A Waste Composition Analysis of curbside recycling in Portsmouth, New Hampshire

Recycling Recovery Rate Analysis

Submitted to:

The Department of Public Works and the City of Portsmouth

By:

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Executive Summary

Figure 1 describes the entirety of Portsmouth's waste stream, as of 2014. The goal of this study was to find out what lies within the 24% wedge in the curbside recycling section. Understanding the composition of curbside recycling in conjunction with curbside trash would then help the city develop outreach strategies in order to further improve Portsmouth's recycling recovery rate, which currently stands at a 55% average.

For this study, we collected 30 samples of residential curbside recycling and trash set-outs. Eight-hundred and sixty-six pounds of waste was sorted and analyzed over the span of a week in July 2016.

Figure 1

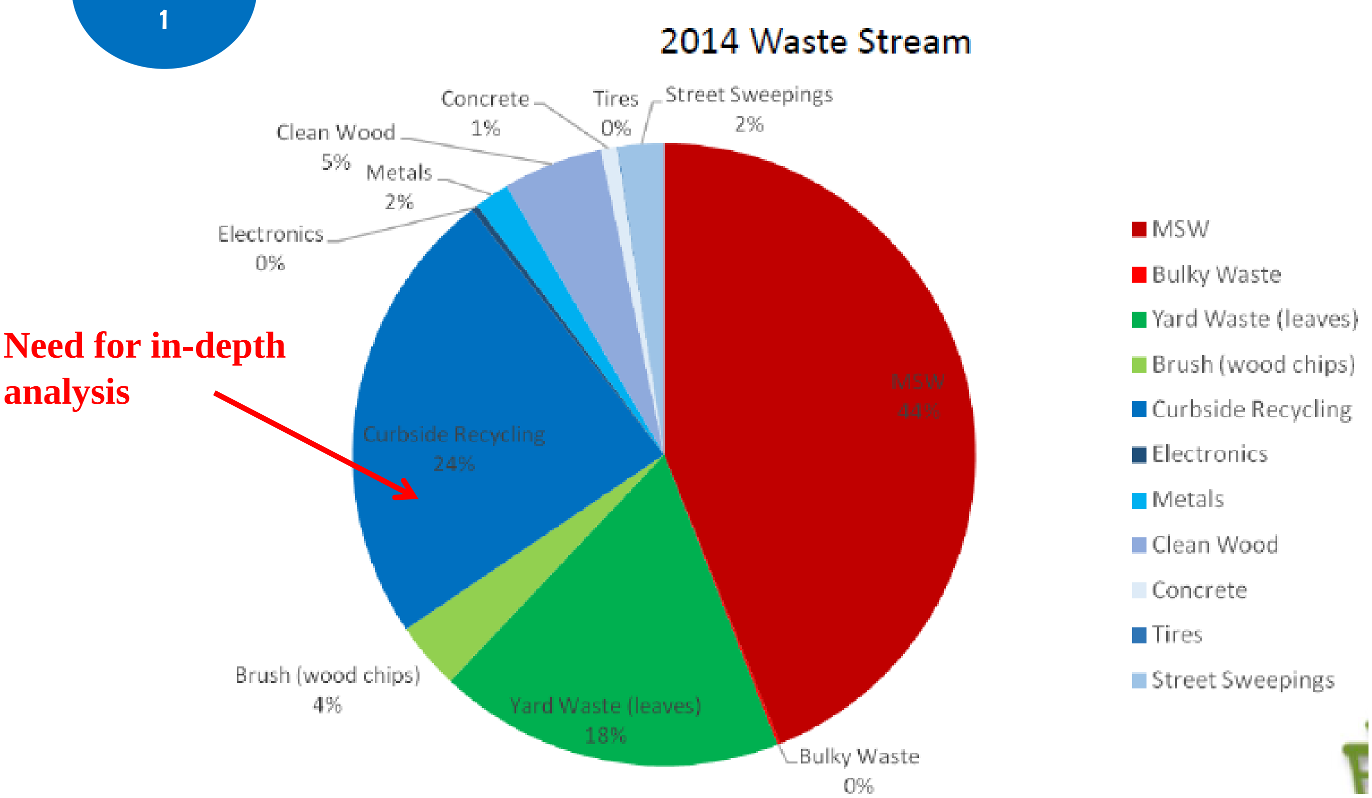

Figure 1: 2014 Waste Stream

The main findings that emerged from this study are as follows:

