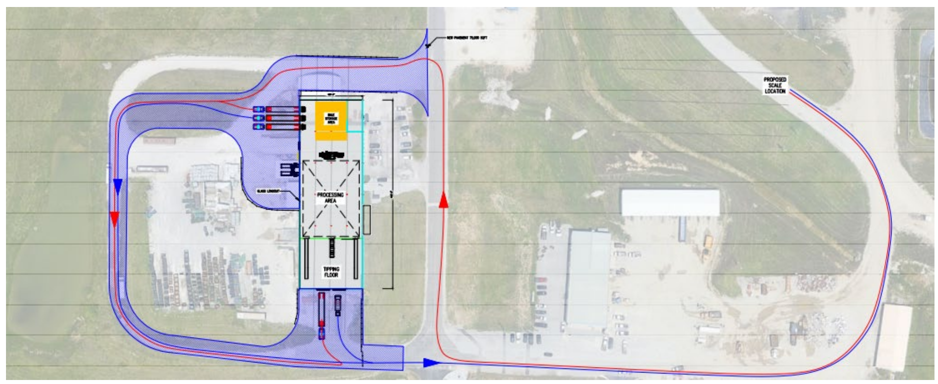

REPORT ON

RECYCLING AND WASTE DIVERSION PROGRAM EVALUATION

FINAL – NOVEMBER 17, 2023

SUBMITTED TO

city of Columbia

Table of Contents

List of Figures

List of Tables

Appendices

Glossary

ASL	Automated Side Loading (Collection truck)
CAAP	Climate Action and Adaptation Plan
CID	Community improvement District
Commingled	Mixed together, not separated into two streams
ECS	Eddy Current Separator
EPS	Expanded Polystyrene
HHW	Household hazardous Waste
ICI	Industrial, Commercial and Institutional
LOC	Landfill Operations Center
Mizzou	University of Missouri
MRF	Materials Recovery Facility
MU	University of Missouri
OCC	Old Corrugated Cardboard
ONP	Old Newspaper
PAYT	Pay-as-you-throw
TPH	Tons per Hour
UMC	University of Missouri Campus

Executive Summary

The City of Columbia provides a comprehensive solid waste system for its residential and industrial, commercial, and institutional (ICI) customers. The City retained RRT Design & Construction (RRT) to conduct a multi-faceted evaluation of the Solid Waste Utility's (SWU's) recycling and waste diversion programs, focusing on both the short-term and long-term success of the Recycling and Waste Diversion program. The process included a robust stakeholder input process that involved interviews with City Council members; a public open house and an Interested Party session; a presentation at a Pre-Council work session; ongoing input meetings with staff in the SWU and related agencies; and, a BeHeard survey.

The scope of the study included the evaluation of residential and commercial recycling collection programs; the Columbia Material Recovery Facility (MRF) and Recycling Center Drop-off facilities, a study of the composition of materials at the MRF along with a study of the composition of waste delivered to the landfill; and, a review of the City's overall waste management system. [1]

The study found that Columbia recycling program has **three urgent issues** that need to be resolved as soon as possible:

1. The suspension of curbside recycling collection;
2. Contaminated loads from the Recycling Drop-off Centers negatively impact program quality while consuming staff time and other resources;
3. Operational issues at the MRF which are inefficient, along with safety concerns.

The first priority should be the curbside collection crisis. The capital investment decisions must have valid data from curbside collection. The program urgently needs to put all available resources towards resuming curbside collection, either biweekly or weekly. Although they are major changes, making resources available comes from temporarily ceasing or reducing operations at the MRF, closing and consolidating Recycling Drop-off Center locations, and re-routing of the recycling routes for greater efficiency. Even if biweekly is the level of service that can be achieved presently, that will be critical for the recycling program to continue.

The other major decision the City needs to make is what level of capital investment is appropriate for Columbia. The two biggest differentiators in the project costs are how much building needs to be constructed and whether the City wants to accommodate future growth in tonnage with larger capacity equipment or staffing additional shifts per day.

The study finds that once Columbia can resolve the issues with collection (both at the curb and at any Recycling Drop-off Center locations) by refocusing its resources, then the City can begin working toward long-term solutions for recycling in a way it values—processed locally, using City assets, with convenient options for residents and businesses to recycle and divert as much as possible. These solutions can be achieved in a timeframe of approximately three years from initiation.

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[1] Because recycling collection is in a state of flux, detailed evaluation of collection operations (such as trucks, routing, and staffing) was not part of the study.

MRF Findings and Recommendations

The evaluation of the MRF confirmed:

- ✓ Almost all the equipment in the MRF is at or near end of useful life.
- ✓ The equipment is not performing as designed and valuable materials are not being recovered.
- ✓ Performance is impacted by the high levels of contamination originating from the Recycling Drop-off Centers.
- ✓ There are safety concerns related to the deterioration of the system.

RRT prepared and analyzed several options for Columbia to replace the end-of-life MRF. Across the options that include designing and building a new MRF, the main difference in the capital costs is related to construction of the building—i.e., there would be little difference in the capital costs of the actual MRF equipment.

- **Option 1: Ceasing MRF operations permanently and implementing transfer to an out-of-town MRF.** This was analyzed mostly for the purpose of comparing it to the capital options—a so-called “do nothing” option. Interestingly, on an annual basis, the estimated transportation costs to transfer the City’s annual recycling tonnage to St. Louis were projected to be roughly the same as the operating costs at the current MRF, making the primary differentiator between all the options the City’s appetite for investment in recyclables processing.
- **Option 2: Retrofit or upgrade the existing MRF.** This option is essentially to design and build a new system in the same footprint. The primary drawback of this option is that even with modern state-of-the-art equipment, there would not be much capacity for growth in the number of recycling tons that the MRF could handle per year. That means that eventually, the MRF would have to add shifts (and operating costs) in order to accommodate growth in generation, and difficulty staffing labor is a long-term trend. Assuming the existing building has some retained value as a structure, this option likely requires the least capital investment. Savings would be somewhat offset by the need to transfer recyclables out of town for a period of one to two years during construction.
- **Option 3: Construct a New MRF on the current site.** This option would salvage or reuse whatever possible of the existing MRF building, design and build a new processing system, and construct additional building(s) as needed. This option requires a greater capital investment, but it could be sized with room for growth, for materials from Columbia and possibly from surrounding communities. This option would require recyclables to be transferred out of town for a period of one to two years, possibly more, during construction.
- **Option 4: Construct a New MRF on another site at the Landfill.** This option would construct an entirely new building on a new location on the Landfill. This option requires the greatest level of capital investment, but it also allows for the greatest flexibility in the design. Assuming the current MRF could continue to operate during construction, there would be no need to transfer recyclables out of town, saving the expense of hauling and procuring processing at another MRF.

It has the additional benefit that when the old MRF is decommissioned, the City now has a building available for other operations.

Importantly, during the course of the study, the City had to suspend its curbside recycling program indefinitely, due to staffing issues. A key piece of information for MRF operational cost models is the quality and quantity of tons requiring processing. At present, the Solid Waste Utility does not have the relevant information available, and the project was unable to gather such data. Until the City can resolve the current collection issues, operational cost models cannot be appropriately evaluated, and any decision about the MRF options will not be fully informed.

Recycling Drop-off Center Findings and Recommendations

A review of the Recycling Drop-off Centers confirmed:

- ✓ Several sites are highly abused by individuals disposing of trash.
- ✓ These materials contaminate the overall recycling stream and consume program resources.
- ✓ Sites can benefit from refreshed and improved signage and critical monitoring on a routine basis.

The following recommendations were developed:

- **Close the worst-performing sites.** It is recommended that the three most-abused sites be closed immediately. These sites are not serving their intended function, and they consume operational resources without contributing to the recycling effort:
    - Downtown (10th and Cherry) – South side of 10th & Cherry Parking Garage;
    - University of Missouri (Bluford Hall) – along Kentucky Blvd; and,
    - University of Missouri (East Campus Plant Growth Facility) – near East Campus Road and Ashland Road.
- **Consolidate, improve, and staff the remaining sites.** A few improvements could result in two of the busiest sites being open during daylight hours and gated and closed as needed. Ideally, with the closure of the most contaminated sites, and consolidation and relocation of others, the City would also be able to staff these sites:
    - Consolidate the two sites that are in very close proximity to each other: S. Providence Rd. and State Farm Parkway, to the S. Providence Rd. location—i.e., close the State Farm Parkway site. With some improvements it could be gated and staffed.
    - Relocate or upgrade the site at Cosmo Park. It could be upgraded with a gate and improvements added at its current location, or it could be relocated across the park to inside the fence at the Yard Waste Drop-off Center, thereby making it both staffed and gated.
- **Monitor and respond.** The two sites at Columbia College along with the Downtown Armory location were observed to be serving their intended function acceptably. It is recommended they continue operating as-is, with the City monitoring them critically to evaluate their operation.

An important part of making these changes will be communicating clearly with residents and businesses why they are necessary. There are likely many individuals who properly use the sites recommended for closure. The purpose of the Recycling Drop-off Centers is to collect processible recyclables, not to provide free disposal of mattresses and other debris. In a situation where there are staffing shortages preventing the collection of recyclables curbside, the prudent course is to identify ways to allocate resources toward the mission.

Curbside Collection of Recyclables Findings and Recommendations

A review of the City's current program confirmed:

- ✓ Some people find biweekly recycling collection insufficient and/or inconvenient.
- ✓ There are many people and businesses in Columbia who actively participate in recycling and waste reduction, and it is a valued service in this city.
- ✓ Columbia prioritizes having local recycling capacity over transfer to the MRFs in St. Louis or Kansas City—i.e., reducing the climate impact of transporting more than 100 miles each way, focusing resources on an asset rather than a service, and having confidence in what happens to the materials.
- ✓ The City has, and continues to, struggle with labor shortages and the chronic inability to adequately staff the collection operations.
- ✓ The recycling collection routes could likely benefit from optimization using dedicated software from a specialized vendor.

The following are recommended to assist the City with restoring curbside collection of recyclables:

- Discontinue collecting glass at the curb and focus on collecting glass in purple bins at Recycling Drop-off Centers.
- Implement a program to co-collect bagged containers and loose fiber in one cart. This would allow Columbia to preserve dual-stream recycling while collecting all materials in one single-body truck.
- Implement collection of recyclables in a cart and collect using Automated Side-Loading (ASL) trucks. This allows each route to be completed by one employee instead of three.
- Procure specialized services to route the trucks using computer software, in order to create the most efficient routes.
- Set a long-term goal of increasing collection frequency to weekly.

Specific recommendations were developed for the ICI sector:

- Installation of equipment to help divert passersby to proper litter bins.

Cardboard is the most-wasted recyclable material delivered to the landfill, according to the waste composition study, and 12% of the material ICI generators send to the landfill is cardboard. If half the cardboard disposed by ICI customers in FY22 had been recycled, it would have been an additional 2,800 tons diverted.

- Specialized recycling bins with restricted openings to encourage proper use.
- Increase recycling of cardboard.

Program-related findings and recommendations

In general, the study found that:

- ✓ The City's diversion program could be boosted by a robust program of outreach and education.
- ✓ The workload for SWU staff does not have available capacity to focus on the types of long-range planning and detailed project management needed to successfully make improvements to the City's Recycling and Diversion Program.
- ✓ There is potential to divert more materials currently being landfilled (mattresses, bulky plastics like buckets and toys, and expanded polystyrene (Styrofoam) if markets can be reached.
- ✓ The City is currently using a weight-based performance metric (recycling rate) from the Climate Action and Adaptation Plan (CAAP) that is not very meaningful and does not reflect recycling efforts.
- ✓ At present, baled commodities produced by the Columbia MRF are put out to bid by the full truckload. Potential bidders (mostly commodity brokers) are registered with the City as vendors, and the highest bid wins, typically to one of four or five repeat bidders. There is no way to sell smaller quantities to local buyers.

Overall recommendations to improve the Recycling and Waste Diversion program include:

- Develop an outreach program with campaigns to promote planned messages, targeted education in classrooms and to community groups, and more.
- Hire a new staff person in the role of a Recycling Coordinator.
- Continue to monitor the potential for markets for other materials (e.g., hard-to-recycle plastics) as this is a rapidly expanding area of innovation in solid waste management, so there could be markets in the future.
- Adopt and work towards new performance metrics including generation, capture and participation rates.
- Create a Community Environmental Center at the Landfill campus, perhaps by re-purposing the current MRF building or constructing a simple structure. The function of this facility would be a one-stop-shop for residents to bring recyclables and other wastes, including household hazardous waste (HHW) to a clean, staffed, easy-to-use location with design features that make it safer and more accessible.
- Post rates for a ton or pound of recycled commodities, similar to landfill disposal rates, which would be tied to prevailing market rates, plus either a fixed amount or a percentage for the handling fee, and adjusted on a quarterly basis, so that smaller buyers can purchase commodities.

Next Steps

Figure ES-1 provides a roadmap for implementing the recommendations in this report.

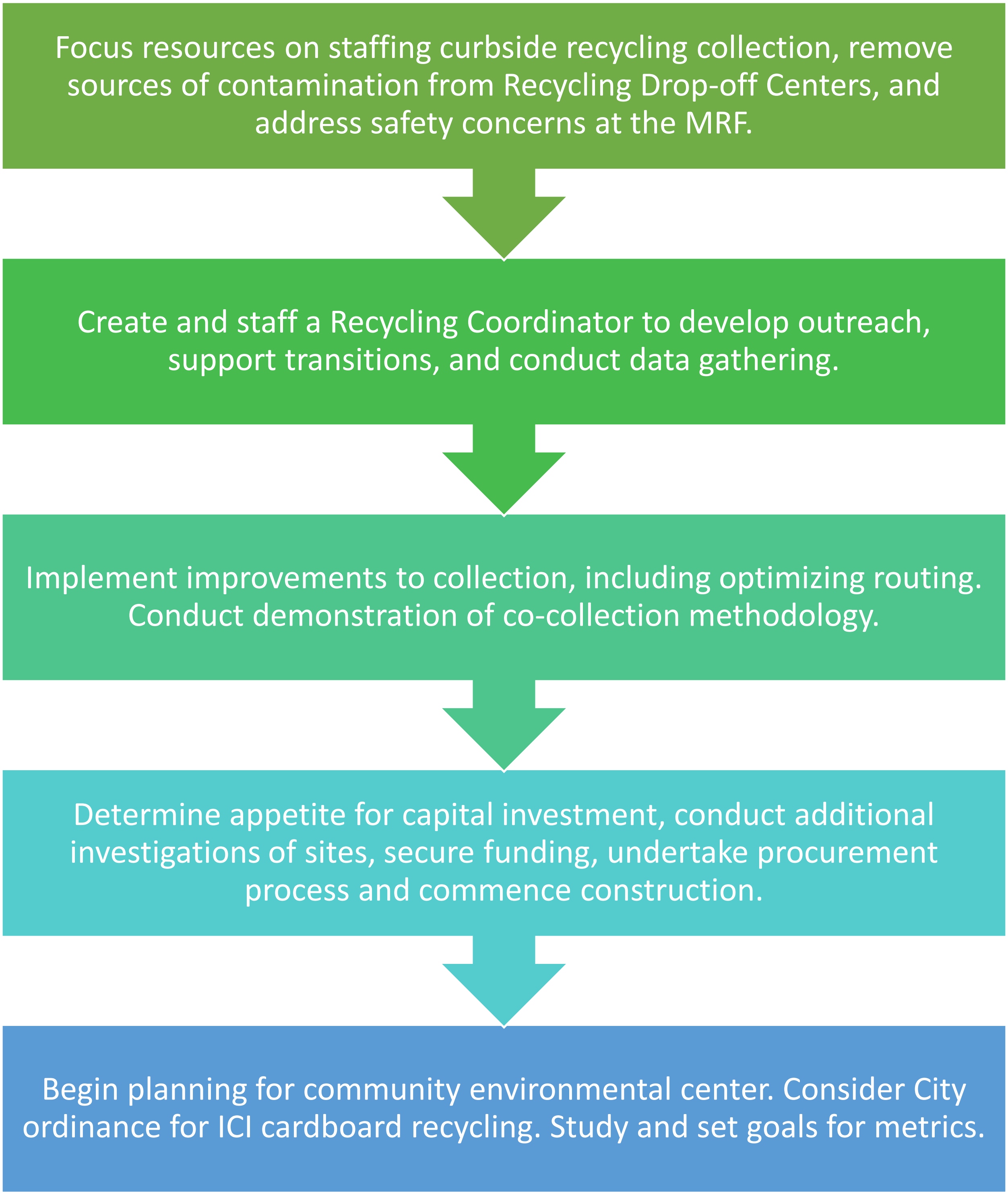


Figure ES-1: Roadmap for Recommendations

Figure ES-2 provides more detailed potential timeline for implementing the recommendations. Within each grouping, many of the activities would be ongoing simultaneously, not sequentially.

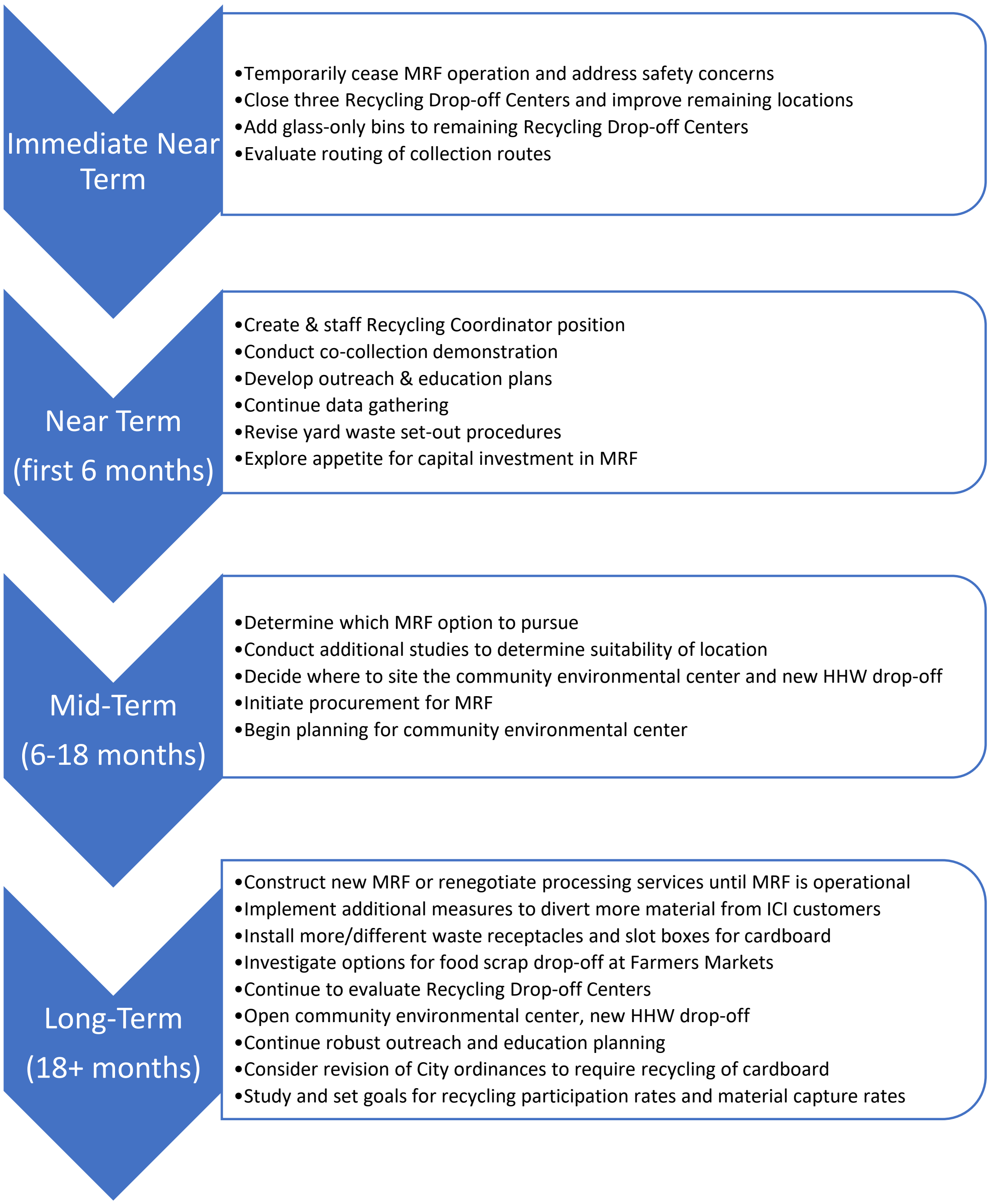
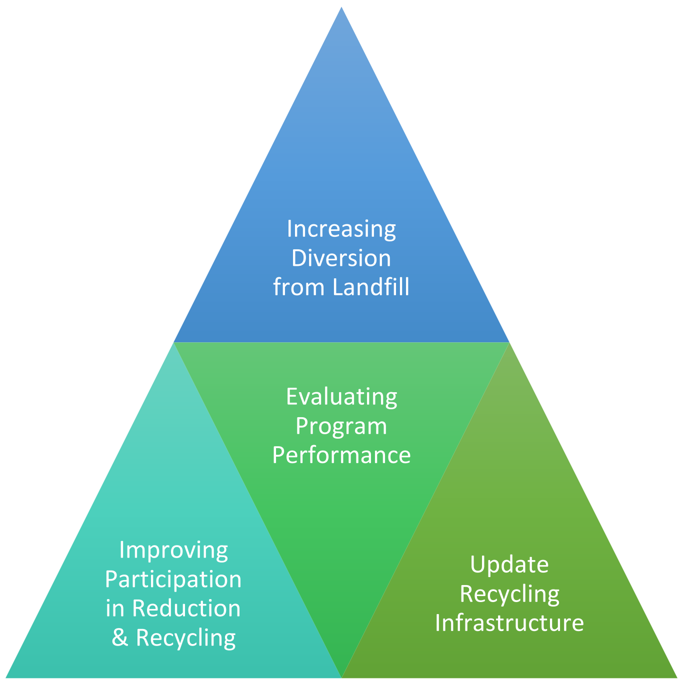


Figure ES-2: Timeline of Recommendations

1 Introduction

The City of Columbia has undertaken a comprehensive evaluation of its recycling and waste diversion programs to assist the City in meeting its goals established in the Climate Action and Adaptation Plan, increase recycling, improve collection operations, make improvements to the existing MRF, optimize, and enhance the sustainability, cost effectiveness and life of the landfill and the recycling and waste diversion program. The evaluation has considered the current condition and operation of the MRF, the quantity and quality of recycling, and waste composition. Specifically, the study examined options for the following:



This report presents the results of the evaluation of the recycling and waste diversion programs and the recommendations developed to increase diversion from landfill and improve participation in recycling. Options for updating the recycling infrastructure are discussed in detail. Recommendations for new metrics for evaluating climate action and recycling performance are described, and the potential impact on diversion of the recommendations is demonstrated.

2 Background

The City of Columbia has been providing waste diversion programs since 1986 through the Solid Waste Utility. The programs expanded in size and frequency over the years with the addition of Recycling Drop-off Centers in 1989 and construction of a MRF in 2002 to accommodate the recyclable materials requiring processing. Over the years, the City has continued with its Blue Bag recycling program but recently, the City has been unable to provide a consistent level of collection services to customers, particularly for recycling due to labor shortages. At times, recycling collection was suspended.[2] The City has been investigating options to continue to provide improved service to residents including through the use of

[2] At the time of writing this report (August 2023), recycling had been suspended in May 2023, indefinitely.

automated collection which requires less labor. In March 2023, Columbia City Council approved ordinance amendments that will allow the use of roll carts for automated trash collection. This ordinance is scheduled to go into effect in March 2024. Customers will have the choice of three cart sizes, with a corresponding fee for each size.

The following sections provide a brief description of the programs and services provided to manage waste generated by the residential and commercial sectors, as well as the facilities used to manage waste.

2.1 Current Programs and Waste Management Facilities

The City provides waste management services to approximately 51,000 accounts, which includes approximately 36,000 single family homes. The following provides a brief overview of the services provided:

- The City provides waste collection services to single and multi-family homes. Single family homes are provided with curbside service whereas multi-family homes are provided with trash and recycling bins collected at a designated location.
- The City's trash collection program will be transitioning from weekly collection of trash placed out in a trash bag[3] (no limits on the number of bags, with a weight limit of 50 pounds), to a pay-as-you-throw (PAYT) system for trash in March 2024. Residents will be able to choose, and pay for, the size of a roll cart that meets their needs.
- The City operates a dual stream recycling program. Currently, residents place mixed containers (rigid plastics, #1-7, aluminum and metal cans, glass bottles and jars) in City-issued blue recycling bags. Mixed fibers (cardboard, office paper and envelopes, newspaper, magazines and catalogs, boxboard, and chipboard) may be placed in a box or paper bag.
- Customers pay a monthly utility fee for collection, depending on the type of residence and service received.
- Yard waste can be placed into a plastic refuse bag for collection on a regular collection day. It is co-collected with trash. Residents can also take loose yard waste to one of two drop-off centers or to the landfill for free, where it is mulched and used for various purposes.
- Large items are collected from residential customers receiving curbside collection. Pickup of items must be arranged in advance and a fee is charged. One large item per residence will be collected annually at no cost, with the remainder of items being charged as follows: first item $21.50, each additional item $5.00. Similarly, appliances will be collected at a fee of $29 per appliance with refrigerants and $21.50 per appliance which does not have refrigerant. (2023 fees)
- The City provides trash and recycling collection from small and large commercial customers ranging from collection of single bags to 40 cubic yard compactors. Recycling may be collected in carts or dumpsters. Fees depend on the frequency of collection, type and size of container, and material collected.

The City utilizes the following solid waste management facilities to manage waste:

- Nine Recycling Drop-off Centers for recycling

[3] Originally the City required the use of City-provided refuse bags as an initial pay-as-you-throw program. This requirement was eliminated in December 2022.

- Two-yard waste drop-off centers for grass clippings, leaves, brush, and small tree limbs.
- A composting site near the bioreactor Landfill for food waste and yard waste.
    - Yard waste is also accepted at this site at no charge.
- A bioreactor landfill which converts methane gas to electricity at the on-site Bioenergy Plant, which generates enough electricity to power about 1,500 homes.
    - Landfill rates (2023) are $55 per ton, with a $25 minimum charge.
- A dual stream Materials Recovery Facility (MRF).

2.1.1 City of Columbia MRF

The City of Columbia owns and operates a 26,000 square-foot dual stream MRF located on the Landfill facility complex at 5700 Peabody Road. The MRF received and processed approximately 13,000 tons of recyclables in 2022. The MRF is configured as two parallel sorting lines, one each for fiber and for commingled containers. Almost all of the material processed at the MRF is hand-sorted, supplemented with some equipment including a magnet, an Eddy Current Separator (ECS), and two fiber screens. A two-ram baler bales all recovered commodities. The baler feed system is configured so it may be loaded from either processing line or straight from the tipping floor.[4]

What is a Bioreactor Landfill?
In most landfills, waste is compacted and covered, taking decades to passively decompose in a nearly anaerobic environment. In a bioreactor landfill, liquid is actively added to the waste, causing it to break down faster and increasing the rate of landfill gas generation. The gas is collected, cleaned, and converted to electricity on an industrial scale. This renewable energy source not only displaces the combustion of fossil fuels, but it also extends the life of the landfill, as the decomposing material reduces in volume over time.

Commingled Container Stream Process

When containers are brought to the MRF, they are emptied on the west side of the tipping floor by the container sort line in-feed conveyor. A skid-steer loader is used to push the bagged commingled containers onto the container in-feed conveyor. Workers adjacent to the conveyor belt tear open bags by hand and empty the contents onto the conveyor belt. The blue bags and trash are placed into a bunker adjacent to the conveyor belt.

Once the material is on the belt, it is positively sorted by hand into three bunkers: #1 PET, #2 HDPE, and commingled #3-#7. After the plastic containers are removed, there is a magnet to remove ferrous containers and an eddy current separator to capture aluminum cans. The negative sort material remaining on the belt is glass, which is stored in a bunker outside of the building.

Commingled Fiber Stream Process

When fiber is brought to the MRF, it is emptied on the east side of the tipping floor by the fiber sort line in-feed conveyor. Workers adjacent to the in-feed conveyor belt remove any large pieces of Old Corrugated Cardboard (OCC) or trash on the conveyor belt. The fiber is passed over a star screener where containers and other non-fiber materials fall through. The fiber is then positively sorted by hand sorted into four

[4] Large commercial loads which are nearly or totally cardboard are often directed straight to the baler instead of going through the MRF.

bunkers: OCC, mixed paper, office paper, and trash. The negative sort material remaining on the belt is Old Newspaper (ONP), which passes over a screen to remove any final contamination and then into a bunker.

Disposal of Residue and Marketing of Commodities

To dispose of material not baled for sale—including trash, the empty blue bags, and the material the MRF processing equipment leaves as residue—an operator uses a skid-steer to move the material from its bunker to the tipping floor, and uses a loader to put it into a roll-off container or a trailer, and then transports it across the campus to the working face of the landfill. No interfund or interagency tipping fees are charged. The City does have to pay to the state of Missouri a mandatory fee of $2.11 [5] per ton for those loads, and also incurs the operational costs to landfill the material, about $25 per ton. [6]

Baled commodities are sold to the market in several different ways, but they are all "bid out" by the City procurement office. The cardboard and the mixed paper grades are sold via a 5-year contract to Midland Davis corporation, a large commodity broker in Illinois which won the contract by bidding the highest/best price in an open procurement. The other commodities are put out to bid by the truckload. Potential bidders register with the City as vendors, and when a load is close to full, procurement lists a request for bids to buy it. The highest bid wins. Most of the bidders are brokers, although occasionally other MRFs will bid and win. Most of the sales are to one of four or five frequent bidders.

2.1.2 Recycling Drop-off Centers

The City operates nine Recycling Drop-off Centers located throughout the City. The locations are not staffed with attendants and use different configurations of roll-off containers (some are covered, some are not). With the indefinite suspension of curbside recycling collection, the role of the Recycling Drop-off Centers is more critical than it has been in many years. Unfortunately, some of the centers are particularly susceptible to illegal dumping and abuse. In May 2023, at which time curbside collection had been temporarily suspended, RRT made the following observations at the Recycling Drop-off Centers.

Columbia College (Wightman Bldg.) – South End of Pannell Street

The site is in a permit parking lot on the Columbia College campus. The receptacles consist of a compactor for fiber and a gable-top roll-off for containers. Contamination was relatively limited, which may be a function of the location being somewhat restricted. The posted instructions for use were not within line of sight when approaching and using the receptacles. The recycling guidelines are partially concealed behind the roll-off container.

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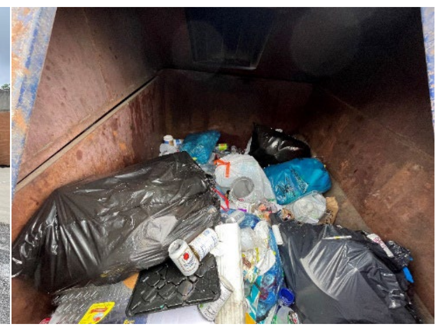
[5] https://dnr.mo.gov/waste-recycling/business-industry/permits-licenses-registrations-fees/fees/solid-waste-tonnage-fees-allocations

[6] The FY23 Solid Waste budget had $4,741,614 in the Landfill cost center; dividing this value by 184,776 tons disposed in FY22 yields an approximate disposal cost of $25.66 per ton.

Columbia College (Dulany Hall) – Near 8th Street and Hickman Avenue

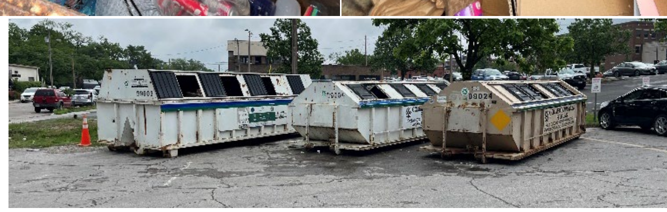
Users may perceive this location as being less accessible due to its location next to a loading dock. Contamination was relatively limited, which may be a function of the location being somewhat restricted. The posted instructions for use were not within line of sight when approaching and using the receptacles.

Downtown (The Armory) – Along Park Ave, between 7th and 8th Street

RRT observed this location to be busy with users. The receptacles are gable-top roll-offs for both streams. The site and the receptacles are out in the open. The receptacles were observed to be more contaminated than other sites, with bagged trash in both the container and fiber roll-offs, somewhat more so with the commingled containers. The recycling guidelines are posted directly on the roll-offs.

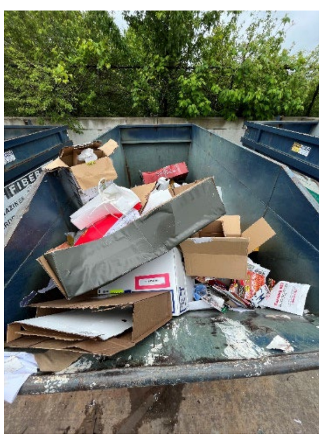


South Providence – 3601 S Providence Road, on the Outer Road

This site is a notably larger location. The containers are open top 8- to 12-cubic yard "dumpsters" with no closures. The site was observed to be clean and had minimal contamination in containers and fiber dumpsters, despite the wide-open access for users and being heavily screened from the street. This could have to do with the location being in a busy commercial and shopping area.

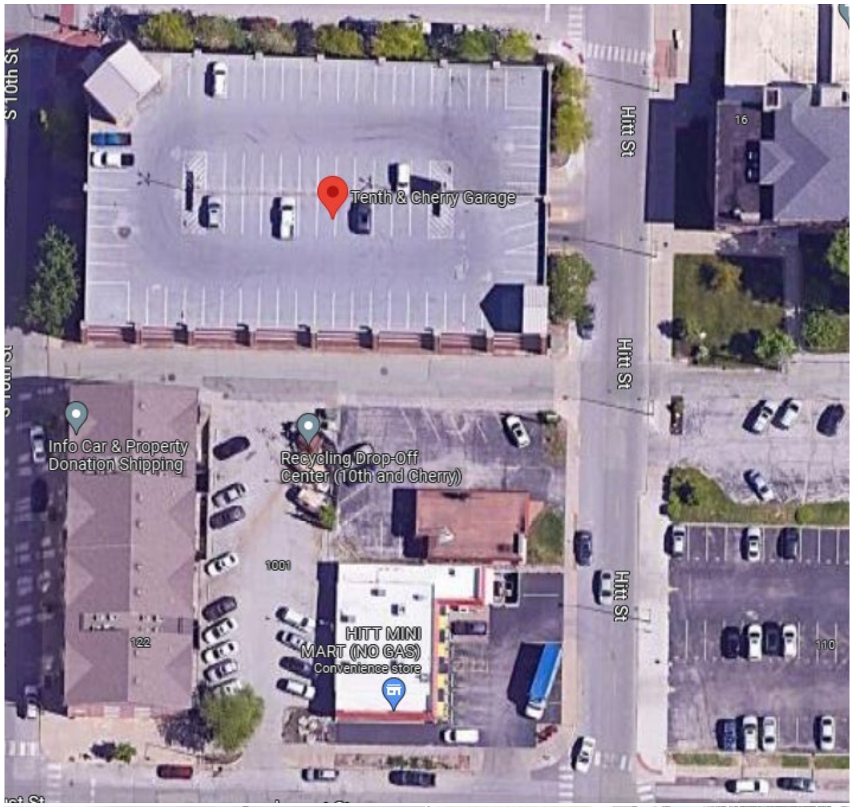

State Farm Parkway – Near Grindstone, North of E. Nifong Blvd

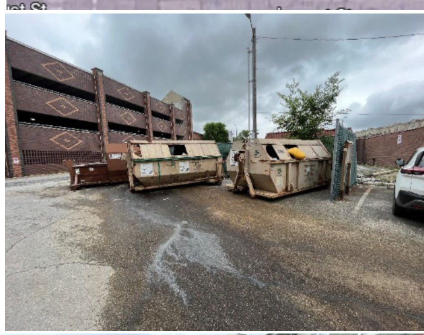
This site is another notably larger location. The containers are open top 8- to 12-cubic yard "dumpsters," most without closures. This is the only drop-off center with a dedicated receptacle for glass. A City employee who happened to be on site noted this is the busiest location. The site was observed to be clean and had minimal contamination in containers and fiber dumpsters, despite the wide-open access for users, the somewhat secluded location, and being heavily screened from the street. There was minor contamination in the dumpsters from bagged trash, although much of the cardboard had Styrofoam inside of it and one of the fiber dumpsters had carpets placed inside of it.



Downtown (10th and Cherry) – South Side of 10th & Cherry Parking Garage

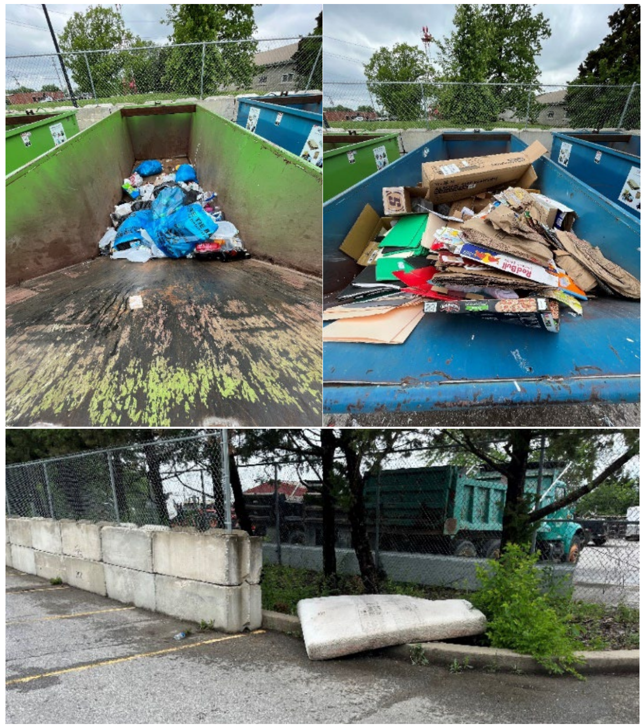
The receptacles consist of a compactor for fiber and a gable-top roll-off for containers. Despite being in the middle of Downtown, the sightlines make it somewhat secluded because it is surrounded by an enclosure and faces a parking garage, the back sides of commercial buildings, and a small apartment building. This encourages improper dumping; the apartments may also be a source of contamination. RRT found this was the most contaminated site observed, with many dumped items forced into the openings of the roll-offs.





Parks Management Center – at Cosmo Park off Business Loop 70 W

The containers are open top 8- to 12-cubic yard “dumpsters” with no closures. The site was observed to be clean and had minimal contamination in the containers and fiber dumpsters. This could have to do with the location being only somewhat screened and co-located with other City functions. Also, it may have been recently serviced when the observations were made because the containers were not very full. There was a mattress dumped on the ground.



University of Missouri (Bluford Hall) – Along Kentucky Boulevard

The site is in a permit parking lot on the Mizzou campus. The receptacles consist of gable-top roll-offs for both streams. Contamination was uneven, with little contamination in the fiber receptacles but a high incidence of bagged trash, bulky plastics, and more in the commingled containers.

University of Missouri (East Campus Plant Growth Facility) – Near East Campus Road and Ashland Road

The site is adjacent to a residence hall on the Mizzou campus. The receptacles consist of gable-top roll-offs for both streams. The site had apparently been serviced relatively recently, but contamination in receptacles was already observed, including blankets, pillows, bulky plastic home goods, foam, crockery, film plastics, and cardboard in the wrong bin.

2.2 Tonnages Managed

The City collects trash from single family homes, duplexes, and multi-family buildings containing a maximum of four units as well, as some ICI generators, which is managed at its landfill. The City also provides collection services to some participating larger multi-family buildings, the downtown community improvement district, the University of Missouri (MU) and the commercial sector. Additional trash is collected by the private sector, from the multi-family and ICI sectors which is also managed at the City's landfill.

Table 1 presents the tonnages of trash managed by the City and the private sector at the City's landfill from 2013 to 2022.

Table 1: Incoming Tons of Trash to Landfill (2013-2022)

	City-Collected Trash to Landfill							
Year	**Residential**	**Commercial**	**Roll-off**	**MU**	**Landfill**	**Total City Collected**	**Private Haul to Landfill**	**Total tons to Landfill**
2013	30,435	35,128	20,379	5,699	74,194	91,642	74,194	165,836
2014	29,393	20,379	18,673	6,060	73,964	74,504	73,964	148,468
2015	33,290	33,020	19,514	6,120	81,129	91,944	81,129	173,073
2016	34,383	31,948	19,552	6,561	81,408	92,445	81,408	173,853
2017	35,200	31,497	22,184	6,429	117,057	95,312	17,057	212,369
2018	33,763	31,217	21,289	6,360	133,405	92,629	133,405	226,034
2019	29,257	32,074	24,148	6,515	81,202	91,993	81,202	173,196
2020	31,979	28,763	21,439	5,019	85,104	87,200	85,104	172,303
2021	25,002	30,558	24,172	5,932	104,559	85,665	104,559	190,224
2022	24,477	31,666	22,404	5,796	100,433	84,344	100,433	184,776

Source: City of Columbia Sanitary Landfill Solid Waste Tonnage Fee Report

Table 2 presents the incoming tons of recycling to the City's MRF, collected at the curb and from the recycling drop-off centers, as well as the outgoing (marketed) tons of recycling. Recently the contamination rate, based on this data, is approximately 38% which was confirmed during the MRF evaluation (see Section 3) which showed a contamination rate of approximately 36%. Table 2 also shows the incoming tons from the recycling drop-off centers, and the percentage of the incoming tons of recycling this source represents. The percentage of incoming tons is very close to the contamination rate, which confirms that the recycling drop-off material is very heavily contaminated. This was confirmed visually and supports the recommendation to close the two sites on the Mizzou campus and the site at 10th & Cherry, Downtown (See Section 2.1.2 for descriptions and pictures of the recycling drop-off centers and Section 8.1 for discussion of closing contaminated sites).

Table 2: Incoming and Outgoing Tons of Recycling (FY20-FY22)

	Incoming Tons of Recycling	Outgoing Tons of Recycling	Contamination Rate	Recycling Drop-off Center Tons	% of Incoming Tons
FY20	12,084	8,441	30%	3,401	28%
FY21	13,176	8,156	38%	4,897	37%
FY22	13,070	8,156	38%	3,435	26%

Source: Recycling Material Sold and Recycling Delivery Reporting Grid Summary Report (provided by the City of Columbia)

2.3 Climate Action and Adaptation Plan

In 2019, Columbia City Council approved and adopted the Climate Action and Adaptation Plan (CAAP) which outlines goals for reducing community and municipal greenhouse gas emissions. The CAAP includes strategies for implementation related to energy, housing, building and development, transportation, health, safety and well-being, natural resources, and waste.

2.3.1 Solid Waste Strategies for Climate Action and Adaptation

The following table presents the waste-related strategies and how they were considered in this project.

Table 3: CAAP Waste Strategies

Strategy	How Considered in the Recycling and Waste Diversion Evaluation
W-1 – Reduce waste generation	
Strategy W-1.1: Encourage Reuse	Recommendation for Promotion and Education campaigns to encourage reuse and waste reduction.
W-2 – Increase waste diversion	
Strategy W-2.1: Reduce landfill waste through customer education, rate structures and increasing City recycling programs	Recommendation for Promotion and Education campaigns to encourage reuse and waste reduction. Recommendation for new MRF capacity to allow City to accept more material from more customers.
Strategy W-2.2: Expand composting participation and operation	Organics are converted to biofuel at City landfill, so a curbside program was not considered at this time. Would be difficult for City to resource such a program currently.
Strategy W-2.3: Divert construction and demolition waste	Not considered in the Recycling and Waste Diversion Evaluation. Could be a future initiative.

Strategy W-2.4: Require and incentivize recycling	Recommendation for new MRF. Once MRF has more capacity, City can consider recycling ordinances.
W-3 – Improve waste system management	
Strategy W-3.1: Encourage proper disposal of products containing high Global Warming Potential (GWP) gases	Development of a community environmental center could facilitate more/better recycling of appliances with GWP gases, along with other potentially polluting materials like household hazardous waste.
Strategy W-3.2: Upgrade solid waste facilities	Recommendations for a new MRF and community environmental center.
Strategy W-3.3: Track waste diversion	A waste composition study was undertaken. Recommend repeating every five years, or prior to major changes to the system. Recommendations for new performance indicators.

As the CAAP narrative notes and the waste strategies highlight, one of the most important things the City and its Solid Waste Utility can do to have positive climate action is empower individuals and businesses in reducing the amount of material deposited in the landfill, especially those which can return to the economy as commodities or otherwise useful materials as opposed to being lost to disposal forever. Reducing waste in the first place has positive impacts "up" the supply chain by reducing use of virgin materials, energy needs to produce products, and the overall demand for new products. It also has positive impacts "downstream," by returning commodities to the production cycle, fueling opportunities for innovation in the manufacturing sector, diverting non-putrescible materials from Columbia's bioreactor. In the case of reuse of durable items, waste reduction provides opportunities for others to reduce their environmental impact by procuring pre-owned items.

Strategy W-2.2 calls for expanding composting participation and operations. As discussed in greater detail in Section 4.1.4, this program evaluation did not examine creation of a wide-ranging program for organics diversion, largely due to two factors: the transportation and labor requirements to collect food waste, and the infrastructure needs to process the material. Nevertheless, there is value beyond tons in engaging people to reduce food waste in the first place, and Section 4.1.4 discusses that as part of "Other Options" for optimizing current programs.

2.3.2 Key Performance Indicators for Solid Waste Strategies

The CAAP also has key performance indicators (KPIs) associated with waste, by means of a city recycling rate calculated by a simple ratio of the tons of material recycled to all material generated. As shown in the equation in Figure 3, this is commonly referred to as a tons-over-tons recycling rate.

$$\frac{Tons\ recycled}{(Tons\ recycled + Tons\ disposed)}\% = Recycling\ Rate$$

Figure 3: Traditional "Tons-Over-Tons" Recycling Rate Calculation Method

The 2021 CAAP Annual Report showed a table listing City recycling rates as baseline, actual (2020), and goals for the future (see Figure 4).

G = Meets or exceeds target value Y = Within 20% of target value R = 20% or more from target value

Status	Sector	Key Performance Indicator	2015 Baseline	2020 Actual	2020 Target	2035 Target	2050 Target
R	Waste	City Recycling Rate (tons of recycling/tons of waste)	14%	7.5%	14%	15%	28%

Figure 4: Waste Sector KPIs, Excerpted from CAAP 2021 Annual Report

Unfortunately, weight-based performance indicators can be difficult to achieve due to several factors outside the City's control. For example, for decades many items that are part of recycling programs—plastic bottles, newspapers, aluminum beverage cans—have been subject to a process called *lightweighting.* Producers have used innovation and design to make each individual item weigh less than previously, in an effort to reduce both packaging and transportation costs. Pointedly, the shortcomings of a tons-over-tons recycling rate are highlighted by the 2021 report, when the calculated 2020 rate fell precipitously, likely due to the emergency suspension of curbside collection of recyclables in response to the COVID-19 pandemic.[7] It is anticipated that the 2023 rate will be very low due to the ongoing suspension of recycling collection which commenced in May 2023 for an indefinite amount of time.

In an effort to make evaluation metrics more meaningful, many municipalities have moved away from simple weight-based metrics and instead focus on indicators such as disposal and generation rates. Different options for performance indicators are discussed further in Section 6.

3 Data Collection

In order to collect data and information on the City's programs, services and infrastructure, a number of studies were conducted over the course of this project. This included an evaluation of the MRF and contamination rates at the MRF, a waste composition study, and a curbside collection study. Additionally, stakeholder engagement was conducted to gather feedback about current and future program changes. The following sections provide more information about the studies. Full reports can be found in the relevant appendices.

3.1 MRF Evaluation

In February 2023, RRT performed an evaluation of the Columbia dual stream MRF. The following is a summary of the evaluation and the findings. For the complete report, including details on the work performed and the results, please see Appendix A.

The processing equipment was installed twenty-one years ago in 2002 and there have been limited equipment retrofits since the initial construction. As part of this study, RRT completed the following tasks:

[7] Collection was first delayed due to staffing issues in April 2020, and within a few weeks service was suspended due to COVID-related health issues among the staff; service issues continued through the summer due to staffing shortages.

- A comprehensive site assessment of the current condition of the MRF;
- Determination of the current physical, reliability and operating condition as well as the maintenance and repair status of the existing equipment;
- Estimation of the remaining useful life of the MRF (assuming the historic record of maintenance continues); and,
- Description and potential benefits for repairs, replacements or upgrades that can be completed in the near term that can assure the recycling facility will operate reliably, both in terms of up-time and of accuracy.

The scope of the inspection included evaluating the condition of all equipment onsite as well as the building and site, as much as they could be visually observed. A review of safety and maintenance programs and facility operation was also completed. The review consisted of on-site observations and review of technical information as provided.

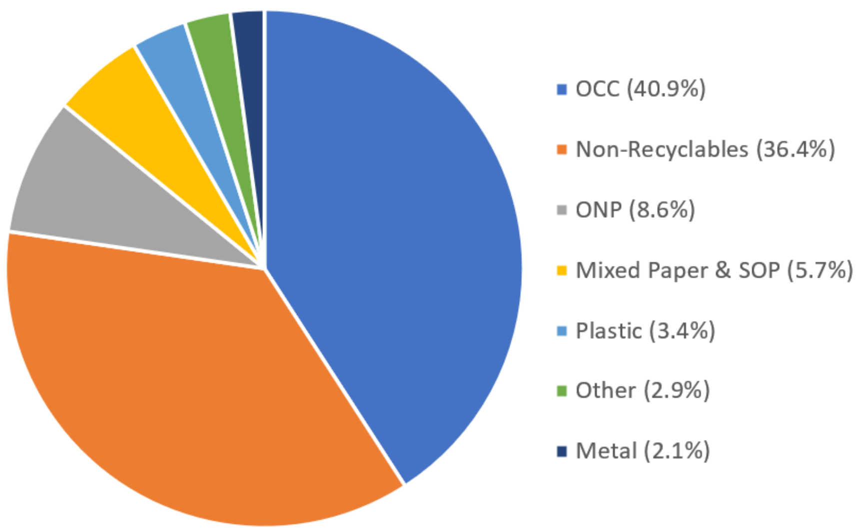


Figure 5: Outbound Composition FY20 – FY22

Figure 5 shows the quantities of outbound material for the last three fiscal years (FY20, FY21 & FY22). Notably, over 36% of the material received is being sent to the landfill as non-recyclables (observations showed that this includes both not-accepted materials and accepted materials which the MRF failed to capture). The remainder of the materials are being shipped to markets.

This level of contamination is higher than what would be expected at a dual stream MRF. It is unclear whether the non-recyclables sent to landfill truly consist of trash/contamination, or whether this stream contains a considerable amount of recyclables are not being successfully recovered by the MRF processing system and are being sent to the landfill as if they were trash.

During the inspection, the inbound material piles on this tipping floor were observed. The material seemed clean and did not appear to contain 36% contamination. This material may have been collected from the curbside program and did not include any material from the Recycling Drop-off Centers which is typically more contaminated. If the material was representative of a mixture of both sources, it could indicate that the equipment is not functioning optimally. A MRF with a low recovery rate loses revenue from material sales and incurs higher costs for disposal.

Based on this inspection's comprehensive review of processing equipment condition, the building, and site condition, the findings of the evaluation are:

- The MRF is determined to be in poor/fair condition.
- Excluding the baler, the MRF has a remaining useful life of less than five years. The expected useful life of the baler is ten years, assuming all proper preventative maintenance tasks are completed.
- Generally, damage observed was not indicative of ineffective maintenance nor improper operation.
- This MRF will require a capital improvement within the next five years to reliably process the City's recyclable materials, based on the current generation rates.
- The MRF is at or exceeding its operational capacity. If the quantity of materials received were to increase due to improved resident participation, population growth, etc., the MRF may not be able to keep up.
- If the recovery rate from the existing inbound material is improved or increases, resulting in more commodities, downstream systems such as bale storage and loadout may not be able to keep up.
- Operations at the MRF need to be reviewed through the lens of safety and adjusted accordingly.

In summary, the Columbia MRF needs immediate attention to the above findings if it is going to continue for any significant period of time as the City's destination for processing source separated recyclables. To see options for the MRF to carry on operations until a replacement can be identified or implemented, please see Section 7.

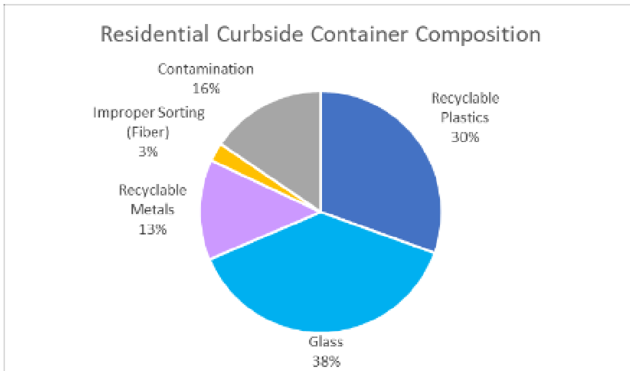
3.2 MRF Contamination Study

The purpose of this study was to evaluate the quality and composition of the recyclables delivered to the MRF, to evaluate the effectiveness of equipment in sorting material and to identify the composition of sorted materials at the MRF. It was designed to confirm the findings of the MRF evaluation described above.

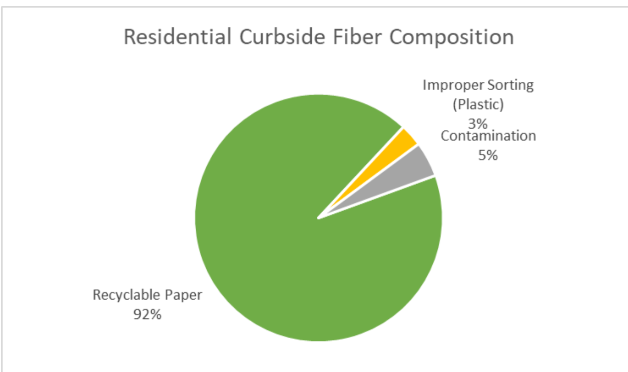
In February and March 2023, a recycling composition analysis was conducted of the current system at the City of Columbia's MRF. Due to the nature of the current system (i.e., manual sorting), most of the bales produced are of very good quality; however, the capture rate of the recyclables is low.

During the study, eight different recycling streams were audited to determine contamination rates present in the material sorted at the MRF. The analyzed streams include #2 HDPE, #3-#7 Mixed Plastics, Fiber Residual Material, Container Residual Material, Fiber Screen Residual Material (2), Curbside Containers, and Curbside Fiber. The recyclable materials in the waste streams were sampled and sorted into their corresponding categories. Both the container and fiber waste streams were separated into eighteen (18) unique material classifications. Additionally, the recyclable material from the drop-off centers was visually inspected for contamination. Figure 7 and Figure 7 present some highlights of the contamination study.

Components are categorized as either "Recyclable," "Outthrows," or "Non-Recyclable Material." For a material to be classified as "Outthrow," it must be a material that is in Columbia's recycling and trash guidelines but was sorted into the incorrect bunker. Any material that is not included in Columbia's recycling and trash guidelines or is explicitly prohibited is classified as "Contamination." For the residential container composition, some material has been identified as having been improperly sorted (i.e., in the wrong stream).

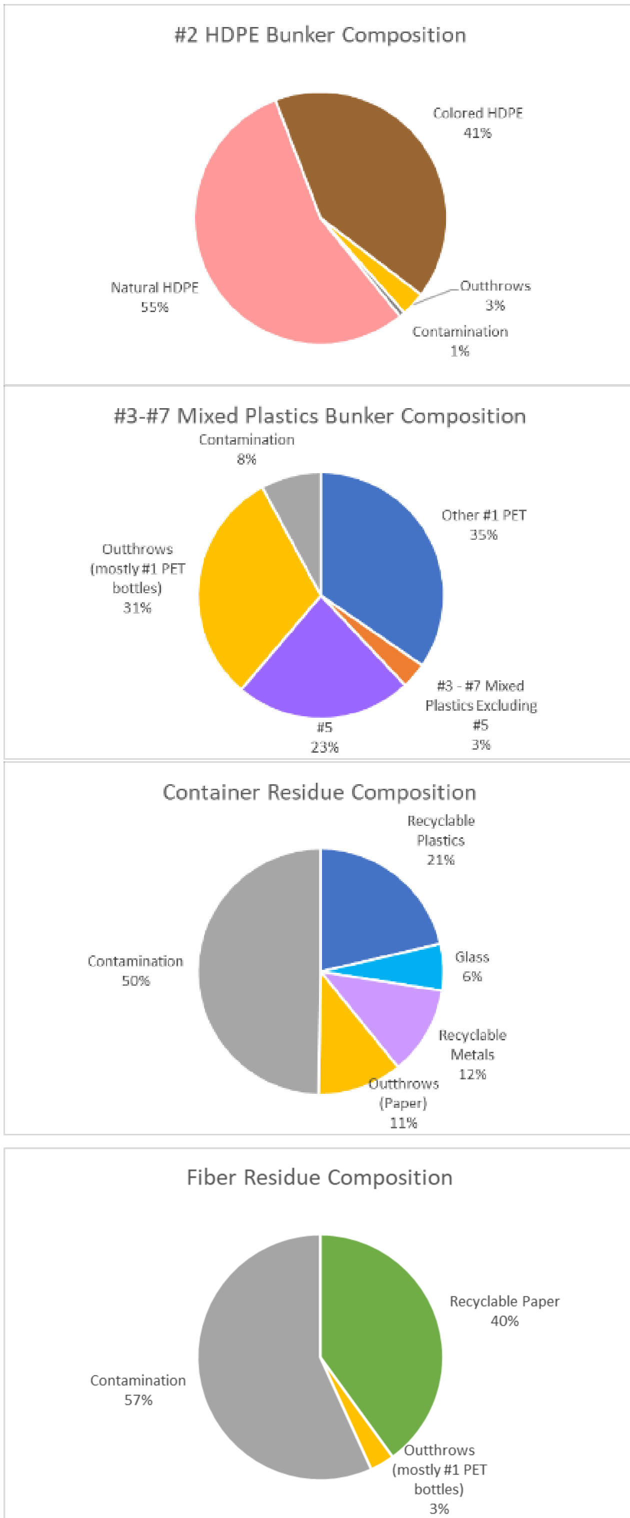


- The contamination rate (15.5%) in the residential curbside container samples is on-track with the national average contamination rate (16.9%).
- The predominant material incoming in the residential curbside containers is glass. Glass accounts for approximately half of the total recyclable fraction by weight. Due to the density of the glass, it constitutes a larger proportion of the waste stream when compared to plastics and metals.



- The contamination levels in the residential curbside fiber samples are remarkably low (but a more robust analysis is needed to confirm).
- Enforcement at the curb helps to reduce contamination.

Figure 6: Composition of Curbside Recyclables—Commingled Containers and Fiber



- Very clean commodity.
- Contamination <1%.
- More natural HDPE than colored HDPE.

- Includes other #1 PET which is considered recyclable but cannot be marketed with other PET at current vendor request.
- Other #1 PET and #5 comprise the majority of recyclable material and are more valuable than the price currently received for the mixed plastic.

- Approximately 40% of the container residue consisted of recyclable materials, with plastic comprising the majority.
- Some materials may be ending up as residue due to equipment not performing optimally.

- Approximately 40% of the fiber residue consisted of recyclable materials, with mixed paper comprising the majority.
- There were fewer outthrows, but more contamination in the fibers compared to containers.
- Contamination mostly consisted of remainder/composite paper, predominantly envelopes with plastic windows, but also napkins, waxed cardboard, and paper plates.

Figure 7: Summary of Recycling Composition by Type

With respect to sorting practices at the MRF:

- Outthrows were highest at the #3-#7 mixed plastic bunker, approximately 30%, predominantly consisting of #1 bottles (with a screw-off top). Any #1 bottles that are not captured in the #1 bottles bunker are placed into the #3 - #7 mixed plastics bunker.
- In the residue bunkers, outthrows in the container residue bunker were approximately 11%, consisting mainly of paper. The City should consider a targeted campaign to reduce paper in the containers stream as it is difficult for collection staff to see contamination in blue bags. Outthrows in the fiber residue bunker were only 3%, perhaps reflecting additional enforcement at the curb.
- In the containers residue bunker, approximately 39% consisted of recyclable materials and in the fiber residue bunker, approximately 40% consisted of recyclable fiber. This may be due to equipment that is not performing optimally due to wear and/or age.
- Both residue bunkers consisted of over 50% contamination, which may be due to residents dumping trash at the Recycling Drop-off Centers.

With respect to incoming material from the residential curbside program:

- In the containers stream, 82% consisted of recyclable containers, 3% consisted of fibers placed in the wrong container and 16% consisted of contamination (non-accepted materials and trash).
- The fibers stream was cleaner with 95% recyclable fiber, only 0.3% consisting of plastics (incorrectly placed in the fibers containers) and 4.7% contamination (non-accepted materials and trash).

As noted elsewhere in this document, much of the material originating from the Recycling Drop-off Centers is heavily contaminated which contributes to the large quantities of non-recyclable material managed at the MRF. It is likely that material from the commercial sector is cleaner and contains more materials like cardboard.

Further details on this study can be found in Appendix B.

3.3 Waste Composition Study

A waste composition study was undertaken in May 2023 to evaluate what proportion of the material delivered to the landfill could have been recycled or otherwise diverted from the landfill. A stratified, weighted sampling plan was used to improve the confidence and reliability of the statistically valid data.

Samples of waste were taken from single family residential (includes some multi-family), industrial, commercial, and institutional (ICI), community improvement district (CID), University of Missouri Campus (UMC) and multi-family. Samples were sorted into 46 material categories. Materials were categorized by their "recyclability" as follows,

- Targeted curbside recyclables currently accepted in the City's current program;
- Materials that are recyclable or managed at City facilities such as yard waste or household hazardous waste (HHW);
- Materials that are recyclable at private facilities (e.g., private or non-profit that accept film plastic, electronic items, tires, etc.);

- Recyclable, but no regional markets exist such as bulky plastics, carpet/padding, mattresses/box springs, Styrofoam; and,
- Not currently recoverable, for materials for which there are no known commercial scale recycling programs or other ways to divert material from landfill.

The following Figure 8 presents the overall composition of City-managed waste.

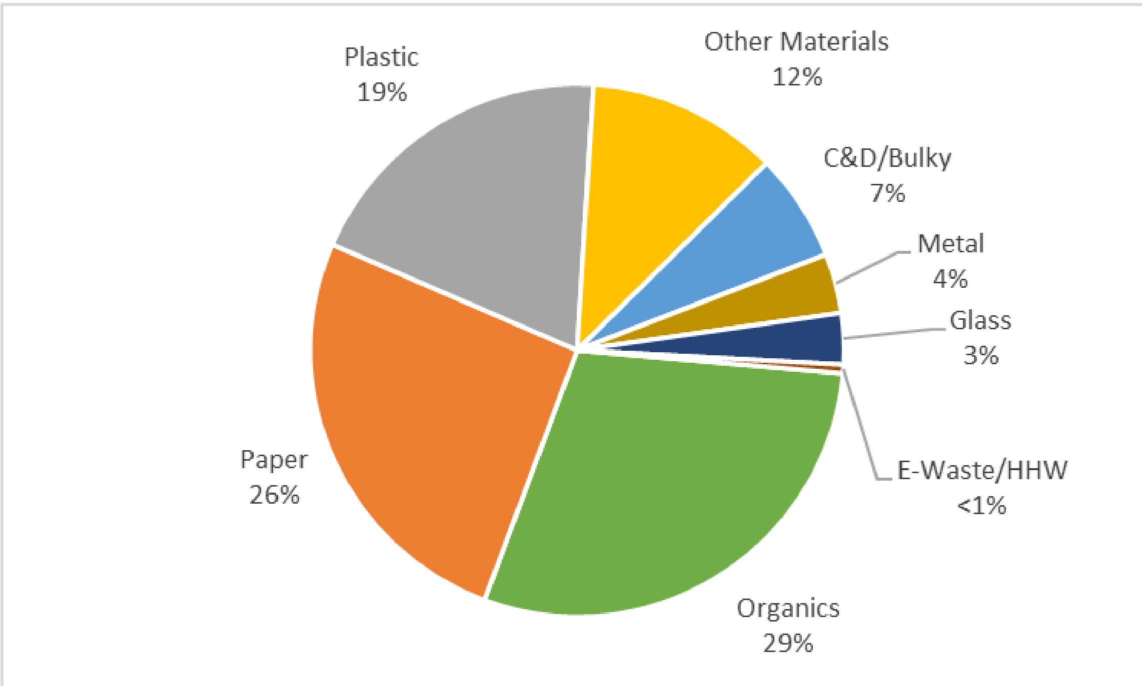


Figure 8: Composition of City-managed Waste (2023)

Of the City-managed waste disposed of at the landfill, over 50% has the potential to be diverted as presented in Figure 9. About 15% of residential waste comprised targeted recyclables while about 25% of commercial waste comprised targeted recyclables.

