Materials Recovery Facility Assessment: Recyclables Characterization

King County Waste Monitoring Program

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King County
Department of
Natural Resources and Parks
Solid Waste Division

Waste **Prevention** | *Resource* **Recovery** | *Waste* **Disposal**

www.kingcounty.gov/solidwaste

Acknowledgments

This study would not have been possible without the cooperation and assistance of the management and operators of the recycling facilities that generously agreed to participate. Such studies are an imposition on their time and their cooperation is greatly appreciated. Special thanks are given to the facilities that hosted and assisted sampling activities as well as provided tonnage data and market information.

- King County Shoreline Recycling and Transfer Station (sorting location only)
- Recology Seattle
- Republic Services
- Waste Management Cascade Recycling Center
- Waste Management JMK Fibers
- Waste Management Recycle Northwest Transfer Station (RNW)

Market information and quantity and composition data resulting from the collection and sorting of material samples at each MRF were obtained under non-disclosure agreements and are not presented within this report. The data from individual facilities were aggregated to present summary results.

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Glossary of Terms, by Topic Area

MATERIAL CATEGORIES *(see Figure 15 on page 33)*

Commodity of Interest (COI): Material processed and baled together to be sold in a market that is a particular focus of the study, such as commodity Cardboard or commodity PET.

Inbound material: Recyclable material collected from commercial and single-family residential sectors across King County, not including those from the City of Seattle, and delivered to *Material Recovery Facilities (MRFs)* for processing.

Throughput: Material designated as "finished product" and considered to be a marketable commodity. The throughput includes all *Commodities of Interest* grouped together.

Rejected material or Reject: Non-commodity residual material that is rejected by MRFs during the sorting process because it is not accepted as a commodity and considered to be contamination in the recycling stream.

Non-commodity residue: Rejected material that cannot be sold and is destined for landfill.

Commodity residue: Residual material that would normally be considered part of the rejected stream but can be separated and sold to a buyer. Because this material generates revenue, it is referred to as a "commodity." Rejected material that does not generate revenue is called *Non-commodity residue*.

Mass balance: A way of accounting for the quantity and type of materials that enter the MRF (*Inbound material*), and the quantity and type of material that is processed and categorized by the MRF either as a commodity (*Throughput*) or as *Rejected material*. The goal is to have a balance, where material quantities are accounted for at each stage of the system: incoming materials, processing at the MRF, and output of materials as commodities and rejected material.

RECYCLABILITY

Recyclability Group: The 42 material types included in this study were each classified into three recyclability groups: Recyclable, Potentially Recyclable, and Contaminants (defined below). (Note that this term is a modification of *Recoverability Group* as used in the 2019 Waste Characterization Study, to reflect the distinction that recoverability also includes composting and potential other diversion.)

Recyclable: Materials for which recycling technologies and material markets are well-developed, and infrastructure and programs are readily available and currently used.

Potentially Recyclable: Materials for which there is limited recyclability through other, non-curbside recycling channels. For such materials, recycling technologies, programs, and markets exist, but are not well-developed or not currently utilized.

Contaminants: Materials that are not readily recyclable or face other market, technology, or programmatic related barriers.

WASTE STREAMS AND FACILITIES

Commercial stream: Commercially-hauled, recyclable material collected from commercial sources across King County at four regional *Material Recovery Facilities (MRFs)* and one transfer station that handle recyclable materials from King County. For the purpose of this study, the commercial stream does *not* include quantities from multifamily sources that are typically mixed with commercial loads.

Single-family stream: Commercial-hauled recyclable material collected from single-family residential sectors across King County at four regional *Material Recovery Facilities (MRFs)* and one transfer station that handle recyclable materials from King County.

Material Recovery Facility (MRF): In this study, MRFs refer to recycling facilities handle recyclable materials collected from homes and businesses in King County. The covered facilities are Recology Seattle, Republic Services (Third & Lander), Waste Management Cascade Recycling Center, Waste Management JMK Fibers, and Waste Management Recycle Northwest Transfer Station (RNW). RNW is a transfer station, not a MRF, but it is included in the study because it handles the *Inbound material* that is sorted and processed at JMK Fibers.

1. Executive Summary

This document describes the methods and findings of the recycling assessment of regional Material Recovery Facilities (MRFs) conducted by Cascadia Consulting Group in 2019 on behalf of the King County Solid Waste Division. This assessment includes two components: 1) a characterization study of recyclable materials generated in King County and processed by regional recycling facilities and 2) interviews with representatives from the three major single-stream recycling collection and processing companies that handle materials from curbside recycling programs in King County.

Material Characterization Study

Objectives

The objectives of the material characterization study were to:

- Characterize the inbound recyclable material collected from commercial and single-family residential sectors across King County (not including those from the City of Seattle).[1]
- Quantify the rejected material disposed by the participating facilities.
- Characterize the throughput (commodity materials or finished products) processed by the MRFs and assess the level of contamination in these commodities.

Methods

Cascadia worked with participating facilities that handle recycled materials from King County—four regional Material Recovery Facilities (MRFs) and one transfer station—to identify loads to sample from the inbound material, rejected material, and finished products streams. Cascadia collected and sorted a total of 187 material samples: 40 from the inbound single-family residential recycling stream, 62 from the inbound commercial recycling stream, 26 from the rejected stream, and 59 from the throughput stream. These samples were hand-sorted into 42 material types divided into 12 material classes (see *Appendix A. Material Definitions*). Cascadia analyzed the data from the study to develop estimated composition estimates at a 90% confidence level.

Key Findings

Overall Material Flows

The overall flow of materials for regional MRFs handling recyclables from King County was calculated by compiling aggregated sample compositions from participating facilities and King County tonnage data reported by the haulers. Figure 1 shows the overall material flow, with more than 230,000 tons of recyclables generated from commercial locations and single-family homes and processed in regional

[1] Since haulers typically collect multifamily and commercial recyclables on mixed routes, sampling multifamily residences would have required running special routes. This was considered logistically problematic for securing cooperation from haulers/MRFs. Accordingly, the multifamily stream was excluded from the sampling protocol, as explained in Section 2.3, *Sampling Universe.*

MRFs. Of that material, approximately 88 percent was baled as commodities or products and the remaining 12 percent was rejected.

Figure 1. Overall Flow of King County Recyclable Materials

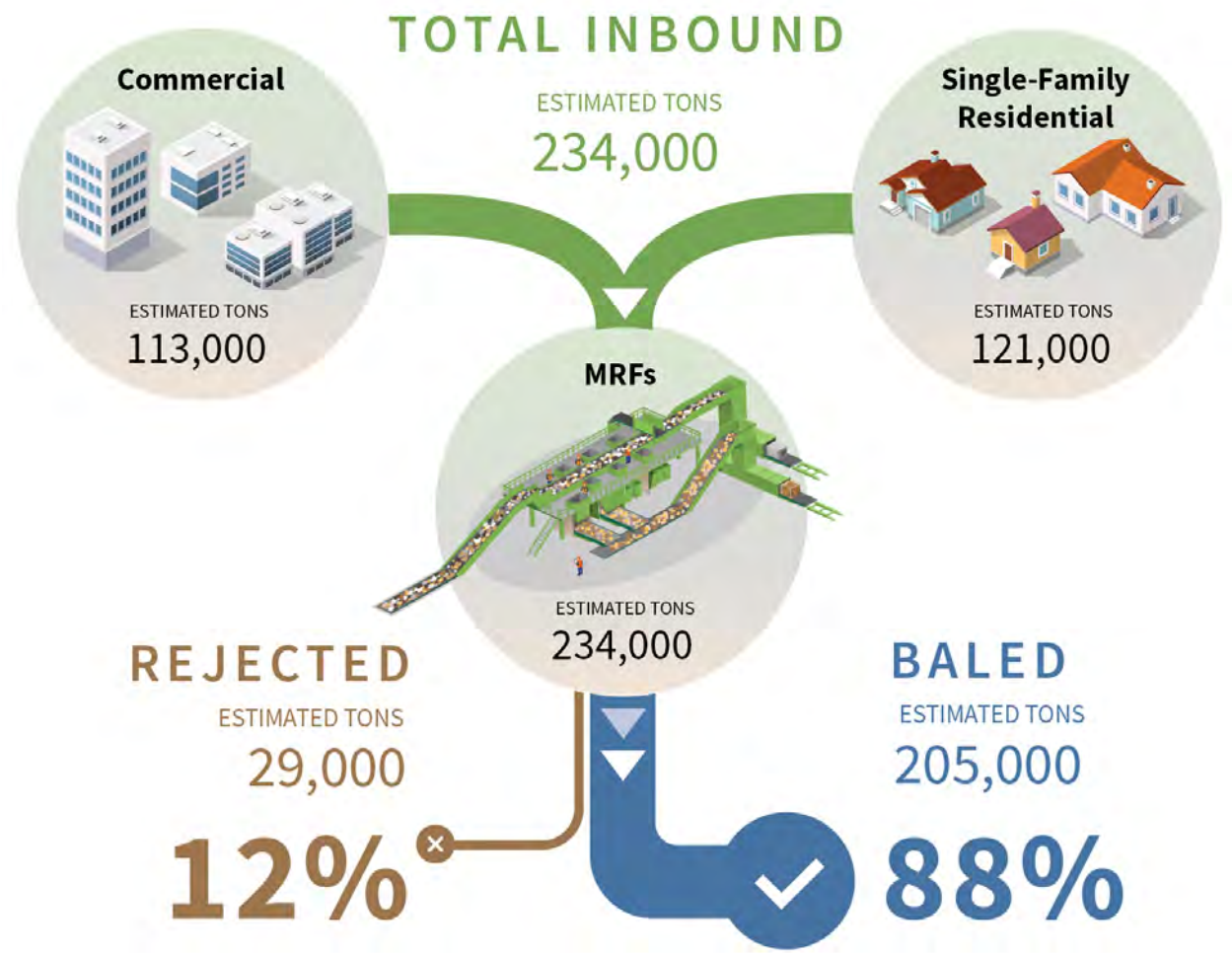


Table 1 shows the overall material quantities, followed by a description of the key findings for inbound, rejected, and throughput (processed product or commodity) materials. Please note these tonnages are estimates based on composition analysis of representative samples collected for this study. Due to estimating methods (as explained in *Section 5.4, Estimating Commodity Quantities*), note that the quantities in this table do not add to the exact totals; the difference is less than 0.1 percent.

Table 1. Estimated Quantities of King County Materials Collected and Processed for Recycling

TOTAL INBOUND *(excluding multifamily)*	**234,034**	**Tons**						
	Single-family Residential		**Commercial**					
Estimated Tons	**121,179**	***52%***	**112,855**	***48%***				
Recyclable	93,846	*77.4%*	91,259	*80.9%*				
Potentially Recyclable	5,258	*4.3%*	3,800	*3.4%*				
Contaminants	22,074	*18.2%*	17,796	*15.8%*				
TOTAL THROUGHPUT	**205,427**	**Tons**						
PAPER COMMODITIES	**Cardboard**		**Mixed Paper**					
Estimated Tons	**83,839**	***41%***	**61,219**	***30%***				
Target Commodity	78,049	*93%*	41,732	*68%*				
Other COI	3,664	*4%*	13,777	*23%*				
Potentially Recyclable	904	*1.1%*	1,107	*2%*				
Contaminants	1,222	*1.5%*	4,603	*7.5%*				
PLASTIC COMMODITIES	**PET**		**HDPE Natural**		**HDPE Colored**		**Plastics**	
Estimated Tons	**5,262**	***3%***	**1,756**	***1%***	**1,465**	***1%***	**1,196**	***1%***
Target Commodity	3,671	*70%*	1,691	*96%*	1,343	*92%*	210	*18%*
Other COI	94	*2%*	50	*3%*	29	*2%*	394	*33%*
Potentially Recyclable	1,400	*27%*	14	*0.8%*	81	*6%*	445	*37%*
Contaminants	97	*1.8%*	1	*0.06%*	12	*0.8%*	147	*12%*
METAL COMMODITIES	**Aluminum Cans**		**Mixed Metals**		**Tin**			
Estimated Tons	**3,465**	***2%***	**2,277**	***1%***	**2,907**	***1%***		
Target Commodity	3,318	*96%*	2,079	*91%*	2,540	*87%*		
Other COI	40	*1.2%*	5	*0.2%*	19	*0.7%*		
Potentially Recyclable	104	*3%*	1	*0.0%*	298	*10%*		
Contaminants	3	*0.1%*	192	*8%*	50	*1.7%*		
OTHER COMMODITIES	**Commodity Glass***		**Commodity Residue***					
Estimated Tons	**26,573**	***13%***	**15,468**	***8%***				
TOTAL REJECT	**28,831**	**Tons**						
	Non-Commodity Residue		**Non-Commodity Glass***					
Estimated Tons	**19,882**	***69%***	**8,950**	***31%***				
Recyclable	7,105	*35.7%*						
Potentially Recyclable	2,342	*11.8%*						
Contaminants	10,436	*52.5%*						

** Did not sample*

Inbound

- According to the calculations derived from hauler-reported data, the total inbound recyclable material from single-family residential and commercial generators was estimated at 234,034 tons (Table 2).
- The single-family residential sector generated slightly more than half (52 percent, or 121,179 tons), and the commercial sector generated the remainder (112,855 tons).
- Estimated quantities from multifamily residences are not included in these totals, as explained in Section 2.3, *Sampling Universe*. Collectors report that they typically operate combined commercial/ multifamily routes and that the inbound commercial material is assumed to contain about 30 percent multifamily material. Accordingly, the hauler-reported inbound commercial tonnage was reduced by 30 percent to estimate the tonnage from commercial-only sources.

- Approximately 77 percent (93,846 tons) of inbound **single-family residential** material consisted of Recyclable material, and 18 percent (22,074) was considered Contaminants, as defined in *Appendix A. Material Definitions*.
- About 81 percent (91,259 tons) of inbound **commercial** material was Recyclable material, and 16 percent (17,796 tons) was Contaminants.

Table 2. Total Inbound Material

TOTAL INBOUND	234,034	Tons
Sector	Estimated Tons	%
Single-family Residential	**121,179**	***52%***
Recyclable	93,846	*77.4%*
Potentially Recyclable	5,258	*4.3%*
Contaminants	22,074	*18.2%*
Commercial	**112,855**	***48%***
Recyclable	91,259	*80.9%*
Potentially Recyclable	3,800	*3.4%*
Contaminants	17,796	*15.8%*
** excluding multifamily*		

Rejected

- An estimated 28,831 tons of material were rejected during the material recovery process (Table 3). Of this rejected material, 69 percent (19,882 tons) was considered non-commodity residue. Composition analysis of rejected samples indicated that about 36 percent (7,105 tons) of non-commodity residue consisted of Recyclable material types, and about 12 percent (2,342 tons) of this rejected material consisted of Potentially Recyclable material.[2] More than half (52%) consisted of Contaminants such as food and other compostables, "tanglers" that can jam equipment such as cord, and other non-recyclable waste.

Table 3. Total Rejected Material

TOTAL REJECT	28,831	Tons
Sector	Estimated Tons	%
Non-Commodity Residue	**19,882**	***69%***
Recyclable	7,105	*35.7%*
Potentially Recyclable	2,342	*11.8%*
Contaminants	10,436	*52.5%*
Non-Commodity Glass*	**8,950**	***31%***
** Did not sample*		

[2] Because MRFS do not process materials smaller than 3 inches, some items of a recyclable material type are not actually recyclable at the MRF due to their small size.

Throughput

- The total throughput—materials or finished products that have been processed by the MRFs and are baled and sold as a commodity—was estimated to be about 205,000 tons (Table 4).
- The commodity Cardboard (material processed and sold by MRFs as bales made of the material type *Cardboard*) was estimated to be about 41 percent (83,839 tons) of the total throughput. Composition analysis of the commodity Cardboard samples showed that about 93 percent (78,049 tons) of the commodity Cardboard was *Cardboard* material, while about 1.5 percent (1,222 tons) was Contaminants (materials that are not meant to be included in the commodity Cardboard bale).
- The commodity Mixed Paper accounted for about 30 percent of the total throughput (61,219 tons)**.** Composition analysis of the commodity Mixed Paper showed that about 68 percent (41,732 tons) was *Mixed Paper* material, nearly 20 percent (12,128 tons) was improperly sorted *Cardboard,* and about 7.5 percent (4,603 tons) was Contaminants.
- The commodity Glass[3] was 26,573 tons of the total throughput.
- The commodity Residue[4] was an estimated 15,468 tons of the total throughput.
- The commodity PET Plastic contained about 70 percent (3,671 tons) *PET* material and 1.8 percent (97 tons) Contaminants (Table 4).
- The commodity HDPE Natural was 96 percent (1,691 tons) *Natural HDPE* material and less than 0.1 percent (1 ton) Contaminants.
- The commodity HDPE Colored was about 92 percent (1,343 tons) *Colored HDPE* material and 0.8 percent (12 tons) Contaminants.
- The commodity Mixed Plastics accounted for 1,196 tons of the total throughput. Only 18 percent of commodity Mixed Plastics was targeted materials: *PP (#5) Bottles and Jars* and *PP (#5) Small Other Rigid Plastics*. *Bulky Rigid Plastics* (30.8%), although not a targeted material, formed the most prevalent material type in the Mixed Plastics bale.
- The commodity Aluminum Cans was 96 percent (3,319 tons) *Aluminum Cans* and less than 0.1 percent (3 tons) Contaminants.
- The commodity Tin was about 87 percent (2,540 tons) *Tin Food Cans* and 1.7 percent (50 tons) Contaminants.
- The commodity Mixed Metals was approximately 91 percent (2,079 tons) *Mixed Metal* materials and 8.4 percent (192 tons) Contaminants.

Table 4 shows the proportional composition of the total throughput material for each Commodity of Interest (COI). For example, of the commodity Cardboard, 93 percent was the targeted commodity (Cardboard), 4 percent was other COIs (e.g., Mixed Paper, PET, HPDE Natural), 1.1 percent was Potentially Recyclable material, and 1.5 percent was Contaminants. Potentially Recyclable materials are defined in *Appendix A. Material Definitions*. Chapter 5 presents the material composition for each COI.

[3] Commodity Glass was not sampled as a targeted material but is included in the overall material quantities.
[4] Some MRFs are able to sell certain materials from the rejected stream. This material is described as commodity Residue; it was not sampled as part of this study but is included in the overall material quantities.

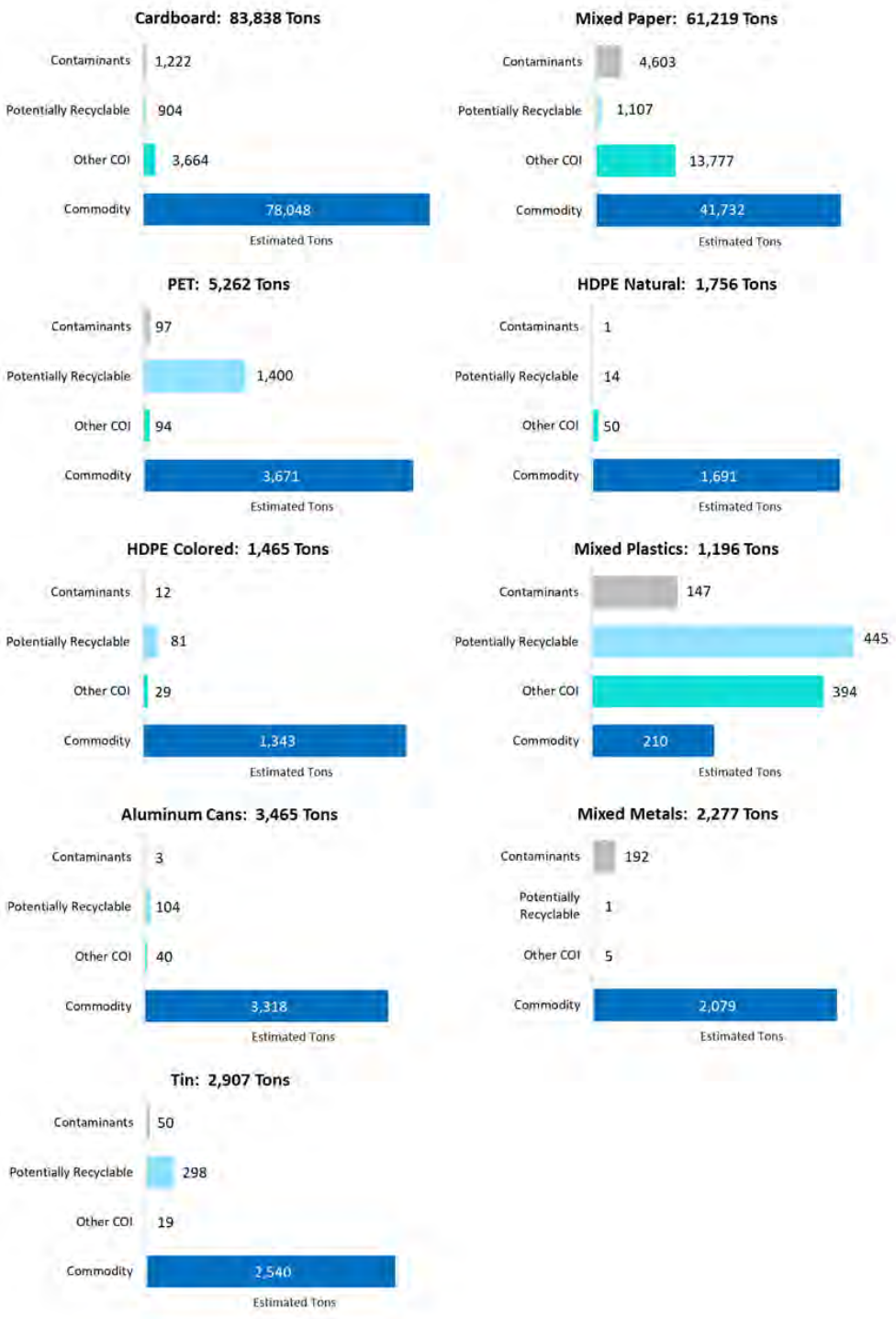
Table 4. Total Throughput Material

Sector	Estimated Tons	%
TOTAL THROUGHPUT	**205,427**	**100%**
Cardboard	**83,839**	***41%***
Target Commodity	78,049	*93%*
Other COI	3,664	*4%*
Potentially Recyclable	904	*1.1%*
Contaminants	1,222	*1.5%*
Mixed Paper	**61,219**	***30%***
Target Commodity	41,732	*68%*
Other COI	13,777	*23%*
Potentially Recyclable	1,107	*2%*
Contaminants	4,603	*7.5%*
PET	**5,262**	***3%***
Target Commodity	3,671	*70%*
Other COI	94	*2%*
Potentially Recyclable	1,400	*27%*
Contaminants	97	*1.8%*
HDPE Natural	**1,756**	***1%***
Target Commodity	1,691	*96%*
Other COI	50	*3%*
Potentially Recyclable	14	*0.8%*
Contaminants	1	*0.06%*
HDPE Colored	**1,465**	***1%***
Target Commodity	1,343	*92%*
Other COI	29	*2%*
Potentially Recyclable	81	*6%*
Contaminants	12	*0.8%*
Mixed Plastics	**1,196**	***1%***
Target Commodity	210	*18%*
Other COI	394	*33%*
Potentially Recyclable	445	*37%*
Contaminants	147	*12%*
Aluminum Cans	**3,465**	***2%***
Target Commodity	3,318	*96%*
Other COI	40	*1.2%*
Potentially Recyclable	104	*3%*
Contaminants	3	*0.1%*
Mixed Metals	**2,277**	***1%***
Target Commodity	2,079	*91%*
Other COI	5	*0.2%*
Potentially Recyclable	1	*0.0%*
Contaminants	192	*8%*
Tin	**2,907**	***1%***
Target Commodity	2,540	*87%*
Other COI	19	*0.7%*
Potentially Recyclable	298	*10%*
Contaminants	50	*1.7%*
Commodity Glass*	**26,573**	***13%***
Commodity Residue*	**15,468**	***8%***

** Did not sample*

Figure 2 shows the composition of each COI by tons. For example, the commodity Cardboard was 78,048 tons of the targeted material type *Cardboard*; 3,664 tons of other COI; 1,222 tons Contaminants; and 904 tons of Potentially Recyclable materials.