42%	Portsmouth's overall curbside recycling rate.
44.1%	The maximum achievable single stream curbside recycling rate.
95.8%	Portsmouth's Curbside Recovery Rate
6%	The proportion of recycling contaminants in the overall curbside municipal solid waste stream.
3%	Proportion of recoverable recyclables in the overall MSW curbside stream
4.7%	Proportion of overall MSW curbside stream that could have been recycled through source separation.
True recyclables	Predominant component materials: 50% Fibrous, 31% glass, 13% plastic, and 5% metal alloys.
Recoverable recyclables in trash	Predominant component materials: 40% fibrous, 23% textiles, 18.5% plastic

Table 1: Executive Summary: Main findings

Introduction

In 2014, the city of Portsmouth achieved an overall landfill diversion rate of 55%, with 33% of it being recycled and 22% of it being composted (Figure 2) [1]. Curbside recycling forms 24% of Portsmouth's Municipal Solid Waste stream [1]. However, there was still a need to audit the contents of curbside recycling in order to characterize and quantify the nature of materials within that stream, as well as identify and quantify contaminants in order to improve the recycling efficiency of Portsmouth.

Figure 2

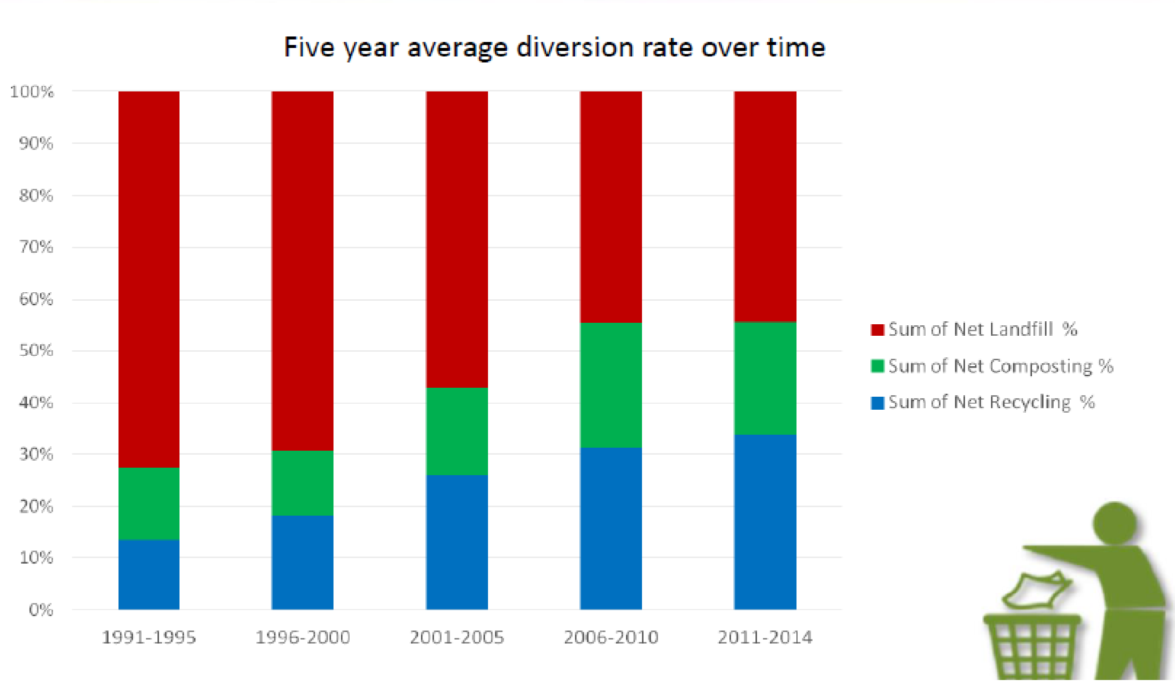

Figure 2: Five year average diversion rate over time

Scope

This study focuses on curbside recycling and curbside trash only. It does not include yard waste, bulky waste, household hazardous waste, construction and demolition waste, or the drop-off recycling program. The aim of this study is to characterize the contents of the curbside recycling stream, while also gaining an insight into the quantity and type of contaminants that are present in the recycling stream. This study also sampled the trash stream in order to detect the presence of recoverable recyclables and thus calculate the curbside recycling recovery rate.

Project Goals

1) To calculate the recycling rate and recovery rate[1] for the curbside recycling stream.
2) To calculate the rate of contamination in the recycling stream.
3) Identify opportunities for improvement through communications and outreach

Portsmouth's Recycling Program

The Department of Public Works makes it mandatory for Portsmouth's residents to recycle. The program in effect is single stream recycling, which means that all recyclables are processed as one common stream, and the non-recyclable materials are disposed of as trash, bulky waste, or household hazardous waste depending on the type of material. Some categories of recycling that are not eligible for single stream processing can be dropped off at the transfer station such as tires, eyeglasses, vegetable oil, cooking oil, and more. The Department of Public Works is implementing a pilot composting program where residents can now drop off their food waste compost.