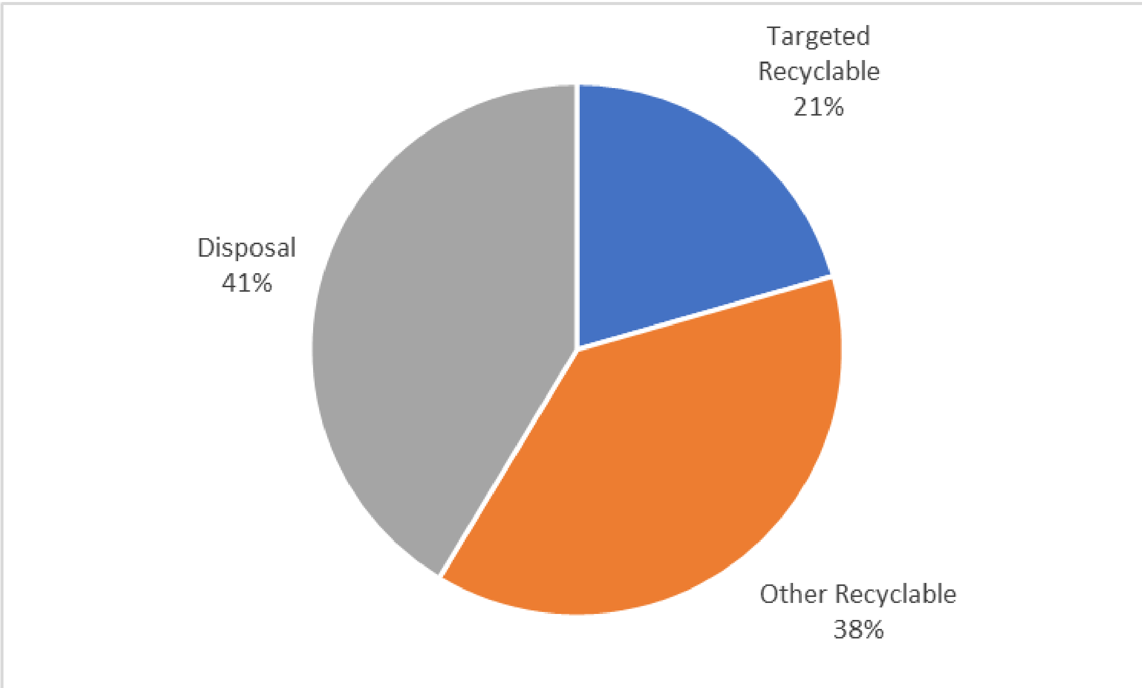


Figure 9: Recyclability of City-Managed Waste Disposed of at City Landfill (2023)

Not unexpectedly, food waste comprises the majority of City-managed waste, as presented in Figure 10. Notably, approximately 8% of waste consists of Cardboard and 5% consists of mixed recyclable paper. Both of these materials could be diverted from landfill.

While it should be noted that these materials could be managed at the City's landfill and would ultimately contribute to creating biogas captured at the bioreactor, a better and higher use of these materials would be through recycling. Some materials, such as food waste, yard waste, and chipped/ground clean wood are managed through the City's bioreactor landfill and do not have separate diversion programs.

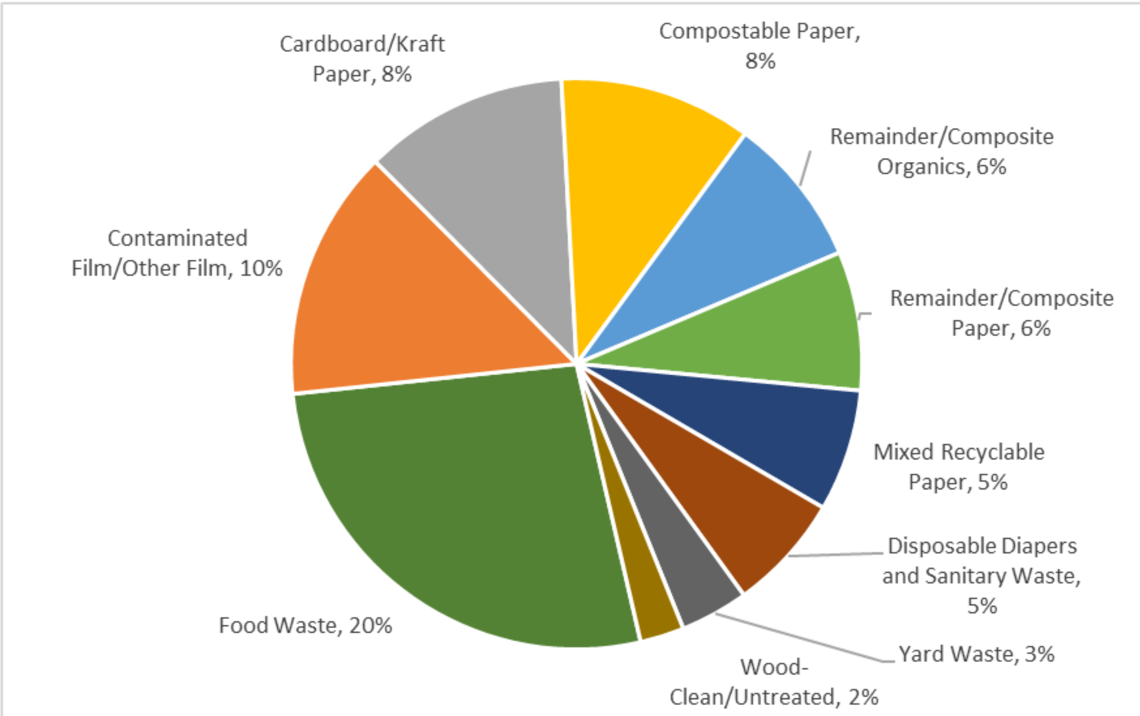


Figure 10: Top 10 Most Prevalent Materials in City-Managed Waste

Source: 2023 Waste Composition Study, Figure 4-3, see Appendix C

Materials that could have been recovered through existing diversion programs (City-run and private) include:

- Clean film & film bags
- Scrap metal items
- Electronics
- HHW
- Textiles and shoes
- Tires

Other materials that could potentially be diverted, for which programs do not currently exist in this region, include:

- Styrofoam (#6 Expanded Polystyrene)
- Bulky plastics
- Mattresses

Further details about the waste composition study can be found in Appendix C.

3.4 Curbside Collection Study

A study was undertaken in March 2023, designed to estimate a participation rate. A participation rate measures the percentage of households that routinely put material at the curb. The number of households who set out recycling was to be counted on two collection days, two months apart.

It was observed that set outs seemed fewer and smaller than would be expected with an every-other-week recycling collection program. Further investigation showed that many people utilize the drop-off center on their "off-week" and/or as needed. As the Recycling Drop-off Centers are not staffed and usage cannot be tracked, it would be very difficult to accurately assess participation rates as households can utilize both curbside collection and Recycling Drop-off Centers.

Due to this finding, compounded by the suspension of recycling collection in the middle of this study, further collection of data was discontinued.

While a true picture of participation could not be determined, it was apparent that future service changes (e.g., removal of Recycling Drop-off Centers) will have major impacts on set-out rates and route efficiencies.

3.5 Stakeholder Engagement

Stakeholder engagement was a major part of this project, seeking input from City Council members, City staff, and the public about the recycling programs through meetings, open houses, and surveys. Table 4 presents a summary of engagement with stakeholders in the City to solicit feedback and provide updates on the project.

Table 4: Summary of Stakeholder Engagement

Stakeholder	Engagement Activities
City Council	Informal first impressions from council members during kickoff. Informal update meetings on March 6-7, 2023. Presentation at Pre-Council meeting on July 17, 2023, to provide an update on the findings of the project so far, information about the options being explored, and an update on the next steps for the project. Final presentation of the project on September 18, 2023.
City Staff	Kickoff with project team November 15-18, 2022. Engagement meetings with additional City Staff Stakeholders during kickoff. Preparation for and participation with Staff in Open House. Ongoing update meetings and collaboration throughout the project.
Residents/ Interested Parties	Open House Meeting on March 7, 2023, where members of the public and the press had the opportunity to learn about the recycling system, ask questions and engage with City staff and the consultant, submit comments, and share their vision for the future of the service. A Fact Sheet and an FAQ were available at the meeting. BeHeard and paper-copy survey for input on recycling services, available from February to April 2023; 36 responses received. Interested Party (IP) Meeting on May 16, 2023, including a presentation by RRT to provide an update on the recycling and waste diversion program evaluation and respond to questions from the attendees.

The City also solicited feedback on solid waste residential curbside collections on an ongoing basis through its BeHeard website, which provided information on proposed options, videos, FAQs, fact sheets and hosted a survey. This page provided an anytime forum for sharing ideas and questions about the project.

Overall, the number of responses to the formal BeHeard survey was low, with only 36 responses submitted, but the answers given were thoughtful. Insights gained from the survey included:

- 64% of respondents indicated they set out their recycling every collection day with the 56% placing out one blue bag, and 64% placing out one bundle of fiber.
- In general, respondents rated the City's current program favorably.
- 53% were in favor of switching to automated collection with a roll cart.
- 19% regularly brought recycling to a Recycling Drop-off Center, while 42% occasionally did so. Most people utilized the Recycling Drop-off Center when they had a lot of material and couldn't wait until the next collection day. Many people indicated that they had missed their curbside recycling day in this way.
- 33% of respondents occasionally brought yard waste to the yard waste drop-off while 25% of respondents regularly did so. Most people utilized the yard waste drop-off to get rid of material for free and avoiding using a service.

Ideas submitted by residents included:

- Increasing recycling collection frequency to return to weekly service;
- Reducing collection of materials that have no market;
- Need for more education;
- Positions both for and against using roll carts for recycling;
- Starting an organics program and move to alternating week trash and single stream recycling; and,
- Teaming with a company out of Kansas City for glass recycling.

A report of the responses to the BeHeard survey and ideas provided by residents is provided in Appendix D. Additional information about the role of stakeholder engagement is discussed throughout the report, particularly in Section 4.1.1, regarding development of a new MRF.

4 Options for Increasing Diversion from Landfill and Participation in Recycling and Waste Reduction

This section provides a discussion of options for the City to increase diversion and participation through new infrastructure, acceptance of new materials, improvements to current programs, and new outreach programs.

4.1 Increasing Diversion

While the Columbia bioreactor landfill has many climate impact advantages over traditional landfills, it is in the interest of the City's climate action goals and environmental protection ambitions to reduce the amount of material deposited in the landfill. There are several opportunities for Columbia to improve upon its infrastructure and programs to increase diversion. The next several sections discuss how the Solid Waste Utility and the City programs can do so.

4.1.1 New MRF

As discussed above in Section 3.1 and in the MRF Evaluation Report (Appendix A), the Columbia MRF is nearing its end of useful life. The MRF needs to cease operations in the relatively near future and be replaced by a new MRF or another option. As there are no other MRFs in the region, "another option" means ceasing to process recyclables locally and trucking recyclables in bulk either to St. Louis or Kansas City, where the major national firms have MRFs.[8] With no comment regarding those processors intended or implied, the stakeholder engagement process discussed in Section 3.5 made it clear that the Council members, staff professionals, and public citizens want to keep processing recyclables locally in Columbia for the following reasons:

- Having a MRF is an asset and provides intrinsic value to the City, which is preferable to paying to transfer recyclables 100 miles or more—well beyond what the solid waste industry generally considers to be an economically feasible distance.
- Processing recyclables locally provides jobs and employment opportunities in Columbia.
- Owning and operating the MRF empowers the City and its residents to know more precisely what happens to the materials processed and the commodities, while sending them elsewhere is dependent on the business model of another entity.

These sentiments were echoed repeatedly by all the stakeholder groups, and Section 7 goes into greater detail about how to pursue that directive. Before that analysis could be developed, however, Columbia had to consider whether to continue dual stream recycling or "convert" to single stream recycling.

The cost to build a new MRF is discussed in greater detail in Section 7. The benefits of a new MRF are many, including less loss of valuable commodities, less dependence on manual sorting, improved safety and productivity, ability to positive sort on more types of commodities, and the ability to accept larger amounts of material as both the City and the recycling programs grow. The time frame to build a new MRF depends on many factors, including construction lead times and budgetary processes; however, the actual design and construction can be completed in two to three calendar years, barring unforeseen major site challenges or equipment delays.

4.1.2 Divert Industrial, Commercial and Institutional Cardboard from Landfill

According to the waste composition study conducted on material delivered to the landfill, the most wasted recyclable material is cardboard, as shown in Figure 11.

[8] An additional option would be to close both the MRF and the recycling program, but clearly that is not open to consideration for Columbia.

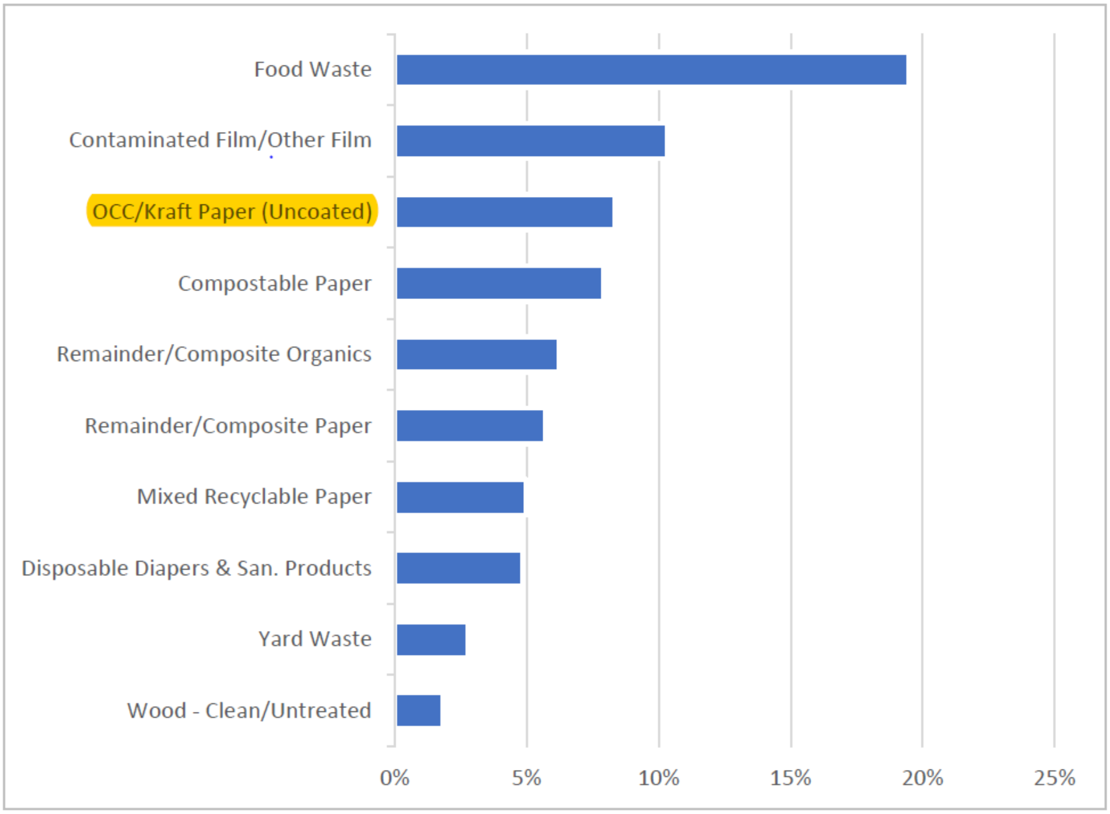


Figure 11: Top Ten Lost Recyclables in the Landfill

2023 MSW Composition Study, MSW Consultants for RRT

While both the residential and the ICI sector generate cardboard, the study also showed that the ICI sector discards cardboard for disposal at a much greater rate than the residential sector. As shown in Figure 12, the ICI sector disposes cardboard 10 to 1 compared to the residential sector, but the overall waste generation ratio is closer to 6 to 4, meaning that the ICI sector disposes of cardboard disproportionately to the amount of the overall waste stream that it generates.

In discussions with City stakeholders, RRT has identified a long-term goal of reducing the amount of cardboard disposed of by the ICI sector. If 50% of the cardboard disposed of by City ICI customers in 2023 [9] had been diverted, it would have resulted in approximately 2,800 fewer tons of cardboard being disposed of in the landfill. Projected out to the year 2030, the potential tonnage that could be diverted—accounting for population growth over time—could be more than 3,000 additional tons diverted from landfill *above and beyond current participation*. [10]

[9] Projected based on 2022 values.
[10] For more detail on waste projections and potential program improvement impacts, please see Section 5.

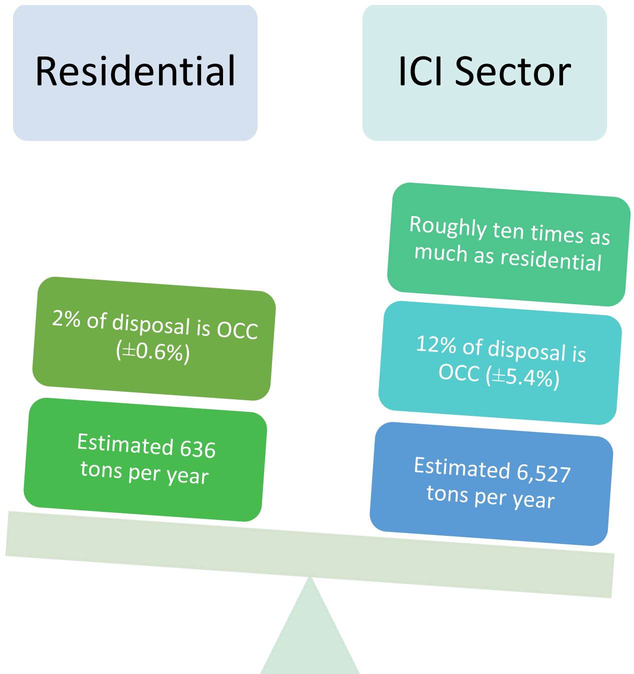


Figure 12: Cardboard Disposal by Residential and ICI Sectors

2023 Waste Composition Study, MSW Consultants for RRT

There are several challenges to increasing the amount of ICI sector cardboard diverted from disposal. Some lie with the generators; others are related to the overall program. A few options for improving ICI diversion of cardboard include:

- Improved and expanded outreach to customers to explain the impact of recycling cardboard on the overall program.
- Revision of City ordinances to create regulatory requirements for some or all ICI customers to recycle cardboard. This of course relies on available capacity to process the material, which the current MRF does not provide.
- Where feasible, provision of compactors for cardboard collection to reduce collection frequency and improve the customer experience.
- Focusing on generators of exceptionally large amounts of cardboard to see if all their material could be processed as “recycling” in a modern, updated MRF—e.g., if the waste stream at a furniture store is overall 90% or more cardboard and 5% to 10% other waste, the complete waste stream could possibly be processed in a modern MRF, eliminating the need for the generator to source separate.
- Supporting generators of significant amounts of cardboard to see if baling on-site might be a better option than putting cardboard in non-compacting containers for collection.
- Ultimately, continuing to grow the ICI customer base to provide affordable cardboard recycling service to more locations.

An overarching recommendation for improving the recycling program in Columbia is the creation of a full-time equivalent (FTE) positions dedicated to improving the recycling programs and executing an outreach and education program. This is discussed in greater detail in Section 4.5.

4.1.3 Optimize Existing Programs

The Solid Waste Utility has several existing programs which can be optimized and promoted to the community in order to increase diversion from landfill and improve environmental protection, short of major investment in infrastructure.

Close Problematic Recycling Drop-off Centers

The two sites on the Mizzou campus and the site at 10th & Cherry, Downtown, are known to experience heavy levels of contamination, which negates whatever proper recyclables might be deposited in the receptacles. While it may seem counterintuitive that reducing service could increase diversion, with less contamination going to the MRF, the equipment and employees can be expected to perform better and be more productive. This will also allow the Solid Waste Utility to divert the resources currently dedicated to servicing and cleaning up those sites—along with the effort to process those tons at the MRF and dispose of the residue—to other more productive purposes. In effect, the materials collected at those sites contribute little to nothing to the recycling program while costing resources. Removing them should have an overall positive impact.

The costs associated with implementing this option are the efforts to remove the containers and any enclosures. Signage would need to be added or updated advising potential visitors of the closure and where materials can properly be delivered. Best practices have shown that residents are not willing to drive further than 15 minutes to a Recycling Drop-off Center. The remaining locations are all located within a 10-to-15-minute drive from all areas in the City. The anticipated impacts are more efficient sorting operations at the MRF and more resources available to focus on optimizing the other drop-off centers. This option can be implemented in the near term. For more discussion on implementing this option, please see Section 8.1.

Modify Collection and Processing of Glass

Currently in the Columbia MRF, the commingled container line consists of an infeed conveyor, a sort line, an overbelt magnet to capture ferrous metals, and an eddy current separator to sort non-ferrous metals (mostly aluminum cans). The sort line is picked manually for #1 PET, two types of #2 HDPE (Natural, like milk jugs, and Color, like detergent bottles), #3-7 Mixed Plastic, and non-recyclables. The negative sort, which essentially means the "leftover" material after passing the sorters, the magnet, and the eddy current separator, consists mainly of glass, grit, and fines. This material is conveyed to the exterior of the building where it falls into a glass bunker. Although glass was marketed when the facility was first constructed, glass is now only used as cover for trailer loads to the landfill, to prevent spilling and litter. This is due to the high contamination of the glass and the lack of markets for product in that condition.

Across the country, many recycling programs have removed glass from commingled containers and opened drop-off locations for glass, instead. These glass-only systems have become popularly known as "purple bin programs," due to many of the receptacles being painted purple, like the one Columbia has at the State Farm Parkway Recycling Drop-off Center. In Columbia, collecting glass in this way would have a positive impact on commodity values. The glass that is collected as its own stream is of a much higher value than glass that has gone through commingled collection and MRF processing. For example, two major vendors in Missouri—Ripple Glass in Kansas City and Strategic Materials in St. Louis—gladly accept "purple bin" glass that has not gone through a MRF. The location in Kansas City brings experience and knowledge about Columbia's program, while the St. Louis program has direct rail access to receive loads by train car.

The second benefit to commodity values lies with the two types of #2 HDPE plastic. While processing of recyclables at the current MRF continues,[11] if little to no glass were entering the commingled container line, the existing processing system could then start using the negative sort function to drop out plastics #3-7, instead of glass. This would free up one of the bunkers used for positive sorting to allow sortation of HDPE-Natural (like milk jugs) and HDPE-Color (like detergent bottles) as two separate streams. Historically, HDPE-Natural has commanded a market price 3, 4, 5, even 6 and 7 times greater than HDPE-Color (see Figure 13). When Columbia sells HDPE-Natural commingled with HDPE-Color, as happens now, the market provides the much lower price for Color for the entire load, and the City forfeits potential revenue on over half of the HDPE material it sells.[12]

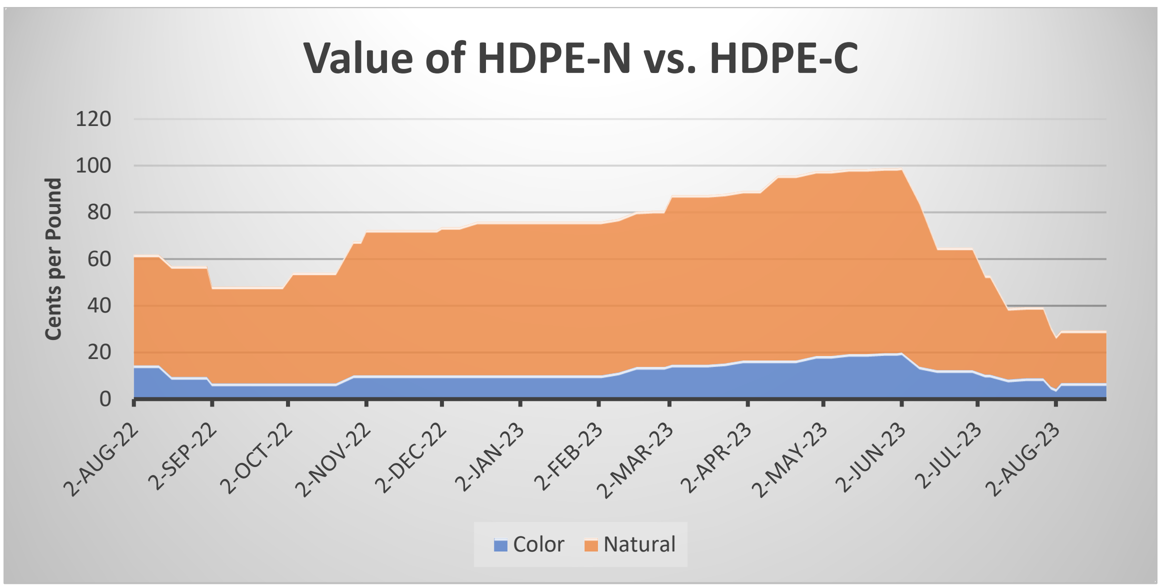


Figure 13: Historical Values of HDPE-N and HDPE-C in the Midwest/Central U.S.

Source: RecyclingMarkets.net

Costs associated with this change will include preparing and servicing purple glass-only receptacles for five sites (Downtown-Armory, South Providence, Cosmo Park, and the Columbia College locations). The City would need to run an intensive information campaign encouraging recycling participants to separate their glass, and why. The benefit to diversion is the creation of much higher-value HDPE-Natural bales, along with freeing up the attention of the sorting staff to focus on capturing as many #1 and #2 items as possible. This option can be implemented in the near term.

[11] Please see Section 9, Recommendations, for further discussion of the near future of the current MRF.
[12] The MRF Contamination study found that over half of the HDPE in the bunker was Natural, vs. Color. See Appendix B.

For more discussion about glass in the commingled container stream going forward, please see Section 4.4.2.

Preserve Recycling Container Capacity for City ICI Customers

During the stakeholder engagement activities, City staff related that many ICI recycling customers—particularly those in the Downtown area—express frustration because the recycling receptacles near them become full quickly, resulting in mess and overflow. Field observations and spot-checking have shown that some of the containers are prone to abuse by passersby or neighboring businesses. To help the ICI customers who want to recycle have the best access to service, the City can evaluate, on a case-by-case basis, if a particular location might be better served by a different receptacle type.

One example is a type known as a "slot-box." Shown here, this is a closed receptacle with a locked lid and an opening which is restricted in shape and size to facilitate the insertion of cardboard and paper but discourage or even prevent users from putting in bagged waste. Evaluation of a site prone to abuse might find the customers are better served by this kind of container, so they can have better access to capacity. They may have little or no commingled containers, and can instead focus on paper and cardboard, knowing their recycling capacity is protected from random dumping or abuse. Educating customers of this benefit would ideally lead to them collapsing cardboard to put in the slot-boxes, further alleviating overflow situations. The cost to retrofit existing 2-yard receptacles would be marginal. The benefit is preserving container capacity for recycling participants. This option can be implemented in the near future.

Another container type which can help with overcrowding of the Downtown recycling containers is a BigBelly solar compactor trash container. Many cities across the world, including North America, Central America, Europe, Australia, and Japan have implemented these containers to combat littering and other problems with waste in the wrong place. It is a receptacle for passersby to deposit their personal trash and litter. The container has either a 50-gallon or 150-gallon volume; however, due to the internal compactor, it can hold the equivalent of several times that amount. The compactor is powered by a 5-year battery and/or solar panels, and has a foot-pedal for hands-free use. The units can also communicate via wireless network to let the City know when they need to be emptied. These could be placed at the locations with the greatest issues of dumping and abuse of the recycling containers. The City could paint attention-getting signage directly on the sidewalk next to the BigBelly containers, to make sure pedestrians see them, and the containers can be "wrapped" with color printing to communicate with users.

In 2019, the University of Mississippi leased BigBelly trash bins on a 5-year lease at a monthly cost of $1,900 for 25 bins (about $4,560 per unit). The plan covers most maintenance and repairs. The larger size container can replace up to four regular trashcans and sends out a signal when it is full, reducing the need for staff time to check trash cans.

The cost is dependent on several factors, but BigBelly containers cost several thousand dollars each, so their placement would need to be planned carefully. The benefit is preserving recycling capacity for ICI customers and reducing contamination. Depending on product availability and space planning, this option could be implemented within one year of the decision to do so. This might also be a good option for applying for grant funding.

Update Curbside Residential Yard Waste Set-out Information

This option has two efforts working together to both increase diversion and improve the resource recovery within the bioreactor landfill. First, the City would revise the set-out instructions and encourage residents setting out yard waste at the curb, with their trash, to put their material in paper or biodegradable bags.

Relatedly, with the advent of the carts and pay-as-you-throw for trash, customers may find that from time to time they cannot fit all their material in the cart, and yard waste could be a reason. The instructional information distributed with the carts (and in future outreach materials) can communicate explicitly and emphatically that customers can bring that material to the two yard waste drop-off centers in paper bags or loose in personal containers at no charge, freeing up space in their trash carts.

This two-pronged option can be implemented as soon as the next time instructions are distributed to customers, with the impending roll-out of pay-as-you-throw trash carts providing an excellent opportunity. The cost to implement this change is negligible, consisting primarily of the staff effort involved to communicate the information to the public. The benefits are the material is more bio-available in the reactor, resource recovery is improved, and more yard waste is diverted from the landfill, along with improved customer experiences.

4.1.4 Opportunities for Diverting New Materials

One of the options for both increasing diversion and improving participation is to pursue recycling and diverting more materials. (For more details about the role of a new community environmental center in diverting new materials, see Section 4.2.2.). The following sections provide options for diverting new materials, for the City's consideration. Potential tonnages are based on the recent waste composition study and only include City-managed waste. There would be additional quantities of these materials available in privately-hauled waste.

Styrofoam

Most municipalities dispose of expanded polystyrene (also known as EPS, or the brand name Styrofoam) by landfill or incinerator. Some are trying to recycle EPS by densification and marketing to processors who convert this material to items like picture frames, clothes, carpets and more. Some municipalities have purchased their own densifiers, others utilize the services of mobile densification units, but most simply continue to dispose of EPS due to the level of effort required. There are some innovations in processing EPS through chemical recycling, although to-date, this is on a small scale.

The City could implement a program to recycle EPS dropped off at a future community environmental center. Approximately 825 tons (1.65 million pounds) of EPS are disposed annually in the landfill. EPS could be collected in a roll-off container or sea container and a densifier used to compact the EPS for sale. The City would need to confirm costs for such a program and the availability of markets for this material.

If Columbia diverted 10% of the 825 tons of Styrofoam disposed annually, it would need equipment capable of processing approximately 82 tons annually or 450 pounds per day.

RRT contacted a supplier of equipment to densify EPS located in Missouri. As a very rough estimate, equipment that could process about 240 pounds per hour would be approximately $56,000, plus shipping from Germany. Processing would need one to two staff depending on the shape/quantity of EPS. It appears there are no markets for this material within a reasonable hauling distance from Columbia. [13] (See also a case study, *right*)

A first step to recycling EPS in Columbia would be to collect information on quantities generated, including at commercial establishments which might have larger quantities of clean material, and at the institutions (colleges and universities) to gauge the potential for processing materials from other sources, and to size the equipment required. If this is a feasible endeavor, collection and processing this material could take place at the new community environmental center. The City could also investigate whether any grants may be available to help offset the cost of the equipment.

Mecklenburg County, NC, uses RecycleTech XT-200E machines to densify EPS. In 2022, two machines were purchased for $46,000, each. The densifier can process 200 pounds of EPS per hour. It has a footprint similar to a snack vending machine.

In about eight months, Mecklenburg accumulated about 30,000 pounds of EPS which is stored on pallets of 1,500 pounds each and shrink wrapped. Shipments of approximately 40,000 pounds (or a truckload) are sent to market which is just under what Mecklenburg would manage annually (30,000 pounds collected in 35 weeks, or approximately 44,000 pounds (22 tons) annually). Material is processed twice weekly, assuming approximately 400 to 500 pounds per day, requiring approximately four hours per day by each staff person.

Bulky Plastics

The City managed approximately 1,400 tons of bulky plastics at the landfill in 2022. These materials consist of items such as five-gallon buckets, very large detergent bottles, kids' toys, plastic kids' play equipment (slides, chairs, tables), plastic deck chairs, wading pools, etc., consisting of a variety of colours and resins.

[13] In September 2023, the U.S. EPA announced the first round of Solid Waste Infrastructure for Recycling (SWIFR) grants. Recipients included the East Central Missouri Solid Waste Management District, which serves Warren, Lincoln, Montgomery, and Franklin Counties. Some of the grant funding is for an EPS compactor. In the future, given the close proximity, the City could perhaps partner with the District to capture EPS from Columbia.

RRT contacted an industrial plastic recycling and scrap buyer in Missouri. A representative of this company indicated that this material would need sorting to separate each type of plastic and to remove any metal or foreign components. Material would need to be shipped to Memphis, TN, by rail, and there would be a fee of 0.20 cents per pound ($400 per ton) to recycle these materials.

If the City was able to divert 10% of this material (141 tons or 282,000 pounds), the fee to recycle this material would be approximately $56,400 annually, in addition to rail costs and the labor costs associated with sorting and preparing material. The distance to processing makes recycling the material in this way very cost inefficient. Capturing hard-to-recycle plastics is a rapidly developing area in the industry, however, so new opportunities might arise in the future.

Clean, Unfinished Wood

At present, about 1,500 tons per year of clean wood is being disposed of at the landfill. The City is able to grind clean wood delivered separately, making it available either for a mulch product or to make the material more bio-available in the landfill. There is an opportunity to divert more of this material to processing through promotion and education. It is plausible that pallets comprise much of this waste stream which can be reused or recycled. The City could develop a promotional campaign to inform commercial customers that pallets have value, do not need to be broken up to be reused/recycled, are expensive to dispose of in roll offs/dumpsters, and can be disposed of with no tipping fee assessed.

Mattresses and Foundations

Mattresses and foundations are materials that are difficult to manage in a landfill, being hard to compact and they can damage landfill equipment. It is unknown how many mattresses and/or foundations Columbia manages at its landfill, but according to the Mattress Recycling Council, a nonprofit organization formed by the mattress industry to operate recycling programs in those states that have enacted mattress recycling laws, more than 50,000 mattresses are discarded every day in the United States. Mattresses and foundations are typically composed of multiple layers of textiles, foams, metal structures, and wood. They must be de-manufactured (or disassembled) before the various materials can be used to make other products; however, the Mattress Recycling Council states that more than 75 percent of a mattress can be recycled. Much of the fiber, textile, and foam components are shredded to make other padded textiles, such as carpet padding or building insulation. Steel springs and other structures are recycled as scrap metal.

In other communities, diversion of these items is accomplished by collecting them in a storage container until sufficient quantities have been collected to warrant hauling to a processor. Columbia could potentially accomplish this at a future community environmental center; RRT followed up on several leads but unfortunately at this time, there are no processors within a three-hour drive of Columbia. A first step for possibly collecting mattresses for recycling in Columbia would be to monitor the number of mattresses and foundations managed at the landfill and, if there are sufficient quantities to make diversion feasible, the City can investigate whether there is a processor within a reasonable hauling distance that would accept these items.

Carpet and Padding

It is estimated that approximately 960 tons of carpet/padding are disposed of in the City's landfill annually. According to the Carpet America Recovery Effort (CARE), an industry-based nonprofit created to help manage the California Carpet Stewardship Program, carpet is made of two basic components: the face fiber and the backing system. The face fibers are most commonly made from one or more fiber types: Nylon 6,6; Nylon 6; Polypropylene (also know as olefin); or Polyester. The face fiber is the most valuable part, but each type has different properties so they cannot be commingled. The two most common types of backing systems are latex, more common in homes, and PVC, more common in commercial settings. [14]

Post-consumer carpet is recycled by processors into fibers or plastic pellets, which can be used to make a broad range of products, including carpet, carpet tiles, carpet underlayment, and products for the automotive, transportation, and construction industries. RRT could not locate any carpet processors located within a reasonable hauling distance of the City at this time. CARE provides information on vendors across the country who have reported that they accept carpet for recycling; unfortunately, both the locations listed in Missouri have closed permanently. The City can continue to monitor the status of carpet stewardship programs to see if funding would become available in Missouri to assist the implementation of a carpet/padding diversion program.

4.1.5 Other Options

Some options to increase diversion are more about the larger impact on the participants and the environment, as opposed to tons and pounds. Two examples are household hazardous waste and food scrap composting.

Expand Household Hazardous Waste Opportunities

Columbia currently has a very good household hazardous waste (HHW) program that can serve as an example to other communities, especially with regard to cost efficiency. There are sixteen collection days per year, always on the same days (first and third Saturdays) and always at the same location. Having a permanent site with an HHW storage pod (commonly referred to as a "hut") where materials can be safely stored until a specialized vendor collects them makes the per-pound cost much more efficient than other models. However, the MSW composition study projects that at least 170 tons of HHW are disposed in the landfill each year from City residential customers, and about 92 tons of electronic waste from both residential and ICI customers. Pound for pound these materials are more potentially polluting than other discards, and batteries of all types are particularly concerning due to their fire risk. To provide residents as much opportunity as possible to divert these materials to proper management (and in the case of batteries, to recycling) the City can create an additional HHW facility as part of a new staffed community environmental center, located at the landfill. (See Section 4.2.2 for more about the community environmental center.)

Because the community environmental center would be staffed full time, the HHW drop-off effectively could be available most or all of the hours the community environmental center is open, providing any-time service for residents. This weekday-hours facility might also open the opportunity for the City to host events for Conditionally Exempt Small Quantity Generators (CESQGs). These are businesses who meet certain conditions, including generating very small amounts of hazardous waste per month, and are therefore exempt from Federal laws related to hazardous waste but also not regulatorily eligible to participate in HHW events. Events for CESQGs usually charge nominal fees which are considerably lower

[14] https://carpetrecovery.org/about-care/faqs/#2

than retail rates to accept materials such as lamps, automotive fluids, batteries, paints and finishes, cleaning products, and chemicals such as pesticides or herbicides.

Beyond the marginal cost staff time to tend to the HHW drop-off, the main costs for having an HHW facility at a new community environmental center lie with the HHW hut itself (including appropriate security and safety infrastructure) and the disposal fees for the new pounds of material the facility would ideally attract. HHW huts are quite expensive, usually $250,000 or more; however, they can be financed and amortized over a long useful life. For disposal fees, pricing depends on the exact materials collected. By way of comparison, in FY2022, the City served just over 4,000 HHW customers at a cost of about $75,000; if the same success were duplicated at the new HHW drop-off center—which would be an impressive accomplishment—similar costs could be expected. The benefits are securing potentially polluting and fire risk materials into a proper management system and engaging members of the public to think about the impacts of their waste discards.

While the implementation of this option is envisioned as being part of the concept of the new community environmental center, opening a new HHW facility is not dependent on that timeline because it would need to be physically separate from other structures. Therefore, this option could be implemented within 12 to 18 months.

Engage Residents Regarding Food Waste

Many stakeholders in this study expressed interest in food scrap composting. This kind of waste management requires a specialized facility that can manage food scraps, which are very different than yard waste and other organic materials. If Columbia were to develop a facility to recover resources from food scraps, the City would effectively build above ground what is already below ground: a bioreactor that recovers energy from the organic material and sequesters carbon emissions. Collecting food scraps also requires a collection and transportation network and related emissions that would to some extent offset the climate action benefit of the food scrap processing.

Studies by the Waste and Resources Action Programme (WRAP) in the United Kingdom and the Natural Resources Defense Council (NRDC) worldwide, however, have found that individuals and families who compost their food scraps begin to waste less food over time—and reducing waste in the first place is the highest ambition of waste management. In this way, a food scrap recovery program for residents is as much about waste reduction and cultural engagement as it is pounds or tons diverted.

In addition to providing information and resources for at-home composting, a popular program in many communities is food scrap drop-off co-located with weekly Farmer's Markets. Often staffed with volunteer support, these are low-technology set-ups where visitors can drop-off small quantities of their household food scraps. Some programs offer a "kitchen pail exchange" model, where participants register and given a kitchen pail for collecting scraps. When they bring a full one to the market, they leave the entire pail and are given a clean one to take back. Other models ask residents to bring the scraps in their own pail or compostable wrapping, and the material is deposited in a cart with a lid or similar receptacle. The final component of the program is a facility to accept the food scraps. There is one vendor in the Mid-Missouri region that collects and accepts food scraps for composting. The City could perhaps work with this or another organization to accept the food scraps as a corporate sponsor.

The cost to implement this option would likely consist of some equipment—a pop-up tent, informational displays, collection containers—and a few hours of staff time per month to be present at the Farmer's Market. Ideally, the corporate partner would collect the food scraps at no charge. The impact on tons would be minimal; the deeper benefit would be building engagement with people who want to reduce waste and improve their climate impact. Programs in communities both large and small report engaging hundreds of people each time they are open.[15] This option could be implemented within one year, to allow for planning and partnerships to be developed.

Use posted rates to spot-market commodities from the MRF

The current method of marketing commodities, as described in 2.1.1, allows only for selling full tractor trailer-loads of material. On a regular basis, however, the City is approached by interested buyers who want to purchase smaller quantities. To price smaller quantities, the City could set per-ton or per-pound pricing based on an industry-published price, such as www.recyclingmarkets.net, plus a handling fee. The price could be set on a quarterly basis, with new pricing posting on January 1, April 1, July 1, and October 1. The price could be the average for the previous quarter. For example, Table 5 shows the posted pricing from www.recyclingmarkets.net for the 3rd quarter of 2023.

Table 5: Secondary Fiber Pricing for PS11 Corrugated Containers, Q3-2023, Midwest/Central Region
Source: Recyclingmarkets.net

	Regional Low Price	Regional High Price	Regional Average
30-Sep-23	$ 55.00	$ 60.00	$ 57.50
7-Sep-23	$ 55.00	$ 60.00	$ 57.50
31-Aug-23	$ 50.00	$ 55.00	$ 52.50
7-Aug-23	$ 50.00	$ 55.00	$ 52.50
31-Jul-23	$ 50.00	$ 55.00	$ 52.50
7-Jul-23	$ 50.00	$ 55.00	$ 52.50
	Posted Price Per Ton		**$ 54.17**

Under this system, the posted price on October 1, 2023, for PS11 cardboard produced by the Columbia MRF would have been $54.17 plus a handling fee. The handling fee would be a percentage or a flat price per ton, based on market research. While this system might not sell every ton at the highest possible price, it does allow Columbia to sell smaller quantities on the spot market, and posted pricing tied to a metric is

[15] For more information, see this article about Madison, WI, https://www.cityofmadison.com/news/food-scraps-drop-off-at-farmers-markets-a-success or this older article about Emmet County, MI, https://wasteadvantagemag.com/food-scrap-composting-removes-thousands-of-pounds-from-waste-stream/.

the most equitable way to do so. If this system resulted in unbearably lower pricing, the City could discontinue the practice, or tie the posted pricing to the most recent bids.

4.2 Improving Participation

The preceding sections discussed ways to increase diversion from landfill. These next several sections are about improving participation in recycling and waste diversion. While improved participation would also certainly result in increased diversion, it is about more than simply counting tons. Improved participation means “sometimes” recyclers become “most of the time” recyclers. It means individuals, families, or businesses who declined to recycle start to participate, even if on a limited basis. And it means the access, experience, and engagement are improved for all participants. The following options aim to improve participation, in addition to increasing diversion.

4.2.1 Improve Current Recycling Drop-Off Centers for the Near Term

In Section 4.1.3, above, options to close Recycling Drop-off Centers with chronic high levels of contamination are discussed, along with making changes at the remaining locations. While most of those locations function well, one of the busiest—the State Farm Parkway Recycling Drop-off Center—has been observed to have considerable contamination and illegal dumping. Likely causes include that the site is completely screened from the street, and the immediate surrounding areas are unoccupied greenspace. One option to help alleviate this problem is to convert this to a staffed location, with posted hours of operation. Although this will require staffing resources and investment in some accommodations, a reduction in the need to clean up dumped materials and improved recyclables will offset those costs somewhat.

Costs to implement this change would depend on how many hours the site is open, perhaps requiring 1 or 1.5 FTEs for daylight hours. If no gate is currently present, a gate or chain would need to be installed to close the site during inactive hours. There would also need to be some investment in the site, including an appropriate shelter for the staff and sanitation facilities. Benefits would include a better customer experience for customers, reduction in dumping, and improved site cleanliness. This option could be implemented in approximately one year to 18 months, depending on planning and staff allocation needs.

Another option would be to consolidate the State Farm Parkway and the S. Providence Road locations. State Farm Parkway would be closed, and users re-directed to the S. Providence Road location, which is less than 1 mile away. The S. Providence Road site could then stay in operation long-term (see Section 7.3.1 for an example), making investment in its success a valuable allocation of resources.

4.2.2 Develop New Community Environmental Center for the Long-term

Columbia currently operates Recycling Drop-off Centers—simple facilities that essentially duplicate or extend the curbside recycling collection service. This section describes the option to develop a facility referred to as a community environmental center, where participants can bring a variety of materials to one consolidated location, accessing a broad spectrum of services in one place. A modern community environmental center offers the following improvements to the customer participation experience:

- Staffing – employees are on site to instruct incoming customers how to use the site, answer questions, monitor for proper usage, and manage the materials. The design is easy to keep clean, and servicing of the receptacles is straightforward.

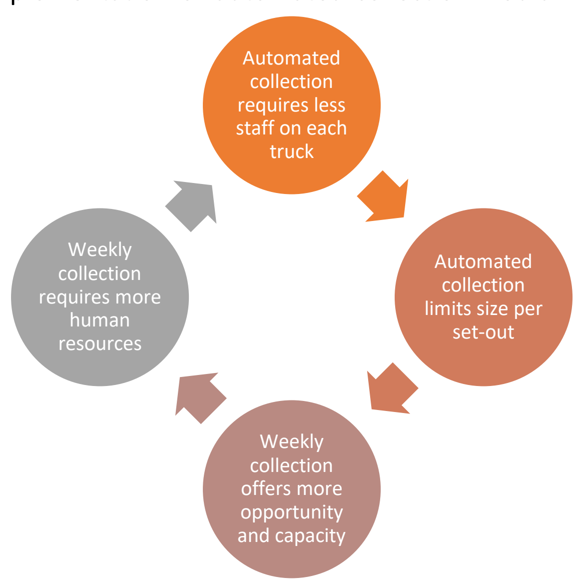
- Safety – the facility can be designed in a way that participants do not have to lift materials above their shoulders to place them in receptacles, improving equity and accessibility for users. There is clearly designated traffic flow to protect pedestrians, and barriers prevent scavenging.
- Ease of use – participation is touchless, as there are no lids or doors to open. Labeling for what goes in which receptacle is clear and concise, and users can see clearly into the receptacles to verify their actions are correct.
- Flexibility – the staff can adjust which materials are collected at what point in the facility in response to demand, volume, and use patterns. Also, new materials (like those discussed in Section 4.1.2) can be added as markets become available.

Developing a new community environmental center to replace most of the current Recycling Drop-off Centers is a keystone of improving participation in waste reduction and recycling. As described, it will provide a more accessible and comprehensive facility with the benefit of staffing. This will alleviate illegal dumping and facilitate the ability to offer collection of special wastes such as batteries, HHW, and more. Options for designs and operations for the facility are described in greater detail in Section 7.2.1.

4.2.3 Restore Curbside Recycling Collection

Reframing the Issues

Implementing weekly curbside collection of recyclables was frequently endorsed by stakeholders in every group. Weekly collection is best practice, but at present, the Solid Waste Utility has had to suspend curbside collection entirely due to staffing issues. Implementation of automated collection would help with staffing issues because each truck would need only one employee on board instead of three; however, automated collection inherently limits how much material customers can set out per collection day because of the cart. As a result, customers still need either Recycling Drop-off Centers, as they did with biweekly service, or increased collection frequency to weekly.



The figure to the right illustrates how the path from suspended curbside recycling to weekly curbside recycling can seem to have competing priorities. Each of the statements could be preceded by the word "but," and be seen as a stumbling block. Instead of this approach, consider a holistic path that addresses the concerns with "what if," instead of "but," as illustrated in the figure below:

What if the collection routes were made more efficient by re-routing or automated collection, or both? How many routes would we need for biweekly collection? How many for weekly?

What if weekly collection were possible? Would neighborhood Recycling Drop-off Centers still be needed? Could some of them close? What staff and resources would that make available?

What if some of the neighborhood Recycling Drop-off Centers were closed? Would that improve contamination at the MRF? Would that make resources available for staffing a convenience center? Would customers benefit from a one-stop-shop?

Recycling Collection Modeling

When the City was collecting curbside recyclables biweekly, most of the routes were roughly 1,100 to 1,300 customers, and most days three trucks covered the routes. Although the curbside participation study could not be completed as planned (see Section 3.4), RRT did observe that the set-out rate on the recycling routes ranged from about 35% to 60%, with the most common observation being 40% to 60%. Applied to the route sizes, that would mean the trucks were collecting from approximately 385 customers per day on the low end to about 780 customers per day on the high end. Best practice for manual collection with one helper/laborer is to collect 600-800 customers per 8-hour day. Subjectively, the route performance was slightly inefficient but, when properly staffed, able to conduct the work in a satisfactory manner.

Automated side loading (ASL) vehicles can run much larger routes, and each truck can collect more customers per day. With efficient routing, each truck should be able to collect 800 to 1,000 carts per 8-hour day. If the set-out rate is 50%, each route would be around 1,600 customers. Because each truck can collect more customers on longer routes—and using only one employee—the work can be completed more efficiently.

The simple model below makes the following assumptions to estimate how many routes, trucks, and drivers could provide weekly recycling collection service:

- The City's customer base is 36,040 units as of 2023; the City has a 92% occupancy rate which when applied to the customer base results in 32,436 active units;

- On any given day, 50% of active units will set out their recycling cart; [16]
- All routes should be scientifically designed by computer software to make them efficient and minimize non-productive time;
- Material is set out in City-provided roll carts and collected using ASL trucks operated by one employee, averaging 30 seconds per stop; [17]
- Factors such as geography, individual behavior and actions, and traffic patterns will result in some routes needing to be shorter, which can influence the model; and,
- To ensure adequate resources, routes are best served by having one or more spare trucks and by being overstaffed in order to account for absences and vacancies.

Table 6: Weekly Collection of Recyclables, Simple Model

Carts to collect per week, with 50% set-out rate	16,218
Carts to collect per day, 5 days per week	3,243
Routes per day	4
Carts to collect per route	810
Trucks needed available per day (includes spare)	5
Drivers needed available per day (includes overstaff)	5

As shown in Table 6, a 50% set-out rate results in 16,218 carts to collect each week. Divided by five workdays, each day has 3,243 carts to collect. Dividing the carts to collect into workable routes results in each of four trucks collecting about 810 carts from a route of just over 1,600 units. This is at the low end of the best practice of 800 to 1,000 carts, in the interest of estimating conservatively and in allowing operational capacity to accommodate growth. In summary, weekly recycling collection could feasibly be provided using 4 routes operated by single-person ASL trucks collecting from roll carts.

Re-assigning Resources from Recycling Drop-off Centers

In the FY23 budget, the cost center "Solid Waste Recycling" had an original budget of $1,815,865. That includes both residential collection and effort to service and care for the Recycling Drop-off Centers. Solid Waste Utility staff estimate that approximately $20,445.74 is for activity related to the three Recycling Drop-off Centers located Downtown (10th & Cherry) and on the Mizzou campus. If these three Recycling Drop-off Centers were closed, there would accordingly be resources available to drive curbside recycling

[16] During the observation of curbside set-outs in March 2023, most of the routes had set-out rates ranging from 40% to 60%. A set-out rate of 50% to 60% for weekly collection would be typical.

[17] Stop time is measured from the time the collection vehicle begins accelerating from one stop to completing the collection at the next stop. During the observation period in March 2023, the stop length averaged just under 20 seconds. Manually-collected set-outs can take less than 10 seconds if there is only one easily-lifted box or bag; automated collections each need to allow for positioning the arm and for the lift arm to cycle. A stop length of 30 seconds, typical for automated side loaders, was used in this analysis.

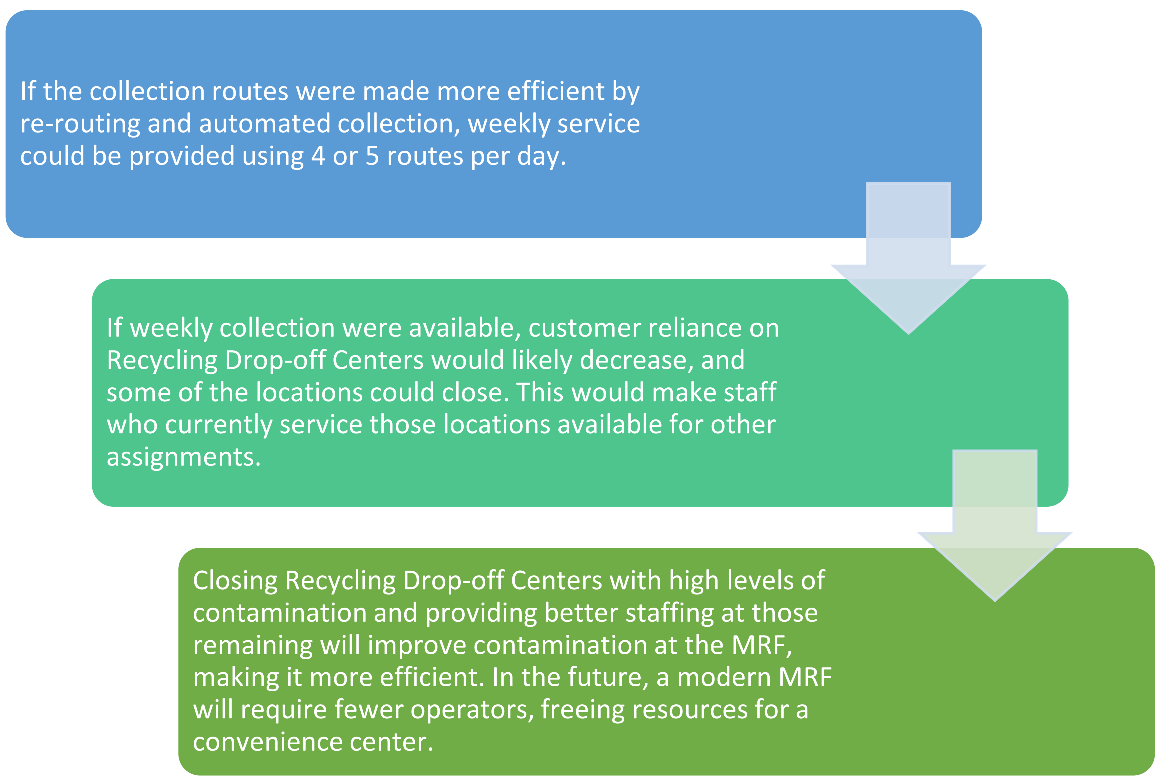
routes, staff one or more of the remaining Recycling Drop-off Centers, or generally provide redundancy as needed.

Producing Better Material with Less Contamination

With the most-contaminated un-staffed Recycling Drop-off Centers closed and staffing present at one or more others, contamination of loads from those locations should improve. This is important both in the present, with the current MRF, and in the future with a new MRF. Less contamination means equipment can work more effectively and run at designed speeds with fewer shutdowns. Eventually, a modern MRF design could potentially run with only three or four operators, freeing up considerable resources for a community environmental center and expanded opportunities for residents to divert material from the landfill.

Seeing the Possibilities

The operational challenges in the Solid Waste Utility are interrelated. As shown in the figure below, if they can be realigned to operate more effectively and concentrate effort where it has the biggest impact, diversion can be increased and both opportunity and accessibility can be improved.



4.3 Outreach, Promotion, and Education

Many of the ideas received as part of the stakeholder engagement for this study involved education about recycling, indicating that people have identified a need for more promotion and education by the Solid Waste Utility. The City can do this by developing renewed and vigorous outreach, promotion, and education campaigns. The results of the waste composition study and the MRF contamination study have provided some potential messaging points to educate residents about how to use existing programs and services:

General outreach and education

- How to use PAYT and ideas for reducing the amount of landfill trash you generate.
- "Did you know?" regarding existing community waste reduction and recycling programs in Columbia.
- Information about how personal actions impact climate action.
- Importance of recycling electronics, especially batteries (can be toxic or start a fire).
- Tires can be recycled.
- Promotion of yard waste drop-off centers.
- Promotion of hazardous waste collection.
- Promotion of donating reusable textiles, shoes, belts, leather items, furniture and other gently used goods etc. to non-profit organizations.
- How to reduce food waste.
- Why it's important to recycle properly (impact of contamination).

Targeted education campaigns

- For commercial
  - Cardboard is an easily recycled material.
  - Clean pallets can be reused.
  - Used/broken pallets can be brought to landfill for chipping/grinding for mulch instead of going to landfill.
  - Scrap metal can be recycled.
- Curbside
  - Envelopes with windows are not recyclable.
  - Cardboard and paper are the most wasted recyclables in residential landfill trash, and some of the most valuable.
  - Film plastic is not accepted in the City's curbside recycling program. City should advertise locations that accept this material.
  - Not all paper can be recycled (e.g., napkins, waxed cardboard, and paper plates).
  - Expanded Polystyrene is not accepted in the City's curbside recycling program.
- Recycling Drop-off Centers
  - Trash is not accepted in these locations.
  - Only materials accepted in the City's recycling program can be recycled here.

If the City moves ahead with some of the recommendations in this report, targeted campaigns will be required for:

- Educating people that glass is no longer accepted at the curb (see Section 4.4.2) and that glass will only be collected at certain locations in the City. This campaign would include an explanation of why glass is no longer collected at the curb, and how this material will be collected and processed moving forward.

- Changes to Recycling Drop-off Center locations if those which are highly contaminated and consistently mis-used are closed.
- Phasing out of all or most of the Recycling Drop-off Centers once a new community environmental center has been built.
- How to place recycling at the curb (containers in a bag, fiber loose) with a roll cart.

A quality solid waste outreach and education plan includes:

- Different ways to disseminate information, such as social media, printed media, videos, mailers with utility bills, curbside signs, bus/vehicle wraps, etc.
- In-person events, such as "lunch & learns," community presentations, displays at public events like farmers markets and festivals, school visits, etc.
- Providing feedback to residents when materials are improperly sorted (e.g., Oops stickers).
- A year-long and multi-year schedule for regular, consistent communication with the public.

Campaigns should have clearly identified goals, target audiences, objectives, and performance metrics. For example, a goal could be to decrease contamination in the City's recycling program, targeting single-family residences, with objectives of reducing contamination in the container stream by 15% in 6 months, measured by audits of MRF material.

Development of a campaign includes the following steps:

1. Defining and understanding the problem and the intended outcome.
2. Identifying how to measure the outcome.
3. Designing and implementing the campaign.
4. Evaluating and re-assessing the campaign.

Developing and delivering outreach, promotion, and education campaigns can be costly, so the City will need to decide what to focus on and how to deliver the messages. Best practices show that municipalities need to spend $2-$3 per household annually for outreach and education; in years with more intense, targeted campaigns, $5 per household is more typical. While many aspects of a campaign may be done internally (e.g., custom web landing pages, banners/callouts, email marketing), others may require outside resources (e.g., ads through Facebook, Google, and X[18], graphic design services, ads on buses and billboards).

Changes to programs or services provide an excellent opportunity to promote current programs at the same time as educating residents on new programs/services. Should the City decide to proceed with hiring a recycling coordinator, outreach, education, and promotion could be part of their responsibilities, working in partnership with the City's Public Information Officers/Specialists.

[18] Social media platform formerly known as Twitter.

4.4 Curbside Changes

The following sections provide an overview of options for the City to make changes to how recyclables are collected at the curb and what materials are accepted in order to create efficiencies in collection and processing.

4.4.1 Collect Dual Stream Recyclables Using a Cart and Single-body Truck

As mentioned throughout this document, Columbia currently has dual stream recycling, meaning that participants must separate fiber (paper and cardboard) from containers (bottles, cans, jugs, and jars). Little to none of the stakeholder feedback expressed dissatisfaction or frustration with this method of participation. Set-outs at the curb observed by RRT showed that those households participating, by and large, followed the instructions accurately. Overall, no observations or stakeholder feedback indicated customer demand to change the set-out method.

Industry knowledge has shown that single-stream collection offers several operational advantages versus dual stream. Primarily, there is perceived greater convenience for users, and in the experience of RRT, that usually leads to an increase in set-outs and participation on any given collection day.[19] Single-stream recycling also provides an easy transition to implementing automated collection, which saves labor resources—a challenge with which Columbia is especially familiar. At the same time, decades of single stream recycling have shown that contamination by participants also increases, often to as much as 50%. The number of tons set out for "recycling" increases, but so does the amount of residue and outthrows that must eventually be disposed of. Furthermore, some municipalities that have introduced a pay-as-you-throw program for trash experience higher rates of contamination in the recycling stream as residents try to dispose of unrecyclable material in the recycling stream, to save money.

In addition to the burden of contamination on collection, the sophistication of the MRF equipment required to process a highly contaminated feedstock is expensive and complex, and the commodity values can still suffer. Industry experience shows that commodities produced by dual stream programs are of superior quality and value. The volume of commodities generated by Columbia makes the City a "quality" seller, not a "quantity" seller. Purity of the bales is of utmost importance.

Based on the above information along with their own experience and priorities, the stakeholders in Columbia expressed clearly that they wanted to preserve dual stream recycling, if possible and feasible. RRT discussed the following with the stakeholders and received their feedback to help inform the MRF options discussed in Section 7:

- The most critical issue in the recycling program, in 2023, is that residential curbside collection has been suspended indefinitely. This is the direct result of a labor shortage and the chronic inability to adequately staff the collection operations. The stakeholders expressed clearly to RRT that they were seeking a solution that could avoid sacrificing the success of the dual stream program solely in the interest of adopting automation in order to resolve labor demands.

[19] Based on many years of field experience, the set-out rate can increase by 25% to 30%. There are many variables that affect that figure, such as frequency of collection and usage of drop-off centers.

- RRT discussed with the City staff and City Council members that across the industry, there are two traditional options for collecting dual stream recycling using automation:
    - Providing customers with two carts—one for fiber and one for containers—and collecting them either on two routes or with a split-body truck. This option could reduce the overall labor burden (each truck requires only one employee), but it also increases truck traffic with either a third "pass" or by needing a greater overall number of trucks to complete the shorter, more time-consuming routes using specialized split-body trucks. Both are incongruent with the City's climate action goals. The burden for homeowners of managing two additional carts was also not inconsiderable.
    - *Providing customers with a split-body cart, to be served by a split-body truck.* This is a time-proven method of automated collection; however, considering the large and increasing proportion of the recycling stream that is cardboard, the project team estimated that the fiber side of the cart would likely often be "jammed" with cardboard, a condition also known as "bridging," causing the customer experience to suffer.[20] In addition, this method would almost certainly require weekly collection. While this level of service was clearly expressed as an ambition for residents, it forces the issue rather than allowing for it. Also, split-body trucks routinely find one side fills before the other, requiring the operator to return to the MRF to empty the load even though one compartment has empty space.