Figure 2. Material Composition for Commodities of Interest[5]



[5] Commodity Glass and commodity Residue were not sampled for this study.

MRF Interviews

Objectives

The second component of this study includes findings from interviews with representatives from the three major single-stream recycling MRFs that process materials from King County curbside recycling programs. The objectives of the confidential interviews with MRF operators were to:

- Evaluate system performance and understand the challenges associated with collecting and processing material.
- Assess future capacity at regional MRFs.
- Identify opportunities for expanding regional processing and improving system performance.

Key Findings

These key themes were identified during interviews with MRF representatives:

- **The leading challenges for MRFs regarding the incoming stream of recyclables are contamination and worker safety.** Contaminants and materials that are difficult to sort present quality concerns for successfully selling products into recycling markets. Unsafe materials that do not belong in the recycling bin not only slow down processing efficiency but pose a safety risk for employees.
- **Processors agree that education for residents and businesses as well as innovative new collection methods are key to reducing levels of contamination.** Current collection methods lead to issues such as moisture and hard-to-sort materials that may not be accepted in the recycling bin.
- **MRF processing capabilities are limited by current equipment.** Contaminants often damage equipment and lead to forced downtime. In addition, equipment varies between facilities and is often outdated and/or unable to handle the changing material streams. **Education, equipment upgrades, and investment in new technology were all identified as potential solutions for processing challenges.**
- **Processors agree there is generally enough capacity** at MRFs to meet today's demands, but equipment upgrades are needed to modernize and keep pace with the changing recycling stream.
- **Substantial amounts of incoming material arriving at the MRFs cannot be reliably processed and/or marketed**. Polystyrene/Styrofoam, shredded paper, aseptic containers, and plastic film were recommended as materials that should be removed from the list of accepted materials.
- **It is important to maintain an acceptance list for items that are actually able to be recycled.** The list of acceptable materials in the recycling bin controls how the MRF is designed, and MRFs must be able to process and market materials effectively to maintain a successful business case.

2. Project Overview

2.1. Background

Since 1990, the King County Solid Waste Division (County) has conducted its Waste Monitoring Program (Program) to help plan for future community needs, improve services, and track progress toward recycling goals. The Program assesses how much and what types of materials King County's residents and businesses generate, dispose, and recycle. This work supports efforts to increase diversion, reduce contamination, and identify opportunities for strengthening markets for recyclables.

In 2019, the King County Solid Waste Division commissioned Cascadia Consulting Group to assess recyclables from homes and businesses in King County that are handled at Material Recovery Facilities (MRFs) in the Puget Sound region. The 2019 MRF assessment updates the material characterization work that Cascadia conducted for the County in the 2006 MRF assessment. This assessment includes two components: 1) a characterization study of the recyclable materials processed by selected recycling facilities and 2) confidential interviews with representatives from the three major single-stream recycling MRFs that process materials from King County curbside recycling programs.

The material characterization study analyzed material delivered to single-stream recycling MRFs from single-family and commercial sources, including non-recyclable materials collected from customer recycling collection containers. The study quantified and characterized the rejected streams at each participating MRF (and one transfer station), the amounts and types of processed materials, and other contaminants in processed materials and products.

Cascadia also conducted interviews with representatives from the three major single-stream recycling MRFs that process materials from King County curbside recycling programs. The findings from the interviews offer valuable insight to collection and processing challenges, future processing capacity, and recommendations for materials to add or remove from the accepted list of recyclables.

This report is organized into six chapters and three appendices:

- Chapter 1, *Executive Summary*, summarizes the project and its key findings.
- Chapter 2, *Project Overview*, describes the project background, objectives, and sampling plan.
- Chapter 3, *Methodology*, presents an overview of the methods used in this study.
- Chapter 4, *Data Analysis*, briefly describes the data analysis approach.
- Chapter 5, *Results and Discussion*, presents the results of the waste characterization study including quantities of commodities.
- Chapter 6, *MRF Interview Summary*, presents the findings and recommendations from the interviews with representatives of the three MRF companies.
- *Appendix A* provides material definitions, material classes, and recyclability groups.
- *Appendix B* describes the methodology for estimating waste composition.
- *Appendix C* provides the interview guide used with MRF representatives.

2.2. Objectives

The objectives of the 2019 recyclable materials characterization study were to:

- Characterize the inbound recyclable material collected from commercial and single-family residential sectors across King County (not including those from the City of Seattle).
- Quantify the rejected material disposed by the participating facilities.
- Characterize the throughput (commodity materials or finished products) processed by the MRFs and assess the level of contamination in these commodities.

The objectives of the interviews with single-stream MRF operators were to:

- Evaluate system performance and understand the challenges associated with collecting and processing material.
- Assess future capacity at regional MRFs.
- Identify opportunities for expanding regional processing and improving system performance.

2.3. Sampling Universe

The "sampling universe" refers to the materials that were targeted for sampling. In this study, the sampling universe consisted of:

- Inbound recyclable material collected from commercial and single-family residential sectors across King County at four regional Material Recovery Facilities (MRFs) and one transfer station that handle recyclable materials from King County (see Table 5 below);
- Material rejected as non-recyclable material during the processing of the inbound recycling loads at the five participating facilities; and
- Throughput material designated as "finished product" considered as marketable commodity by the five facilities.

Materials generated by residents or commercial businesses within the City of Seattle were excluded from the study. The multifamily sector was only slated for inclusion if haulers had dedicated routes with pure loads. However, the companies reported that they usually collect multifamily and commercial materials on mixed routes, so sampling multifamily residences would have required running special routes. This was considered logistically problematic for securing cooperation from haulers/MRFs. Accordingly, the multifamily stream was excluded from the sampling protocol.

Commodity Glass and commodity Residue were not sampled in this study since they were not identified as priority materials by the King County Solid Waste Division. Plastic and Paper materials were identified as higher-priority commodities of interest; Metal commodity bales were also sampled.

Table 5. Participating Facilities *(WM = Waste Management)*

Facility	Location
Recology Seattle	7 S Idaho St, Seattle
Republic Services	2733 3rd Ave S, Seattle
WM—Cascade Recycling Center	14020 NE 190th St, Woodinville
WM—JMK Fibers	1440 Port of Tacoma Rd, Tacoma
WM—Recycle Northwest	355 H St NW, Auburn

2.4. Sampling Schedule and Sample Distribution

Following an introductory letter from King County, Cascadia worked closely with the participating facilities to identify an appropriate and feasible sampling plan and fieldwork schedule. Before fieldwork, Cascadia project leads conducted site visits at each of the participating facilities. During the site visits, Cascadia completed a walkthrough with the facility personnel to determine the number and location of all material ejection points. Cascadia gathered information from facility operators including usual traffic patterns at the facility (e.g., typical schedules of inbound commercial trucks versus single-family trucks, heavy versus light traffic days, estimated number of incoming trucks on any given day) and discussed plans for intercepting the inbound trucks for surveying, identification of the trucks for sampling, and protocols for sample extraction and collection.

Fieldwork occurred in two phases. The first phase of the fieldwork occurred from August 20 through September 2, 2019. The second phase of the fieldwork occurred from November 5 to 14, 2019. Due to construction-related site constraints at Republic Services' Third and Lander facility, samples in Phase 1 were collected on-site and then sorted at King County's Shoreline transfer station; the site could not accommodate participation in Phase 2 due to the construction. Phase 2 focused on sampling inbound materials, particularly from the commercial stream, to meet the study goals. Accordingly, JMK Fibers was not included in Phase 2, as its incoming materials are first delivered for Recycle Northwest in Auburn. Table 6 below shows the fieldwork schedule at each facility.

Table 6. Sampling Schedule by Facility (2019)

Facility	Phase 1	Phase 2
Recology Seattle	August 20-22	November 5-6
Republic Services	August 27-30	*not included*
Cascade Recycling Center	September 18-20	November 7-8
Recycle Northwest	September 24-25	November 13-14
JMK Fibers	October 1-2	*not included*

Cascadia worked with each facility to identify sampling loads from inbound material, rejected material, and throughput (finished products). Overall, Cascadia collected and sorted 187 material samples across the five sampling sites. Table 7 shows the distribution of samples across the material streams and the targeted sample weight for each stream.

Table 7. Sample Counts and Weights

Stream	Samples		Targeted Weight per Sample	Average Actual Weight
	Planned	Actual		
Inbound – Single-Family	40	39	125-150 lbs	138.8 lbs
Inbound – Commercial	60	60	125-150 lbs	146.8 lbs
Reject	25–30	26	10-30 lbs	14.1 lbs
Throughput	45–50	62	125-150 lbs	132.9 lbs
TOTAL	**180**	**187**	N/A	N/A

Table 8 shows the sample distribution across each facility. In consideration of the diversity of covered commodity bale types, some additional sampling was conducted for the throughput stream.

Table 8. Sample Distribution by Material Stream and by Participating MRFs

	Phase 1				Phase 2				Total
	Inbound Single-Family	Inbound Commercial	Reject	Throughput	Inbound Single-Family	Inbound Commercial	Reject	Throughput	
Recology	10	9	10	26	1	10	-	-	**66**
Republic	8	7	10	11	-	-	-	-	**36**
CRC	9	9	-	9	2	7	-	-	**36**
RNW	8	8	-	-	1	10	-	-	**27**
JMK	-	-	6	16	-	-	-	-	**22**
TOTAL	**35**	**33**	**26**	**62**	**4**	**27**	-	-	**187**

3. Methodology

3.1. Sample Selection

Cascadia developed a sampling plan for selecting representative samples from each material stream at each participating facility and for each sampling phase. Each facility had unique features and therefore required customized sampling plans. In general, the sampling methodology for each material stream (inbound, reject, and finished product stream) followed these steps.

Inbound Single-Stream Recycling Samples

1. Cascadia pre-selected trucks that deliver single-stream recycling loads to the participating facilities using a systematic random selection process to ensure unbiased and reliable composition estimates. This process consisted of sampling every n^{th} vehicle after a random start time. This sampling interval was determined by dividing the total anticipated number of incoming single-stream recycling loads by the number of samples needed each day, both for commercial sector and for single-family residential sector. The resulting number was the sampling frequency and determines whether, for example, every 3^{rd}, 6^{th}, or 12^{th} vehicle was selected for sampling.

2. On each sampling day, Cascadia's field crew placed a Surveyor at the entry point of the participating facility (e.g., a scale house) (Figure 3). The Surveyor interviewed the driver of the incoming truck to determine whether the vehicle was eligible for sampling—that is, whether the truck contained single-stream recycling loads either from commercial or single-family residential sectors from within King County (excluding the City of Seattle). The Surveyor also collected the net weights of the incoming truck loads from the scale house.

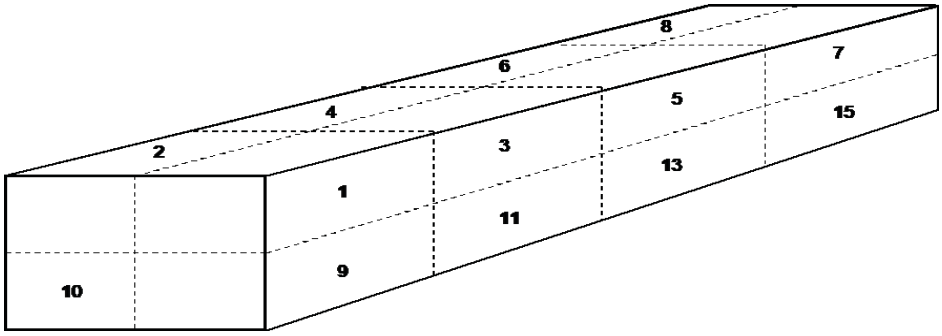
Figure 3. Vehicle Survey

3. If the incoming truck was eligible for sampling, the surveyor handed over a brightly colored sample placard to the driver and instructed the driver to put the placard on the windshield and then drive the truck to a designated sample capture area.

4. Upon arriving at the sample capture area, the Crew Lead intercepted the selected truck and procured the placard. The Crew Lead then instructed the truck driver to tip the contents of the truck in an elongated pile.

5. The field crew then chose a sample for extraction using an imaginary 16-cell grid (Figure 4) superimposed over the tipped material. The Crew Lead identified a random pre-selected "cell" from the tipped load, representing a cross-section of material from top to bottom. If the designated cell was blocked due to site constraints, an alternate cell was randomly selected.

Figure 4. 16-Cell Grid Applied to Selected Loads



6. The Crew Lead then instructed the loader operator at the facility to extract approximately 125 pounds of the material for the chosen cell.

7. The extracted material was placed either in two or three 96-gallon carts or on a tarp placed on the floor by the Crew Lead (Figure 5). The Crew Lead checked the weight of each sample using a pre-calibrated scale. If judged to be too light, additional material was manually pulled from the same cell area and put in the cart or on the tarp until the desired weight was achieved. Samples judged to be excessively heavy were pared down by removing a random, homogenous slice of material.

Figure 5. Sample Extraction

8. A sampling placard was placed in the cart or on the tarp for sample identification. The Crew Lead then pulled the cart or the tarp into the sorting area assisted by the field crew (Figure 6).

9. The field crew hand-sorted the samples, as described in Section 3.2., according to the pre-designated material and contaminant categories, as agreed upon with King County. A detailed material list can be found in *Appendix A. Material Definitions*.

Figure 6. Sampled Material with Sample Placard

MRF Reject Samples

1. Before the sampling event, Cascadia conducted a site survey with the facility personnel at each participating facility and determined the number and location of all ejection points of rejected material. Cascadia used this information to develop a site-specific method for extracting samples from each ejection point.
2. On each sampling day, the field crew collected samples from the selected ejection points. Sample collection either involved placing a barrel under the ejection point to collect material (typically used for final rejects) or shoveling the material from the receptacle at the ejection point on to a tarp. The field crew determined the appropriate method of sample collection in consultation with the facility operator.
3. The recommended weight of the samples depended on the average size of the material being characterized. Generally, material with greater average "particle size" required larger samples for characterization, while finer material—such as grit or tiny pieces—could be characterized adequately with relatively smaller samples. Samples ranged from 10 to 30 pounds (Figure 7).
4. The field crew hand-sorted reject samples, as described in Section 3.2., according to the pre-designated material and contaminant categories as described in *Appendix A. Material Definitions*.

Figure 7. Rejected Sample

Finished Product Samples

1. Before the sampling event, Cascadia conducted a site survey at each participating facility. During the site survey, Cascadia personnel did a walkthrough with the facility personnel to determine the number and location of points through which the processed or "finished" product is processed at the MRF.
2. Based on this assessment, Cascadia developed a method of extracting samples of processed product at each participating facility. Typically, the Crew Lead worked with the facility operators either to collect the finished product before baling, or to break the bales and extract material from a random section of the bale. In either case, once the material was extracted, it was delivered to the sorting area and tipped on to a tarp placed down by the field crew (Figure 8 and Figure 9). Each sample of finished product weighed approximately 125 pounds.
3. The field crew hand-sorted finished product samples according to the pre-designated material and contaminant categories, as described in the next section.

Figure 8. Finished Product Sample (HDPE)

Figure 9. Finished Product Sample (Aluminum Cans)

3.2. Sample Sorting

The field crew followed a hand-sort protocol to characterize each collected sample. Before sorting, the field crew reviewed the methodology, sorting categories, and material definitions to ensure consistent sorting.

1. To prepare for sorting, the field crew emptied the sample carts on to a tarp or, if the samples were tarped, opened the tarps. The field crew placed the sample identification placard on top of the material and photographed the sample (Figure 10).
2. The field crew then sorted the material by hand into pre-designated material categories (Figure 11), placing each material type into individual plastic laundry baskets or barrels (Figure 12). Each member of the field crew typically specialized in groupings of materials, such as papers or plastics, and the Crew Lead monitored for accuracy. For detailed material list, please refer to *Appendix A. Material Definitions*.

Figure 10. Extracted Sample with Sample ID

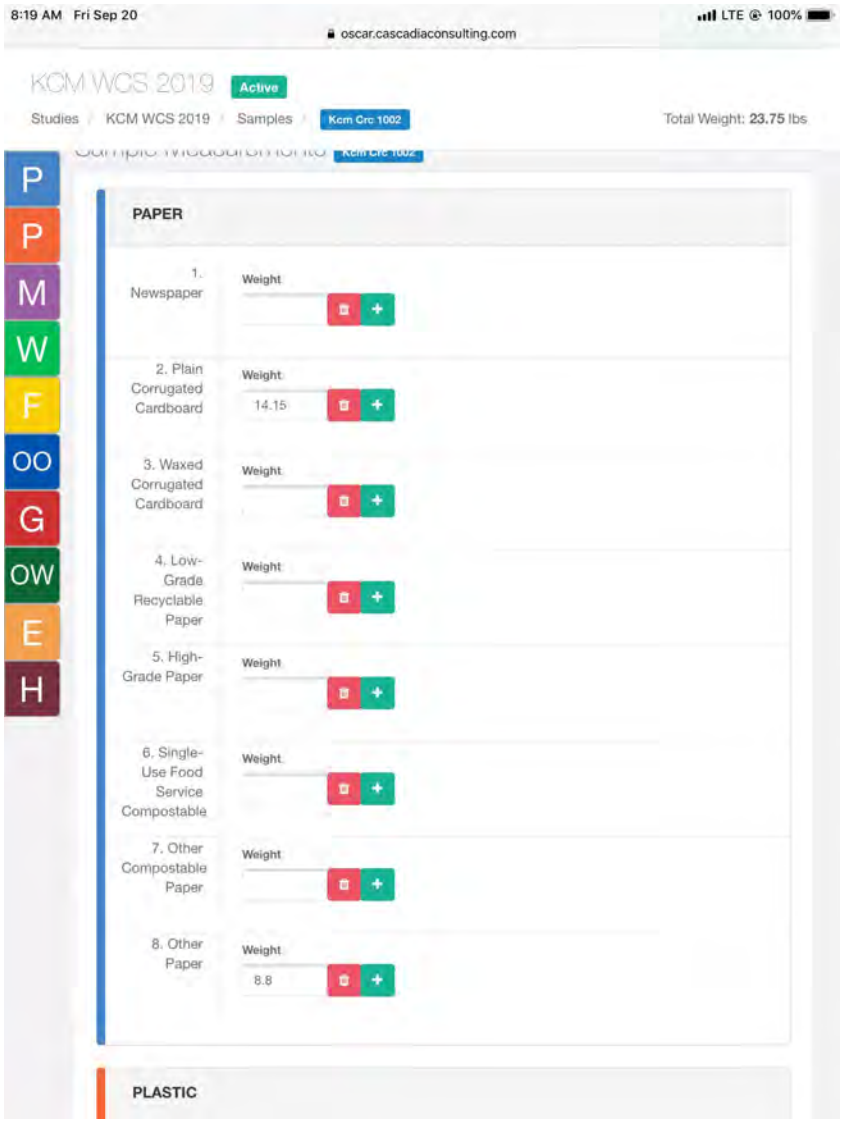
Figure 11. Sample Sorting

Figure 12. Sorted Materials

3. The field crew then weighed each sorted material in its own container using a pre-calibrated scale (**Error! Not a valid bookmark self-reference.**). The Crew Lead recorded the weight on a digital sampling form on Cascadia's cloud-based database management system, OSCAR (Online Statistical Composition Analysis Repository), customized for this study (Figure 14).

Figure 13. Sample Weighing

Figure 14. OSCAR Digital Data Entry Form



4. During sorting, the Crew Lead continually monitored the homogeneity of material in the baskets and re-sorted any improperly classified materials. The Crew Lead conducted ongoing quality control review of the entered data, flagging and resolving anomalies, to ensure completeness of information for each sample. In addition, the OSCAR database contains built-in logic and error-checking to prevent data-entry errors. It also sums sample weights so the Crew Lead can confirm weight targets are being met. The data are automatically synced to a cloud-based storage system, reducing data loss and transcription errors.
5. After completing fieldwork each day, the field crew cleaned the sorting location and the gear to prepare for the next day of sorting. The field crew collected all equipment at the end of the weeklong sampling event.

4. Data Analysis

4.1. Approach Overview

The following section describes the approach and the calculations that Cascadia used to derive detailed estimates of materials composition based on the sampling data. The sample data from the sorting process for each sample included the sample ID number, date of collection, sector, material stream, total sample weight, weight of each material type, and any notes. Following each sampling event, all sort data were reviewed for data entry errors. Cascadia implements sound quality control practices to ensure consistency, comparability, and accuracy of data.

The data were treated with a statistical procedure that provides the following composition information for each of the material types:

- **A bar chart shows composition by recyclability group (in percent):** The 42 material types were grouped into three recyclability groups: Recyclable, Potentially Recyclable, and Contaminants. Composition percentages for the recyclability groups are reported in bar charts for each material stream: inbound material, rejected material, and throughput commodities. For commodities, the bar chart was modified to show the Commodity of Interest (COI) separately from the rest of the recyclability groups.
- **A bar chart shows composition by material class (in percent):** The bar chart shows the estimated composition for the material types combined into the 12 material classes.
- **A table shows the top ten materials (in percent and in tons):** A table for each material stream shows the top ten most prevalent materials found in that stream by percent composition.
- **A detailed composition table shows composition by material type (in percent and in tons):** Cascadia used the composition percentages derived from the MRF assessment, in conjunction with the vehicle surveys and facility and hauler-reported tonnages, to determine the annual quantities for the material types and material classes. All estimates are presented along with confidence intervals associated with all estimates at the industry-standard 90 percent confidence level. The estimated percentages are rounded to the nearest tenth of a percent.

The composition information was generated for each material stream (inbound single-stream recycling, reject stream, and throughput) for overall King County. The composition of each material stream was calculated using the statistical methods developed and accepted for prior County waste characterization studies. These methods are described below in *Appendix B. Estimating Waste Composition*. Both the sample data and the analyses were analyzed in a workbook in a Microsoft Excel format.

4.2. Interpreting the Results

The waste characterization data are presented as a detailed table listing the full composition and quantity results for the 42 material types and the 12 material classes. For clarity in text descriptions, material classes such as **Recyclable Paper**, **Recyclable Glass**, and **Recyclable Metal** are bold, and individual material types such as *Cardboard* or *Mixed Residue* are italicized.

The example in Table 9 below illustrates how the results can be interpreted. Using this example data, the best estimate of the amount of *Cardboard* present in the Cardboard commodity was 93.1 percent. The 3.0 percent figure reflects the precision of the estimate. When calculations are performed at the 90 percent confidence level, we are 90 percent certain that the true mean for *Cardboard* was between 90.1 percent (93.1% minus 3.0%) and 96.1 percent (93.18% plus 3.0%).

Table 9. Example Percent Composition and Confidence Interval

Material	Estimated Percent	± %	Estimated Tons	± Tons
Cardboard	93.1%	±3.0%	78,049	±2,480

When interpreting the results in the tables and figures in this report, the effect of rounding should be considered. To keep the waste composition tables and figures readable, estimated percentages are rounded to the nearest tenth of a percent. Due to rounding, the data in the report, when added together, may not exactly match the subtotals and totals. Percentages less than 0.05 percent are rounded to show as 0.0 percent even though there may be a miniscule amount of the material.

Material types were classified into 12 material classes for the purpose of grouping similar material types. To identify additional diversion opportunities, material types were also classified according to their recyclability, using the following three recyclability groups, which generally align with King County's 2019 waste characterization study (modified to focus on recyclability, not including compostability):

- **Recyclable**: Materials for which recycling technologies and material markets are well-developed, and infrastructure and programs are readily available and currently used.
- **Potentially Recyclable**: Materials for which there is limited recyclability through other, non-curbside recycling channels. For such materials, recycling technologies, programs, and markets exist, but are not well-developed or not currently used.
- **Contaminants**: Materials that are not readily recyclable or face other market, technology, or programmatic related barriers.