Portsmouth has five collection days: Monday through Friday. The trash routes include residential curbside collection and downtown commercial curbside collection. DPW is responsible for the collection and transportation of trash, recycling and yard waste from these sources, while outside vendors are contracted for processing and disposal. Apartment buildings and multi-unit residences, however, contract a scheduled pick-up through a private firm.

With a population of 21,440 residents (2014 census), out of which 5,244 households are part of the curbside single stream recycling program, Portsmouth has a 55% landfill diversion rate, which is well above the American average of 34.3%. The average Portsmouth resident sends 1.25 pounds of waste per day to the landfill whereas the average American sends 2.89 pounds of waste per day to the landfill. Thus, it is evident that Portsmouth's recycling efforts are well above national levels [1]. This could be attributed, in part, to the fact that Portsmouth has been designated as an Eco-Municipality, which means that there is a commitment and desire to follow the four sustainability principles outlined by *The Natural Step* [2]:

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[1] A recycling rate is the proportion of waste recycled within the overall waste stream. A recovery rate is the proportion of waste recycled among all the recyclables materials in the waste stream. For more details on how these are calculated, see Appendix A.

- Reduce dependence upon fossil fuels and extracted underground metals and minerals;
- Reduce dependence on chemicals and other manufactured substances that can accumulate in nature;
- Reduce dependence on activities that harm life-sustaining eco-systems; and
- Meet the hierarchy of present and future human needs fairly and efficiently.

Study Methodology

Table 2

Sample size

Municipal Solid Waste Sampling	**Minimum number of Households**	**Minimum weight in pounds**
Recommended [3-6]	30	200
Our target	50	500
Actual achieved sample size	30	868.6

Table 2: Sample Size

Sorting Categories

The sorting categories were defined as per the City of Portsmouth's waste management contract with Waste Management. These categories were developed on the basis of how Waste Management accepts and processes recyclable materials. Some allowances were made for categories to emerge by themselves on the basis of the MSW sampled.

Two levels of sorting took place. At the first level, curbside recycling was sorted into "true recycling", "contaminants in recycling", and "bagged recycling". On the same level, trash was sorted into "true trash" and "recyclables in trash".

At the second level of sorting, "true recycling" was sorted into 13 categories, "contaminants in recycling" was sorted into 14 categories, and "recyclables in trash" was sorted into 15 categories (Table 3 and Table 4).