In an effort to find a solution, RRT researched so-called "Blue Bag" programs. This a long-standing co-collection method whereby participants gather their single-stream recyclables in a blue translucent bag and place the closed bag into their ***trash*** cart. The recyclables and trash are co-collected in one single-body truck. When the truck empties its load at the processing facility, the blue bags are taken for processing and the trash continues to its destination. RRT designed some of the first such facilities, several of which are still in operation.

RRT discussed with the City stakeholders the option of using a similar approach, but instead of co-collecting recyclables with trash, a single cart would be used to collect bagged containers with loose fiber. The experience for participants would be very similar to the most recent program: gather bottles, cans, jugs, and jars in a blue bag, seal the bag and toss it in the cart. They can then add paper and cardboard loose, as long as it can fit in the cart and not cause bridging. Somewhat different than the most recent program, RRT advised that residents could use any commercially available blue recycling bag, of which there are several major brands. The stakeholders were generally positive to the idea, which could facilitate adoption of automated collection while keeping a dual stream program. While there is considerable precedent for co-collection of recyclables and trash, this protocol would be less well tested. The following needs to be taken into consideration for this initiative:

[20] Some communities, such as Sault Ste. Marie in Ontario, address this issue by having participants cut cardboard down, into 2' by 2' pieces to be placed beside the carts. The labor demand to manually collect material beside carts undermines the benefit of automated collection, and the burden on participants to cut down cardboard so significantly is likely unacceptable in Columbia.

- The collection vehicles will likely not be able to compact the loads as heavily as they might otherwise, to reduce breaking the bags in the compartment and thereby contaminating the two streams. This makes each route slightly less efficient than it might be, and also requires the tipping floor of the MRF to be sized to accommodate less compacted, “fluffier” loads.
- The MRF will also need to be designed to have space and equipment to capture the blue bags from the tipped loads and break the bags, and both must be done in a way that is safe and efficient.
- The MRF will further need to be designed to accommodate the presence of errant materials on the “wrong” line—especially containers on the fiber line—and capture as many of them as practical rather than wasting them as outthrows. This is a straightforward engineering task, but it is an added layer of sophistication for the processing system.

All of these challenges can be overcome, as they have in other communities. They are highlighted here to emphasize their importance in future economic analyses of adopting this method of collection.

4.4.2 Evaluate Not Resuming Glass Recycling Curbside

As described in Section 4.1.3, contaminated and dirty glass that has gone through commingled collection and the MRF process does not have a market value; however, source separated glass from purple bins is very useful and marketable, and RRT confirmed there are sizeable facilities that accept it in both Kansas City and St. Louis. For the near term, removing glass from the commingled containers recycling program can both raise commodity values and improve the overall effectiveness of the current MRF.

The options recommended in Section 9 of this report aim for the City to accomplish both the resumption of curbside recycling and modernization of the MRF capabilities in Columbia. If curbside collection can be reactivated while the current MRF is still in service, the City can continue only accepting glass in purple bins at the drop-off centers, and instruct residents not to put glass out at the curb. The reasons and benefits are all the same as discussed just above.

Looking further into the future, there is the question of whether to design the new MRF so that it can accept and satisfactorily process glass in the commingled container stream. Many programs in the past were hesitant to remove glass from their programs because it comprises such a hefty portion of the recycling stream, by weight, and their performance metrics relied on weight captured. This was one of the primary reasons not to remove glass from curbside. Without that artificial burden, the facts of the matter are that while “purple bin” programs might collect less glass, by weight, than curbside, the “purple bin” material will be of higher value and nearly 100% of it recycled. The same cannot be said for MRF glass. Furthermore, purple bin programs cost little to operate, while both the collection and processing glass with commingled containers will have higher per-ton costs. (See Figure 14.)

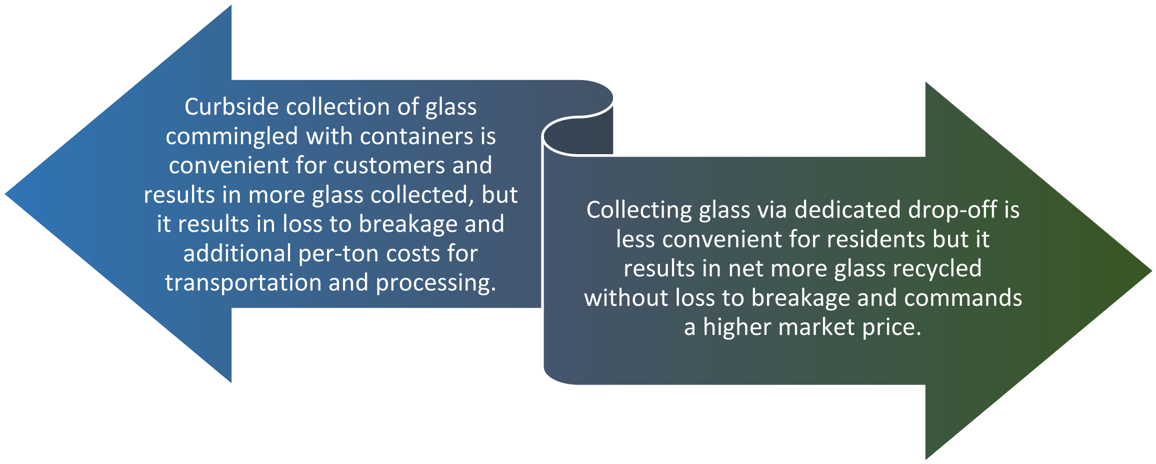


Figure 14: Glass Recycling at the Curb Versus Dedicated Drop-Off

By not including glass in curbside recycling while collecting glass via dedicated drop-off locations, Columbia can keep curbside recycling capacity focused on higher-value commodities of metal and plastic while selling glass as a marketable commodity.

4.5 Creation of Recycling Coordinator Position

Many of the options for increasing recycling and improving participation would benefit from being managed by a new role in the Solid Waste Utility, that of a Recycling Coordinator or similarly-titled position.

Typical job duties would include:

- Acting as a subject matter expert, providing training and assistance on solid waste and recycling programs.
- Responding to inquiries.
- Providing education and outreach at in-person and virtual events.
- Developing promotional and educational content (in coordination with the City's communications department as described in Section 4.3).
- Drafting reports, compiling data, and tracking statistics.
- Coordinating information and education resources for solid waste recycling programs with other departments, municipalities, outside agencies, citizen groups, and businesses.
- Keeping up to date on current and future recycling best practices and legislation.
- Pursuing grants or other funding opportunities.

This person could be responsible for implementing many of the recommendations in Section 9 of this study, providing support to the Solid Waste Manager. Most of the City's solid waste staff have operational responsibilities, and are involved with the landfill, collections, and the MRF. Implementation of the recommendations from this study will require planning and coordination with operational staff.

The salary range would be in the $25/hour range, along the Pay Grade C5, similar to a Sustainability Analyst.

5 Potential Impact on Diversion

Projections for future quantities of waste to be managed was developed using tonnage estimates provided by the City and population estimates from Census data. Population estimates from Census data were within the range of those estimated in the Columbia Area Transportation Study Organization (CATSO) and the Columbia Imagined Plan (Show-Me).

Table 7 presents the projected tons of trash requiring management until 2043. From 2013 to 2022, actual tonnages were used to calculate the generation rate, based on population estimates. Data from the City was used to calculate the proportion of tons of waste generated among residential, commercial (includes commercial, roll-off, and MU) and private haul to the landfill which worked out to 13% residential, 32% ICI and 54% private haul. From 2023 to 2043, an average generation rate from 2005 to 2022 was used to project the tonnage of waste generated by the population and apportioned to the three types of generators using this split.

Table 7: Projected Tons of Waste (2013-2043)

Year	Tonnage	City Managed Waste			Private Haul	Population	Generation Rate (TPY/Individual)
		Projected Residential Tonnage	Projected Commercial Tonnage	Total City Managed			
2013	165,836	21,968	53,730	75,698	90,138	113,767	1.46
2015	173,073	22,927	56,075	79,002	94,072	117,632	1.47
2017	212,369	28,132	68,806	96,939	115,430	121,497	1.75
2019	173,196	22,943	56,114	79,057	94,138	125,362	1.38
2021	190,224	25,199	61,631	86,830	103,394	129,226	1.47
2023	204,001	27,024	66,095	93,119	110,882	133,091	1.53
2025	208,173	27,577	67,447	95,023	113,150	136,956	1.52
2027	214,048	28,355	69,350	97,705	116,343	140,821	1.52
2029	219,922	29,133	71,253	100,386	119,536	144,686	1.52
2031	225,797	29,911	73,157	103,068	122,729	148,550	1.52
2033	231,671	30,689	75,060	105,749	125,922	152,415	1.52
2035	237,546	31,468	76,963	108,431	129,115	156,280	1.52
2037	243,420	32,246	78,867	111,112	132,308	160,145	1.52
2039	249,295	33,024	80,770	113,794	135,501	164,010	1.52
2041	255,169	33,802	82,673	116,475	138,694	167,874	1.52
2043	261,044	34,580	84,576	119,157	141,887	171,739	1.52

Table 8 presents the projected generation of materials in City managed trash from 2023 to 2043. Materials have been classified as targeted recyclables (i.e., those materials accepted in the City's current recycling program), other recyclables (i.e., those materials that can or could be diverted through other programs such as film bags, non-bag film, bulky plastics, EPS, other ferrous metal, food waste, yard waste, clean wood, carpet, mattresses and foundations, tires, electronic waste and HHW). The remainder of the materials that cannot be diverted would be sent for disposal.

Table 8: Projections of City Managed Waste by Commodity 2023-2043 (tons)

City Managed Waste	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041	2043
Tonnage	93,119	95,023	97,705	100,386	103,068	105,749	108,431	111,112	113,794	116,475	119,157
Paper	25,422	25,941	26,673	27,405	28,138	28,870	29,602	30,334	31,066	31,798	32,530
Plastic	18,251	18,625	19,150	19,676	20,201	20,727	21,252	21,778	22,304	22,829	23,355
Metal	3,632	3,706	3,810	3,915	4,020	4,124	4,229	4,333	4,438	4,543	4,647
Glass	2,421	2,471	2,540	2,610	2,680	2,749	2,819	2,889	2,959	3,028	3,098
Organics	26,539	27,082	27,846	28,610	29,374	30,139	30,903	31,667	32,431	33,195	33,960
C&D / Bulky Materials	6,798	6,937	7,132	7,328	7,524	7,720	7,915	8,111	8,307	8,503	8,698
E-Waste / HHW	372	380	391	402	412	423	434	444	455	466	477
Other Materials	9,684	9,882	10,161	10,440	10,719	10,998	11,277	11,556	11,835	12,113	12,392
Total Target Recyclables	19,834	20,240	20,811	21,382	21,953	22,525	23,096	23,667	24,238	24,809	25,380
Total Other Recyclables	33,150	33,828	34,783	35,738	36,692	37,647	38,601	39,556	40,511	41,465	42,420
Disposal	40,321	41,145	42,306	43,467	44,628	45,789	46,951	48,112	49,273	50,434	51,595
Total	93,305	95,213	97,900	100,587	103,274	105,961	108,648	111,335	114,021	116,708	119,395

As outlined in Section 4.1.2, the waste composition study revealed large quantities of OCC discarded by the ICI sector. The City could actively encourage diversion of this material through promotion and education; encouraging the use of compactors, or ultimately, creating an ordinance to required recycling of OCC. Table 9 presents a conservative estimate of tons of OCC that could be diverted from landfill, with additional outreach and education starting in 2024. An ordinance would greatly increase the tonnage diverted, but that is a longer-term, more complicated initiative for the City to undertake. The City could also focus on other materials discarded by the ICI sector that could be diverted from landfill, such as clean wood, as the ICI sector gets accustomed to increased recycling.

Similarly, if the Columbia was to undertake an outreach and education campaign to increase residential recycling, more materials could be diverted from the landfill. With the introduction of the cart-based PAYT program in 2024 and the accompanying promotion and education campaign, the City is likely to experience an uptick in participation in its recycling program. The table below shows modest improvements in capturing paper, plastic, metals, and glass, primarily through outreach and education.

With these two initiatives alone, in 10 years the City could be diverting an additional 10,000 tons annually.

Table 9: Projected Additional Diversion of Commercial and Residential Recyclables (2024-2034)

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Commercial Diversion											
% annual increase of OCC	20%	23%	26%	29%	32%	35%	38%	41%	44%	47%	50%
Tons diverted from landfill	1,117	1,303	1,494	1,689	1,890	2,095	2,305	2,520	2,739	2,963	3,193
Residential Diversion											
% annual increase of paper, plastic, metal, glass	5%	10%	15%	20%	25%	30%	33%	35%	37%	40%	42%
Tons diverted from landfill	726	1,473	2,240	3,028	3,837	4,667	5,202	5,590	5,987	6,555	6,970
Total Additional Materials Diverted from Landfill	1,843	2,776	3,734	4,717	5,727	6,762	7,507	8,110	8,726	9,518	10,163

6 Options for Evaluating Performance

The following sections provide a description of current metrics for evaluating the City's performance for waste management and potential future performance metrics which could more accurately measure the City's performance and progress towards goals.

6.1.1 Current Metrics

The Solid Waste Utility does not report on the performance of its waste management system, but the CAAP has a key performance indicator related to waste of a recycling rate (tons of recycling/tons of waste) (see Section 2.3 for background on the CAAP). The 2021 CAAP Annual Report indicated the actual recycling rate was 7.5% for 2020 (down from the baseline of 14% in 2015).

Recycling rates can vary dramatically depending on the inputs to the calculation. For example, using 2022 data, the City has a recycling rate of about 13% using tons of recycling collected divided by all waste generated in the City. When calculated using the tons of recycling marketed, that rate falls to about 4%, due to the large quantities of contamination.

As described in Section 2.3.2, this is a simple tons-over-tons calculation commonly used by municipalities across North America, but which has some fundamental flaws. Municipalities have no control over the composition of recycling – as noted, many products have been lightweighted (i.e., thinner containers), or packaged in non-recyclable packaging (e.g., stand-up pouches). Other packaging trends include a condition commonly referred to as "shrinkflation," in which producers reduce package content/sizes in order to keep the retail price steady, and there is a long-term overall trend away from heavy packaging materials such as glass and metal. These all negatively impact the value of weight-based metrics, even when participation increases, and more units of packaging are being delivered to MRFs.

A recent article in *Plastics Today*[21] noted that in addition to thinner and lighter bottles, many brands are foregoing labels or wraps on their bottles and instead printing or etching information directly onto the bottle. The article also featured one packaging maker who had found a way to reduce the weight of the threaded neck of the bottle by about 50%. Because this part contains so much of the plastic in the package, the net impact on a bottle's weight could be as much as -20%. This illustrates how even if recycling participants recycle more of their containers, and more people participate in recycling, each item weighs less than in previous years, making tons-over-tons recycling rates of limited use as performance metrics over time.

The recycling rate calculation also includes tons of material hauled to the City's landfill from the ICI and multi-family sectors that are not required to or choose not to recycle, over which the Solid Waste Utility and the City have no control.

Many municipalities have moved from weight-based metrics (e.g., a recycling rate), and instead are refocusing the lens away from landfill capacity and more towards sustainability, social justice, and climate impact. New metrics used include generation rates, disposal rates, changes to greenhouse gas emissions, and other more operational metrics such as capture or contamination rates.

[21] https://www.plasticstoday.com/packaging/amcor-lightweights-pet-bottle-finish-50, January 5, 2023

6.1.2 New Metrics

The CAAP was designed to be a living document with targets and goals updated every five years. At that time, the City will have a better understanding of the status of its recycling infrastructure and ability to offer diversion programs. The key performance indicator for waste could be adjusted at that time to better reflect the reality of what the City is able to achieve.

The following presents some new potential metrics the City could consider that more accurately reflect progress the City is making on diversion.

Generation Rates

The City would be looking for a decrease in generation rates on a per capita basis to reflect waste reduction or reuse initiatives by residents. This would be measured by dividing the total tons of waste (disposed and diverted) by the City's population. Generation rates would reflect waste reduction or reuse since these materials would not enter the waste stream (for diversion or disposal).

Based on 2022 data, the City's waste generation rate is approximately 8.3 pounds per person per day. The EPA reports that the 2018 MSW generation rate across the U.S. is 4.9 pounds per person per day.

Capture Rates

The City could explore ways to increase capture rates for acceptable recyclable materials (i.e., fewer materials in the trash and more in the recycling bin). These rates could be measured through curbside audits. The City could calculate capture rates for individual commodities and track progress in increasing the tonnages being recycled.

In 2023, 21% of City-managed waste disposed in the landfill consisted of targeted recyclables (See Figure 8).

Examples of materials the City could focus on include:

- Cardboard: Currently 8% of the material going to landfill is cardboard, as seen in Figure 10 on page 20. The City reported marketing 5,266 tons of OCC/Kraft Paper in FY 2022, while it was estimated that in 2022, there were approximately 7,085 tons generated resulting in a capture rate for this material of 74%.[22] Cardboard is one of the most price-steady recyclable commodities and most straightforward to recycle. Keeping this capture rate at this level or above is a meaningful metric for Columbia.
- Aluminum: The City marketed 92 tons in FY22, while it is estimated that 590 tons were generated, resulting in a capture rate for aluminum of 16%. Considering that aluminum is a high-value commodity and recycling aluminum cans has significant positive environmental and climate impacts, improving on this capture rate would be a meaningful ambition for Columbia.

Contamination Rates

The City would be looking for lower contamination rates in recycling programs (curbside and/or drop-off center) with increased enforcement or promotion to inform residents of what materials are accepted in

[22] Capture rates are estimates only. Data sets would need to use the same time period (either annual or fiscal years) to calculate capture rates more accurately.

the City's recycling program. From a programmatic perspective, the City's commitment to dual stream recycling is a large part of preventing contamination.

Participation Rates

As mentioned in Section 3.4, it is currently very difficult to determine a participation rate in Columbia since many people use both the curbside program and Recycling Drop-off Centers if they miss a collection day or have too much material. Should the City decide to close the Recycling Drop-off Centers, and if frequency of collection was increased to weekly collection, a curbside recycling participation rate could be determined, with annual goals of increased participation.

7 Options for Updating Waste Management Infrastructure

The options in the previous sections for improving participation in recycling and increasing diversion involve choices made at the point of discard, availability of services, and program opportunities. As the MRF Evaluation found, however, the current infrastructure at the MRF could not successfully accept and process any additional tons that would result. Furthermore, the current design is labor-intensive, resulting in operational inefficiency, and the existing equipment is not performing as designed. For this reason, the recycling infrastructure for handling materials once individuals and businesses take the action to separate and divert it to reuse, recycling, or other proper management needs to be improved. In addition, to increase diversion and improve participation as described throughout Section 4, a modern and convenient location where residents and small businesses can bring their materials will be needed.

7.1 MRF Options

The project team discussed several options for improving the processing capacity and quality at the City's MRF. They are summarized in Table 10, below. Greater detail about each option is discussed in Sections 7.1.1 through 7.1.5.

Table 10: Comparison of Options for Processing of Recyclables

Description	Cease MRF operations and implement transfer operations	Retrofit or upgrade existing MRF	Construct a New MRF on Current Site	Construct a New MRF on New Site at Landfill
Stakeholder acceptance	Stakeholders have indicated they want the City to continue processing recyclables locally, so this option is less acceptable than options that keep an active MRF in Columbia.	Would be more acceptable from a cost standpoint, compared to a new MRF, but does not allow for much future growth.	Requires transfer of recyclables during construction period, makes the MRF building unavailable for development as a community environmental center. Less acceptable from a cost standpoint than retrofitting.	May be more acceptable due to ability to continue to process recyclables at old MRF during construction, and ability to use old MRF for community environmental center. Less acceptable due to higher cost of new MRF.
Level of Effort	City would need to convert the MRF tipping floor to transfer operations, and procure both trucking and processing (or implement hauling operation)	Less effort than building a new MRF, but still major procurement effort for equipment. May require construction of an entirely new building. Would require alternate handling of recyclables until MRF is operational.	Significant level of effort for City, including major procurement effort. Would require some permitting, design and construction of MRF. Would require alternate handling of recyclables until MRF is operational.	Significant level of effort for City, including major procurement effort. Would require permitting, design and construction on new site.
Timing	Less than 6 months	1-2 years	2-3 years	2-3 years
Cost	Lowest cost, capital expenditure relatively minimal.	Lower cost than the other MRF options, approximately $8,800,000.	Higher Cost, offset somewhat by reusing existing building, approximately $16,600,000.	Highest Cost for MRF, develops entirely new building, approximately $28,120,000.

Description	Cease MRF operations and implement transfer operations	Retrofit or upgrade existing MRF	Construct a New MRF on Current Site	Construct a New MRF on New Site at Landfill
Impact on Diversion	City has limited ability to monitor contamination and modify programs to increase diversion.	Current building size could limit the size/type of new equipment which might restrict the ability of the City to divert more materials.	MRF could be sized larger to accommodate growth and diversion of more recyclables.	MRF could be sized larger to accommodate growth and diversion of more recyclables.
Variations	City could modify recycling program to focus on higher value materials such as OCC, some plastics (#1, #2) and metal.	City could build additional storage capacity for storing baled material, creating more space within the current building for equipment.	N/A	The conceptual design could be implemented at either of two locations on the landfill campus
Implementation Considerations	City may need to do some compaction to increase density of collected materials to reduce hauling costs.	City would need to transfer recyclables during construction. City would not be able to use existing structure for community environmental center.	City would need to transfer recyclables during construction. Site of relocated Landfill Operations Center used for community environmental center.	City could continue to use old MRF during construction. Old MRF site could be used for community environmental center. Depending on the location of the new MRF, other activities (e.g., container repair) will need to be accommodated.

7.1.1 Cease MRF Operations and Implement Recyclables Transfer Operations

The first option discussed was to decommission the MRF, end that line of business, and implement transfer of Columbia's recyclables to another MRF, likely near St. Louis or Kansas City.

It is an established and well-known standard in the recycling industry that transporting recyclable material more than 100 miles is not economically sustainable. Waste Advantage magazine notes that waste is generally transported in 20-ton loads by tractor trailers.[23] Assuming Columbia will continue to receive approximately 13,000 tons per year, that is 650 truckloads per year. TCI Business Capital reported[24] on cost tracking by trucking industry firm DAT Freight and Analytics that in August 2023, per-mile trucking costs in the Midwest were $2.21 per mile. (The report also noted a long-term trend of trucking costs in the Midwest being some of the highest in the U.S.) The closest MRF to Columbia that could be identified was the "Recycle City" processing facility in St. Peters, almost exactly 100 miles away. Privately-owned MRFs are located in Hazelwood (229.2 miles round trip) and Kansas City (258 miles round trip). These locations would result in trucking charges of about $329,000 to $371,000 per year, or about $25 to $28.50 per ton. As the American Transportation Research Institute notes in its reporting, "deadhead" miles (carrying no cargo) usually cost more for trucking companies. A trailer that hauled recyclables for the City would probably return as a "deadhead," possibly resulting in higher-than-average rates.

Industry insight shows that processing fees at present are typically $80 to $100 per ton, depending on contract length and the presence of any revenue sharing. Contracts are commonly at least 7 years long (5 years with 2 years of possible extensions) with many being 10 years long (7 years with 3 years of possible extensions). Longer contracts help with MRF business planning, including investments in up-to-date equipment. They are more likely to provide more value to municipal customers, especially in terms of revenue sharing or rebates.

It bears noting that in the case of Columbia, the annual transfer operations might not be much different than the current MRF operations. The difference would be in the capital expenditures: building transfer facilities for the recyclables would cost much less than any of the MRF options.

FY23 MRF Operations	Estimated Recycling Transfer Operations
$1,656,375 Budget	Trucking $329,000 to $371,000 per year + Tipping fees $1,300,000 per year 1,629,000 to $1,671,000 per year Does not include operations for receiving recyclables and loading transfer trailers

Transfer activity could start within a very short amount of time, and the MRF building could be repurposed as a transfer station within 12 to 18 months. As discussed in Section 4.1.1, the stakeholders from all sectors expressed a preference for operating a MRF locally; however, temporarily transferring recyclables could be necessary depending on which MRF Option the City might pursue.

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[23] https://wasteadvantagemag.com/transfer-trailers-safety-over-the-road/
[24] https://www.tcicapital.com/tci-insights/current-freight-trends/

7.1.2 Retrofit or Upgrade of Existing MRF

The findings of the MRF Evaluation, which are summarized in Section 3.1. and which can be found in Appendix A, make it clear that the current equipment and system is not only at end of life but over capacity and incapable of accommodating any growth in the recycling program. The full report has details for improvements that need to be made if the current MRF is going to continue processing recyclables for any considerable period of time.

Depending on the condition of the existing building and the ability for it to be rehabilitated, a new dual stream MRF could be designed to fit within the current frame and footprint. Such a design would greatly improve on the current system by employing modern technologies that can recover more recyclable commodities from the incoming material. It would also greatly reduce the number of sorters needed: the fiber line would need only one person, to quality-check cardboard, and the commingled containers line would need actually no manual sorting—just two employees to grab and break the blue bags. This would be a considerable upgrade as compared to the current system without the significant cost to enlarge the current building or build a new one.

Fitting a new MRF system into the existing footprint would almost certainly require a much smaller capital expenditure compared to the other MRF options. It might also be accomplished in a shorter time frame than options requiring a new building, resulting in additional savings on the length of time for which recyclables have to be transferred out of town. However, the design would have limitations due to the confines of the existing building, running an estimated throughput of 2-3 tons per hour (tph) on the container line and 4-5 tph on the fiber line. When the recycling tons increase, even if only due to population growth, processing capacity would eventually need to be expanded by adding shifts (more operating hours), increasing operations costs and possibly creating staffing issues.

7.1.3 Construct a New, Larger-Capacity MRF on Current Site

Figure 15 shows the expansion of the existing MRF building 40 feet north to accommodate the new process equipment and additional bale storage. The proposed process throughput of the MRF is 3 TPH of commingled containers and 8 TPH of fiber, including ICI cardboard. The processing area is a conceptual footprint and is subject to change based upon the final design.

Truck traffic would weigh at the proposed scale location (see also Figure 16, below) and proceed along the path lined in red. Trucks would pass in front of the solid waste administration building. The proposed tipping floor has two (2) overhead doors for trucks to enter and exit. The tipping floor is 8,000 ft^2 and is designed to store fiber and containers for approximately two (2) days. The tipping floor has three (3) infeed conveyors: one for fiber, one for commingled containers, and a direct-bale conveyor for ICI cardboard. This design would keep the tipping floor in the same configuration as the existing MRF building.

The infeed conveyors will convey the material to the 11,000 ft^2 processing area. Two (2) compactors are shown along the exterior of the west wall, where residue will be compacted, loaded into roll-off containers, and transported to the landfill. This concept includes one (1) single-ram baler.

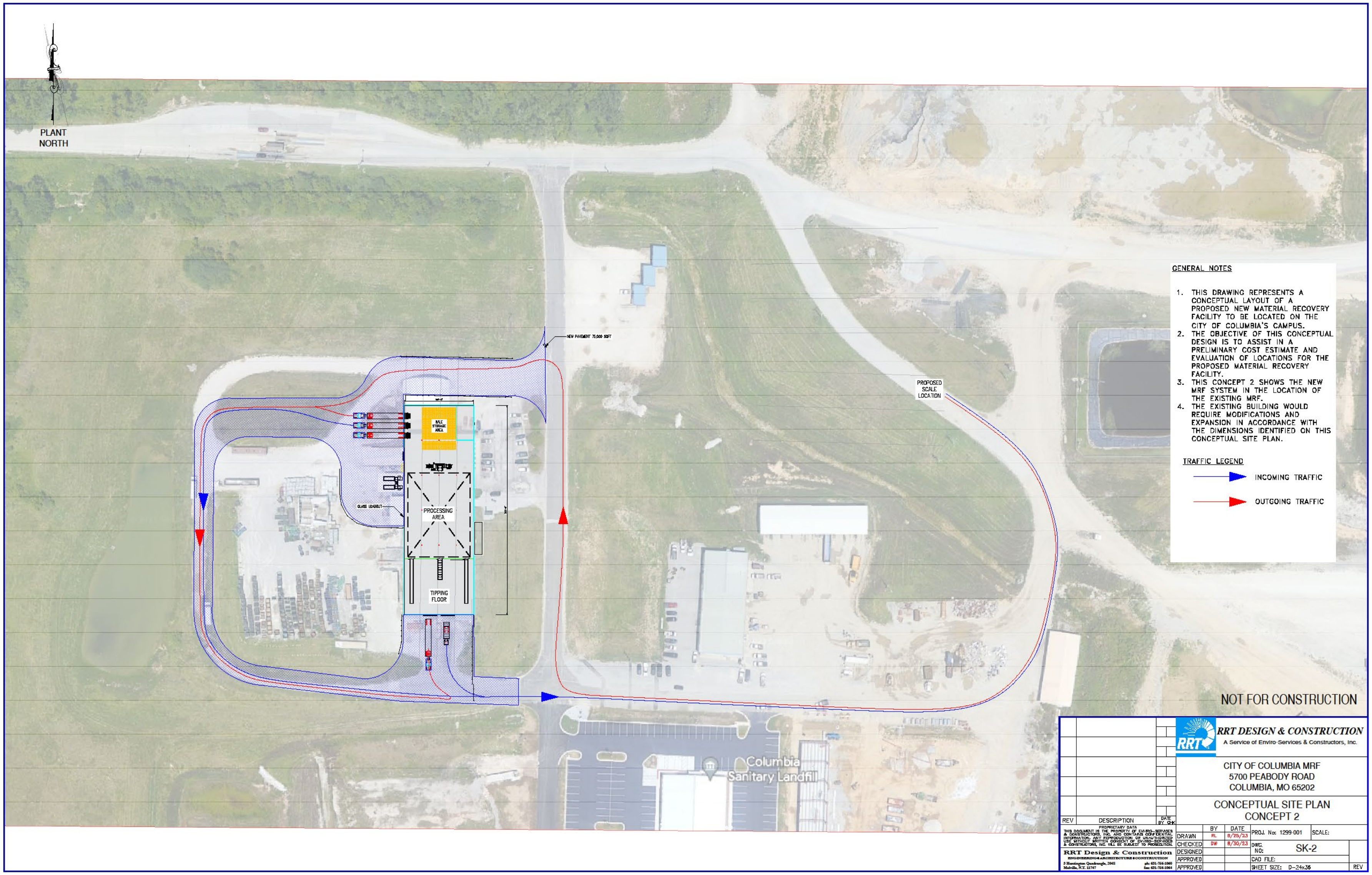


Figure 15: Conceptual Site Plan for New, Larger-Capacity MRF on Existing MRF site

The bale storage, loading docks, and administrative area are shown along the north side. The bale storage is 2,255 ft^2 and is designed to store bales for approximately three (3) days of production. The bales are stacked four (4) high and the total bale storage area can store approximately 415 bales. East of the bale storage area is a 1,500 ft^2 administration area that may include office space, breakroom, and/or employee locker room. The exterior sitework around the new building would include adding 75,000 ft^2 of pavement around the building, indicated in blue. The existing employee parking area would remain.

In part due to a long-term trend of construction supply delays and scheduling setbacks being experienced across the U.S., this option would likely take 2 to 3 years from start to finish. The need to decommission the current MRF and assess the foundation before construction can begin also contributes to the longer timeline. In addition to construction costs, Columbia would need to transfer recyclables from the time the current MRF is decommissioned until the new one is ready. Because this contract would be relatively short, it is likely that the negotiated price would include a premium for that factor, and revenue sharing would not be offered.

7.1.4 Construct a New, Larger-Capacity MRF on a New Site at the Landfill

To consider construction of a new MRF on a new site, for the purpose of avoiding the need to bypass recyclables during construction and to then have the existing MRF building available for repurposing, RRT and the project team looked at two possibilities, as shown in the aerial photo in Figure 16: Location A, which is a gravel lot south of the current MRF location, and Location B, which overlays the current Landfill Operations Center (LOC).

Also shown on the photo are other future changes on the campus, as proposed by the Solid Waste Utility:

- opening of the next landfill cell (Cell 7),
- relocating the scalehouse forward along the road, to eventually provide a more direct route from the scale to Cell 7, and,
- relocating the LOC southward to be closer to Cell 7.

The City is also planning on relocating the LOC which would free up that area for redevelopment for the new MRF. The current container repair operations would need to be accommodated elsewhere.

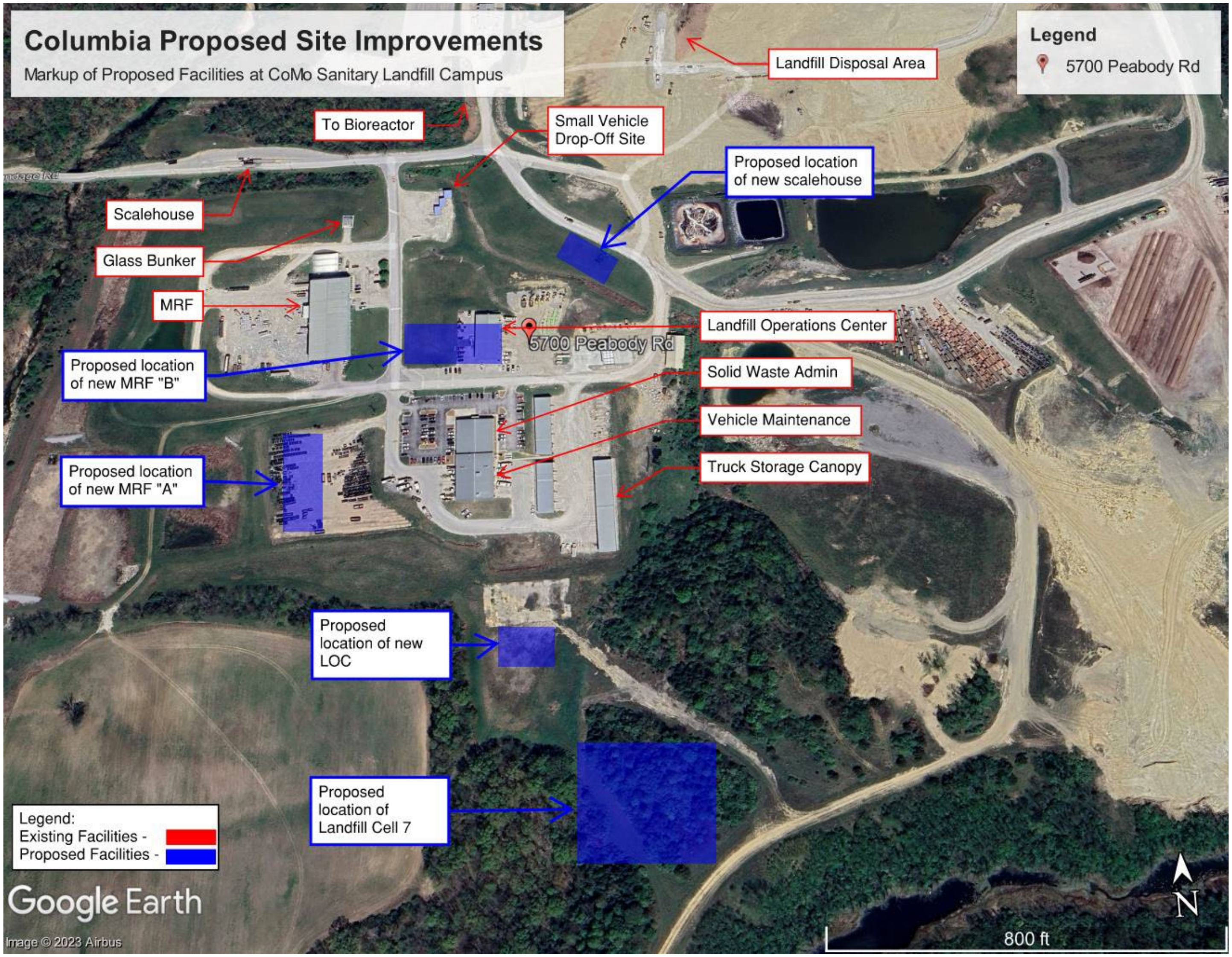


Figure 16: Aerial Photo of Columbia Landfill Property, Showing Proposed Locations for Infrastructure

Table 11 shows a comparison of the two sites with regards to possible traffic flow, what is known about the condition of the site, and other factors which might influence its selection.

Table 11: Comparison of Suitability for Location of a New MRF on a New Site

	Location A (gravel lot)	Location B (current LOC location)
TRAFFIC	If the scalehouse is relocated, recycling trucks accessing a MRF at Location A would have to pass in front of the Administration building to go from the scale to the MRF, creating risk for visitors and staff. If the scalehouse is not relocated, recycling trucks would have to make a left turn when exiting the MRF to go back to the scale, creating risk.	Regardless of whether the scalehouse is relocated, if the MRF was at Location B, recycling trucks could access the scale, the MRF, and the scale again without needing to pass in front of the Administration building or make any left-hand turns.
SITE	Location A is an unknown quantity: it has not been developed and there are no utilities in place. As shown in the photo, to the west and downgrade is a stormwater pond. Building a new foundation and building on the gravel site may be complicated by groundwater or stormwater issues.	Location B is already developed and there are utility lines there. To accommodate heavy truck traffic, some improvements will be required.
OTHER	Location A does not require the relocation of any current operations—in fact, traffic patterns would be slightly safer if the scalehouse were *not* relocated.	Location B requires the relocation of the LOC, but its traffic safety is unaffected by whether or not the scalehouse moves.

All else being equal, Location B has preferable traffic patterns and has the advantage of having been previously developed. Accordingly, Figure 17, below, shows a conceptual design tailored to Location B, the current LOC location. It should be noted, the same design could be developed on Location A, depending on site suitability. The proposed process throughput of the MRF is 3 TPH of commingled containers and 8 TPH of fiber, including ICI OCC. The processing area is a conceptual footprint and is subject to change based upon the final design.

Truck traffic will weigh at the proposed scale location and proceed southwest to the tipping floor or loading dock. The proposed tipping floor has two (2) overhead doors for trucks to enter and exit. The tipping floor is 8,000 ft^2 and is designed to store fiber and containers for approximately two (2) days. The tipping floor has three (3) infeed conveyors: one for fiber, one for commingled containers, and a direct-bale conveyor for ICI OCC. This conveyor configuration is similar to the MRF's existing tipping floor.

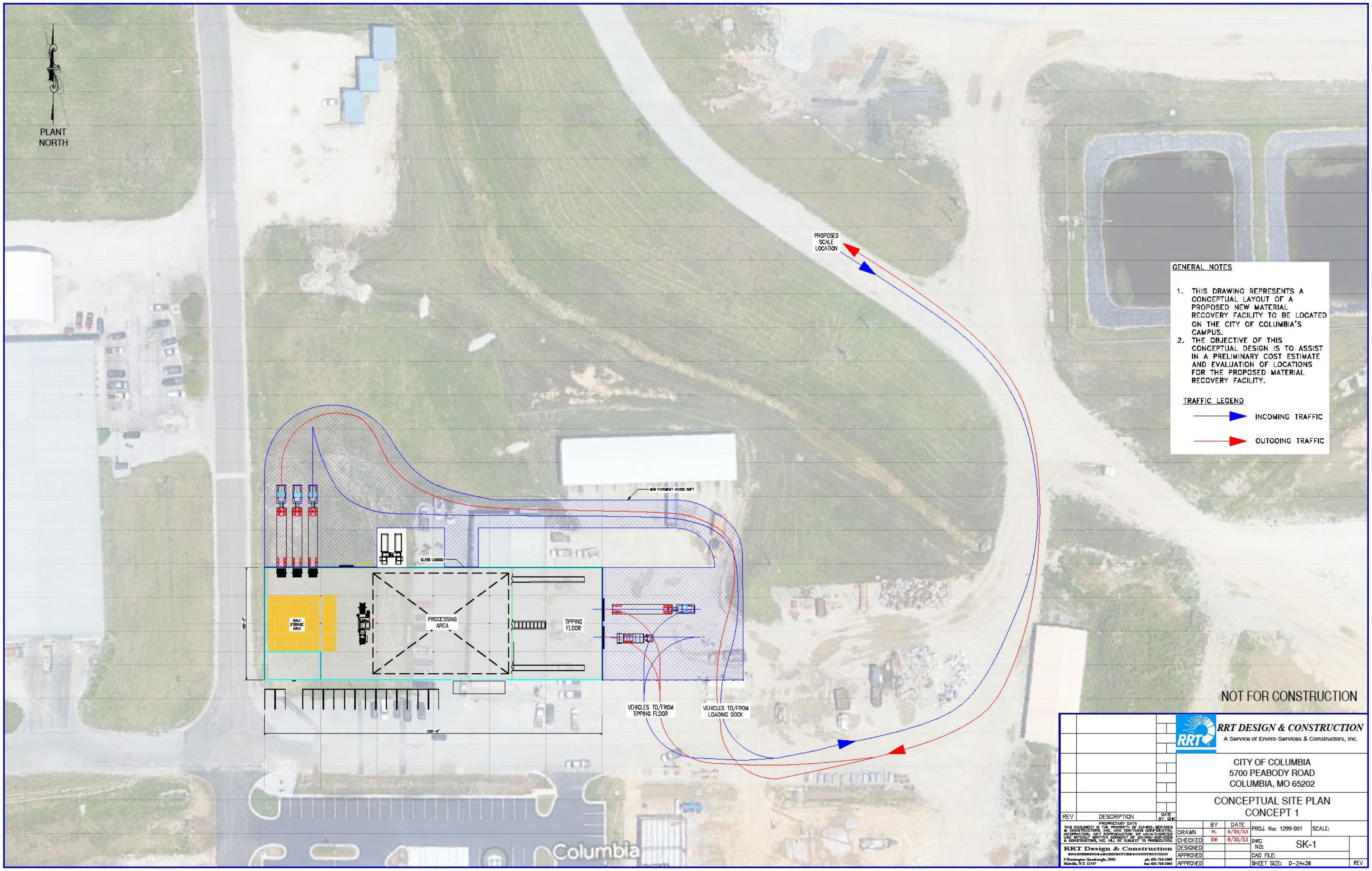


Figure 17: Conceptual Site Plan for New, Larger-Capacity MRF on Site of Existing LOC (Location B)

The infeed conveyors will convey the material to the 11,000 ft^2 processing area. Two (2) compactors are shown along the exterior of the north wall, where residue will be compacted, loaded into roll-off containers, and transported to the landfill. This concept includes one (1) single-ram baler.

The bale storage, loading docks, and administrative area are shown on the west side. The bale storage is 2,255 ft^2 and is designed to store bales for approximately three (3) days of production. The bales are stacked four (4) high and the total bale storage area can store approximately 415 bales. Along the north wall of the building are three (3) loading docks for trucks to be loaded with bales. South of the bale storage area is a 1,500 ft^2 administration area that may include office space, breakroom, and/or employee locker room.

The exterior sitework around the new building would include adding 40,000 ft^2 of pavement, indicated in blue. Additionally, new employee parking spaces would be created along the south of the building. In part due to a long-term trend of construction supply delays and scheduling setbacks being experienced across the U.S., this option would likely take 2 to 3 years from start to finish.

7.1.5 MRF Option Cost Analyses

High-level cost estimates were generated for development of each of the MRF options. [25] They are based on industry standards, recent projects, and the size of the processing system. Many construction costs were calculated on a per-square-foot basis and multiplied by the square footage needed. MRF equipment costs are based on recent projects and include commissioning by the manufacturer. Engineering costs include design, building engineering, construction management, and other related costs. Not included here are costs related to any of the relocation efforts the Solid Waste Utility has proposed (i.e., the LOC and the scalehouse). Also not included here are costs related to secondary activities which might be required, such as transferring recyclables, relocating the container maintenance activities, and roadbuilding.

As shown in Table 12, the construction and engineering costs for the building that is constructed to contain the MRF are really the biggest differentiators in the three MRF options.

[25] No cost estimate was prepared for the option to cease MRF operations.

Table 12: Project Costs to Develop MRF Options

	Retrofit/Replace Existing MRF	New larger MRF on existing site	New larger MRF on new site
PROCESSING EQUIPMENT	$ 5,000,000	$ 10,000,000	$ 10,000,000
New Dual Stream Equipment System with 3 TPH Container line, 8 TPH Fiber line	-	$ 10,000,000	$ 10,000,000
Retrofit/Replace with 2 TPH Container line, 4 TPH Fiber line	$ 5,000,000	-	-
BUILDING & SITE IMPROVEMENT	$ 3,300,000	$ 5,300,000	$ 16,520,000
Repair existing building damage	$ 300,000	$ 300,000	-
Repair existing site/pavement (approximately 75,000 ft^2)	$ 3,000,000	$ 3,000,000	-
Construct new 4,000 ft^2 building addition	-	$ 2,000,000	-
Construct new 30,000 ft^2 pre-engineered metal building	-	-	$ 15,000,000
New sitework/pavement (approximately 38,000 ft^2)	-	-	$ 1,520,000
DEMOLITION	$ 100,000	$ 300,000	$ 300,000
ENGINEERING	$ 400,000	$ 1,000,000	$ 1,600,000
Equipment Systems OEM Engineering and Design	$ 200,000	$ 300,000	$ 300,000
Owner's Engineer & Construction Management (equipment)	$ 100,000	$ 300,000	$ 300,000
Owner's Engineer & Construction Management (building)	$ 100,000	$ 400,000	$ 1,000,000
TOTAL	$ 8,800,000	$ 16,600,000	$ 28,420,000

7.2 New Community Environmental Center at Landfill Campus

As discussed in Section 4.2.2, developing a staffed, multi-material community environmental center will provide strength to efforts at increasing recycling and improving participation. It increases recycling by consolidating operationally inefficient un-staffed Recycling Drop-off Centers and allowing for allocation of resources to curbside collection. It improves participation by providing a location where multiple types of recyclables and potentially polluting or hazardous items can be accepted, in a setting that is safe and accessible to users of all abilities.

Two examples of community environmental center designs are described below that could provide these benefits—one that is indoors and one that is outdoors. Considering the typical seasonal weather conditions in Columbia, including a relatively long winter and very hot summers, an indoor design would be preferable. The existing MRF building has great potential for being repurposed as an indoor community environmental center, if its condition is acceptable. If the LOC is relocated and the site is not used for a new MRF, it could also be redeveloped into a community environmental center.

7.2.1 Community Environmental Center Design

There are many different designs for community environmental centers, but one that is a very popular with users and offers excellent flexibility over time is a "Z-wall" design (sometimes called a "sawtooth" design), which refers to the zig-zag line revealed when looking at the drawings and plans or viewing aerial photographs. The experience for users is similar to standing on a loading dock and depositing items into a "dumpster" or other receptacle which is adjacent but situated at a lower elevation. In each "notch" of the "Z-wall," there is an open-top roll-off container into which users deposit the material indicated on signage nearby. Users enter in a passenger vehicle and park in marked spots according to what material(s) they have. There is a bar or safety chain between the user and the receptacles below, and bollards to keep vehicles and pedestrians safe. Users can make multiple stops along the "Z-wall" as needed, or can walk between points. Safety measures include one-way traffic and rules such as requiring all children and pets to stay in vehicles.

The benefits of this design are well-suited for the needs of Columbia for a community environmental center to increase diversion and improve participation, as shown in Figure 18:

Flexibility & Versatility	Adjust accepted material types with simple changes to signage
	Respond to customer conditions quickly by opening or closing access to receptacles
	Activate as an emergency debris site if needed
Safety & Accessibility	One-way traffic protects employees, pedestrians, and drivers
	Users do not need to raise arms over head when depositing items; facility is accessible to users of wheelchairs and other mobility aids
	No interaction between customers and the heavy trucks servicing the receptacles
Operational Best Practice	Staffing improves material quality and reduces improper dumping
	Site is easy to keep clean with brooms and/or wash-down
	Assigning 2 or more receptacles to popular materials, then opening and closing them one at a time, allows for better management of trips to the MRF

Figure 18: Benefits of Z-wall Design Community Environmental Center

The following are two examples of facilities that utilize "Z-wall" designs. The first is two-sided and indoors; the second is smaller and located outdoors. Columbia could possibly develop a one-sided indoor design by repurposing the current MRF building or the current LOC structures, or re-develop the current "Small Vehicle Drop-off Site" at the landfill for a similar design with a roof and wind screens.

Self-haul Center in Olmsted County, MN

Olmsted County is located in southeastern Minnesota, with a population of about 163,000 people. Almost two-thirds of that population is clustered in the city of Rochester, home to the headquarters of the world-renowned Mayo Clinic, meaning much of the county is rural. Many residents therefore self-haul their trash and recyclables to the County solid waste campus, where they use a facility called the Recycling Center Plus. RRT created conceptual designs for an indoor two-sided Z-wall facility. Customers would drive up an incline ramp from level and enter the facility above ground level. They would park and discard their materials into open-top containers below, at ground level. They would exit the building and then drive down another ramp, back to ground level. Figure 19, below, shows a design prepared for a new self-haul facility at Olmsted County. Description of the elements shown in the figure follow.

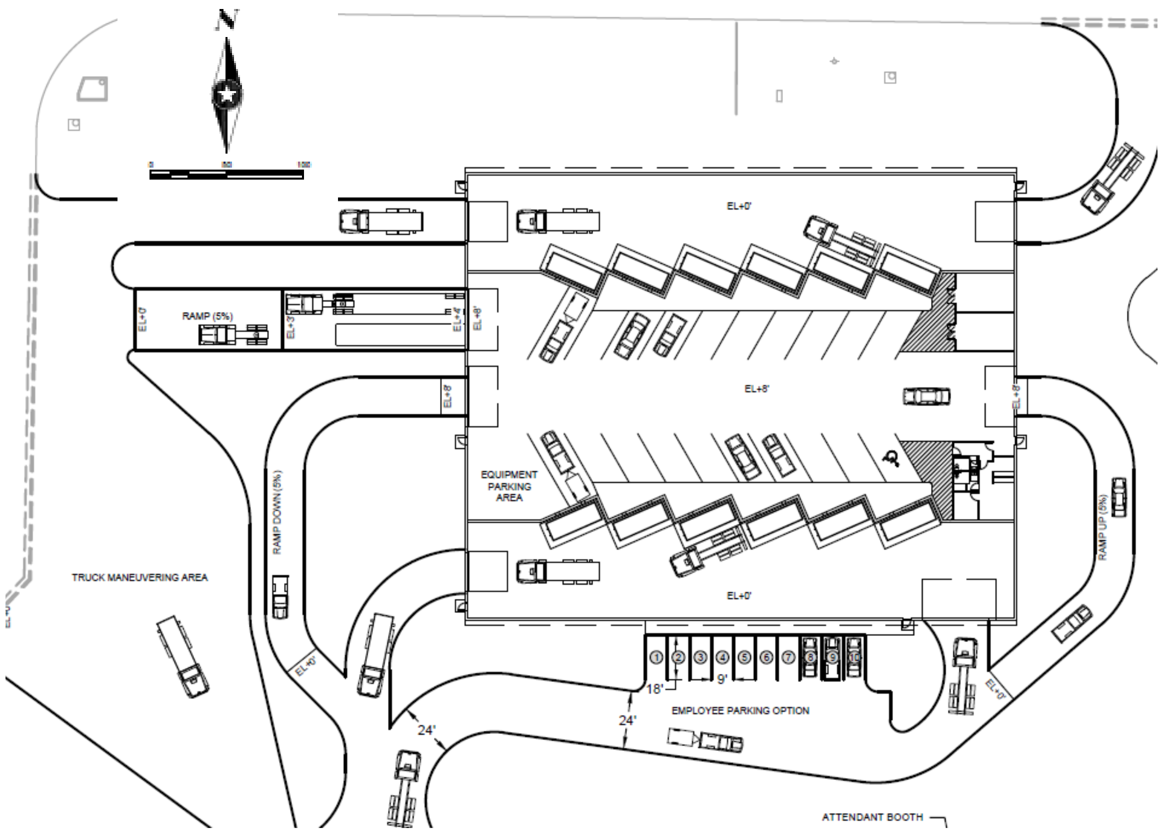


Figure 19: Design for an Indoor Z-wall Drop-off Center

This figure shows the footprint of the building and how vehicles move through the facility. Most traffic enters from the south, at the lower edge of the drawing, just left of center, and proceeds counterclockwise through the facility. Trucks servicing the southern bays enter at ground level just past the employee parking spots. They pick up roll off containers and continue one-way to exit the building and take the material to its destination. Customers follow the roadway up an incline and enter the building above ground level. They back into market parking spots to deposit their materials. As shown, some of the parking spots are longer, to accommodate customers pulling a trailer. At the end of the building, there are two loading docks for tractor trailers. Trailers can be parked here for longer periods of time to collect different types of materials, for example bicycles for charitable use or electronics for recycling. (Trucks servicing the northern bays enter from that side and have their own traffic pattern, to reduce crossings and turns.) This design also has employee areas for the staff working here, including indoor restrooms, a break area, and office space.

Recycling Center in Tampa, Florida

This recycling center is integrated with a waste transfer station where contractors and residents can bring debris such as furniture, brush, etc. Users drive up a curved incline ramp from ground level to the platform, from which they can discard their materials into open-top containers below at ground level. They exit by driving down another curved ramp, and can then leave the facility or proceed to the transfer station scales to dispose of additional materials.

Figure 20: Back-In Parking Areas for Customers, City of Tampa "Z-Wall" Recycling Center

Figure 20 is a photo taken from above the finished recycling center, showing the parking spaces and the difference between the elevation of the containers and the customer area. Note the bollards and chain to keep customers and vehicles on the platform, and the waiting containers below. In this design, customers enter from the left side of the photo, back into a parking spot, discard their items, and exit to the right of the photo.

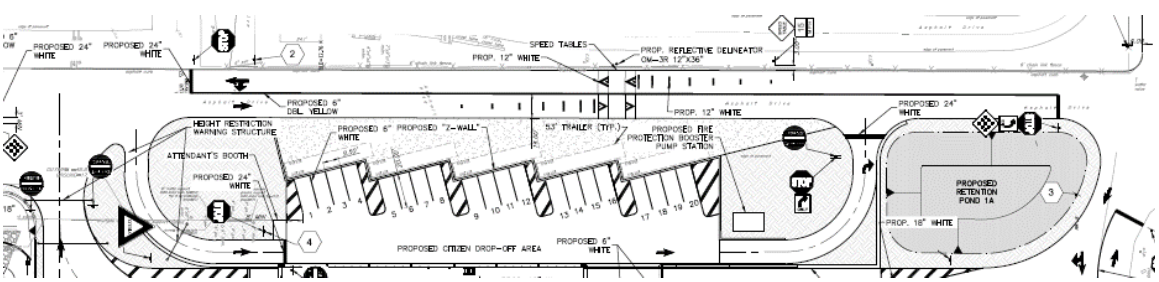


Figure 21: Signing and Pavement Markings, City of Tampa Recycling Center

Figure 21 is an excerpt of the signing and pavement markings plan for directing traffic at the recycling center. It illustrates the "Z-wall" design, and shows the entry ramp up, on the left side of the figure, and the exit ramp down, on the right side of the figure. It shows how the angle of the parking spots induces customers to back into the spots. Also shown is the small attendant booth near the entry. Very light gray rectangles show where the collection containers are placed.

7.3 Recycling Drop-off Centers

Because a new community environmental center at the Landfill campus would be greater than a 15-minute drive for residents in the southwest-most portion of Columbia, the City could keep either the Recycling Drop-off Center on either S. Providence Rd. or State Farm Parkway open and convert it to a staffed site. Both already have a fence in place, and are popular with well-engaged participants in recycling. The following is an example of a successful, long-time drop-off center and some of its operational costs.

7.3.1 Example of a Small-Scale Staffed Drop-off Center

The Rivanna Solid Waste Authority serves the City of Charlottesville, VA, and surrounding areas. The Authority operates a small, staffed recycling center near the heart of downtown Charlottesville. Home to the University of Virginia and a long-established progressive community, curbside recycling is offered but many residents avail themselves of this facility as needed. In addition to typical recyclables, the facility hosts collection points for used cooking oil, empty oyster shells, and a small-scale food scrap compost program. The facility is open 60 hours a week, 8:30 a.m. to 6:30 p.m. on most days but closed on Tuesdays. Accordingly, it is staffed by 1.5 FTEs. A small, air-conditioned shed provides workspace and shelter for the employee, shown in Figure 22.

Figure 22: McIntire Road Recycling Facility in Charlottesville, VA; Operated by Rivanna Solid Waste Authority

Figure 23: Aerial Photo of McIntire Road Recycling Facility in Charlottesville, VA

The site is small in area—about half an acre not including the access driveway. As shown in Figure 22, the layout is simple. A row of roll-off compactors accept material. Visitors park in marked spots and walk in the pedestrian area from one container to the next as needed. Figure 24 provides an aerial view of the facility and the immediate surrounding area. The site is heavily screened from the street—there are single family homes across the street, and just out of frame in this photo is a baseball diamond, immediately adjacent. The access driveway is gated when the facility is closed, and the community uses a combination of police presence and surveillance cameras to discourage and pursue illegal dumping. All of these management techniques allow the facility to be a "good neighbor" and a popular resource for residents.

8 Recommendations for Near Term, Mid-term, and Long-term

Throughout the data collection period of this project, including the stakeholder engagement and the various studies, it became clear that there are many people and businesses in Columbia who actively participate in recycling and waste reduction, and it is a valued service in this city. There are also those who find biweekly recycling collection insufficient and/or inconvenient, while the people who abuse the Recycling Drop-Off Centers cause serious harm to the success of the entire program. And finally, the labor-intensive collection and processing systems are no longer sustainable.

8.1 Recommendations for the Immediate and Near Term (within 6 months)

Essentially, the Columbia recycling program has **three urgent issues** that need to be resolved as soon as possible, before the recycling program collapses:

1. The current labor-intensive collection method has resulted in the total suspension of curbside recyclables collection for the foreseeable future, putting a serious burden on participation and almost certainly affecting waste diversion negatively.

2. Several of the Recycling Drop-off Centers serve only to negatively impact the recycling program. Contaminated loads delivered to the MRF from these facilities waste staff and other resources.

3. Based on RRT's evaluation, the MRF equipment is not performing as designed, including losing/wasting marketable materials, and the almost-total reliance on manual sorting is an

obsolete and inefficient model. As a result, the City is realizing less revenue than it could and incurring costs to landfill material that should have been captured. There are also serious concerns about safety conditions in the facility.

Until the City can resolve these immediate and urgent issues, a decision about the MRF options will not be fully informed. A key piece of information for MRF operational cost models is how many tons will be delivered and what the composition will be; at present, the Solid Waste Utility does not have the relevant information available.

It is recommended that once Columbia can resolve the issues with collection (both at the curb and at any Recycling Drop-off Center locations) by refocusing its resources, then the City can begin working toward long-term solutions for recycling in a way it values—processed locally, using City assets, with convenient options for residents and businesses to recycle and divert as much as possible.

To address these three urgent issues, the following actions are recommended in order to redirect resources towards reinstating curbside recyclables collection as soon as possible:

1. Temporarily suspend local recyclables processing, procure services in St. Louis, and transfer recyclables to another facility. This would be a temporary measure to address both staffing and safety issues. Possible destinations include the St. Peters "Recycle City" MRF and a Republic Services MRF in Hazelton. The Solid Waste Utility could use the MRF tipping floor to consolidate collected recyclable materials and load them for transfer without the need to construct any infrastructure. The service contract should include pricing for times when the City might request that the MRF audit a delivery from Columbia for composition.

    - The current MRF should not return to operation in any capacity unless and until the safety concerns in the MRF Evaluation report (Appendix A) are addressed.

2. Reallocate resources regarding the Recycling Drop-off Centers in the following ways:

   Three of the sites should be closed immediately. They are not serving their intended function, and Solid Waste Utility staff estimate that eliminating the need to service them could free up a CDL driver and other resources. To accommodate the impact of the effort on the City workforce, this could be done during the winter when tonnages often decrease and some of the student population will be away for a couple of weeks.

   First, the sites proposed to be closed are:

   - Downtown (10th and Cherry) – South side of 10th & Cherry Parking Garage;
   - University of Missouri (Bluford Hall) – along Kentucky Blvd; and,
   - University of Missouri (East Campus Plant Growth Facility) – near East Campus Road and Ashland Road.

Next, of the six remaining Recycling Drop-off Centers:

- Consolidate operations at S. Providence Rd. and State Farm Parkway to the S. Providence Rd. location and make changes as described in Section 4.2.1 and Section 7.3.1 to make it a gated, staffed site.
- Erect a gate around the Cosmo Park location or relocate the facilities a short distance to the Yard Waste Drop-off Center. With a few improvements it could then be inside that fence, and thereby both staffed and gated.
- Continue to operate the two sites at Columbia College and the Downtown Armory location, monitoring their use critically in order to evaluate their operation.

Figure 24 illustrates the recommended actions to reduce contamination in recyclables and concentrate resources on resuming curbside recycling collection.

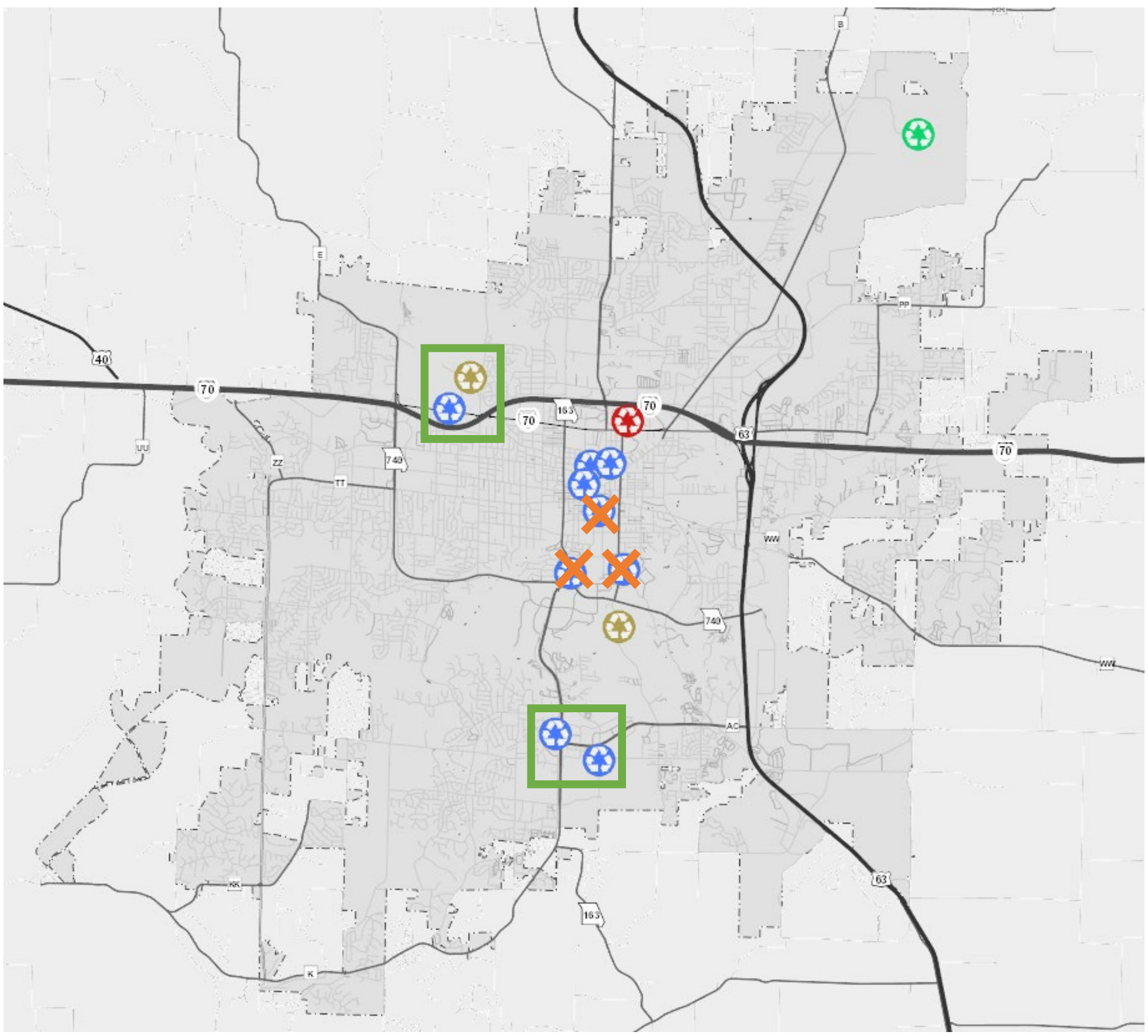


Figure 24: Recommendations for Consolidating and Closing Recycling Drop-off Centers

3. Add glass-only purple bins to all remaining operating Recycling Drop-off Centers, contract for delivery of the material to either the location in Kansas City or in St. Louis, and begin education with the public about the benefits of separate collection, as described in Section 4.1.3. This will both reduce the number of tons that need to be transferred and prepare customers for curbside service that does not include glass (Section 4.4.2).
4. Procure computerized routing services from a specialized vendor to evaluate the recycling routes for both biweekly and weekly service. RRT's experience has shown that almost any collection operation can benefit from this activity, but especially when transitioning from non-computerized routing. As shown in Section 4.2.3, RRT estimates that there is a high probability that Columbia could run the recycling routes with fewer than the previous count of 5 trucks.