Materials were categorized into the recyclability groups and material classes shown in Table 10. The material class called **Other Non-Recyclable** contains identified contaminant materials that are generally not accepted in curbside recycling and are not a specific material type like plastic or metal. This material class includes *Tanglers*, *Household Hazardous Waste (HHW)*, *Electronics and Small Appliances*, *Diapers*, *Textiles*, *Shoes*, *Construction and Demolition Debris (C&D)*, *Furniture*, and *Mixed Residue* (see *Appendix A. Material Definitions* for material descriptions). This material class was originally called Contaminants, but the name was changed to avoid confusion with the Contaminants recyclability group, which includes organics (e.g., *Edible Food)* and non-recyclable paper, glass, metal, and plastic (e.g., *Disposal Bags*).

Please note that some material types (e.g., *Other Metal)* are classified into "non-recyclable" material classes (e.g., **Non-recyclable Metal)** and the recyclability group Potentially Recyclable. This is because a material type can be prohibited in the curbside recycling stream but have the potential to be recycled through other, non-curbside recycling channels. The recyclability groupings generally align with the recoverability groups used in the 2019 Waste Characterization Study, as explained further in *Appendix A*.

Table 10. Material Groupings (MG), Material Classes, Material Types, and Recyclability Groups

MG	Material Classes (12)	Material Types (42)	Recyclability Groups (3)
PAPER	RECYCLABLE PAPER	Cardboard	Recyclable
		Newspaper	Recyclable
		Aseptic and Gable Top Cartons	Recyclable
		Mixed Paper	Recyclable
	NON-RECYCLABLE PAPER	Compostable Paper	Contaminants
		Other Paper	Contaminants
GLASS	RECYCLABLE GLASS	Glass Containers	Recyclable
	NON-RECYCLABLE GLASS	Other Glass	Contaminants
METAL	RECYCLABLE METAL	Aluminum Cans	Recyclable
		Aluminum Foil and Trays	Potentially Recyclable
		Tin Food Cans	Recyclable
		Empty Aerosol Cans	Potentially Recyclable
	NON-RECYCLABLE METAL	Other Metal	Potentially Recyclable
PLASTIC	RECYCLABLE PLASTIC	PET (#1) Bottles and Jars	Recyclable
		PET (#1) Small Rigid Plastics	Potentially Recyclable
		Clear HDPE Bottles and Jars	Recyclable
		Colored HDPE (#2) Bottles and Jars	Recyclable
		HDPE (#2) Other Containers	Potentially Recyclable
		LDPE (#4)	Potentially Recyclable
		PP (#5) Bottles and Jars	Potentially Recyclable
		PP (#5) Small Other Rigid Plastics	Potentially Recyclable
		PS (#6) Rigid Plastics	Potentially Recyclable
	FOAM PLASTIC	EPS Food Packaging	Contaminants
		EPS Foam Blocks and Shapes	Potentially Recyclable
	NON-RECYCLABLE PLASTIC	Bulky Rigid Plastics	Potentially Recyclable
		Compostable Plastics	Potentially Recyclable
		Other Plastic	Contaminants
	FILM PLASTIC	Clean Plastic Bags and Film	Potentially Recyclable
		Disposal Bags	Contaminants
		Other Plastic Film	Contaminants
ORGANICS	ORGANICS	Edible Food	Contaminants
		Non-edible Food	Contaminants
		Other Compostables	Contaminants
		Yard Debris	Contaminants
OTHER	OTHER NON-RECYCLABLE	Tanglers	Contaminants
		Household Hazardous Waste	Contaminants
		Electronics and Small Appliances	Contaminants
		Diapers	Contaminants
		Textiles Shoes	Contaminants
		Construction and Demolition Debris	Contaminants
		Furniture	Contaminants
		Mixed Residue	Contaminants

4.3. Establishing Overall Material Quantities

Cascadia requested and obtained tonnage data from each MRF for the calendar year 2019. The data provided includes tons of:

- Inbound material accepted.
- Rejected material disposed.
- Total throughput commodities sold (aggregate tonnages only).

Market information and quantity and composition data resulting from the collection and sorting of material samples at each MRF were obtained under non-disclosure agreements and are not presented within this report. The data from individual facilities were aggregated to present summary results.

The tonnages obtained from each participating MRF were used to estimate quantities of materials collected (inbound material) and then processed to be baled for sale as a commodity or rejected (as non-commodity residue (Figure 15 and Table 11). Due to estimating methods explained in *Section 5.4, Estimating Commodity Quantities*, the quantities in this table do not add to the exact totals; the difference is less than 0.1 percent.

Figure 15. Material Flows of Recyclables Collected and Processed in King County

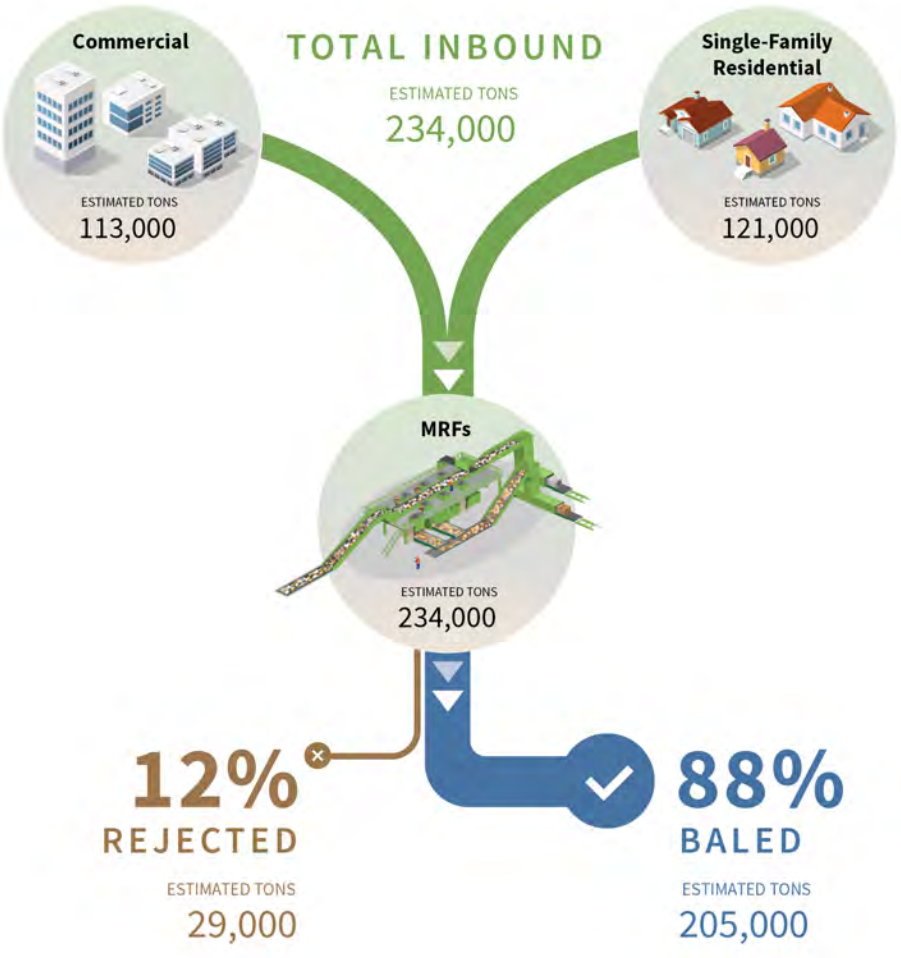


Table 11. Estimated Quantities of King County Materials Collected and Processed for Recycling

OVERALL	Modified tonnage (excluding MF)
Total Inbound	**234,034**
Inbound - all residential from KC	234,034
Inbound - SF Residential from KC	121,179
Inbound - Commercial from KC	112,855
Inbound - Multifamily from KC	-
Total Reject	**28,831**
Non-commodity Residue	**19,882**
Non-commodity Residue as percent of total inbound	*8.5%*
Non-commodity Glass	**8,950**
Non-commodity Glass as percent of total inbound	*3.8%*
Outbound Commodities - all residential from KC	**205,202**
Outbound commodity residue	15,468
Outbound commodity glass	26,573
Other outbound commodities	163,162
Total Throughput (sum of residue + glass + all commodities)	**234,034**

Table 12. Total Material Detailed by Type

TOTAL INBOUND *(excluding multifamily)*	**234,034**	**Tons**						
	Single-family Residential		**Commercial**					
Estimated Tons	**121,179**	***52%***	**112,855**	***48%***				
Recyclable	93,846	*77.4%*	91,259	*80.9%*				
Potentially Recyclable	5,258	*4.3%*	3,800	*3.4%*				
Contaminants	22,074	*18.2%*	17,796	*15.8%*				
TOTAL THROUGHPUT	**205,427**	**Tons**						
PAPER COMMODITIES	**Cardboard**		**Mixed Paper**					
Estimated Tons	**83,839**	***41%***	**61,219**	***30%***				
Target Commodity	78,049	*93%*	41,732	*68%*				
Other COI	3,664	*4%*	13,777	*23%*				
Potentially Recyclable	904	*1.1%*	1,107	*2%*				
Contaminants	1,222	*1.5%*	4,603	*7.5%*				
PLASTIC COMMODITIES	**PET**		**HDPE Natural**		**HDPE Colored**		**Plastics**	
Estimated Tons	**5,262**	***3%***	**1,756**	***1%***	**1,465**	***1%***	**1,196**	***1%***
Target Commodity	3,671	*70%*	1,691	*96%*	1,343	*92%*	210	*18%*
Other COI	94	*2%*	50	*3%*	29	*2%*	394	*33%*
Potentially Recyclable	1,400	*27%*	14	*0.8%*	81	*6%*	445	*37%*
Contaminants	97	*1.8%*	1	*0.06%*	12	*0.8%*	147	*12%*
METAL COMMODITIES	**Aluminum Cans**		**Mixed Metals**		**Tin**			
Estimated Tons	**3,465**	***2%***	**2,277**	***1%***	**2,907**	***1%***		
Target Commodity	3,318	*96%*	2,079	*91%*	2,540	*87%*		
Other COI	40	*1.2%*	5	*0.2%*	19	*0.7%*		
Potentially Recyclable	104	*3%*	1	*0.0%*	298	*10%*		
Contaminants	3	*0.1%*	192	*8%*	50	*1.7%*		
OTHER COMMODITIES	**Commodity Glass***		**Commodity Residue***					
Estimated Tons	**26,573**	***13%***	**15,468**	***8%***				
TOTAL REJECT	**28,831**	**Tons**						
	Non-Commodity Residue		**Non-Commodity Glass***					
Estimated Tons	**19,882**	***69%***	**8,950**	***31%***				
Recyclable	7,105	*35.7%*						
Potentially Recyclable	2,342	*11.8%*						
Contaminants	10,436	*52.5%*						

** Did not sample*

The list below summarizes the quantities of recyclable materials:

- The total inbound recyclable material from single-family residential and commercial generators was estimated to be 234,034 tons. Approximately 52 percent (121,179 tons) was generated by single-family residential generators, and approximately 48 percent (112,855 tons) was generated by commercial generators.
- Based on data reported by participating MRFs, the total quantity of material rejected by the MRFs during processing was estimated to be 28,831 tons. Of this, non-commodity residue was estimated to be 19,882 tons and non-commodity glass was estimated to be 8,950 tons.

- The total estimated quantity of all throughput commodities was estimated to be about 205,000 tons. Of this, commodity Residue was estimated to be 15,468 tons. Commodity Glass was estimated to be 26,573 tons.[6]
- The total quantity of other throughput commodities was estimated at about 163,000 tons. The MRFs did not provide tonnages sold for each individual commodity, so the individual commodity tonnages are estimates. Estimated compositions for commodities are included in Sections 5.5 through 5.13.

[6] Although commodity Residue and glass were not sampled in this study, they are included in the overall quantity estimates to account for all material processed at the MRFs.

5. Results and Discussion

This chapter describes the results of the composition analysis by sampling stream for inbound materials (Sections 5.1 and 5.2), rejected material (Section 5.3), and Commodities of Interest (Sections 5.5 through 5.13).

5.1. Composition of Inbound Single-Family Residential Recycling

The waste composition of the inbound single-family residential recycling substream is the estimated weighted average of **39 samples** from the substream. Based on data reported by the participating facilities, the total quantity of inbound single-family recycling substream was estimated at 121,179 tons.

Key Findings

- Over three-quarters of inbound single-family recycling material was classified as Recyclable (77.4% and 93,846 tons), 4.3 percent (5,258 tons) was considered Potentially Recyclable material, and 18.2 percent (22,074 tons) was classified as Contaminants (Figure 16).
- **Recyclable Paper** (59.0%) material class constituted more than half of the inbound single-family residential recycling stream (Figure 17). Specifically, *Cardboard* (29.8%) and *Mixed Paper* (24.7%) formed about half of the inbound single-family residential recycling stream (Figure 17).
- **Recyclable Glass** (11.9%) material class was the second most prevalent material class of the inbound single-stream residential recycling stream (Table 13).
- **Recyclable Plastic** (6.4%) material class was mostly *PET (#1) Bottles and Jars* (2.9%) (Table 14).
- **Recyclable Metal** (4.1%) material class was mostly *Aluminum Cans (2.1%)***.**
- **Non-Recyclable Paper** (4.0%), **Non-Recyclable Glass** (4.1%), **Non-Recyclable Metal** (1.1%), and **Non-Recyclable Plastic** (2.7%) material classes together formed about 12 percent of the inbound single-family residential recycling stream.
- **Film Plastic** (1.3%) material class was composed of *Clean Plastic Bags Film* (0.5%) (not accepted in curbside recycling as of 2020), *Disposal Bags* (0.2%), and *Other Film* (0.7%).
- **Organics** and compostable material that can contaminate recyclables, such as *Edible Food* (0.7%), *Non-edible Food* (0.2%), *Other Compostables* (0.4%), and *Compostable Paper* (1.4%), combined were 2.8 percent of the inbound single-family residential recycling stream.
- **Contaminants** (3.8%) was composed of Mixed Residue (2.6%), *Household Hazardous Waste* (0.2%), and *Textiles Shoes* (0.5%) in the inbound single-family residential recycling stream.

Figure 16. Composition by Recyclability Group – Inbound Single-Family Residential Recycling

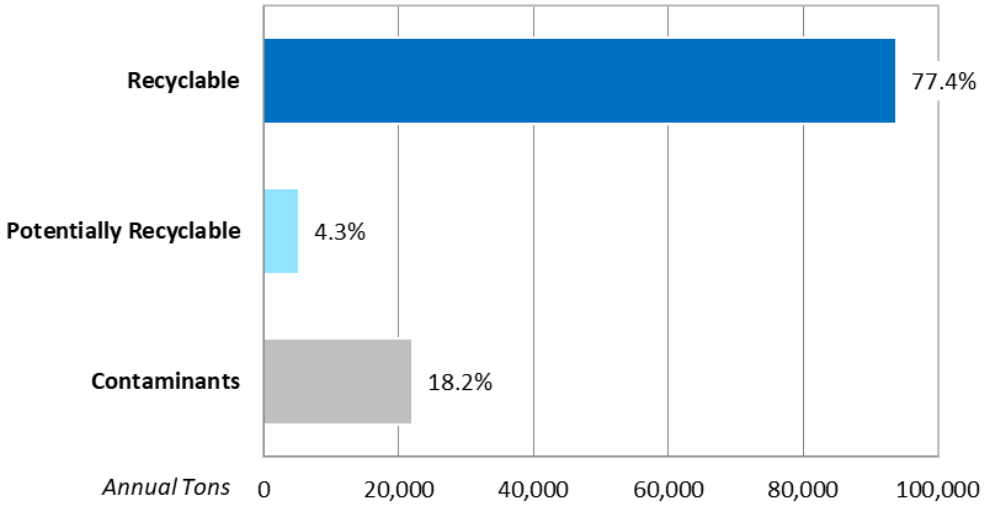


Figure 17. Composition by Material Class – Inbound Single-Family Residential Recycling

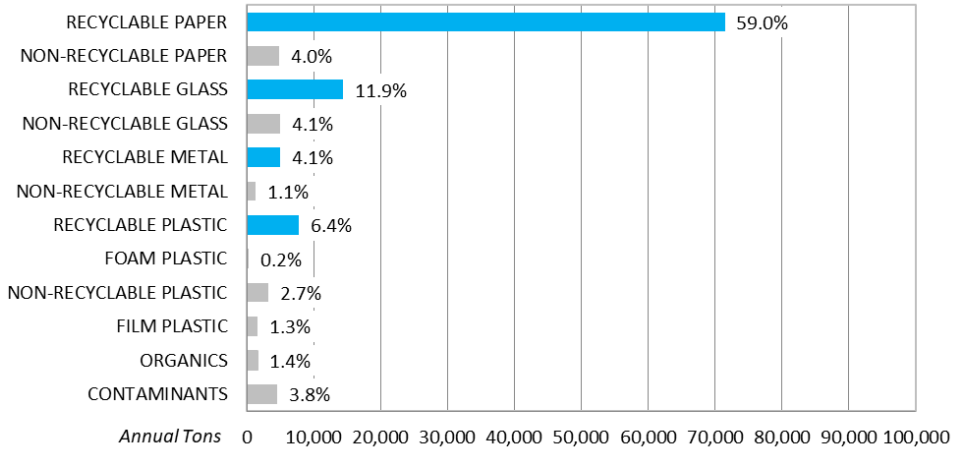


Table 13. Ten Most Prevalent Materials – Inbound Single-Family Residential Recycling

Material	Est. Percent	Est. Tons
Cardboard	29.8%	36,152
Mixed Paper	24.7%	29,933
Glass Containers	11.9%	14,424
Other Glass	4.1%	5,003
Newspaper	3.9%	4,685
PET (#1) Bottles and Jars	2.9%	3,514
Mixed Residue	2.6%	3,170
Other Paper	2.6%	3,154
Other Plastic	2.5%	3,005
Aluminum Cans	2.1%	2,506
Total for Top Materials	**87.1%**	**105,547**

Table 14. Composition by Material Type – Inbound Single-Family Residential Recycling

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**59.0%**	**4.9%**	**71,476.6**
Cardboard	29.8%	6.5%	36,151.6
Newspaper	3.9%	1.0%	4,684.5
Aseptic and Gable Top Cartons	0.6%	0.2%	707.1
Mixed Paper	24.7%	4.8%	29,933.4
NON-RECYCLABLE PAPER	**4.0%**	**1.5%**	**4,846.3**
Compostable Paper	1.4%	0.6%	1,691.9
Other Paper	2.6%	1.1%	3,154.4
RECYCLABLE GLASS	**11.9%**	**3.6%**	**14,423.7**
Glass Containers	11.9%	3.6%	14,423.7
NON-RECYCLABLE GLASS	**4.1%**	**1.5%**	**5,003.4**
Other Glass	4.1%	1.5%	5,003.4
RECYCLABLE METAL	**4.1%**	**1.5%**	**4,975.8**
Aluminum Cans	2.1%	0.8%	2,506.2
Aluminum Foil and Trays	0.5%	0.7%	624.6
Tin Food Cans	1.4%	0.3%	1,728.5
Empty Aerosol Cans	0.1%	0.1%	116.6
NON-RECYCLABLE METAL	**1.1%**	**0.8%**	**1,345.1**
Other Metal	1.1%	0.8%	1,345.1
RECYCLABLE PLASTIC	**6.4%**	**0.8%**	**7,767.0**
PET (#1) Bottles and Jars	2.9%	0.4%	3,514.5
PET (#1) Small Rigid Plastics	0.7%	0.2%	819.4
Clear HDPE Bottles and Jars	0.6%	0.1%	745.6
Colored HDPE (#2) Bottles and Jars	0.9%	0.2%	1,037.5
HDPE (#2) Other Containers	0.3%	0.2%	320.9
LDPE (#4)	0.0%	0.0%	19.5
PP (#5) Bottles and Jars	0.2%	0.1%	297.8
PP (#5) Small Other Rigid Plastics	0.5%	0.2%	662.9
PS Rigid Plastics	0.3%	0.2%	349.0
FOAM PLASTIC	**0.2%**	**0.1%**	**233.2**
EPS Food Packaging	0.1%	0.0%	79.9
EPS Foam Blocks and Shapes	0.1%	0.1%	153.2
NON-RECYCLABLE PLASTIC	**2.7%**	**1.3%**	**3,242.7**
Bulky Rigid Plastics	0.2%	0.1%	191.4
Compostable Plastics	0.0%	0.0%	46.6
Other Plastic	2.5%	1.3%	3,004.8
FILM PLASTIC	**1.3%**	**0.3%**	**1,618.1**
Clean Plastic Bags Film	0.5%	0.1%	558.6
Disposal Bags	0.2%	0.1%	218.1
Other Plastic Film	0.7%	0.2%	841.4
ORGANICS	**1.4%**	**0.7%**	**1,649.2**
Edible Food	0.7%	0.3%	873.1
Non-edible Food	0.2%	0.2%	289.7
Other Compostables	0.4%	0.6%	483.1
Yard Debris	0.0%	0.0%	3.3
CONTAMINANTS	**3.8%**	**1.1%**	**4,597.9**
Tanglers	0.3%	0.4%	347.5
Household Hazardous Waste	0.2%	0.2%	207.1
Electronics and Small Appliances	0.0%	0.0%	16.8
Diapers	0.0%	0.0%	23.2
Textiles Shoes	0.5%	0.2%	569.3
Construction and Demolition Debri	0.1%	0.0%	102.2
Furniture	0.1%	0.1%	161.6
Mixed Residue	2.6%	0.8%	3,170.3
TOTAL	**100.0%**		**121,179**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.2. Composition of Inbound Commercial Recycling

The waste composition of the inbound commercial recycling substream is the weighted average of **60 samples** from the substream. Commercial waste is a mixture of commercial and multifamily waste because haulers typically collect the recyclables for these two generator groups on mixed routes. Based on data reported by the participating facilities, the total quantity of the inbound commercial recycling substream was estimated to be 112,855 tons (excluding the estimated multifamily portion).[7]

Key Findings

- Four-fifths (80.9%) of inbound single-family recycling material was classified as Recyclable (91,259 tons), 3.4 percent (3,800 tons) was Potentially Recyclable, and 15.8 percent (17,796 tons) was Contaminants (Figure 18).
- **Recyclable Paper** material class represented nearly three-quarters (70.1%) of the inbound single-stream commercial recycling stream (Figure 19). Specifically, *Cardboard* (43.1%) formed more than half of the substream. *Mixed Paper* was the second most prevalent material type at 23.6 percent of the inbound single-stream commercial recycling stream (Table 15Figure 19).
- **Recyclable Glass** (5.1) was the second most prevalent material class of the inbound single-stream commercial recycling stream.
- **Recyclable Plastic** (4.8%) material class was mostly *PET (#1) Bottles and Jars* (2.0%) (Table 16).
- **Recyclable Metal** (2.2%) material class was mostly *Tin Food Cans (1.2%)***.**
- **Non-Recyclable Paper** (4.4%), **Non-Recyclable Glass** (4.3%), **Non-Recyclable Metal** (0.9%), and **Non-Recyclable Plastic** (1.9%) material classes together formed about 11.7 percent of the inbound single-stream commercial recycling stream.
- **Film Plastic** (2.1%) was composed of *Clean Plastic Bags Film* (0.5%) (not accepted in curbside recycling as of 2020), *Disposal Bags* (0.7%), and *Other Film* (0.8%).
- **Organics** (1.6%) and other compostable material that contaminate recyclables, such as *Edible Food* (1.0%), *Non-edible Food* (0.5%), *Compostable Paper* (1.3%), and *Yard Debris* (0.1%), together formed 2.9 percent of the inbound single-stream commercial recycling stream.
- **Contaminants** (2.4%) was composed primarily of Mixed Residue (0.9%), and *Electronics and Small Appliances* (0.6%).

[7] Haulers report that they typically operate combined commercial/multifamily routes and the inbound commercial material was assumed to contain about 30 percent multifamily material. Since sampling from the multifamily sector would have required special routes and was logistically problematic for securing cooperation from haulers/MRFs, this study does not include the multifamily sector. The hauler-reported inbound tonnage of the combined route was reduced by 30 percent to estimate the tonnage from commercial-only sources.