A special case of contaminants is "**Bagged Recycling**" i.e., recyclable materials that were enclosed in a plastic bag. For this study, materials that met this definition were weighed separately to get an idea of the quantity of bagged recycling. However, after noting down these weights separately, the bag was opened, and its contents were included into the "True Recycling" category, unless there were other contaminants within, in which case those contaminants went into the "Contaminants in Recycling" category.

Table 3

The materials in the recyclable stream were sorted as follows:

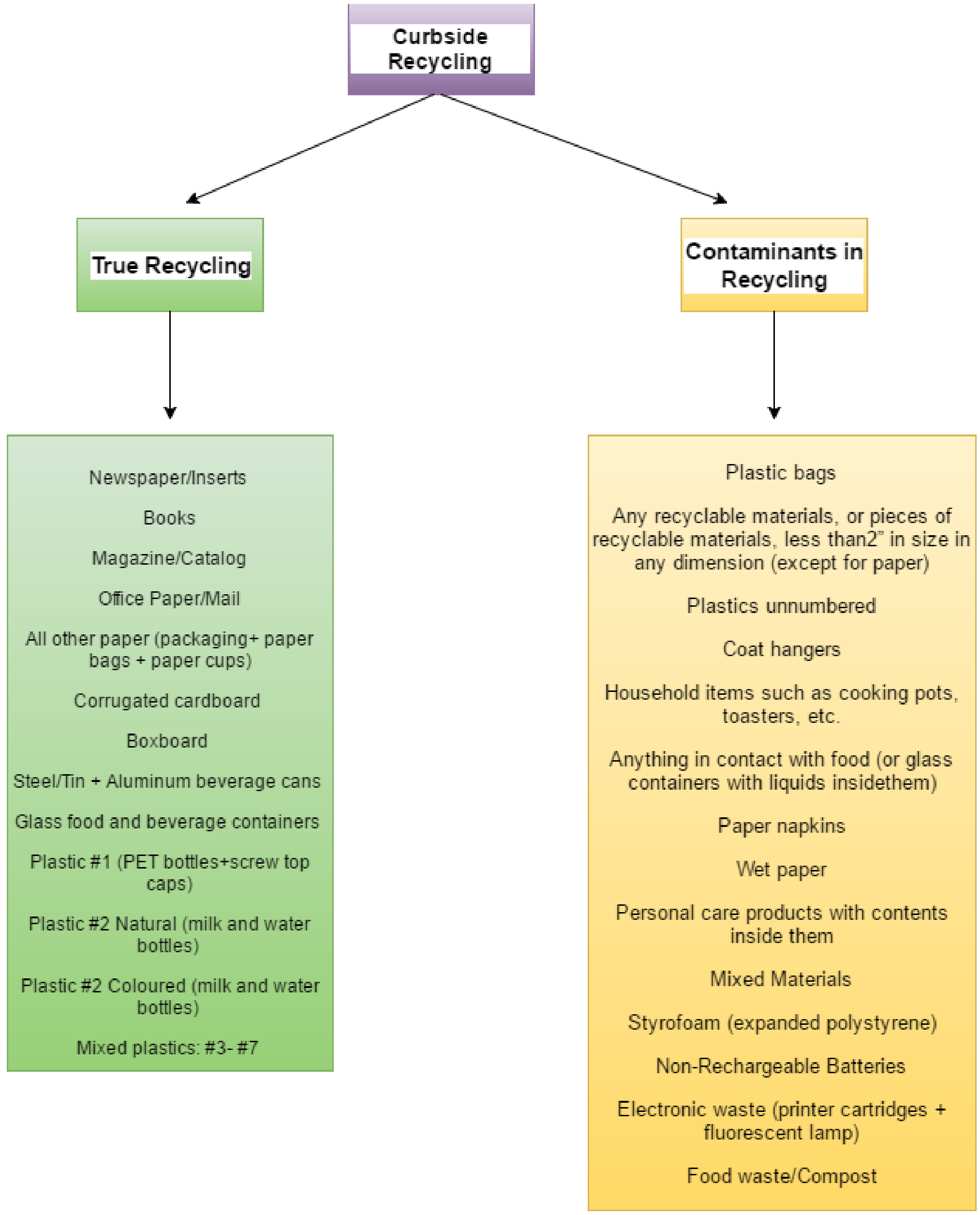

Table 3: Recycling Stream: Sorting Categories

Table 4

The materials in the trash stream were sorted as follows:

