials.*

[3] *We conducted two film trails that may increase the film recovery from MRFs which is detailed on pages 28-34 of this report and added all sorted LDPE and PE film for chemical and advanced recycling end users. This tonnage was not used as part of our WARM model GHG offsets.*

[4] *EPA WARM model version 16*

- Moving 32,121 tons per year from landfill to another end use other than mechanical recycling or waste-to-energy, such as advanced or chemical recycling, may reduce GHG emission; however, the current version of the WARM model has not been designed to calculate the impact.[5]
- Harmonizing and expanding municipal recycling programs to include low-volume and difficult-to-sort materials significantly increases the volumes of materials available for recycling.
- Secondary MRFs offer a more efficient and cost-effective solution to upgrade material recovery infrastructure in the Great Lakes region and beyond by focusing on separating low volume hard to sort materials from primary MRFs, collecting traditional recyclables that a primary MRF misses, and aggregate to truckload quantities for mechanical, advanced and chemical recyclers.[6] Producing a high volume (truckload quantities) of material that meets end user expectations is necessary for a circular economy. Without economies of scale, the cost for a primary MRF to sort low volume material collected curbside is significantly higher.
- The Chicago region is well-suited to benefit from a regional secondary MRF given the high population that generates significant recycling volume using the entrenched single stream collection system already in place. Some investment may be required at primary MRFs to isolate materials.
- The remaining life of the local landfill in the Chicago area is less than 9 years, even after considering landfill tonnage currently sent to Wisconsin and Michigan. A secondary MRF will help extend existing landfill space in the Chicago area[7]or reduce costs since the cost to ship trash out of state verse local is approximately $14 per ton and trending upward. Recovering 67,901 tons more per year of recyclates will extend the local landfill life.

Conclusion and Next Steps

Consistent with similar studies conducted in California, Pacific Northwest and the Northeast markets performed by Titus, this study helps demonstrate a secondary sorting facility in Chicago will enhance primary MRFs servicing the city and the Great Lakes region by creating economies of scale for processing low-volume, hard-to-sort packaging and materials.

A secondary MRF business model, such as licensing of patent US 8,813,972 B1, is designed to cost-effectively optimize our recycling infrastructure by aggregating low-volume and difficult-to-sort materials along with machine yield loss containing core recyclables from a network of primary MRFs, reprocessing and separating the materials, and supplying it to existing or new end-markets, enhancing curbside recycle programs and delivering benefits to all stakeholders involved in managing post-consumer materials within a large catchment area, or “waste-shed”. We believe the existing curbside collection and sorting system in place today still offers the least cost and most convenient system to recycle household waste.

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[5] *EPA WARM model version 16*

[6] *Resource-Recycling Dec 2024. PCR Packaging remains out of reach without quality feedstock.*

[7] *ILCCSWMA/SWANA joint conference Oct 15*

To inform next steps, a detailed business plan from Titus, with input from the CGLR Foundation and other Circular Great Lakes partners, will be presented to stakeholders to evaluate the best funding and operational strategies. This collaborative approach will help in closing the loop and enhancing the range of materials residents can recycle, contributing to a more sustainable recycling system.[8]

BACKGROUND

Over the past several years, the shift away from export markets for recyclable commodities,[9] combined with brand owner commitments to drastically increase PCR content in packaging and products, has led to significant investments in mechanical and advanced recycling capacity in the United States and Canada. To meet the growing demand for PCR, it will be necessary to further expand our recycling programs, increase public participation, and improve our ability to sort and process more types of materials into reusable commodities.

The Recycling System and A Circular Economy for Plastics

The recycling ecosystem consists of several key elements (Figure 1). Municipalities establish the recycling program that identifies the materials that the system is designed to recover, residents and businesses put their recyclable packaging and products in the recycling system for collection, haulers collect the recyclable material and deliver it to sorting facilities, primary 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 the PCR content into new products for sale to consumers.

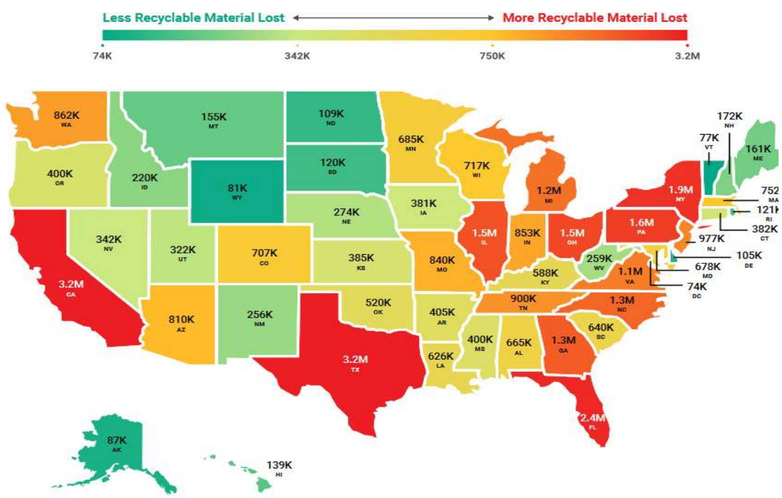
Figure 1: The Recycling System

Unfortunately, as noted in previous Titus studies, our existing recycling system has several limitations. In addition to issues with the lack of access and resident participation, which limits the quantity of material available for processing (Figure 2), residents that do recycle often "wish-cycle" by placing non-program materials and other trash into their recycling bins. Recycling programs can be confusing and often lack harmonized messaging across regions. Sorting

[8] *State of Residential Recycling 2024 page 18 The Recycling Partnership*
[9] *Resource Recycling. (2022). US scrap plastic exports continue years-long decline.*

facilities, with a few exceptions, lack the space and scale necessary to sort additional low-volume and/or difficult to sort materials. And finally, domestic recycling operations only exist if there is enough high-quality feedstock available to sell to an end-market; in other words, materials must be included in the recycling program, collected, sorted and recycled by material type to create the necessary supply chain for recycling to take place.

Figure 2: State Residential Recyclable Material Lost (Tons per year)[10]



Consequently, in the United States, the recycling rate for plastics in the marketplace has plateaued at about 9%[11], with national residential recycling rates, Figure 3, ranging from a high of 28% for PET bottles, including those collected through state deposit return programs, and as low a 1% for #3-7 plastics and film and flexible plastic packaging.

Figure 3: Residential Recycling Rates by Material Category in the United States (per year)[12]

Material	Tons Generated	Tons Recycled	Recycling Rate	Total Tons Lost (homes & MRFs)	% Lost (homes & MRFs)
Cardboard	7,509,483	2,371,572	32%	5,137,912	68%
Mixed Paper	14,814,158	3,401,524	23%	11,412,635	77%
Aseptic & Gabletop	422,553	35,762	8%	386,791	92%
Glass Containers**	8,000,677	2,152,303	27%	5,848,374	73%
Steel Cans	1,198,282	231,156	19%	967,126	81%
Aluminum Cans**	1,308,956	393,488	30%	915,469	70%
PET Bottles**	3,412,310	971,215	28%	2,441,095	72%
Non-bottle PET	748,974	58,443	8%	690,531	92%
HDPE Natural Bottles	739,178	188,704	26%	550,474	74%
HDPE Colored Bottles	928,780	208,624	22%	720,155	78%
Polypropylene Containers	1,225,325	94,881	8%	1,130,444	92%
Plastics 3-7 (minus Polypropylene)	754,006	8,909	1%	745,097	99%
Bulky Rigid Plastics	1,516,711	17,231	1%	1,499,479	99%
Film & Flexible	4,787,126	4,569	<1%	4,782,556	>99%
TOTAL	47,366,519	10,138,381	21%	37,228,139	79%