Figure 18. Composition by Recyclability Group – Inbound Commercial Recycling

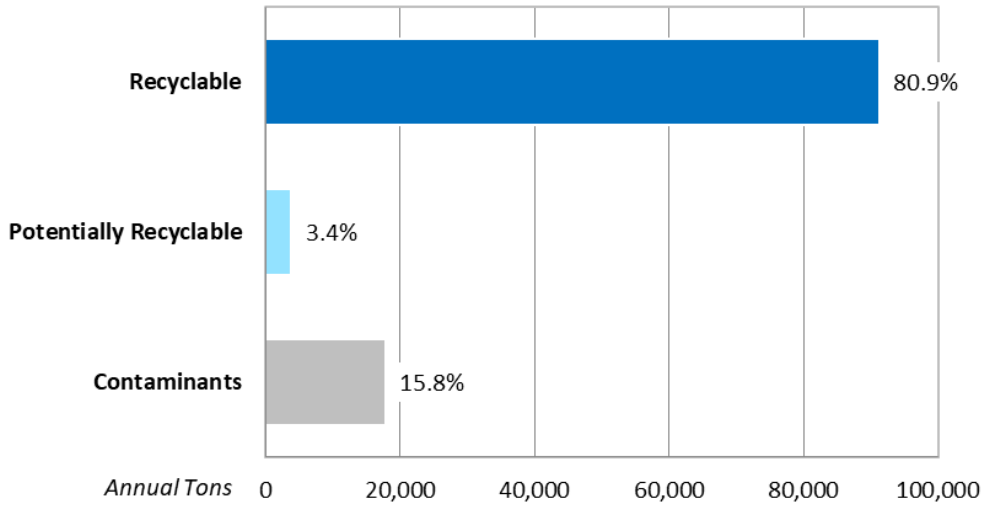


Figure 19. Composition by Material Class – Inbound Commercial Recycling

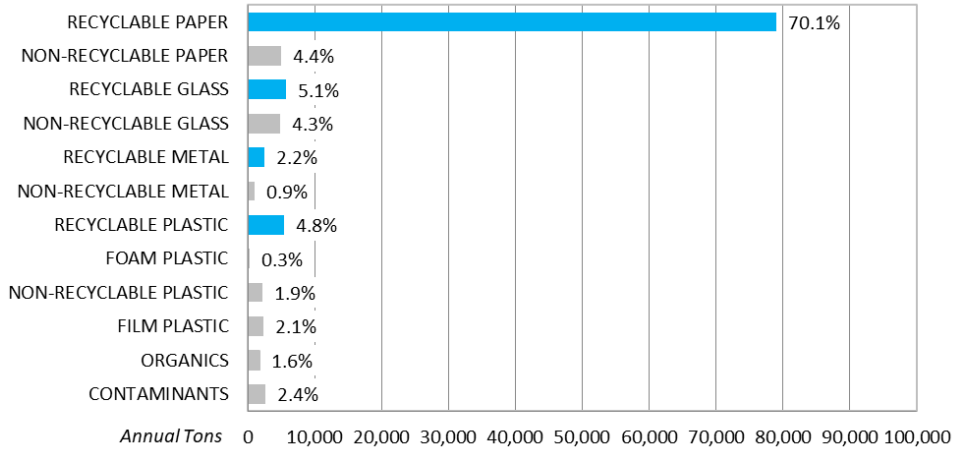


Table 15. Ten Most Prevalent Materials – Inbound Commercial Recycling

Material	Est. Percent	Est. Tons
Cardboard	43.1%	48,607
Mixed Paper	23.6%	26,625
Glass Containers	5.1%	5,723
Other Glass	4.3%	4,836
Other Paper	3.1%	3,538
Newspaper	2.7%	3,023
PET (#1) Bottles and Jars	2.0%	2,278
Other Plastic	1.5%	1,684
Compostable Paper	1.3%	1,428
Tin Food Cans	1.2%	1,302
Total for Top Materials	**87.8%**	**99,044**

Table 16. Composition by Material Type – Inbound Commercial Recycling

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**70.1%**	**5.4%**	**79,090.3**
Cardboard	43.1%	5.5%	48,606.7
Newspaper	2.7%	1.6%	3,022.9
Aseptic and Gable Top Cartons	0.7%	0.3%	835.3
Mixed Paper	23.6%	5.5%	26,625.4
NON-RECYCLABLE PAPER	**4.4%**	**1.3%**	**4,965.9**
Compostable Paper	1.3%	0.4%	1,428.1
Other Paper	3.1%	1.2%	3,537.8
RECYCLABLE GLASS	**5.1%**	**1.4%**	**5,722.8**
Glass Containers	5.1%	1.4%	5,722.8
NON-RECYCLABLE GLASS	**4.3%**	**1.9%**	**4,836.4**
Other Glass	4.3%	1.9%	4,836.4
RECYCLABLE METAL	**2.2%**	**0.6%**	**2,526.7**
Aluminum Cans	1.0%	0.3%	1,154.2
Aluminum Foil and Trays	0.0%	0.0%	31.0
Tin Food Cans	1.2%	0.4%	1,302.4
Empty Aerosol Cans	0.0%	0.0%	39.0
NON-RECYCLABLE METAL	**0.9%**	**0.5%**	**1,036.1**
Other Metal	0.9%	0.5%	1,036.1
RECYCLABLE PLASTIC	**4.8%**	**1.4%**	**5,371.4**
PET (#1) Bottles and Jars	2.0%	0.7%	2,277.8
PET (#1) Small Rigid Plastics	0.6%	0.3%	704.1
Clear HDPE Bottles and Jars	0.9%	0.4%	1,050.6
Colored HDPE (#2) Bottles and Jars	0.5%	0.1%	531.4
HDPE (#2) Other Containers	0.1%	0.0%	61.2
LDPE (#4)	0.0%	0.0%	4.0
PP (#5) Bottles and Jars	0.1%	0.1%	153.0
PP (#5) Small Other Rigid Plastics	0.3%	0.2%	382.1
PS Rigid Plastics	0.2%	0.1%	207.3
FOAM PLASTIC	**0.3%**	**0.1%**	**324.0**
EPS Food Packaging	0.0%	0.0%	38.3
EPS Foam Blocks and Shapes	0.3%	0.1%	285.7
NON-RECYCLABLE PLASTIC	**1.9%**	**0.7%**	**2,154.9**
Bulky Rigid Plastics	0.4%	0.5%	443.9
Compostable Plastics	0.0%	0.0%	27.4
Other Plastic	1.5%	0.5%	1,683.6
FILM PLASTIC	**2.1%**	**0.6%**	**2,378.7**
Clean Plastic Bags Film	0.5%	0.3%	609.3
Disposal Bags	0.7%	0.3%	833.2
Other Plastic Film	0.8%	0.2%	936.2
ORGANICS	**1.6%**	**0.5%**	**1,777.0**
Edible Food	1.0%	0.4%	1,121.6
Non-edible Food	0.5%	0.4%	551.8
Other Compostables	0.0%	0.0%	2.1
Yard Debris	0.1%	0.1%	101.6
CONTAMINANTS	**2.4%**	**1.0%**	**2,670.9**
Tanglers	0.0%	0.0%	39.5
Household Hazardous Waste	0.1%	0.1%	121.2
Electronics and Small Appliances	0.6%	0.7%	641.0
Diapers	0.1%	0.1%	149.2
Textiles Shoes	0.3%	0.2%	305.4
Construction and Demolition Debri	0.3%	0.2%	340.6
Furniture	0.0%	0.0%	33.4
Mixed Residue	0.9%	0.3%	1,040.6
TOTAL	**100.0%**		**112,855**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.3. Composition of MRF Rejected Materials

The waste composition of the MRF rejected material is the weighted average of **26 samples** from the participating facilities.[8]

Key Findings

- More than one-third of MRF rejected material were considered Recyclable (35.7% and 7,105 tons), 11.8 percent (2,342 tons) was Potentially Recyclable, and 52.5 percent (10,436 tons) was Contaminants (Figure 20).
- **Recyclable Paper** (27.7%) constituted more than one-quarter of the MRF rejected material stream. Specifically, *Mixed Paper* (22.2%) accounted for about one-fifth of the MRF rejected material stream (Figure 21).
- **Contaminants** (23.0%) formed nearly one-quarter of the MRF rejected material stream.
- **Non-Recyclable Paper** (12.0%), composed of *Compostable Paper* (5.5%) and *Other Paper* (6.5%), formed the third most prevalent material class in the MRF rejected material stream.
- **Film Plastic** (7.8%) was composed of *Clean Plastic Bags Film* (3.6%) (not accepted in curbside recycling as of 2020), *Disposal Bags* (2.1%), and *Other Film* (2.1%) (Table 18).
- **Non-Recyclable Glass** formed 3.6 percent of the MRF rejected material stream.
- **Organics** (3.3%) was composed primarily of *Edible Food* (3.2%).

[8] The MRFs do not process materials smaller than 3 inches, but the research crew for this project sorted materials in greater detail. In the study, material smaller than 3 inches was categorized by its material type (e.g., plastic caps and lids less than 3 inches were placed in "Other Plastics" category). Materials that were indistinguishable were categorized as "*Mixed Residue.*" Accordingly, the data for rejected material may not match system sort realities, meaning that some items of a recyclable material type are not actually recyclable at the MRF due to their small size.

Figure 20. Composition by Recyclability Group – MRF Rejected Material

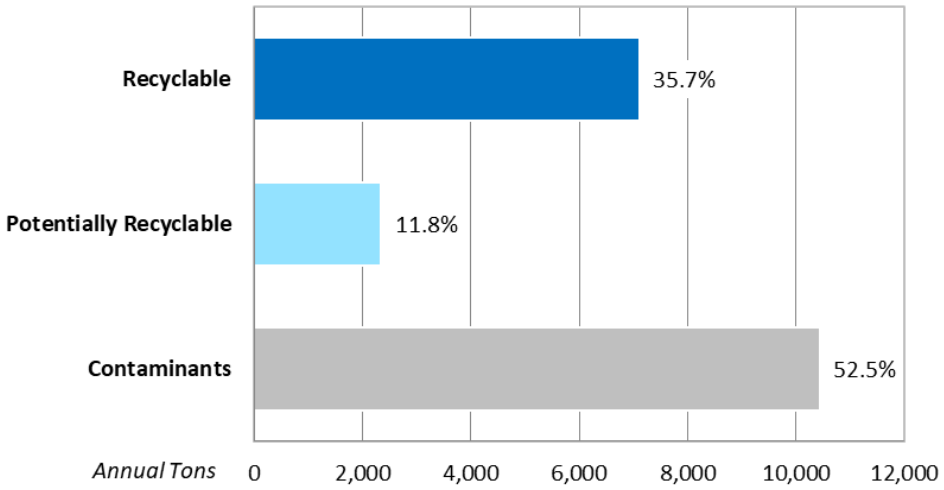


Figure 21. Composition by Material Class – MRF Rejected Material

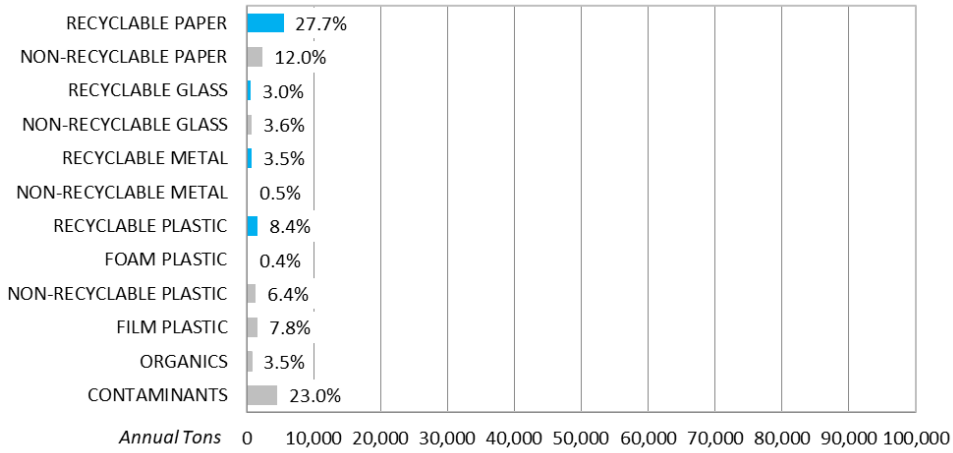


Table 17. Ten Most Prevalent Materials – MRF Rejected Material

Material	Est. Percent	Est. Tons
Mixed Paper	22.2%	4,422
Mixed Residue	11.7%	2,329
Other Paper	6.5%	1,300
Textiles Shoes	6.2%	1,224
Other Plastic	5.9%	1,167
Compostable Paper	5.5%	1,087
Cardboard	4.6%	919
Other Glass	3.6%	725
Clean Plastic Bags Film	3.6%	724
Edible Food	3.2%	639
Total for Top Materials	**73.1%**	**14,535**

Table 18. Composition by Material Type – MRF Rejected Material

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**27.7%**	**12.5%**	**5,508.6**
Cardboard	4.6%	2.3%	919.0
Newspaper	0.5%	0.6%	105.4
Aseptic and Gable Top Cartons	0.3%	0.2%	62.5
Mixed Paper	22.2%	10.8%	4,421.8
NON-RECYCLABLE PAPER	**12.0%**	**5.9%**	**2,386.6**
Compostable Paper	5.5%	4.0%	1,086.5
Other Paper	6.5%	3.8%	1,300.1
RECYCLABLE GLASS	**3.0%**	**1.9%**	**602.8**
Glass Containers	3.0%	1.9%	602.8
NON-RECYCLABLE GLASS	**3.6%**	**2.9%**	**724.7**
Other Glass	3.6%	2.9%	724.7
RECYCLABLE METAL	**3.5%**	**3.3%**	**699.1**
Aluminum Cans	1.0%	0.3%	194.7
Aluminum Foil and Trays	1.8%	2.7%	366.9
Tin Food Cans	0.6%	0.6%	124.0
Empty Aerosol Cans	0.1%	0.1%	13.5
NON-RECYCLABLE METAL	**0.5%**	**0.3%**	**104.5**
Other Metal	0.5%	0.3%	104.5
RECYCLABLE PLASTIC	**8.4%**	**3.9%**	**1,674.0**
PET (#1) Bottles and Jars	2.7%	1.0%	530.9
PET (#1) Small Rigid Plastics	0.5%	0.5%	109.3
Clear HDPE Bottles and Jars	0.2%	0.1%	40.6
Colored HDPE (#2) Bottles and Jars	0.5%	0.5%	103.2
HDPE (#2) Other Containers	0.1%	0.1%	10.5
LDPE (#4)	0.0%	0.0%	2.2
PP (#5) Bottles and Jars	1.4%	0.3%	274.4
PP (#5) Small Other Rigid Plastics	2.8%	3.1%	560.4
PS Rigid Plastics	0.2%	0.2%	42.4
FOAM PLASTIC	**0.4%**	**0.2%**	**77.1**
EPS Food Packaging	0.3%	0.2%	50.0
EPS Foam Blocks and Shapes	0.1%	0.1%	27.1
NON-RECYCLABLE PLASTIC	**6.4%**	**2.7%**	**1,273.5**
Bulky Rigid Plastics	0.1%	0.1%	15.8
Compostable Plastics	0.5%	0.4%	90.6
Other Plastic	5.9%	2.6%	1,167.0
FILM PLASTIC	**7.8%**	**3.5%**	**1,551.9**
Clean Plastic Bags Film	3.6%	2.8%	723.8
Disposal Bags	2.1%	1.0%	408.5
Other Plastic Film	2.1%	0.9%	419.6
ORGANICS	**3.5%**	**2.2%**	**698.7**
Edible Food	3.2%	2.2%	638.9
Non-edible Food	0.0%	0.0%	1.4
Other Compostables	0.1%	0.0%	10.0
Yard Debris	0.2%	0.3%	48.3
CONTAMINANTS	**23.0%**	**11.1%**	**4,580.7**
Tanglers	0.0%	0.0%	1.1
Household Hazardous Waste	0.0%	0.0%	9.4
Electronics and Small Appliances	0.1%	0.1%	14.4
Diapers	1.8%	2.0%	360.4
Textiles Shoes	6.2%	4.0%	1,223.6
Construction and Demolition Debri	1.9%	1.6%	369.3
Furniture	1.4%	2.2%	273.3
Mixed Residue	11.7%	10.0%	2,329.3
TOTAL	**100.0%**		**19,882**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may i due to rounding.

5.4. Estimating Commodity Quantities

A "commodity" generally refers to material processed and sold at a positive revenue by the MRF. After processing, commodity material is typically compacted into uniformly sized parcels or "bales." A commodity bale should be mostly recyclable material(s) that form the commodity; bale specifications may also allow trace contaminants (either other recyclable commodities or non-recyclable material) up to a stated limit. For example, a bale of the commodity Cardboard should consist of mostly the material type *Cardboard*, with or without trace amounts of, for example, *Mixed Paper* or *Other Plastic Film*. For the King County study, Cascadia estimated the quantity and composition of commodity bales generated at the participating MRFs—specifically, of the commodity material for selected commodities of interest (COIs), other COIs, other potentially recyclable materials, and contaminants.

Commodity Definitions

Based on commodity definitions provided by the participating MRFs, Cascadia aligned certain study material types with the commodity types, as shown in Table 19. A commodity sometimes has the same definition as one of the study material types (e.g., Cardboard); in other cases, a commodity is the combination of several material types (e.g., Mixed Paper).

Table 19. Commodity Type Definitions

Commodity Type	Study Material Types Included
Cardboard	*Cardboard*
Mixed Paper	*Newspaper* *Aseptic and Gable Top Cartons* *Mixed Paper*
Aluminum Cans	*Aluminum Cans*
Tin	*Tin Food Cans*
Mixed Metal	*Other Metal*
PET	*PET (#1) Bottles and Jars*
HDPE Natural	*Clear HDPE Bottles and Jars*
HDPE Colored	*Colored HDPE (#2) Bottles and Jars*
Mixed Plastic	*LDPE (#4)* *PP (#5) Bottles and Jars* *PP (#5) Small Other Rigid Plastics* *PS (#6) Rigid Plastics*

Estimating Commodity Quantities

As mentioned in Section 4.3, the MRFs did not provide tonnages sold for each individual commodity. Cascadia estimated the individual commodity tonnages using the following equation to estimate the tonnage of a commodity of interest (COI):

Weight of bale of COI = Weight of COI in the inbound material − Weight of COI in rejected material

These steps provide an example of how to estimate the quantity of the Cardboard commodity bale.

1. The total inbound recyclable material from single-family residential and commercial generators was estimated to be 234,034 tons. About 52 percent (121,179 tons) was generated by single-family residential generators while about 48 percent (112,855) was generated by commercial generators. These estimates were derived from hauler-reported data.
2. *Cardboard* was estimated to be 29.8 percent (36,152 tons) of the inbound single-family residential stream (Table 14 above) and 43.1 percent (48,607 tons) of the inbound commercial stream (Table 16 above). The total quantity of *Cardboard* in the total inbound material (residential plus commercial) was estimated to be 84,758 tons.
3. The total quantity of MRF rejected materials was estimated to be 19,882 tons, based on data reported by participating MRFs. The estimated quantity of *Cardboard* in the MRF rejected material stream was estimated to be 919 tons (Table 18 above).
4. Using the equation above, the difference between inbound *Cardboard* material (84,758 tons) and the rejected *Cardboard* material (919 tons) was calculated to be 83,839 tons. This is the best approximation of the actual quantity of Cardboard commodity bale.

This process was repeated to estimate the approximate quantities of bales of different commodities of interest (Table 20). The total quantity of commodities of interest was estimated at about 163,000 tons.

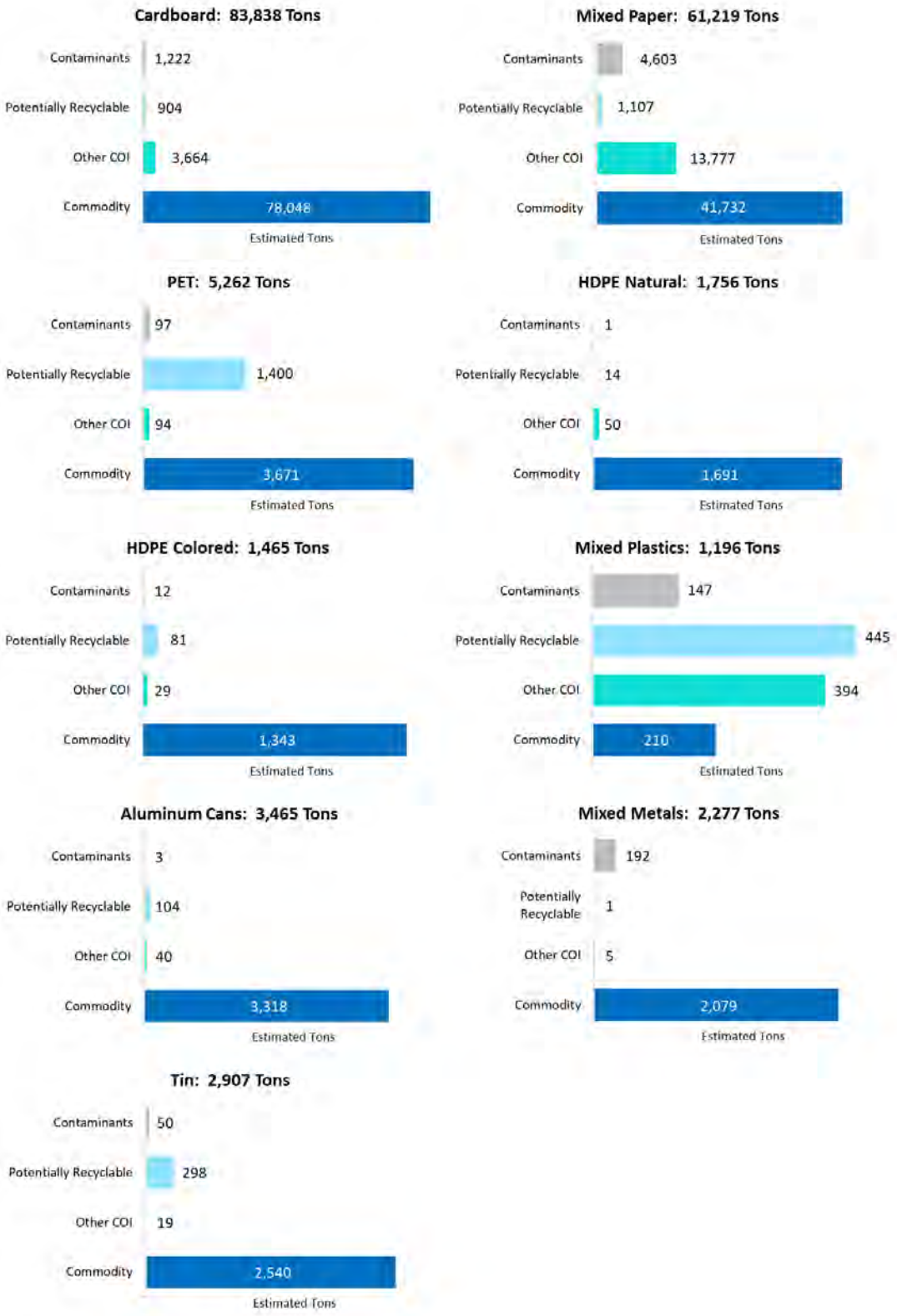
Table 20. Estimating the Quantity of Commodity of Interest (COI) Bale

	A	*B*	*C*	*D*	*E*
Commodity of Interest (CoI)	**Estimated CoI in Inbound (SF residential) (tons)**	**Estimated CoI in Inbound (commercial) (tons)**	**Estimated CoI in Total Inbound (SF+COM) (tons)**	**Estimated CoI in residue (tons)**	**Approximate quantity of CoI bale *(C - D)***
Cardboard	36,152	48,607	84,758	919	83,839
Mixed Paper	35,325	30,484	65,809	4,590	61,219
Aluminum Cans	2,506	1,154	3,660	195	3,466
Tin	1,728	1,302	3,031	124	2,907
Mixed Metal	1,345	1,036	2,381	104	2,277
PET	3,514	2,278	5,792	531	5,261
HDPE Natural	746	1,051	1,796	41	1,756
HDPE Colored	1,037	531	1,569	103	1,466
Mixed Plastic	1,329	746	2,075	879	1,196
Total CoI (Estimated)	**83,683**	**87,189**	**170,872**	**7,486**	**163,386**

This approximation enabled estimation of the quantity of COI in its own bale (e.g., *Cardboard* material in Cardboard commodity bale) and the quantity of COI in other bales (e.g., *Cardboard* material in Mixed Paper commodity bale), as described in Section 5.14. Estimated compositions for individual commodities of interest are described in Section 5.5 through 5.13.