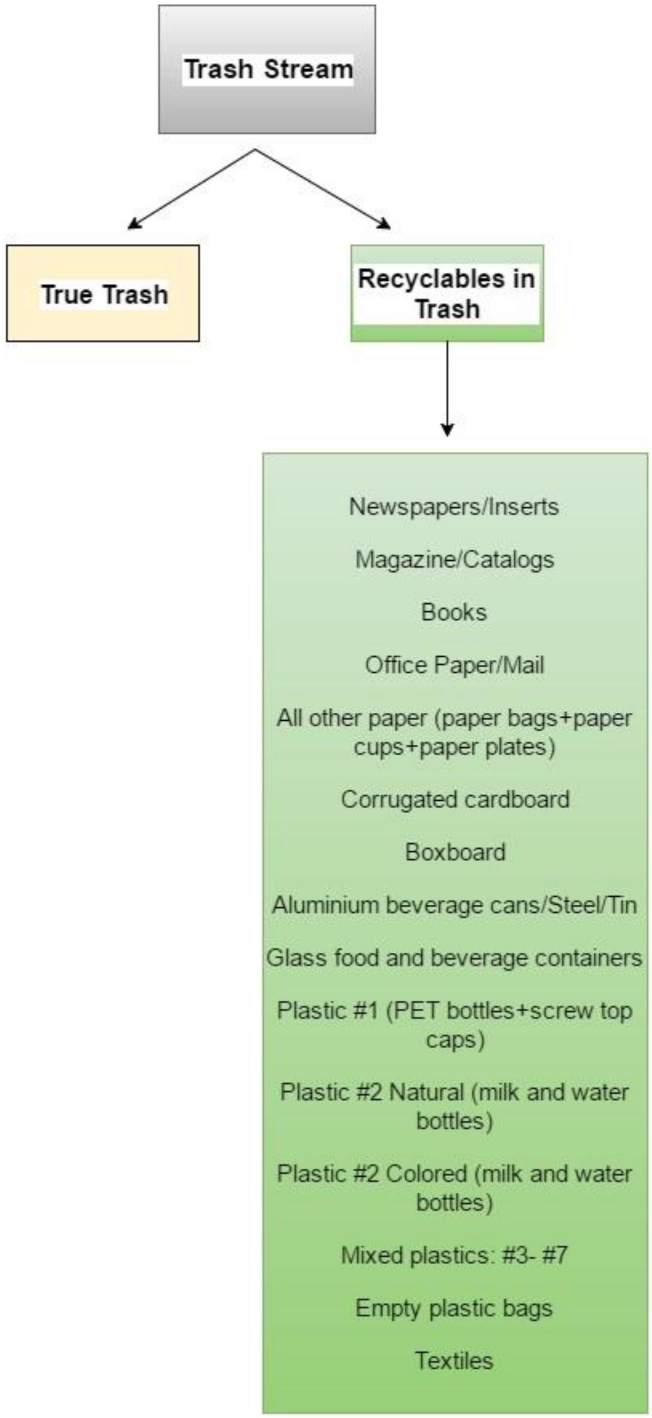

Table 4: Contaminants in Recycling: Sorting Categories

Field Collection Logistics

- **Stratified Sampling.** The sampling was stratified on the basis of routes. Each day, we randomly selected 10 households on the active route for that day.
- **Random selection within each stratum.** We used the attribute table of the GIS map which shows each household on the route. The attribute table was exported to Excel, the other inactive routes for the day were filtered out, and out of those, 10 routes were selected using the random number generator on Excel. Once each record was assigned a random number, the records were sorted in ascending order of random numbers. The top 10 records i.e., the 10 records with random numbers of the least value were the selected households for that day. **
- **Mapping.** Once the households were selected, the addresses were plotted on the respective day's recycling route map. These plotted addresses were helpful in determining the most efficient route to take. This also assisted in identifying the houses that would be targeted first by the trash/recycling trucks, so that we could get to those houses before the regular trucks got there.
- **Collection.** Each morning, we headed out to collect the trash and recycling for the selected households. We had big black trash bags to empty the contents of the recycling bin into. These black trash bags with recycling materials were marked off with masking tape in order to differentiate them from regular trash bags.
- **Set-out bias.** In order to avoid set-out bias, we made sure to collect trash and recycling only from households that set out both. However, this has its drawbacks, as will be explained later. The reason for collecting "complete" set-outs is to avoid the "set-out bias" described as
  "in some situations the households sampled for waste may differ from the households sampled for recyclables. This is due, in part, to the fact that almost all the households on a given route will put out their trash weekly or

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** For this study, we sampled houses from Monday through Thursday, but skipped the Friday route because we had already exceeded the recommended sample size, and knew that further sampling would confuse and overwhelm the effort. In research terminology, this means that saturation was reached, which is a point at which additional data no longer yields new information.

bi-weekly depending on their pickup schedule. However, they may put out their recyclables only when their bins are full. As a result, some households may have had their trash sampled but not their recyclables, while others may have had their recyclables sampled but not their trash" [7]