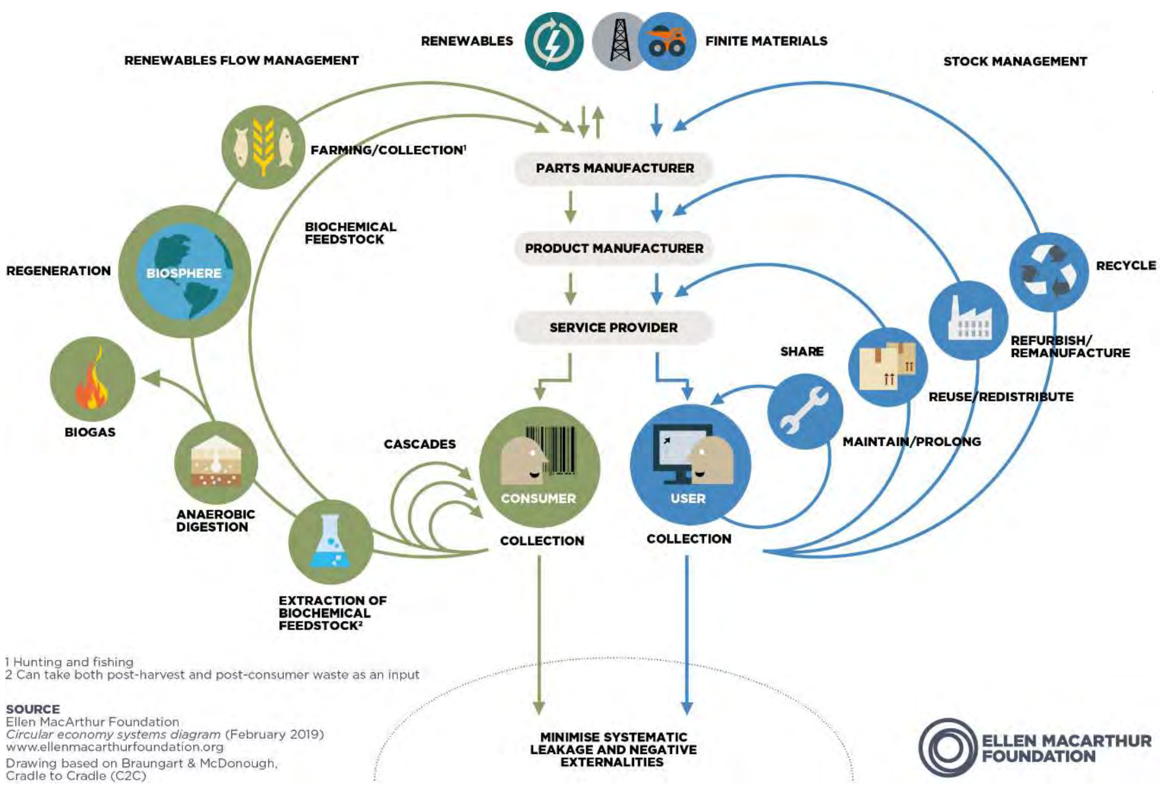
* out of tons generated
**includes material captured through state deposit return systems

[10] *The Recycling Partnership. State of Recycling: Present and Future of Residential Recycling in the USA (2024).*
[11] *US EPA. National Overview: Facts and Figures on Materials, Wastes and Recycling (2018).*
[12] *The Recycling Partnership. State of Recycling: Present and Future of Residential Recycling in the USA (2024).*

It would be reasonable to assume that the United States, Canada, and the Great Lakes region could reach a recycling rate of 30 – 40% for plastics using traditional means through increased access, participation, and capture rates. Achieving recycling rates of this level would enable many brands to attain their recycling content goals.

To enable even higher recycling rates and a circular economy (Figure 4), including for plastics, it will be necessary to commercialize other advanced recycling processes, such as purification, depolymerization, and conversion technologies such as pyrolysis and gasification. Moreover, it will be critical to have expanded recycling programs and sorting capabilities in place and ready to deliver the required feedstock material to these new recycling processes, which can include textiles, durable plastics, and packaging.

Figure 4: Circular Economy Butterfly Diagram[13]



Municipal Recycling Programs and Collection and Sortation Systems

The MRF industry is usually a for-profit system, and each MRF bids for residential curbside material by city or by municipality that includes more than one city. The contract specifies what the MRF must collect and sort so the MRF owner can design a system using best practices that is effective in meeting the contract terms and is price competitive. Often, these contracts are awarded for 5 to 15 years in duration.

[13] *A Great Lake Circular Economy Strategy & Action Plan for Plastics Jan 2022*

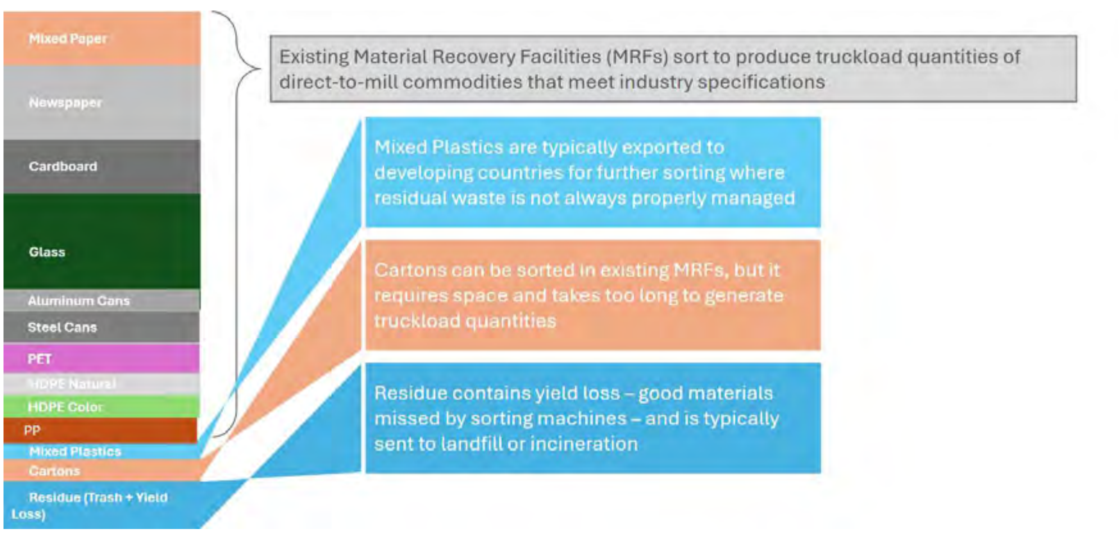
There are different types of MRFs that sort inbound recyclable material into commodities for end-markets. Several variables impact the quality and quantity of the material sorted, such as residential compliance to what is placed in the recycling bin (Figures 11-12), weather, workforce participation, ever changing packaging designs by brand owners, and the availability of end markets for the material that the MRF sorts by material type in truckload quantities weekly or daily.

The combination of medium to long term contracts and ever-changing material streams puts the primary MRF sorting systems at sub optimal sorting efficiency. Couple that with ever changing scrap value prices for sorted commodities and rising costs to sort incoming materials into these commodities, many MRFs are moving to a fee for sort model for the cities they serve. In addition to a fee for sorting, the MRF shares in revenue generated by selling the commodities to market. We believe the existing curbside collection and sorting system that used primary MRFs under contract with haulers or direct with the cities they service for sorting offers the least cost and most convenient system to recycle household waste.

Primary Material Recovery Facilities

Primary MRFs typically recover 80% to 90% of materials collected for recycling and produce direct-to-mill commodities that meet industry specifications for core recyclables. Most primary MRFs can produce high-quality baled products for each of the top nine materials shown in Figure 5, independent of whether the MRF is highly automated or primarily a manual-sorting operation. Technology applied to processing these materials improves efficiency, but not necessarily the quality.

Figure 5. Commodities Recovered at Primary MRFs and Opportunities for Secondary Sorting



Plastics Recovery Facilities

Primary MRFs can economically sort HDPE, PET and in many cases based on high volumes PP that meets quality and quantity for mechanical and advanced recycling. In most cases MRFs can take these truckload quantities directly to mechanical recyclers (reclaimers). Plastics Recovery Facilities ("PRFs") are a type of secondary sorting process that is designed to sort mixed plastics, and, to date, they continue with the recycling process to produce a flake or pelletized resin product for one or more of the sorted commodities. PRFs require a large waste-shed from which to source enough material to reach capacity and achieve the economies of scale necessary for efficient operation

Glass Beneficiating Facilities

Glass Beneficiating Facilities ("BPs") are a type of secondary sorting process that are designed to sort mixed glass by removing non glass, sorting by color, and sizing the material for end markets. The recycling process is designed to produce cullet (furnace ready post-consumer glass), fine grind for fiberglass end users, or as a blasting media. BPs need a large waste-shed from which to source enough material to reach capacity and achieve the economies of scale necessary for efficient operation. Given glass is heavy and transport costs are high, many communities in the United States cannot ship glass to end markets and do not include glass in the curbside recycling bin as a result. A BP facility is like a secondary material recovery facility given they sort a material stream from a primary MRF that has been determined over time, cannot meet end user quality and quantity requirements (at a reasonable cost).