Figure 22 shows the estimated composition of each COI. For example, the commodity Cardboard was 78,048 tons of the targeted material type *Cardboard*; 3,664 tons of other COIs (e.g., Mixed Paper, PET, HPDE Natural); 1,222 tons Contaminants; and 904 tons of Potentially Recyclable materials.

Figure 22. Material Composition for Commodities of Interest[9]



[9] Commodity Glass and commodity Residue were not targeted materials sampled for this study.

5.5. Composition of Commodities – Cardboard

The composition of commodity Cardboard is the weighted average of seven samples taken from participating facilities. The Cardboard commodity bale consists of the *Cardboard* material type. Table 21 shows the ten most prevalent materials found in the Cardboard commodity bale, and Table 22 shows the detailed composition. The targeted material type of the Commodity of Interest is highlighted in green.

Key Findings

- *Cardboard* (93.1%) represented the majority of the Cardboard commodity bale.
- *Mixed Paper* (3.7%) and *Newspaper* (0.5%) were also found in the Cardboard commodity bale. Although these materials have their own separate bale types, they are more compatible with *Cardboard* for MRF processing, compared to non-fiber recyclable materials such as *PP (#5) Small Other Rigid Plastics* or *Other Metal*.
- Essentially no *Glass* (less than 0.01 percent) was found in the Cardboard commodity bale.

Table 21. Ten Most Prevalent Materials, Commodity – Cardboard

Material	Est. Percent	Est. Tons
Cardboard	93.1%	78,049
Mixed Paper	3.7%	3,063
PP (#5) Small Other Rigid Plastics	0.8%	694
Newspaper	0.5%	442
Other Paper	0.5%	409
Textiles Shoes	0.3%	277
Compostable Paper	0.2%	169
Mixed Residue	0.2%	157
Other Metal	0.1%	103
Other Plastic	0.1%	93
Total for Top Materials	**99.5%**	**83,454**

Table 22. Composition of Commodity – Cardboard

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**97.3%**	**0.9%**	**81,576.7**
Cardboard	93.1%	3.0%	78,048.7
Newspaper	0.5%	0.4%	441.9
Aseptic and Gable Top Cartons	0.0%	0.0%	22.9
Mixed Paper	3.7%	2.1%	3,063.3
NON-RECYCLABLE PAPER	**0.7%**	**0.7%**	**577.4**
Compostable Paper	0.2%	0.1%	168.8
Other Paper	0.5%	0.7%	408.6
RECYCLABLE GLASS	**0.0%**	**0.0%**	**4.0**
Glass Containers	0.0%	0.0%	4.0
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**0.1%**	**0.0%**	**59.1**
Aluminum Cans	0.0%	0.0%	34.3
Aluminum Foil and Trays	0.0%	0.0%	-
Tin Food Cans	0.0%	0.0%	24.8
Empty Aerosol Cans	0.0%	0.0%	-
NON-RECYCLABLE METAL	**0.1%**	**0.0%**	**102.5**
Other Metal	0.1%	0.0%	102.5
RECYCLABLE PLASTIC	**0.9%**	**0.1%**	**792.9**
PET (#1) Bottles and Jars	0.1%	0.0%	61.1
PET (#1) Small Rigid Plastics	0.0%	0.0%	25.4
Clear HDPE Bottles and Jars	0.0%	0.0%	10.7
Colored HDPE (#2) Bottles and Jars	0.0%	0.0%	1.3
HDPE (#2) Other Containers	0.0%	0.0%	-
LDPE (#4)	0.0%	0.0%	-
PP (#5) Bottles and Jars	0.0%	0.0%	-
PP (#5) Small Other Rigid Plastics	0.8%	0.0%	693.7
PS Rigid Plastics	0.0%	0.0%	0.7
FOAM PLASTIC	**0.0%**	**0.0%**	**31.8**
EPS Food Packaging	0.0%	0.0%	29.0
EPS Foam Blocks and Shapes	0.0%	0.0%	2.8
NON-RECYCLABLE PLASTIC	**0.1%**	**0.0%**	**93.0**
Bulky Rigid Plastics	0.0%	0.0%	-
Compostable Plastics	0.0%	0.0%	-
Other Plastic	0.1%	0.0%	93.0
FILM PLASTIC	**0.1%**	**0.0%**	**97.7**
Clean Plastic Bags Film	0.1%	0.0%	79.2
Disposal Bags	0.0%	0.0%	4.2
Other Plastic Film	0.0%	0.0%	14.3
ORGANICS	**0.0%**	**0.0%**	**8.0**
Edible Food	0.0%	0.0%	7.4
Non-edible Food	0.0%	0.0%	-
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	0.7
CONTAMINANTS	**0.6%**	**0.2%**	**496.1**
Tanglers	0.1%	0.1%	47.1
Household Hazardous Waste	0.0%	0.0%	2.7
Electronics and Small Appliances	0.0%	0.0%	-
Diapers	0.0%	0.0%	12.7
Textiles Shoes	0.3%	0.0%	276.8
Construction and Demolition Debri	0.0%	0.0%	-
Furniture	0.0%	0.0%	-
Mixed Residue	0.2%	0.1%	156.8
TOTAL	**100.0%**		**83,839**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may d due to rounding.

5.6. Composition of Commodities – Mixed Paper

The composition of commodity Mixed Paper is the weighted average of seven commodity samples taken at participating facilities. The Mixed Paper commodity bale includes the *Newspaper*, *Aseptic and Gable Top Cartons*, and *Mixed Paper* material types. Table 23 shows the ten most prevalent materials found in the commodity bale. Table 24 shows the detailed composition of the commodity bale. The targeted material types of the Commodity of Interest are highlighted in green.[10]

Key Findings

- About 68.2 percent of the Mixed Paper bale was *Mixed Paper* (52.5%), *Newspaper* (14.5%), and *Aseptic and Gable Top Cartons* (1.2%) material types.
- *Cardboard* formed about one-fifth (19.8%) of the Mixed Paper bale. Although *Cardboard* has its own separate bale type, for MRF processing, *Cardboard* is more compatible with the Mixed Paper commodity than plastic materials such as *PET (#1) Bottles and Jars* or *PET (#1) Small Rigid Plastics*.
- The **Recyclable Plastic** (3.3%) material class found in the Mixed Paper bale included mostly *PET (#1) Bottles and Jars* (1.6%).
- The **Film Plastic** (1.8%) material class found in the bale was mostly *Other Plastic Film* (1.3%).

Table 23. Ten Most Prevalent Materials, Commodity – Mixed Paper

Material	Est. Percent	Est. Tons
Mixed Paper	52.5%	32,111
Cardboard	19.8%	12,128
Newspaper	14.5%	8,905
Other Paper	2.8%	1,738
PET (#1) Bottles and Jars	1.6%	980
Other Plastic	1.5%	906
Other Plastic Film	1.3%	806
Aseptic and Gable Top Cartons	1.2%	716
Compostable Paper	0.6%	394
PET (#1) Small Rigid Plastics	0.4%	241
Total for Top Materials	**96.3%**	**58,925**

[10] One MRF reported that some markets accept *Cardboard* in Mixed Paper bales. This is important to note because *Cardboard* represents a significant portion of the Mixed Paper commodity and removing small pieces of *Cardboard* during processing can be a challenge for MRFs.

Table 24. Composition of Commodity – Mixed Paper

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**88.0%**	**3.4%**	**53,860.3**
Cardboard	19.8%	1.7%	12,128.2
Newspaper	14.5%	4.0%	8,905.2
Aseptic and Gable Top Cartons	1.2%	0.1%	715.6
Mixed Paper	52.5%	3.8%	32,111.3
NON-RECYCLABLE PAPER	**3.5%**	**3.4%**	**2,132.3**
Compostable Paper	0.6%	0.2%	394.3
Other Paper	2.8%	3.4%	1,738.0
RECYCLABLE GLASS	**0.0%**	**0.0%**	**1.3**
Glass Containers	0.0%	0.0%	1.3
NON-RECYCLABLE GLASS	**0.1%**	**0.1%**	**71.7**
Other Glass	0.1%	0.1%	71.7
RECYCLABLE METAL	**0.7%**	**0.1%**	**431.3**
Aluminum Cans	0.3%	0.1%	213.4
Aluminum Foil and Trays	0.0%	0.1%	28.5
Tin Food Cans	0.3%	0.0%	172.3
Empty Aerosol Cans	0.0%	0.0%	17.0
NON-RECYCLABLE METAL	**0.2%**	**0.0%**	**98.9**
Other Metal	0.2%	0.0%	98.9
RECYCLABLE PLASTIC	**3.3%**	**0.4%**	**1,998.6**
PET (#1) Bottles and Jars	1.6%	0.3%	980.0
PET (#1) Small Rigid Plastics	0.4%	0.1%	240.7
Clear HDPE Bottles and Jars	0.1%	0.1%	50.7
Colored HDPE (#2) Bottles and Jars	0.4%	0.0%	231.0
HDPE (#2) Other Containers	0.3%	0.0%	193.5
LDPE (#4)	0.1%	0.0%	84.8
PP (#5) Bottles and Jars	0.0%	0.0%	-
PP (#5) Small Other Rigid Plastics	0.3%	0.1%	158.6
PS Rigid Plastics	0.1%	0.0%	59.2
FOAM PLASTIC	**0.2%**	**0.0%**	**123.6**
EPS Food Packaging	0.1%	0.0%	80.9
EPS Foam Blocks and Shapes	0.1%	0.0%	42.7
NON-RECYCLABLE PLASTIC	**1.6%**	**0.1%**	**996.9**
Bulky Rigid Plastics	0.0%	0.0%	-
Compostable Plastics	0.1%	0.0%	90.6
Other Plastic	1.5%	0.1%	906.3
FILM PLASTIC	**1.8%**	**0.1%**	**1,072.0**
Clean Plastic Bags Film	0.2%	0.1%	92.5
Disposal Bags	0.3%	0.0%	174.0
Other Plastic Film	1.3%	0.2%	805.5
ORGANICS	**0.2%**	**0.0%**	**92.7**
Edible Food	0.0%	0.0%	12.8
Non-edible Food	0.0%	0.0%	-
Other Compostables	0.0%	0.0%	-
Yard Debris	0.1%	0.0%	79.9
CONTAMINANTS	**0.6%**	**0.3%**	**339.3**
Tanglers	0.0%	0.0%	3.5
Household Hazardous Waste	0.0%	0.0%	-
Electronics and Small Appliances	0.0%	0.0%	5.2
Diapers	0.1%	0.0%	32.5
Textiles Shoes	0.2%	0.1%	97.6
Construction and Demolition Debri	0.0%	0.0%	2.6
Furniture	0.0%	0.0%	-
Mixed Residue	0.3%	0.1%	197.8
TOTAL	**100.0%**		**61,219**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.7. Composition of Commodities – PET

The composition of PET plastic commodity is the weighted average of eight commodity samples taken at participating facilities. The PET commodity bale consists of the *PET (#1) Bottles and Jars* material type. Table 25 shows the ten most prevalent materials found in the commodity bale and Table 26 shows the detailed composition. The targeted material type of the Commodity of Interest is highlighted in green.

Key Findings

- *PET (#1) Bottles and Jars* (70%) was the majority of the commodity PET bale, followed by *PET (#1) Small Rigid Plastics* (25.7%). Together, these two material types formed over 95 percent of the PET bale.
- The PET commodity bale is intended to consist of the *PET (#1) Bottles and Jars* material type. The material type *PET (#1) Small Rigid Plastics* is considered more compatible with the PET bale in MRF processing than other non-PET materials such as *Mixed Paper* or *Aluminum Cans*.

Table 25. Ten Most Prevalent Materials, Commodity – PET

Material	Est. Percent	Est. Tons
PET (#1) Bottles and Jars	69.8%	3,671
PET (#1) Small Rigid Plastics	25.7%	1,351
Other Plastic	1.1%	59
Mixed Paper	0.6%	33
HDPE (#2) Other Containers	0.6%	32
Colored HDPE (#2) Bottles and Jars	0.4%	22
Aluminum Cans	0.4%	21
Mixed Residue	0.2%	13
Other Plastic Film	0.1%	7
EPS Foam Blocks and Shapes	0.1%	7
Total for Top Materials	**99.1%**	**5,216**

Table 26. Composition of Commodity – PET

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**0.8%**	**0.1%**	**43.6**
Cardboard	0.1%	0.0%	4.5
Newspaper	0.1%	0.0%	3.4
Aseptic and Gable Top Cartons	0.1%	0.1%	2.9
Mixed Paper	0.6%	0.1%	32.9
NON-RECYCLABLE PAPER	**0.1%**	**0.1%**	**6.3**
Compostable Paper	0.1%	0.1%	4.4
Other Paper	0.0%	0.0%	2.0
RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Glass Containers	0.0%	0.0%	-
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**0.4%**	**0.1%**	**21.6**
Aluminum Cans	0.4%	0.1%	21.3
Aluminum Foil and Trays	0.0%	0.0%	-
Tin Food Cans	0.0%	0.0%	-
Empty Aerosol Cans	0.0%	0.0%	0.3
NON-RECYCLABLE METAL	**0.0%**	**0.0%**	**-**
Other Metal	0.0%	0.0%	-
RECYCLABLE PLASTIC	**96.7%**	**0.4%**	**5,089.0**
PET (#1) Bottles and Jars	69.8%	4.2%	3,670.7
PET (#1) Small Rigid Plastics	25.7%	4.3%	1,351.1
Clear HDPE Bottles and Jars	0.1%	0.0%	6.6
Colored HDPE (#2) Bottles and Jars	0.4%	0.2%	22.1
HDPE (#2) Other Containers	0.6%	1.1%	32.1
LDPE (#4)	0.0%	0.0%	0.3
PP (#5) Bottles and Jars	0.0%	0.0%	1.1
PP (#5) Small Other Rigid Plastics	0.1%	0.1%	5.1
PS Rigid Plastics	0.0%	0.0%	0.1
FOAM PLASTIC	**0.2%**	**0.1%**	**12.9**
EPS Food Packaging	0.1%	0.0%	6.0
EPS Foam Blocks and Shapes	0.1%	0.1%	6.9
NON-RECYCLABLE PLASTIC	**1.1%**	**0.2%**	**59.3**
Bulky Rigid Plastics	0.0%	0.0%	0.2
Compostable Plastics	0.0%	0.0%	-
Other Plastic	1.1%	0.2%	59.2
FILM PLASTIC	**0.2%**	**0.0%**	**10.7**
Clean Plastic Bags Film	0.1%	0.0%	3.4
Disposal Bags	0.0%	0.0%	-
Other Plastic Film	0.1%	0.0%	7.3
ORGANICS	**0.1%**	**0.1%**	**4.1**
Edible Food	0.1%	0.1%	3.5
Non-edible Food	0.0%	0.0%	0.6
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	-
CONTAMINANTS	**0.3%**	**0.2%**	**13.9**
Tanglers	0.0%	0.0%	0.2
Household Hazardous Waste	0.0%	0.0%	-
Electronics and Small Appliances	0.0%	0.0%	-
Diapers	0.0%	0.0%	-
Textiles Shoes	0.0%	0.0%	0.4
Construction and Demolition Debri	0.0%	0.0%	0.5
Furniture	0.0%	0.0%	-
Mixed Residue	0.2%	0.2%	12.8
TOTAL	**100.0%**		**5,261**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may n due to rounding.

5.8. Composition of Commodities – HDPE Natural

The composition of commodity HDPE Natural is the weighted average of eight commodity samples taken at participating facilities. The HDPE Natural commodity bale consists of the *Clear HDPE (#2) Bottles and Jars* material type. Table 27 shows the ten most prevalent materials found in the commodity bale and Table 28 shows the detailed composition. The targeted material type of the Commodity of Interest is highlighted in green.

Key Findings

- *Clear HDPE (#2) Bottles and Jars* (96.3%) formed the majority of the HDPE Natural commodity bale.
- Minimal amounts of *Colored HDPE (#2) Bottles and Jars* (2.4%) and *HDPE Other Containers* (0.6%) were found mixed in the commodity HDPE Natural.
- About 2.4 percent of the HDPE Natural commodity bale is composed of *Colored HDPE (#2) Bottles and Jars* material type. Although this material has its own separate bale type, it is relatively compatible with the HDPE Natural commodity bale in these small quantities. Incompatible material types, such as *Cardboard* and *Tin Food Cans*, were present only in minute quantities, of 0.2 percent or less.

Table 27. Ten Most Prevalent Materials, Commodity – HDPE Natural

Material	Est. Percent	Est. Tons
Clear HDPE Bottles and Jars	96.3%	1,691
Colored HDPE (#2) Bottles and Jars	2.4%	42
HDPE (#2) Other Containers	0.6%	11
Cardboard	0.2%	3
Tin Food Cans	0.1%	2
Clean Plastic Bags Film	0.1%	1
Aluminum Cans	0.1%	1
Mixed Paper	0.0%	1
PET (#1) Bottles and Jars	0.0%	1
Other Plastic Film	0.0%	0
Total for Top Materials	**99.9%**	**1,754**

Table 28. Composition of Commodity – HDPE Natural

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**0.2%**	**0.2%**	**3.7**
Cardboard	0.2%	0.2%	3.0
Newspaper	0.0%	0.0%	-
Aseptic and Gable Top Cartons	0.0%	0.0%	-
Mixed Paper	0.0%	0.1%	0.8
NON-RECYCLABLE PAPER	**0.0%**	**0.0%**	**0.1**
Compostable Paper	0.0%	0.0%	-
Other Paper	0.0%	0.0%	0.1
RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Glass Containers	0.0%	0.0%	-
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**0.2%**	**0.1%**	**3.6**
Aluminum Cans	0.1%	0.1%	1.2
Aluminum Foil and Trays	0.0%	0.0%	0.0
Tin Food Cans	0.1%	0.0%	2.5
Empty Aerosol Cans	0.0%	0.0%	-
NON-RECYCLABLE METAL	**0.0%**	**0.0%**	**-**
Other Metal	0.0%	0.0%	-
RECYCLABLE PLASTIC	**99.4%**	**0.0%**	**1,745.4**
PET (#1) Bottles and Jars	0.0%	0.0%	0.7
PET (#1) Small Rigid Plastics	0.0%	0.0%	0.0
Clear HDPE Bottles and Jars	96.3%	3.5%	1,690.6
Colored HDPE (#2) Bottles and Jars	2.4%	2.7%	42.3
HDPE (#2) Other Containers	0.6%	0.3%	11.3
LDPE (#4)	0.0%	0.0%	-
PP (#5) Bottles and Jars	0.0%	0.0%	0.0
PP (#5) Small Other Rigid Plastics	0.0%	0.0%	0.4
PS Rigid Plastics	0.0%	0.0%	-
FOAM PLASTIC	**0.0%**	**0.0%**	**0.4**
EPS Food Packaging	0.0%	0.0%	-
EPS Foam Blocks and Shapes	0.0%	0.0%	0.4
NON-RECYCLABLE PLASTIC	**0.0%**	**0.0%**	**0.3**
Bulky Rigid Plastics	0.0%	0.0%	-
Compostable Plastics	0.0%	0.0%	-
Other Plastic	0.0%	0.0%	0.3
FILM PLASTIC	**0.1%**	**0.0%**	**1.9**
Clean Plastic Bags Film	0.1%	0.0%	1.4
Disposal Bags	0.0%	0.0%	-
Other Plastic Film	0.0%	0.0%	0.5
ORGANICS	**0.0%**	**0.0%**	**-**
Edible Food	0.0%	0.0%	-
Non-edible Food	0.0%	0.0%	-
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	-
CONTAMINANTS	**0.0%**	**0.0%**	**0.1**
Tanglers	0.0%	0.0%	-
Household Hazardous Waste	0.0%	0.0%	-
Electronics and Small Appliances	0.0%	0.0%	-
Diapers	0.0%	0.0%	-
Textiles Shoes	0.0%	0.0%	-
Construction and Demolition Debri	0.0%	0.0%	-
Furniture	0.0%	0.0%	-
Mixed Residue	0.0%	0.0%	0.1
TOTAL	**100.0%**		**1,756**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.9. Composition of Commodities – HDPE Colored

The composition of commodity HDPE Colored is the weighted average of five commodity samples taken at participating facilities. The HDPE Colored commodity bale consists of the *Colored HDPE (#2) Bottles and Jars* material type. Table 29 shows the ten most prevalent materials found in the commodity bale. Table 30 shows the detailed composition of the commodity bale. The targeted material type of the Commodity of Interest is highlighted in green.

Key Findings

- *Clear HDPE (#2) Bottles and Jars* (91.6%) formed the majority of the commodity HDPE Colored.
- Other plastic material types in the **Recyclable Plastic** material class collectively formed about 5.1 percent of the HDPE Colored bale.
- About 2.9 percent of the HDPE Colored commodity bale is composed of *HDPE (#2) Other Containers* material type. For MRF processing, this material type is relatively more compatible with the HDPE Colored commodity bale than non-HDPE materials such as *Mixed Paper*, which was present only in minute amounts, at 0.1 percent.

Table 29. Ten Most Prevalent Materials, Commodity – HDPE Colored

Material	Est. Percent	Est. Tons
Colored HDPE (#2) Bottles and Jars	91.6%	1,343
HDPE (#2) Other Containers	2.9%	42
Bulky Rigid Plastics	2.2%	32
Clear HDPE Bottles and Jars	1.5%	23
Other Plastic	0.6%	8
PET (#1) Bottles and Jars	0.3%	4
PP (#5) Small Other Rigid Plastics	0.2%	3
Mixed Paper	0.1%	2
Other Paper	0.1%	1
LDPE (#4)	0.1%	1
Total for Top Materials	**99.6%**	**1,460**

Table 30. Composition of Commodity – HDPE Colored

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**0.2%**	**0.0%**	**2.3**
Cardboard	0.0%	0.0%	-
Newspaper	0.0%	0.0%	0.2
Aseptic and Gable Top Cartons	0.0%	0.0%	0.2
Mixed Paper	0.1%	0.0%	1.9
NON-RECYCLABLE PAPER	**0.1%**	**0.1%**	**2.1**
Compostable Paper	0.0%	0.0%	0.7
Other Paper	0.1%	0.1%	1.4
RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Glass Containers	0.0%	0.0%	-
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**0.0%**	**0.0%**	**0.2**
Aluminum Cans	0.0%	0.0%	0.2
Aluminum Foil and Trays	0.0%	0.0%	0.0
Tin Food Cans	0.0%	0.0%	0.0
Empty Aerosol Cans	0.0%	0.0%	-
NON-RECYCLABLE METAL	**0.0%**	**0.0%**	**-**
Other Metal	0.0%	0.0%	-
RECYCLABLE PLASTIC	**96.8%**	**0.5%**	**1,418.7**
PET (#1) Bottles and Jars	0.3%	0.1%	4.2
PET (#1) Small Rigid Plastics	0.0%	0.0%	0.1
Clear HDPE Bottles and Jars	1.5%	0.6%	22.5
Colored HDPE (#2) Bottles and Jars	91.6%	0.8%	1,343.2
HDPE (#2) Other Containers	2.9%	0.4%	42.4
LDPE (#4)	0.1%	0.0%	1.3
PP (#5) Bottles and Jars	0.1%	0.1%	1.0
PP (#5) Small Other Rigid Plastics	0.2%	0.2%	3.3
PS Rigid Plastics	0.0%	0.0%	0.6
FOAM PLASTIC	**0.0%**	**0.0%**	**0.2**
EPS Food Packaging	0.0%	0.0%	0.0
EPS Foam Blocks and Shapes	0.0%	0.0%	0.2
NON-RECYCLABLE PLASTIC	**2.7%**	**0.3%**	**39.9**
Bulky Rigid Plastics	2.2%	0.1%	31.8
Compostable Plastics	0.0%	0.0%	-
Other Plastic	0.6%	0.3%	8.1
FILM PLASTIC	**0.1%**	**0.0%**	**0.9**
Clean Plastic Bags Film	0.0%	0.0%	0.0
Disposal Bags	0.0%	0.0%	0.1
Other Plastic Film	0.1%	0.0%	0.7
ORGANICS	**0.0%**	**0.0%**	**0.1**
Edible Food	0.0%	0.0%	-
Non-edible Food	0.0%	0.0%	0.1
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	0.1
CONTAMINANTS	**0.1%**	**0.1%**	**1.3**
Tanglers	0.0%	0.0%	-
Household Hazardous Waste	0.0%	0.0%	0.1
Electronics and Small Appliances	0.0%	0.0%	-
Diapers	0.0%	0.0%	-
Textiles Shoes	0.0%	0.0%	0.2
Construction and Demolition Debri	0.0%	0.0%	0.1
Furniture	0.0%	0.0%	-
Mixed Residue	0.1%	0.0%	0.9
TOTAL	**100.0%**		**1,466**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.10. Composition of Commodities – Mixed Plastics

The composition of commodity Mixed Plastics is the weighted average of nine commodity samples taken at participating facilities. The Mixed Plastics commodity bale includes the *LDPE (#4)*, *PP (#5) Bottles and Jars*, *PP (#5) Small Other Rigid Plastics*, and *PS (#6) Rigid Plastics* material types. Table 31 shows the ten most prevalent materials found in the commodity bale. Table 32 shows the detailed composition of the commodity bale. The targeted material types of the Commodity of Interest are highlighted in green.