It is recommended to make these four changes as soon as possible.

Once these changes are made and curbside collection can restart, whether weekly or biweekly, the following options are recommended to be implemented within 12 months:

1. Create and staff the Recycling Coordinator position for FY24, if not sooner. One of their first responsibilities will be to work with the Public Information Specialist to conduct outreach about the renewed recycling program and upcoming improvements customers will experience.
2. Conduct a demonstration of the proposed co-collection methodology (Section 4.4.1) to test how the bags and materials perform. The Solid Waste Utility can use carts it already has for trash and any single-body collection vehicle. The Solid Waste Utility can use the existing MRF site to evaluate how the proposed collection method works. It is recommended that the new co-collection service not include glass as an accepted material (Section 4.4.2) and that Columbia focus on collecting glass via dedicated drop-off locations.
3. With the Recycling Coordinator and the Public Information Office working together, develop a 12-month outreach and education plan for reinvigorating residents' engagement with recycling.
4. Continue data gathering. This includes monitoring of the material being collected for recycling, including requesting audits from the destination MRF, and set-out rates at the curb. This information can begin to be used for preliminary operations cost modeling. It can also be used to start forming costs per-ton for managing recyclables in Columbia.
5. Conduct internal review of what level of capital investment the City wants to make to restore MRF processing locally in Columbia.
6. Include in communications related to the initiation of trash collection in carts instruction to prepare yard waste in paper bags and information about the yard waste drop-off centers (see Section 4.1.3).

8.2 Recommendations for Mid-Term (6 to 18 months)

1. Considering the recyclable material that has been collected at the curb and in the reconfigured Recycling Drop-off Centers, determine which MRF option the City wants to pursue further.

- The recommendation is that any of the three MRF options can serve Columbia's needs if properly designed and if the assumptions described throughout Section 7.1 hold.
- To help with the decision, the City needs to do several things, including inspection and evaluation of the existing MRF building, geotechnical research on Location A (gravel lot), and evaluation of the timing of relocation of the LOC for Location B (LOC). Operational cost models should also be created and populated for each MRF option the City is considering.
- Once this decision is made, the City can also decide where to site the nearby community environmental center and new HHW drop-off.

2. Finalize strategy, secure funding, and begin procurement for the following services:
    - Engineering and Design services;
    - MRF equipment manufacturing and commissioning;
    - Site work, including engineering, stormwater, geotechnical; and,
    - Construction of building and surrounding concrete.
3. Begin planning for development of community environmental center.
4. Update the Key Performance Indicator in the CAAP for solid waste to a per-capita generation rate, with a baseline of the current year. Begin tracking contamination rates in order to evaluate the performance of the recycling program. Initially, when materials are being transferred to another MRF, contamination rates can be roughly calculated using audits at the destination MRF; later, the same analysis can be done at the new MRF. In addition, rates can be checked against field studies such as composition studies and curbside audits (see Section 6.1.2).
5. Continue evaluating Recycling Drop-off Center locations for viability and sustainability by documenting their condition regularly with photos and notes.

8.3 Recommendations for Long-Term (18 months and beyond)

1. Construct new MRF facility as determined by the decision-making process OR either re-negotiate or re-procure processing services for longer and more advantageous terms.
    - If a new MRF is constructed, the City can begin processing at the MRF using loads from the demonstration area to test the entire process.
2. Resume local processing of recyclables in Columbia.
3. Recommended options for increasing diversion:
    - Include in outreach and education plan intensive outreach to ICI customers to increase diversion of cardboard from those generators, including improved actions by current customers and the addition of new customers (Section 4.1.2).
    - Employ litter receptacles like BigBelly and slot boxes for cardboard to help with crowded containers Downtown (Section 4.1.3).

- Begin research and possibly planning for Food Scrap drop-off partnership at Farmer's Markets (Section 4.1.5).

4. Recommended options for improving participation:
   - Continue to evaluate Recycling Drop-off Centers.
   - Open community environmental center and new HHW drop-off (Section 4.2.2 and Section 4.1.5).
   - Make curbside collection the operational priority over drop-off capacity.
5. Continue robust year-long planning for outreach and education efforts including targeted campaigns (Section 4.3).
6. Consider revision of City ordinances to create regulatory requirements for some or all ICI customers to recycle cardboard.
7. Study and set goals for both recycling participation rates and material capture rates. They will take field work, but they are directly related to long-term planning (see Section 6.1.2).

9 Next Steps

The first priority should be the curbside collection crisis. The capital investment decisions must have valid data from curbside collection.

As described in the previous section, Columbia urgently needs put all available resources towards resuming curbside collection, either biweekly or weekly. Making resources available will rely heavily on closing and consolidating Recycling Drop-off Center locations, and re-routing of the recycling routes for greater efficiency. Even if biweekly is the level of service that can be achieved presently, that will be critical for the recycling program to continue.

The other major decision the City needs to make is what level of capital investment is appropriate for Columbia. As mentioned in Section 7.1.5, the two biggest differentiators in the project costs are how much building needs to be constructed and whether the City wants to accommodate future growth in tonnage with larger capacity equipment or staffing additional shifts per day.

The willingness of Columbia residents to participate in stakeholder engagement is clearly evident, both through this project and by observing other matters in town. Throughout all discussions, the City should continue to engage the public and also draw in the ICI customers to keep them apprised of the process and gather their input.

CITY OF COLUMBIA, MISSOURI
MATERIAL RECOVERY FACILITY

MRF EVALUATION

REPORT

INSPECTION DATES: FEBRUARY 1 – 2, 2023

Table of Contents

List of Tables

Appendices

Appendix 1 – Equipment List and Drawings
Appendix 2 – Commingled Container System Inspection & Photo Sheets
Appendix 3 – Fiber System Inspection & Photo Sheets
Appendix 4 – Baling System Inspection & Photo Sheets
Appendix 5 – Building and Site Photos
Appendix 6 – MRF Operations and Procedures Manual
Appendix 7 - MRF Bale Count by Day (sample)
Appendix 8 – Employee Health and Safety Concerns Letter

1. EXECUTIVE SUMMARY

1.1. Background & Approach

The City of Columbia Material Recovery Facility (MRF) is a 26,000 square-foot dual stream MRF that received and processed approximately 13,000 tons of recyclables in 2022. The MRF is owned and operated by the City of Columbia, Missouri. The processing equipment that is utilized in the MRF was installed in 2002 and there have been limited equipment retrofits since the initial construction. The MRF is configured as two parallel sorting lines, for fiber and commingled containers respectively. On both lines, manual sortation is the primary sortation method. In addition to manual sortation, the MRF utilizes an overbelt magnet, an eddy current separator, and two fiber screens. A two-ram baler bales all recovered commodities. The baler feed system is configured so it may be loaded from either processing line.

RRT was contracted by the City of Columbia ("City", "Operator") to conduct a comprehensive evaluation of the Solid Waste Utilities (SWU) recycling and waste diversion programs. This program-wide evaluation will focus on ensuring the short-term and long-term success of the recycling and waste diversion program. Task 2 of the Recycling and Waste Diversion Program Evaluation is a Comprehensive Evaluation of the City's MRF, with the stated goals of:

- Completing a comprehensive site assessment of the MRF's current condition and better understand the design and costs associated with a new system.
- Determining the current physical, reliability and operating condition as well as the maintenance and repair status of the existing equipment
- Providing an estimate on the remaining useful life of the MRF, assuming the historic record of maintenance continues.
- Providing description and potential benefits for repairs, replacements or upgrades that can be completed in the near term that can assure the recycling facility will operate reliably.

This MRF Evaluation Report evaluates the existing condition of the MRF and will provide a basis for the analysis of the feasibility and viability of capital improvements to the City's recycling infrastructure. This Report will be used in conjunction with other RRT deliverables, such as the composition and participation studies to complete the scope of Task 2. A subsequent Report will be prepared by RRT and will provide the City with a roadmap of recommendations for the future of its recycling infrastructure. This subsequent report will model, discuss and evaluate the City's options for capital improvements to the MRF.

1.2. Findings

Based on the comprehensive review of the processing equipment condition, building, and site conditions, the City of Columbia's Material Recovery Facility is determined to be in poor to fair condition.

The original equipment has been in service for approximately twenty-one (21) years. RRT's standard specification for the procurement of a Dual Stream Processing System specifies that all stationary parts of the equipment system be designed for a minimum of twenty (20) years. It is the opinion of RRT that the Commingled Container Processing System and the Fiber Processing System have a remaining useful life of fewer than five (5) years. The expected remaining useful life of the baler and the baler feed conveyors is ten (10) years, assuming all proper preventative maintenance tasks are completed.

Frame damage and corrosion were observed on several conveyors. In many instances, the damage that was observed would constitute typical wear for equipment of this age. Generally, the damage was not indicative of ineffective maintenance or improper operation. Consumables such as belts appeared to be in fair condition overall, indicating that preventative maintenance tasks are being performed at the MRF.

Based on discussions with the City and RRT's visual inspection of each, the equipment identified below represents the most significant findings of this Inspection. This means that this equipment is either at or approaching the end of its useful life, or is no longer performing as intended:

- The Fiber Residue Screen and ONP Screen are not functioning properly due to the excessive levels of wear observed on their discs. This appears to have resulted in low recovery rates of fiber.
- The Eddy Current Separator is not a reliable piece of equipment and is scheduled to be replaced in Q2 of 2023. The poor reliability of this unit has resulted in a decrease in commingled container throughput and an accumulation of commingled containers onsite.
- Commingled Container Infeed Conveyor (#1467) was observed to have extensive corrosion and damage in the tail pit caused by a buildup of materials and fluids in this pit.

The Excel 2R10 Two-Ram Baler has been in service for ten years and appears to be in fair condition, with only limited damage and wear. The integrity of plastic bales was observed to be poor. Fiber and metal bale integrity appeared to be fair. The quantity of bale ties being applied to plastic bales appears to be excessive. It is recommended that the bale wire gauge and the wire tie unit are studied further to determine if adjustments can be made to improve bale integrity and reduce wire tie quantity on plastic bales.

Recommended near-term repairs of each piece of processing equipment are identified in Table 1, Table 2 and Table 3. All equipment safety items are identified in Table 4.

The building and site were observed to be in poor condition. Significant damage to the building siding was observed on the north, east and west exterior walls. As a result, all three walls have gaps and loose siding. Paved driving surfaces are limited on the site. The dirt driving surfaces throughout the site are unsuitable for their intended purpose and were observed to be severely rutted and damaged. The yard to the west of the site is a main traffic route for both tractor trailers and forklifts. Due to the extensive damage, this area is not a suitable driving surface and is a safety hazard to vehicles and pedestrians.

A large stockpile of unprocessed material has accumulated in the southwest area of the site. The material in this stockpile is a mixture of unprocessed commingled containers, fiber, and trash. This material is degrading and since it is not contained in any way, litter has been promulgated throughout the site. Bale storage appears to be adequate for the existing operation, although all plastic and metal bales are stored in the exterior bale storage area in the aforementioned west yard.

Several employee safety concerns were identified and are listed in Section 5.5. These safety concerns should be addressed as they directly relate to the safety of MRF operators. RRT issued the Employee Health and Safety Concerns Letter (Appendix 8) to the City immediately following the inspection to notify the City promptly. All safety concerns should be addressed promptly.

It is the finding of this inspection that the MRF is at or exceeding its operational capacity. As the equipment is approaching its end of life, reliability and effectiveness will continue to diminish. If the quantity of materials received at the MRF were to increase due to increased resident participation, population growth, etc., the MRF may not be able to meet the demand. If the recovery rate from the existing inbound material is improved, then downstream systems such as bale storage and loadout may not be able to keep up. Three significant bottlenecks have been identified that would prevent the MRF from processing additional material in its current state:

1. Lack of automation – The existing MRF relies on manual sorting which leaves the MRF exposed to risk due to a lack of personnel. If insufficient sorters are available, only one of the two processing lines can operate, severely lessening the capacity of the MRF. Automating sorting tasks would limit this risk.
2. Limited Bale Storage – In order to utilize both of the existing two loading docks, the existing bale storage area must be relocated. Addition dedicated bale storage space is recommended.
3. Unsuitable site conditions – The driving surfaces on the site are not suitable for the existing operation and would deteriorate further if throughput increased.

It is the opinion of RRT that this MRF will require a capital improvement within the next five years in order to reliably process the City's recyclable materials, based on the current generation rates. This determination is supported by (1) the equipment system approaching end of life and (2) the existing MRF appears to have reached or is exceeding its capacity. Any program that seeks to bring additional tons to this MRF should consider methods of improving the capacity of the MRF accordingly. Without adding capacity, any additional tons would not be able to be processed effectively and may end up being dumped in the material stockpile. As such, additional tons are not recommended unless suitable measures have been taken to improve capacity.

The scope and breadth of capital improvements must be analyzed to evaluate financial and operational viability. Along with this Report which identifies the condition of the existing building, site, and equipment, RRT will produce separate reports pertaining to material composition and local participation rates. All of these variables will be modelled to better inform the discussion of future capital improvements.

2. OVERVIEW

A detailed inspection of the City of Columbia's MRF was conducted by RRT over a two-day period from Wednesday, February 1, to Thursday, February 2, 2023. The scope of the inspection included evaluating the condition of all equipment onsite as well as the building and site. A review of safety and maintenance programs, and facility operation, was also completed. Mobile equipment was not included in the scope of the inspection.

Prior to arriving onsite, a virtual kickoff meeting was held on January 19 and was attended by RRT and the City. During this meeting, the objectives of the inspection were discussed and tasks to be completed during the inspection were reviewed. Following the meeting, the City provided RRT with additional reference documentation that had been requested.

Ryan Lawlor arrived at the MRF at 6:30 AM on Wednesday, February 1, and met with Recovery Superintendent Nick Paul and Solid Waste Supervisor Tom Elliott. During this meeting the anticipated operating schedule for the MRF was identified. The daily operating schedule was confirmed to be 6:30 AM – 5:00 PM, Monday through Thursday. Operations on Friday were dependent on quantities of materials that needed to be sorted and/or baled. Generally, the two lines (Commingled Container and Fiber) were not run simultaneously due to lack of staff. Also, the quantities of materials received did not frequently warrant the simultaneous operation of the two processing lines. Maintenance activities were identified to be performed at times throughout the day on whichever line was not active. Maintenance activities are also completed on Fridays as needed. Following a site safety briefing, Nick and Tom provided a site walkthrough, including their experience with various pieces of equipment.

Following the walkthrough, RRT began the inspection. RRT assessed each piece of equipment to evaluate its condition and the effectiveness of the preventative maintenance program. All stationary equipment of the MRF was included in the inspection. The building and site condition was also assessed and photographed as part of this inspection.

RRT assessed the safety, operations and maintenance practices in place at the MRF through document review, interviews with staff members, and observations of behaviors onsite.

3. EQUIPMENT CONDITION ASSESSMENT

3.1. Commingled Container Processing System

The Commingled Container Processing System equipment is original to the facility (2002). The Commingled Container Processing System consists generally of an infeed conveyor, a sort line, an overbelt magnet to sort ferrous metals, and an eddy current separator to sort non-ferrous metals. Non-recyclables are collected in barrels along the sort line and dumped off the sorting platform into a bunker. The negative sort from the sorting line includes glass, grit and fines. This material is conveyed to the exterior of the building where it falls into a glass bunker.

The Commingled Container Processing System produces the following material grades: #1 PET, #2 HDPE (there is no separation of natural and colored), #1-7 Mixed Plastic, Aluminum, Ferrous (referred to as 'Tin'), and Glass. Plastics are all positively sorted, resulting in a high-purity product. Metals are sorted by the magnet and eddy current separator. Glass is the negative sort of the sort line and as a result is contaminated with fines, grit, etc. Although glass was marketed when the facility was first constructed, glass is now only used as cover for trailer loads to the landfill. This is due to the high contamination and lack of markets for the glass product.

Table 1 below identifies the condition and comments of every piece of equipment in the Commingled Container Processing System. Comments that relate to safety are indicated in red text.

Table 1: Commingled Container Processing System Equipment Condition Table

Equipment Number	Equipment Description	Overall Condition	Comments
1467	COMMINGLED INFEED CONVEYOR	POOR/FAIR	Cleats contacting frame. Conduit damage at motor. Platform missing kickplate. Belt is loaded by staff who are standing near mobile equipment. Sorter standing on bale. Motor supports damaged. Small hole in frame. Material buildup all around unit. Interior of frame very corroded. Tail pit plates damaged. Tail pit packed with material and fluid. Frame in pit very corroded. Concrete near tail damaged. Pedestrians and vehicles by tail is a safety hazard.
1455	COMMINGLED SORT CONVEYOR	POOR/FAIR	Frozen idlers. Tail section platform should be guarded by access chain. Spillage at hopper transition. Chutes corroded. Wear plates replaced recently. Drive chain dusty. Support steel damaged. Stairs to platform are blocked by plywood.
-	ECS	POOR/FAIR	Unit to be replaced. Platform, missing kickplate. Motor wobble significant.

Equipment Number	Equipment Description	Overall Condition	Comments
1469	UBC TRANSFER CONVEYOR	POOR/FAIR	Head pulley cutting through frame LHS. Low visibility of belt. Corrosion on hopper. Tail is significant spillage point of UBC. Tail guard missing. Tail frame cut.
1457	GLASS TRANSFER CONVEYOR	FAIR	Holes in splice, scheduled to be repaired. Consistent glass and fines spillage at tail. Operator planning to modify underpan to correct spillage. Plywood positioned as guard on platform stairs, should be replaced with a safety gate. Rollers not visible. Unit is scheduled for repair in February. Corrosion at head section and head pulley.
-	OVERBELT MAGNET	FAIR	Limited visibility of unit appears to be in fair condition. Moderate corrosion throughout. Recovery rate appears good. Plastic observed in ferrous bunker.

The Commingled Container Processing System is fed by a skid steer pushing material from the tipping floor onto feed conveyor #1467. Sorters on the tipping floor are tasked with tearing open bagged material and removing trash from conveyor #1467. There is no metering capability which results in the material being fed unevenly. Metering capability could improve the performance of equipment and sorters downstream.

Infeed Conveyor #1467 was observed to be in poor/fair condition, with some concerns that should be addressed. The tail pit was observed to be full of both material and fluids, which has corroded the frame in this pit. Bearings in this pit require attention. The tail pulley could not be inspected but based on the condition of other components observed in this pit, there is concern that the tail pulley and sprockets may be in poor condition and at risk of potential failure. At the head section, the cleats of the belt were observed to be contacting the equipment supports. The motor has damaged conduit and is not properly mounted. The belt was observed to be in fair condition.

The glass transfer conveyor #1457 was observed to have consistent spillage points and a damaged splice. The platform adjacent to this conveyor is using plywood to guard a gap in the railing. Additional railing should be installed to correct this. The Operator reported that this unit was scheduled for repair to correct the splice and the spillage points.

The UBC transfer conveyor #1469 was observed to be consistently spilling material at the tail section. The head pulley of this conveyor appears to be contacting and cutting through the frame on the left-hand side. The missing tail guard should be replaced.

The commingled container sort conveyor #1455 was observed to have a potential oil leak at the motor/gearbox and one frozen idler. This conveyor is positioned directly above the commingled container material bunkers. The support structure for both the sorting platform and the conveyor has been damaged, likely as a result of impacts from mobile equipment. The platform is serviced by one staircase.

During the inspection, staff was observed to have positioned a piece of plywood across the staircase, likely in an attempt to prevent accidental falls. If fall hazards exist, proper guarding should be installed.

The MRF utilizes a single overbelt magnet to collect ferrous metals. The magnet was installed in 2008 and is configured as a cross belt magnet on the commingled container sort line. The magnet ejects ferrous directly into the ferrous bunker below the conveyor. The belts and cleats appeared to be in fair condition. The frame showed signs of corrosion but no significant damage was observed. The recovery rate of ferrous metals appeared to be good. Purity of the material in the ferrous bunker appeared to be fair. This magnet appeared to be susceptible to a decrease in purity during material surges. When the burden depth of the commingled container sorting belt increased, more non-ferrous materials were observed to be inadvertently knocked into the ferrous bin, decreasing purity. Material surges were observed with regularity due to the absence of metering on the commingled container line. The overall condition of the overbelt magnet was observed to be fair.

The Eddy Current Separator (ECS) was installed in 2008 and is the sole method of sorting non-ferrous metals from the commingled containers. The ECS is positioned at the head of the commingled container sort line, and all of the ECS's negative sort (non-ejects) are conveyed to the exterior glass/grit bunker for disposal. There is no quality control sorting station following the ECS.

Approximately eighteen months prior to the inspection (August 2021), the ECS unit became inoperable. Due to the lack of critical spare parts onsite and the long lead time for parts, the ECS remained inoperable for seven (7) months. In the year prior to the inspection, the ECS has required major repairs twice, causing additional downtime. During the periods when the ECS was inoperable, it was necessary for the Operators to slow the commingled container sort line so that non-ferrous metals could be sorted manually. This decrease in line speed negatively impacted the capacity of the Commingled Container Processing System. The MRF was not capable of processing commingled containers at the same rate that they were being delivered, and material was stockpiled in the yard to the west of the MRF. This material stockpile was observed during the inspection and is discussed further in Section 4.2.

The ECS is scheduled to be replaced in May 2023. Because of the criticality of this piece of equipment, it is recommended that critical spare parts are procured and kept onsite to prevent further events of prolonged downtime.

The overall condition of the existing ECS was observed to be poor/fair. The unit frame is corroded/damaged. The recovery rate was fair, with quantities of UBC observed to be missed and sent to the glass bunker. The motor was observed to vibrate consistently. The ECS platform is missing a kickplate. As part of the installation of the new ECS, the platform should be repaired to meet OSHA specifications. The new installation should include a proper chute.

3.2. Fiber Processing System

The Fiber Processing System equipment is original to the facility (2002) except for the paddle wheel and the ONP screen, which were installed in 2007 and 2010 respectively.

The Fiber Processing System consists generally of an infeed conveyor, a residue screen, a sort line and an ONP screen. Two sorters are positioned on the infeed conveyor and pick OCC. Material falls from the infeed conveyor to the residue screen. The unders of this screen fall to a residue bunker. The overs of the residue screen fall on the sort line. OCC, mixed paper, and non-recyclables are manually picked on the sort line. The negative sort of the sort line falls onto the ONP screen. The overs of this screen are baled as ONP and the unders fall into a residue bunker. The material from the two residue bunkers is aggregated to a larger residue bunker located on the tipping floor. Sporadically, sorters will be assigned to pull OCC from this residue bunker.

The Fiber Processing System produces the following material grades—OCC, ONP, Mixed Paper, Sorted Office Paper—along with the non-recyclables. OCC and Mixed Paper are positively sorted on the sort line, resulting in high purity products. ONP is collected as the overs from the ONP screen. Due to the configuration and condition of the ONP screen, the ONP product has a high purity.

Table 2Table 1 below identifies the condition and comments of every piece of equipment in the Fiber Processing System. Comments that relate to safety are indicated in red text.

Table 2: Fiber Processing System Equipment Condition Table

Equipment Number	Equipment Description	Overall Condition	Comments
1465	FIBER FEED CONVEYOR	FAIR	Auto lube leaking. Platform needs guard or chained off. Pit not inspected. Hole cut into frame on left hand side. Corrosion observed within frame.
1466	FIBER RESIDUE SCREEN	POOR/FAIR	Discs need to be replaced. Screen is ineffective, refer to photo of unders, sent to residue. Objective is to remove fines and grit, losing excessive fiber/OCC. Motor observed to be leaking oil. Platform missing guard. Platform is exposed to the screen deck.
-	FIBER PADDLE WHEEL	FAIR	Appears to need centering, may contact frame. Bearings require servicing.
1456	FIBER SORT CONVEYOR	FAIR	Possible oil leak at motor. Repair frozen idlers. Belt contacting frame left hand side, will damage belt. Damaged conduit. Head pulley may be contacting frame. Frame damage at head and tail.
-	ONP SCREEN	POOR/FAIR	Discs need to be replaced, losing product to residue stream. If discs were replaced unit would be in fair condition. Plywood board covering impact zone. Bearings are greased and caked in dust. Motor making mid pitch winning continuously. Containers stuck in bottom two shafts wearing out stars.

The Fiber Processing System is fed in the same process as the Commingled Container Processing System. The skid steer pushed material piled onto the fiber infeed conveyor #1465. The Fiber Processing System has two sorters positioned as presorters in the tipping floor area. Unlike the Commingled Container Processing System, the two presorters are located on a platform and are positioned on either side of the feed conveyor.

Infeed conveyor #1465 appears to be in fair condition. A hole has been cut on the right-hand side of the frame to allow access to the chain. This hole should be repaired. The autolube system was observed to be leaking onto the platform. The belt and chain appeared to be in fair condition. Chain rollers were observed to be spinning properly. The platform should be cleaned of all material. The paddle wheel appeared to be off-centered and is nearly contacting the frame. The bearings of the paddle wheel were dusty and should be cleaned. During the inspection, the paddle wheel did not appear to be affecting the material flow in any discernable way. This may be due to the quantities that were being loaded onto the feed conveyor or the height setting of the paddle wheel. The burden depth on the sort line appeared to be good.

The fiber sort conveyor #1456 appeared to be in fair condition. The belt was recently replaced and was in good condition. The belt was not centered and was observed to be contacting the frame on the left-hand side of the head and tail pulleys. This will quickly damage this belt and should be corrected. The motor/gearbox showed evidence of an oil leak.

The residue screen (#1466) has been in service for over twenty years and the ONP screen has been in service for over thirteen years.

In its twenty-year service life, the discs on the residue screen have been replaced once in 2013. The discs of the ONP screen have never been replaced. Moving parts in direct contact with feedstock have an estimated service life of 7,000 hours. This equates to approximately 3.4 years based on a standard 40 hours per week operating schedule. Factors like the type of feedstock may modify the expected service life of components. Generally, fiber is a lower impact material when compared to other MRF feedstocks such as glass. Although the City's MRF operates for forty (40) hours per week, simultaneous operation of both processing lines is not standard operating procedure. Accordingly, if it is assumed that the Fiber Processing Line is operating an average of twenty (20) hours per week, then the expected service life of the discs would be 6.7 years. In either case, based on the age of the discs on both screens it would be expected that these discs have exceeded their useful life. This corresponds with the observations made during the inspection.

Gaps between discs were observed to be excessively large. As a result, the quantity and type of materials that were observed to fall through the unders of the screen indicated that the screen is not functioning in accordance with the manufacturer's specifications. Quantities of mixed paper, OCC and other fiber are being sent in the unders stream to the residue bunker. This contributes to the MRF's low recovery rate discussed in Section 5.1. However, a corollary of this is the materials in the overs stream have a high purity. This contributes to the high quality ONP that the MRF is producing.

The impact area of the ONP screen has been blocked by a piece of plywood. Discs in the impact area receive the most wear and this plywood was likely added to remediate the excessive wear on these discs. Although the plywood does prevent material from falling through the impact area, it was observed to create material buildup at the lower end of the screen.

The residue screen is located on a platform adjacent to the fiber tipping area. As such there is significant material accumulation around the platform and frame of the residue screen. The motor/gearbox appears to be leaking oil and a conduit is damaged.

The motor of the ONP screen was observed to continuously produce a high-pitched noise which may be indicative of a mechanical problem. The bearings appeared to be overlubricated and as a result had a buildup of dust and grit.

One of the City's stated priorities is to focus on producing high-quality products. High purity can be attained by sacrificing the recovery rate, but the quantities of fiber that are not being recovered at the MRF appear to be excessive. This will be investigated in greater detail during RRT's Composition Analysis to be conducted in the Spring of 2023.

3.3. Baling System

Commodities from the Commingled Container Processing Line and the Fiber Processing Line are stored in bunkers beneath the respective sorting lines. When sufficient material has accumulated to be baled, an operator must manually open the bunker gate. Then, a skid steer pushes the material onto the baler feed belt #1464. This conveyor transfers the material to conveyor #1445, which dumps the material into the baler hopper. These two conveyors are rubber-belt chain-driven conveyors. The baler is a two ram baler manufactured by Excel, model 2R10, and was installed in 2013. All commodities apart from glass are baled. Residue is not baled.

No quality control sorting is performed on either the Commingled Container Processing Line or the Fiber Processing Line. When material is pushed from its bunker into the baler feed system, frequently one or two sorters will perform quality control sorting while standing on or near the baler feed conveyor #1464. This is an unsafe practice and is discussed further in Section 5.5.

Table 3 below identifies the condition and comments of every piece of equipment in the Baling System. Comments that relate to safety are indicated in red text.

Table 3: Baling System Equipment Condition Table

Equipment Number	Equipment Description	Overall Condition	Comments
1464	BALER FEED INCLINE CONVEYOR	FAIR	Platform requires additional guarding and kickplate. Head section, pulley and motor very dusty and dry. Ladder needs chain. OCC falls over sidewalls. Disconnect not properly mounted. All rollers appear to be spinning properly. Chain may be over lubricated. Direct bale loading unsafe with sorter standing on belt near bobcat loading. Belt worn but minimal damage observed. Missing guard on right hand side. Underpans damaged. Tail pit clean, limited damage.

Equipment Number	Equipment Description	Overall Condition	Comments
1445	BALER FEED CONVEYOR	FAIR	Platform ladder needs chain. Potential leak at autoluber. Head bearing dry dusty. Baler hopper bridges with large occ, cleared with stick through opening in hopper. Quantity of dust is fire hazard.
	EXCEL 2R10 TWO RAM BALER	FAIR	See below

The baler feed conveyor #1464 was observed to be in fair condition. When baling OCC, material was observed to fall over the sidewalls and onto the ground below. A guard was not in place on the right hand side, leaving the chain exposed. The chain and rollers appeared to be well lubricated and functioning properly. The tail pit was generally free of material buildup. The tail pulley and sprocket appeared to be in good condition with limited damage or wear observed. The two platforms at the head of the pulley had significant dust and material accumulation and should be cleaned regularly. The motor/gearbox had evidence of an oil leak.

The head bearings of conveyor #1445 appeared dry, dusty and in need of servicing. Material was observed to be packed into the underpans of this conveyor. The autoluber had evidence of an oil leak. Significant dust and debris buildup was observed on the motor and the gearbox.

The Excel 2R10 two-ram baler has been in service for 10 years. The hours meter on the baler control cabinet was not functioning. The ejection ram was replaced in 2020. Significant dust and material buildup was observed on and around the baler. Tools are stored in and around a workbench that is located adjacent to the baler. No damaged welds were observed on the baler frame. Minor corrosion was observed at locations throughout the baler, but levels of corrosion did not appear to be significant. The control panel and platform were generally clean.

The hydraulic power unit (HPU) utilizes two motors which were both clean and free of dust. Leaks were observed in several locations throughout the HPU and hydraulic oil was observed on many of the HPU's components. The housing of the air filter was not in place and was located on the ground near the main ram. The air filter appeared to be free of dust.

The floor of the bale chamber was replaced in 2020 by the baler manufacturer and appears to be in good condition. The baler chamber walls and ejection ram platen appear to be in fair condition with minor wear and small gauging observed. The main ram platen was not inspected.

The hopper was observed to be in fair/good condition with very limited damage or corrosion. Photo eyes appeared to be in place and unobstructed. Bridging was observed in the hopper when baling OCC. Per the baler operator, bridging is experienced frequently while baling OCC. To clear the bridging, the baler operator inserted a flat metal bar through an access hole in the hopper. If the material bridging was unable to be cleared in this method, poor judgement by the baler operator could result in a hazardous, potentially fatal situation. In other facilities, improper methods of clearing baler hopper jams have resulted in injuries and fatalities. A full review of the operating procedures for cleaning baler hopper jams is recommended.

The steel on the bale runout table is damaged, likely from a vehicle impact. Effluent was observed to pool in the area around the bale exit. Effluent was contained by a containment curb but was in constant contact with the baler frame. This effluent will expedite corrosion and should be removed.

The wire tie system appeared to be functioning properly and several wire tie cycles were observed. The wire tie system functions automatically depending on the material that is being baled. The Operators reported that the MRF had two wire tie systems in stock (one primary tie system and one backup). During the inspection, the backup wire tie system was in service and the primary unit was being repaired. All fiber bales received six wire ties. Metal bales received four wire ties. OCC bale integrity was observed to be fair. Mixed paper and ONP bale integrity were observed to be poor/fair. Metal bale integrity appeared to be fair/good. Plastic bales received 18 wire ties. The integrity of plastic bales appeared to be poor/fair.

Overall, the baler appeared to be in fair condition. The levels of wear observed generally corresponded with the age of the baler. However, corrective action should be taken to prevent the condition of this baler from worsening. The area around the baler should be cleaned and measures should be taken to prevent the pooling of effluent on the baler. All leaks in the HPU should be repaired. The configuration of the baler for plastics should be investigated to improve bale integrity and limit the quantity of wire ties. The bale runout table should be repaired to prevent further damage. When baling OCC, the belt speed of the baler feed conveyor should be slowed as needed to prevent delays caused by bridging. The hours meter should be repaired so that the service hours can be tracked. This baler is an extremely valuable piece of equipment for the MRF so its condition should be monitored very closely.

3.4. Equipment Safety Items

The following equipment positions have deficiencies which relate to safety concerns as indicated in red on Table 4 and identified on inspection sheets:

Table 4: Equipment Safety Items

Equipment Number	Equipment Description	Safety Item
1467	Commingled Infeed Conveyor	Sorter standing on bale, not in proximity to E-stop. Pedestrians and vehicles by tail is a safety hazard.
1455	Commingled Sort Conveyor	Tail section platform should be guarded by access chain. Stairs to platform are guarded by plywood.
1457	Glass Conveyor	Plywood positioned as guard on platform stairs, should be replaced with a safety gate
1465	Fiber Feed Conveyor	Platform needs guard or chained off.

Equipment Number	Equipment Description	Safety Item
1466	Fiber Residue Screen	Platform missing guard. Platform is exposed to the screen deck.
-	ONP Screen	Plywood board covering impact zone.
1464	Baler Feed Incline Conveyor	Platform requires additional guarding and kickplate. Missing guard on right hand side
1445	Baler Feed Conveyor	Platform ladder needs chain. Quantity of dust is fire hazard.

4. BUILDING AND SITE ASSESSMENT

4.1. Building

The building and site were observed to be in poor condition, with many items in need of repair. As discussed in this Section, the damage and wear observed to the building and site appear to be negatively impacting the operation of the MRF. The limitations created by the existing condition of the building and site would likely impede any attempt for the City to increase the capacity of the MRF.

Exterior Walls

The exterior walls on the east and west sides of the tipping floor have been damaged. On the east side, the siding has deformed but no holes or gaps were observed. The west wall is more damaged and appears to have been impacted from the exterior of the building. Portions of the west wall have been repaired in the last year. The repaired siding appears to be in good condition. At many locations throughout the tipping floor the insulation is damaged or missing.

The east and west walls of the processing area also have been damaged significantly. In the traffic lanes adjacent to the fiber and container bunkers, siding has been contacted by mobile equipment. The damage on the west wall also appears to be a result of the material stockpile (located on the exterior of the building) being piled up against the building which was not designed to support a material pile.

The severity of the damage is comparable on both the east and west walls, with approximately fifty feet (50’-0”) of damaged siding on each of the walls. The damage has resulted in gaps/holes in the siding on both the east and west walls. The damaged siding is not properly secured to the bottom track. On the west wall, a jersey barrier has been placed against the wall to attempt to minimize future damage. No repairs are evident.

The north wall of the MRF has similar damaged sections. The siding above the overhead door on the north wall has been impacted by mobile equipment and has been severely damaged. This damage does not appear to have affected the operation of the overhead door. Siding adjacent to the overhead door is also severely damaged. The Operator reported that during a previous incident, the baler was not being monitored and produced a number of bales that eventually contacted the exterior wall and caused the damage. The damaged siding in this area is not secured to the bottom track. Two ferrous bales have been positioned to minimize the movement or future damage to this siding.

Tipping Floor

The tipping floor is 10,000 square feet and is shared between commingled container tipping (west side) and fiber tipping (east side). The southwest corner of the tipping floor is used as a residue bunker. The tipping floor was observed to be in fair condition with certain locations requiring repair. No damage was observed on the concrete pushwall. Damaged metal siding was observed above the concrete pushwalls on both the eastern and western exterior walls. This damage was visible from the building exterior and was likely caused by material piles being compressed with a pile height larger than the pushwall. The Operator reported that repairs had recently been performed to remediate wall damage on the east wall. Recently installed wall panels were observed and appeared to be in good condition. It is recommended that this repair should be performed for all the damaged exterior walls on the tipping floor.

The concrete to the south of the commingled container infeed conveyor is significantly damaged. The Operator reported that in 2021, repairs were made to this area. Approximately two hundred square feet (200 sq ft) of concrete was replaced. As part of these repairs, steel beams were embedded into the concrete to provide additional strength. The concrete in which the steel was embedded quickly eroded away leaving the steel beams exposed. As the concrete continued to wear away, the steel has become proud of the finished floor level. As a result, skid steer operators that are consistently moving in this area must avoid hitting the exposed steel beams. When the steel beams are impacted by the skid steer, the operator is suddenly jarred. This may result in acute or prolonged injury to the skid steer operator. The Operator reported that when this two hundred square foot area was repaired, insufficient hardener was used. Due to the localization of the concrete damage, it is possible that an incorrect repair may be the cause. The abrasive nature of commingled material containing glass would also have been a factor. As a result, this area of concrete has quickly degraded while the remainder of the tipping floor concrete remains in fair condition. This concrete should be repaired.

Storage Bunkers

The Commingled Container Processing System includes five push-through bunkers. The gates of the five push-through bunkers are opened manually. All manual gates have evidence of damage including dents, but no damage was observed that impacted the functionality of the gates. The steel bunker wall is corroding, most notably in the HDPE bunker (south bunker). Trash is collected in barrels by the sorters and is manually dumped off the platform to a collection area.

The Fiber Processing System includes four push-through bunkers. The gates of the four push-through bunkers are opened manually. All manual gates have evidence of damage including dents, but no damage was observed that impacted the functionality of the gates. The steel and structure of these four bunkers appear to be in fair/good condition with limited damage evident. A fifth bunker has been created using OCC bales. This bunker collects the unders of the ONP screen which are transported to the residue.

On the tipping floor, two bunkers have been constructed using OCC bales. These bunkers contain trash and shredded office paper. These bunkers appear functional but are taking up valuable tipping floor capacity.

The glass bunker is located on the west side of the site, along the exterior building wall. This bunker has been constructed using jersey barriers. There is litter and material scattered throughout the glass bunker and surrounding area.

Bale Storage Areas

Bales are stored in three areas:

Indoor Bale Storage (1,500 sq ft) - The area along the north wall of the MRF building is used to store OCC bales, UBC bales and other bales which are scheduled to be shipped imminently. Indoor bale storage space within the facility is limited. During the inspection, bale stacks of both OCC and UBC were observed to be five (5) bales high in the indoor bale storage area. The indoor bale storage area does not include concrete pushwalls.

Canvas Bale Storage Building (4,900 sq ft) - This 70’ x 70’ canvas building was constructed directly north of the MRF building for the purpose of providing additional indoor bale storage. This area was observed to store fiber bales (OCC, ONP, & MP). The canvas building was observed to be in good condition with limited damage and typical levels of wear. The floor of the canvas building was compacted fill. Although some gouging/damage was observed, it still appeared to be level and a safe driving surface. Bales were observed to be stacked four (4) bales high and appeared to be dry. There was no precipitation during the inspection. No evidence of leaks was observed. Quantities of loose mixed paper were observed on the floor of the canvas building. The perimeter of the canvas building contains a small concrete curb and jersey barriers to serve as pushwalls. These seem to be effective in protecting the canvas building.

Yard to the west of the MRF building (exterior storage) - Plastic and metal bales are stored in the yard to the west of the MRF building. No improvements have been made to this exterior yard to assist in the storage of bales. This area is unpaved and was not observed to be a safe driving surface. Severe ruts and potholes were observed to be large enough to pose a hazard to forklift drivers. This is discussed further in Section 4.2. There are loose materials (commingled containers, trash) scattered throughout the area where bales are stored. No environmental barriers exist to contain the material or bales. Exterior bale storage is not best practice, as bales may degrade when exposed to weather for prolonged periods. Additionally, exterior bale storage creates risks pertaining to stormwater management and litter.

Loading Docks

The MRF contains two loading docks. All commingled container product bales and all mixed paper and ONP bales are loaded through the loading docks into trailers. OCC is typically loaded into flatbed trailers in the yard to the west of the facility, not requiring a loading dock. During the inspection, the north loading dock was observed to be obstructed by a bale stack. Because of this only the south loading dock was able to be used. It was reported that based on the existing throughput, only one loading dock is required, and due to the limited bale storage area within the building, bales are frequently stacked in such a way as to obstruct one loading dock without impacting operations. Both loading docks included manually operated dock levelers. The south dock leveler was inspected and appears to be functional. The dock seal on the south loading dock was observed to be damaged and in need of repair or replacement.

Miscellaneous/Other

Two methods of heating the processing area of the MRF are installed. The MRF has a series of gas-powered infrared tube heaters. Based on discussions with MRF maintenance staff, these units are non-functional and have not been functional for an estimated three years. The MRF also includes wall-mounted heat-exchangers that provide heat from the nearby bioreactor landfill. Based on discussions with maintenance staff, approximately 50% of the heat exchangers are non-functional. Due to the locations of the infrared tube heaters and heat exchangers, the units were not closely inspected as part of this MRF Evaluation.

4.2. Site

The MRF's site is in poor condition. Paved driving surfaces are limited and unpaved driving areas are damaged and unsuitable for driving. A large material stockpile is positioned against the southwest corner of the building. No method of containing the stockpile has been installed and as a result, litter/debris is scattered throughout the site. An annotated site plan is shown below to identify aspects of the site that were observed during the inspection.

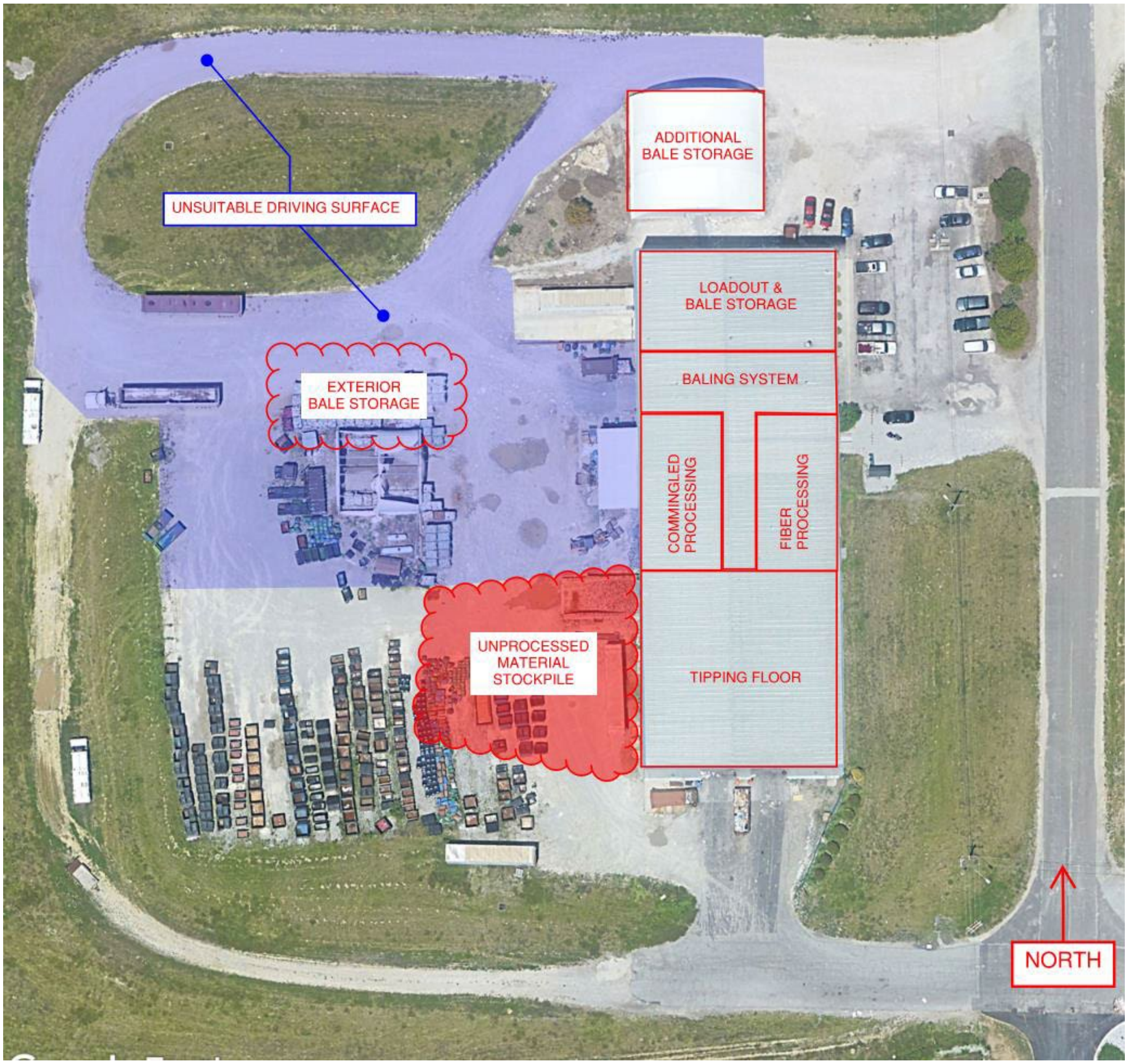


Figure 1: Site Schematic

Generally, the eastern portion of the site, including the parking lot, contains some quantities of litter and trash. The parking lot is unpaved and is in fair condition. The south and west areas of the site were observed to contain high quantities of litter.

As shown in Figure 1, a large uncontained material stockpile was observed along the south half of the western exterior wall of the MRF. This stockpile occupies an area of approximately 10,000 square feet. This is a stockpile of unprocessed material that has been dumped by collection vehicles. Material is not well-contained in this stockpile, and litter and debris are scattered throughout the west yard.

The material stockpile is a result of an extended period of reduced capacity or complete outage of the Commingled Container Processing System caused by the ECS (August 2021). During this period of reduced capacity or outage, inbound commingled container loads were not able to be processed and the tipping floor reached its capacity. The Operator stated that they attempted to ship this material to another MRF but were unsuccessful. There were no other contingency plans in place. As a result, the commingled containers were dumped in the west yard.

This stockpile continued to grow. If an inbound load is discovered to have an improper mix of fiber and commingled containers, Operators may direct it to dump on the stockpile rather than contaminate the material on the tipping floor. Because the stockpile is exposed to the atmosphere and weather, the material has degraded and any fiber or organic matter has begun to disintegrate. The contents of this stockpile cannot easily be processed due to the poor quality of the material and the mixture of fiber with the commingled containers. This stockpile is an eyesore, an environmental hazard and will encourage vectors including but not limited to the cats that were observed. This stockpile should be removed from the site.

The exterior driving surfaces are not suitable for their intended use. Other than the MRF access road, all driving surfaces are dirt and many of them are in a state of disrepair. The driving surfaces in the northwest quadrant of the site are regularly used by tractor trailers that access the loading docks, flatbed trailers that receive loads of OCC bales, and forklifts that load OCC bales onto the flatbed trailers. During the inspection, these driving surfaces were observed to be very damaged, with ruts having formed in the mud and frozen solid. Along with being rutty, large craters were observed. The damage to the driving surfaces creates challenges and safety concerns for truck drivers and represents a safety hazard for forklift drivers. The uneven surface can lead to loaded forklifts tipping over.

Per the Operator, these driving surfaces are very susceptible to turning into mud during freeze/thaw cycles of the spring and fall. This creates a new, but equally challenging problem for MRF Operations as forklifts and tractor trailers have to be cautious not to become immobilized by the mud. If this mud/dirt is not manually levelled by the Operator using a tractor, the ruts and craters freeze when the temperature drops. This is consistent with the state of the roadways that was observed.

As a result, during three seasons of the year this roadway presents challenges to the operation of the MRF that require dedicated hours for repair/maintenance and vigilance on the part of forklift and tractor trailer drivers. In a scenario where the driving surface is determined to be unusable, the flatbed trailers will be loaded on the tipping floor. This is not a feasible long-term solution as it limits the usability of the tipping floor when a trailer is being loaded.

5. OPERATIONS, SAFETY AND MAINTENANCE ASSESSMENT

5.1. Tonnages, Production & Composition

The MRF receives and processes approximately 13,000 tons of material per year. An estimated 60% of the inbound material is residential or commercial fiber. Inbound split body trucks are not weighed separately for commingled containers and fiber tons, so the total quantity of commingled containers and total quantity of fiber are not specified. Based on outbound material records, an estimated 60% of the inbound material is fiber.

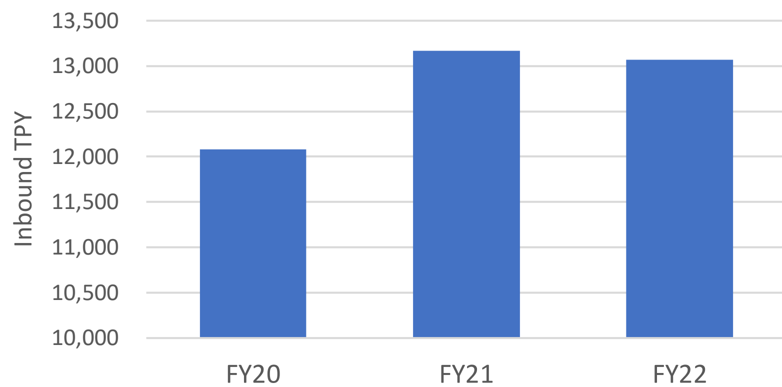


Figure 2: Inbound Tons

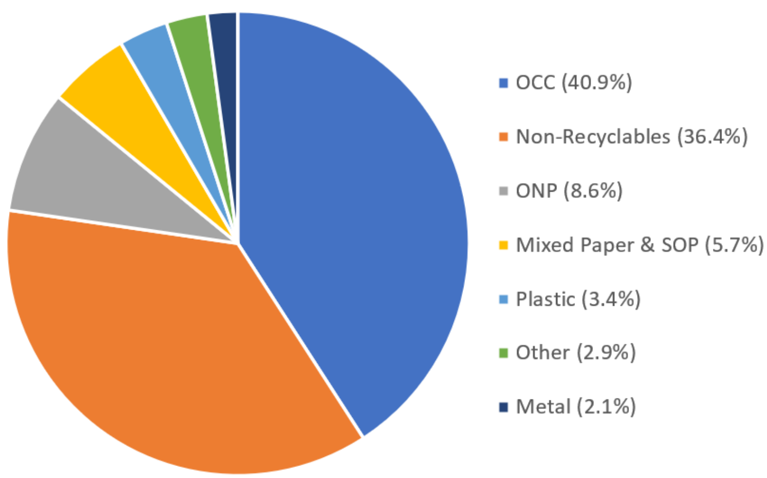


Figure 3: Outbound Composition FY20 – FY22

Figure 2 shows the quantities of outbound material for the last three fiscal years (FY20, FY21 & FY22). Figure 3 identifies the composition of the outbound material over this same period. Notably, over 36% of the material received is being sent to the landfill as non-recyclables. This quantity is higher than what would be expected at a dual stream MRF. During the inspection, the inbound material piles on this tipping floor were observed. The material seemed fairly clean and did not appear to contain 36% contamination. This would indicate that recyclables are not being successfully recovered and are being sent to the landfill.

In addition, a visual inspection of the non-recyclables indicated that the recovery rate of the MRF is low. A MRF with a low recovery rate loses revenue from material sales and also incurs higher costs for disposal. Based on this inspection, it appears there are two main causes of the low recovery rate.

1. Fiber Disc Screen Deficiencies – The discs of both fiber disc screens were observed to be severely worn. As a result, the gap distance between discs is larger than manufacturer's specifications. As such, these screens are not functioning as designed (for additional details refer to Section 3.2). Excessive quantities of OCC and other fibers are falling into the screen unders instead of being recovered. At the MRF, the unders from both of these screens are sent directly to the non-recyclable bunker. Although the operator reports having staff manually pick OCC from the non-recyclable bunker, this is not a sufficient solution to this deficiency. The recovery rate of the fiber system appears to be poor. Further analysis should be performed to confirm this finding.

2. Insufficient Capacity and Material Stockpiling – The MRF has limited tipping floor area so there is very limited buffer space to accommodate a system outage. When the MRF is not able to process material at its typical throughput (for reasons including equipment downtime, lack of staff, etc.) inbound material is stockpiled on the west side of the site (refer to Figure 1). In this stockpile, commingled containers mix with fiber, and all materials degrade. This negatively impacts the recoverability and value of these materials. Often these materials must be sent to the landfill and therefore are not recovered.

5.2. Capacity

Based on the MRF inspection and the review of documents provided by the City, the MRF is currently at or exceeding its capacity. As such, it is not recommended that any additional tons of recyclables are sourced for processing at the MRF. In the existing operation, there are instances where the MRF processing equipment is unable to keep up with the recyclables that are being delivered. The Operator reported that during busier weeks, fiber loads are sometimes baled directly and sold as a mixed paper bale with high contamination. During the period in which the Eddy Current Separator was inoperable (refer to Section 3.1) the quantities of commingled containers that were received outpaced the quantities of commingled containers that could be processed, resulting in the large material stockpile described in Section 4.2.

The lack of capacity at the MRF is caused by several factors, discussed in the following paragraphs. If one or more of these factors was addressed, the capacity of this MRF may increase. Lack of capacity is generally caused by:

- Reliance on manual sorting
- Lack of redundancy and equipment reliability
- Loadout and bale storage limitations

The most significant limitation to the MRF's capacity is the reliance on manual sorting. Because the MRF primarily sorts materials manually, the number of sorters available directly impacts the MRF's capacity. As is a common trend in the solid waste and recycling industries, the Operator has reported difficulty finding and keeping sorters. The number of sorters that are typically available is not sufficient to run both the Fiber Processing System and the Commingled Container Processing System simultaneously. This severely diminishes the MRF's capacity. If more automated sorting processes were implemented, the impact of limited sorting staff would be decreased and the facility capacity would be increased. If additional manual sorters could be hired, the capacity of the MRF could be improved in the short term. If sufficient sorters were available to run both processing lines simultaneously, the MRF's capacity would increase.

The level of redundancy in the MRF is low. When the ECS became inoperable in 2021, the Commingled Container Processing System needed to be operated at a reduced throughput for over six months. The MRF only contains a single baler. The lack of redundancy to the baler poses a risk to the Operator. Additionally, if the product tons were to increase, the single baler may become a bottleneck in the process.

The product loadout process is not scalable. In the current building, the Operator has to choose between additional bale storage or having two usable loading docks. If the capacity was to increase, this would be a lose-lose situation. Additional indoor bale storage would be required and at least two usable loading docks would be required.

A non-recyclables bunker has been constructed on the tipping floor using OCC bales. Although this bunker appears to be functioning as intended, this bunker occupies valuable space on the tipping floor. Although the tipping floor capacity was not observed to be a bottleneck during the inspection, the capacity of the tipping floor should be considered as a potential bottleneck to capacity.

The Operator has been able to load OCC in the west yard despite the unsuitable driving conditions. It is unlikely that this would continue if the quantities of OCC increased. More loads would mean more tractor trailers and forklifts which would exacerbate the damaged driving surface. From FY2020 to FY2022, 41% of the total outbound material was OCC. If non-recyclables are excluded and only recovered products are considered, OCC represents 64% of the City's outbound products, by weight. If the MRF was to increase capacity with the same material composition, the loadout process for OCC would need to be changed to meet the increased demand. This would likely require a dedicated loading dock to be live-loaded or a paved driving surface where flatbed trailers could be loaded quickly and safely.

In the current operation, 36% of the inbound material is being sent out as non-recyclables. As discussed in Section 5.1, this is likely a result of recyclable fiber being lost in the two disc screens. If these disc screens were to be repaired to function properly, there would be repercussions on the bale storage and loadout systems. For example, if the residue rate decreased from 36% to 18% as a result of equipment repairs, the quantity of bales that would need to be stored and loaded would increase by 28%. Based on the current 13,000 TPY of inbound material, this would be an increase of approximately 2,300 tons of product material per year. It is critical that if repairs or improvements are made to the equipment system, an analysis must be performed to confirm that the back-end system (including the baling system, bale storage & loadout) does not negate any benefits from capital improvements by becoming bottlenecks.

5.3. Product Quality

Throughout the inspection, products from both the Commingled Container Processing System and the Fiber Processing System appeared to be high-purity. A benefit of relying on manual sorting rather than automated processes is that manually sorted material may have higher purity, consistent with what was observed. All products other than ONP are positively sorted. The Operator takes pride in the high-quality products. During down-market periods, this high quality has allowed the City to continue to market its materials when other MRFs were unable to. The Operator reported that it is extremely rare for a load of material to be downgraded by a consumer, and the fiber products can be moved very quickly. Markets are difficult to predict and this is a notable advantage.

As discussed in Sections 3.2 and 5.2, the condition of the two fiber screens is resulting in low recovery rates, but high purity material. If action is taken to improve the recovery rate of these screens the purity of recovered fiber should be monitored.

5.4. Housekeeping

The housekeeping practices within the building are fair. Sorters regularly clean before breaks and consistent points of spillage are swept. The high-traffic areas of the MRF are generally clean by the end of each shift. Equipment such as the baler was observed to be cleaned daily.

Low-traffic areas of the MRF, such as the baler platforms or the storage areas above the office appear to be cleaned very rarely. Notable quantities of dust have accumulated and may be an environmental and fire hazard to staff. Platforms where staff are stationed were observed to have accumulated items such as brooms or tools that should be removed. This is especially evident on the fiber presort platform. The housekeeping activity on the site and exterior of the building appears to be minimal. The west yard is covered in debris coming from the material stockpile. The parking lot is generally orderly.

5.5. Safety & Training

The following operational safety hazards were observed during the MRF inspection. The following safety concerns pose a risk to the City of Columbia and to the employees of the MRF. Immediately following the inspection on Friday, February 3, RRT issued a letter (Appendix 8) to the City to identify the most significant safety concerns that were raised.

Required Personal Protective Equipment

Section III of the City's MRF Operations and Procedures Manual (Appendix 6) specifies the personal protective equipment (PPE) to be worn at all times within the MRF. Safety goggles/glasses and gloves are identified as being supplied by the City and to be worn at all times. Steel/safety toe boots are also stated to be required. Although this section specifies that 'yellow or orange shirts for use in the MRF' will be supplied by the City, the language does not specify that high-visibility clothing is a part of the required PPE. In discussion with the MRF supervisors, it is understood at the MRF that high visibility clothing is optional. High visibility clothing or vests should be required PPE for any employee on the tipping floor or any other location with regular mobile equipment traffic. Due to the layout of the MRF, the majority of the processing area has regular mobile equipment traffic.

Long sleeves shirts are also not required PPE. The City offers its employees removable protective sleeves. Hard hats are also not specified as required PPE.

The PPE program should be updated to include high-visibility clothing or vests as PPE for all plant personnel, including employees, managers, and guests that enter the processing area. It is also recommended that long sleeve shirts are required for sorters and hard hats are required for maintenance/mobile equipment operators.

All employees were observed to be wearing appropriate safety glasses, gloves and footwear, as specified by the MRF Operations and Procedures Manual. The MRF office was well-supplied with glasses and gloves to be provided to employees as needed. Based on the reported frequency of cuts/pokes on the sorting lines, it is recommended that the PPE requirement for gloves be updated to specify ANSI rated, cut resistant gloves.

Tipping Floor Safety

Employees were observed on the tipping floor breaking bags and removing trash – obviously to make sorting easier downstream. These employees are sharing the area with a skid steer and delivery vehicles and are at risk from impact by mobile equipment. **Industry best practice is to work within a protected area – e.g., guarded by concrete barriers, and to implement a "Tipping Floor Policy" that if followed maintains a safe distance between people and mobile equipment.**

One sorter was sorting while standing on a bale (not an approved platform). The possibility of falling onto the belt is real and could result in a significant injury to an employee. Also, it appeared that one or both sorters had no access to an e-stop if someone fell onto the conveyor. **Industry best practice (and OSHA requirement) is to have proper floor/platform surfaces – with railings if above 4 feet – and have positioning lanyards attached to their person.**

Walking on Conveyors

Employees were observed to be standing on the baler feed conveyor (#1464) while performing quality control sorting. If an individual slipped, panicked and/or had a medical event, they could end up in the baler, resulting in serious injury or death. **Industry best practice is to never walk on any live conveyors.**

Bale Stacking

OCC and UBC bales were observed to be stacked six-high and straight-stacked. ANSI standards state that bales shall only be four-high in straight stacks but can be higher if stair-stepped. Straight-stacked bales greater than four bales increase risk of bales falling and potentially causing serious injury or death to employees.

Egress from Sorting Platforms

The MRF contains three sorting platforms: Two on the fiber sort line and one on the commingled container sort line. All three of these sorting platforms are designed with five to seven sorting stations. Each platform has a dedicated staircase for ingress and egress. However, no platform has more than a single egress route. The NFPA 101 Life Safety Code specifies that no less than two means of egress should be provided. In the event of an emergency, employees should have access to multiple routes of escape. Future equipment/platform modifications or retrofits should provide additional egress routes to employees.

Unsuitable Driving Surfaces

As discussed in Section 4.2, the driving surfaces on the west side of the site are not suitable for their intended use. The damage to the driving surfaces creates risks of forklifts tipping over which can lead to injury.

Bloodborne Pathogens

All MRF Training and Safety Programs should contain a Bloodborne Pathogen Program. Based on discussions with the Operator, it is not uncommon for needles or other sharps to be found on the sort line. The Operator reported that sorters receive cuts through the provided gloves frequently – on a semi-weekly basis. In the event of a cut/poke/stick, an employee is provided first aid and fills out a “non-medical injury report” or a “Report of Employee Injury”, depending on the severity. This is consistent with the “New Hire Training – Sharps” document provided by the City.

When a needle is identified on the sorting line, it is removed and placed in a metal container which is then taken to residue. The Operator reported that if the needle is clearly visible, sorters may remove the needle without stopping the conveyor. The “New Hire Training – Sharps” training document states that the conveyor belt must be stopped whenever a needle is identified. This is a critical practice and must be followed to prevent needle sticks. Supervisors should ensure that this safety procedure is followed. Any object containing needles or other sharps should be clearly labelled as such.

Processing Equipment Safety Hazards

Refer to Section 3.4.

Training

New-hire training is provided to all new employees before they begin work in the MRF. New Hire training documentation was provided by the City and includes pertinent topics to MRF safety and operations. Before an employee is allowed to operate mobile equipment, they must pass a written exam created by the City.