- **Alternatives.** If a household had not set out its trash and recycling for the day, we picked the next household in the approaching direction. Allowances were made to choose the next most convenient household on the basis of pedestrian and motor vehicle traffic so as not to obstruct the usual flow of the neighborhood.
- If a neighborhood's trash and recycling was already collected by Public Works, we headed to the next neighborhood and sampled the same number of households that was assigned to the previous neighborhood.
- **Delivery.** Finally, the collected trash and recycling were brought to the boiler room at City Hall for sorting and auditing.
- **Items used for sample collection:** Gloves, vest, big black trash bags for recycling, masking tape, scissors.

Items Needed

- Data sheets
- Digital scale (Figure 3)
- Notebook and pencils
- Camera to take pictures of sorted waste
- Recycling bins (~30 in number)
- Cheat sheet with sorting categories and an explanation of what materials to include in which categories.
- Gloves.
- Hand sanitizer.
- Labels for labelling the bins for each category.
- Extra trash bags to dispose of the post-sorted waste.
- "DO NOT DISPOSE" signs to carry over waste to the next day.
- DPW shirt, vest.
- Water for hydration.
- Masking tape
- Scissors

Figure 3

Digital scale

Limitations

1) While this study was designed to avoid the set-out bias, it had the contrary effect of being likely to have yielded an inaccurate picture of recyclables in trash. Since we only sampled households that set out both recyclables and trash, the percentage of recyclables in trash was found to be lower than would have been if we sampled households that would have set out trash only (because these households would be less likely to recycle).

2) This procedure needs to be carried out at least once more during a different season in order to paint a cohesive picture of curbside recycling [3]. This study serves as the baseline for further data collection and analysis.

3) The scale that we used could only detect weights of 0.2 lbs. or above. As such, some of the materials that weighed less than 0.2 lbs. were still recorded as 0.2 lbs. If the true weight of a material was 23.3 lbs., the digital scale automatically rounded up the weight to 23.4 lbs.

4) The weight of each recycling bin varied slightly. To accommodate for these variations, the weight of each bin was recorded, and the average weight of all the bins was used as the tear weight.