Secondary Material Recovery Facilities

The concept of a secondary MRF (Figure 6), is about combining advanced sorting technologies and a robust business model that achieves economies of scale for sorting all materials by type within a metropolitan-area or regional waste-shed's existing curbside recycling systems, such as the Great Lakes, California, Pacific Northwest or the Northeast.

Secondary MRFs enhance the services provided by a network of primary MRFs. Secondary MRFs target about 10% of the primary MRFs stream defined as mixed rigids, container line residual and discards from the fiber lines. Based on the Chicago study, a secondary MRF can divert about 80% from landfill or 8% increase in diversion for each city served. In addition, given the primary MRF is sorting and shipping to market 80% collected and sending the remaining unsorted to a secondary MRF or to landfill, a primary MRF supported by a Secondary MRF provides recycling bin accountability for the residents and cities this system services. Finally, a secondary MRF produces truckload quantities of high-quality feedstock for advanced and chemical recycling end uses.

The equipment and technologies utilized at Titus secondary MRFs employ a unique proprietary design that digs deeper into the recycling stream to recover low-volume and difficult-to-sort materials along with machine yield losses.

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 aggregate the remaining mixed materials from a network of existing primary MRFs within the region to reach the critical mass necessary for an economically viable secondary MRF.

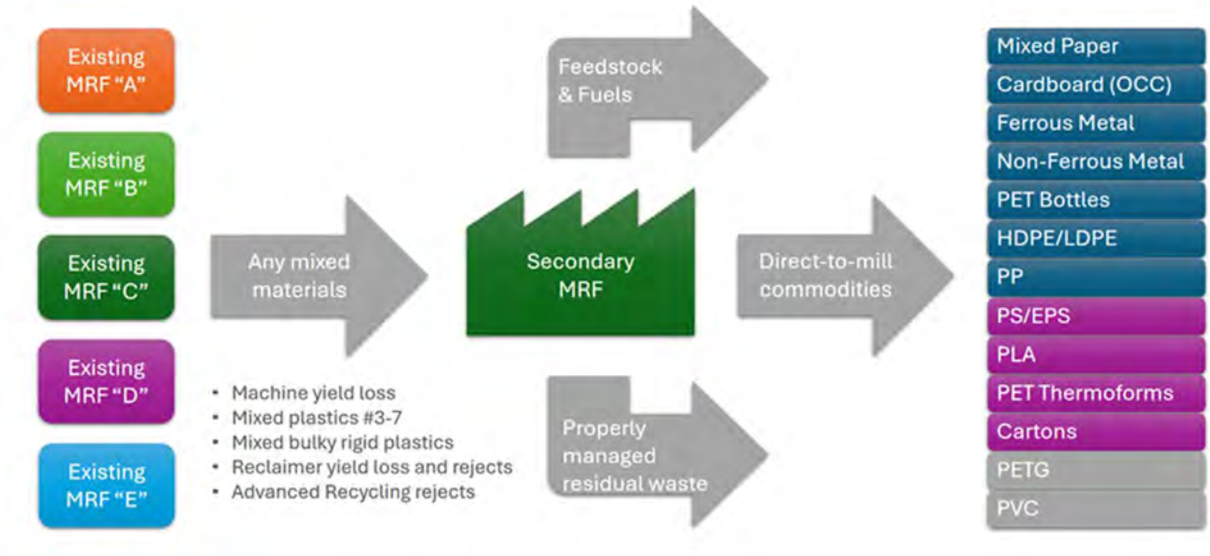
In addition to providing sorting services to primary MRFs, a secondary MRF, such as one run by Titus MRF Services in California can recycle material from reclaimer reject streams, Hefty Renew Bag® programs, primary MRF participants and other mixed streams collected for value. Similar opportunities are available to process the yield loss from local paper mills[14].

Figure 6 – Full-Scale Secondary MRF (Example Only)

These differences allow secondary MRFs to recover a larger portion of the materials lost in the recycling stream, extending the capabilities of all primary MRFs within a city or region, as shown in Figure 7, increasing overall material recovery and recycling rates with the most efficient use of capital.

[14] *Recycling Markets Evaluation December 2019 SWALCO and SWANCC page 72*

Figure 7 – Secondary MRF Process Flow



The secondary MRF can benefit stakeholders in several ways, as outlined below:

- Municipalities and Residents
  - Provides additional "Blue Bin Accountability," data for product stewardship.
  - Reduces environmental impacts.
  - Improves recycling/diversion rates.
  - Creates new recycling and clean technology jobs.

- Material Recovery Facilities
  - Increases operational flexibility.
  - Extends ability to adapt to the "evolving ton."
  - Reduces environmental costs associated with machine yield loss.
  - Receives revenue from material sales from secondary MRFs.

- Downstream Mills and Processors
  - Increases the overall volume of feedstock (no longer landfilled).
  - Produces feedstock that meets domestic mill requirements.
  - Processes mill rejects to improve overall yield.
  - Reacts quickly to support new businesses.

- Brand Owners and Packaging Producers
  - Adapts to, and facilitates introduction of, new packaging formats and/or materials.
  - Sorts different packaging for new value chains to recycle packaging not currently recycled and recovers more volume to provide additional PCR to help meet PCR content commitments
  - Creates markets for low volume materials.
  - Provides a cost-effective pathway to product stewardship.

Secondary MRF Contributions to Recyclability, Recycle Rates, and Recycled Content

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%.[15]

The challenge today is that many of the non-contracted packaging materials and other low-volume and difficult-to-manually sort materials deposited in the recycling system cannot be readily recycled at a primary MRF due to space, volume, and difficulty to sort. Secondary MRFs would allow a waste-shed and network of primary MRFs to adapt more easily to the range of plastic packaging formats on the market and changing packaging designs as end-markets continue to develop.

A secondary MRF also offers another level of system optimization. Core recyclables lost to a primary MRF's residual waste can be collected and reprocessed at a scale and in a manner that is more efficient and cost-effective than a primary MRF, helping primary MRFs achieve recovery rates up to 9% for contracted materials.

In both situations above, secondary MRFs would help avoid landfilling or incineration, the least preferred options for managing materials sustainability, as well as costly landfill tipping fees, and would contribute to extending the life of aging landfills across the Great Lakes region at a time when siting and permitting new landfills is politically challenging.

Finally, secondary MRFs will dramatically increase access rates for materials throughout a regional waste-shed through recycling program harmonization; expanding the type of packaging formats allowed in the recycling system, notably film and flexible plastics; and simplifying recycling program messaging and decreasing confusion among participants.

Overall, achieving higher recovery and recycling rates are a combination of access, participation, collection, sortation and processing capabilities, and end-market demand. Secondary MRFs are uniquely positioned to improve all these elements. Most important, secondary MRFs can be implemented within a timescale more likely to meet the increased demand for recycled content from brand owners for in the United States and Canada.[16]

CHICAGO SECONDARY SORT DEMONSTRATION PROJECT

Home to over one hundred million people across eight states and the Canadian provinces of Ontario and Quebec, the Great Lakes economic region, with its deeply integrated sectors and supply chains, is an engine of economic activity in North America, fueling the competitiveness and prosperity of the United States and Canada, as well as commerce between both countries. But, according to the US Chamber of Commerce Foundation, it is estimated that 81% of the post-consumer waste in the region is lost to landfills, including valuable materials like plastic[17].

[15] *Federal Trade Commission. Part 260 – Guides for the use of Environmental Marketing Claims.*
[16] *Resource Recycling December 2024. PCR Packaging remains out of reach without quality feedstock.*
[17] *US Chamber of Commerce Foundation. Creating a Circular Economy in the Great Lakes Region (2020)*

At the center of this dynamic economic region are the five Great Lakes, the largest surface freshwater system on the planet. According to a study by the Rochester Institute of Technology, an estimated twenty-two million pounds (10,000 metric tons) of plastic debris enters the Great Lakes every year from the United States and Canada. Other beach clean-ups show that 80% of the litter washed up on the Great Lakes shoreline is plastic.