Ongoing training is provided by the MRF supervisors on a weekly basis. Topics for the weekly training are not selected in advance and are recorded following each safety meeting. Generally, training topics are selected by the MRF supervisors based on recent observations. It is recommended that the new-hire training and ongoing training program are updated to include the topics listed below. Additionally, it is a best practice to develop a schedule of weekly training in advance so that materials can be prepared. Supplemental training sessions based on recent observations can be provided in addition to the scheduled training topic. Training programs topics should include:

- Personal Protective Equipment
- First Aid
- Housekeeping
- Heavy Lifting
- Confined Spaces
- Fall Protection
- Emergency Response
- Hazard Communication
- Spill Prevention
- Industrial Equipment Safety
- Lock Out Tag Out
- Blood-borne Pathogens

5.6. Maintenance & Spare Parts

The MRF shares a team of three mechanics with other nearby City solid waste facilities and operations. It can be difficult to get mechanics to prioritize MRF repairs in place of other tasks. Certain preventative maintenance tasks (such as lubrication of bearings) are completed by the MRF Supervisors. Based on the inspection, it appears that preventative maintenance tasks are being performed on a regular basis. No belts were observed to be in need of short-term replacement.

More specialized maintenance tasks (namely the replacement of discs) are not being performed. Based on interviews with staff, it appears that procuring replacement discs has been a challenge. Additionally, the task of replacing the discs requires both time and technical knowledge from the mechanics. It appears that the City mechanics may not have the resources and technical knowledge of these screens needed to perform this task.

Spare parts are stored in a separate maintenance building on the same campus. The inventory of spare parts is limited to certain belts, components, and a spare wire tie system. In discussions with the maintenance team, the limited spare parts inventory does not present an issue because the standard parts that would be stocked (such as pulleys) are readily available nearby with a lead time of fewer than two days. More specialized parts, such as components for the eddy current separator or the screens, are not stored onsite and are not readily available. However, the technical skills and knowledge to install/repair this equipment is limited as well. Due to the relatively few pieces of equipment in the MRF, this spare parts strategy appears to be reasonable. However, if the MRF was to add equipment (both in number and complexity), it would be prudent to store critical spares onsite.

5.7. Housekeeping

Housekeeping within the MRF was observed to be good. During the five minutes preceding a break, all staff spent time cleaning. Certain spillage points (such as around the fiber residue screen) were not frequently accessed by staff and as such did not appear to be cleaned frequently. Maintenance platforms, which did not appear to be used frequently, had significant buildup of dust. Notably, the platforms on the baler feed conveyor had excessive dust buildup, which is both a health and fire risk. These areas should be blown down regularly to limit dust buildup.

6. RECOMMENDATIONS

All deficiencies identified in this Report should be evaluated by the City and timely and appropriate corrective actions should be taken. The following are considered the most important recommendations, but the City is encouraged to review all identified maintenance, operational and safety related issues contained in this Report.

1. Correct all safety items identified in Section 5.5 and Table 4.
2. Update PPE requirements to include high-visibility clothing and long sleeves.
3. PPE requirements for gloves should be updated to specify ANSI rated, cut-resistant gloves. This will better protect sorters and limit the frequency of cuts/sticks.
4. Provide additional egress routes from the sorting platforms.
5. Add metering capability to the container line to present material more consistently for sorting.
6. Limit pedestrians on the tipping floor to the greatest extent possible. Where sorters are required on the tipping floor, guard from mobile equipment should be provided.

7. Replace the discs of both the Fiber Residue Screen and the ONP Screen.
8. Consider reducing the quantity of bale ties on plastic bales.
9. Develop a list of critical spare parts to keep in stock to prevent extended outages.
10. Purchase and store critical spare parts for the new Eddy Current Separator to be installed in Q2 2023. Request that the equipment manufacturer provide a list of critical spare parts. Request that the equipment manufacturer train City maintenance staff on how to perform repairs and maintenance on the new unit.
11. Limit traffic (mobile & pedestrian) on the west yard to the greatest extent possible until a suitable driving surface is constructed.
12. The commingled container infeed conveyor tail pit should be cleaned out regularly to limit further corrosion/damage.
13. Correct the spillage point at the tail of the UBC transfer conveyor.
14. Consider relocating the non-recyclable bunker from the tipping floor. This would increase tipping floor capacity.
15. Blowdown the platforms regularly.
16. Remove the material stockpile from the site. Prohibit any additional material from being added to this stockpile.
17. Repair the damaged concrete slab in front of the commingled container infeed conveyor.
18. Regularly blowdown the baler platform to prevent the accumulation of dust.
19. Install proper safety gates on staircases and remove plywood guards.
20. Install convex safety mirrors throughout the ground level wherever mobile equipment traffic may overlap with pedestrian traffic.
21. Prior to completing capital improvements, a system-wide analysis should be performed to address any bottlenecks that would undermine the intent of capital improvements.
22. No additional tons should be pursued unless measures are taken to increase capacity and ensure the material stockpile does not grow.
23. All equipment motors are to have their fan intake shrouds cleaned of dust/debris accumulation on a regular basis. Failure to clean the shrouds will lead to overheating and premature motor failure.
24. All personal belongings of the staff such as clothing, bags etc. should be stored in the locker room and not in the processing area.
25. Continue utilizing the ‘MRF Bale County by Day’ spreadsheet (Appendix 7) to track production. This information is very valuable for evaluating future upgrades.
26. A full review of the procedures for addressing jams/bridging in the baler hopper should be conducted to ensure that the task is performed in a safer manner.

CITY OF COLUMBIA, MISSOURI
MATERIAL RECOVERY FACILITY

MRF CONTAMINATION STUDY

REPORT

INSPECTION DATES: FEBRUARY 27 – MARCH 10, 2023

Table of Contents

Table of Tables

Table of Figures

Appendix A Tables

1. Executive Summary

1.1. Introduction

The City of Columba's Solid Waste Authority utilizes curbside collection, drop-off sites, and event recycling to manage recycling, HHW, and yard waste from its commercial, industrial, and residential generators. The City provides dual-stream curbside collection for its residential accounts on a biweekly basis. Residents are required to separate fiber recyclables from containers such as plastic, metal, and glass. On collection day, the fiber recycling must be placed on the curb in a brown paper bag or box, while the containers must be placed in a blue bag with the City's logo. The City provides vouchers to residents in January and June for an 18-count roll of bags that are redeemable at local stores or city hall. Additional vouchers are available at no additional cost to the resident.

For commercial and industrial generators, the City provides these businesses with dumpsters or roll carts depending on the need. Companies are incentivized to recycle because the cost is estimated to be 15% less when compared to MSW collection. Additionally, both commercial and residential generators can utilize any of the nine drop-off centers located around Columbia at no cost. Commercial generators are encouraged to utilize recycling collection services if they have a high volume of materials. The drop-off centers are open 24/7, and users are expected to separate fiber from container recyclables.

As part of a multi-faceted approach to develop long-term waste management strategies and better align goals with Columbia's Climate Action and Adaptation Plan (CAAP), the City sought to analyze contamination within its recycling. During the weeks of February 27th - March 3rd, 2023, and March 6th - March 10th, 2023, RRT conducted a recycling composition analysis of the current system at the City of Columbia's Material Recovery Facility (MRF). Much of the material processed at the MRF is hand-sorted, with the only equipment being a magnet, ECS, and two fiber screens. Due to the nature of the current system, it is anticipated that the material is clean, however, the capture rate of the recyclables is low.

During the study, eight (8) different recycling streams were audited to determine contamination rates present in the material sorted at the MRF. The analyzed streams include #2 HDPE, #3-#7 Mixed Plastics, Fiber Residual Material, Container Residual Material, Fiber Screen Residual Material (2), Curbside Containers, and Curbside Fiber. The recyclable materials in the waste streams were sampled and sorted into their corresponding categories. Both the container and fiber waste streams were separated into eighteen (18) unique material classifications. Additionally, the recyclable material from the drop-off centers was visually inspected for contamination.

1.2. Objectives

- Re-sort the #2 HDPE bunker into HDPE Natural and HDPE Color. Also, removing any outthrows or contamination found in the bunker.
- Re-sort the #3-#7 Mixed Plastic bunker to remove outthrows including #1 PET bottle, #2 HDPE, and ferrous cans. The Mixed Plastic bunker was re-sorted with #5 plastics separated from the #3-#7 plastics.

- Sort the fiber and container residue bunkers to determine the types of contamination at the MRF and to discern the amount of recycled material being lost in these streams.
- Sort the residual material from the fiber screens to analyze the effectiveness of this equipment and discern the amount of recycled material being lost in these streams.
- Sort loads from curbside fiber and containers to determine incoming material composition and types of contamination.

1.3 Summary and Findings

In total, eight (8) different recycling streams were audited to determine the contamination rates of the material sorted at the MRF. The eight (8) analyzed streams were #2 HDPE, #3-#7 Mixed Plastics, Container Residue, Fiber Residue, Residential Curbside Containers, Residential Curbside Fiber, Fiber Screen Residue, and ONP Screen Residue.

<u>#2 HDPE Bunker Results</u>

The sorters are effective at identifying and capturing #2 HDPE plastic from the container recycling stream. Approximately 96.2% of the material in the bunker was correctly sorted. Natural HDPE constitutes a larger proportion of the bunker compared to colored HDPE. There was minimal contamination (<1%) found in this bunker.

<u>#3-#7 Mixed Plastics Bunker Results</u>

The material quality captured in the #3-#7 bunker could be improved because over 1/3 of the material was improperly sorted and should have gone in one of the other bunkers for plastic. #1 PET bottles, #2 HDPE – Natural, and #2 HDPE – Colored account for 29.9% of the total material in the Mixed Plastics bunker. These materials have dedicated bunkers and combining them into the #3-#7 bunker is forfeiting their commodity value. Contamination in this bunker is estimated to be 7.9% and much of the contamination can be attributed to unnumbered plastic containers.

<u>Container Residue</u>

Approximately 40% of the container residue sorted was recyclable, with plastic being the most common recyclable material type identified. Additionally, 11.7% of the container residue was recyclable metal, which could indicate that the belt magnet and eddy current separator are not performing optimally. Unexpectedly, recyclable paper constituted over 10% of the container residue. Recyclable paper should not be entering the commingled container stream and additional education for generators may be required to minimize the inclusion of fiber into the container stream.

<u>Fiber Residue</u>

Approximately 40% of the fiber residue sorted was recyclable, with mixed paper and OCC being the most common recyclable materials identified. There were minimal amounts (3.2%) of recyclable containers in the fiber residue bunker. This indicates that waste generators are effective at separating containers from the fiber stream.

<u>Residential Curbside Containers</u>

Columbia’s residential curbside container contamination rate is 15.5%, which is marginally better than the national average (16.9%). The predominant material in residential curbside containers by weight is glass, which accounts for half of the material. Minimal contamination of remainder/composite plastic indicates that residents are effective at identifying recyclable plastics.

Residential Curbside Fiber

Residential curbside fiber had minimal contamination; however, further analysis is needed to confirm these results. OCC constitutes 2/3 of recyclable material in the residential curbside fiber stream. Effective enforcement at the curb has minimized sources of contamination from entering the residential curbside fiber stream. Collections should be encouraged to continue to exclude contamination at the curb.

Fiber Screen Residue

The Columbia MRF Inspection conducted by RRT in February 2023 found that the discs on the screen have exceeded their useful life. Due to the excessive wear on the discs, recyclable fiber is being incorrectly diverted to residue. Over 2/3 of the fiber screen unders were recyclable, with OCC and mixed paper being the predominant materials. The fiber screen residue had minimal outthrows (8.0%), which indicates that waste generators are effectively excluding containers from the fiber stream.

ONP Screen

The sorters and screens are effectively removing containers from the fiber stream because the ONP screen unders had only trace amounts of commingled containers. The Columbia MRF Inspection conducted by RRT found that the discs on the screen must be replaced. Of the screen unders that were sorted, approximately 80% of the material was recyclable fiber. The predominant recyclable fiber in the screen unders was mixed paper, boxboard, and high-grade paper.

2. Methodology

2.1 Material Streams and Generator Sectors

The City of Columbia operates a dual-stream curbside collection program for residents, compulsory recycling collection for businesses, and drop-off sites for all generators within the City. The recycling composition study had a focus on the end products generated in the MRF after the recyclable material had been sorted. Additionally, the study analyzed collection routes from the residential curbside collection and visually inspected roll-off containers from the drop-off sites.

2.1.1 Commingled Container Stream Description

The commingled containers stream includes materials that might be informally referred to as “bottles and cans,” or “metal, plastic, and glass.” Accepted program materials include any rigid plastics numbered #1-#7, aluminum cans, metal cans, and glass bottles. Prohibited materials include Styrofoam, film plastic, aluminum foil, aluminum tins, cat food containers, and composite containers. Additionally, any material that isn’t explicitly stated to be an accepted program material for the container stream, even if recyclable, is considered trash. This includes any fiber that would be recyclable if it were in the commingled fiber stream.

2.1.2 Commingled Fiber Stream Description

The commingled fiber stream includes materials that might be informally referred to as "cardboard, and any clean paper that tears." Accepted program materials include any cardboard, office paper, envelopes, newspaper, magazines/glossy, and boxboard. Prohibited materials include aseptic/gable top cartons, paper products, and any composite paper products. Composite paper products include materials such as envelopes with plastic windows or waxed OCC.

As with the commingled container stream, any extraneous containers found on the fiber line are considered trash. However, in events of high container volume in the fiber stream, sorters are instructed to remove containers from the line and place them in trash cans. These cans are then emptied onto the container line where they can be sorted. During the two weeks of conducting the study, this practice was not observed. Employing this practice successfully depends on the availability of workers.

2.2 Material Definitions

Material Group	Material Category	Material Definition
Paper	OCC/Kraft	Uncoated cardboard boxes with a fluted middle liner. Includes craft and other brown paper bags. Excludes soiled, wax, or plastic covered boxes.
	ONP	Printed ground newsprint.
	High-Grade Paper	Paper used in an office including photocopy paper, printer paper, manila folders, envelopes, shredded paper, and index cards. Excludes envelopes that contain plastic windows or colored paper.
	Mixed Paper	Low-grade recyclable paper that includes discard/junk mail, soft-cover books, phone books, books/catalogs with groundwood paper, colored paper, and glossy/catalogs.
	Boxboard	Contains the same fiber as corrugated cardboard but lacks the fluted middle liner. Includes cereal boxes and unsoiled fiber egg cartons.
	R/C Paper	Any low-grade non-recyclable paper which does not fit into any other category. Includes aseptic and gable top containers, soiled or contaminated paper products, composite papers, tissue paper, napkins, and coated or waxed OCC.
Plastic	#1 PET Bottles	Plastic bottles with a screw-off top that is labelled #1. Excludes tubs such as peanut butter containers.

Material Group	Material Category	Material Definition
	#1 PET Containers	Plastic containers without a screw-off top that are labelled #1. Includes materials such as berry or other food containers, tubs, and cups.
	#2 HDPE Natural	Non-pigmented plastic bottles and containers that are labelled #2. Includes milk jugs.
	#2 HDPE Colored	Pigmented plastic bottles and containers that are labelled #2. Includes detergent bottles and coffee tubs.
	#3 - #7 Mixed Plastic excl. #5	Plastic bottles, containers, and other packaging that are labelled numbers excluding #1, #2, and #5. Includes items made of LDPE, PVC, PS, vinyl, or other plastics. May be numbered as 3, 4, 6, or 7.
	#5 Plastics	Plastic bottles, containers, and other packaging that are labelled #5.
	Film Plastic	Includes merchandise bags, garbage bags, shrink wrap, and other non-rigid plastic.
	R/C Plastics	Any non-recyclable plastic which does not fit into any other category. Includes rigid plastic, EPS or Styrofoam, straws, and plastic cutlery.
Ferrous	Ferrous Cans	Ferrous food and beverage cans. Including bi-metal and non-aerosol spray cans.
Non-Ferrous	Aluminum Cans	Aluminum beverage containers. Excludes cat food cans.
Glass	Glass	Recyclable glass beverage and food bottles/jars of any color.
Residue	Trash/Residue	Any material not included in the categories above. Includes materials such as food, organics, and household hazardous waste.
	Fines	Any material that can pass through a 2” screen regardless of material composition.

2.3 Historical Generation

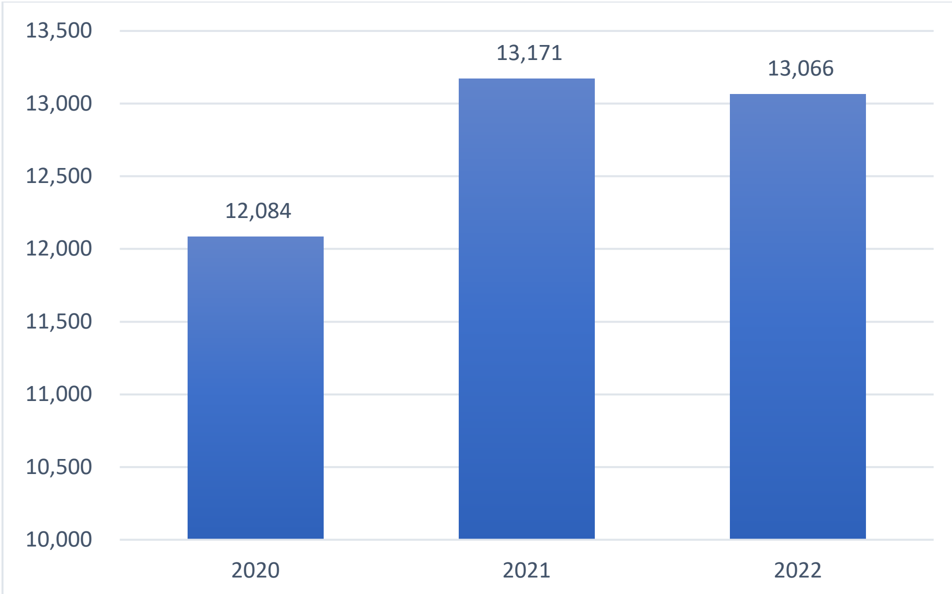


Figure 1. Inbound Recyclable Tonnage to MRF (2020 – 2022)

The Columbia MRF processes an average of approximately 13,000 tons per year. It would be anticipated that 2020, under normal conditions, would have similar inbound recycling tonnage rates to 2021 and 2022. However, worker shortages during the coronavirus pandemic necessitated a pause on recycling curbside collection in July 2020. This policy change is also reflected in Figure 2, which shows elevated levels of participation at the drop-off centers. The pause on recycling collection didn't significantly impact inbound recyclable tonnages because residents diverted these materials to the drop-off centers until recycling curbside collection was reinstituted in February 2021.

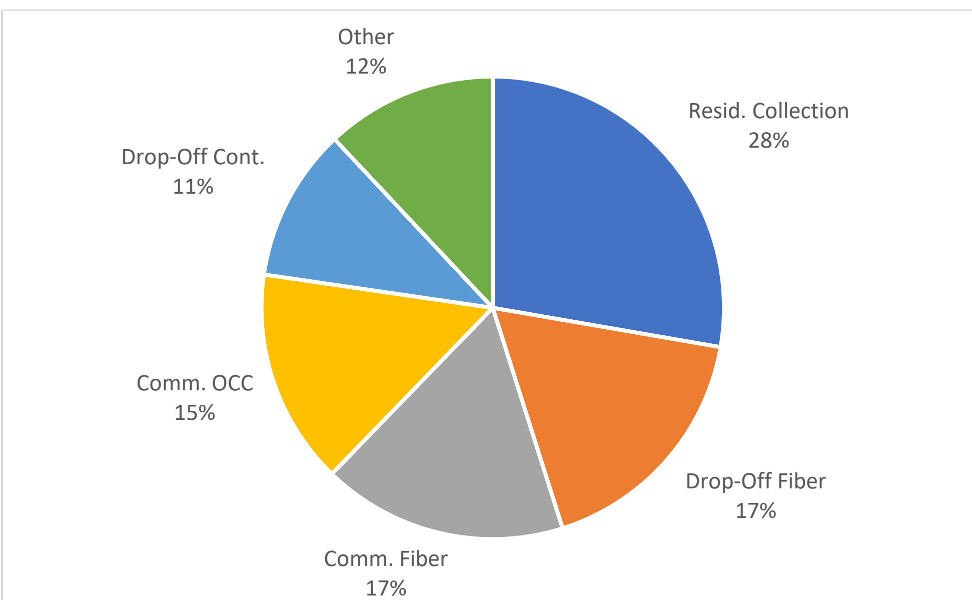


Figure 2. Major Inbound Recycling Streams – 2020

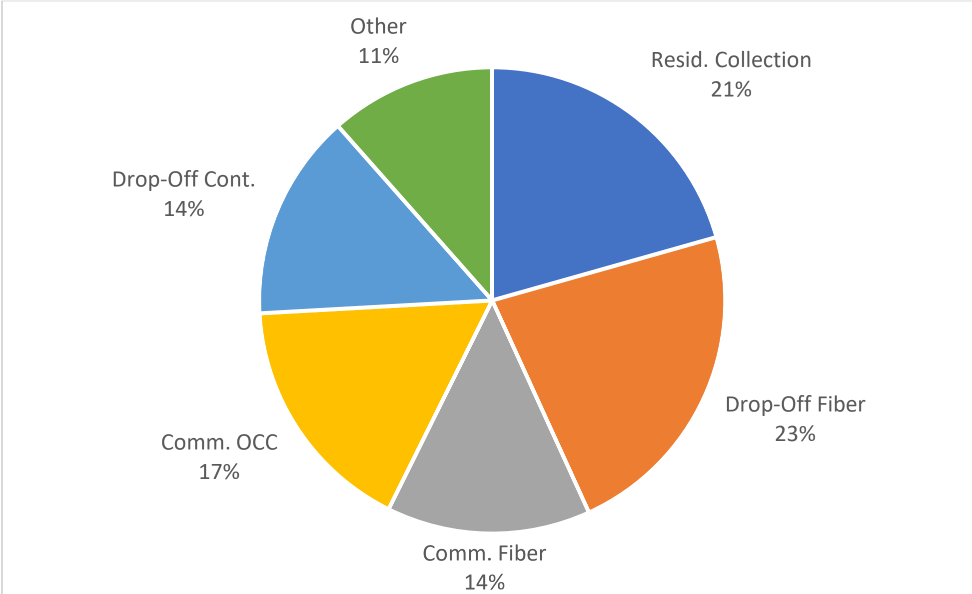


Figure 3. Major Inbound Recycling Streams – 2021

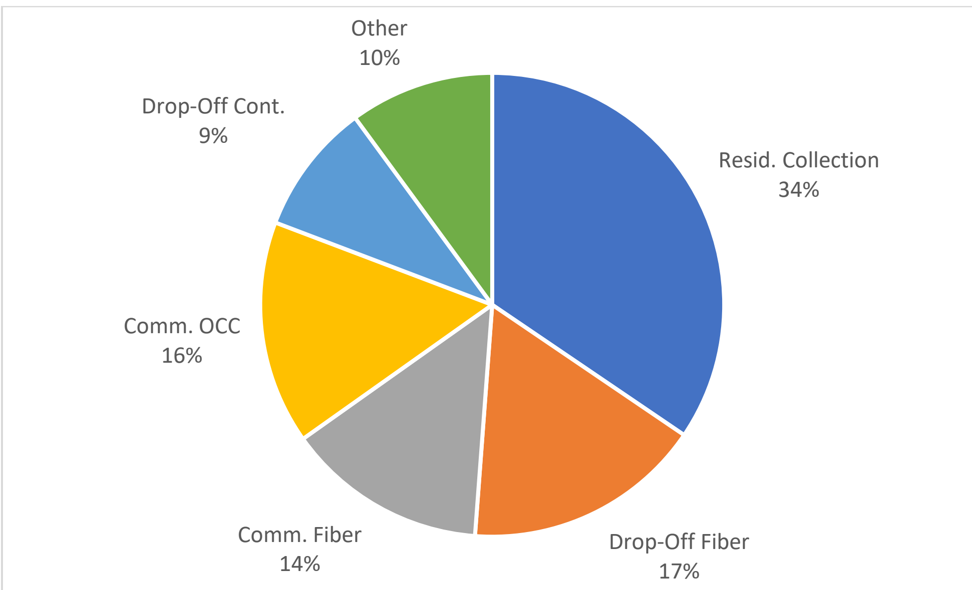


Figure 4. Major Inbound Recycling Steams – 2022

Over 88% of all inbound materials come from five (5) sources: residential recycling, recycling drop-off center fiber, commercial fiber, commercial cardboard, and recycling drop-off center containers. Apart from 2021, residential collection is the predominant source of recycling entering the MRF.

It is necessary to understand which material streams contribute the most to the inbound materials because it can be used to manage contamination rates. Efforts to mitigate contamination in recycling should prioritize these streams because it will have the greatest impact.

2.4 Sorting Facility and Schedule

2.4.1 Material Recovery Facility Background

The MRF is located at 5700 Peabody Road, Columbia, Missouri in the Columbia Sanitary Landfill facility complex. The MRF is 26,000 ft^2 with a 16,000 ft^2 processing, storage, and administration area where the sampling was conducted. The MRF is open 6:30am – 5:00pm Monday through Thursday and 6:30am – 3:00pm on Friday. On Fridays, the MRF does not process any material, but the facility still receives curbside collection and drop-off center loads. All sampling was conducted when the facility was in operation.

Commingled Container Stream Process

When containers are brought to the MRF, they are emptied on the west side of the tipping floor by the container sort line in-feed conveyor. A skid-steer loader is used to push the bagged commingled containers onto the container in-feed conveyor. Workers adjacent to the conveyor belt tear open bags by hand and empty the contents onto the conveyor belt. The blue bags and trash are placed into a bunker adjacent to the conveyor belt.

Once the material is on the belt, it is hand sorted into three bunkers - #2 HDPE, #1 PET, and #3-#7. After the plastic containers are removed, there is a magnet to remove ferrous containers and an eddy current separator to capture aluminum cans. The only remaining material on the belt is glass, which is stored in a bunker outside of the building.

Commingled Fiber Stream Process

When fiber is brought to the MRF, it is emptied on the east side of the tipping floor by the fiber sort line in-feed conveyor. Workers adjacent to the in-feed conveyor belt remove any large pieces of OCC or trash on the conveyor belt. Then, the fiber is passed over a star screener where containers and other non-fiber materials fall through. The fiber is then hand sorted into four bunkers – OCC, mixed paper, office paper, and trash. The only remaining material on the belt is ONP, which passes over a screen to remove any final contamination and then into a bunker.

2.4.2 Field Data Collection Schedule

Coordination between the study coordinator and facility manager occurred every morning before starting each day’s samples. The sample collection schedule was fluid depending on the availability of material and which line was in operation. Typically, two samples were collected from a bunker during the sorting procedure.

After both samples from a specific bunker were completed, the material was replaced into the bunker where it was collected from. To prevent re-sorting of the same material, the corresponding bunker would then be emptied, and the material would be baled. It would take approximately two (2) days for the bunker to reach an adequate capacity to sort the material again.

In total, 36 samples were analyzed at the MRF between February 27th - March 3rd, 2023, and March 6th - March 10th, 2023. For this aspect of the Recycling Contamination Study, RRT’s goal was to sample as many loads as possible without sacrificing the quality of individual assessments or unduly impacting facility operations.

Table 1. Sampling Program Dates

Sample Type	Sample Label	Date	Sample Size (lbs.)
MSW	Container Residue	2/28/2023	105.1
	Container Residue	2/28/2023	127.4
	Container Residue	3/3/2023	190.5
	Container Residue	3/3/2023	200.1
	Container Residue	3/6/2023	120.9
	Container Residue	3/6/2023	159.2
	Container Residue Total:		903.2
	Fiber Residue	2/28/2023	96.8
	Fiber Residue	2/28/2023	148.0
	Fiber Residue	3/2/2023	152.3
	Fiber Residue	3/2/2023	171.7
	Fiber Residue	3/8/2023	252.7
	Fiber Residue	3/8/2023	233.4
	Fiber Residue Total:		1054.9
	Fiber Residue Screen	3/7/2023	140.7
	Fiber Residue Screen	3/7/2023	185.3
	Fiber Residue Screen	3/9/2023	229.1
	Fiber Residue Screen Total:		555.1
	ONP Screen	3/1/2023	67.9
	ONP Screen	3/2/2023	66.1
	ONP Screen	3/2/2023	104.3
	ONP Screen	3/7/2023	66.7
	ONP Screen Total:		305.0
Recyclables	#2 HDPE	2/27/2023	241.9
	#2 HDPE	2/27/2023	276.8
	#2 HDPE	3/1/2023	236.3
	#2 HDPE	3/1/2023	248.3
	#2 HDPE	3/3/2023	236.6
	#2 HDPE	3/3/2023	233.6
	#2 HDPE Total:		1473.5
	#3-#7	2/27/2023	111.2
	#3-#7	2/27/2023	89.2
	#3-#7	3/1/2023	105.1
	#3-#7	3/1/2023	100.9
	#3-#7	3/3/2023	172.4
	#3-#7	3/8/2023	87.3
	#3-#7 Total:		666.1
	Residential Curbside Container	3/6/2023	162.4
	Residential Curbside Container	3/8/2023	209.3
	Residential Curbside Container	3/9/2023	169.3
	Residential Curbside Container	3/9/2023	222.7
	Residential Container Total:		763.7
	Residential Curbside Fiber	3/10/2023	250.7

2.5 Sampling Methodology

2.5.1 Sample Selection

To prevent bias, the material designated as the sample was varied with each load using the “clock-face” method. An imaginary clock-face is super imposed over the tipped load and samples are selected randomly from one of the cells in the clock face. If the first sample area is the area from 12 o’clock to 2 o’clock, the next sample should be from 2 o’clock to 4 o’clock (and so on). This procedure was used to select the samples for the residential curbside containers and residential curbside fiber.

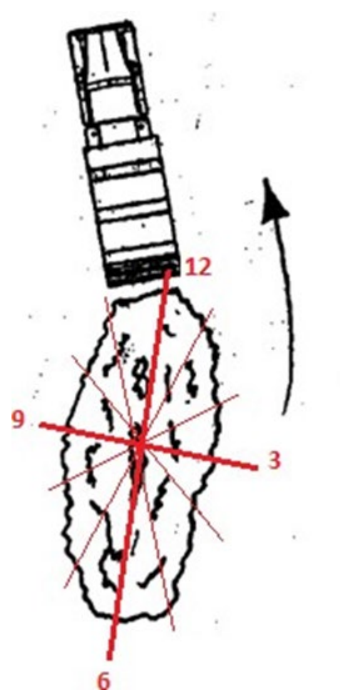
For the samples that were collected from the bunkers, it was assumed that the sample was already randomized. However, the “clock-face” method was still applied to material in the bunker. The storage bunker has three sides, so the open face of the bunker was the one that was most often sampled due to ease of access.

The selected sample was separated from the additional material in the storage bunker and placed on a tarp to be sorted. The attending member of the RRT team was responsible for visually ensuring that the sample collected reflected the composition of the entire load. The targeted weight for each sample was to be between 200lbs – 300lbs, but actual sample weights varied.

2.5.2 Sample Characterization

Once the selected sample was collected and placed on a tarp, it was hand sorted into trash cans and bins corresponding to each material category. The study coordinator monitored the category bins to ensure the homogeneity of the material being sorted. Improperly sorted material was removed from the incorrect bin and re-sorted, when necessary. Any questions regarding an item’s placement in a category were directed to the study coordinator who made the final determination.

For composite materials, they were considered as contamination and included in trash/residual calculations. The selected sample was sorted until only a fine residual material (<2”) remained. This material was measured and included in the composition analysis. The fines were visually analyzed to determine its composition.



Once a sample was sorted, the study coordinator weighed and recorded the tare weights of each material category and container type. All results were recorded on the corresponding sample data sheet. The sample data sheet can be found in Appendix B. Photo documentation of each sample was collected. Any points or materials of interest were noted on the sample data sheet.

The net weight of each material was calculated by subtracting the tare weight of the container from the measured gross weight. The percentage composition and other statistical analyses were conducted after the sampling was completed.

After weighing the sample, the bins and buckets were emptied. All acceptable recycled material was returned to its respective bunker at the end of the day to prevent resorting of the same material. Any contamination found was separated into black garbage bags to be disposed of. Then, the sorting table and tarp were swept clean, in preparation for the next sample analysis.

2.6 Sampling Health and Safety Requirements

An area was designated for waste sorting operations away from moving equipment. This area was marked using high-visibility traffic cones. Additionally, skid-steer operators were informed that areas were off-limits while the sorting team was working there. For further protection, bales were placed as a barricade to prevent access of any mobile heavy machinery. If heavy machinery must enter the work area, the operator must receive permission from the study coordinator. The cones were not removed from the work area unless sampling was completed for the day, or the study coordinator approved its removal.

Before starting the sampling process, workers were given safety training by the study coordinator. Sorters signed a form acknowledging the material that was reviewed and that they understood the potential risks associated with this work. PPE was required while a worker was participating in the sampling process. PPE is intended to minimize the exposure to hazardous materials that can cause injuries or lead to illness in the workplace. Failure to adhere to the PPE requirements resulted in the worker being asked to no longer participate in the sampling process.

3. Composition Study Results

3.1 #2 HDPE Bunker Results

Components are categorized as either “Recyclable,” “Outthrows,” or “Non-Recyclable Material.” The only materials in the #2 HDPE results that are classified as “Recyclable” are #2 Natural and #2 Colored. For a material to be classified as “Outthrow,” it must be a material that is in Columbia’s recycling and trash guidelines but was sorted into the incorrect bunker. Any material that is not included in Columbia’s recycling and trash guidelines or is explicitly prohibited is classified as “Contamination.”

Table 2. HDPE Results

#2 HDPE Results	% Composition (Weighted Average)
Recyclable Material	**96.2%**
Plastics	**96.2%**
#2 HDPE-N	55.0%
#2 HDPE-C	41.2%
Outthrows	**3.1%**
Paper	**0.0%**
OCC / Kraft	0.0%
ONP	0.0%
High-Grade Paper	0.0%
Mixed Paper	0.0%
Boxboard	0.0%
Plastics	**2.8%**
#1 PET Bottles	1.7%
Other #1 PET	0.6%
#3 - #7 Mixed Plastics Excluding #5	0.2%
#5	0.3%
Glass	**0.0%**
Glass	0.0%
Metals	**0.3%**
Aluminum Cans	0.1%
Tin/FE Cans	0.2%
Contamination	**0.7%**
Film Plastic	0.0%
R/C Plastic	0.5%
R/C Paper	0.0%
Residue	0.2%
Fines	0.0%
Grand Total	**100.0%**

Most of the material sorted in the #2 HDPE bunker was recyclable (96.2%), with HDPE Natural being the predominant material sorted. There was very little missorted material within the HDPE bunker, but #1 PET bottles (1.7%) were the major constituent. The #1 PET bottle bunker is adjacent to the #2 HDPE bunker, and this is one potential source of #1 PET bottles entering the HDPE bunker.

A common mistake observed while sampling at the MRF was that there was some difficulty in distinguishing between #2 colored and #5 plastics. This problem is compounded by the speed at which the sorters must process the material. There is often little time to inspect the plastic for its number; therefore, sorters must make quick determinations.

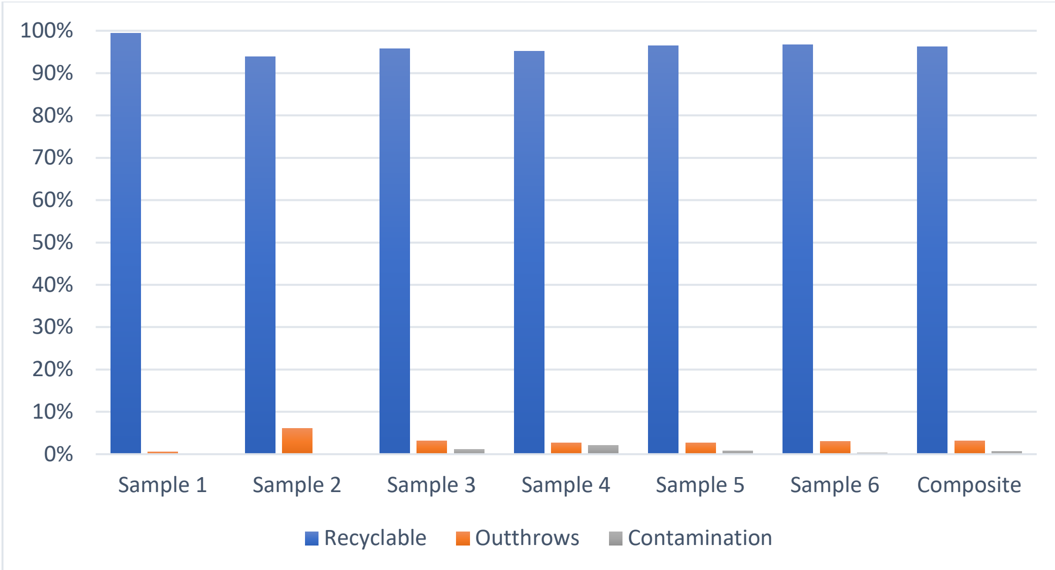


Figure 5. HDPE Sample Comparison

All samples, apart from Sample 2 (93.9%), had a recyclable fraction above 95%. Sample 1 and Sample 2 had no contamination, but Sample 2 had the most outthrows when compared with all other samples. Total contamination for the HDPE bunker was less than 1% of the total. The commodities in the HDPE bunker are considered clean and much of this can be attributed to the hand sorting performed at the MRF.

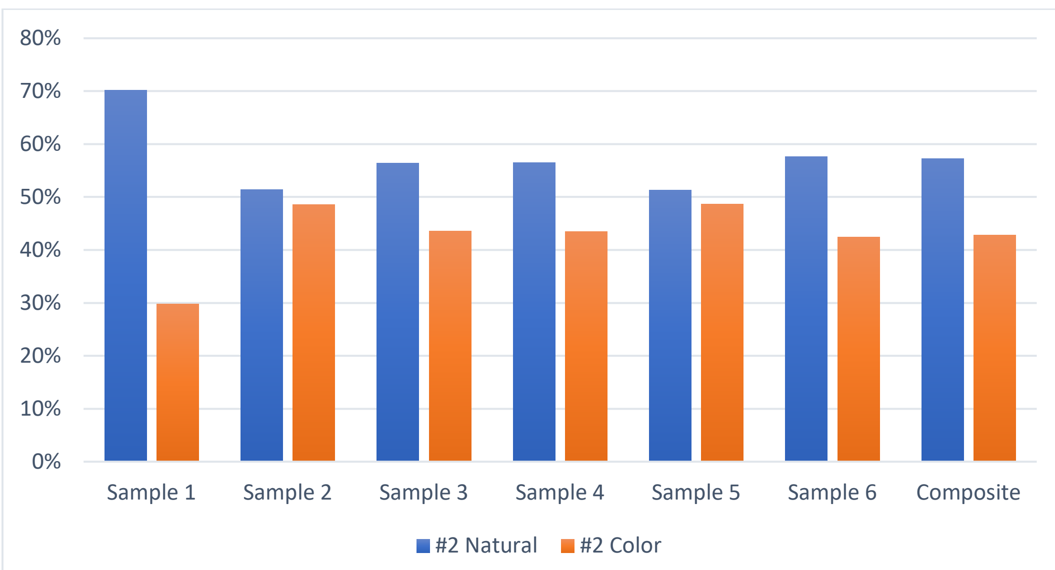


Figure 6. Proportion of HPDE-N and HDPE-C

Comparing the amount of HDPE Natural and HDPE Color to the total weight of HDPE sampled, HDPE-N makes up a greater proportion of the total weight. In every sample, the proportion of #2 Natural (57.2%) was higher than #2 Color (42.8%).

3.2 #3-#7 Bunker Results

Components are categorized as either "Recyclable," "Outthrows," or "Non-Recyclable Material." The materials in the #3 - #7 Mixed Plastics results that are classified as "Recyclable" are other #1 PET, #3 - #7 mixed plastics excluding #5, and #5 plastic. For a material to be classified as "Outthrow," it must be a material that is in Columbia's recycling and trash guidelines but was sorted into the incorrect bunker. Any material that is not included in Columbia's recycling and trash guidelines or is explicitly prohibited is classified as "Contamination."

Table 3. #3 - #7 Mixed Plastics Results

#3 - #7 Mixed Plastics Results	% Composition (Weighted Average)
Recyclable Material	**61.2%**
Plastics	**61.2%**
Other #1 PET	34.6%
#3 - #7 Mixed Plastics Excluding #5	3.4%
#5	23.2%
Outthrows	**30.9%**
Paper	**0.0%**
OCC / Kraft	0.0%
ONP	0.0%
High-Grade Paper	0.0%
Mixed Paper	0.0%
Boxboard	0.0%
Plastics	**29.9%**
#1 PET Bottles	23.9%
#2 HDPE-N	1.3%
#2 HDPE-C	4.7%
Glass	**0.0%**
Glass	0.0%
Metals	**1.0%**
Aluminum Cans	0.9%
Tin/FE Cans	0.1%
Contamination	**7.9%**
Film Plastic	0.0%
R/C Plastic	5.8%
R/C Paper	0.0%
Residue	2.1%
Fines	0.0%
Grand Total	**100.0%**

Approximately two-thirds of the #3-#7 bunker is recyclable material (61.2%), with other #1 PET being the predominant material. Due to current vendor requests, the MRF is unable to market the other #1 PET with the #1 PET bottles. This is diminishing additional revenue for the MRF because the national average price for #3 - #7 is 1¢/lb., while the #1 PET price is averaging 12¢/lb. in the first quarter of 2023. As for the metal outthrows, the aluminum bunker and ferrous bunker both neighbor the #3 - #7 bunker, so it can be reasonably assumed that some of the material is entering the mixed plastic bunker.

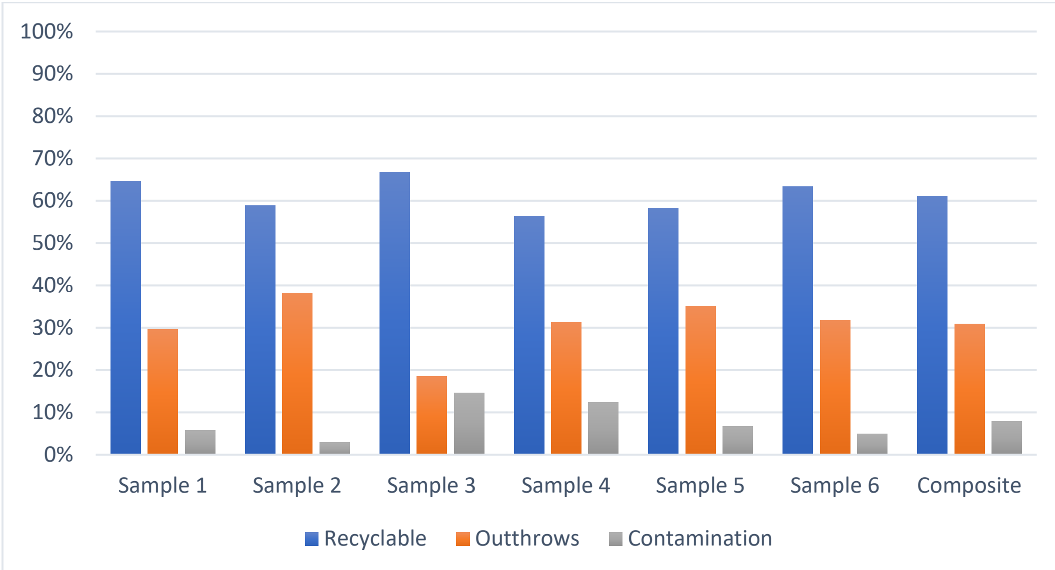


Figure 7. #3 - #7 Sample Comparison

The proportion of recyclables characterized in the #3 - #7 bunker stayed consistent around 60%, while the outthrows and contamination fractions were more variable. The weighted average of the outthrows is 30.9% and the weighted average of contamination is 7.9%. Compared to the #2 HDPE bunker, there is significantly more contamination found in the #3- #7 bunker. Much of this contamination can be attributed to remainder/composite plastic that is entering the bunker. Based on the weighted average, R/C plastic constitutes over 70% of the total contamination. The majority of the remainder/composite plastic contamination is from plastic packaging without numbers.

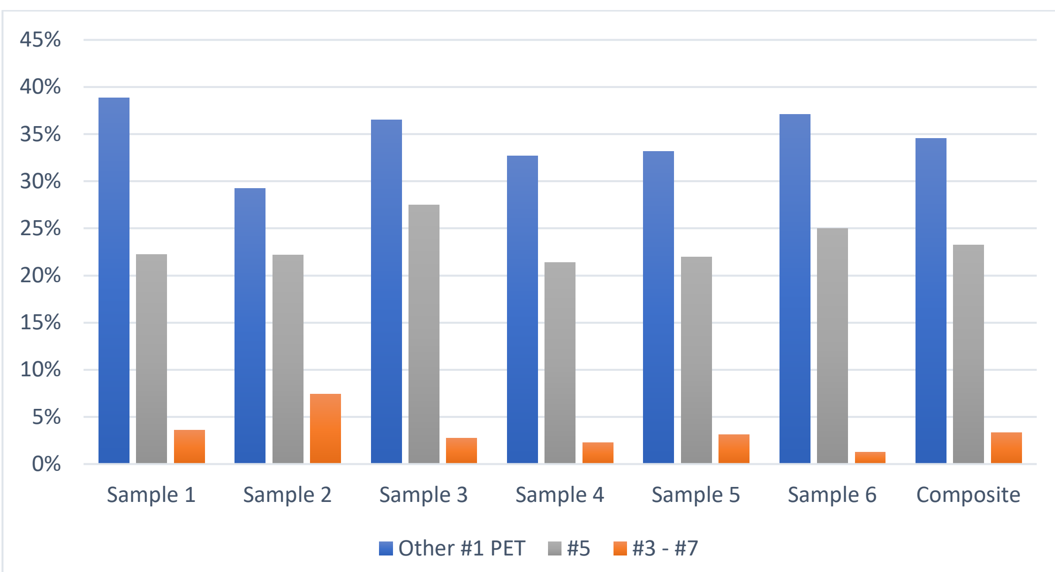


Figure 8. #3 - #7 Recyclable Constituents

The single largest constituent of the #3 - #7 bunker is other #1 PET at 34.6%, this is compared to the 23.2% for #5 plastics and 3.3% for #3 - #7 plastics. Marketing these materials as #3 - #7 is diminishing potential returns. Very little of the material in the #3 - #7 bunker is mixed plastic; rather, the material is primarily #1 and #5 plastics. Both polymers are significantly more valuable than the price currently received for the mixed plastic.

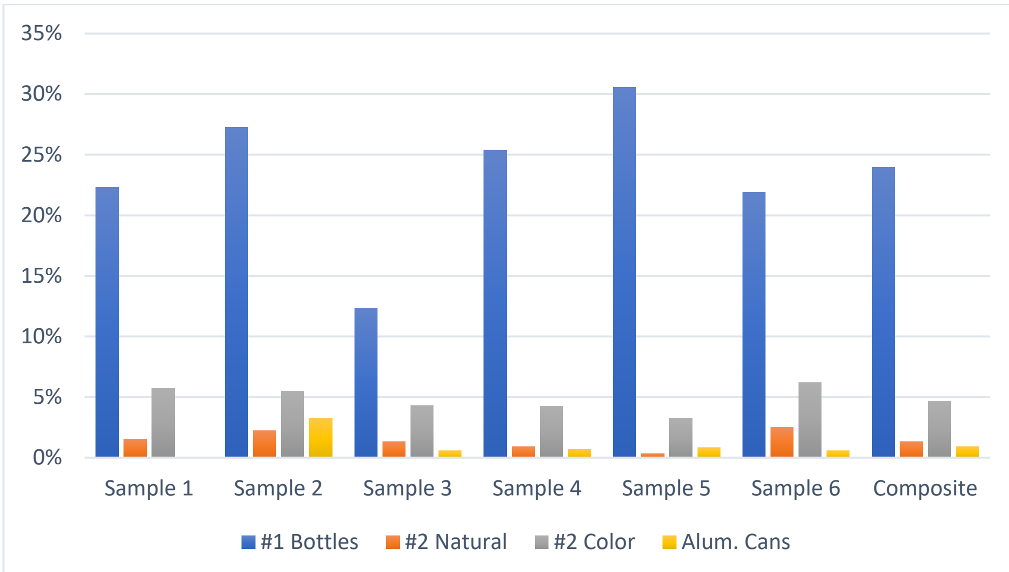


Figure 9. #3 - #7 Top Four Outthrows

The most significant outthrow by weight is #1 bottles. #1 bottles are classified as any #1 plastic with a screw-off top. During discussions with sorters, they said any #1 bottles that aren't captured in the #1 bottles bunker are placed into the #3 - #7 mixed plastics bunker. Aluminum cans account for a small fraction of the total #3 - #7 stream, and it was often observed that the cans were crushed or stuck to the mixed plastic. The cans are not easily separable from the mixed plastic, and it diminishes the quality of the mixed plastic bunker.

3.3 Container Residue Results

The container residue bunker constitutes the trash and refuse that is pulled from the commingled container line. Any acceptable commingled container program material (#1 - #7 plastics, glass, and metals) will be considered recyclable because it indicates that this material isn't being captured.

Table 4. Container Residue Results

Container Residue Results	% Composition (Weighted Average)
Recyclable Material	**39.2%**
Plastics	**21.4%**
#1 PET Bottles	5.8%
Other #1 PET	4.9%
#2 HDPE-N	2.1%
#2 HDPE-C	2.2%
#3 - #7 Mixed Plastics Excluding #5	2.2%
#5	4.1%
Glass	**6.1%**
Glass	6.1%
Metals	**11.7%**
Aluminum Cans	5.4%
Tin/FE Cans	6.3%
Outthrows	**11.1%**
Paper	**11.1%**
OCC / Kraft	3.9%
ONP	0.2%
High-Grade Paper	0.9%
Mixed Paper	2.8%
Boxboard	3.2%
Contamination	**49.8%**
Film Plastic	3.8%
R/C Plastic	14.0%
R/C Paper	0.0%
Residue	30.3%
Fines	1.6%
Grand Total	**100.0%**

Approximately 40% of the total material sorted in the container residue bunker was recyclable, with plastics being the most common material type. It is imperative that the MRF attempt to capture this material because it is losing a significant portion of revenue.

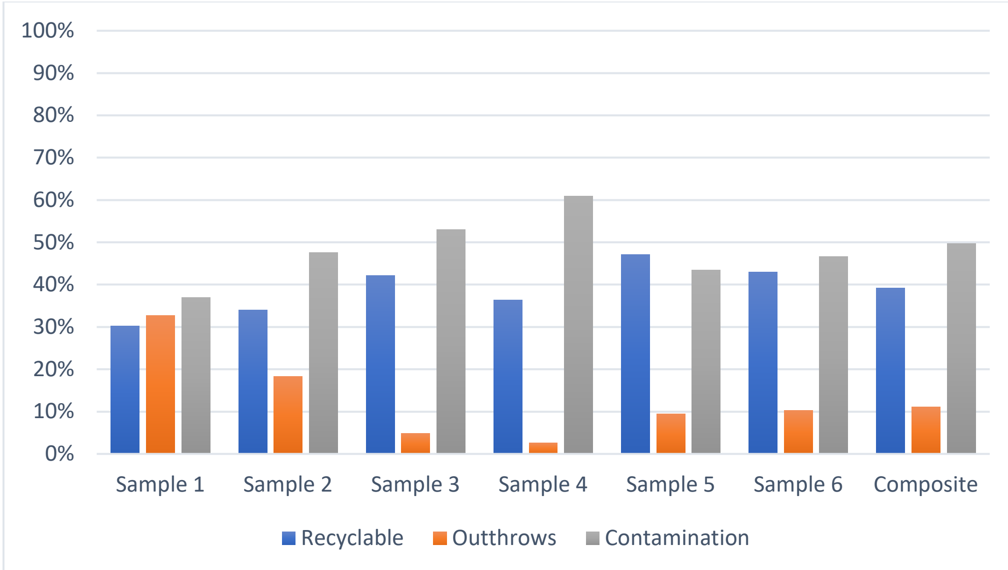


Figure 10. Container Residue Sample Comparison

Apart from Samples 1 and 2, outthrows accounted for less than 10% of the total sample. The outthrows should be considered trash in the context of the MRF; however, these materials should not be entering the commingled container stream to begin with. Additional education for generators may be required to reduce the inclusion of commingled fiber into the container recyclables.

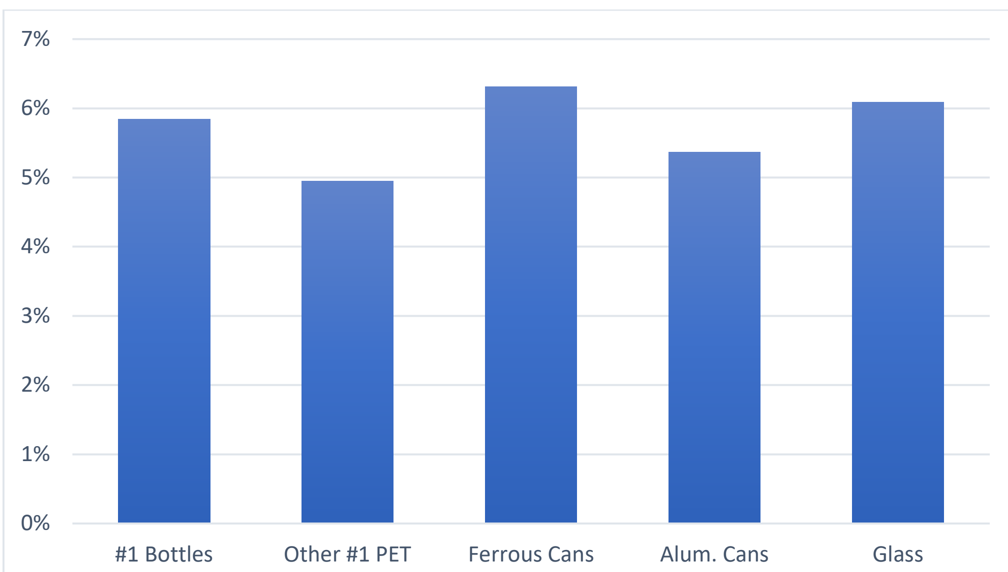


Figure 11. Container Residue 5 Most Common Recyclables

The most common recyclable materials in the container residue bunker were ferrous cans, glass, #1 PET bottle, aluminum cans, and other #1 PET. It should be noted that every commingled container program material was found in the refuse. Ferrous cans and aluminum cans are found in the container residue in a higher volume than anticipated because these materials are sorted via a belt magnet and ECS, respectively. This result could be indicative that the equipment is not performing optimally due to wear and/or age.

Figure 12. Glass Found in Container Residue

The amount of glass found in these samples is unexpected because glass is negatively sorted, meaning it remains on the conveyor belt. The image above was captured on a day with the largest volume of glass found in the container residue sample and depicts the type of glass found in the residue sample. Acceptable glass containers include beverage containers, food containers, and other glass containers. According to those requirements, all glass bottles in the image should be recyclable. Additionally, any glass fragments or shards should not be handled directly because it is a safety hazard for sorters.

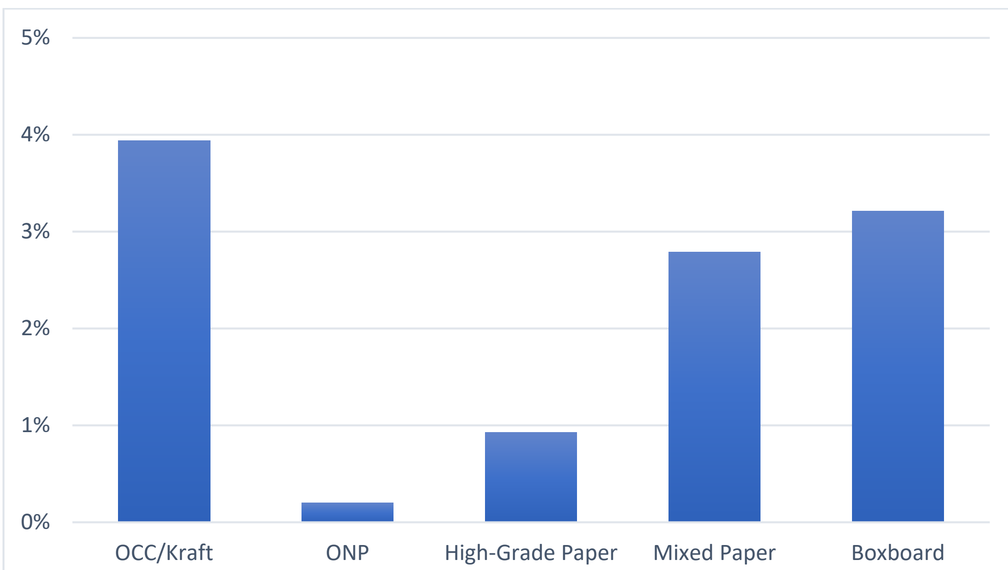


Figure 13. Container Residue Outthrows

While the individual paper category amounts are low, combined they account for over 11% of the total weight of the samples. These are materials that should never have entered this waste stream and will ultimately be disposed of in the landfill. Further outreach and education are required to emphasize the separation between commingled fiber and commingled container waste streams.

3.4 Fiber Residue Results

The fiber residue bunker constitutes the trash and refuse that is pulled from the commingled fiber line. Any acceptable commingled fiber program material (OCC, ONP, boxboard, high-grade paper, and mixed paper) will be considered recyclable.

Table 5. Fiber Residue Results

Fiber Residue Results	% Composition (Weighted Average)
Recyclable Material	**40.0%**
Paper	**40.0%**
OCC / Kraft	10.2%
ONP	2.8%
High-Grade Paper	4.6%
Mixed Paper	14.3%
Boxboard	8.1%
Outthrows	**3.2%**
Plastics	**2.2%**
#1 PET Bottles	1.4%
Other #1 PET	0.5%
#2 HDPE-N	0.1%
#2 HDPE-C	0.0%
#3 - #7 Mixed Plastics Excluding #5	0.1%
#5	0.1%
Glass	**0.5%**
Glass	0.5%
Metals	**0.4%**
Aluminum Cans	0.3%
Tin/FE Cans	0.1%
Contamination	**56.8%**
Film Plastic	2.0%
R/C Plastic	0.0%
R/C Paper	9.8%
Residue	44.4%
Fines	0.6%
Grand Total	**100.0%**

Like container residue samples, the fiber residue is approximately 40% recyclable material. However, the amount of fiber outthrows (3.2%) is considerably less than the container outthrows (11.1%). The bunker had large amounts of residue, and it was observed that bags of trash were entering this waste stream. It is presumed that the trash is entering the stream through residents incorrectly dumping trash at the drop-off sites or through commercial generators. It would be difficult for fiber curbside recycling to contain bags of trash because the material must be in a paper bag or box to be collected.

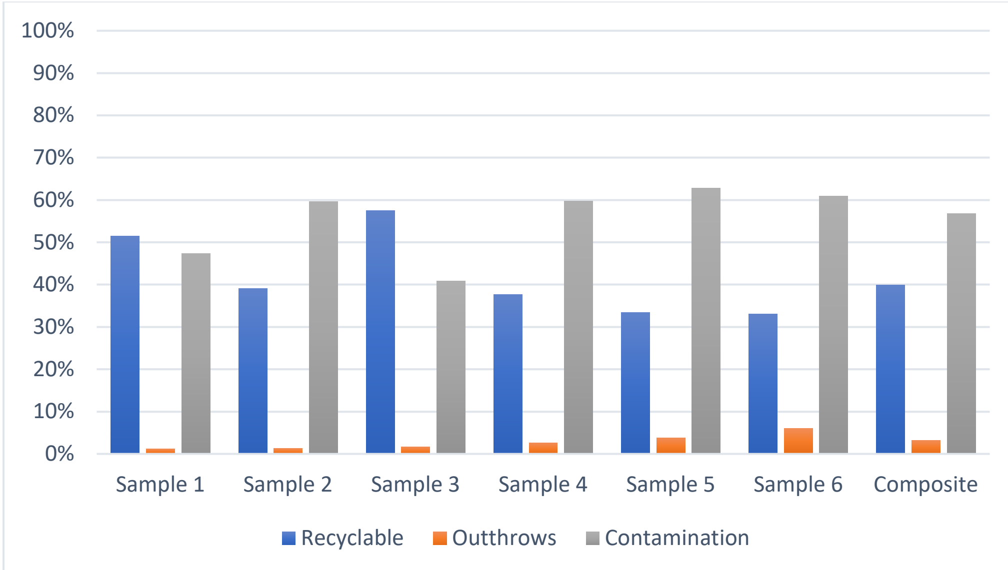


Figure 14. Fiber Residue Sample Comparison

On average, the amount of contamination in the fiber residue bunker was greater than the recyclables, excluding samples 1 and 3. Around 10% of the of the total contamination (55.6%) is remainder/composite paper, which implies that recycling generators still have confusion regarding which materials are recyclable.

Figure 15. Remainder/Composite Paper

Typical examples of remainder/composite paper contamination include napkins, waxed cardboard, and paper plates. However, the most common remainder/composite paper sorted was envelopes with plastic windows. When on the fiber line, the composite envelopes can be confused as high-grade paper and be sorted into the corresponding bunker.

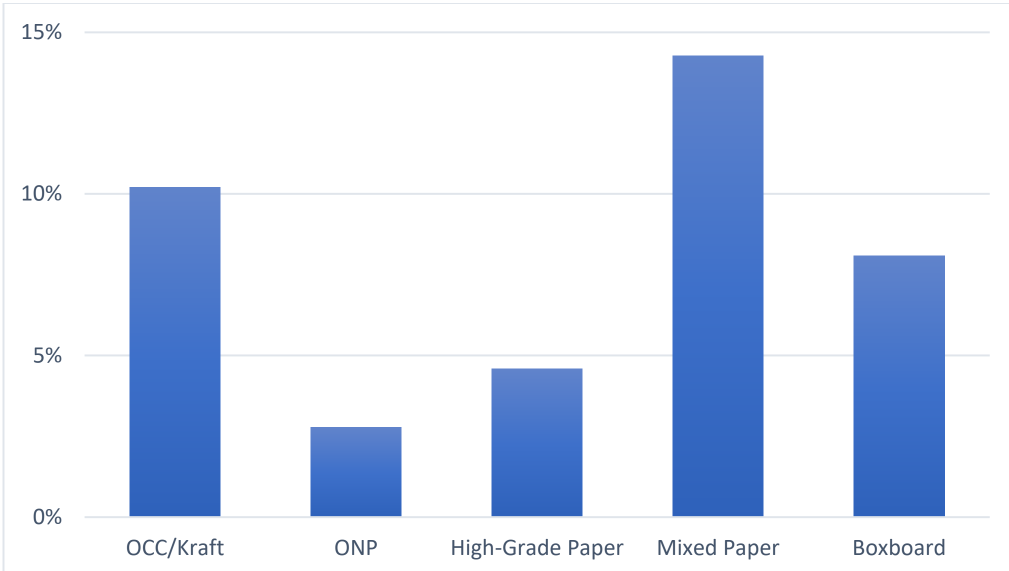


Figure 16. Fiber Residue Recyclable Breakdown

Mixed paper is the single largest component of the recyclable material in the fiber residue. For this study, boxboard was separated from the mixed paper, but the MRF combines mixed paper and boxboard into a single bunker. With boxboard and mixed paper combined, the mixed paper fraction of the fiber residue constitutes over 20% of the total weight of the collected samples.

3.5 Residential Curbside Collection Results

Residential Curbside Containers

Table 6. Residential Curbside Container Results

Residential Curbside Container Results	% Composition (Weighted Average)
Recyclable Material	**82.0%**
Plastics	**30.5%**
#1 PET Bottles	15.4%
Other #1 PET	2.7%
#2 HDPE-N	4.9%
#2 HDPE-C	4.1%
#3 - #7 Mixed Plastics Excluding #5	0.4%
#5	3.1%
Glass	**38.1%**
Glass	38.1%
Metals	**13.4%**
Aluminum Cans	8.0%
Tin/FE Cans	5.4%
Outthrows	**2.5%**
Paper	**2.5%**
OCC / Kraft	0.4%
ONP	0.1%
High-Grade Paper	0.5%
Mixed Paper	0.3%
Boxboard	1.2%
Contamination	**15.5%**
Film Plastic	4.5%
R/C Plastic	2.0%
R/C Paper	0.0%
Residue	7.8%
Fines	1.3%
Grand Total	**100.0%**

The contamination rate in the residential curbside container samples is comparable with the national average contamination rate. According to the Recycling Partnership's "State of Curbside Recycling Report," the national average contamination rate is 16.9%. Columbia's residential curbside container contamination rate is 15.5%, which is performing marginally better than the national average. It should be noted that the film plastic contamination rate is elevated because it includes the City's blue bags.