Key Findings

- Only 17 percent of commodity Mixed Plastics was the targeted material types (*PP (#5) Bottles and Jars* and *PP (#5) Small Other Rigid Plastics)*. Other plastic material types represented the majority of materials.
- *Bulky Rigid Plastics* (30.8%) was the most prevalent material type in the Mixed Plastics bale, though *Bulky Rigid Plastics* were not categorized as a targeted material type in the Mixed Plastics commodity bale.
- Two PET material types—*PET (#1) Bottles and Jars* (7.6%) and *PET (#1) Small Rigid Plastics* (5.4%)—formed 13 percent of the Mixed Plastics commodity bale.
- The top ten most prevalent materials in the Mixed Plastics bale included one non-plastic material type (*Mixed Paper*, 2.8%) and one film plastic material type (*Other Plastic Film*, 2.7%).

Table 31. Ten Most Prevalent Materials, Commodity – Mixed Plastics

Material	Est. Percent	Est. Tons
Bulky Rigid Plastics	30.8%	368
Clear HDPE Bottles and Jars	11.0%	131
PP (#5) Bottles and Jars	10.8%	129
Colored HDPE (#2) Bottles and Jars	9.5%	114
Other Plastic	8.4%	101
PET (#1) Bottles and Jars	7.6%	91
PP (#5) Small Other Rigid Plastics	5.6%	67
PET (#1) Small Rigid Plastics	5.4%	64
Mixed Paper	2.8%	33
Other Plastic Film	2.7%	32
Total for Top Materials	**94.5%**	**1,130**

Table 32. Composition of Commodity – Mixed Plastics

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**3.7%**	**0.2%**	**44.5**
Cardboard	0.5%	0.0%	6.4
Newspaper	0.1%	0.0%	1.0
Aseptic and Gable Top Cartons	0.3%	0.1%	4.2
Mixed Paper	2.8%	0.1%	32.9
NON-RECYCLABLE PAPER	**0.4%**	**0.1%**	**4.7**
Compostable Paper	0.1%	0.0%	0.8
Other Paper	0.3%	0.1%	4.0
RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Glass Containers	0.0%	0.0%	-
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**1.1%**	**0.1%**	**13.6**
Aluminum Cans	1.0%	0.0%	12.3
Aluminum Foil and Trays	0.0%	0.0%	0.0
Tin Food Cans	0.1%	0.1%	1.3
Empty Aerosol Cans	0.0%	0.0%	-
NON-RECYCLABLE METAL	**0.0%**	**0.0%**	**-**
Other Metal	0.0%	0.0%	-
RECYCLABLE PLASTIC	**51.1%**	**19.2%**	**611.0**
PET (#1) Bottles and Jars	7.6%	6.8%	91.0
PET (#1) Small Rigid Plastics	5.4%	0.6%	64.4
Clear HDPE Bottles and Jars	11.0%	8.4%	131.2
Colored HDPE (#2) Bottles and Jars	9.5%	5.8%	114.1
HDPE (#2) Other Containers	0.6%	0.4%	6.7
LDPE (#4)	0.0%	0.0%	0.1
PP (#5) Bottles and Jars	10.8%	2.4%	128.9
PP (#5) Small Other Rigid Plastics	5.6%	3.2%	67.1
PS Rigid Plastics	0.6%	0.2%	7.6
FOAM PLASTIC	**0.8%**	**0.3%**	**9.0**
EPS Food Packaging	0.1%	0.1%	1.7
EPS Foam Blocks and Shapes	0.6%	0.3%	7.3
NON-RECYCLABLE PLASTIC	**39.4%**	**26.9%**	**471.0**
Bulky Rigid Plastics	30.8%	32.9%	368.1
Compostable Plastics	0.2%	0.1%	2.0
Other Plastic	8.4%	4.5%	100.9
FILM PLASTIC	**2.9%**	**0.4%**	**34.7**
Clean Plastic Bags Film	0.2%	0.0%	3.0
Disposal Bags	0.0%	0.0%	0.0
Other Plastic Film	2.7%	0.4%	31.7
ORGANICS	**0.0%**	**0.0%**	**0.5**
Edible Food	0.0%	0.0%	-
Non-edible Food	0.0%	0.0%	0.5
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	-
CONTAMINANTS	**0.6%**	**0.2%**	**7.0**
Tanglers	0.0%	0.0%	0.0
Household Hazardous Waste	0.0%	0.0%	-
Electronics and Small Appliances	0.0%	0.0%	-
Diapers	0.4%	0.0%	4.5
Textiles Shoes	0.0%	0.0%	0.1
Construction and Demolition Debri	0.1%	0.2%	1.7
Furniture	0.0%	0.0%	-
Mixed Residue	0.1%	0.0%	0.7
TOTAL	**100.0%**		**1,196**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.11. Composition of Commodities – Aluminum Cans

The composition of commodity Aluminum Cans is the weighted average of eight commodity samples taken at participating facilities. The Aluminum commodity bale consists of the *Aluminum Cans* material type. Table 33 shows the ten most prevalent materials found in the commodity bale and Table 34 shows the detailed composition. The targeted material type of the Commodity of Interest is highlighted in green.

Key Findings

- *Aluminum Cans* (95.8%) formed the majority of the Aluminum Cans commodity bale.
- Other types of aluminum containers, such as *Aluminum Foil and Trays* (1.8%) and *Empty Aerosol Cans* (0.6%) were the most prevalent other materials found in the Aluminum Cans bale.
- Other non-Aluminum material types—*Tin Food Cans* (0.5%), *Mixed Paper* (0.4%), *PET (#1) Bottle and Jars* (0.2%), *PET (#1) Small Rigid Plastics* (0.2%), *PS Rigid Plastics* (0.1%), and *Other Paper* (0.1%)—were present at 0.5 percent or less.

Table 33. Ten Most Prevalent Materials, Commodity – Aluminum Cans

Material	Est. Percent	Est. Tons
Aluminum Cans	95.8%	3,319
Aluminum Foil and Trays	1.8%	61
Empty Aerosol Cans	0.6%	22
Tin Food Cans	0.5%	18
Mixed Paper	0.4%	14
Other Metal	0.3%	11
PET (#1) Bottles and Jars	0.2%	7
PET (#1) Small Rigid Plastics	0.2%	5
PS Rigid Plastics	0.1%	2
Other Paper	0.1%	2
Total for Top Materials	**99.9%**	**3,461**

Table 34. Composition of Commodity – Aluminum Cans

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**0.4%**	**0.0%**	**14.2**
Cardboard	0.0%	0.0%	-
Newspaper	0.0%	0.0%	-
Aseptic and Gable Top Cartons	0.0%	0.0%	0.4
Mixed Paper	0.4%	0.0%	13.7
NON-RECYCLABLE PAPER	**0.1%**	**0.0%**	**1.8**
Compostable Paper	0.0%	0.0%	0.0
Other Paper	0.1%	0.0%	1.8
RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Glass Containers	0.0%	0.0%	-
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**98.7%**	**0.2%**	**3,420.4**
Aluminum Cans	95.8%	4.3%	3,318.6
Aluminum Foil and Trays	1.8%	2.6%	61.3
Tin Food Cans	0.5%	0.8%	18.1
Empty Aerosol Cans	0.6%	0.9%	22.5
NON-RECYCLABLE METAL	**0.3%**	**0.2%**	**11.0**
Other Metal	0.3%	0.2%	11.0
RECYCLABLE PLASTIC	**0.5%**	**0.1%**	**16.1**
PET (#1) Bottles and Jars	0.2%	0.0%	6.6
PET (#1) Small Rigid Plastics	0.2%	0.0%	5.5
Clear HDPE Bottles and Jars	0.0%	0.0%	0.6
Colored HDPE (#2) Bottles and Jars	0.0%	0.0%	0.4
HDPE (#2) Other Containers	0.0%	0.0%	0.1
LDPE (#4)	0.0%	0.0%	-
PP (#5) Bottles and Jars	0.0%	0.0%	0.9
PP (#5) Small Other Rigid Plastics	0.0%	0.0%	-
PS Rigid Plastics	0.1%	0.0%	2.0
FOAM PLASTIC	**0.0%**	**0.0%**	**0.9**
EPS Food Packaging	0.0%	0.0%	-
EPS Foam Blocks and Shapes	0.0%	0.0%	0.9
NON-RECYCLABLE PLASTIC	**0.0%**	**0.0%**	**0.1**
Bulky Rigid Plastics	0.0%	0.0%	-
Compostable Plastics	0.0%	0.0%	-
Other Plastic	0.0%	0.0%	0.1
FILM PLASTIC	**0.0%**	**0.0%**	**1.1**
Clean Plastic Bags Film	0.0%	0.0%	0.1
Disposal Bags	0.0%	0.0%	-
Other Plastic Film	0.0%	0.0%	1.0
ORGANICS	**0.0%**	**0.0%**	**-**
Edible Food	0.0%	0.0%	-
Non-edible Food	0.0%	0.0%	-
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	-
CONTAMINANTS	**0.0%**	**0.0%**	**0.2**
Tanglers	0.0%	0.0%	0.1
Household Hazardous Waste	0.0%	0.0%	-
Electronics and Small Appliances	0.0%	0.0%	-
Diapers	0.0%	0.0%	-
Textiles Shoes	0.0%	0.0%	0.1
Construction and Demolition Debri	0.0%	0.0%	-
Furniture	0.0%	0.0%	-
Mixed Residue	0.0%	0.0%	-
TOTAL	**100.0%**		**3,466**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.12. Composition of Commodities – Tin

The composition of commodity Tin is the weighted average of six commodity samples taken at participating facilities. The Tin commodity bale consists of the *Tin Food Cans* material type. Table 35 shows the ten most prevalent materials found in the commodity bale and Table 36 shows the detailed composition. The targeted material type of the Commodity of Interest is highlighted in green.

Key Findings

- *Tin Food Cans* (87.4%) represented the majority of the Tin bale.
- *Other Metal* (7.2%) includes materials such as mixed metal items and utensils.
- *Electronics and Small Appliances* and *Aluminum Foil and Trays* each were 1.3 percent of the commodity Tin bale.
- *Household Hazardous Waste* was found at 0.2 percent.

Table 35. Ten Most Prevalent Materials, Commodity – Tin

Material	Est. Percent	Est. Tons
Tin Food Cans	87.4%	2,540
Other Metal	7.2%	210
Empty Aerosol Cans	1.7%	48
Electronics and Small Appliances	1.3%	38
Aluminum Foil and Trays	1.3%	36
Mixed Paper	0.3%	9
Household Hazardous Waste	0.2%	5
Other Paper	0.1%	4
PET (#1) Bottles and Jars	0.1%	4
Clear HDPE Bottles and Jars	0.1%	3
Total for Top Materials	**99.7%**	**2,898**

Table 36. Composition of Commodity – Tin

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**0.3%**	**0.0%**	**8.8**
Cardboard	0.0%	0.0%	-
Newspaper	0.0%	0.0%	0.2
Aseptic and Gable Top Cartons	0.0%	0.0%	-
Mixed Paper	0.3%	0.0%	8.6
NON-RECYCLABLE PAPER	**0.1%**	**0.0%**	**4.2**
Compostable Paper	0.0%	0.0%	0.1
Other Paper	0.1%	0.0%	4.1
RECYCLABLE GLASS	**0.0%**	**0.0%**	**1.0**
Glass Containers	0.0%	0.0%	1.0
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**90.3%**	**0.7%**	**2,625.6**
Aluminum Cans	0.0%	0.0%	1.2
Aluminum Foil and Trays	1.3%	0.0%	36.5
Tin Food Cans	87.4%	1.0%	2,539.6
Empty Aerosol Cans	1.7%	0.3%	48.4
NON-RECYCLABLE METAL	**7.2%**	**0.8%**	**209.9**
Other Metal	7.2%	0.8%	209.9
RECYCLABLE PLASTIC	**0.4%**	**0.1%**	**11.0**
PET (#1) Bottles and Jars	0.1%	0.1%	3.6
PET (#1) Small Rigid Plastics	0.0%	0.0%	0.9
Clear HDPE Bottles and Jars	0.1%	0.0%	3.3
Colored HDPE (#2) Bottles and Jars	0.1%	0.0%	1.5
HDPE (#2) Other Containers	0.0%	0.0%	-
LDPE (#4)	0.0%	0.0%	-
PP (#5) Bottles and Jars	0.0%	0.0%	0.5
PP (#5) Small Other Rigid Plastics	0.0%	0.0%	1.3
PS Rigid Plastics	0.0%	0.0%	-
FOAM PLASTIC	**0.0%**	**0.0%**	**0.1**
EPS Food Packaging	0.0%	0.0%	-
EPS Foam Blocks and Shapes	0.0%	0.0%	0.1
NON-RECYCLABLE PLASTIC	**0.0%**	**0.0%**	**0.8**
Bulky Rigid Plastics	0.0%	0.0%	-
Compostable Plastics	0.0%	0.0%	-
Other Plastic	0.0%	0.0%	0.8
FILM PLASTIC	**0.0%**	**0.0%**	**1.1**
Clean Plastic Bags Film	0.0%	0.0%	0.4
Disposal Bags	0.0%	0.0%	-
Other Plastic Film	0.0%	0.0%	0.7
ORGANICS	**0.0%**	**0.0%**	**-**
Edible Food	0.0%	0.0%	-
Non-edible Food	0.0%	0.0%	-
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	-
CONTAMINANTS	**1.5%**	**1.0%**	**44.3**
Tanglers	0.0%	0.0%	0.3
Household Hazardous Waste	0.2%	0.1%	5.4
Electronics and Small Appliances	1.3%	0.9%	38.5
Diapers	0.0%	0.0%	-
Textiles Shoes	0.0%	0.0%	-
Construction and Demolition Debri	0.0%	0.0%	-
Furniture	0.0%	0.0%	-
Mixed Residue	0.0%	0.0%	-
TOTAL	**100.0%**		**2,907**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may r due to rounding.

5.13. Composition of Commodities – Mixed Metals

The composition of commodity Mixed Metals is the weighted average of four commodity samples taken at participating facilities. The Mixed Metals commodity bale includes items from the *Other Metal* material type such as motors, metal window blinds, metal tableware and utensils. It also includes large electronics that are predominantly metal (e.g., washers and dryers) and other bulky metal items (e.g., patio furniture). Table 37 shows the ten most prevalent materials found in the commodity bale. Table 38 shows the detailed composition of the commodity bale. The targeted material type of the Commodity of Interest is highlighted in green.

Key Findings

- *Other Metal* (73.6%) forms nearly three-quarters of the commodity Mixed Metals.
- *Aluminum Foil and Trays* (16.4%) and *Electronics and Small Appliances* (8.1%) were also prevalent material types.
- *Empty Aerosol Cans* were present at 1.3 percent. All other materials were less than 0.5 percent.

Table 37. Ten Most Prevalent Materials, Commodity – Mixed Metals

Material	Est. Percent	Est. Tons
Other Metal	73.6%	1,676
Aluminum Foil and Trays	16.4%	373
Electronics and Small Appliances	8.1%	183
Empty Aerosol Cans	1.3%	30
Other Plastic	0.4%	9
Colored HDPE (#2) Bottles and Jars	0.1%	3
PET (#1) Bottles and Jars	0.0%	1
PET (#1) Small Rigid Plastics	0.0%	0
Clean Plastic Bags Film	0.0%	0
Bulky Rigid Plastics	0.0%	-
Total for Top Materials	**100.0%**	**2,276**

Table 38. Composition of Commodity – Mixed Metals

Material	Estimated Percent	+ / -	Estimated Tons
RECYCLABLE PAPER	**0.0%**	**0.0%**	**0.1**
Cardboard	0.0%	0.0%	-
Newspaper	0.0%	0.0%	-
Aseptic and Gable Top Cartons	0.0%	0.0%	-
Mixed Paper	0.0%	0.0%	0.1
NON-RECYCLABLE PAPER	**0.0%**	**0.0%**	**-**
Compostable Paper	0.0%	0.0%	-
Other Paper	0.0%	0.0%	-
RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Glass Containers	0.0%	0.0%	-
NON-RECYCLABLE GLASS	**0.0%**	**0.0%**	**-**
Other Glass	0.0%	0.0%	-
RECYCLABLE METAL	**17.7%**	**3.7%**	**403.0**
Aluminum Cans	0.0%	0.0%	0.0
Aluminum Foil and Trays	16.4%	3.4%	372.7
Tin Food Cans	0.0%	0.0%	-
Empty Aerosol Cans	1.3%	0.4%	30.3
NON-RECYCLABLE METAL	**73.6%**	**3.9%**	**1,676.3**
Other Metal	73.6%	3.9%	1,676.3
RECYCLABLE PLASTIC	**0.2%**	**0.0%**	**4.9**
PET (#1) Bottles and Jars	0.0%	0.0%	1.1
PET (#1) Small Rigid Plastics	0.0%	0.0%	0.4
Clear HDPE Bottles and Jars	0.0%	0.0%	-
Colored HDPE (#2) Bottles and Jars	0.1%	0.0%	3.4
HDPE (#2) Other Containers	0.0%	0.0%	-
LDPE (#4)	0.0%	0.0%	-
PP (#5) Bottles and Jars	0.0%	0.0%	-
PP (#5) Small Other Rigid Plastics	0.0%	0.0%	0.1
PS Rigid Plastics	0.0%	0.0%	-
FOAM PLASTIC	**0.0%**	**0.0%**	**-**
EPS Food Packaging	0.0%	0.0%	-
EPS Foam Blocks and Shapes	0.0%	0.0%	-
NON-RECYCLABLE PLASTIC	**0.4%**	**0.1%**	**8.7**
Bulky Rigid Plastics	0.0%	0.0%	-
Compostable Plastics	0.0%	0.0%	-
Other Plastic	0.4%	0.1%	8.7
FILM PLASTIC	**0.0%**	**0.0%**	**0.2**
Clean Plastic Bags Film	0.0%	0.0%	0.2
Disposal Bags	0.0%	0.0%	-
Other Plastic Film	0.0%	0.0%	-
ORGANICS	**0.0%**	**0.0%**	**-**
Edible Food	0.0%	0.0%	-
Non-edible Food	0.0%	0.0%	-
Other Compostables	0.0%	0.0%	-
Yard Debris	0.0%	0.0%	-
CONTAMINANTS	**8.1%**	**1.0%**	**183.4**
Tanglers	0.0%	0.0%	-
Household Hazardous Waste	0.0%	0.0%	-
Electronics and Small Appliances	8.1%	1.0%	183.4
Diapers	0.0%	0.0%	-
Textiles Shoes	0.0%	0.0%	-
Construction and Demolition Debri	0.0%	0.0%	-
Furniture	0.0%	0.0%	-
Mixed Residue	0.0%	0.0%	-
TOTAL	**100.0%**		**2,277**

Confidence intervals calculated at the 90% confidence level. Percentages for material types may due to rounding.

5.14. Commodity Mass Balance

Estimating Commodity Mass Balance

Section 5.4, *Estimating Commodity Quantities*, explains how we estimated the quantities of each throughput commodity type:

Weight of bale of COI = Weight of COI in the inbound material − Weight of COI in rejected material

The calculation above provided an estimate of the total tonnage of each commodity of interest (COI) that was processed and baled (Column E in Table 39). However, that calculation does not differentiate between how much of the COI ended up in the correct bale (e.g., cardboard material in cardboard commodity bale) versus in other bales (e.g., cardboard material in mixed paper commodity bale).

Table 39 is a continuation of Table 20. *Estimating the Quantity of Commodity of Interest (COI) Bale*. It shows how we estimated the quantity of COI in its correct bale and the quantity of COI found in other bale types. The example below shows quantities estimated for the commodity Cardboard.

1. Estimate the approximate quantity of Cardboard commodity baled (Column E).

   84,758 tons − 919 tons = 83,839 tons

2. To calculate the quantity of Cardboard commodity in the correct bale, multiply the approximate quantity of Cardboard commodity baled by the composition of *Cardboard* in the Cardboard commodity bale (Column F).

   83,839 tons * 93.1% = 78,049 tons

3. To calculate the quantity of Cardboard commodity in other bales, multiply the approximate quantity of Cardboard commodity baled by the composition of *Cardboard* in other bales (Column G).

   83,839 tons * 6.9% = 12,142 tons

4. To calculate the estimated throughput Cardboard, sum the estimated quantity of Cardboard commodity in correct bales with the estimated quantity of Cardboard commodity in other bales (Column H).

   78,049 tons + 12,142 tons = 90,191 tons

The total estimated quantity of throughput COI in its own bale and in other bales is given in Column H. The difference between the estimated throughput COIs using inbound and rejected sampling and the total throughput COIs estimated in the composition analysis is shown in Column I. This discrepancy is due to the error range assigned to the composition estimates. It is important to note that all data are estimates as the tonnage provided by haulers and facilities are also estimates. More details regarding this difference are included below at the end of this section.

Table 39. Commodity Quantities (Mass Balance)

	C	*D*	*E*	*F*	*G*	*H*	*I*
Commodity of Interest (CoI)	**Estimated CoI in Total Inbound (SF+COM) (tons)**	**Estimated CoI in residue (tons)**	**Approximate quantity of CoI bale *(C - D)***	**Estimated CoI in CoI bale (tons)**	**Estimated CoI in other bales (tons)**	**Estimated Outbound CoI = Est CoI CoI + Est CoI Oth *(F + G)***	**% difference *(H-E)***
Cardboard	84,758	919	83,839	78,049	12,142	90,191	7.6%
Mixed Paper	65,809	4,590	61,219	41,732	3,631	45,364	-25.9%
Aluminum Cans	3,660	195	3,466	3,319	284	3,602	3.9%
Tin	3,031	124	2,907	2,540	219	2,759	-5.1%
Mixed Metal	2,381	104	2,277	1,676	422	2,099	-7.8%
PET	5,792	531	5,261	3,671	1,148	4,819	-8.4%
HDPE Natural	1,796	41	1,756	1,691	226	1,916	9.2%
HDPE Colored	1,569	103	1,466	1,343	416	1,759	20.0%
Mixed Plastic	2,075	879	1,196	204	1,015	1,219	1.9%
Total CoI (Estimated)	**170,872**	**7,486**	**163,386**	**134,223**	**19,504**	**153,727**	**-5.9%**

The difference between the total throughput COIs estimated using inbound and rejected sampling (163,386 tons) and the total throughput COIs estimated using sampling of commodities (153,727 tons) was 5.9 percent. This difference varied by commodity type; for example, this difference was 1.9 percent for commodity type Mixed Plastic, while it was 25.9 percent for commodity type Mixed Paper.