Though most life-cycle assessments indicate that plastic is the most durable, versatile, and sustainable material when compared to alternatives, especially for consumer packaging, the 'post-use' phase is very wasteful, with much of the material's value being lost to municipal solid waste streams and landfills as well as the natural environment.

Shifting away from our 'take-make-waste' mindset, or the linear economy, to a circular economy is key to forging a future without material waste and pollution. The Save of Our Seas 2.0 Act[18], which became law in 2020, defines the circular economy as an economy where industrial processes and economic activities are restorative or regenerative by design; enable resources used in such processes and activities to maintain their highest values for as long as possible; and, aim for the elimination of waste through the superior design of materials, products, and systems (including business models).

The primary purpose of the Secondary Sortation Demonstration Project in Chicago, organized by the CGLR Foundation as part of its Circular Great Lakes initiative in collaboration with Titus MRF Services and funding by the AEPW and TRP, is to demonstrate a model and business plan for developing a hub-and-spoke approach for collecting, sorting and processing end-of-container-line residue and/or mixed plastics from primary MRFs in the greater Chicago region so that more materials can be diverted from landfill and returned to the economy for use.

The secondary purpose of the demonstration project was to provide a pathway via secondary processing to the transnational Great Lakes region to improve the recovery of plastics as well as other materials from investments in supportive policies, public education, collection, processing, and end-markets on a multistate and bi-national basis to help improve recovery rates and recycling rates.

The Challenge

The recent State of Recycling study from The Recycling Partnership found that 43% of all households in the United States participate in recycling, and of the households participating in a curbside recycling program, 57% of recyclable materials are properly recycled.[19] This means a lot of value is being unnecessarily lost in our trash and landfills.

In the Great Lakes region, a gap analysis prepared by RRS for the CGLR Foundation estimated that 12.8 million tons of plastics, rigid and flexible materials, or 14% of the municipal solid waste stream, is being wasted and lost in the regional economy annually. We are literally throwing out US$1.7 billion (CA$2.1 billion) worth of valuable and reusable plastics every year.

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[18] *https://www.congress.gov/bill/116th-congress/senate-bill/1982/text/pl*
[19] *The Recycling Partnership, State of Recycling (2024)*

Stated in detail later in this report, this study revealed, for the greater Chicago-area alone, the core recyclables and non-core material going to landfill is approximately 67,901 tons per year.

As communities and residents are encouraged to shift more recyclable material from the trash to the recycling bin, the Great Lakes region's 200+ primary MRFs will need to recover and sort an additional 3 million tons of plastic containers and packaging every year to reach the US EPA's 50% recycling rate goal in the region, which will require them to boost their processing capabilities by 60%.

But, as primary MRFs recover, sort, and process more material and plastics, they will also lose more core recyclables, as well as lower volume and difficult-to-sort materials such as plastic films, because of aging infrastructure, lack of investment, cost of labor, and insufficient economies of scale. Secondary MRFs offer a viable means of further optimizing the Great Lakes region's recycling infrastructure and curbside recycling programs.

Therefore, leveraging learnings from the Material Recovery for the Future initiative (e.g., feedstock agreements, collection, automation, policy change, etc.), as well as lessons learned from other supply chain partners, this project deployed Titus MRF Services' Portable Secondary MRF to demonstrate how additional value can be extracted from machine yield loss (end-of-container-line residue) and/or mixed plastics from primary MRFs.

The portable unit (Figure 8) consists of a feed hopper, vibratory screener (removes materials smaller than two inches), air classifier (removes film plastics), high-speed conveyor, and a dual-eject near-infrared optical sorter.

Figure 8 - Portable Secondary MRF System

Site Selection and Sample Methodology

Over an eight-week period, waste samples were collected from four primary MRFs in the Chicago-area (Figure 9) that varied in size, level of automation, sorting strategy, and recycling programs.

Figure 9: Greater Chicago Area Primary MRFs

All the samples collected, ranging between 10,000 and 30,000 pounds per MRF, were sorted and processed in a manner ensuring that the samples were representative of the end-of-container line conveyor outfalls (Figure 10), and any non-paper material defined as sorted contaminants from the fiber line residue.

Figure 10: End-of-Container Line Residue Prior to Sorting

The facilities involved in the demonstration project operated single stream collection systems and processed between 3,300 to 10,000 tons per month using an elevated level of automation (e.g., near-infrared sorting systems, etc.). Materials accepted at the curbside in both Cook and Lake County are shown in Figures 11 and 12.

Figure 11: Cook County Recycling Guidelines

Figure 12: Lake County Recycling Guidelines

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Processing Description

The optical sorter on the portable unit utilizes near-infrared reflectance to identify materials by type and then ejects materials up or down with compressed air according to the recipe programmed into the machine. Materials that were not targeted for ejection report to a third channel – the neutral fraction. The machine typically produces a higher-purity product (approximately 95%) when ejecting up and lower-purity (approximately 90%) when ejecting down, mostly due to the proximity of the air nozzles to the targeted materials.

Mixed materials must be processed through the portable secondary MRF several times to simulate the optical-sorting capabilities of a standard commercial-scale secondary MRF that only requires a single pass to recover all commodities. The portable system is also not equipped with magnets and eddy current separators for sorting metals, so these materials must be sorted manually.

Secondary Sorting Process Description

To simulate the sorting equipment available at a secondary MRF, materials were processed through the portable secondary MRF in a series of passes according to the sorting strategy provided below.

Pass 1
- PE ejected up, followed by manual quality control to produce polyethylene product.
- Fiber ejected down with one manual QC to remove non fiber.
- Neutral mixture further sorted in Pass 2, with ferrous and non-ferrous metals removed manually.

Pass 2
- PET ejected up, followed by manual quality control sorting out non clear PET.
- PP ejected down, followed by manual quality control sorting out non-PP.
- Neutral mixture further sorted in Pass 3, with ferrous and non-ferrous metals removed manually.

Pass 3
- Aluminum ejected up, followed by manual quality control.
- PS/EPS ejected down followed by a manual quality control Removing non-EPS/PVC.
- Neutral mix further sorted in pass four.

Pass 4
- Cartons up.
- PET Color/ PVC down.
- Neutral mix further sorted in pass five.

Pass 5
- Metals up.
- PET Color/ PVC down.
- Neutral mix collected for further analysis to determine % recovered via advanced Recycling processors.

RESULTS AND DISCUSSION

Sample analysis was completed in two phases. First, the basic material characterization was accomplished by manual sorting materials into the following categories: Mixed Paper with some OCC (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.

Furthermore, to better understand the impacts of recycling programs and the behaviors of their participants, the plastics fractions were sorted even further 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 do not allow #1 PET thermoforms.

Lastly, the plastics fractions were further sorted once more 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 cannot be manually sorted and NIR sorting systems cannot 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.

Overall, the project successfully processed 119,120 pounds of material from four MRFs over an eight-week period, summarized below, showing stakeholders in the city and the Great Lakes region that additional value can be extracted from landfill-bound materials from primary MRFs:

- Mixed Paper (33,579 pounds or 28.19% of the material type sorted)
- HDPE (3,671 pounds or 3.08% of the material type sorted)
- PET (3,014 pounds or 2.53% of the material type sorted)
- PP (5,452 pounds or 4.58% of the material type sorted)
- Aluminum (857 pounds or 0.72% of the material type sorted)
- Metal (390 pounds or 0.33% of the material type sorted)
- PE Film (508 pounds 0.43% of the material type sorted)[20]
- PLA (7 pounds or 0.01% of the material type sorted)
- EPS/PVC (656 pounds or 0.55% of the material type sorted)
- Cartons (572 pounds or 0.48% of the material type sorted)
- End-of-Line, yield loss and under two inches (74,520 pounds or 59% of the material type sorted)

Most of the commodities sorted (Figures 13–24) were equivalent to, or like, materials typically recovered at primary MRFs and represent typical yield loss. Some of the commodities sorted, however, were less commonly recovered at primary MRFs due to the economics of sorting low-volume materials, such as cartons, PP, and PLA.