Surprisingly, very little of the contamination was remainder/composite plastic (2.0%). This indicates that residents are effective at identifying which types of plastics are recyclable. Most of the material incoming to the MRF through container curbside collection is an acceptable program material. The sampled loads contained minimal amounts of outthrows, indicating that residents are effectively separating containers from fiber.

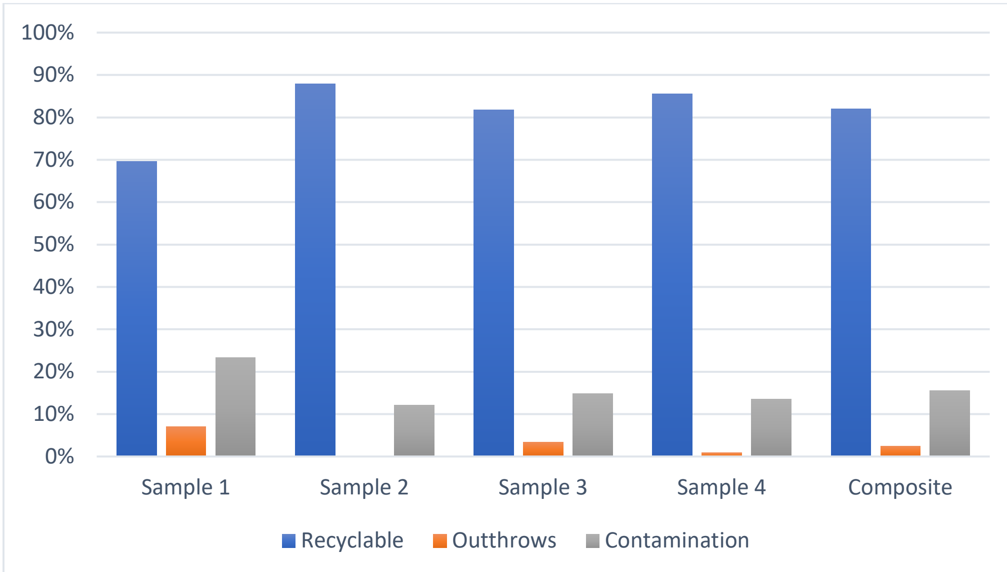


Figure 17. Residential Curbside Container Sample Comparison

Residents have been effective at separating containers from fiber recyclables, with the highest outthrow percentage being 7.0%. Sample 2 had only trace amount of paper outthrows, and Sample 4 had less than 1% outthrows. Sample 1 had higher levels of contamination (23.4%), but all subsequent samples had contamination below 15%.

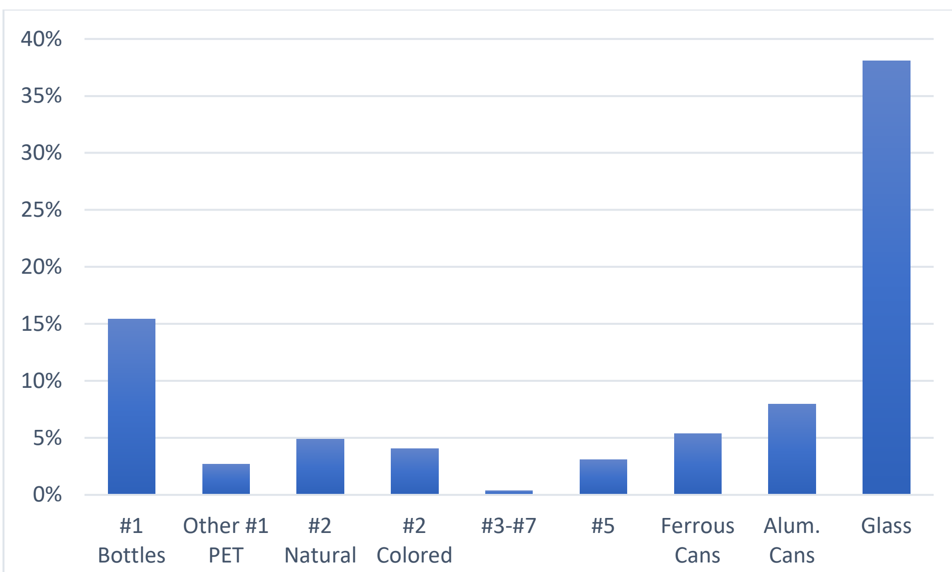


Figure 18. Residential Curbside Container Recyclable Breakdown

The predominant material incoming in the residential curbside containers is glass. Glass accounts for approximately half of the total recyclable fraction by weight. Due to the density of the glass, it constitutes a larger proportion of the waste stream when compared to plastics and metals.

Residential Curbside Fiber

Table 7. Residential Curbside Fiber Results

Residential Curbside Fiber Results	% Composition (Weighted Average)
Recyclable Material	**95.0%**
Paper	**95.0%**
OCC / Kraft	59.0%
ONP	1.2%
High-Grade Paper	2.2%
Mixed Paper	18.3%
Boxboard	14.3%
Outthrows	**0.3%**
Plastics	**0.3%**
#1 PET Bottles	0.3%
Other #1 PET	0.0%
#2 HDPE-N	0.0%
#2 HDPE-C	0.0%
#3 - #7 Mixed Plastics Excluding #5	0.0%
#5	0.0%
Glass	**0.0%**
Glass	0.0%
Metals	**0.0%**
Aluminum Cans	0.0%
Tin/FE Cans	0.0%
Contamination	**4.7%**
Film Plastic	0.1%
R/C Plastic	0.0%
R/C Paper	1.3%
Residue	3.3%
Fines	0.0%
Grand Total	**100.0%**

The contamination levels in the residential curbside fiber are remarkably low, but these results should be tentatively accepted. The sampling of the residential curbside fiber was a cursory examination and would require additional samples for a more robust analysis. However, these results are consistent with the informal discussions regarding the purity of the curbside fiber. Employees at the MRF stated that the residential curbside fiber often has little contamination.

From observations in the field by the RRT team on the curbside collection of fiber, this determination appears to be correct. Employees on the recycling trucks will only collect fiber that is in a paper bag or cardboard box. On multiple occasions, collection employees would reject and tag fiber recyclables that were improperly prepared. This often occurred with cardboard boxes that still contained excessive Styrofoam or other plastics.

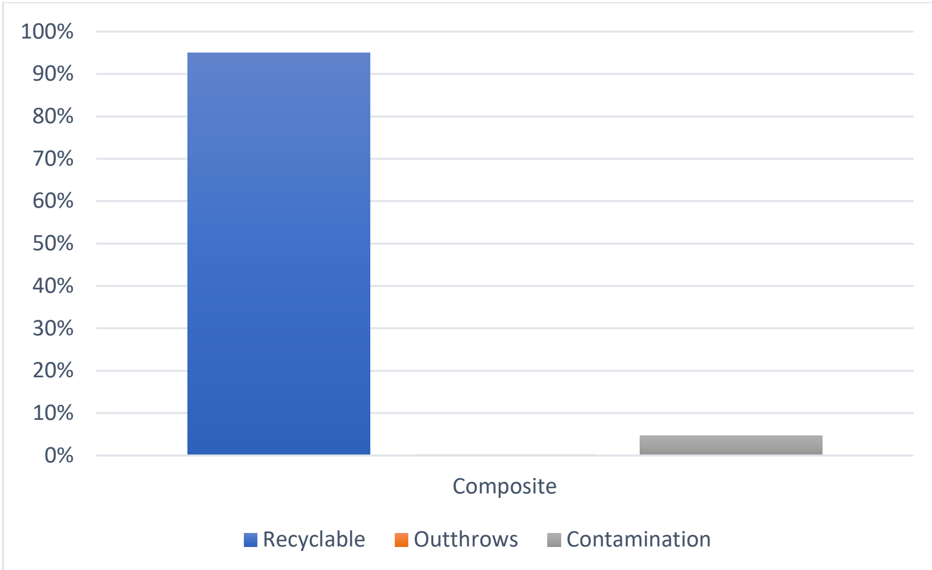


Figure 19. Residential Curbside Fiber Breakdown

Presumably, there are very few outthrows in this sample for the same reason as the low levels of contamination. Unless the outthrows are inside of a bag or box where they aren't visible, the missorted recyclables will be placed onto the container side of the split-body collection truck.

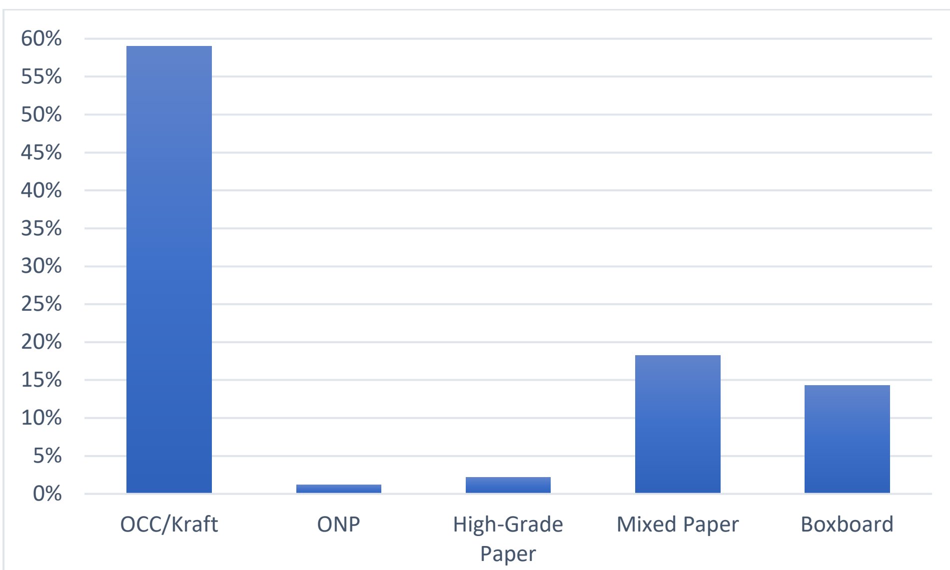


Figure 20. Residential Curbside Fiber Recyclable Breakdown

3.6 Fiber Screen Results

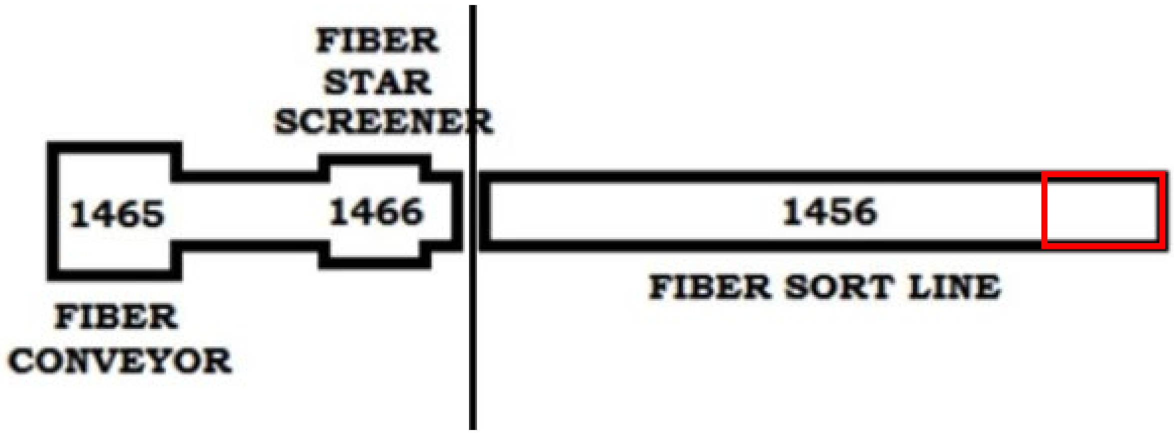


Figure 21. MRF Fiber Screen Layout

Before the discussion of the results of the fiber screens, it is necessary to distinguish between the two different star screeners on the fiber line. The fiber star screen numbered 1466 on the diagram will be referred to as the fiber residue screen. The fiber residue screen is located on the tipping floor, which is responsible for removing containers and contamination. The second star screener's approximate location, while not depicted on this diagram, is outlined in red. The second star screener will be referred to as the ONP screen.

Fiber Residue Screen

Table 8. Fiber Residue Screen Results

Fiber Residue Screen Results	% Composition (Weighted Average)
Recyclable Material	**67.2%**
Paper	**67.2%**
OCC / Kraft	32.7%
ONP	1.0%
High-Grade Paper	4.5%
Mixed Paper	11.8%
Boxboard	14.8%
Outthrows	**8.0%**
Plastics	**1.2%**
#1 PET Bottles	0.7%
Other #1 PET	0.0%
#2 HDPE-N	0.5%
#2 HDPE-C	0.0%
#3 - #7 Mixed Plastics Excluding #5	0.0%
#5	0.0%
Glass	**6.5%**
Glass	6.5%
Metals	**0.3%**
Aluminum Cans	0.3%
Tin/FE Cans	0.0%

Fiber Residue Screen Results	% Composition (Weighted Average)
Contamination	**24.8%**
Film Plastic	0.1%
R/C Plastic	0.0%
R/C Paper	1.0%
Residue	13.4%
Fines	10.4%
Grand Total	**100.0%**

One of the findings in the Columbia MRF inspection conducted in February 2023 by RRT was that the discs in the star screen have exceeded their useful life. Due to the excessive wear on the discs, recyclable commodities are entering the residue piles. This observation is corroborated by the estimated 67.2% of total recyclable material found in the unders of the fiber residue screen, which is diverted to a residue bunker.

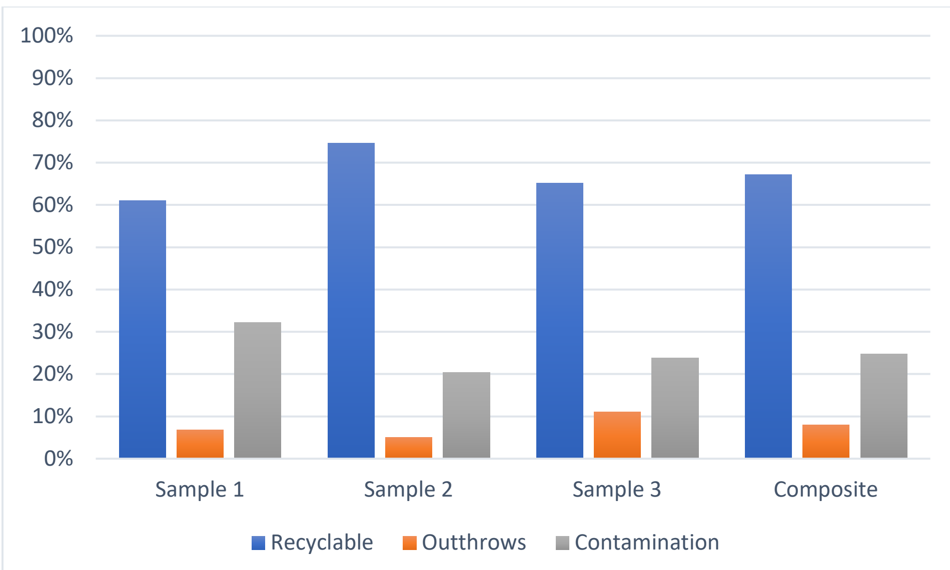


Figure 22. Fiber Residue Screen Sample Breakdown

The recyclable material sampled in the fiber residue screen is more than double the contamination found in the samples. Recyclable material accounts for 67.2% of the total weight, while outthrows only represent 8.0%. The small amount of outthrows reinforces that waste generators are effective at separating commingled containers from fiber.

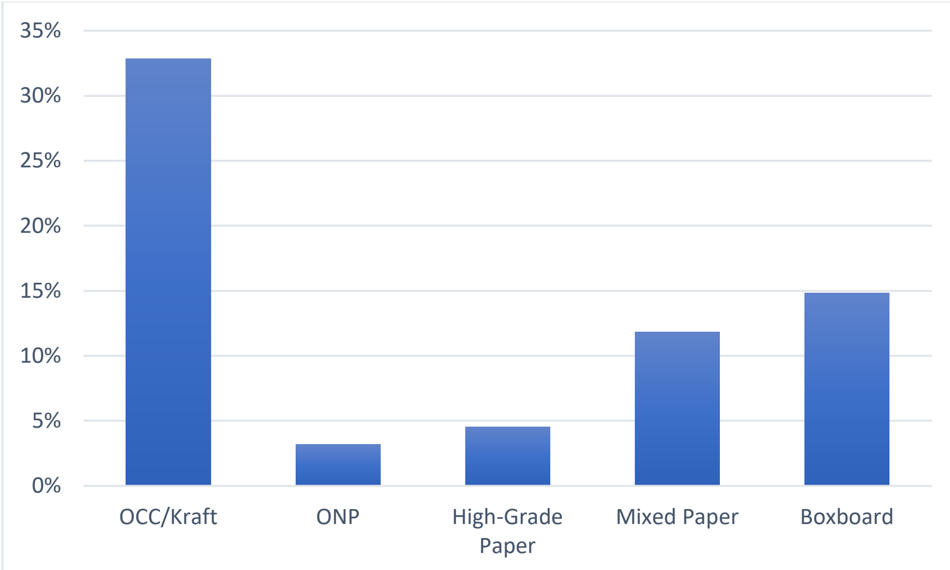


Figure 23. Fiber Residue Screen Recyclable Breakdown

OCC/Kraft paper is the predominant material found in the fiber residue screen. The amount of OCC found in the sample is double the amount of boxboard found in the samples. Even with combining mixed paper and boxboard together, OCC/Kraft paper is still found in larger proportions.

ONP Screen

Table 9. ONP Screen Results

ONP Screen Results	% Composition (Weighted Average)
Recyclable Material	**79.1%**
Paper	**79.1%**
OCC / Kraft	7.4%
ONP	7.8%
High-Grade Paper	13.0%
Mixed Paper	36.5%
Boxboard	14.4%
Outthrows	**0.0%**
Plastics	**0.0%**
#1 PET Bottles	0.0%
Other #1 PET	0.0%
#2 HDPE-N	0.0%
#2 HDPE-C	0.0%
#3 - #7 Mixed Plastics Excluding #5	0.0%
#5	0.0%
Glass	**0.0%**
Glass	0.0%
Metals	**0.0%**
Aluminum Cans	0.0%
Tin/FE Cans	0.0%

Contamination	**20.9%**
Film Plastic	0.2%
R/C Plastic	0.0%
R/C Paper	10.4%
Residue	3.7%
Fines	6.6%
Grand Total	**100.0%**

The ONP screen is performing worse than the fiber residue screen because approximately 80% of the material coming off the screen into residue is recyclable compared to approximately 70% for the fiber residue screen. As with the fiber residue screen, any material that comes off this screen is diverted into the outbound residue stream.

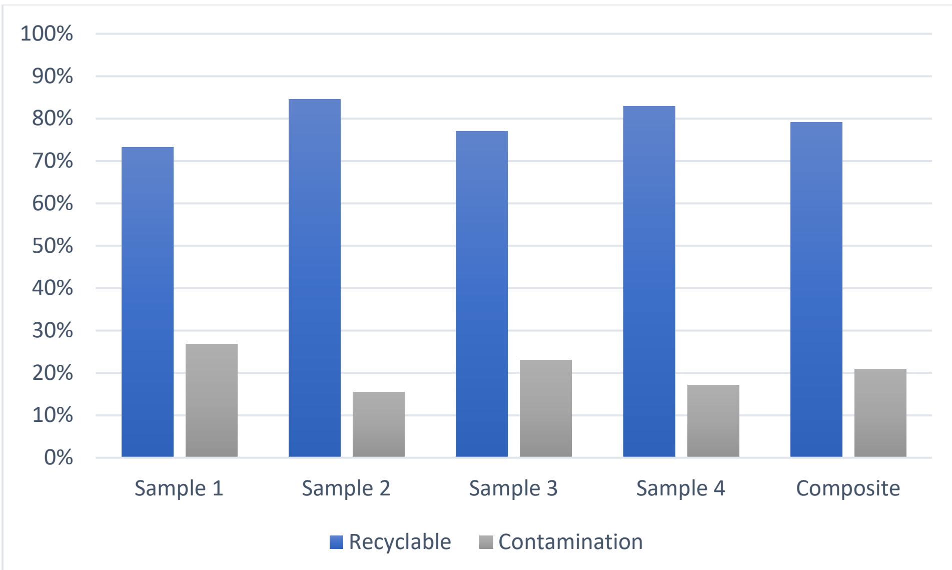


Figure 24. ONP Screen Sample Breakdown

As seen in Figure 22 above, there were no outthrows identified in any of the samples. Aluminum cans and #1 PET bottles were found in trace amounts in all the samples. However, these materials were found in such small quantities that it will have little bearing over the total composition that they were considered to have no weight. The trace materials were documented by the study coordinator.

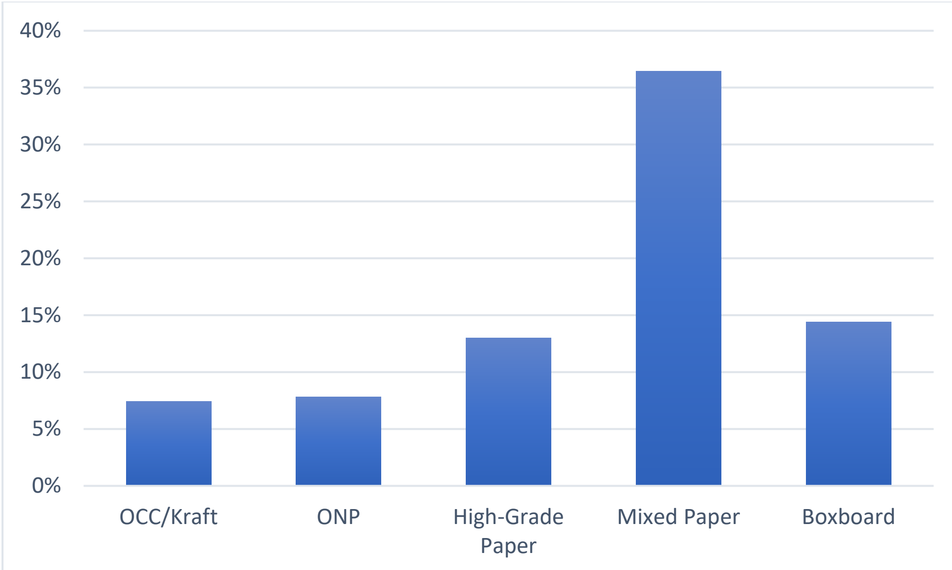


Figure 25. ONP Screen Recyclable Breakdown

Mixed paper is the predominant material coming off the ONP screen, while high-grade paper (13.0%) and boxboard (14.4%) are found in comparable amounts in the samples. It is unexpected to see such a large amount of mixed paper, boxboard, and high-grade paper in the unders because the overs of the ONP screen feed directly into the ONP bunker. If the samples of the ONP screen residue are representative of the material that is entering the ONP bunker, then this material has an incredibly high amount of outthrows.

Figure 26. Representation of the ONP Bunker

As discussed, it appears that much of the material that is entering the ONP bunker is not newspaper. There is a mixture of kraft paper, high-grade paper- mixed paper, and ONP. However, based on discussions with MRF staff, vendors have no concerns regarding the outthrows found in the material. Therefore, it would be ill-advised to alter the composition of this material because selling the material at a lower paper grade would impact revenue at the MRF.

4. Visual Inspection of Drop-Off Center Loads

While conducting the waste characterization of the residential curbside fiber and container loads on the tipping floor, the attending member of the RRT team visually inspected inbound loads from the drop-off centers for contamination. The drop-off center containers had increased levels of contamination compared to the drop-off fiber. These results are consistent with RRT's observations at the City's drop-off sites.

4.1. Visual Inspection of Fiber Drop-Off Loads

Figure 27. Drop-Off Center Fiber Load 1

The first visually inspected load (Load 1) from the fiber roll-off container had minimal contamination. Consistent with the results from the curbside residential fiber characterization, cardboard constitutes a significant proportion of the total fiber stream. Primary sources of contamination included EPS and film plastic.

Figure 28. Drop-Off Center Fiber Load 2

Fiber Load 2 had lower levels of observed contamination compared to Fiber Load 1. Much of the contamination was caused by user error, including separating film and plastic contamination, such as EPS, from the fiber. Many appliance boxes were observed to have expanded polystyrene inside.

4.2. Visual Inspection of Container Drop-Off Loads

Figure 29. Drop-Off Center Container Load 1

Container Load 1 had significant amounts of observed contamination, primarily from bulky plastic. Additionally, many of the containers were improperly prepared by users because they were not placed in a blue bag.

Figure 30. Drop-Off Center Container Load 2

Container Load 2 had significant amounts of observed contamination, primarily from bulky plastic and recyclable fiber. Most of the containers in Load 2 were properly prepared in blue bags.

Appendix A. Composition Study Data

Appendix Table 1. #2 HDPE Sampling Data

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	**240.6**	**260.0**	**226.2**	**236.3**	**228.2**	**225.9**	**1417.2**	**96.2%**
Plastics	**240.6**	**260.0**	**226.2**	**236.3**	**228.2**	**225.9**	**1417.2**	**96.2%**
#2 HDPE-N	168.8	133.6	127.7	133.5	117.2	130.1	810.9	55.0%
#2 HDPE-C	71.8	126.4	98.5	102.8	111.0	95.8	606.3	41.2%
Outthrows	**1.3**	**16.8**	**7.5**	**6.7**	**6.4**	**7.1**	**45.8**	**3.1%**
Paper	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0%**
OCC / Kraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
ONP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
High-Grade Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Mixed Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Boxboard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Plastics	**1.3**	**12.2**	**7.5**	**6.7**	**6.4**	**7.1**	**41.2**	**2.8%**
#1 PET Bottles	1.3	7.6	5.3	2.5	2.7	5.9	25.3	1.7%
Other #1 PET	0.0	2.1	2.2	2.9	1.8	0.2	9.2	0.6%
#3 - #7 Plastics excl. #5	0.0	2.5	Trace	0.0	0.5	0.0	3.0	0.2%
#5	0.0	0.0	Trace	1.3	1.4	1.0	3.7	0.3%
Glass	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0%**
Glass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Metals	**0.0**	**4.6**	**0.0**	**0.0**	**0.0**	**0.0**	**4.6**	**0.3%**
Aluminum Cans	0.0	3.5	Trace	Trace	Trace	0.0	3.5	0.2%
Tin/FE Cans	Trace	1.1	0.0	Trace	Trace	0.0	1.1	0.1%
Contamination	**0.0**	**0.0**	**2.6**	**5.3**	**2.0**	**0.6**	**10.5**	**0.7%**
Film Plastic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
R/C Plastic	0.0	0.0	2.6	5.3	0.0	0.0	7.9	0.5%
R/C Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Residue	Trace	0.0	0.0	0.0	2.0	0.6	2.6	0.2%
Fines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Total Net Weight	241.9	276.8	236.3	248.3	236.6	233.6	1473.5	100.0%

Appendix Table 2. #2 HDPE Sampling Data - Percentage

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Weighted Avg. (%)
Recyclable Material	99.5%	93.9%	95.7%	95.2%	96.4%	96.7%	**96.2%**
Plastics	99.5%	93.9%	95.7%	95.2%	96.4%	96.7%	**96.2%**
#2 HDPE-N	69.8%	48.3%	54.0%	53.8%	49.5%	55.7%	55.0%
#2 HDPE-C	29.7%	45.7%	41.7%	41.4%	46.9%	41.0%	41.2%
Outthrows	0.5%	6.1%	3.2%	2.7%	2.7%	3.0%	**3.1%**
Paper	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
OCC / Kraft	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ONP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High-Grade Paper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mixed Paper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Boxboard	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Plastics	**0.5%**	**4.4%**	**3.2%**	**2.7%**	**2.7%**	**3.0%**	**2.8%**
#1 PET Bottles	0.5%	2.7%	2.2%	1.0%	1.1%	2.5%	1.7%
Other #1 PET	0.0%	0.8%	0.9%	1.2%	0.8%	0.1%	0.6%
#3 - #7 Plastics excl. #5	0.0%	0.9%	0.0%	0.0%	0.2%	0.0%	0.2%
#5	0.0%	0.0%	0.0%	0.5%	0.6%	0.4%	0.3%
Glass	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Glass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Metals	**0.0%**	**1.7%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.3%**
Aluminum Cans	0.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.2%
Tin/FE Cans	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.1%
Contamination	**0.0%**	**0.0%**	**1.1%**	**2.1%**	**0.8%**	**0.3%**	**0.7%**
Film Plastic	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
R/C Plastic	0.0%	0.0%	1.1%	2.1%	0.0%	0.0%	0.5%
R/C Paper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Residue	0.0%	0.0%	0.0%	0.0%	0.8%	0.3%	0.2%
Fines	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Appendix Table 3. #3 - #7 Mixed Plastic Sampling Data

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Weighted Avg. (%)
Recyclable Material	**64.7%**	**58.9%**	**66.8%**	**56.4%**	**58.3%**	**63.3%**	**61.2%**
Plastics	**64.7%**	**58.9%**	**66.8%**	**56.4%**	**58.3%**	**63.3%**	**61.2%**
Other #1 PET	38.8%	29.3%	36.5%	32.7%	33.2%	37.1%	34.6%
#3 - #7 Plastics excl. #5	3.6%	7.4%	2.8%	2.3%	3.1%	1.3%	3.4%
#5	22.2%	22.2%	27.5%	21.4%	22.0%	25.0%	23.2%
Outthrows	**29.6%**	**38.2%**	**18.6%**	**31.2%**	**35.0%**	**31.7%**	**30.9%**
Paper	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
OCC / Kraft	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ONP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High-Grade Paper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mixed Paper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Boxboard	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Plastics	**29.6%**	**35.0%**	**18.0%**	**30.5%**	**34.2%**	**30.6%**	**29.9%**
#1 PET Bottles	22.3%	27.2%	12.4%	25.4%	30.6%	21.9%	23.9%
#2 HDPE-N	1.5%	2.2%	1.3%	0.9%	0.3%	2.5%	1.3%
#2 HDPE-C	5.8%	5.5%	4.3%	4.3%	3.2%	6.2%	4.7%
Glass	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Glass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Metals	**0.0%**	**3.3%**	**0.6%**	**0.7%**	**0.8%**	**1.1%**	**1.0%**
Aluminum Cans	0.0%	3.3%	0.6%	0.7%	0.8%	0.6%	0.9%
Tin/FE Cans	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.1%
Contamination	**5.8%**	**2.9%**	**14.7%**	**12.4%**	**6.7%**	**4.9%**	**7.9%**
Film Plastic	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
R/C Plastic	0.0%	0.0%	14.6%	12.4%	6.3%	0.0%	5.8%
R/C Paper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Residue	5.8%	2.9%	0.0%	0.0%	0.4%	4.9%	2.1%
Fines	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Appendix Table 4. #3 - #7 Mixed Plastic Sampling Data - Percentage

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	**71.9**	**52.5**	**70.2**	**56.9**	**100.5**	**55.3**	**407.3**	**61.2%**
Plastics	**71.9**	**52.5**	**70.2**	**56.9**	**100.5**	**55.3**	**407.3**	**61.2%**
Other #1 PET	43.2	26.1	38.4	33.0	57.2	32.4	230.3	34.6%
#3 - #7 Plastics excl. #5	4.0	6.6	2.9	2.3	5.4	1.1	22.3	3.4%
#5	24.7	19.8	28.9	21.6	37.9	21.8	154.7	23.2%
Outthrows	**32.9**	**34.1**	**19.5**	**31.5**	**60.3**	**27.7**	**206.0**	**30.9%**
Paper	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0%**
OCC / Kraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
ONP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
High-Grade Paper	0.0	0.0	0.0	0.0	Trace	0.0	0.0	0.0%
Mixed Paper	0.0	0.0	0.0	0.0	Trace	0.0	0.0	0.0%
Boxboard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Plastics	**32.9**	**31.2**	**18.9**	**30.8**	**58.9**	**26.7**	**199.4**	**29.9%**
#1 PET Bottles	24.8	24.3	13.0	25.6	52.7	19.1	159.5	23.9%
#2 HDPE-N	1.7	2.0	1.4	0.9	0.6	2.2	8.8	1.3%
#2 HDPE-C	6.4	4.9	4.5	4.3	5.6	5.4	31.1	4.7%
Glass	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0%**
Glass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Metals	**0.0**	**2.9**	**0.6**	**0.7**	**1.4**	**1.0**	**6.6**	**1.0%**
Aluminum Cans	Trace	2.9	0.6	0.7	1.4	0.5	6.1	0.9%
Tin/FE Cans	0.0	0.0	Trace	0.0	0.0	0.5	0.5	0.1%
Contamination	**6.4**	**2.6**	**15.4**	**12.5**	**11.6**	**4.3**	**52.8**	**7.9%**
Film Plastic	0.0	0.0	0.1	Trace	0.0	0.0	0.1	0.0%
R/C Plastic	0.0	0.0	15.3	12.5	10.9	0.0	38.7	5.8%
R/C Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Residue	6.4	2.6	Trace	Trace	0.7	4.3	14.0	2.1%
Fines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Total Net Weight	111.2	89.2	105.1	100.9	172.4	87.3	666.1	100.0%

Appendix Table 5. Container Residue Sampling Data

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	26.7	35.3	101.9	61.2	36.1	61.7	353.8	**39.2%**
Plastics	**16.1**	**20.9**	**57.2**	**38.7**	**23.8**	**36.6**	**193.3**	**21.4%**
#1 PET Bottles	2.9	7.8	19.5	9.8	2.9	9.9	52.8	5.8%
Other #1 PET	2.7	5.2	9.0	11.9	8.0	7.9	44.7	4.9%
#2 HDPE-N	2.9	1.4	3.5	4.3	3.5	3.7	19.3	2.1%
#2 HDPE-C	3.4	1.8	4.6	5.0	1.7	3.7	20.2	2.2%
#3 - #7 Plastics excl. #5	1.8	0.4	6.0	2.9	2.8	5.7	19.6	2.2%
#5	2.4	4.3	14.6	4.8	4.9	5.7	36.7	4.1%
Glass	**1.7**	**3.7**	**1.8**	**11.8**	**19.6**	**16.4**	**55.0**	**6.1%**
Glass	1.7	3.7	1.8	11.8	19.6	16.4	55.0	6.1%
Metals	**14.0**	**18.7**	**21.3**	**22.4**	**13.6**	**15.5**	**105.5**	**11.7%**
Aluminum Cans	11.0	7.3	10.1	7.2	6.9	6.0	48.5	5.4%
Tin/FE Cans	3.0	11.4	11.2	15.2	6.7	9.5	57.0	6.3%
Outthrows	**34.4**	**23.4**	**9.2**	**5.2**	**11.4**	**16.4**	**100.0**	**11.1%**
Paper	**34.4**	**23.4**	**9.2**	**5.2**	**11.4**	**16.4**	**100.0**	**11.1%**
OCC / Kraft	23.3	5.6	1.7	0.0	2.1	2.9	35.6	3.9%
ONP	0.5	0.0	0.0	0.0	0.7	0.6	1.8	0.2%
High-Grade Paper	2.3	1.1	Trace	1.2	1.2	2.6	8.4	0.9%
Mixed Paper	1.5	11.1	3.4	3.0	2.7	3.5	25.2	2.8%
Boxboard	6.8	5.6	4.1	1.0	4.7	6.8	29.0	3.2%
Contamination	**38.9**	**60.7**	**101.0**	**122.0**	**52.5**	**74.3**	**449.4**	**49.8%**
Film Plastic	2.5	4.3	8.1	7.2	5.6	6.6	34.3	3.8%
R/C Plastic	13.7	19.1	33.5	35.6	9.2	15.2	126.3	14.0%
R/C Paper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Residue	15.4	34.7	59.4	79.2	32.9	52.5	274.1	30.3%
Fines	7.3	2.6	0.0	0.0	4.8	0.0	14.7	1.6%
Total Net Weight	105.1	127.4	190.5	200.1	120.9	159.2	903.2	**100.0%**

Appendix Table 6. Container Residue Sampling Data - Percentage

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Weighted Avg. (%)
Recyclable Material	**30.3%**	**34.0%**	**42.2%**	**36.4%**	**47.1%**	**43.0%**	**39.2%**
Plastics	**15.3%**	**16.4%**	**30.0%**	**19.3%**	**19.7%**	**23.0%**	**21.4%**
#1 PET Bottles	2.8%	6.1%	10.2%	4.9%	2.4%	6.2%	5.8%
Other #1 PET	2.6%	4.1%	4.7%	5.9%	6.6%	5.0%	4.9%
#2 HDPE-N	2.8%	1.1%	1.8%	2.1%	2.9%	2.3%	2.1%
#2 HDPE-C	3.2%	1.4%	2.4%	2.5%	1.4%	2.3%	2.2%
#3 - #7 Plastics excl. #5	1.7%	0.3%	3.1%	1.4%	2.3%	3.6%	2.2%
#5	2.3%	3.4%	7.7%	2.4%	4.1%	3.6%	4.1%
Glass	**1.6%**	**2.9%**	**0.9%**	**5.9%**	**16.2%**	**10.3%**	**6.1%**
Glass	1.6%	2.9%	0.9%	5.9%	16.2%	10.3%	6.1%
Metals	**13.3%**	**14.7%**	**11.2%**	**11.2%**	**11.2%**	**9.7%**	**11.7%**
Aluminum Cans	10.5%	5.7%	5.3%	3.6%	5.7%	3.8%	5.4%
Tin/FE Cans	2.9%	8.9%	5.9%	7.6%	5.5%	6.0%	6.3%
Outthrows	**32.7%**	**18.4%**	**4.8%**	**2.6%**	**9.4%**	**10.3%**	**11.1%**
Paper	**22.2%**	**4.4%**	**0.9%**	**0.0%**	**1.7%**	**1.8%**	**11.1%**
OCC / Kraft	0.5%	0.0%	0.0%	0.0%	0.6%	0.4%	3.9%
ONP	2.2%	0.9%	0.0%	0.6%	1.0%	1.6%	0.2%
High-Grade Paper	1.4%	8.7%	1.8%	1.5%	2.2%	2.2%	0.9%
Mixed Paper	6.5%	4.4%	2.2%	0.5%	3.9%	4.3%	2.8%
Boxboard	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%
Contamination	**37.0%**	**47.6%**	**53.0%**	**61.0%**	**43.4%**	**46.7%**	**49.8%**
Film Plastic	2.4%	3.4%	4.3%	3.6%	4.6%	4.1%	3.8%
R/C Plastic	13.0%	15.0%	17.6%	17.8%	7.6%	9.5%	14.0%
R/C Paper	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Residue	14.7%	27.2%	31.2%	39.6%	27.2%	33.0%	30.3%
Fines	6.9%	2.0%	0.0%	0.0%	4.0%	0.0%	1.6%

Appendix Table 7. Fiber Residue Sampling Data

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	**49.8**	**57.8**	**87.5**	**64.7**	**84.4**	**77.2**	**421.4**	**40.0%**
Paper	**49.8**	**57.8**	**87.5**	**64.7**	**84.4**	**77.2**	**421.4**	**40.0%**
OCC / Kraft	10.3	9.7	30.7	17.6	21.5	17.9	107.7	10.2%
ONP	2.8	5.7	4.9	3.3	9.1	3.5	29.3	2.8%
High-Grade Paper	8.8	11.1	13.0	9.0	2.4	4.1	48.4	4.6%
Mixed Paper	14.5	20.3	21.5	17.6	29.2	47.5	150.6	14.3%
Boxboard	13.4	11.0	17.4	17.2	22.2	4.2	85.4	8.1%
Outthrows	**1.2**	**2.0**	**2.6**	**4.5**	**9.6**	**14.0**	**33.9**	**3.2%**
Plastics	**0.7**	**2.0**	**2.2**	**2.6**	**7.7**	**8.5**	**23.7**	**2.2%**
#1 PET Bottles	0.7	2.0	1.9	0.7	4.1	5.2	14.6	1.4%
Other #1 PET	Trace	Trace	Trace	1.5	1.7	2.6	5.8	0.5%
#2 HDPE-N	Trace	0.0	0.2	0.0	0.5	Trace	0.7	0.1%
#2 HDPE-C	Trace	0.0	0.1	0.0	0.4	Trace	0.5	0.0%
#3 - #7 Plastics excl. #5	0.0	Trace	0.0	0.0	0.3	0.3	0.6	0.1%
#5	0.0	0.0	Trace	0.4	0.7	0.4	1.5	0.1%
Glass	**0.0**	**0.0**	**0.0**	**1.3**	**0.0**	**4.2**	**5.5**	**0.5%**
Glass	Trace	Trace	Trace	1.3	Trace	4.2	5.5	0.5%
Metals	**0.5**	**0.0**	**0.4**	**0.6**	**1.9**	**1.3**	**4.7**	**0.4%**
Aluminum Cans	0.5	Trace	0.4	0.6	1.3	0.8	3.6	0.3%
Tin/FE Cans	0.0	Trace	0.0	Trace	0.6	0.5	1.1	0.1%
Contamination	**45.8**	**88.2**	**62.2**	**102.5**	**158.7**	**142.2**	**599.6**	**56.8%**
Film Plastic	2.0	2.6	1.9	2.4	6.0	6.6	21.5	2.0%
R/C Plastic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
R/C Paper	10.6	3.8	20.3	12.9	36.6	18.7	102.9	9.8%
Residue	31.9	79.1	38.5	86.1	116.1	116.9	468.6	44.4%
Fines	1.3	2.7	1.5	1.1	0.0	0.0	6.6	0.6%
Total Net Weight	96.8	148	152.3	171.7	252.7	233.4	1054.9	100.0%

Appendix Table 8. Fiber Residue Sampling Data - Percentage

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Weighted Avg. (%)
Recyclable Material	**51.4%**	**39.1%**	**57.5%**	**37.7%**	**33.4%**	**33.1%**	**40.0%**
Paper	**51.4%**	**39.1%**	**57.5%**	**37.7%**	**33.4%**	**33.1%**	**40.0%**
OCC / Kraft	10.6%	6.6%	20.2%	10.3%	8.5%	7.7%	10.2%
ONP	2.9%	3.9%	3.2%	1.9%	3.6%	1.5%	2.8%
High-Grade Paper	9.1%	7.5%	8.5%	5.2%	0.9%	1.8%	4.6%
Mixed Paper	15.0%	13.7%	14.1%	10.3%	11.6%	20.4%	14.3%
Boxboard	13.8%	7.4%	11.4%	10.0%	8.8%	1.8%	8.1%
Outthrows	**1.2%**	**1.4%**	**1.7%**	**2.6%**	**3.8%**	**6.0%**	**3.2%**
Plastics	**0.7%**	**1.4%**	**1.4%**	**1.5%**	**3.0%**	**3.6%**	**2.2%**
#1 PET Bottles	0.7%	1.4%	1.2%	0.4%	1.6%	2.2%	1.4%
Other #1 PET	0.0%	0.0%	0.0%	0.9%	0.7%	1.1%	0.5%
#2 HDPE-N	0.0%	0.0%	0.1%	0.0%	0.2%	0.0%	0.1%
#2 HDPE-C	0.0%	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%
#3 - #7 Plastics excl. #5	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
#5	0.0%	0.0%	0.0%	0.2%	0.3%	0.2%	0.1%
Glass	**0.0%**	**0.0%**	**0.0%**	**0.8%**	**0.0%**	**1.8%**	**0.5%**
Glass	0.0%	0.0%	0.0%	0.8%	0.0%	1.8%	0.5%
Metals	**0.5%**	**0.0%**	**0.3%**	**0.3%**	**0.8%**	**0.6%**	**0.4%**
Aluminum Cans	0.5%	0.0%	0.3%	0.3%	0.5%	0.3%	0.3%
Tin/FE Cans	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.1%
Contamination	**47.3%**	**59.6%**	**40.8%**	**59.7%**	**62.8%**	**60.9%**	**56.8%**
Film Plastic	2.1%	1.8%	1.2%	1.4%	2.4%	2.8%	2.0%
R/C Plastic	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
R/C Paper	11.0%	2.6%	13.3%	7.5%	14.5%	8.0%	9.8%
Residue	33.0%	53.4%	25.3%	50.1%	45.9%	50.1%	44.4%
Fines	1.3%	1.8%	1.0%	0.6%	0.0%	0.0%	0.6%

Appendix Table 9. Residential Curbside Container Sampling Data

	Sample 1	Sample 2	Sample 3	Sample 4	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	**113.0**	**184.0**	**138.5**	**190.6**	**626.1**	**82.0%**
Plastics	**49.7**	**72.4**	**52.5**	**58.7**	**233.3**	**30.5%**
#1 PET Bottles	29.1	38.6	29.3	20.8	117.8	15.4%
Other #1 PET	4.2	3.6	4.1	8.7	20.6	2.7%
#2 HDPE-N	8.3	8.7	8.7	11.8	37.5	4.9%
#2 HDPE-C	3.5	12.4	5.8	9.3	31.0	4.1%
#3 - #7 Plastics excl. #5	1.2	0.6	0.6	0.4	2.8	0.4%
#5	3.4	8.5	4.0	7.7	23.6	3.1%
Glass	**39.6**	**88.0**	**65.1**	**98.3**	**291.0**	**38.1%**
Glass	39.6	88.0	65.1	98.3	291.0	38.1%
Metals	**23.7**	**23.6**	**20.9**	**33.6**	**101.8**	**13.4%**
Aluminum Cans	12.5	9.5	13.8	25.1	60.9	8.0%
Tin/FE Cans	11.2	14.1	7.1	8.5	40.9	5.4%
Outthrows	**11.4**	**0.0**	**5.7**	**1.9**	**19.0**	**2.5%**
Paper	**11.4**	**0.0**	**5.7**	**1.9**	**19.0**	**2.5%**
OCC / Kraft	0.5	Trace	2.5	Trace	3.0	0.4%
ONP	1.1	0.0	0.0	0.0	1.1	0.1%
High-Grade Paper	4.1	0.0	0.0	0.0	4.1	0.5%
Mixed Paper	2.0	Trace	0.0	Trace	2.0	0.3%
Boxboard	3.7	Trace	3.2	1.9	8.8	1.2%
Contamination	**38.0**	**25.3**	**25.1**	**30.2**	**118.6**	**15.5%**
Film Plastic	7.6	9.7	9.5	7.3	34.1	4.5%
R/C Plastic	4.6	3.3	3.2	4.5	15.6	2.0%
R/C Paper	0.0	0.0	0.0	0.0	0.0	0.0%
Residue	16.2	12.3	12.4	18.4	59.3	7.8%
Fines	9.6	0.0	0.0	0.0	9.6	1.3%
Total Net Weight	162.4	209.3	169.3	222.7	763.7	100.0%

Appendix Table 10. Residential Curbside Container Sampling Data - Percentage

	Sample 1	Sample 2	Sample 3	Sample 4	Weighted Avg. (%)
Recyclable Material	69.6%	87.9%	81.8%	85.6%	**82.0%**
Plastics	**30.6%**	**34.6%**	**31.0%**	**26.4%**	**30.5%**
#1 PET Bottles	17.9%	18.4%	17.3%	9.3%	15.4%
Other #1 PET	2.6%	1.7%	2.4%	3.9%	2.7%
#2 HDPE-N	5.1%	4.2%	5.1%	5.3%	4.9%
#2 HDPE-C	2.2%	5.9%	3.4%	4.2%	4.1%
#3 - #7 Plastics excl. #5	0.7%	0.3%	0.4%	0.2%	0.4%
#5	2.1%	4.1%	2.4%	3.5%	3.1%
Glass	**24.4%**	**42.0%**	**38.5%**	**44.1%**	**38.1%**
Glass	24.4%	42.0%	38.5%	44.1%	38.1%
Metals	**14.6%**	**11.3%**	**12.3%**	**15.1%**	**13.4%**
Aluminum Cans	7.7%	4.5%	8.2%	11.3%	8.0%
Tin/FE Cans	6.9%	6.7%	4.2%	3.8%	5.4%
Outthrows	7.0%	0.0%	3.4%	0.9%	**2.5%**
Paper	7.0%	0.0%	3.4%	0.9%	**2.5%**
OCC / Kraft	0.3%	0.0%	1.5%	0.0%	0.4%
ONP	0.7%	0.0%	0.0%	0.0%	0.1%
High-Grade Paper	2.5%	0.0%	0.0%	0.0%	0.5%
Mixed Paper	1.2%	0.0%	0.0%	0.0%	0.3%
Boxboard	2.3%	0.0%	1.9%	0.9%	1.2%
Contamination	23.4%	12.1%	14.8%	13.6%	**15.5%**
Film Plastic	4.7%	4.6%	5.6%	3.3%	4.5%
R/C Plastic	2.8%	1.6%	1.9%	2.0%	2.0%
R/C Paper	0.0%	0.0%	0.0%	0.0%	0.0%
Residue	10.0%	5.9%	7.3%	8.3%	7.8%
Fines	5.9%	0.0%	0.0%	0.0%	1.3%

Appendix Table 11. Residential Curbside Fiber Sampling Results

	Sample 1	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	**238.2**	**238.2**	**95.0%**
Paper	**238.2**	**238.2**	**95.0%**
OCC / Kraft	148.0	148.0	59.0%
ONP	3.0	3.0	1.2%
High-Grade Paper	5.5	5.5	2.2%
Mixed Paper	45.8	45.8	18.3%
Boxboard	35.9	35.9	14.3%
Outthrows	**0.6**	**0.6**	**0.3%**
Plastics	**0.6**	**0.6**	**0.3%**
#1 PET Bottles	0.6	0.6	0.3%
Other #1 PET	0.0	0.0	0.0%
#2 HDPE-N	0.0	0.0	0.0%
#2 HDPE-C	0.0	0.0	0.0%
#3 - #7 Plastics excl. #5	0.0	0.0	0.0%
#5	Trace	0.0	0.0%
Glass	**0.0**	**0.0**	**0.0%**
Glass	Trace	0.0	0.0%
Metals	**0.0**	**0.0**	**0.0%**
Aluminum Cans	Trace	0.0	0.0%
Tin/FE Cans	0.0	0.0	0.0%
Contamination	**11.9**	**11.9**	**4.7%**
Film Plastic	0.3	0.3	0.1%
R/C Plastic	0.0	0.0	0.0%
R/C Paper	3.3	3.3	1.3%
Residue	8.3	8.3	3.3%
Fines	0.0	0.0	0.0%
Total Net Weight	250.7	250.7	100.0%

Appendix Table 12. Fiber Residue Screen Sampling Results

	Sample 1	Sample 2	Sample 3	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	**85.8**	**138.2**	**149.2**	**373.2**	**67.2%**
Paper	**85.8**	**138.2**	**149.2**	**373.2**	**67.2%**
OCC / Kraft	46.0	70.7	65.6	182.3	32.7%
ONP	1.4	0.4	15.9	17.7	1.0%
High-Grade Paper	8.6	8.0	8.6	25.2	4.5%
Mixed Paper	9.9	27.5	28.3	65.7	11.8%
Boxboard	19.9	31.6	30.8	82.3	14.8%
Outthrows	**9.6**	**9.3**	**25.3**	**44.2**	**8.0%**
Plastics	**2.4**	**1.3**	**2.9**	**6.6**	**1.2%**
#1 PET Bottles	1.2	1.3	1.3	3.8	0.7%
Other #1 PET	0.0	0.0	0.2	0.2	0.0%
#2 HDPE-N	1.2	0.0	1.4	2.6	0.5%
#2 HDPE-C	0.0	0.0	Trace	0.0	0.0%
#3 - #7 Plastics excl. #5	Trace	Trace	Trace	0.0	0.0%
#5	Trace	Trace	Trace	0.0	0.0%
Glass	6.7	7.6	21.8	36.1	**6.5%**
Glass	6.7	7.6	21.8	36.1	6.5%
Metals	0.5	0.4	0.6	1.5	**0.3%**
Aluminum Cans	0.5	0.4	0.6	1.5	0.3%
Tin/FE Cans	Trace	Trace	Trace	0.0	0.0%
Contamination	**45.3**	**37.8**	**54.6**	**137.7**	**24.8%**
Film Plastic	0.3	Trace	0.0	0.3	0.1%
R/C Plastic	0.0	0.0	0.0	0.0	0.0%
R/C Paper	2.6	3.1	0.0	5.7	1.0%
Residue	24.7	11.7	37.8	74.2	13.4%
Fines	17.7	23.0	16.8	57.5	10.4%
Total Net Weight	140.7	185.3	229.1	555.1	100.0%

Appendix Table 13. Fiber Residue Screen Sampling Results - Percentage

	Sample 1	Sample 2	Sample 3	Weighted Avg. (%)
Recyclable Material	**61.0%**	**74.6%**	**65.1%**	**67.2%**
Paper	**61.0%**	**74.6%**	**65.1%**	**67.2%**
OCC / Kraft	32.7%	38.2%	28.6%	32.7%
ONP	1.0%	0.2%	6.9%	1.0%
High-Grade Paper	6.1%	4.3%	3.8%	4.5%
Mixed Paper	7.0%	14.8%	12.4%	11.8%
Boxboard	14.1%	17.1%	13.4%	14.8%
Outthrows	**6.8%**	**5.0%**	**11.0%**	**8.0%**
Plastics	**1.7%**	**0.7%**	**1.3%**	**1.2%**
#1 PET Bottles	0.9%	0.7%	0.6%	0.7%
Other #1 PET	0.0%	0.0%	0.1%	0.0%
#2 HDPE-N	0.9%	0.0%	0.6%	0.5%
#2 HDPE-C	0.0%	0.0%	0.0%	0.0%
#3 - #7 Plastics excl. #5	0.0%	0.0%	0.0%	0.0%
#5	0.0%	0.0%	0.0%	0.0%
Glass	**4.8%**	**4.1%**	**9.5%**	**6.5%**
Glass	4.8%	4.1%	9.5%	6.5%
Metals	**0.4%**	**0.2%**	**0.3%**	**0.3%**
Aluminum Cans	0.4%	0.2%	0.3%	0.3%
Tin/FE Cans	0.0%	0.0%	0.0%	0.0%
Contamination	**32.2%**	**20.4%**	**23.8%**	**24.8%**
Film Plastic	0.2%	0.0%	0.0%	0.1%
R/C Plastic	0.0%	0.0%	0.0%	0.0%
R/C Paper	1.8%	1.7%	0.0%	1.0%
Residue	17.6%	6.3%	16.5%	13.4%
Fines	12.6%	12.4%	7.3%	10.4%

Appendix Table 14. ONP Screen Sampling Results

	Sample 1	Sample 2	Sample 3	Sample 4	Component Weight (lbs.)	Weighted Avg. (%)
Recyclable Material	49.7	55.9	80.3	55.3	241.2	**79.1%**
Paper	49.7	55.9	80.3	55.3	241.2	**79.1%**
OCC / Kraft	4.1	4.1	8.2	6.2	22.6	7.4%
ONP	7.8	5.8	7.6	2.6	23.8	7.8%
High-Grade Paper	8.5	8.1	13.9	9.2	39.7	13.0%
Mixed Paper	22.9	27.2	31.7	29.4	111.2	36.5%
Boxboard	6.4	10.7	18.9	7.9	43.9	14.4%
Outthrows	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0%**
Plastics	0.0	0.0	0.0	0.0	0.0	**0.0%**
#1 PET Bottles	Trace	Trace	Trace	Trace	0.0	0.0%
Other #1 PET	Trace	Trace	0.0	Trace	0.0	0.0%
#2 HDPE-N	Trace	0.0	0.0	0.00	0.0	0.0%
#2 HDPE-C	Trace	0.0	0.0	0.0	0.0	0.0%
#3 - #7 Plastics excl. #5	0.0	0.0	0.0	0.0	0.0	0.0%
#5	0.0	0.0	0.0	0.0	0.0	0.0%
Glass	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0%**
Glass	0.0	Trace	0.0	0.0	0.0	0.0%
Metals	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0%**
Aluminum Cans	Trace	0.0	Trace	Trace	0.0	0.0%
Tin/FE Cans	0.0	0.0	0.0	0.0	0.0	0.0%
Contamination	18.2	10.2	24.0	11.4	63.8	**20.9%**
Film Plastic	0.6	0.0	Trace	0.0	0.6	0.2%
R/C Plastic	0.0	0.0	0.0	0.0	0.0	0.0%
R/C Paper	12.2	2.6	8.6	8.4	31.8	10.4%
Residue	2.8	2.7	4.2	1.6	11.3	3.7%
Fines	2.6	4.9	11.2	1.4	20.1	6.6%
Total Net Weight	67.9	66.1	104.3	66.7	305.0	100.0%

Appendix Table 15. ONP Screen Sampling Results – Percentage

	Sample 1	Sample 2	Sample 3	Sample 4	Weighted Avg. (%)
Recyclable Material	**73.2%**	**84.6%**	**77.0%**	**82.9%**	**79.1%**
Paper	**73.2%**	**84.6%**	**77.0%**	**82.9%**	**79.1%**
OCC / Kraft	6.0%	6.2%	7.9%	9.3%	7.4%
ONP	11.5%	8.8%	7.3%	3.9%	7.8%
High-Grade Paper	12.5%	12.3%	13.3%	13.8%	13.0%
Mixed Paper	33.7%	41.1%	30.4%	44.1%	36.5%
Boxboard	9.4%	16.2%	18.1%	11.8%	14.4%
Outthrows	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Plastics	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
#1 PET Bottles	0.0%	0.0%	0.0%	0.0%	0.0%
Other #1 PET	0.0%	0.0%	0.0%	0.0%	0.0%
#2 HDPE-N	0.0%	0.0%	0.0%	0.0%	0.0%
#2 HDPE-C	0.0%	0.0%	0.0%	0.0%	0.0%
#3 - #7 Plastics excl. #5	0.0%	0.0%	0.0%	0.0%	0.0%
#5	0.0%	0.0%	0.0%	0.0%	0.0%
Glass	0.0%	0.0%	0.0%	0.0%	**0.0%**
Glass	0.0%	0.0%	0.0%	0.0%	0.0%
Metals	0.0%	0.0%	0.0%	0.0%	**0.0%**
Aluminum Cans	0.0%	0.0%	0.0%	0.0%	0.0%
Tin/FE Cans	0.0%	0.0%	0.0%	0.0%	0.0%
Contamination	26.8%	15.4%	23.0%	17.1%	**20.9%**
Film Plastic	0.9%	0.0%	0.0%	0.0%	0.2%
R/C Plastic	0.0%	0.0%	0.0%	0.0%	0.0%
R/C Paper	18.0%	3.9%	8.2%	12.6%	10.4%
Residue	4.1%	4.1%	4.0%	2.4%	3.7%
Fines	3.8%	7.4%	10.7%	2.1%	6.6%

Appendix B. Composition Data Sheet

Characterization Study Data Sheet

Sheet Number:____________________________ Sample Number:______________________________

Date:_____________________________________ Recorded By:_________________________________

No.	Component	Weight (lbs.)		
		Gross	Tare	Net
1	OCC/Kraft			
2	ONP			
3	High-Grade Paper			
4	Mixed Paper			
5	Boxboard			
6	Remainder/Composite Paper			
7	#1 PET Bottles			
8	Other #1 PET			
9	#2 HDPE Natural			
10	#2 HDPE Colored			
11	#3 - #7 Mixed Plastic excl. #5			
12	#5 Plastics			
13	Film Plastic			
14	Remainder/Composite Plastics			
15	Ferrous Cans			
16	Aluminum Cans			
17	Glass			
18	Trash/Residue			
19	Fines			

city of Columbia

2023 Waste Composition Study

REPORT

May 31 2023

MSW CONSULTANTS

Prepared under contract to
RRT Design & Construction

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Table of Contents

TABLE OF CONTENTS

List of Figures

List of Tables

WASTE COMPOSITION STUDY

1. INTRODUCTION

The City of Columbia, Missouri is undergoing a Recycling and Waste Diversion Program Evaluation. In preparation for this initiative, the City identified the need for a baseline profile of the municipal solid waste generated within the City and disposed at the Columbia Landfill. Prior composition studies have been performed at the Landfill in 2017 and 2008 as part of Missouri statewide waste composition projects sponsored by the Department of Natural Resources. However, these studies devoted only two or three days of field data collection at the Columbia Landfill because they were part of the larger study. Further, there have been significant changes in the disposed waste stream since the most recent Missouri study in 2017.

The City retained RRT Design and Construction to perform the Program Evaluation. RRT in turn subcontracted the performance of a weeklong waste composition study of materials being disposed in the City landfill that are collected by City collection crews. This baseline waste composition data will assist the City in identifying opportunities for evolving its materials management system for inclusion in the Program Evaluation.

This report summarizes the City's waste generation, provides the waste composition research methodology, and presents the results of the study.

2. METHODOLOGY

2.1 GENERATOR SECTORS AND MATERIAL STREAMS

The City directly serves a total of five customer classes, which were treated as separate generator sectors for the study. These generators are:

- **Single Family Residential:** Refuse collected curbside from single-family residences up to four units per structure throughout the City,
- **Industrial/Commercial/Institutional (ICI):** Refuse collected from City businesses and institutional generators (e.g., commercial establishments, schools, and government buildings),
- **Community Improvement District (CID):** Refuse collected from a downtown area of the City that contains a mix of commercial, residential, and governmental generators.
- **University of Missouri Campus (UMC):** Refuse collected at facilities on the University of Missouri-Columbia campus. It is noted that UMC staff manage their own recycling collections.
- **Multi-Family Residential:** Refuse collected from multi-family complexes throughout the City.

Multi-family wastes are generally collected by a dedicated frontloader route, by fill-sized or mini-compactors, or by rearloader routes collecting both commercial and smaller multi-family locations.

Collectively, the ICI, CID and UMC waste stream is referenced as "non-residential waste" later in this report.

2.2 CITY OF COLUMBIA WASTE GENERATION

The City provided calendar year 2022 tonnage data as well as detailed scale data for January 2023 from the Columbia Sanitary Landfill, which was used to stratify the inbound refuse deliveries. The annual disposal data is shown in Table 2-1 below. As shown, the majority of waste disposed at the landfill originates in the single-family residential and ICI sectors, with small contributions from the CID and UMC.

Table 2-1 Annual Tonnage by Generator (2022 Data)

Generator	January 2023 Tons	Load Count	% of Total Tons	Extrapolated 2022 Tons
Single-Family Residential (Includes some Multi-family)	2,440	350	36.7%	31,433.10
ICI (Includes some Multi-family)	3,696	889	55.5%	47,598.71
CID	116	78	1.7%	1,490.08
UMC	401	163	6.0%	5,167.56
Total	**6,653**	**1,480**	**100.0%**	**85,689.45**

2.3 SAMPLING PLAN

Stratified sampling targets are shown in Table 2-2, which are based on the percentage of tonnage originating from each generator (as shown in Table 2-1). This table also compares the actual samples obtained to the sampling targets. As shown, actual samples were slightly underweight ICI, which was offset by several additional CID and UMC samples (which represent specific groups of ICI generators). In the professional opinion of MSW Consultants this slight discrepancy between targeted and actual samples fell within an allowable variance for reasonably representing the waste stream.

Table 2-2 Sample Targets

Generator	Percent of Tons	Sample Targets	Actual Samples
Single-Family Residential (Includes some Multi-Family)	36.7%	15	18*
ICI (includes some Multi-family)	55.5%	22	19
CID	1.7%	1	3
UMC	6.0%	2	4
Totals	**100.0%**	**40**	**44**

*Includes 3 Multi-Family Samples.

2.4 MATERIAL CATEGORIES

Each sample of refuse was sorted into 46 material categories. Table 2-3 shows the breakdown of the material categories within their respective material groups.