The difference may have resulted due to a combination of following factors:

1. Absence of throughput commodity tonnage numbers from haulers. For future studies, obtaining throughput commodity tonnages by commodity type will be helpful in developing more accurate estimates of throughput commodity quantities.
2. Approximate overall throughput commodity tonnage numbers are based on assumptions. For example, haulers report that they typically operate combined commercial/multifamily routes and that the inbound commercial material was assumed to contain about 30 percent multifamily material. Because from different sectors cannot be clearly distinguished once they have been mixed into a single load, the hauler-reported inbound commercial tonnage was reduced by 30 percent to estimate the tonnage from commercial sources.
3. The definitions of what constitutes a "commodity" differ across collection companies and MRFs, meaning that while there is significant overlap, their lists of accepted materials for each commodity are not identical. For example, MRFs varied on whether the commodity type PET included only material type *PET (#1) Bottles and Jars* or also included material type *PET (#1) Small Rigid Plastics*. MRFs also varied on whether gable top and aseptic containers were allowed in their Mixed Paper bales. For the purpose of the study, some material types were combined for consistent comparisons across MRFs (e.g., *Newspaper* and *Aseptic and Gable Top Containers* material types were combined to create a uniform definition of the commodity Mixed Paper).
4. The estimated quantities of COI and other materials derived from samples taken from inbound material, rejected material, and throughput may differ from hauler-reported tonnages. The sample data represents the stream being sampled, and the estimates derived from these samples may not match exactly with the hauler-reported tonnages, which are themselves approximations.

5. Sampling data revealed that individual commodities, and their underlying material types, may show noticeable variance in composition that may result in a wider error range associated with the average estimate. For example, the Mixed Paper commodity type contains material type *Newspaper.* The variation in *Newspaper* estimates is shown in Table 40 below.

Table 40. Variability in Estimates

Sample Type	Estimated Percent ± Error range
Inbound residential	3.9% ± 1.0%
Inbound commercial	2.7% ± 1.6%
Residue	0.5% ± 0.6%
Newspaper in "Mixed Paper" commodity bale	14.5% ± 4.0%

The relative error rate suggests that the estimated quantity of *Newspaper* varies widely across different sample types. This variation may help explain the relatively large difference between the total throughput Mixed Paper estimated using inbound and rejected sampling (61,219 tons) and the total throughput COI estimated using sampling of commodity Mixed Paper (45,364 tons).

Overall Mass Balance for Regional MRFs

Cascadia calculated the overall mass balance of King County material flowing through regional MRFs by compiling aggregated sample compositions from different participating haulers and the approximate King County tonnage data reported by the haulers. The hauler-reported throughput and the total calculated throughput based on sampling data differs by about 0.1 percent (225 tons). The overall mass balance is shown in Table 41 below, followed by a description of the findings for Inbound, Throughput, and Reject materials. Please note that these findings are estimated based on composition analysis of representative samples collected for this study.

Table 41. Estimated Quantities of King County Materials Collected and Processed for Recycling

TOTAL INBOUND *(excluding multifamily)*	**234,034**	**Tons**						
	Single-family Residential		**Commercial**					
Estimated Tons	**121,179**	***52%***	**112,855**	***48%***				
Recyclable	93,846	*77.4%*	91,259	*80.9%*				
Potentially Recyclable	5,258	*4.3%*	3,800	*3.4%*				
Contaminants	22,074	*18.2%*	17,796	*15.8%*				
TOTAL THROUGHPUT	**205,427**	**Tons**						
PAPER COMMODITIES	**Cardboard**		**Mixed Paper**					
Estimated Tons	**83,839**	***41%***	**61,219**	***30%***				
Target Commodity	78,049	*93%*	41,732	*68%*				
Other COI	3,664	*4%*	13,777	*23%*				
Potentially Recyclable	904	*1.1%*	1,107	*2%*				
Contaminants	1,222	*1.5%*	4,603	*7.5%*				
PLASTIC COMMODITIES	**PET**		**HDPE Natural**		**HDPE Colored**		**Plastics**	
Estimated Tons	**5,262**	***3%***	**1,756**	***1%***	**1,465**	***1%***	**1,196**	***1%***
Target Commodity	3,671	*70%*	1,691	*96%*	1,343	*92%*	210	*18%*
Other COI	94	*2%*	50	*3%*	29	*2%*	394	*33%*
Potentially Recyclable	1,400	*27%*	14	*0.8%*	81	*6%*	445	*37%*
Contaminants	97	*1.8%*	1	*0.06%*	12	*0.8%*	147	*12%*
METAL COMMODITIES	**Aluminum Cans**		**Mixed Metals**		**Tin**			
Estimated Tons	**3,465**	***2%***	**2,277**	***1%***	**2,907**	***1%***		
Target Commodity	3,318	*96%*	2,079	*91%*	2,540	*87%*		
Other COI	40	*1.2%*	5	*0.2%*	19	*0.7%*		
Potentially Recyclable	104	*3%*	1	*0.0%*	298	*10%*		
Contaminants	3	*0.1%*	192	*8%*	50	*1.7%*		
OTHER COMMODITIES	**Commodity Glass***		**Commodity Residue***					
Estimated Tons	**26,573**	***13%***	**15,468**	***8%***				
TOTAL REJECT	**28,831**	**Tons**						
	Non-Commodity Residue		**Non-Commodity Glass***					
Estimated Tons	**19,882**	***69%***	**8,950**	***31%***				
Recyclable	7,105	*35.7%*						
Potentially Recyclable	2,342	*11.8%*						
Contaminants	10,436	*52.5%*						

** Did not sample*

Inbound

- According to the mass balance calculations derived from hauler-reported data, the total inbound recyclable material from single-family residential and commercial generators was approximately 234,000 tons. About **52 percent (121,179 tons) was generated by the single-family residential sector**, while about **48 percent (112,855 tons) was generated by the commercial sector**.

Throughput

- The total throughput was estimated to be about 205,000 tons.[11] The throughput consisted of materials or finished products processed by the MRFs and sold as a commodity.

[11] The total throughput based on hauler-reported estimates is 205,202 tons. The estimated throughput based on sample data differs by about 225 tons (0.1%).

- **Commodity Cardboard was approximately 41 percent (83,839 tons) of the total throughput.** Commodity Cardboard was primarily composed of *Cardboard* material (93% and 78,049 tons) and minimal Contaminants (1.5% and 1,222 tons).
- **Commodity Mixed Paper represented about 30 percent (62,219 tons) of the total throughput.** Commodity Mixed Paper consisted of *Mixed Paper* (68% and 41,732 tons), *Cardboard* (20 percent and 12,128 tons) and materials in the Contaminants (7.5% and 4,603 tons).
- **Commodity Glass was approximately 13 percent (26,573 tons)** and **commodity Residue** (residue material sold at a positive revenue) **was estimated to be 8 percent (15,468 tons) of the total throughput.** Commodity Glass and commodity Residue material were not sampled to produce additional data on the composition of those two commodities.
- Commodity PET was mostly *PET (#1) Bottles and Jars (70% and 3,651 tons)* and *PET (#1) Small Rigid Plastics* (25.7%) with a small proportion of Contaminants (1.8% and 97 tons).
- Commodity HDPE Natural was primarily *Natural HDPE* materials (96 percent and 1,691 tons) with minimal Contaminants (<0.1 percent and 1 ton).
- Commodity HDPE Colored was mostly *Colored HDPE* materials (92% and 1,343 tons) with trace amounts of Contaminants (0.8% and 12 tons).
- Commodity Mixed Plastics was estimated to be about 1 percent (1,196 tons) of the total throughput.
- Commodity Aluminum Cans was primarily *Aluminum Cans* (96% and 3,318 tons) with minimal Contaminants (0.1% and 3 tons).
- Commodity Tin was mostly commodity Tin materials (87% and 2,540 tons) with minimal Contaminants (1.7% and 50 tons).
- Commodity Mixed Metals was primarily commodity Mixed Metal materials (91% and 2,079 tons) and Contaminants (8% and 192 tons).

Reject

- An estimated 28,831 tons of material was rejected during the material recovery processing at the regional MRFs. **Of the rejected material, 69 percent (19,882 tons) was considered non-commodity residue**. Approximately 31 percent (8,950 tons) of the total rejected material was non-commodity glass.[12]

[12] Non-commodity glass is glass that is neither sold at a positive revenue nor repurposed. This glass is generally considered reject material, but since it is primarily glass, it was separated into its own category to distinguish it from other rejected material.

6. MRF Interview Summary

This chapter presents key themes and aggregated information from interviews completed with representatives from the three major single-stream recycling MRFs that process materials from King County curbside recycling programs. As in prior studies, the responses from individual MRF interviewees remain confidential.

The interviews were designed to:

- Evaluate system performance and understand the challenges associated with collecting and processing material.
- Assess future capacity at regional MRFs.
- Identify opportunities for expanding regional processing and improving system performance.

This chapter summarizes current collection and processing systems based on the interviews and includes a set of recommendations for refining collection methods. In addition, in consultation with MRF operators, this chapter addresses many recommendations for altering the list of acceptable materials in King County's curbside recycling programs designed to minimize processing inefficiencies and contamination in MRF products. The interview guide can be found in *Appendix C. Interview Guide*.

6.1. Terms and Definitions

- **Stream**: describes the source and/or composition of the material (such as garbage, recycling, organics).
- **Single-stream**: a recycling system in which all recyclable material (including paper, plastics, and metals) are mixed in a single bin and collected together.
- **Rejected material**: the non-recyclable waste material left over after the recyclables have been sorted and/or processed.
- **Curbside**: Garbage and recycling collection service provided to households by commercial haulers.

6.2. Summary of Methodology

To assess recycling collection and processing systems, Cascadia interviewed single-steam recycling MRF operators and managers from facilities serving King County. In April 2020, Cascadia conducted confidential teleconference interviews with representatives who oversee operations at Recology, Republic Services, and Waste Management Puget Sound area MRFs. Table 42 lists contact information for representatives interviewed for each MRF.

Table 42. MRF Interview Contacts

MRF	Location	Contact
Waste Management	Cascade Recycling Center JMK Fibers Recycle Northwest Transfer Station	Matt Stern (Area Director of Recycling Operations, Pacific Northwest BC Area)
Recology	Seattle	Derek Ruckman (Vice President & Group Manager – Pacific Northwest) Kevin Kelly (General Manager) Anthony Brocato (Operations Manager – MRF)
Republic Services	Seattle (Third & Lander)	Jeffery Nguyen (General Manager) Don Zimmerman (MRF Operations Manager)

The interviews were designed to:

- Evaluate current system performance and understand the challenges associated with collecting and processing material,
- Assess future capacity at regional MRFs, and
- Identify opportunities for expanding regional processing and improving system performance.

This document summarizes current collection and processing systems based on the interviews and includes a set of recommendations for refining collection methods. In addition, in consultation with MRF operators, this chapter addresses many recommendations for altering the list of acceptable materials in King County's curbside recycling programs designed to minimize processing inefficiencies and the presence of contamination in MRF products.

This chapter presents themes and aggregated information from completed interviews. As in prior studies, the responses from individual MRF interviewees remain anonymous. The interview guide can be found in *Appendix C*. Interview Guide

6.3. Summary of Findings

Current Materials and Processing

The objective of this section is to assess the collection and processing of incoming material streams to develop recommendations to minimize MRF processing inefficiencies and the amount of contamination in MRF products. Though all three companies interviewed are involved in both collection and processing of curbside recyclables in King County, the majority of the interview focused on processing as this study is focused on MRFs.

Incoming Materials and Collection Methods

Q: What are your greatest challenges with the incoming stream of recyclable materials at your MRF? How to they affect MRF operations? Do you have any other concerns related to the types or quality of recyclable materials that you handle?

Contamination in the recycling stream is one of the greatest challenges to processing inbound material to MRFs from King County curbside programs. Even with growing media attention and additional efforts by government agencies, contamination continues to trend upward across material categories and increase over time. Materials that cannot be recycled make it to the facility regardless, and risk damaging the equipment.

- MRF processing equipment was not originally designed to sort the range of incoming materials today; it is only capable of sorting materials for which the facility was originally designed to handle.
    - Some materials, such as two-dimensional items and fines, such as shredded paper, caps, and straws, cannot be properly processed.
    - "Tanglers," such as plastic bags, ropes, Christmas lights, garden hoses, chains, and textiles often become wrapped around processing equipment.
- One processor noted, "This has been an issue since the 1980s when contamination was 2-4%. And now it's out of control… so you have to ask yourself, what happened?"
- "There is a wishful recycling culture… a level of ambition to do the right thing," one processor noted.

Contaminants and materials that are difficult to sort present quality concerns for successfully selling products into recycling markets. Many incoming materials risk contaminating bales.

- Film plastic, specifically plastic bags, are prevalent in the recycling stream. One processor reported that many plastic bags contain rejected material, including food.
    - Cross-contamination of dirty plastic bags can lead to entire loads being rejected.
    - One processor hopes that the number of plastic bags entering the facilities will decrease with new local and statewide plastic bag bans.
- Mixed materials, such as packaging envelopes that are paper on the outside and plastic on the inside, are not accepted by any markets and belong in the rejected stream, reported processors.
    - This material in particular, reported one processor, often ends up in the paper bales and has to be routinely pulled out to reduce contamination. "As many of these companies are wanting to recycle, [they] put the cart before the horse."
- One processor reported contamination from moisture as a common challenge in the Pacific Northwest.
    - Materials can absorb moisture at just about any point in the recycling process (such as curbside bin lids are left open, materials becoming wet in collection trucks during

loading or transferring materials at receiving facilities, or even in transit in containers being shipped overseas).

- High levels of moisture reduces the marketability of paper and other materials. One respondent noted that loads may be rejected if the moisture content of the material is over 12 percent.

Safety is a main concern for MRF staff. Unsafe materials that do not belong in the recycling bin not only slow down processing efficiency but pose a safety risk for employees.

- Household garbage, such as diapers, animal carcasses, and household hazardous waste are not uncommon in the recycling stream.
- The presence of sharps, medical waste, and sharps require facility staff to suit up and manually pick these items off of the line. One processor reported receiving large quantities of hazardous materials stored in milk cartons or PET liter-bottles, which are more easily identified and safely sorted than loose hazardous materials.
- Flammables such as propane tanks, batteries, and fireworks arrive at the MRFs in consistent and predictable quantities. Holidays, such as Memorial Day weekend, as one processor noted, can generate barbeque coals creates issues in both collections and processing.

Q: How do current collection methods affect the incoming stream of material? Could collection methods be improved? If so, how?

Processors agree that education for residents and businesses in King County is key to reducing recycling contamination. There is often confusion among customers about the specific materials accepted in their recycling program.

- In-field auditors can only cover so much of King County, and education and broad-based outreach efforts, such as flyers or school visits could be increased.
- Much of the collection by collectors is automated and does not leave an opportunity to physically check for contamination, let alone provide feedback to the customer. The responsibility should be placed on customers to put the correct materials in recycling bins.

Current collection methods lead to contamination issues, such as moisture and the presence of hard-to-sort materials. Material placed in recycling carts can become wet due to customers reportedly leaving their lids open. If materials, especially paper, get wet, this can have a major impact on the marketability of the material.

There is a need for the development of innovative new collection methods. Processors recommended efforts to minimize contamination and increase processing efficiency.

- One processor mentioned an every-other-week dual-stream collection model with paper collection one week and containers (bottles and cans) collection on alternating weeks, all using the same bin. This would require customers to thoughtfully manage and store recycling at home before setting out individual recycling streams for collection.

- Another processor mentioned using optical sensors on side-loading collection trucks to scan for contamination every time a bin is serviced. This would allow drivers to act on this information at the point of collection (e.g., reject cart, note for customer feedback, etc.).
- The evolution of recycling requires more investment in infrastructure. The following innovative new MRFs are designed to address today's recycling stream versus outdated facilities that address the recycling stream of two decades ago, such as those in the Puget Sound area.

Waste Management's highly automated MRF of the Future in Chicago is designed to process approximately 1,000 tons per day. The MRF uses "intelligent sorting," which is advanced automated equipment that actually communicates with each other to improve material quality and eliminate downtime.

Recology recently upgraded its largest MRF in San Francisco to include a new sorting system. The transfer station now holds seven optical sorters and the longest initial sort deck in North America. Expansion of the facility will increase daily collection capacity for food and yard waste from 750 tons per day to more than 1,000.

Republic Services' new state-of-the-art "Next-Gen" recycling facility in Plano, Texas, uses highly advanced sorting technologies including optical sorters and innovative anti-wrap fiber screens. An automated, touch screen control system and new tablet-based technology will increase remote capabilities, data acquisition, and real-time systems management.

Processing

Q: Are there processing issues that your facility experiences on a regular basis?

Contaminants present processing challenges for incoming materials. Food waste leads to substantial contamination, and paper and pulp mills are demanding higher quality materials with their bale specifications. Moisture is also a common contaminant, and biological waste, such as human or animal waste, can pose safety hazards.

A major processing challenge is facility and equipment downtime caused by contaminants. Current MRF equipment needs constant repair, which can halt throughput and materially slow down productivity. Materials such as film and other cord-like "tanglers" can become wrapped around the equipment. One processor said they lose more than one hour, and sometimes up to four hours per day managing contamination, which leads to substantial amounts of material not getting processed.

MRF processing capabilities are primarily limited by their aging equipment. According to one processor, no two MRFs are the same and they all have their own limitations.

Q: What are the causes and potential solutions to these processing challenges?

Education for customers, including maintaining an accurate list of acceptable materials are important for solving processing challenges. One processor said aligning recycling programs across the region would create consistency. Ideally, these recycling programs and acceptable materials lists are aligned with the functionality of the system to reduce processing inefficiencies and resulting rejected waste.

Processors identified equipment upgrades as a solution to processing challenges, but this solution requires large investments. One processor said that it is possible to clean paper bales up to <1% contamination, but this performance would require 3-4 optical sorters and approximately $4 million of investment. Another processor mentioned subsidizing the recycling industry as a potential solution to the high cost of a MRF upgrade and to prevent landfilling.

One processor recommended investing in technology to spot contamination before materials are fed into MRF equipment for processing. Examples could include adding cameras at the MRF tipping floor or auditing a set number of loads per day. Another processor mentioned a probe system to identify contamination in bales and assign a value based on their purity levels.[13]

Product Streams

Q: Do you have challenges with your product stream, such as: Are you moving products to market? Are you meeting buyer's specifications? Do you have high levels of prohibitives and outthrows [rejected material]? If so, what is the cause, why the variance, and what are the potential solutions?

Substantial amounts of incoming material arriving at the MRFs cannot be reliably processed and/or marketed. The incoming stream of single-stream materials has become increasingly contaminated over the last few years.

- **Mixed paper is not currently considered to have a reliable market,** and therefore, presents a challenge for MRFs. Demand for mixed paper appears flat or trending downward. There does not appear to be sufficient domestic capacity currently to buy all of the mixed paper being generated by area MRFs. However, emerging local markets appear promising, such as NORPAC's expanded paper recycling capabilities.[14]
- One processor reported that **paper bales have a 3-5% contamination rate, on average**. Two-dimensional plastics (chip bags, notebooks, plastic wrapping, etc.) can end up in the paper bales and be nearly impossible to remove.
- **Plastics markets have experienced recent declines in demand** (especially for low-value commodities), but overall, the MRFs report being able to move these materials to markets. Reportedly, plastics #3 - #7 have the weakest markets and film plastics have limited to no market. "The material got backed up for a long time and then Merlin started taking it again at a cost," noted one MRF.

[13] Taylor, Brian. Recycling Today. *Paper mills are deploying new technologies to obtain more definitive answers as to what is in an unopened bale.* (February 2018). Retrieved from www.recyclingtoday.com/article/measuring-moisture-in-paper-bales/

[14] NS Packaging. *Norpac to convert waste paper into recycled papers.* (August 2019). Retrieved from www.nspackaging.com/news/company-news/norpac-waste-paper-recycling/

- **COVID-19 has led to additional complications with product markets** due to diminishing demand for construction materials. For example, the demand for plastic to be recycled into carpet and tin cans to make construction-related metal products have decreased, and without demand, prices plummet.

Other products such as cardboard, high-grade plastics, and metals remain consistent.

- **The demand for cardboard is up** and there has been a recent bump in market value, most likely due to increased e-commerce consumption.
- **Plastics #1 and #2 have the strongest market of the plastic categories and have not been a problem moving to market**. One processor reports that their facility is very effective at sorting PET bottles and claim to sort this product "down to two decimal places." Currently marketable plastic commodities include PET, HDPE natural, HDPE colored, mixed rigid plastics (such as buckets and large plastic items), and mixed #3-#7.
- **Metal materials maintain stable, domestic markets.** One processor responded that pricing has been flat and there has not been challenges to selling the material to market. Due to COVID-19, domestic mills have increased capacity.

Glass has a steady local market currently but has only one secondary processor and market in Seattle. This creates vulnerable market conditions. One processor pointed out that when Seattle's glass plant closed last summer, a stockpile of glass accumulated. As it sat, it became increasingly contaminated.

Processors agree that it is essential to maintain productivity at their facility. Slowing everything down and processing fewer tons per hour has an "exponential cost impact" and it is not possible from a capacity perspective. Common contaminants such as medical waste, diapers, and household garbage pose issues to maintaining productivity.

Q: Are there any items you think should be added or removed from King County's acceptable recyclables list? Why?

- **Polystyrene/Styrofoam** can end up in the wrong plastic product bales. Markets are not as tolerant as they were previously, and loads can be rejected if they are contaminated.
- **Shredded paper**
- **Aseptic containers**
- **Plastic film** was removed, but it still shows up at the MRFs.

Recommendations

Q: What could King County and the cities do to help reduce MRF costs and improve efficiency and product quality?

- One processor recommended **mandatory 3-cart waste collection** countywide for all residents to reduce contamination, self-hauling inefficiencies, and illegal dumping impacts.
- Another processor recommended **education and imposing fines on customers** who are improperly recycling to prevent contamination.

Future Processing Capacity

The objective of this section is to estimate future processing capacity to determine if it will be adequate to handle projected future quantities of recyclable materials.

Q: Is the infrastructure to process recyclable materials in King County and the region adequate? What changes or new investments do you think are required? Looking 10 years into the future, what do you see as the top needs in terms of collection and processing infrastructure?

Processors agree there is generally enough capacity at MRFs today to process current volumes of recyclables collected from customers in King County. Based on Cascadia's 2019 recyclables characterization of MRFs in King County, the total inbound recyclable material from single-family and commercial generators was estimated to be approximately 234,000 tons. Of this material, about 205,000 tons were estimated to be processed and sold to market. The remainder was handled as non-commodity residue.

Upgrades are needed to modernize and keep pace with the changing recycling stream and require substantial capital investments. New infrastructure requires buy-in and support from elected leaders, rate payers, etc. to support the costs of upgrades. One processor noted, "there has to be a willingness to pay a rate that supports infrastructure that can recycle."

It is important to maintain an acceptance list for items that are actually able to be recycled. According to one processor, we went a little too far with what's acceptable now and now we commonly see items that belong in the garbage. The list of acceptable materials in the recycling bin controls how the MRF is designed. To avoid costly upgrades, the accepted material list should account for the capabilities of the processing equipment.

One processor said this country could benefit from **building domestic recycling infrastructure** and create more buyers and a stronger demand for material.

MRFs must be able to process and market materials effectively to maintain a successful business case. If materials are heavily contaminated, this will affect processing efficiency and therefore, the business case itself.

Q: To confirm, we understand that your facility processes [number] tons of incoming recyclables material per year. Could your MRF operations process additional recyclable materials? If so, how many more tons per year? How would you increase capacity?

All MRFs suggested they could increase processing capacity by adding more processing shifts, but this leaves a very thin margin for error. Without additional MRF floor space, this could lead to bottle-necking issues during processing, especially due to aging equipment.

Repairs and preventive maintenance lead to more equipment downtime. More throughput pushes equipment past operational limits and can lead to more wear and tear on the equipment.