[20] *The Portable unit used to conduct process MRF residual is under designed to sort film using screening, air classification followed by optical sorting. The machinery could not identify black film nor was the system wide enough to sort film at scale. Due to machine limitations, we used the machine to sort clear PE film only and met quality levels for mechanical end uses. We believe we would capture a lot more film with a full-scale sort line at a secondary MRF.*

Figure 13: Mixed Paper

Figure 14: Film

Figure 15: Non-Ferrous (Aluminum UBC)

Figure 16: Non-Ferrous (Aluminum Other)

Figure 17: Clear PET

Figure 18: Color PET sorted.

Figure 19: HDPE Clear

Figure 20: Color HDPE

Figure 21: Cartons and TetraPaks

Figure 22: PLA sorted.

Figure 23: PS sorted.

Figure 24: Metal

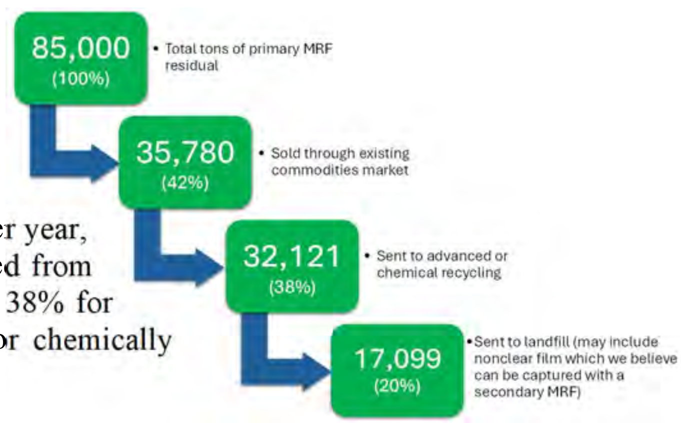
LRS, the host of the portable unit and a project partner of the CGLR Foundation, was able to deliver most of the sorted material to markets in the greater Chicago area as much as possible (Figures 25-27), with the remainder being delivered to emerging or niche markets outside of Chicago and the Great Lakes region.

Figure 25: Clear PET film sorted prior to baling for market.

Figure 26: Clear HDPE sorted prior to baling for market.

Figure 27: Aluminum sorted prior to baling for market.

Based on these results and data from the SWALCO/SWANCC Recycling Market Study,[21] we believe up to 85,000 tons/yr of residual could be sent to a regional secondary MRF for reprocessing. Using the percentage of material sorted during the project, we estimate that 80% of the 85,000 tons, or 67,901 tons per year, could be positively sorted for end-markets and diverted from landfills, 42% for traditional commodity markets and 38% for other end-market uses, such as advanced recycling or chemically recycling, including:



[21] *MRF and Recycling Markets Evaluation December 2019 SWALCO and SWANCC*

Material	Tons per Year
Mixed paper (ISRI PS-54)	24,183
Polypropylene (#5 PP)	3,927
Polyethylene terephthalate (#1 PET)	2,171
Polyethylene (#2 HDPE, #4 LDPE)	2,644
Polystyrene (#6 PS)	472
Aluminum cans	617
Cartons (ISRI PS-52) [22]	411
Clear PE Film[23]	*See note*
Polylactic acid (PLA)	791
Metal	564
Chemical or advanced recycling	32,121
	67,901

Comparison to the Northeast, Pacific Northwest, and California Studies

Mass balance data for the Chicago Secondary Sorting Demonstration Project for residual feedstock processed during this project (Figure 28) is based on taking in residual from four MRFs in the greater Chicago area. The data is presented as averages so as not to reveal individual facility data. For comparison, to follow is the average MRF residual composition data from the Northeast (Figure 29), California (Figure 30), and Pacific Northwest (Figure 31) studies.

The studies in these other regions did not include separating film and marketing the film to advanced and chemical recycling. We believe, due to increased use of film for flexible packages, both primary and secondary MRFs will focus on sorting out film and marketing the film to these rapidly developing markets.

The Chicago study captured film using screening, air systems and near infra-red optical sorting and we were able to achieve a film bale that met grade C for recycling end markets. We believe, a full scale regional secondary MRF would include a "film upgrade line" to capture film from primary MRF residue streams and sort into Grade A, B, or C and/or into a mix film bale that mechanical recyclers or pyrolysis end users could recycle.

[22] *Based on the data obtained during this project and a regional model where MRFs recover 88% of recyclable materials.*
[23] *We conducted two film trials that may increase the film recovery from MRFs which is detailed page 28-34 of the report.*