Table 2-3 Material Categories, Groups & Recyclability Class

Material Group and Category	
PAPER	**GLASS**
Corrugated Cardboard/Kraft Paper (Uncoated)	Clear Glass Containers
Newsprint	Brown Glass Containers
High-Grade Office Paper	Green Glass Containers
Mixed Recyclable Paper	Remainder/Composite Glass
Compostable Paper	**E-WASTE/HOUSEHOLD HAZARDOUS WASTE**
Remainder/Composite Paper	Electronic Waste
PLASTICS	HHW
#1 PET Bottles/Jars	**C&D/BULKY**
#1 PET Non-Bottle Containers	Wood-Clean Untreated
#2 HDPE Natural Containers	Wood - Painted/Stained/Treated
#2 HDPE Colored Containers	Drywall/Gypsum Board
Clean Film Bags	Asphalt, Brick, Concrete & Rocks
Clean Industrial/Commercial Film (non-bag)	Carpet & Carpet Padding
Contaminated Film/Other Film	Other Construction & Demolition Debris
#3-7 Plastic Containers	Bulky Items/Furniture
#6 Expanded Polystyrene	Tires
Bulky Durable Plastic Products	Mattresses/Box Springs
Remainder/Composite Plastic	**OTHER**
METALS	Fines
Aluminum Cans - Non Magnetic	Textiles - Clothing
Other Aluminum (foil, pans, etc.) - Not Magnetic	Textiles - Non-Clothing
Tin/Steel Containers - Magnetic	Shoes/Belts/Leather
Other Ferrous - Magnetic	Disposable Diapers & Sanitary Products
Other Non-Ferrous - Not Magnetic	Other/Non-Classified
ORGANICS	
Food Waste	
Yard Waste	
Remainder/Composite Organic	
Recyclability Class	
Targeted Curbside Recyclable	*Recyclable but No Regional Markets Exist*
Recyclable/Managed at City Facilities	*Processible Organics*
Recyclable at Private Facilities	*Not Currently Recoverable*

One of the objectives of this study was to identify constituents that have potential for diversion from the landfill. Accordingly, each material was assigned a "recyclability class" which included:

- **Targeted Curbside Recyclable**: All material categories targeted in the City's curbside collection programs. This includes cardboard, newspaper, high-grade office paper, plastic containers, glass bottles, aluminum beverage containers, and steel cans.
- **Recyclable/Managed at City Facilities**: These are items that the City will accept at its facilities for recycling or proper management. Includes yard waste and household hazardous wastes (HHW).
- **Recyclable at Private Facilities**: There are a variety of private and non-profit organizations in and around Columbia that will accept materials and help keep them out of landfills. Includes clean plastic bags and films, scrap metal, electronic items, tires (Solid Waste District collections) and various clothing, shoes, and textiles.

- **Recyclable, but No Regional Market Exists**: These are items that are successfully recycled in some regions of the country where end-users have emerged to accept these secondary materials. However, no such outlet for these materials currently exists in the region. Includes #6 expanded polystyrene, bulky plastics, clean wood, carpet and padding, and mattresses/box springs.
- **Processible Organics**: The Columbia Bioreactor Landfill is designed to recover energy from organic materials such as food waste. Yard wastes entering the landfill are also considered processible in the bioreactor.[1]
- **Not Currently Recoverable**: Includes all other materials for which there are no known commercial scale recycling programs nor other ways to readily divert the material from landfill.

These recyclability classes are identified with color-coding shown in Table 2-3.

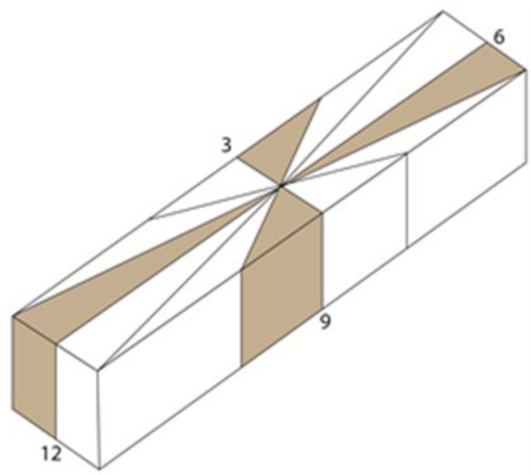
3. FIELD DATA COLLECTION METHODS

3.1 SAMPLING

Inbound loads of material were randomly selected within the stratified sampling plan. MSW Consultants interviewed the drivers of selected loads to confirm the geographic origin and type of waste, as well as any other pertinent data. This information was noted on a handheld tablet computer, along with a unique identifying number associated with that vehicle on that day.

Selected loads of waste designated for sorting were tipped in the designated area at the landfill. From each selected load, one sample of material was selected based on systematic "grabs" from the perimeter of the load. For example, if the tipped pile is viewed from the top as a clock face with 12:00 being the part of the load closest to the front of the truck, the first samples was taken from 3 o'clock, 6 o'clock, 9 o'clock, 12 o'clock, and then from 1, 4, 7, and 10 o'clock, and so-on. This is illustrated in Figure 3-1.

Figure 3-1 Sample Segmentation



Once the area of the tipped load was selected, the Field Supervisor took a photograph of the load with the sample placard and identification number visible in the picture. The Field Supervisor then coordinated with a facility-provided loader operator to take a "grab" sample of waste from that point in the tipped

[1] It should be noted that Columbia's bioreactor landfill is also technically processing other organics in addition to Food Waste and Yard Waste. For example, the landfill routinely receives cellulose casing discards from a local food manufacturer, which were characterized as Remainder/Composite Organics in this study. However, this recyclability class has been defined to only include Food and Yard Wastes to be consistent with other waste composition studies and to reflect the constituents which are routinely targeted in communities with traditional curbside collection programs for these materials (i.e., communities which do not have bioreactor landfills).

load. The Field Supervisor then collected the sample directly from the bucket of the front-end loader operated by City staff. This was accomplished by arranging 35-gallon trash cans side-by-side with the loader bucket positioned directly overhead. The Field Supervisor collected the sample systematically, working from one side of the bucket to the other, emptying all the contents from the front of the bucket to the back, until the desired sample weight was achieved. To help minimize sample collection bias, samples were collected from the loader bucket in an alternating fashion, that is, working from the left side of the bucket to the right side for one sample, and then from right to left on the next sample.

Samples weighing at least 200 pounds were taken from the loader bucket and pre-weighed (to verify that the minimum sample weight was achieved and to prevent sorting overly large samples. Pre-weighed samples were loaded into barrels for placement on the sort table. Any bulky items in the sample were weighed and recorded separately (thereby eliminating the need to characterize them at the sort table).

3.2 MANUAL SORTING

Once the sample has been acquired and appropriately staged for sorting, the material was manually sorted into the prescribed component categories. Plastic 20-gallon bins, 35-gallon barrels, and 5-gallon buckets labeled with the appropriate material category to sort the sampled material. A picture of the sorting area is shown in Figure 3-2 below.

Figure 3-2 Sorting Setup at Columbia Landfill

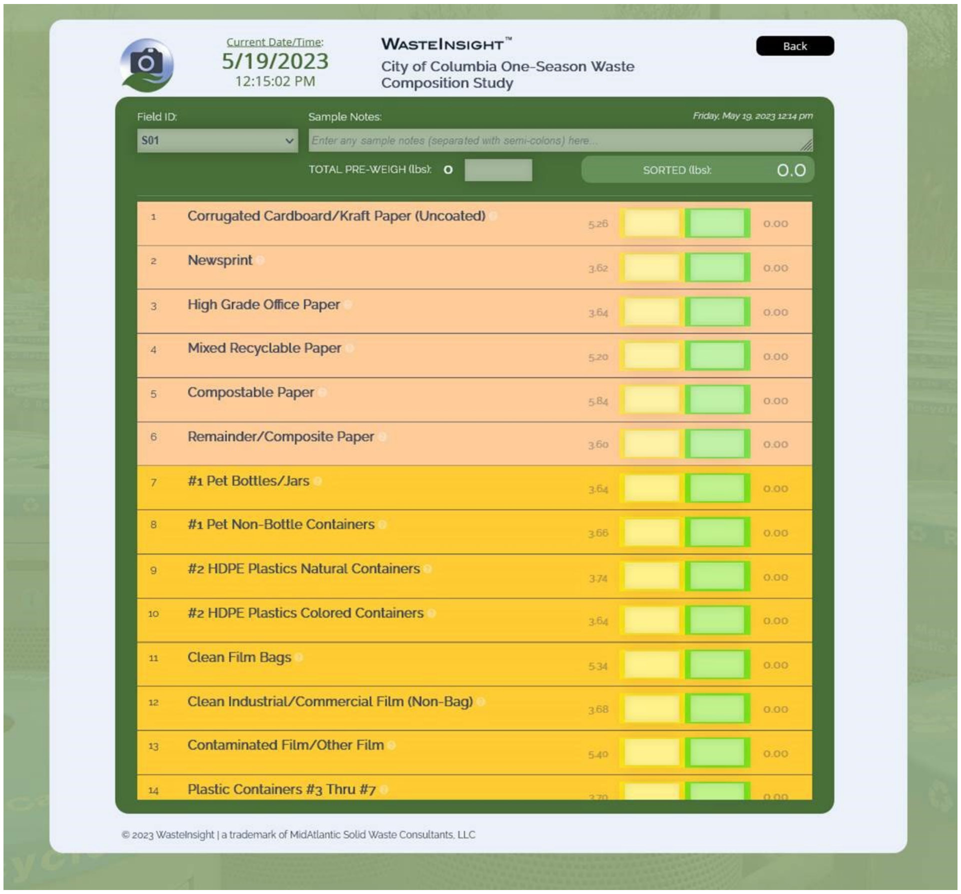
3.3 DATA RECORDING

The weigh-out and data recording process is the most critical process of the sort. The Crew Chief oversaw all weighing and data recording of each sample. Once each sample was sorted, and fines appropriately characterized, the weigh-out was performed. Each bin containing materials from the sorted sample was carried over to the scale. The sorting crew assisted with carrying and weighing the bins of sorted material, and the Crew Chief recorded all data.

The Crew Chief used a rugged tablet computer to record the composition weights. The tablet allowed for samples to be tallied in real time so that field data collection could immediately identify and rectify errors associated with light sample weights. A screenshot of the app is provided in Figure 3-3 The tablet synchronizes with the Cloud via internet, providing excellent data security. Each sample was cross-referenced against the Field Supervisor's sample sheet to assure accurate tracking of the samples each day. The real-time data entry offered several important advantages:

- The template contains built-in logic and error checking to prevent erroneous entries.
- The template sums sample weights in real time so the Crew Chief can confirm achievement of weight targets for each sample.

Figure 3-3 Data Management App



3.4 DATA ANALYSIS

A statistical analysis was performed to calculate the mean composition for each of the material categories and for each material stream in this study. Samples were first normalized by converting the sample data from weight to percentage. Then, the sample mean was determined by averaging the percent composition of each material across all samples.

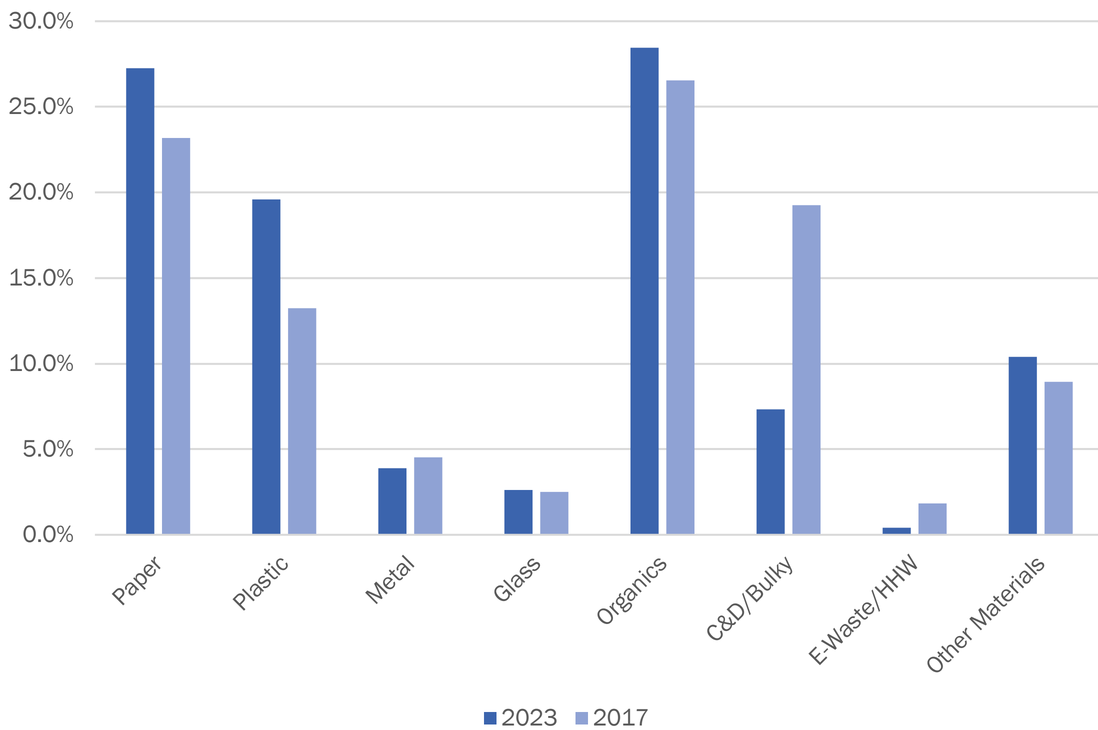
The margin of error (MOE) is provided for each material category as well as for major material groups (e.g., "paper", "plastic", etc.). The margin of error quantifies the range of uncertainty associated with an estimated sample mean. It provides an indication of the potential deviation between the sample mean and the true population mean. Although not shown in the table, the MOE can be used to calculate upper and lower confidence intervals at a 90 percent level of confidence, meaning that we can be 90 percent sure that the upper and lower bounds of a confidence interval successfully capture its respective population mean. (The converse is also true: that there is a 10 percent chance that a confidence interval will fail to capture its population mean). In general, as the number of samples increases, the MOE decreases, although the more variable the underlying waste stream composition, the less noticeable the improvement in accuracy for adding incremental samples.

4. RESULTS

4.1 AGGREGATE COMPOSITION: CITY MANAGED WASTE

Figure 4-1 shows the composition of the City's landfilled municipal solid wastes by material group. This figure also compares the 2023 results with the 2017 Missouri statewide waste composition study results for the Columbia Landfill.

Figure 4-1 Aggregate City-Collected (2023) vs. All Incoming (2017) Waste Composition Summary



Readers are cautioned that there were meaningful differences in the sampling targets for the 2023 Study and the 2017 Study. The statewide study included all wastes entering the landfill, including loads brought by private haulers. Additionally, the 2017 Study captured a smaller number of samples, which means the 2017 results are subject to a higher margin of error than the 2023 Study. However, the comparison is provided for context and reflects both similarities and differences in the results from the two studies.

Figure 4-2 provides the recyclability of the aggregate disposed refuse stream in the 2023 Study in comparison to the 2017 Missouri statewide study. This graphic shows that roughly twenty-one to fifty-six percent of the materials being disposed could be diverted through existing recycling programs, composting programs, and third-party recovery programs.

Figure 4-2 Recoverability of City-Collected (2023) vs. All Incoming (2017) Waste Disposed

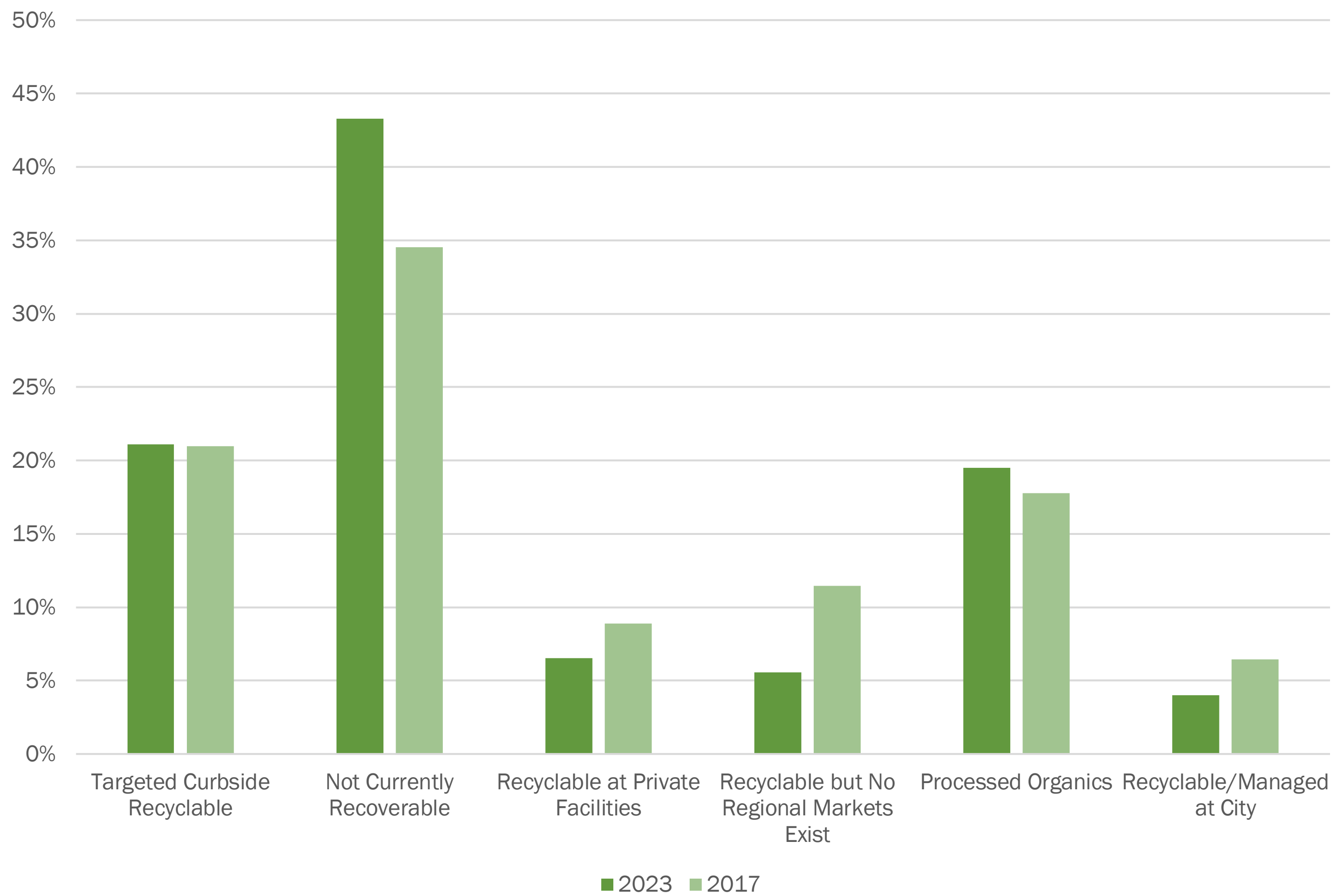
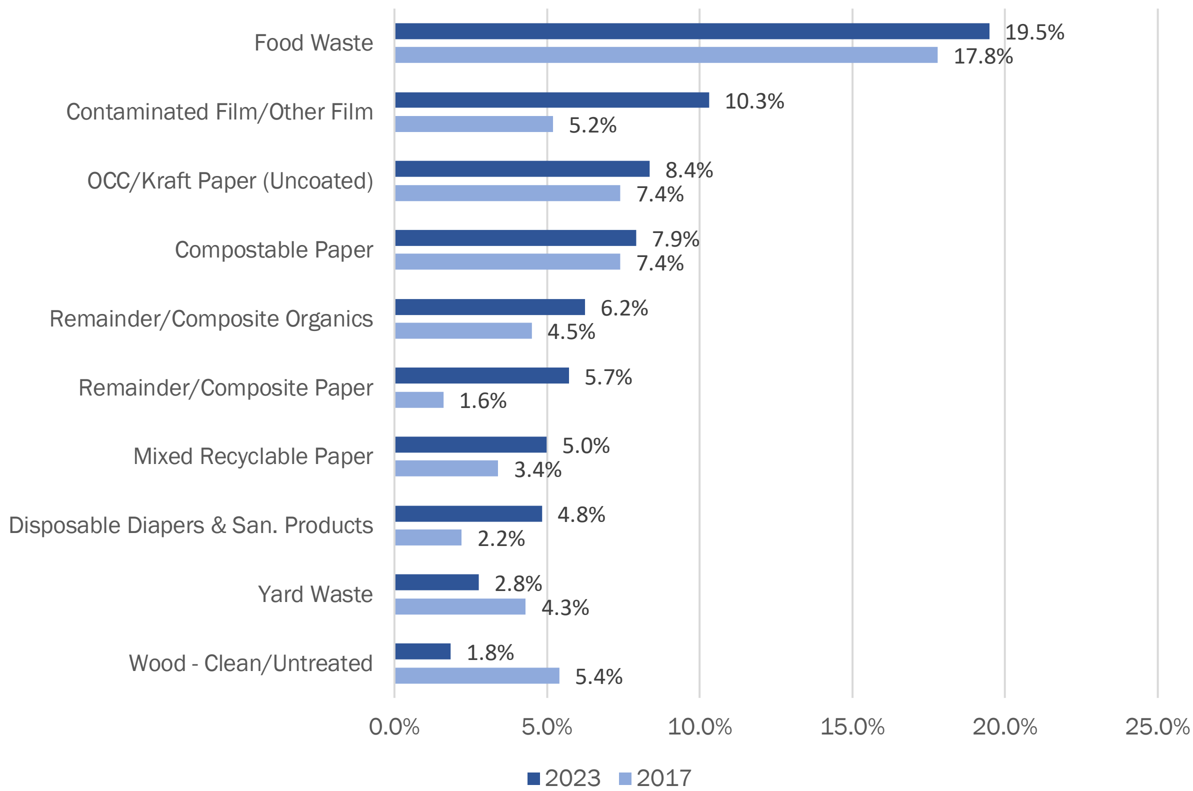


Figure 4-3 compares the ten most prevalent material categories within city-managed waste in the current study against the same categories in the Statewide study in 2017 (Columbia Landfill data only). The most prevalent materials were reasonably consistent in both studies despite the differences in sampling targets.

Figure 4-3 Top 10 Most Prevalent Materials in City-Managed Waste



A detailed compositional profile of Aggregate refuse is provided in Table 4-1. As shown, Organics was the most prevelant material group.

Table 4-1 Detailed Aggregate Waste Composition

Material	Percent	MOE	Est. Tons	Material	Percent	MOE	Est. Tons
Paper	**27.3%**	**3.9%**	**23,353**	**Organics**	**28.5%**	**4.5%**	**24,397**
OCC/Kraft Paper (Uncoated)	8.4%	3.6%	7,164	Food Waste	19.5%	3.0%	16,692
Newsprint	0.1%	0.1%	87	Yard Waste	2.8%	1.7%	2,364
High Grade Office Paper	0.2%	0.2%	162	Remainder/Composite Organics	6.2%	4.1%	5,341
Mixed Recyclable Paper	5.0%	1.0%	4,265				
Compostable Paper	7.9%	1.4%	6,781	**C&D / Bulky Materials**	**7.3%**	**2.7%**	**6,281**
Remainder/Composite Paper	5.7%	2.8%	4,894	Wood - Clean/Untreated	1.8%	1.4%	1,575
				Wood - Painted/Stained/Treated	1.5%	1.0%	1,267
Plastic	**19.6%**	**1.7%**	**16,790**	Drywall/Gypsum Board	0.1%	0.1%	46
#1 Pet Bottles/Jars	1.3%	0.2%	1,087	Asphalt, Brick, Concrete & Rocks	0.1%	0.1%	85
#1 Pet Non-Bottle Containers	0.4%	0.1%	314	Carpet & Carpet Padding	1.1%	1.2%	963
#2 HDPE Plastics Natural Containers	0.5%	0.2%	414	Other C&D Debris/Materials	1.8%	1.5%	1,514
#2 HDPE Plastics Colored Containers	0.6%	0.3%	532	Bulky Materials/Furniture	0.0%	0.1%	29
Clean Film Bags	0.7%	0.8%	599	Mattresses & Box Springs	0.0%	0.0%	0
Clean Industrial/Commercial Film (Non-Bag)	0.2%	0.3%	196	Tires	0.9%	0.9%	804
Contaminated Film/Other Film	10.3%	1.2%	8,830				
Plastic Containers #3 Thru #7	1.2%	0.2%	1,036	**E-Waste / HHW**	**0.4%**	**0.2%**	**353**
Expanded Polystyrene #6	1.0%	0.3%	827	Electronic Waste	0.1%	0.1%	92
Bulky Durable Plastic Products	1.7%	0.8%	1,415	HHW	0.3%	0.2%	261
Remainder/Composite Plastics	1.8%	0.3%	1,540				
				Other Materials	**10.4%**	**2.0%**	**8,923**
Metal	**3.9%**	**1.1%**	**3,349**	Fines	1.4%	0.2%	1,194
Aluminum Cans	0.7%	0.1%	566	Textiles - Clothing	1.4%	0.7%	1,160
Other Aluminum (Foil, Pans, Trays)	0.2%	0.1%	147	Textiles - Non Clothing	1.3%	0.6%	1,143
Tin/Steel Containers	0.6%	0.2%	535	Shoes, Belts, Leather Products	0.4%	0.3%	313
Other Ferrous Metal - Magnetic	1.2%	0.8%	1,054	Disposable Diapers & San. Products	4.8%	1.3%	4,137
Other Non-Ferrous Metal - Not Magnetic	1.2%	0.7%	1,047	Other/Not Elsewhere Classified	1.1%	0.4%	976
Glass	**2.6%**	**0.8%**	**2,244**	**Category Totals**	**100.0%**		**85,689**
Clear Glass Containers	1.2%	0.3%	1,009	**Sample Count**	**44**		
Brown Glass Containers	0.8%	0.4%	654				
Green Glass Containers	0.3%	0.2%	254	*Targeted Recyclable*	21.1%	3.6%	18,079
Remainder/Composite Glass	0.4%	0.2%	327	*Other Recyclable*	35.6%	2.9%	30,504
				Disposal	43.3%	3.9%	37,106
				Recyclability Totals	**100.0%**		**85,689**

Margin of error was calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

4.2 COMPARISONS

Figure 4-4 compares residential refuse composition to non-residential wastes, which is the combination of ICI, UMC and CID waste. As can be seen in the figure, a relatively higher percentage of organics was found in residential waste compared to non-residential waste, while non-residential waste was found to have a higher percentage of paper and plastics.

Figure 4-4 Residential vs. Non-Residential (Combined ICI/CID/UMC) Composition

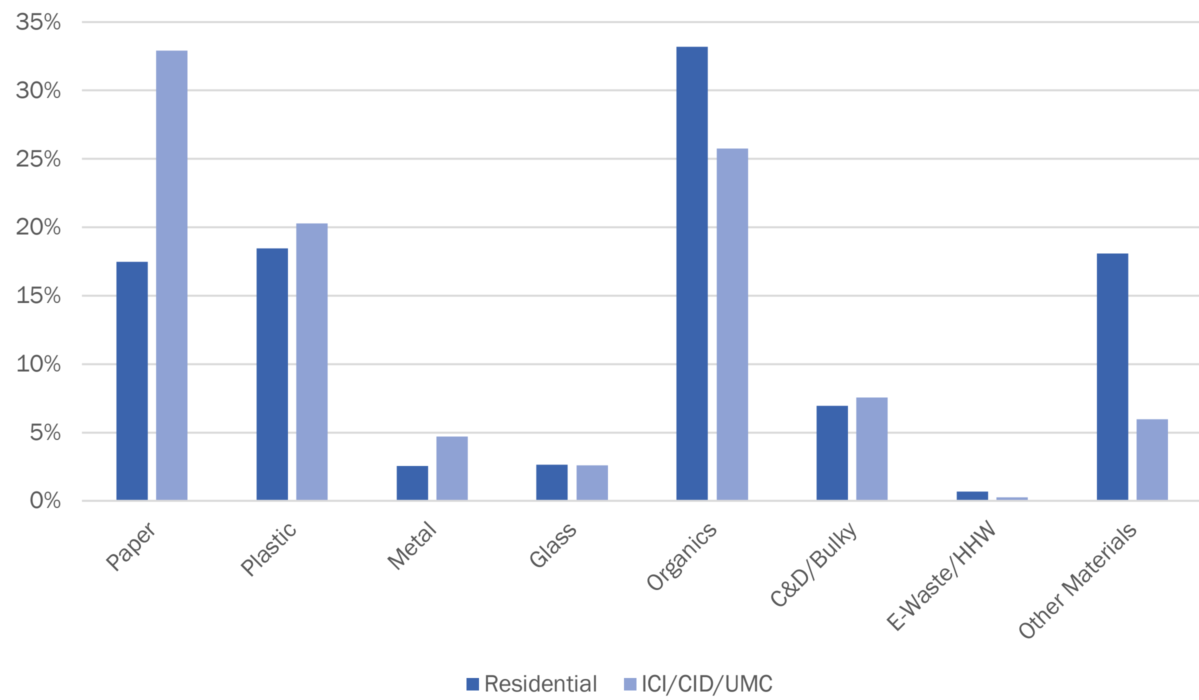


Figure 4-5 below compares the recoverability of residential refuse composition to non-residential waste. As can be seen in the figure, a relatively higher percentage of recyclables was found in non-residential waste compared to residential waste, while residential waste was found to have a higher percentage of "other recyclable material", which is likely a reflection of the higher proportion of organic materials in residential waste.

Figure 4-5 Residential vs. Non-Residential (Combined ICI/CID/UMC) Recoverability

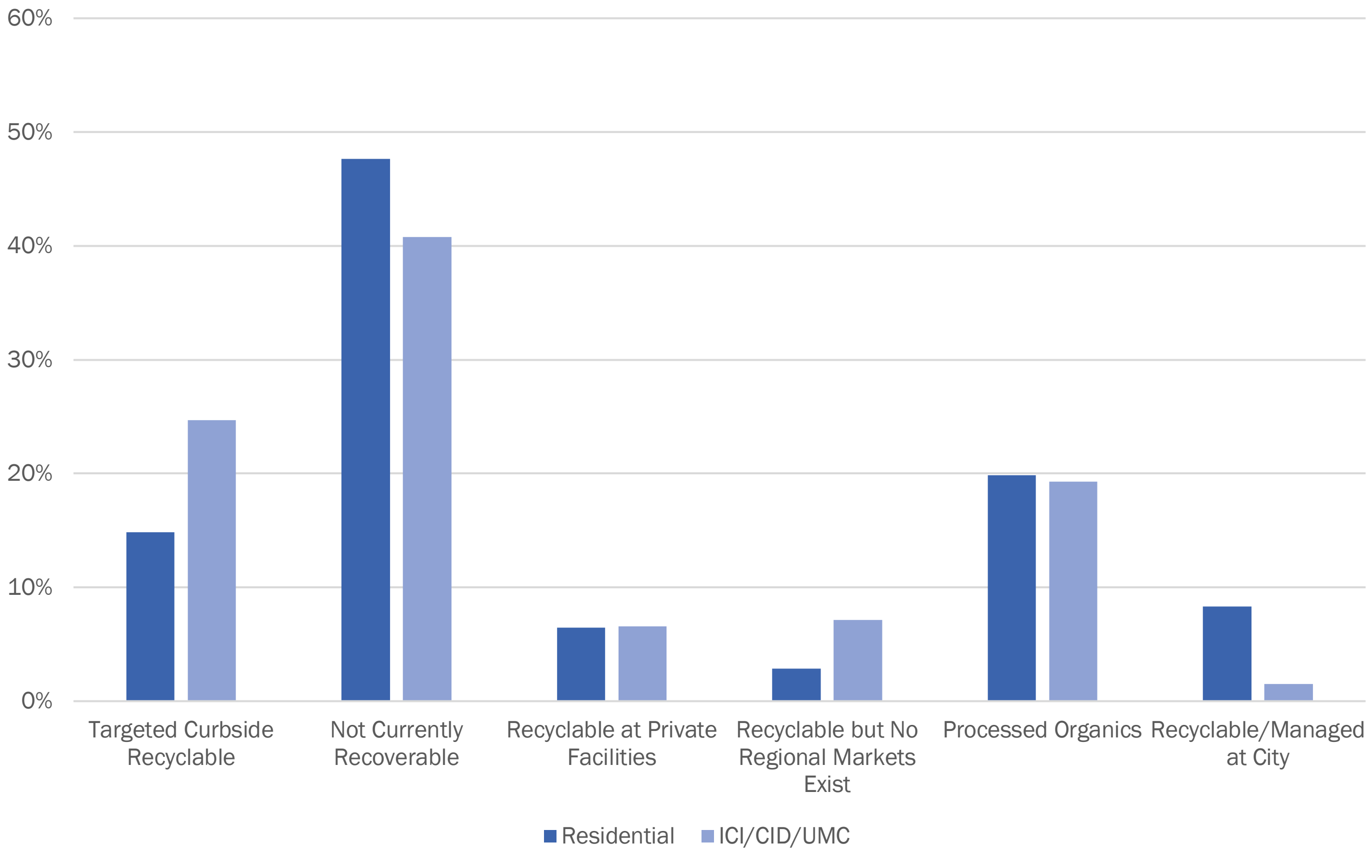


Table 4-2 and Table 4-3 below provide detailed compositional profiles of Residential refuse and non-residential waste, respectively.

Table 4-2 Detailed Residential Waste Composition

Material	Percent	MOE	Est. Tons	Material	Percent	MOE	Est. Tons
Paper	**17.5%**	**2.2%**	**5,489.3**	**Organics**	**33.2%**	**4.8%**	**10,426.9**
OCC/Kraft Paper (Uncoated)	2.0%	0.6%	636.3	Food Waste	19.9%	2.0%	6,242.2
Newsprint	0.0%	0.1%	12.4	Yard Waste	6.1%	4.2%	1,916.2
High Grade Office Paper	0.0%	0.1%	12.5	Remainder/Composite Organics	7.2%	3.0%	2,268.5
Mixed Recyclable Paper	4.8%	1.0%	1,499.7				
Compostable Paper	7.0%	1.2%	2,186.5	**C&D / Bulky Materials**	**7.0%**	**3.7%**	**2,187.3**
Remainder/Composite Paper	3.6%	0.6%	1,141.9	Wood - Clean/Untreated	0.1%	0.1%	16.4
				Wood - Painted/Stained/Treated	1.7%	1.7%	534.3
Plastic	**18.4%**	**1.9%**	**5,797.2**	Drywall/Gypsum Board	0.1%	0.1%	25.5
#1 Pet Bottles/Jars	1.7%	0.3%	533.8	Asphalt, Brick, Concrete & Rocks	0.1%	0.1%	39.0
#1 Pet Non-Bottle Containers	0.5%	0.1%	152.1	Carpet & Carpet Padding	0.6%	1.1%	198.6
#2 HDPE Plastics Natural Containers	0.4%	0.1%	130.3	Other C&D Debris/Materials	2.6%	2.3%	817.8
#2 HDPE Plastics Colored Containers	0.5%	0.1%	145.1	Bulky Materials/Furniture	0.1%	0.2%	28.9
Clean Film Bags	0.1%	0.1%	18.5	Mattresses & Box Springs	0.0%	0.0%	0.0
Clean Industrial/Commercial Film (Non-Bag)	0.0%	0.0%	0.0	Tires	1.7%	2.0%	526.8
Contaminated Film/Other Film	9.8%	1.5%	3,087.3				
Plastic Containers #3 Thru #7	1.4%	0.3%	442.4	**E-Waste / HHW**	**0.7%**	**0.5%**	**214.7**
Expanded Polystyrene #6	1.2%	0.3%	374.6	Electronic Waste	0.1%	0.1%	43.3
Bulky Durable Plastic Products	1.0%	1.0%	307.2	HHW	0.5%	0.5%	171.4
Remainder/Composite Plastics	1.9%	0.5%	605.9				
				Other Materials	**18.1%**	**2.7%**	**5,676.6**
Metal	**2.6%**	**0.6%**	**805.7**	Fines	2.0%	0.3%	613.0
Aluminum Cans	0.7%	0.2%	210.9	Textiles - Clothing	1.8%	1.2%	572.9
Other Aluminum (Foil, Pans, Trays)	0.2%	0.1%	67.7	Textiles - Non Clothing	2.5%	1.4%	791.3
Tin/Steel Containers	0.8%	0.2%	236.9	Shoes, Belts, Leather Products	1.0%	0.7%	311.5
Other Ferrous Metal - Magnetic	0.6%	0.3%	181.8	Disposable Diapers & San. Products	9.6%	2.0%	3,016.3
Other Non-Ferrous Metal - Not Magnetic	0.3%	0.3%	108.4	Other/Not Elsewhere Classified	1.2%	0.7%	371.6
Glass	**2.7%**	**0.7%**	**835.5**	**Category Totals**	**100.0%**		**31,433.1**
Clear Glass Containers	1.4%	0.4%	453.0	**Sample Count**	**18**		
Brown Glass Containers	0.3%	0.1%	95.7				
Green Glass Containers	0.3%	0.3%	109.7	*Targeted Recyclable*	14.9%	2.2%	4,670.8
Remainder/Composite Glass	0.6%	0.5%	177.2	*Other Recyclable*	37.5%	3.3%	11,781.1
				Disposal	47.7%	3.3%	14,981.3
				Recyclability Totals	**100.0%**		**31,433.1**

Margin of error was calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

Table 4-3 Detailed Non-Residential (Combined ICI/CID/UMC) Waste Composition

Material	Percent	MOE	Est. Tons	Material	Percent	MOE	Est. Tons
Paper	**32.9%**	**3.7%**	**17,864**	**Organics**	**25.7%**	**4.6%**	**13,970**
OCC/Kraft Paper (Uncoated)	12.0%	5.4%	6,527	Food Waste	19.3%	5.0%	10,450
Newsprint	0.1%	0.1%	75	Yard Waste	0.8%	0.9%	448
High Grade Office Paper	0.3%	0.3%	150	Remainder/Composite Organics	5.7%	7.9%	3,072
Mixed Recyclable Paper	5.1%	1.7%	2,765				
Compostable Paper	8.5%	2.2%	4,595	**C&D / Bulky Materials**	**7.5%**	**2.4%**	**4,094**
Remainder/Composite Paper	6.9%	4.8%	3,752	Wood - Clean/Untreated	2.9%	2.1%	1,558
				Wood - Painted/Stained/Treated	1.3%	1.2%	732
Plastic	**20.3%**	**1.7%**	**10,993**	Drywall/Gypsum Board	0.0%	0.0%	20
#1 Pet Bottles/Jars	1.0%	0.3%	553	Asphalt, Brick, Concrete & Rocks	0.1%	0.1%	46
#1 Pet Non-Bottle Containers	0.3%	0.1%	162	Carpet & Carpet Padding	1.4%	2.0%	764
#2 HDPE Plastics Natural Containers	0.5%	0.3%	284	Other C&D Debris/Materials	1.3%	2.1%	696
#2 HDPE Plastics Colored Containers	0.7%	0.5%	387	Bulky Materials/Furniture	0.0%	0.0%	0
Clean Film Bags	1.1%	1.2%	580	Mattresses & Box Springs	0.0%	0.0%	0
Clean Industrial/Commercial Film (Non-Bag)	0.4%	0.4%	196	Tires	0.5%	0.9%	277
Contaminated Film/Other Film	10.6%	1.9%	5,743				
Plastic Containers #3 Thru #7	1.1%	0.3%	594	**E-Waste / HHW**	**0.3%**	**0.3%**	**138**
Expanded Polystyrene #6	0.8%	0.4%	452	Electronic Waste	0.1%	0.1%	48
Bulky Durable Plastic Products	2.0%	1.2%	1,108	HHW	0.2%	0.1%	90
Remainder/Composite Plastics	1.7%	0.5%	934				
				Other Materials	**6.0%**	**2.2%**	**3,246**
Metal	**4.7%**	**1.0%**	**2,544**	Fines	1.1%	0.2%	581
Aluminum Cans	0.7%	0.2%	355	Textiles - Clothing	1.1%	0.9%	587
Other Aluminum (Foil, Pans, Trays)	0.1%	0.1%	80	Textiles - Non Clothing	0.6%	0.4%	352
Tin/Steel Containers	0.6%	0.3%	299	Shoes, Belts, Leather Products	0.0%	0.0%	2
Other Ferrous Metal - Magnetic	1.6%	1.3%	872	Disposable Diapers & San. Products	2.1%	1.2%	1,120
Other Non-Ferrous Metal - Not Magnetic	1.7%	1.1%	938	Other/Not Elsewhere Classified	1.1%	0.4%	605
Glass	**2.6%**	**1.0%**	**1,408**	**Category Totals**	**100.0%**		**54,256**
Clear Glass Containers	1.0%	0.4%	556	**Sample Count**	**26**		
Brown Glass Containers	1.0%	0.7%	559				
Green Glass Containers	0.3%	0.2%	144	*Targeted Recyclable*	24.7%	3.6%	13,408
Remainder/Composite Glass	0.3%	0.2%	150	*Other Recyclable*	34.5%	3.0%	18,723
				Disposal	40.8%	3.9%	22,125
				Recyclability Totals	**100.0%**		**54,256**

Margin of error was calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

Figure 4-6 compares non-residential waste streams, showing the ICI, CID, and UMC generators.

Figure 4-6 Non-Residential Composition Comparison

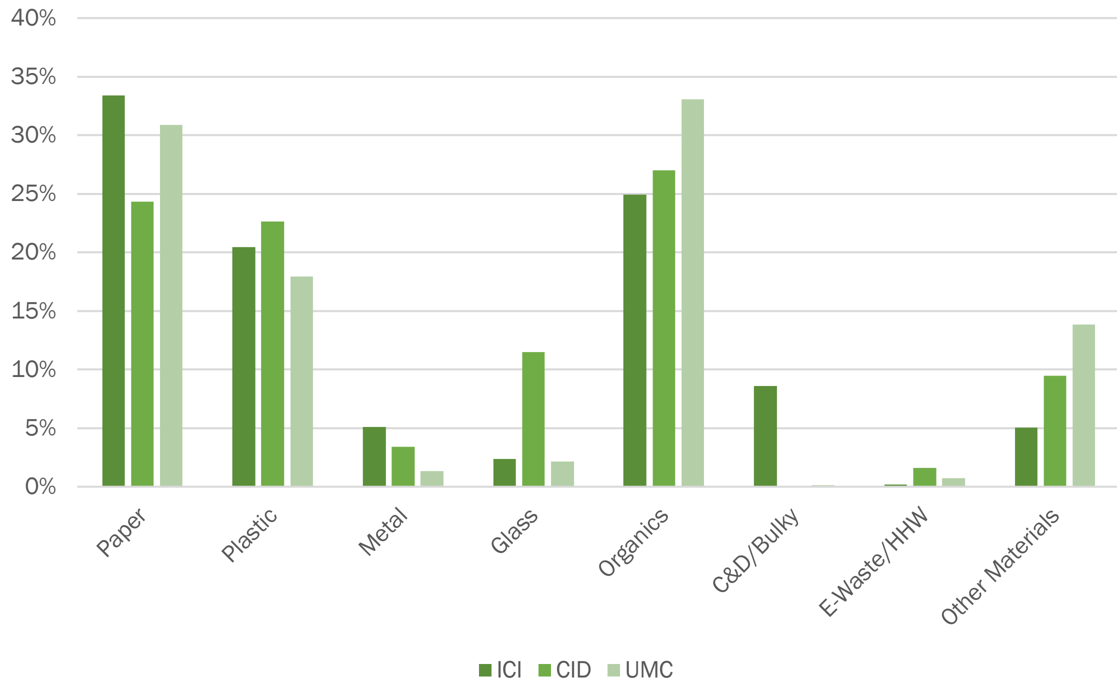
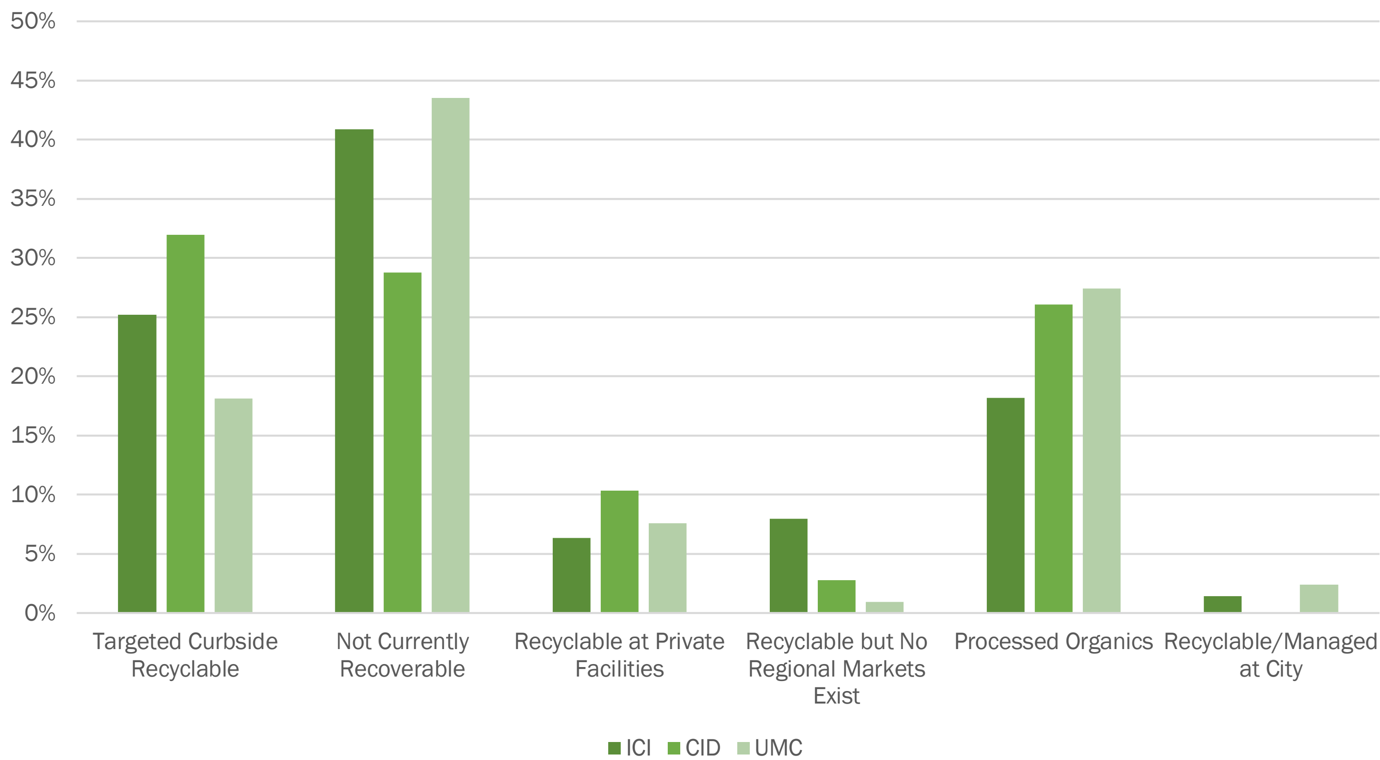


Figure 4-7 compares the recoverability of the waste streams from the non-residential generator types. Of particular interest, over thirty percent of the CID stream was found to be acceptable recyclables.

Figure 4-7 Non-Residential Recoverability Comparison



5. CONCLUSIONS

This composition study was performed in support of a broader recycling and diversion program evaluation being undertaken by the City. The results contained in the report provide a detailed baseline snapshot of the targeted recyclables, and other potentially recoverable constituents, which are currently being disposed in the City Landfill. Solid waste and recycling planners can use these findings as a basis to evaluate the effectiveness of current recycling programs, and to identify and prioritize new recycling and diversion initiatives within the context of the diversion plan.

With prior composition studies being performed at the Columbia Landfill in 2017 and 2008, this study also reflects a growing time series data set. The City should consider updating this study every five to seven years to evaluate the effectiveness of the diversion initiatives arising from the current planning process.

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800.679.9220 | mswconsultants.com

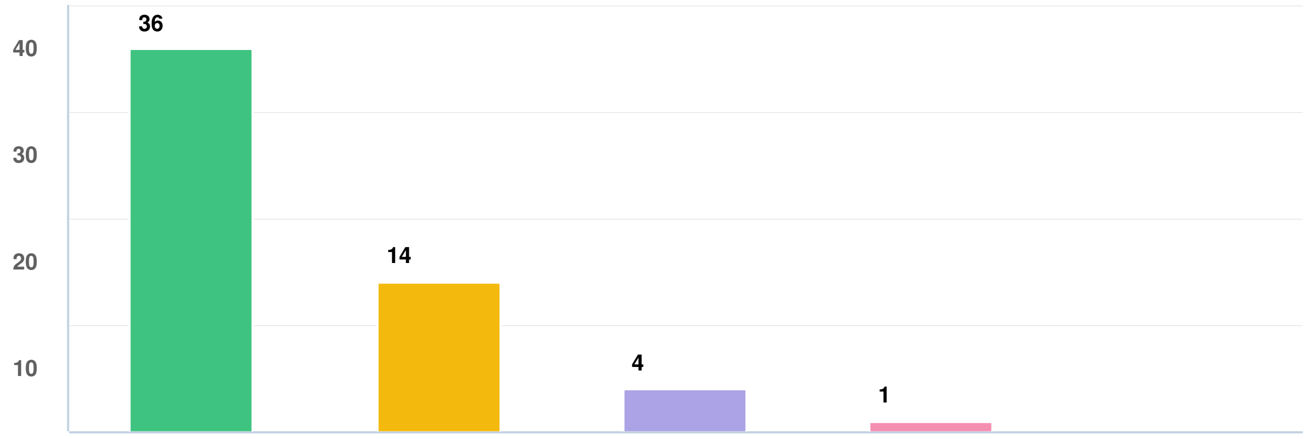
Recycling survey

SURVEY RESPONSE REPORT
22 February 2022 - 24 April 2023

PROJECT NAME:
Customer input on the future of the City recycling system

REGISTRATION QUESTIONS

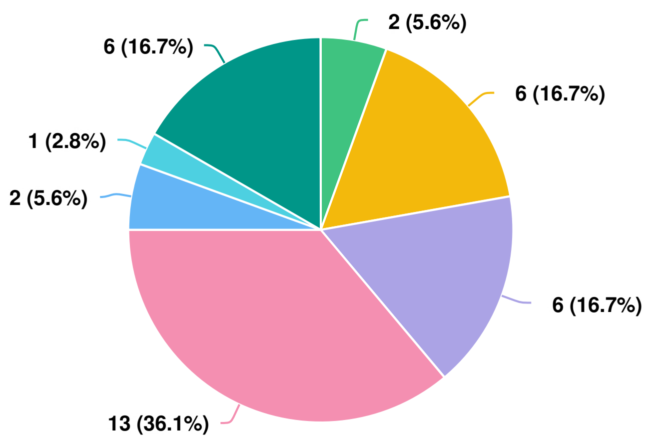
Q1 What is your relationship to the City of Columbia?



Question options
I live in Columbia · I work in Columbia · I am a Columbia Business Owner · I visit Columbia regularly · I am not a resident or frequent visitor

Mandatory Question (36 response(s))
Question type: Checkbox Question

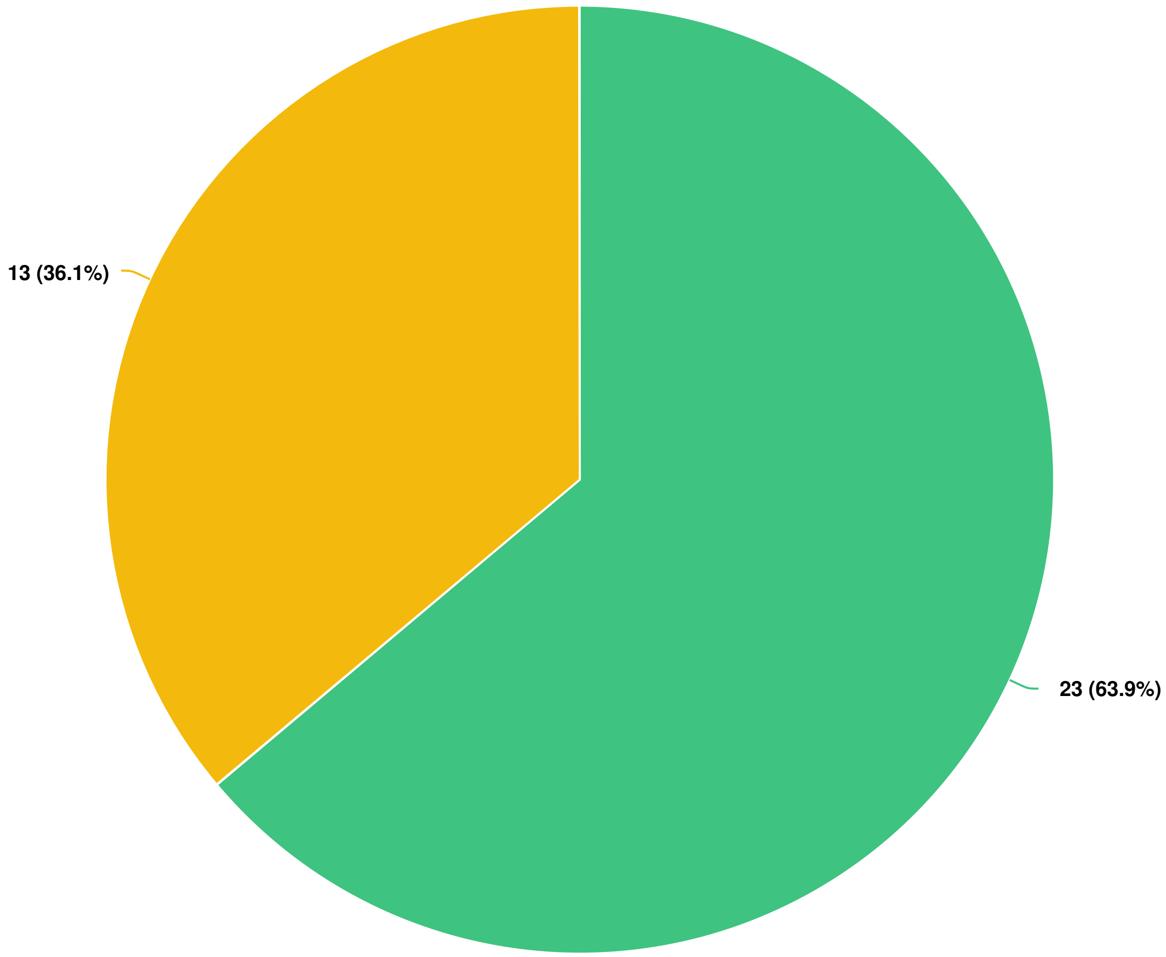
Q2 What ward do you live in?



Question options
Ward 1 · Ward 2 · Ward 3 · Ward 4 · Ward 5 · Ward 6 · I don't know

Optional question (36 response(s), 0 skipped)
Question type: Radio Button Question

Q3 **Are you interested in answering additional demographic questions to help provide more contextual information?**



Question options

Yes No

Optional question (36 response(s), 0 skipped)
Question type: Radio Button Question

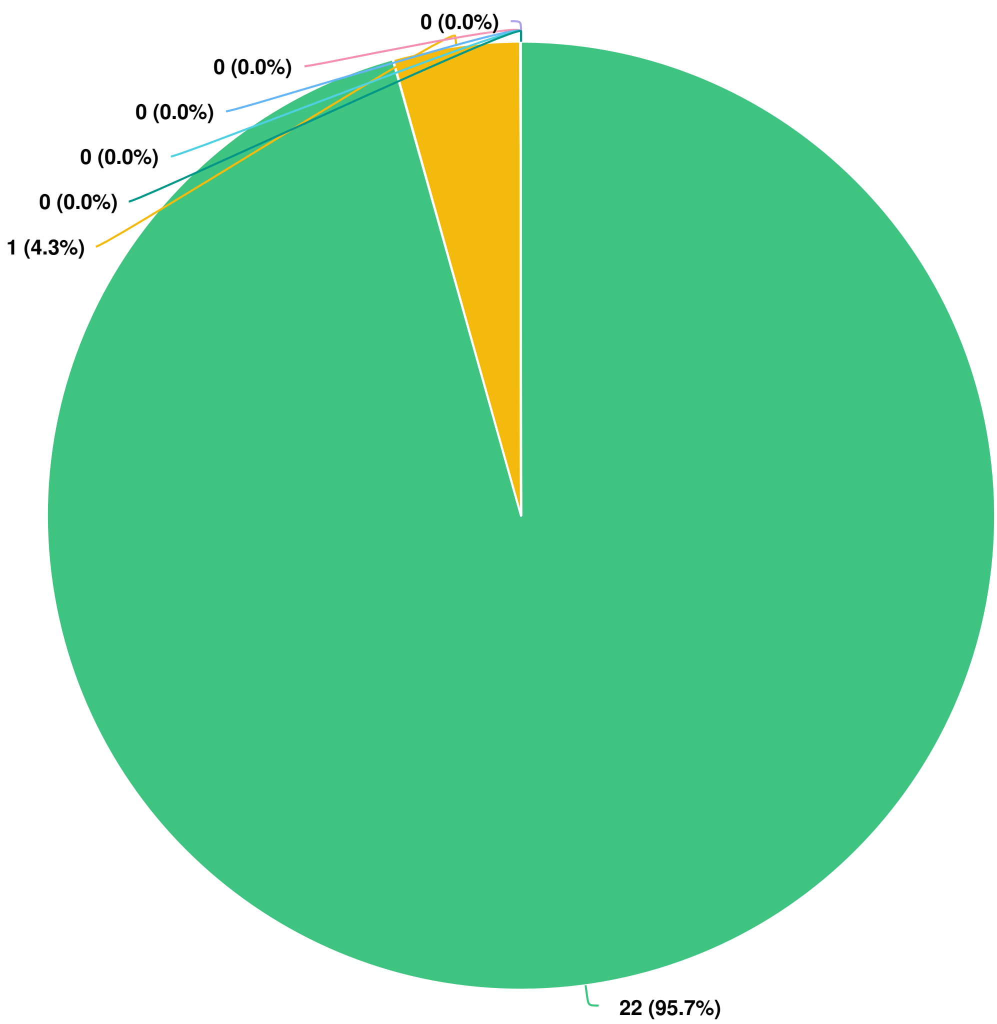
Q4 What is your age?

Screen Name Redacted 2/23/2022 08:45 AM	70
Screen Name Redacted 4/01/2022 04:28 PM	50
Screen Name Redacted 6/09/2022 07:06 PM	43
Screen Name Redacted 6/17/2022 12:15 PM	65
Screen Name Redacted 6/29/2022 08:44 PM	60
Screen Name Redacted 11/12/2022 01:03 PM	41
Screen Name Redacted 11/29/2022 12:34 AM	63
Screen Name Redacted 1/11/2023 09:24 AM	69
Screen Name Redacted 1/11/2023 11:01 AM	48
Screen Name Redacted 1/19/2023 02:29 PM	42
Screen Name Redacted 2/14/2023 05:47 PM	58
Screen Name Redacted 2/25/2023 05:50 PM	73
Screen Name Redacted 3/08/2023 06:13 AM	47

Screen Name Redacted 3/08/2023 09:55 AM	74
Screen Name Redacted 3/08/2023 03:01 PM	60
Screen Name Redacted 3/08/2023 04:05 PM	54
Screen Name Redacted 3/09/2023 04:55 AM	70
Screen Name Redacted 3/09/2023 11:16 AM	43
Screen Name Redacted 3/16/2023 12:04 PM	31
Screen Name Redacted 3/17/2023 03:20 PM	39
Screen Name Redacted 3/21/2023 11:15 AM	74
Screen Name Redacted 4/02/2023 03:48 PM	60
Screen Name Redacted 4/18/2023 07:58 PM	64

Optional question (23 response(s), 13 skipped)
Question type: Number Question

Q5 What race or ethnicity do you most identify with?

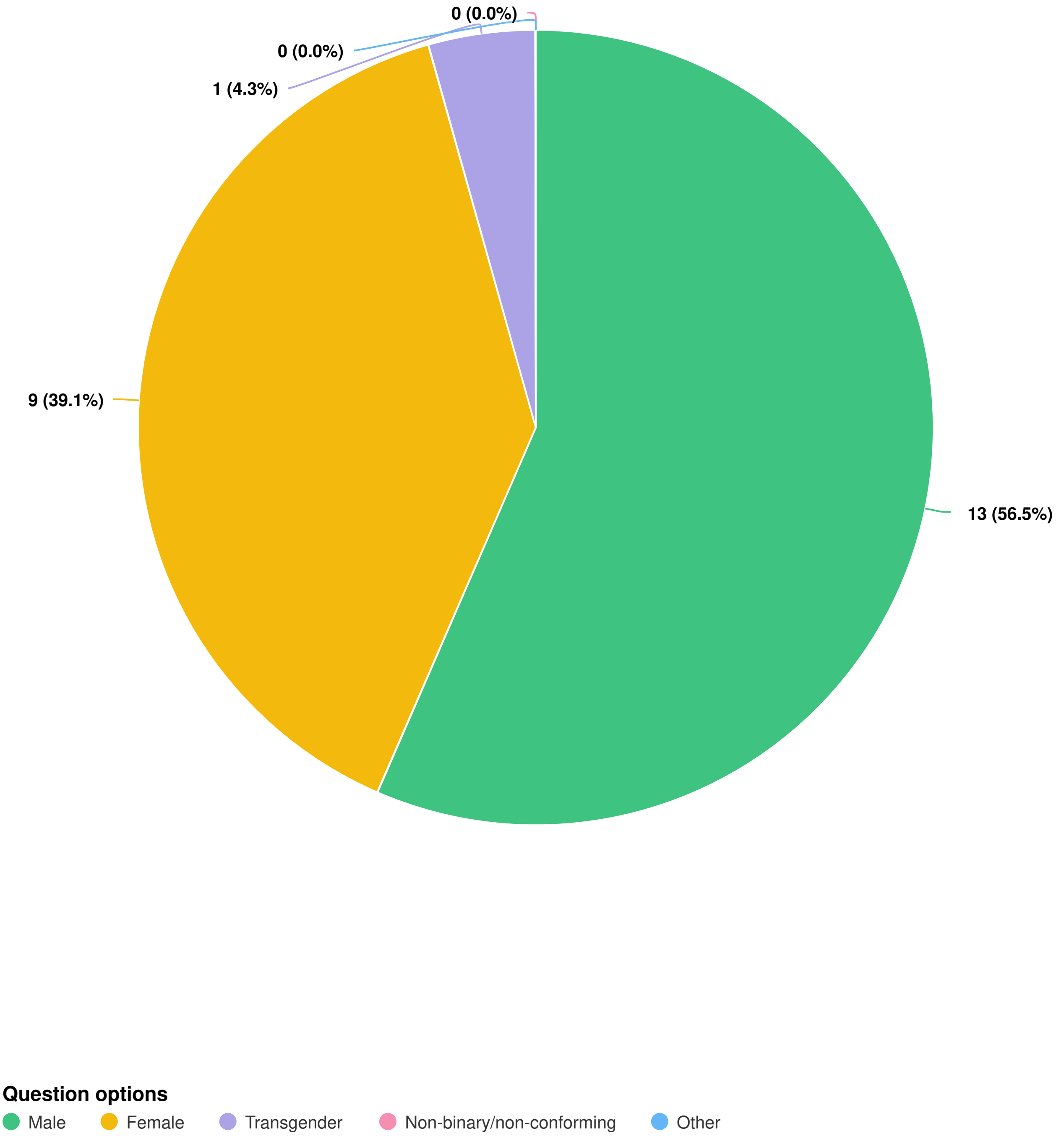


Question options

White · Two or more races · Hispanic/Latino · Asian · Black or African American · Native Hawaiian or Pacific Islander · Other

Optional question (23 response(s), 13 skipped)
Question type: Dropdown Question

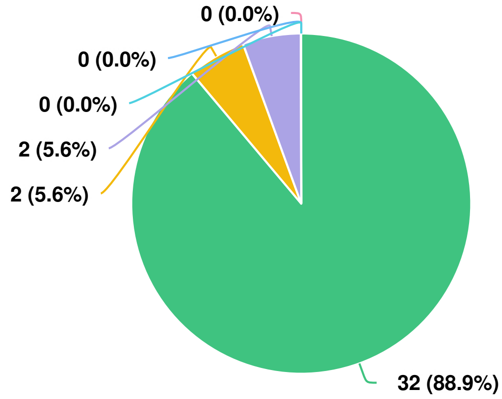
Q6 What gender do you most identify with?