Current MRF operations have the potential to process additional material. One processor reported that their current operation is capable of processing an additional 12,000 tons per year and another reported 25,000 tons per year. A third processor projects they could process an additional 120,000 tons per year by running shifts 24 hours per day.

Q: For each method you described above in the previous question, could you please estimate the potential new tons of processing capacity that could be added and the approximate time frame for each (up to 10 years in the future)?

Assuming a 5-day, 2-shift, 14-hour operation schedule, **one processor said that while it is difficult to predict ten years into the future, they estimate they could process additional 24,000 tons per year on top of their current processing capacity.** Another reported that their tip floor space and transportation reach would limit them long before processing capacity could be significantly expanded. A third processor said that to process more than their current processing capacity, technological advances would be required to process more material without expanding their footprint.

Q: (If applicable) What is the current status of your plans to expand or construct new facilities?

All respondents said that while their companies are exploring opportunities, **they do not have specific plans to construct new or expand existing facilities.**

Q: Is there anything else we should know about?

Processors mentioned the following additional relevant topics:

- In 1999, the European Union banned organics from landfill disposal. This policy opened up capital investment in areas other than landfills.
- Robotic and artificial intelligence (AI) technology applications may be the future of processing.

6.4. Summary of Recommendations

This section summarizes recommendations for changes to collection methods and the list of acceptable materials in the King County curbside recycling program, based on MRF interviews responses. These recommendations are designed to minimize MRF processing inefficiencies and the amount of contamination in products.

Accepted List of Recyclables

- Maintain an accurate list of acceptable materials to reduce contamination and avoid customer confusion.
- Align the list of acceptable materials with the current processing capabilities at area MRFs.
- Consider removing these items from the accepting list of recyclables:
    - Polystyrene/Styrofoam
    - Shredded paper
    - Plastics (#3-#7)
    - Aseptic containers
    - Plastic film

Refining Collection and Processing Methods

- Increase capital investment to modernize handling infrastructure and adapt to the changing recycling stream.
- Increase innovation and consider collection methods such as an every-other-week collection system that alternates between paper and containers and/or new technologies to identify contamination.
- Consider a mandatory 3-cart collection countywide for all residents who pay utilities.
- Prevent moisture accumulating in curbside collecting bins and during transport and transfer to market.
- Increase education for King County residents and businesses focused on reducing contamination.
- Impose fines on customers who are improperly recycling.

Appendix A. Material Definitions

Materials definitions for this study were developed with King County's review and input. The list of 42 **Material Types** is generally consistent with the 105 materials included in the 2019 King County Waste Characterization Study and is a subset focused on curbside recyclable materials and contaminants of recycling. Some modifications were made to reflect current products, packaging, and recycling practices, particularly regarding Plastic materials. The definitions considered plastics and recycling studies underway in Washington and Oregon, materials accepted for curbside recycling in King County communities, and model bale specifications from the Association of Plastic Recyclers. The material types are grouped in 12 Material Classes, which include recyclable and non-recyclable paper, glass, metal, and plastics as well as organics and other non-recyclable materials.

Material types were classified according to their recyclability. **Recyclability Groups** are aligned with the *Recoverability Groups* assigned by King County in the 2019 Waste Characterization Study, with some adjustments to reflect the focus on recycling (not including composting). This study uses the three categories of **Recyclable** (previously called *Readily Recyclable*), **Potentially Recyclable** (was *Limited Recyclability*), and **Contaminants** of recycling (*Not Recyclable* was the third category in the prior study). The recyclability groups are defined in the *Glossary* on page vi.

MATERIAL CLASS	#	MATERIAL TYPE	DESCRIPTION	RECYCLABILITY GROUP
RECYCLABLE PAPER	1	Cardboard	Unwaxed corrugated cardboard containers/boxes. Includes CLEAN pizza boxes (with only traces of contamination or moisture).	Recyclable
	2	Newspaper	Newspaper and newspaper inserts.	Recyclable
	3	Aseptic and Gable-Top Containers	Polycoated fiber and foil containers (e.g., Tetra Pak) and polycoated containers with a gable-shaped top most often containing juice drinks, coconut waters, and dairy substitutes (soy, almond, rice milk), or soups, broths, sauces, and liquid refills, etc.	Recyclable
	4	Mixed Paper	Glossy paper, office paper, mail, magazines, colored papers, greeting cards, paper bags, uncoated boxboard, construction paper, calendars, wrapping papers, gift bags, paperback books, paper egg crates, paper tubes, and phone books. Also includes paper cartons (ice cream/deli/take-out). Polycoated paper products (plates, cups that are not food-soiled) and polycoated boxes (refrigerator/freezer/frozen food containers) are also included here.	Recyclable
NON-RECYCLABLE PAPER	5	Compostable Paper	Food-soiled pizza boxes, napkins/paper towels/tissues, food-soiled and uncoated paper plates/bowls/cups, parchment/waxed paper, bakery boxes/paper liners, wax-coated cardboard boxes, and compostable dishes/utensils/to-go containers (e.g., corn, potato, bamboo; must say compostable).	Contaminants
	6	Other Paper	Other paper items that are predominantly paper with other materials attached (e.g., spiral notebooks, cigarette packs, manila envelopes with bubble wrap padding), other non-recyclable paper items such as carbon-copy paper, hardcover books, shredded paper, and photographs.	Contaminants

MATERIAL CLASS	#	MATERIAL TYPE	DESCRIPTION	RECYCLABILITY GROUP
RECYCLABLE GLASS	7	Glass Containers	Clean glass bottles and jars (with only traces of contamination or moisture).	Recyclable
NON-RECYCLABLE GLASS	8	Other Glass	Non-recyclable glass. Examples include window/plate glass, drinking glasses/mugs, pitchers, windshields, light bulbs, mirrors, fluorescent tubes, ceramics, pottery, Pyrex and other baking dishware.	Contaminants
RECYCLABLE METAL	9	Aluminum Cans	Aluminum beverage cans (UBC) and bi-metal cans (e.g., cat food containers).	Recyclable
	10	Aluminum Film, and Trays	Aluminum foil, trays, and pie plates that are NOT FOOD-SOILED.	Potentially Recyclable
	11	Tin Food Cans	Tinned steel food containers, including bi-metal cans mostly of steel.	Recyclable
	12	Empty Aerosol Cans	EMPTY, mixed material/metal aerosol cans.	Potentially Recyclable
NON-RECYCLABLE METAL	13	Other Metal	Mixed metal items such as motors, metal window blinds, metal tableware and utensils. Other metal that are and metal items that are too contaminated to be marketed. Also includes large electronics that are predominantly metal (e.g., washer and dryer), and other bulky metal items (e.g., patio furniture).	Potentially Recyclable
RECYCLABLE PLASTIC	14	PET (#1) Bottles and Jars	Polyethylene terephthalate (PET or #1) bottles OF ANY COLOR (clear, light tinted translucent green or blue, opaque or colored, or black pigmented). Examples include water and beverage bottles, and peanut butter jars. Caps/lids left on if attached.	Recyclable
	15	PET (#1) Small Rigid Plastics	Non-bottle PET containers >3" (up to 2 gal), including tubs (can be round or squarish), trays, deli and take-out containers, single-use drink cups, and lids >3" OF ANY COLOR (including clear, light tinted translucent green or blue, opaque or colored, or black pigmented). Also includes other PET clamshells and PET thermoform packaging including blister pack without paperboard backing (lidded and non-lidded).	Potentially Recyclable
	16	Clear/Natural HDPE (#2) Bottles and Jars	Translucent ("natural") high-density polyethylene (HDPE or #2) bottles and jars (up to 2 gal). Examples include translucent gallon milk and juice jugs, beverage bottles, laundry detergent bottles, some shampoo/personal care product bottles. Caps/lids left on if attached.	Recyclable
	17	Colored HDPE (#2) Bottles and Jars	Colored HDPE bottles (up to 2 gal) OF ANY COLOR (e.g., light tinted translucent green or blue, opaque or colored, or black pigmented). A bottle has a neck (usually threaded) or mouth narrower than the base. Also includes jars or canisters that are blow molded or injection blow molded. Examples include opaque gallon milk and juice jugs, beverage bottles, laundry detergent bottles, some shampoo/personal care product bottles. Caps/lids left on if attached.	Recyclable

MATERIAL CLASS	#	MATERIAL TYPE	DESCRIPTION	RECYCLABILITY GROUP
RECYCLABLE PLASTIC *(continued)*	18	HDPE (#2) Small Rigid Plastics	Non-bottle HDPE/LDPE plastic packaging >2" (up to 2 gals) OF ANY COLOR (e.g., clear, light tinted translucent green or blue, opaque or colored, or black pigmented). Examples include storage containers and polyethylene tubs (can be round or squarish, such as some dairy or flower pots).	Potentially Recyclable
	19	LDPE (#4)	Low-density polyethylene (LDPE or #4) bottles, jars, and other small rigid plastics.	Potentially Recyclable
	20	PP (#5) Bottles and Jars	Polypropylene (PP or #5) screw top bottles such as tea and juice beverages, syrup bottles, shampoo/personal care product, prescription bottles and storage bottles or jars of any color.	Potentially Recyclable
	21	PP (#5) Small Other Rigid Plastics	Polypropylene (PP or #5) cups, and other containers >2" (up to 2 gals) of any color. Examples include PP tubs (can be round or squarish such as for yogurt, margarine, ice cream, tofu), clamshells, deli and take-out containers, dishwasher safe storage containers, cold drink cups, microwavable trays, flowerpots.	Potentially Recyclable
	22	PS (#6) Rigid Plastics	Polystyrene (PS or #6) rigid non-foam packaging, such as PS cups, dairy containers and deli take-out containers.	Potentially Recyclable
FOAM PLASTICS	23	EPS (#6) Food Packaging	Expanded polystyrene (#6) foam packaging including foodservice containers. Examples include EPS egg cartons, clamshells, trays, and cups.	Contaminants
	24	EPS (#6) Transport Blocks and Other	Expanded polystyrene (#6) foam blocks and shapes.	Potentially Recyclable
NON-RECYCLABLE PLASTIC	25	Bulky Rigid Plastics (>2 gals)	Large rigid plastic products (including bottles and containers >2 gal). Many of these products are intended for long term use or to be reused multiple times. Examples include baskets, buckets, crates, pallets, pipes, utensils, tableware, lawn furniture, and large mostly plastic toys. Items are typically HDPE (#2) or PP (#5), but other resins are present. Large tubs and bucket lids are also included here.	Potentially Recyclable
	26	PLA / Compostables	Compostable plastic items, that are marked with the words "compostable" or "#7 PLA" in the plastic code. Examples include compostable bags and film (e.g., BioBag, EcoSafe), compostable food plastic containers and food packaging (e.g., deli/take-out containers, produce packaging, meat/produce trays IF compostable), compostable service ware and utensils (e.g., compostable straws, cups/lids, bowls, clamshells, plates, trays, cutlery).	Potentially Recyclable

MATERIAL CLASS	#	MATERIAL TYPE	DESCRIPTION	RECYCLABILITY GROUP
NON-RECYCLABLE PLASTIC *(continued)*	27	Other Plastics	Any non-bottle and non-container plastic not categorized elsewhere. Examples include plastic materials such as heavily soiled rigid plastics of any kind, loose caps/lids (<3'' diameter), disposable razors, pens, lighters, "blister" packaging for toys, electronics, toiletries, batteries, toothbrushes, and 3-ring binders. Includes plastic tubes (e.g., shampoo, conditioner, lotions, cosmetics, toothpaste). Also includes non-bio-based, non-compostable, non-PLA plastic items marked "#7" (e.g., Nalgene/Lexan). Also includes plastic long and thin items like twine, rope, and strappings (plastic tanglers).	Contaminants
FILM AND FLEXIBLE PLASTICS	28	Clean Plastic Consumer Bags and Film	Clean polyethylene (PE) consumer bags and film that would be accepted through a store-based collection program. Includes grocery "t-shirt" and retail bags; bread, produce, and newspaper bags; dry cleaner film; napkin, towel, tissue, and diaper overwrap; case and stretch wrap (e.g., for bottled water); plastic air pillows; clean PE food storage (Ziploc) bags; and clean pouches *with the How2Recycle store drop-off label*.	Potentially Recyclable
	29	Disposal Bags	Plastic bags used to contain items placed in the recycling cart. Includes single-use "t-shirt" and retail bags reused as disposal bags, dirty pouches with the How2Recycle store drop-off label, and pouches WITHOUT the How2Recycle label (clean or soiled).	Contaminants
	30	Other Plastic Film	All other film packaging, including multi-layer and opaque food packaging such as chip bags, candy bar wrappers, prewashed salad bags, frozen food bags, and other film items. Includes plastic (Saran) wrap, heavily contaminated film, dirty food storage (Ziploc) bags, dirty pouches *with the How2Recycle (H2R) store drop-off label*, and pouches *WITHOUT the H2R label* (clean or soiled).	Contaminants
ORGANICS	31	Edible Food	Food scraps that are deemed edible. Examples include edible fruit/vegetable scraps, peels, trimmings, pits, spoiled/outdated foods, dairy scraps, paper coffee filters, coffee grounds, tea bags, eggshells, leftovers/table scraps, meat, fish, shellfish scraps (including bones and shells).	Contaminants
	32	Non-edible Food	Food scraps that are deemed non-edible. Examples include non-edible fruit/vegetable scraps, peels, trimmings, pits, spoiled/outdated foods, dairy scraps, paper coffee filters, coffee grounds, tea bags, eggshells, leftovers/table scraps, meat, fish, shellfish scraps (including bones and shells).	Contaminants
	33	Other Organics	Includes other compostable organic materials, not included above, such as hair, popsicle sticks, chopsticks, real corks, and toothpicks.	Contaminants
	34	Yard Debris	Leaves, grass clippings, sod, garden wastes, brush, pruning, logs, and clumped soil and rocks associated with yard debris.	Contaminants

MATERIAL CLASS	#	MATERIAL TYPE	DESCRIPTION	RECYCLABILITY GROUP
OTHER NON-RECYCLABLE	35	Tanglers (non-plastic)	Unaccepted, non-plastic items that are long and thin. Examples include electrical cords, garden hoses, caution tape (and similar tape), streamers, and chains. All plastic long, thin items like twine, rope and strapping are in a separate category ("Other Plastics").	Contaminants
	36	HHW / Special Waste	Potentially hazardous products such as radioactive or dangerous waste(s), ammunition, explosives, paints and solvents, old gasoline, solvents, antifreeze, asbestos, glues and adhesives, hot ashes, caulking compounds and grouts, hazardous cleaners and household chemicals, pesticides/herbicides, oil/gas/fuel tanks, any substances or products containing potentially hazardous chemicals. Also includes non-hazardous soaps, cleaners, medicines, cosmetics, fire extinguishers, and other household chemicals. FULL aerosol containers and roadkill/dead animals are also included here. Hypodermic needles and other items used to puncture or lacerate the skin.	Contaminants
	37	Electronics and Small Appliances	Computer monitors and television sets containing a cathode ray tube (CRT) Other electronics and small electric appliances Includes cell phones, answering machines, electronic toys, stereos, radios, tape decks, other audio/visual equipment, VCRs, DVD players, computer processors, mice, keyboards, disk drives, monitors and TV's that do not contain cathode ray tubes, printers, scanners, gaming systems, tablet computers, e-readers, laptops. Also includes small electric appliances such as toasters, blenders, microwave ovens, power tools, curling irons, and light fixtures.	Contaminants
	38	Diapers	Disposable baby diapers and adult protective undergarments.	Contaminants
	39	Textiles and Shoes	Clothing, rags, and accessories made of natural and synthetic textiles such as cotton, wool, silk, woven nylon, rayon, polyester, leather, and other materials. Examples include pants, shirts, fabric purses, bed sheets, towels, and shoes.	Contaminants
	40	Construction and Demolition Waste	Dimensional lumber, pallets/crates, treated/contaminated wood, gypsum, insulation, rock/concrete/bricks, loose soil and rocks, asphalt shingles/roofing, other construction debris, and mixed fine building material scraps.	Contaminants
	41	Furniture / Bulky	Furniture made of mixed materials and in any condition. Mattresses made of mixed materials and in any condition. general category of flooring applications consisting of various natural or synthetic fibers bonded to some type of backing material.	Contaminants
	42	Mixed Residue	All items not defined in the above categories will be included here. Examples include non-distinguishable fines, animal feces, corks, candles, Q-tips/cotton swabs, sports equipment (e.g., basketball).	Contaminants

Appendix B. Estimating Waste Composition

Waste composition estimates were calculated using a method that gave equal weighting or "importance" to each sample within a given stratum. Confidence intervals (error ranges) were calculated based on assumptions of normality in the composition estimates. Cascadia will rely on MRF and County records to complete the analysis of the amounts of inbound material, reject material, and marketed products. These records include the commercial organics tonnage data for the participating MRFs.

Estimating the Composition

For a given stratum (that is, for the samples belonging to the same generator type collected by the same hauler type), the composition estimate denoted by r_j represents the ratio of the component's weight to the total weight of all the samples in the stratum. This estimate was derived by summing each component's weight across all the selected samples belonging to a given stratum and dividing by the sum of the total weight of waste for all the samples in that stratum, as shown in the following equation:

$$r_j = \frac{\sum_i c_{ij}}{\sum_i w_i}$$

where:

c = weight of particular component

w = sum of all component weights

for i = 1 to n, where n = number of selected samples

for j = 1 to m, where m = number of components

For example, the following simplified scenario involves three samples. For the purposes of this example, only the weights of the component composable plastic are shown.

	Sample 1	Sample 2	Sample 3
Weight (*c*) of *compostable plastic* (in lbs.)	5	3	4
Total Sample Weight (*w*) (in lbs.)	80	70	90

$$r_{Carpet} = \sum \frac{5+3+4}{80+70+90} = 0.05$$

To find the composition estimate for the component compostable plastic, the weights for that material are added for all selected samples and divided by the total sample weights of those samples. The resulting composition is 0.05, or 5%. In other words, 5% of the sampled material, by weight, is compostable plastic. This finding is then projected onto the stratum being examined in this step of the analysis.

The confidence interval for this estimate was derived in two steps. First, the variance around the estimate was calculated, accounting that the ratio included two random variables (the component and total sample weights). The variance of the ratio estimator equation follows:

$$\mathrm{Var}(r_j) \approx \left(\frac{1}{n}\right)\left(\frac{1}{\overline{w}^2}\right)\left(\frac{\sum_i \left(c_{ij} - r_j w_i\right)^2}{n-1}\right)$$

where:

$$\overline{w} = \frac{\sum_i w_i}{n}$$

(For more information regarding Equation 2, refer to *Sampling Techniques, 3rd Edition* by William G. Cochran [John Wiley & Sons, Inc., 1977].)

Second, precision levels at the 90% confidence level were calculated for a component's mean as follows:

$$r_j \pm \left(z\sqrt{\mathrm{Var}(r_j)}\right)$$

Where, z = the value of the z-statistic (1.645) corresponding to a 90% confidence level.

Composition results for strata were then combined, using a weighted averaging method, to estimate the composition of larger portions of the waste stream. For example, the commercially collected residential substream was combined with the commercially collected nonresidential substream to estimate the composition for the County's overall commercially collected waste stream. The relative tonnages associated with each stratum served as the weighting factors. The calculation was performed:

$$O_j = \left(p_1 * r_{j1}\right) + \left(p_2 * r_{j2}\right) + \left(p_3 * r_{j3}\right) + \ldots$$

where:

- p = the proportion of tonnage contributed by the noted waste stratum (the weighting factor);
- r = ratio of component weight to total waste weight in the noted waste stratum (the composition percent for the given material component); and
- for j = 1 to m, where m = number of material components.

For example, the above equation is illustrated here using three waste strata.

	Stratum 1	**Stratum 2**	**Stratum 3**
Ratio (r) of *compostable plastic*	5%	10%	10%
Tonnage	25,000	100,000	50,000
Proportion of tonnage (*p*)	14.3%	57.1%	28.6%

To estimate the larger portions of the waste stream, the composition results for the three strata are combined as follows.

$$O_{Carpet} = (0.143 * 0.05) + (0.571 * 0.10) + (0.286 * 0.10) = 0.093 = 9.3\%$$

Therefore, 9.3% of this examined portion of the waste stream is *compostable plastic*.

The variance of the weighted average was calculated as:

$$\mathrm{Var}(O_j) = \left(p_1^2\ \mathrm{Var}(r_{j1})\right) + \left(p_2^2\ \mathrm{Var}(r_{j2})\right) + \left(p_3^2\ \mathrm{Var}(r_{j3})\right) + \ldots$$

Appendix C. Interview Guide

King County Material Recovery Facilities (MRF) Assessment

Interview Guide

April 2020 (Revised Version)

Date	
Interviewee	
Organization	
Phone	
Email	
Interviewer	

Preparation: Assemble and review data for MRFs before the interview, including filling in Question 10. See 2006 study for reference.

Introduction

On behalf of King County's Solid Waste Division, Cascadia Consulting Group is conducting interviews with Material Recovery Facilities (MRFs) that process recyclable materials from King County. We appreciate your participation in the prior fieldwork portion of this work involving sample collection of incoming and outgoing materials. The current interviews are intended to cover collection, incoming materials, processing, and products. As with the sampling data, results will be aggregated across companies and facilities for confidentiality, and identifiable company-specific information will not be shared without prior review and consent. Thank you for your participation.

Part I: Current Materials and Processing

Objective: Develop recommendations to minimize MRF processing inefficiencies and the amount of contamination in MRF products. *(Explain that a goal of the interview is to identify what measures, such as changes in acceptable materials and collection methods, King County could enact to help alleviate these concerns.)*

Incoming Materials and Collection Methods

1. What are your greatest challenges with the incoming stream of recyclable materials at your MRF? How do they affect MRF operations? *(Probe to identify specific concerns with the incoming stream that may **adversely impact** MRF operations in terms of **efficiency, safety, cost, or product quality**, along with their **impacts, causes, and potential solutions**.)*

2. Do you have any other concerns related to the types or quality of recyclable materials that you handle? *(Also probe for details regarding their **impacts, causes, and potential solutions**.)*

3. How do current collection methods affect the incoming stream of material? Could collection methods be improved? If so, how?

Processing

4. Are there processing issues (other than any identified above) that your facility experiences on a regular basis? *(Explain that we are interested in anything that might **adversely impact efficiency, safety, cost, or product quality**.)*

5. What are the causes and potential solutions to these processing challenges?

Product Streams

6. Do you have challenges with your product streams, such as: Are you moving them to market? Do they meet buyers' specifications? Do you have high levels of prohibitives and outthrows? If so, what is the cause, why the variance, and what are potential solutions? (*Probe about their complete portfolio of products.*)

7. Are there any items that you think should be added or removed from King County's acceptable recyclables list? Why? *(for each material recommended for addition or removal)*

Recommendations

8. What could King County and the cities do to help reduce MRF costs and improve efficiency and product quality? (*Probe to identify **specific recommendations**.*)

Part II: Future Processing Capacity

Objective: Estimate future processing capacity. *(Explain that this information will be used to determine if future regional capacity will be adequate to handle projected future quantities of recyclable materials.)*

9. Is the infrastructure to process recyclable materials in King County and the region adequate? What changes or new investments do you think are required? Looking 10 years into the future, what do you see as the top needs in terms of collection and processing infrastructure?

10. To confirm, we understand that your facility processes _____ tons of incoming recyclable material per year. Could your current MRF operations process additional recyclable materials? If so, how many more tons per year? (*Confirm **total throughput capacity** for recyclable materials.*)

11. How would you increase capacity? *(Probe for potential methods to **increase capacity**, such as changing operations, adding shifts/hours, adding new equipment, expanding or constructing new facilities, etc.)*

12. For each method you described above in the previous question, could you please estimate the potential new tons of processing capacity that could be added and the approximate time frame for each (up to 10 years in the future)?

13. *(If applicable)* What is the current status of your plans to expand or construct new facilities? *(Probe to determine if: 1. space is available, 2. permits have been obtained, 3. design is completed, and 4. construction is underway and, if so, the expected completion dates.)*

14. Is there anything else we should know about issues facing King County MRFs?