Figure 28: Average Chicago Residual Sorting

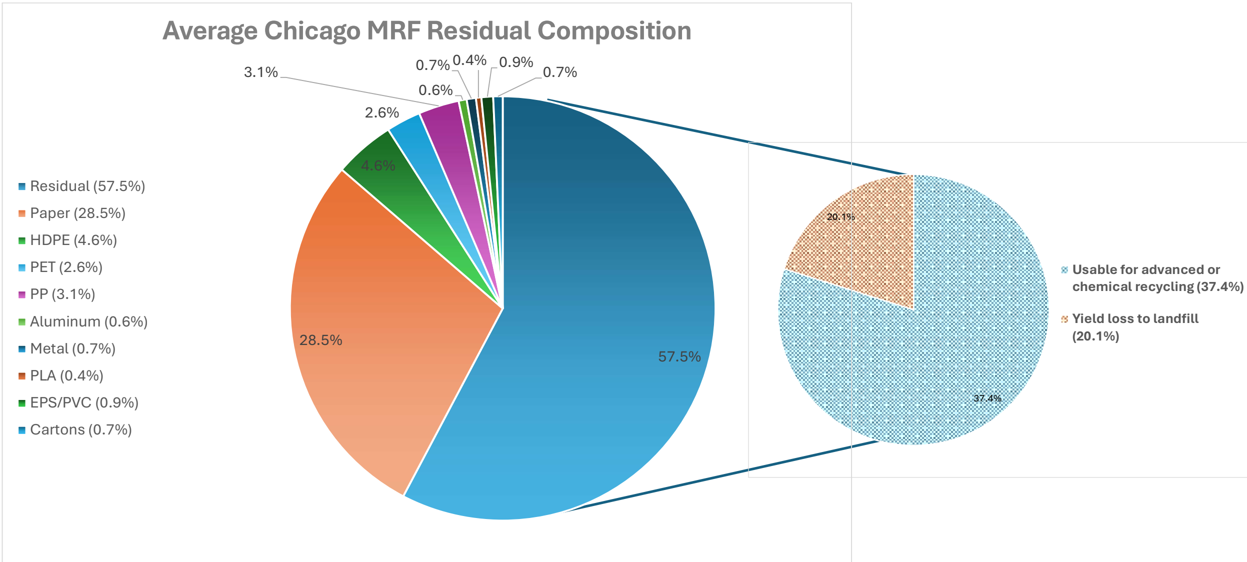


Figure 29: Average Northeast MRF Residual Composition

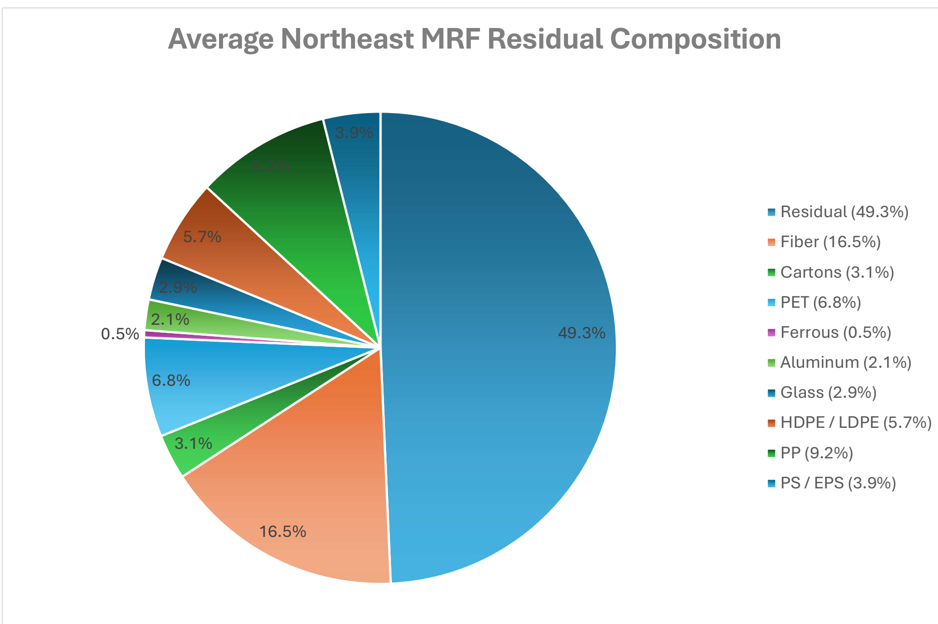


Figure 30: Average California MRF Residual Composition

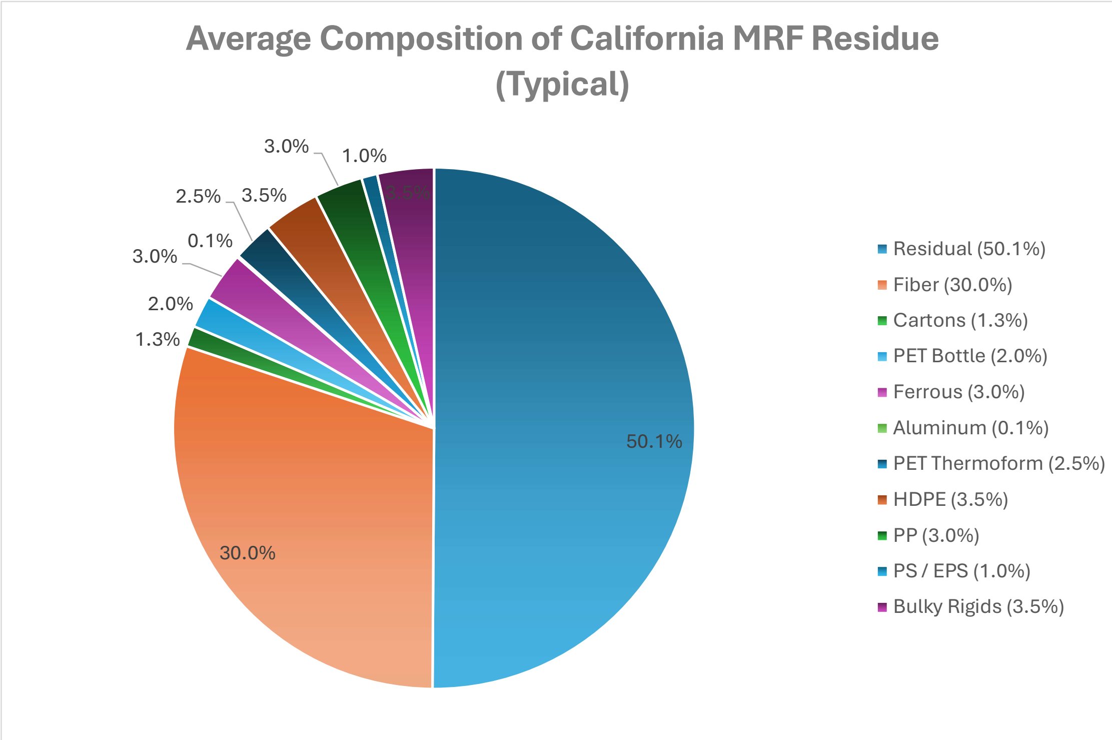
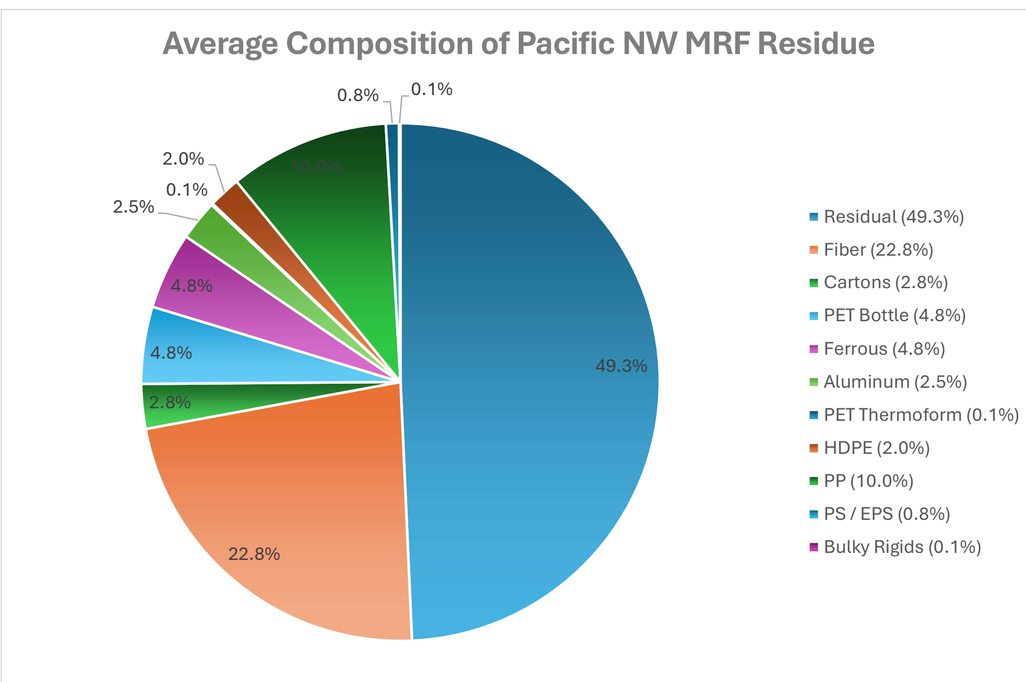


Figure 31: Average Composition of Pacific Northwest MRF Residual Composition



The Chicago area study, with the opportunity to market chemical recycling, achieved a 79% recovery rate for the sampled material (42% to mechanical end use and 37% to chemical recycling end use). This compares to 50.7% for the Northeast study, 49.9% in the California study, and 50.7% for the Pacific Northwest study. We believe, as advanced and chemical recycling expands to these regions, similar results would be possible.

Paper continued to be a significant material in the residual at primary MRFs, with Chicago being at 27% compared to the range of 16.5 to 30% in the other regions.

Polypropylene (PP) in the residual of primary MRFs continued to decrease given these MRFs have started to sort this material by installing new equipment, with PP representing close to 5% in the Chicago study compared to a low of 3% in California and a high of 10% in Pacific Northwest.

There were two other major revelations in the Chicago study versus the others that are worth noting: 1) the amount of film in the material stream; and 2) the availability of advanced recycling markets that can recycle that film as well as other PE/PP packaging not sorted for mechanical recycling.

A significant factor that increased diversion from landfill in the Chicago study was the availability of advanced (chemical) recycling markets for the material not useable by traditional mechanical recycling. We have one potential chemical recycling end user who forecasts they could use up to 65% of the non-mechanical sorted pass through from the secondary MRF as feedstock. Test results from two other companies with chemical recycling assets are expected but were not ready when this report was written. Based on our study, we would include a film recovery line in a secondary MRF to recover film and flexibles from primary MRF residue to create bales of required quality for mechanical and/or chemical recycling.

Other factors influencing the percentage of recoverable commodities included the type of collection system, alignment of the recycling program materials with the capabilities of the corresponding MRF, design of the sorting line where the presort trash combines with the yield loss from the fiber and container line, and the age of the sorting line.

Perspectives on Difficult-to-Sort Packaging Products

Certain packaging 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 do not provide enough reflectance because they absorb much of the NIR energy. Today’s sorting systems can detect and eject these items via vision or camera-based sorting. A secondary MRF would use both NIR, camera-based sorting, and other proven advanced sorting technologies to sort black plastics and multi-layer film. Figures 32-37 provide examples of non-recoverable commodities due to contamination or entrapment within other materials.

Figure 32: Contaminents (Aluminum Sort)

Figure 33: Contaminants (Clear PET Sort)

Figure 34: Non-HDPE (HDPE Sort)

Figure 35: Non-Cartons/Tetra sort.