Optional question (23 response(s), 13 skipped)
Question type: Dropdown Question

SURVEY QUESTIONS

Q1 In what type of residence do you reside?

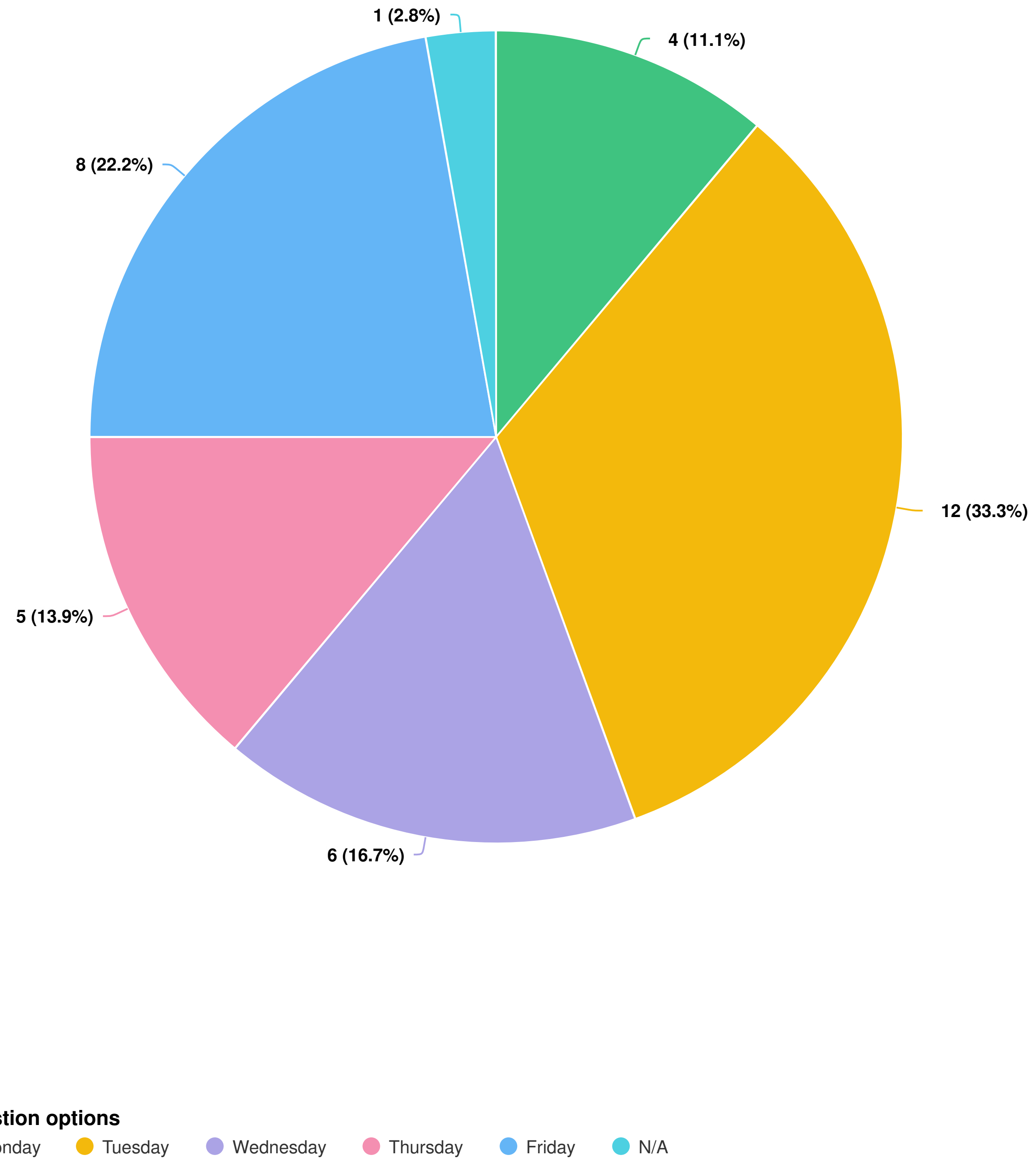


Question options

- Single-family home - own
- Single-family home - non-student rental
- Multi-family unit
- Single-family home - student rental
- Mobile home
- Duplex/Townhome

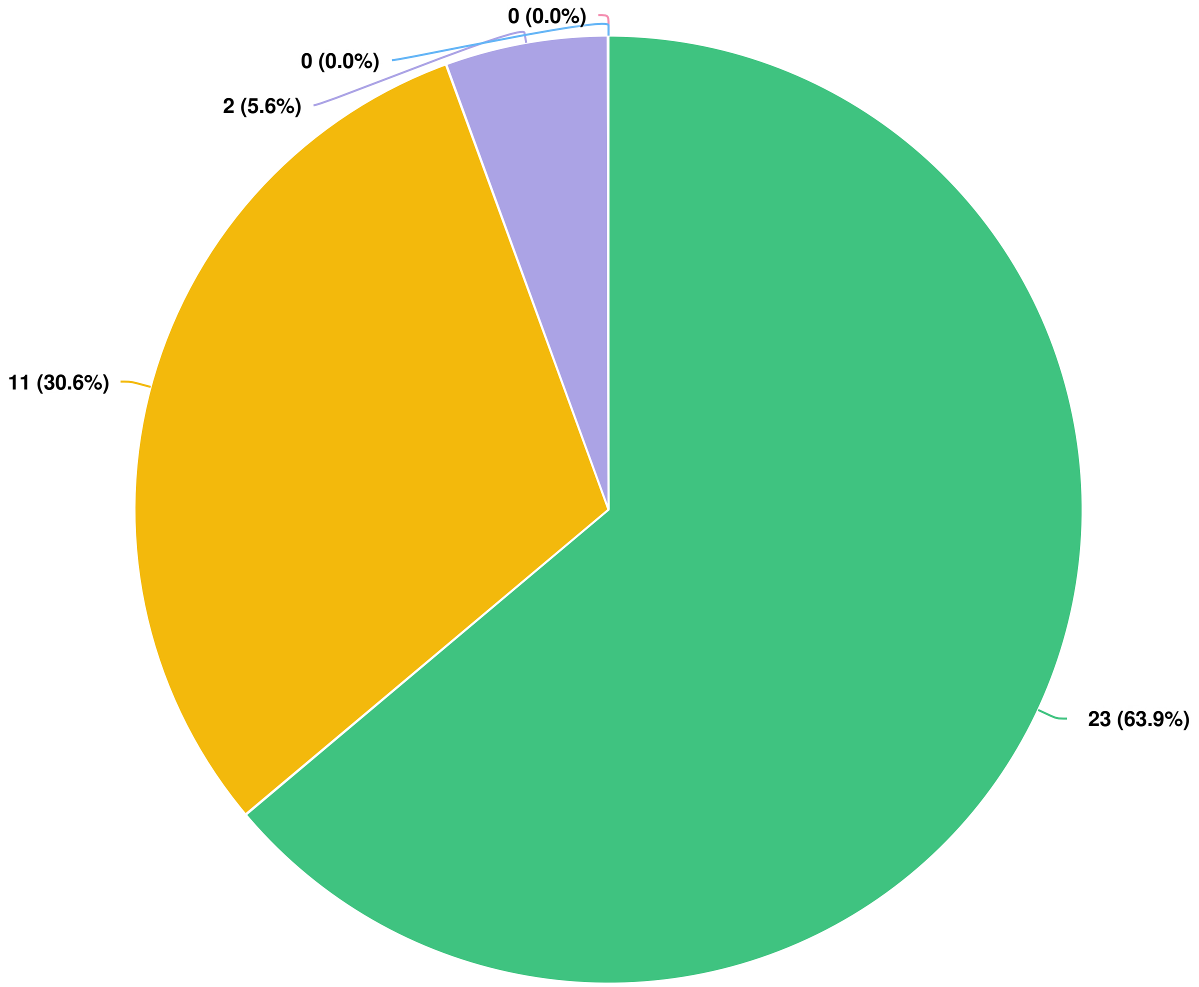
Mandatory Question (36 response(s))
Question type: Dropdown Question

Q2 What day is your recycling collected?



Mandatory Question (36 response(s))
Question type: Dropdown Question

Q3 On a regular basis, how often do you set out recyclables at the curb?

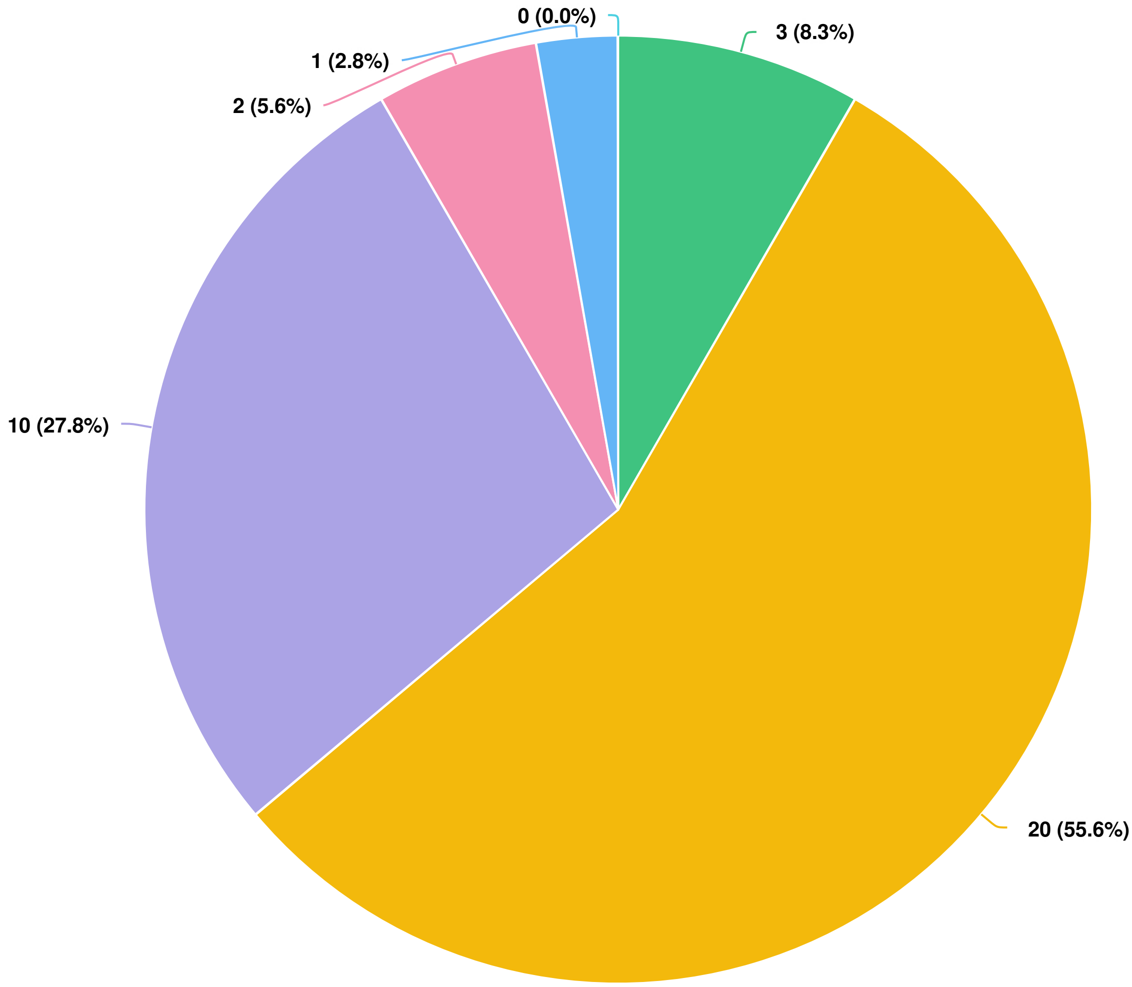


Question options

- Every recycling collection day
- Sometimes / most of my collection days
- Rarely
- Never
- N/A

Mandatory Question (36 response(s))
Question type: Dropdown Question

Q4 Approximately how many blue bags do you place at the curb?

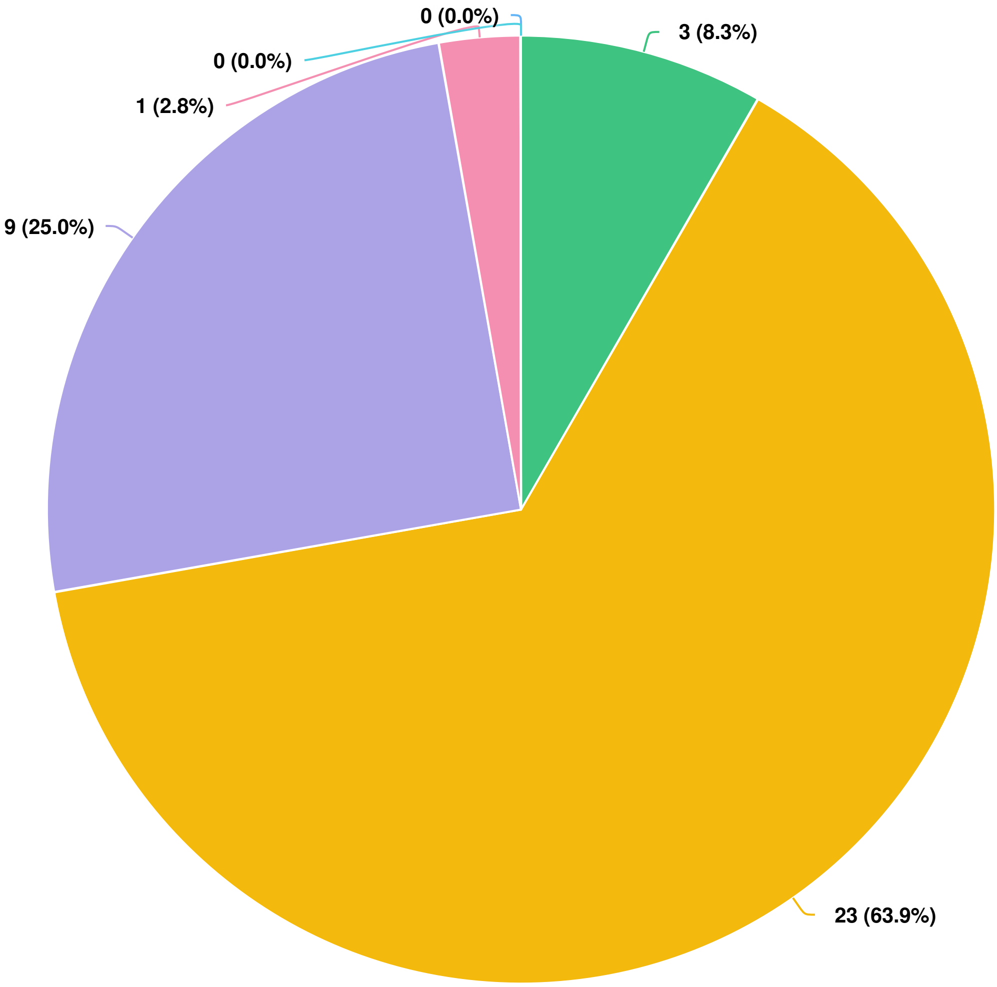


Question options

0 · 1 · 2 · 3 · 5 or more · 4

Mandatory Question (36 response(s))
Question type: Dropdown Question

Q5 Approximately how many bundles of paper/cardboard do you place at the curb?



Question options

0 · 1 · 2 · 5 or more · 3 · 4

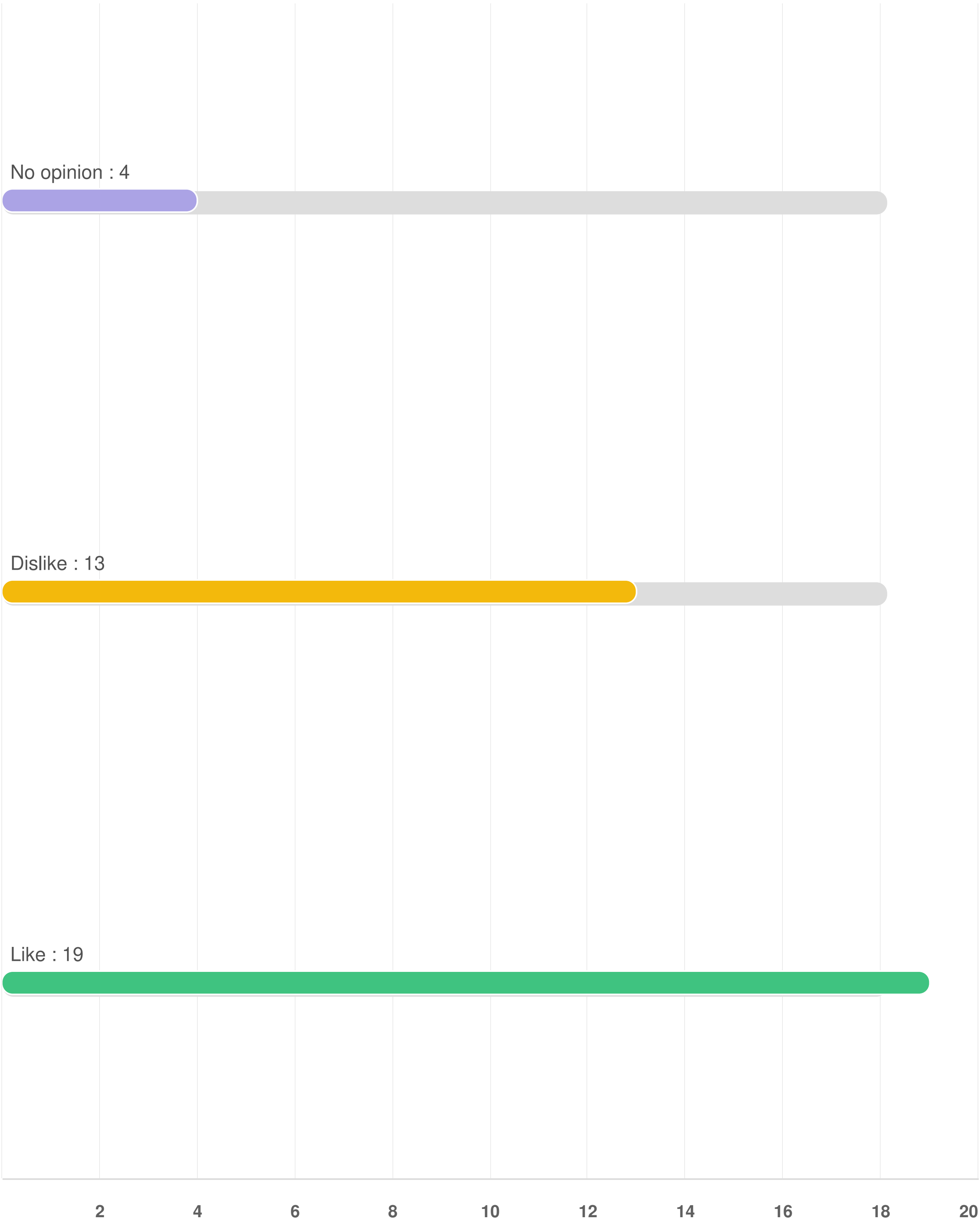
Mandatory Question (36 response(s))
Question type: Dropdown Question

Q6 Please rate the following features of the current curbside collection recycling program.

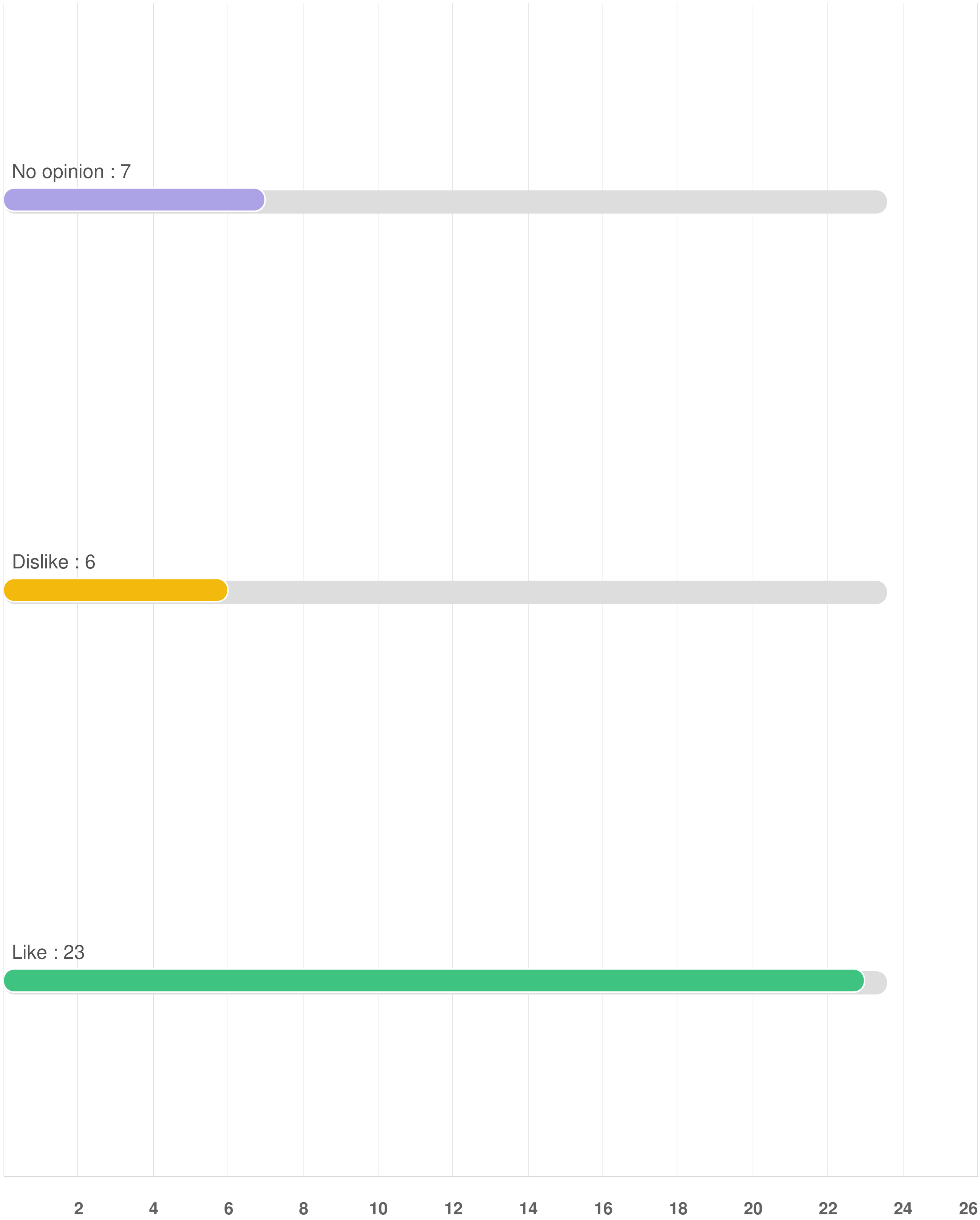
Mandatory Question (36 response(s))
Question type: Likert Question

Q6 Please rate the following features of the current curbside collection recycling program.

Every-other-week collection

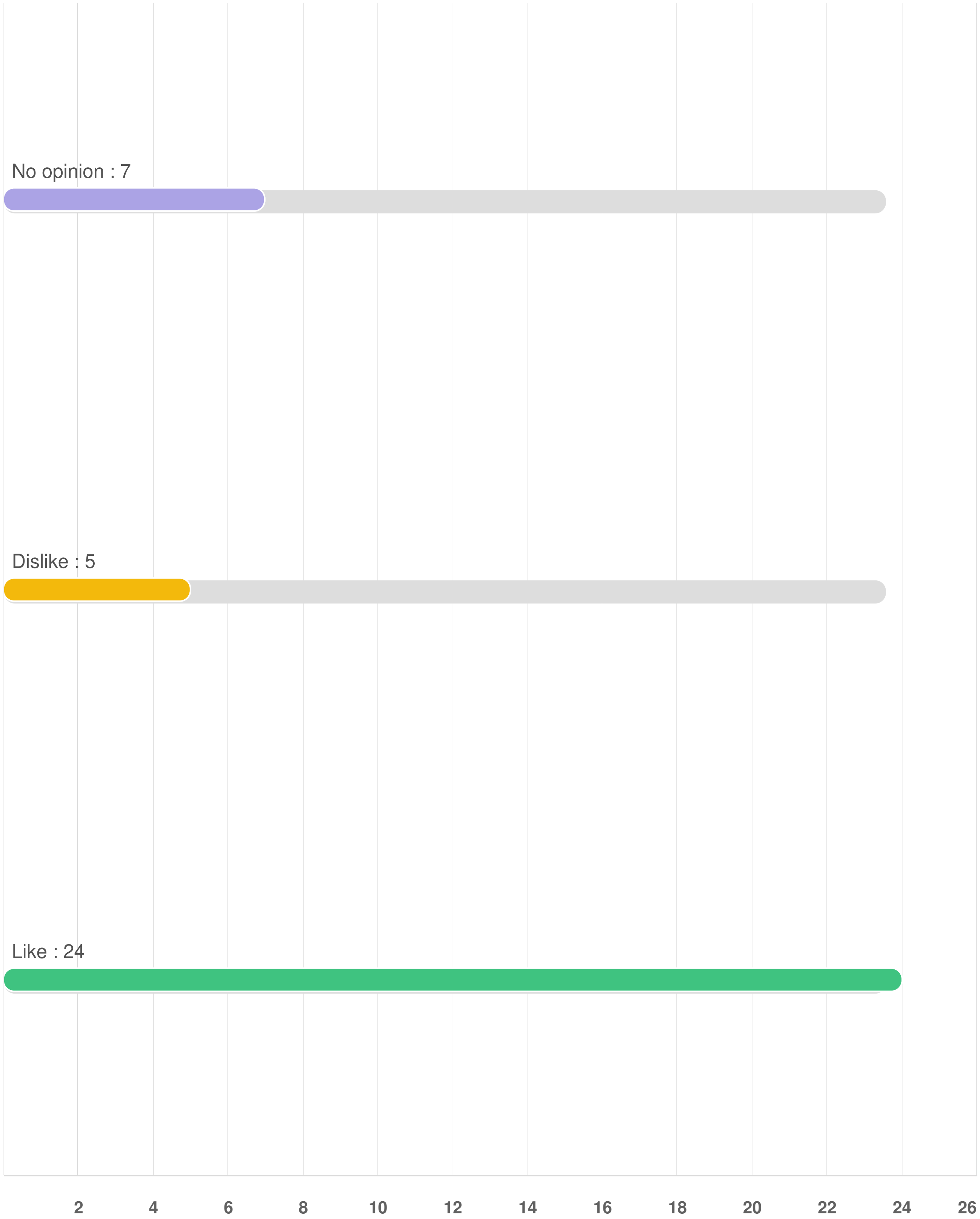


Separation of paper/cardboard from plastic/metal/glass



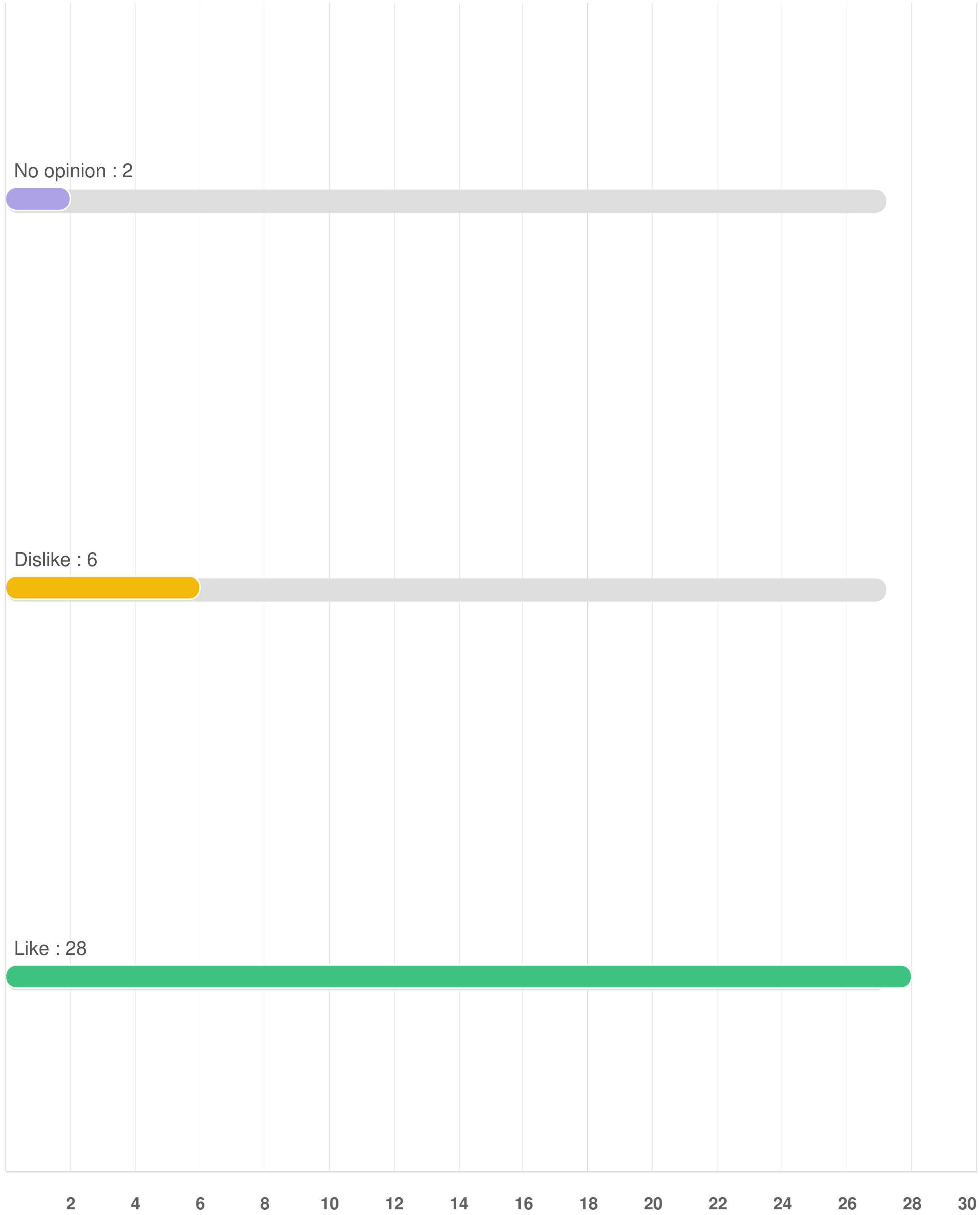
Available instructions on how to recycle

Number of types of materials accepted



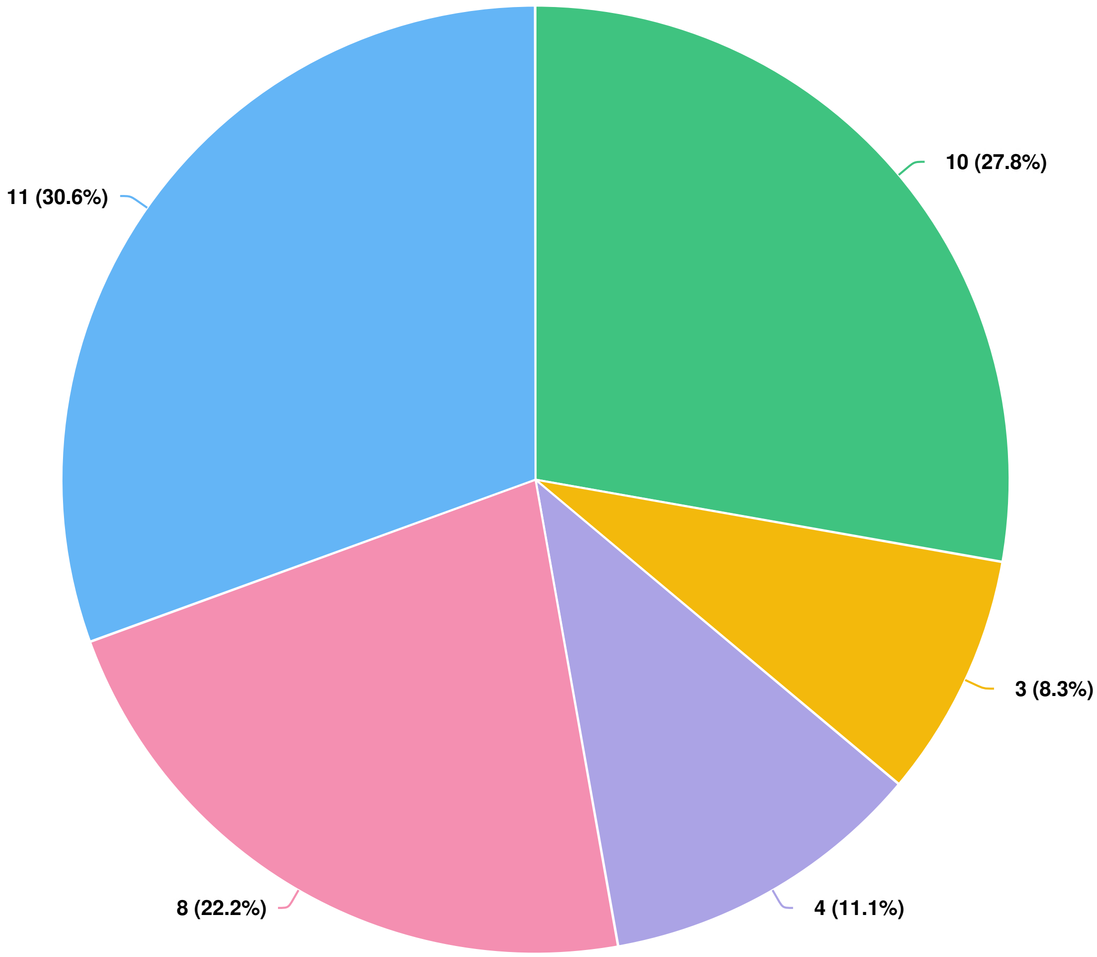
Using City-provided blue bags for plastic/metal/glass

Using own box/bag for paper/cardboard



Using City-provided blue bins

Q7 If the City switched to automated collection with a City-provided rolling recycling cart, would you be in favor of that change?

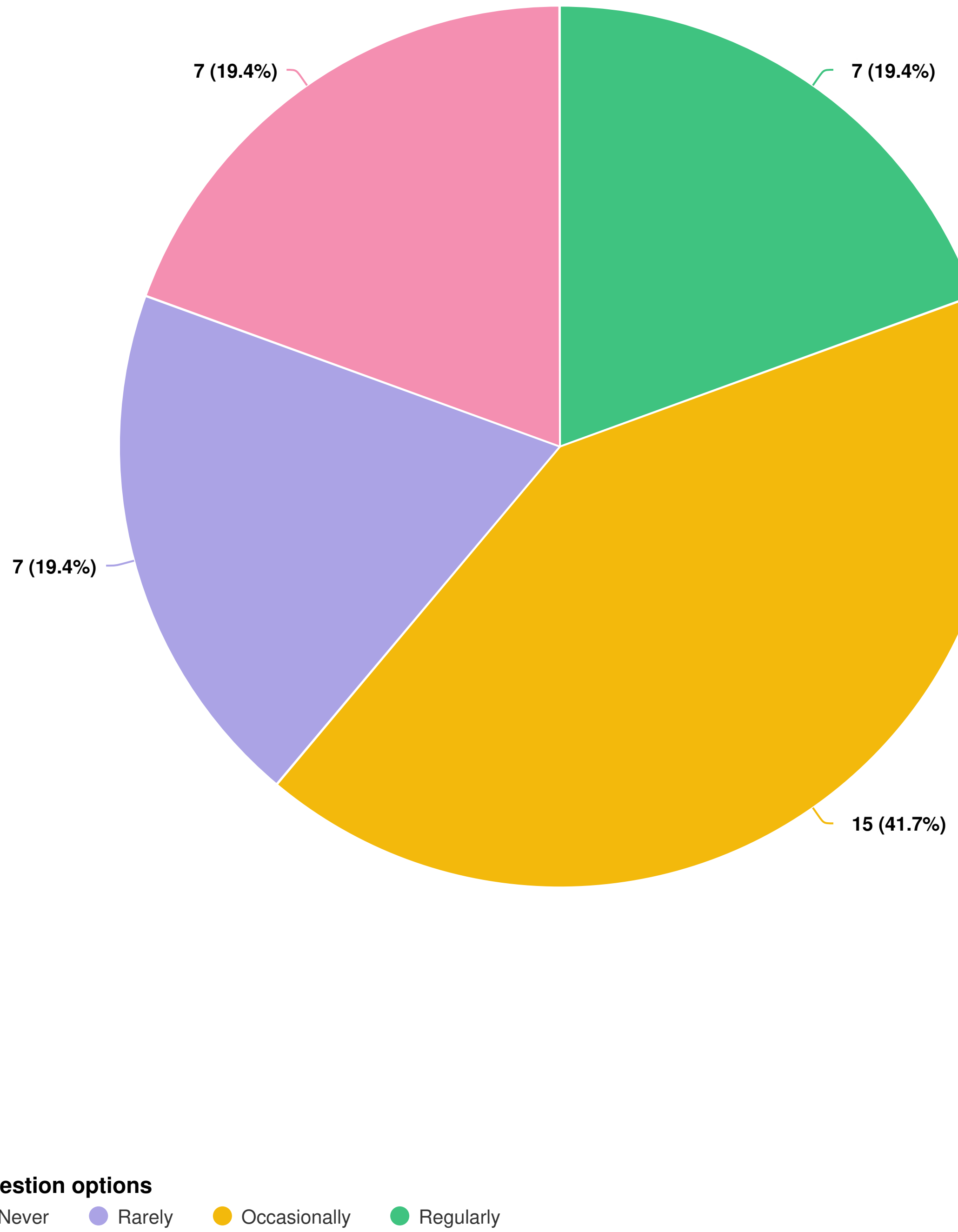


Question options

- Definitely Yes
- Probably Yes
- Maybe
- Probably No
- Definitely No

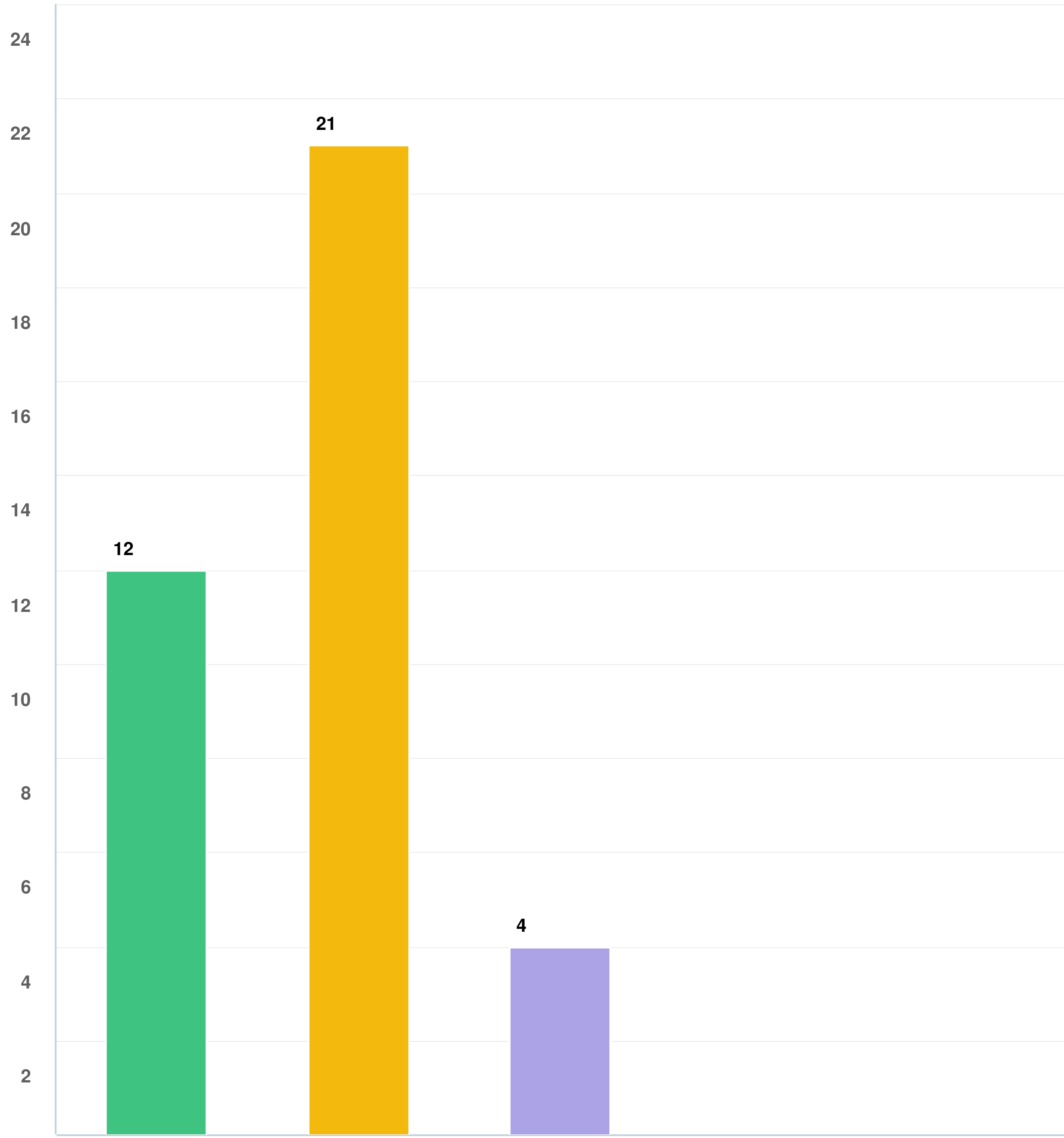
Mandatory Question (36 response(s))
Question type: Dropdown Question

Q8 How often do you bring recyclable material to one of the City's drop-off centers?



Mandatory Question (36 response(s))
Question type: Dropdown Question

Q9 Generally, what brings you to the recycling drop-off center? (Check all that apply.)

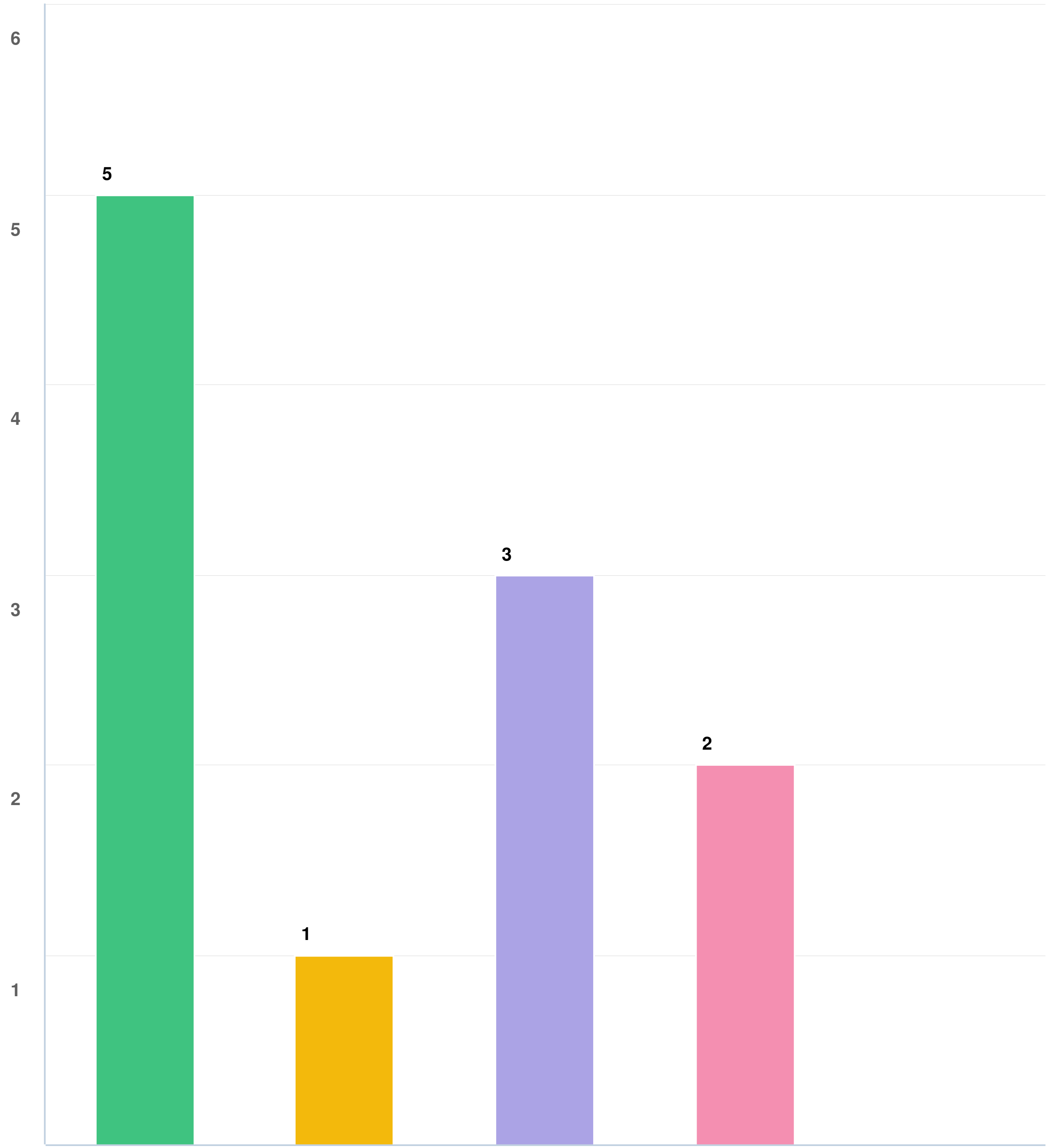


Question options

- I don't have curbside recycling collection
- I don't usually recycle, but sometimes I take something to the drop-off center
- Other
- I had a lot of material and couldn't/didn't want to wait until my curbside recycling day
- I missed my curbside recycling day

Optional question (28 response(s), 8 skipped)
Question type: Checkbox Question

Q10 You answered that you have never brought material to a recycling drop-off center. Can you please share with us why?

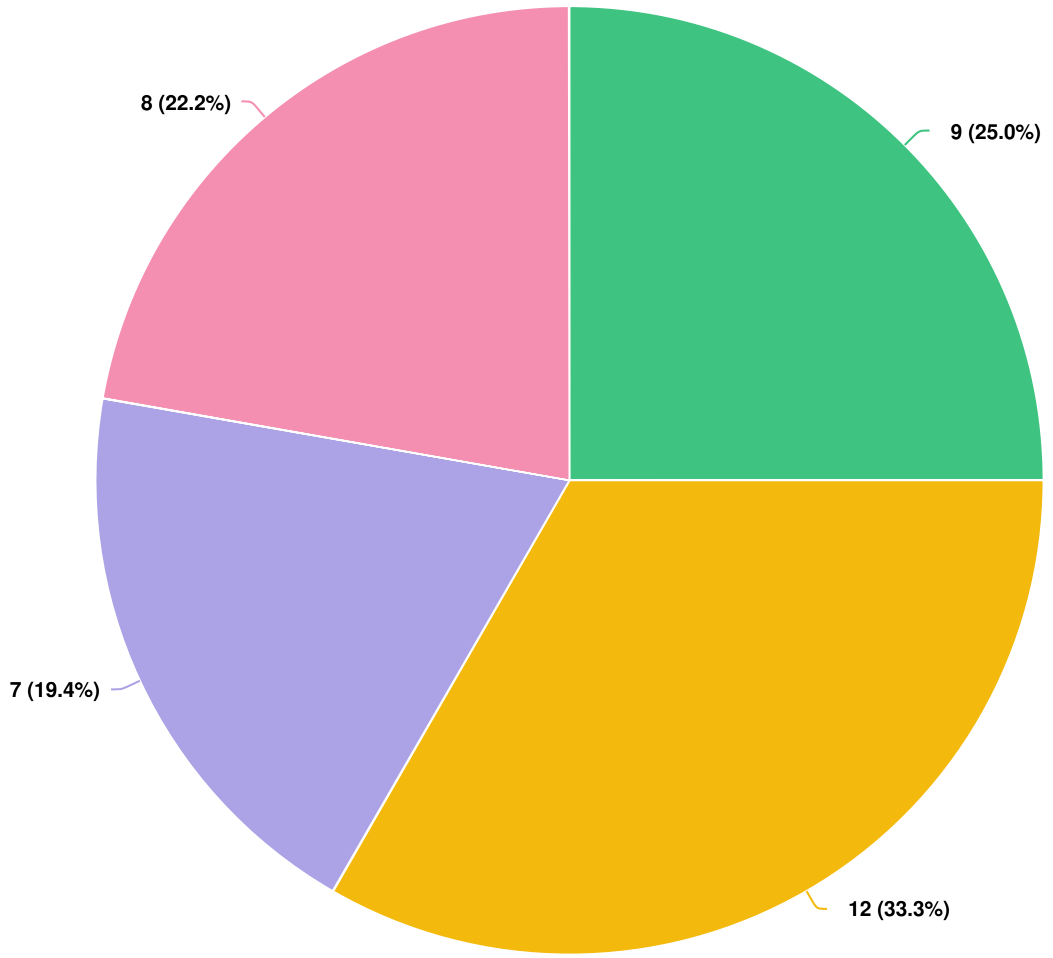


Question options

- The locations are inconvenient
- Other
- I don't know where the recycling drop-off centers are
- I didn't know we had recycling drop-off centers
- I don't have a need to visit the recycling drop-off center

Optional question (7 response(s), 29 skipped)
Question type: Checkbox Question

Q11 How often do you bring yard waste to one of the City's yard waste drop-off centers?

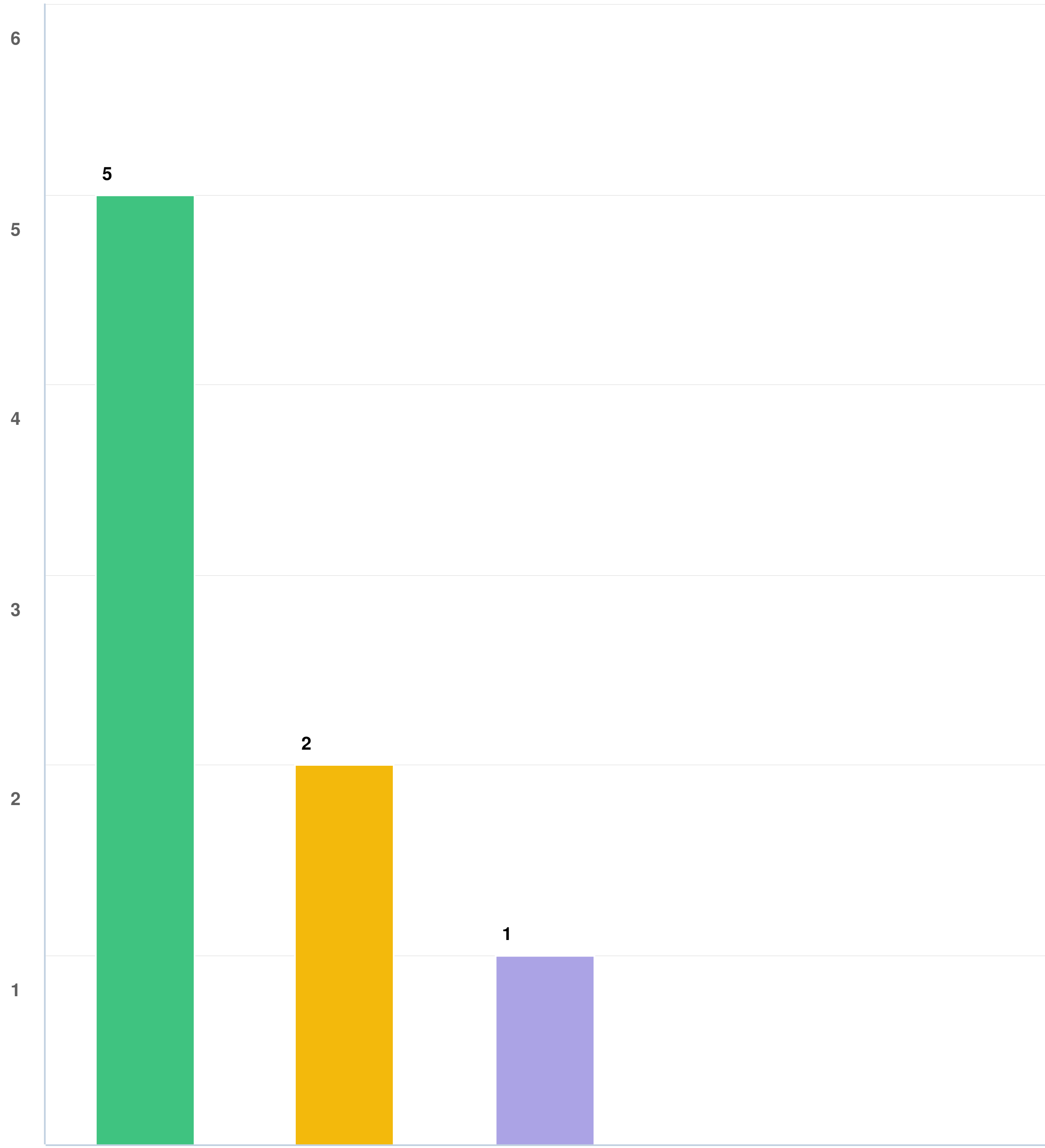


Question options

- Never
- Rarely
- Occasionally
- Regularly

Mandatory Question (36 response(s))
Question type: Dropdown Question

Q12 **You answered that you have never brought material to a yard waste drop-off center. Can you please share with us why?**

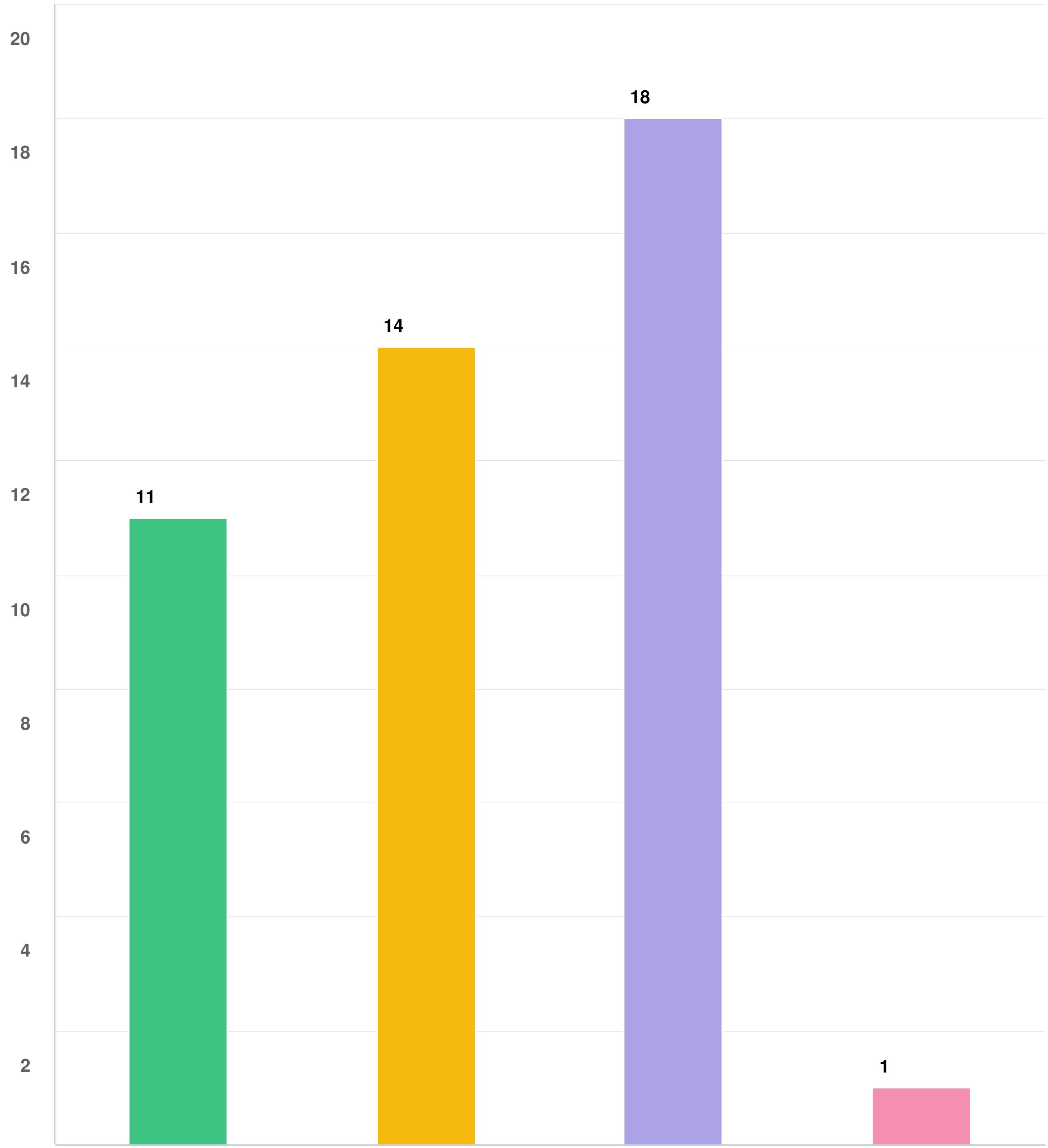


Question options

- I didn't know we had yard waste drop-off centers
- The locations are inconvenient
- Other
- I don't know where the yard waste drop-off centers are
- I don't have a need to visit the yard waste drop-off center

Optional question (7 response(s), 29 skipped)
Question type: Checkbox Question

Q13 Generally, what brings you to the yard waste drop-off center?



Question options

- Other
- I want to get rid of the material for free and avoid using a service
- I want to recycle the material
- I have too much material to put in bags

Optional question (28 response(s), 8 skipped)
Question type: Checkbox Question

Summary of Ideas Received from the City's BeHeard page on the Future of the City Recycling System

1 Wouldn’t the spot where A-1 rental used to be, on Vandiver road, be a great location for all things recyclable.

2 We need to open back up 5 routes instead of 3 routes that's breaking down employees

3 Doing 5 routes picks up every week instead of two weeks and alot of customers forget what week they have then all their stuff is left out

4 Dortrav sounds like he knows the situation, and I do miss the every week pick up

5 1. Recycle after cleaning item, as is not trash. 2.Very difficult now to find recycling points. WHY? 3. Not any promotion of recycling BAD

6 Only what is truly recycled
Description: Can we streamline what is actually being recycled to mirror what markets demand? Anything collected that is not at least breaking even could be removed from the program.

7 Needs promotion, people still don't know how or what to recycle.
Problem is fiber/glass/cans are ACTUALLY recycled, most plastic is not.

8 Recycle Roll Cart instead of bags
Description: I moved here from another city which has had roll carts for trash and recycles since early 2000's. Recycles were picked up every other week. Single stream recycles. No separation of plastics, glass, metal or paper products. All separation was completed at the recycling center. Very easy and very high satisfaction rates from the residents. Residents will need to learn rinse any non paper recyclables which keeps the rolls cart clean. I rinsed/washed my carts maybe once per year.

9 Provide recycling tubs and optional roll carts
Description: I live in a neighborhood where Columbia provided recycling tubs nearly 20 years ago. I love them and, judging by the fact that many people still use them, so does most everyone else. I would like to see the tub option city-wide. This would eliminate a recycling cart for me and save money and space. Also, if roll carts, then use trucks that do not require the carts to be perfectly aligned for automatic grabbers. These trucks require elimination of parking spaces and the driver has to exit the vehicle on the traffic side to straiten crooked carts. Use the kind where a person brings the cart to the truck, instead. It will take me about 4 months to fill up a small cart. I would like the option to stick with bags. Those take me about 2 months to fill, but won't take up space, look ugly and bread roaches. Another big concern with carts is that they will be left on sidewalks, lids open, blocking the paths and spreading garbage on windy days.

10 We are suppose to be helping the environment, but with the wind the cardboard and blue bags go everywhere. Cart needed to secure items.
Description: Carts for Recycling

11 Fix recycling routes
Description: Solid waste needs to run six recycling trucks five days a week. Solid waste management has no idea what they are doing. We can’t keep doing things the way we are. It is too much of struggle with staff and trucks. They need to do better job of of educating the public on what is recycling and what’s trash. The mrf needs new supervisors who is focused on training workers and getting best material processed. Too much good material is going in landfill. No one is held accountable

12 Move to a three bin system and start recycling organic waste.
Description: I grew up in CoMO and remember when the current curbside recycling program was started. It was very revolutionary for its time, but is now showing its age. The dual-stream system is confusing for today’s recyclers and the system does not address the increasing amount of food waste we generate. Food waste decomposes in landfill and produces methane, a harmful greenhouse gas that has much more warming power than carbon dioxide. To this end, Columbia has the chance to be revolutionary again in establishing a curbside organics recycling service to handle both food waste and garden waste, collected weekly. This could allow the single-stream recycling and garbage to be moved to fortnightly collection on alternating weeks (organics and recycling one week, organics and garbage the next). Having garbage collected only fortnightly encourages use of the organics and recycling carts, which helps keep material out of landfill. Several municipalities in suburban Canada and Australia use this structure with great success, including the city of Guelph, Ontario which has similar population to Columbia. There are videos all across YouTube from multiple municipalities explaining how their systems work, and I would encourage Columbia to look at them and adapt to our

13 Due to the changes in trash bag requirements, it has become increasingly difficult to find blue recycling bags at retail locations. Why?
Description: Blue recycling bag shortage?

14 Team up with Ripple Glass out of KC for all glass recycling. Be honest with citizens about myth of plastic waste "recycling".
Description: Since plastic is not actually being recycled, we should spend the money that we currently use on "recycling" on a program for education and monetary incentives for reducing disposable plastic use

15 Keep same! It's awesome! Some cities do not even offer a recycling option.
Description: Please, please, keep this program as is. And do NOT introduce recycling roll carts. I beg you. It's a travesty we have to use carts soon for our trash.

16 Why are we not heard. Recycling has been doing same dumb 3 routes which makes it hard on employees and trucks.

17 We need a better supervisor with knowledge of how to run recycling could also be a reason lack of workers

18 Employees need to be asked what's the problem of what's going wrong with staffing issues (problem is supervisor) treatment of employees.

19 Columbia should also have a container deposit program. Like how some States do. Where we pay an extra nickel at the sale, but we get it back
This is a simple solution to all that litter. City of Columbia, and the downtown development district employs people to clean all that litter.

However, The city should employ us all to clean it all up, by charging a bottle deposit for each purchase of a container, which may be chashed back when brought back to a retailer, a kiosk, or a recycling center.

That means whoever littered then pays for whoever cleaned up that litter, which may be you, or anybody. Therefore, the litter cleaners are everybody and anybody. We must have container deposit to curb our litter problem.

20 Privatization - The city should privatize all trash and recycling.

21 To get employees you gotta start questioning of why no one's try to apply and that starts with the recycling supervisor that was hired

22 Stop being greedy - Quit charging customers for a pickup service you aren't providing. Out of 6 total pickups we pay for per 4weeks (4 trash, 2 recycling), only 4 are being picked up. I'm not asking for a 33% decrease, but it should not be full price. Additionally, make all trash positions permanent and therefore benefited and you might actually get applicants. People are smart enough to see when you're trying to take advantage of them, so stop treating your citizens like children.

23 The city needs to pro rate our bills when recycling is suspended. Taking money for a service and then not providing that service is STEALING

24 The new MRF's design should leverage trends towards Circular Economy opportunities, serving as the hub for local benefication and upcyling.
Design for a Circular Economy MRF

25 Composting!
We already have tree debris going to Capen, and I remember the clear bags that could be set out for Capen pickups; it shouldn't be too hard to make extra space for food waste, and the same machines that move those piles of wood mulch around could also turn and aerate orange peels and old lettuce.

26 Pick up bundled sticks
Please pick up bundled sticks again. Here's some science before you say no: sticks weigh the same for workers to pick up whether they are bundled or cut up and thrown into bags. So what's the problem?