Figure 36: Non-PLA sorted

Figure 37: Non-PS sorted.

Figure 38 represents material under two-inch that the portable unit separated using a screen so that air and optical sorting could be applied to the large fraction. The regional secondary MRF would use advanced sorting technology to recover materials in this under two-inch stream for existing or chemical recycling markets.

Figure 38: Under Two-Inch Material

Can a Secondary MRF take film sorted from a primary MRF and improve the quality?

In most residential curbside recycling programs, films (better known as plastics bags and flexible plastic materials) are not allowed in the program (see figures 8 that bans film from the recycling bin). However, some residents put film into their curbside bins so primary MRFs are seeking solutions that are cost effective and divert from landfill. One such MRF provided Titus with bales of film that were ejected from a fiber line using near-infrared optical sorters. These bales did not meet a standard to market as a film bale. The bale had too much non-film and too much paper to qualify as a grade C bale.

Film recyclers rate bales on a scale of A, B or C. The C grade is considered the worst quality and is produced by a primary MRF typically via a positive sort by hand or using robotics. Film is a prevalent packaging material and MRFs are looking at means and methods for recycling film through the residential recycling bin. While Cook County and Lake County in the Chicago area do not accept films, all the primary MRFs sampled as part of the study had film as part of the residual.

The film bales provided were sorted through the portable unit using the aspirator to extract light film from paper and then the optical sorter was adjusted to eject all film up. All the pass-through material and material under two inches were collected and sampled.

Film bales made at a single stream MRF are less than C grade quality and cannot be sold to an end-user, so it is often landfilled. The material is problematic for MRFs given removing large film helps the sorting machines but the method for removal is typically by hand given the diverse sizes of the film in the stream. Once the film is removed the quality of that collection is typically less than C grade. Based on our analysis of film bales generated from a MRF, these film bales can be consolidated at a regional secondary MRF, equipment can be deployed to remove all clear PE film for mechanical recycling and send the remaining film to advanced or chemical recycling.

Figure 39: Film generated where MRF removed film from the fiber line for sale as film.

Figure 40: Film extracted from paper using an aspirator and two-inch shaker screen adjusted per the downstream optical.

Figure 41: Film ejected via an optical sorter after presentation from the shaker screen and aspirator[24]

Conclusions from running film bales from a primary MRF:

- The sorting system using the aspirator adjusted to remove film from paper created a film product that was 84.1% film (Figure 40).
- The sorting system adjusted to shoot all film up created a film product that was 91% by weight (Figure 41).
- Combining two film streams - one separated using an aspirator and further downstream optical sorter shooting film up - generated an 89% film bale by weight. We delivered truck load quantities of this cleaned up bale to market under a "C grade" quality.

Overall, primary MRF film delivered to a secondary MRF for further sorting would improve the quality of the film recovered to C grade, thereby diverting this material from landfills and would help establish end markets consistent with the circular economy model.

Our analysis of these film bales was an effort to provide insight as to how best to move forward if film becomes an acceptable package to be placed in the recycling bin.

While we were able to clean those bales to a quality level of C grade, the cost to process still exceeded the value of the C grade film bale. Titus believes we would improve the quality and reduce the cost of the sort if we had a larger scale film sorting line at a secondary MRF and we

[24] *US8813972B1 Secondary separation system for recyclables claims 1 and 7.*

believe we would achieve a higher grade than C, which could provide the economics in order to support the collection and sortation of films in a municipal recycling system.

Can a Secondary MRF take Hefty ReNew™ Bag program from a primary MRF and improve the quality?

Designed to complement current recycling efforts, the Hefty ReNew Bag™ program run by Reynolds Consumer Products ("Reynolds"), formerly the Hefty Energy Bag® Program, establishes one way to collect otherwise hard-to-recycle plastics at curbside and uses them as valued resources. These hard-to-recycle plastics include common items like candy wrappers and foam takeout containers.

Residents in a participating Hefty ReNew Bag™ community, who choose to recycle more than what is offered by the existing curbside service provider, can purchase 10 bags for approximately $10. On average, it takes consumers 2-4 weeks to fill their bags. Based on pre-arranged agreements with primary MRFs serving the community, these bags are placed by the resident into the recycling bin and removed by the primary MRF at the presort. The orange bags are then baled by the MRF and sent to an end-user designated by Reynolds.

Reynolds sent Titus a four-yard Gaylord box of hefty bags from a collection program already in place in the Midwest. Titus ran this material through the portable to demonstrate the effectiveness of sorting Hefty ReNew Bag™ material at a regional secondary MRF.

Our findings, based on the sample material provided (Figure 42) and our understanding of the Hefty ReNew Bag™ program, are:

- The Hefty bag system allows a secondary MRF to sort a higher quality of material versus having that material loose with all other recyclables.
- Based on our discussions with the Hefty ReNew Bag™ team at Reynolds, every month residents who participate increase the quality and quantity of the material placed in the orange bag (participants average 1.9 pounds per orange bag).
- This is a voluntary program and residents who participate pay $10 for bags that last about 10 months. These residents are willing to pay more to improve recycling from their home and on average these residents are paying an additional $1 per month for their "enhanced" curbside recycling service.
- The Hefty ReNew™ Bag captured at the primary MRF can be sent to a secondary MRF for further sorting by material type.
    - Figures 43 and 44 show high quality sorts by material type and all this material would go to mechanical end use.
    - Figures 45 - 47 show materials that are more difficult to sort by material type, but due to isolation via the orange bag system, these samples were cleaner in appearance than Figures 21, 22 and 23.
    - Based on the % of the hefty bag that is PE or PP, at least 74% of the contents could go to Advanced or Chemical Recycling see table under Figure 42.

- The Hefty ReNew Bag™ contents included items not in the program. See figures 45-47. Many of these items, paper and rigid plastics could be sorted and sent to recycling markets by a secondary MRF.

The film was placed in the Hefty ReNew™ Bag by residents, isolating this hard-to-sort material giving primary MRFs more opportunity to capture program materials for shipment to establish markets. In addition, the quality of the film was significantly cleaner than MRF film sorted by our portable that was placed loose by residents in their recycling bin. Compare figure 45 to figure 40 and 41.

Figure 42: Hefty ReNew™ bag prior to sorting approximately 15-pound sample of contents

Material	Weight	%	PE/PP	Contaminants
PE	6.868	45.85%	45.85%	
PP	2.827	18.87%	18.87%	
Paper	2.172	14.50%		14.50%
PP Film	0.875	5.84%	5.84%	
Others	0.768	5.13%		5.13%
PS	0.455	3.04%		3.04%
HDPE	0.370	2.47%	2.47%	
PVC	0.310	2.07%		2.07%
PE Film	0.215	1.44%	1.44%	
PET	0.103	0.69%		0.69%
ABS	0.006	0.04%		0.04%
PLA	0.005	0.03%		0.03%
AS	0.004	0.03%		0.03%
	14.978	100.00%	74.48%	25.52%

Figure 43: Sorted rigid PP from the Hefty ReNew™ Bags.

Figure 44: Clear PE film from the Hefty ReNew™ Bags.

Figure 45. Paper removed via optical sorting from the Hefty ReNew™ Bags.

Figure 46. Under two inches removed from the Hefty ReNew™ Bags

Figure 47. Non sorted materials from the Hefty ReNew™ Bags.

CONCLUSIONS AND RECOMMENDATIONS

The growing demand for PCR, driven by corporate recycling content goals and minimum recycled content legislation, as well as the growing demand for feedstock for chemical recycling, necessitates immediate solutions to improve domestic recycling capabilities. Achieving these targets will require significant investments in processing infrastructure.[25]

As shown in California, the Pacific Northwest and the Northeast studies conducted by Titus, a secondary sorting facility in the Chicago area can enhance primary MRFs servicing the region by creating economies of scale for processing low-volume, hard-to-sort packaging and materials. Other anticipated key benefits of a secondary MRF in the Chicago region include:

- The creation of **46 direct green jobs (at the secondary MRF)**.
- **Diverting 67,901 tons from landfill annually**, avoiding expensive tipping fees and/or extending the life of existing landfills.
- The existing primary MRF system in the greater Chicago area processes approximately 850,000 tons per year and successfully diverts 86% to recycling end use. By adding a regional **secondary MRF** in the Chicago area we project increasing the diversion from landfill an additional 8% to 94% for the area serviced, generating an additional 67,901 ongoing, consistent, and predictable **quantities** of recyclable materials.
- **Reducing greenhouse gas emissions by over 103,141 MTCO2E equivalent** annually by circulating material back into the economy for recycling.[26]
- Enhanced **traceability and recovery for all recyclable materials**.

The benefits of a secondary MRF in Chicago are contingent on establishing long-term supply agreements between existing primary MRFs and the secondary MRF to ensure truckload quantities of feedstock are available on a consistent basis. The end markets for approximately 50% of the material are already in place. The fraction we uncover from the primary MRF residual, after sorting for high value commodities, is available for advanced and chemical recycling end markets. The secondary MRF can process this stream to meet advanced and/or chemical end user specifications for the greater Chicago region at volumes forecasted at 3000 tons per month or 35 truckloads of predictable and consistent feedstock per week.

Furthermore, like previous studies, it may be necessary to fund minor modifications to the primary MRFs to facilitate the production of suitable feedstock materials for the secondary MRF. Expanding and harmonizing recycling collection programs and developing complementary policies could also help to further assure that the system remains sustainable.

The proposed secondary MRF offers various approaches to long-term financial stability. However, it is important to note that some additional costs may be passed from the Primary MRFs to the rate payers if the difference between the secondary MRFs processing fee and the primary MRFs' landfill disposal cost avoidance is not sufficiently covered by the revenue sharing from commodity sales. However, it is also to note that some additional revenue may be passed from the Secondary MRF to the Primary MRF and rate payers if revenue exceeds processing fee

[25] *Resource Recycling December 2024. PCR packaging remains out of reach without quality feedstock.*
[26] *EPA WARM model version 16*

targets. 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.

Moreover, with the addition of new advanced (chemical) recycling plants in the Great Lakes region and across the United States and Canada, the demand for hard-to-recycle plastic feedstock will increase.

Finally, given Chicago's size and the need for a consistent supply volume, a multi-state, hub-and-spoke approach is essential for sorting and processing more consumer plastics, such as flexible packaging, and other core commodities lost at primary MRFs, to ensure truckload quantities of material can be generated for a secondary MRF in Chicago as well as future secondary MRFs in the region.

Based on the above, as well as past studies and practices deployed over the past 10 years by Titus MRF Services, below is a notional business case for building a secondary MRF in the greater Chicago area:

Supply Volume:

- Recycling Tonnage (2018): Estimated to be 834,430 tons of curbside collected single stream recycling volume across the greater Chicago area MRFs, with an estimated 14% residual or trash content.[27] Total market area residual for potential secondary processing in 2018 was 116,820 tons.
- Targeted Residual for Sorting 2025: The secondary MRF is targeting to process 85,000 tons per year.
- Residual from primary MRFs is not the picked pre-sort trash rather it is MRF residual, from container and fiber rejects line. Target volumes have been adjusted for future growth and presort trash removal.
- 2025 Volume Estimate: The secondary facility will have a design capacity to process up to 10,000 tons per month.

Cost of Sorting:

- Initial Investment: $21 million for equipment and $4 million in working capital. The facility is sized at 45,000 square feet on 2-3 acres.
- Operating Costs: Sorting costs are estimated at $100 per ton, totaling $708,300 per month. This includes all costs such as rent, power, insurance, labor, maintenance, and other overhead.

Revenue Stream:

- Material Breakdown:
  - Forty-one percent are sold at $0.069 per pound.[28]

[27] *SWANCC/SWALCO Recycling Market Study December 2019*

[28] Recycling resource May 2024 issue publishing scrap prices and total tons sorted by material type weighted average revenue per pound is a picked-up price FOB the SMRF.

  - Thirty-nine percent are sold to advanced recycling at a range of $0 to $60 per ton (for our model we used $10 per ton). Grade C pricing is $2.60 per ton and Grade B is $148 per ton.
  - Twenty percent was sent to landfill at $50 per ton, totaling $70,830 per month.
  - Revenue: $487,000 per month.
  - Landfill Cost Avoidance: $354,150 per month (from diverting material from landfill).

Financial Summary:

- Cash flow positive month to month: At landfill cost equivalent and without subsidies or scrap price changes, the secondary MRF generates monthly income of $94,000.
- Environmental Impact: The system provides. [29]
  - Eight percent increase in landfill diversion
  - Reduces over 103,141 tons of GHG emissions annually.
  - Reduces marine pollution risk given this material is processed locally. Eliminate the case where MRF residuals are shipped overseas for additional processing where waste can be mismanaged
  - Change in energy moving this material from landfill to recycling is equal to 10,893, households' annual energy consumption, 171,755 barrels of oil or 8,284,569 gallons of gasoline.
  - Total change in labor hours by diverting from landfill is expected to generate 592,223 person hours equal to 284 direct and indirect full time jobs per year.

Levers to increase the profitability of the secondary MRF:

- Market Prices for Commodities will vary:
  - A $30 per ton increase in mixed film bale pricing for chemical recycling, would increase the profitability of the secondary MRF $54,000 per month.
  - An 18% increase in value for the 41% of additional recovered traditional recycled materials would increase the profitability of the secondary MRF $63,750 per month.
- Increase Volume Sorted:
  - Increasing volume to 85% of capacity (by sorting 1,300 incremental tons/month) would increase the profitability of the secondary MRF $104,000 per month.
- Match MRF Sorting Fees:
  - Aligning the sorting fee to $70 per ton (compared to a $25 to $50 per ton landfill cost) would increase the profitability of the secondary MRF to $144,000 per month.
- Engage End Users and Generators:
  - If end users and/or generators would embrace this model for advancing the recycling system, the cost to make it a 13% ROI 100% funded by private investors is fifty cents per household per month or $6 per year per residence in pick up fees.

[29] *EPA WARM model version 16*

- Extended Producer Responsibility (EPR): The emergence of EPR in the United States and Canada, and potentially included portions of the Great Lakes region, will revolutionize the way waste is managed, shifting the burden from consumers and municipalities to the manufacturers. This shift may accelerate the need for secondary processing to achieve high recycling rates and recover valuable materials from complex waste streams, enabling a circular economy, reducing environmental impacts, and creating economic value. Specifically, EPR significantly increases the importance and value of secondary processing because of:
  - Higher Material Recovery: EPR systems incentivize the recovery of a larger percentage of materials from waste streams, which often requires secondary processing to manage more complex materials.
  - Enhanced Sorting Efficiency: Producers under EPR schemes are encouraged to improve the recyclability of their products. However, many materials still require secondary processing to be fully recovered, reducing landfill use and increasing the number of high-quality recyclables.
  - Innovation in Recycling Technologies: As manufacturers are pushed to meet recycling quotas under EPR, there is a greater need for advanced technologies like chemical recycling, mechanical recycling of complex materials, and automated sorting systems.
  - Economic Value: Secondary processing facilities create economic opportunities by extracting valuable materials (e.g., rare metals, plastics) from residual waste streams. This adds revenue potential for waste management companies and reduces the demand for virgin materials.

Summary of the Business Case for a Secondary MRF

The secondary MRF presents multiple pathways to financial sustainability. This business case emphasizes a low-cost, scalable solution that could serve as a model for other cities and regions struggling to improve recycling services. By establishing a regional secondary MRF, we aim to address the growing challenge of collecting and sorting residential discarded packages for recycling.

Financial Sustainability

- The proposed secondary MRF offers various approaches to achieve long-term financial stability.

Scalable Solution

- This model can be easily adapted and implemented in different regions, showcasing its scalability.

Regional Benefits

- The facility can demonstrate to other municipalities the advantages of a regional approach to recycling services.

Governance Options

- The operation of the secondary MRF in Chicago could follow different governance structures, including:
    - Private Venture
    - Public-Private Partnership
    - Non-Competitive Non-Profit Collaboration

By licensing this endeavor through Titus, we have the flexibility to explore and determine the most effective governance model. This initiative not only aims to enhance recycling efforts but also to set a precedent for sustainable waste management practices.