5) Identifying recyclables in trash was a subjective procedure because it was tricky to determine whether the recyclable was contaminated after being in the trash (in which case, it would be a recoverable recyclable) or whether the resident threw the recyclable into the trash stream because it was contaminated (in which case, it would have been the correct choice). One way to differentiate between the two cases was to check which surface was contaminated. If it was the outside surface, it was classified as a recoverable recyclable. If it was the inside surface, it was considered as belonging to the trash stream. This, however, led to insufficient data to calculate recovery rates for materials like glass. *(see: "Recovery Rate by Material", and "Opportunities to improve and streamline future studies" section)*

6) Balancing weight vs. volume: This study recorded the waste by weight. However, because of the "evolving ton"[2], weights are not necessarily the best representation of quantity [5]. To overcome this, most of the sorted waste was photographed so that we could spot contaminants and other

[2] This refers to the changing waste stream, where there is now a need to process more volume and less weight. This is due to the decline of newspapers in the recycling stream, and the increase of plastic-based substances. Higher volumes lead to higher processing costs. This also means that these materials are of lower value, which reduces overall revenue, and further drives up recycling costs.

categories of waste that deserves attention. These would otherwise have not been represented adequately through quantitative information.

Data Review and Analysis

Pre-sort

A total of 868.8 pounds of curbside municipal solid waste was collected, sorted, and analyzed. Nearly half of this material was from the trash totes, while the other half was from the recycling bins.

Table 5 shows the total weights of all the trash samples and recycling samples collected.

Figure 4 shows the percentage of materials in each of the two streams, which also serves as an indicator for residents' perceptions of what belongs in each stream.

Table 5

Municipal Solid Waste sampled

Type of Samples	Weight (lbs.)
Trash samples	445.1
Recycling samples	423.5
Total MSW sampled	**868.6**

Table 5: Municipal Solid Waste Sampled

Figure 4

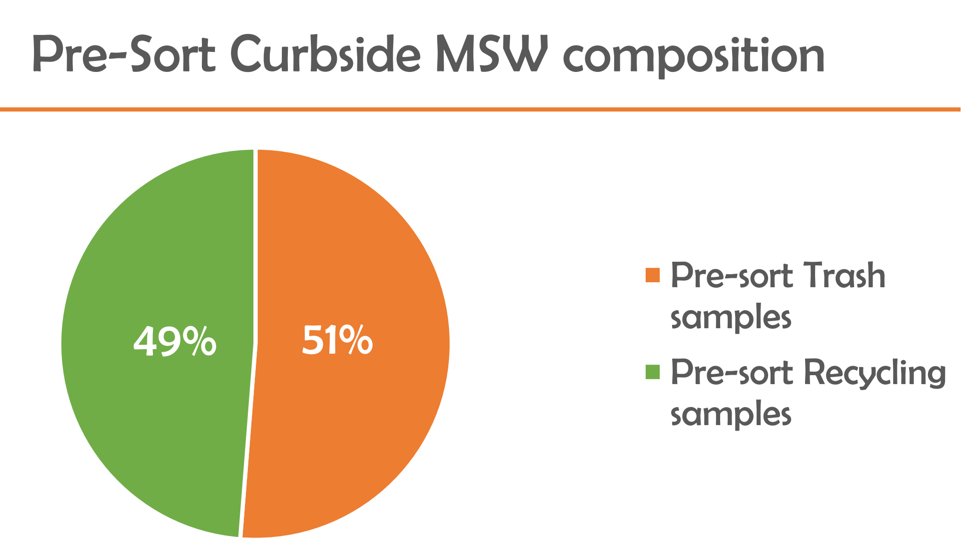

Figure 4: Pre-Sort Curbside Municipal Solid Waste composition

Post-sort

After sorting through the samples, the proportions represented in Figure 4 changed. This is because the recycling stream contained some contaminants, and the trash stream contained some recoverable recyclable materials.

Figure 5 depicts a breakdown of what was really in each stream after it was audited. This is a representation of the composition of true trash, true recycling, recyclables in trash, and contaminants in recycling, and their percentage composition within the overall curbside MSW stream.

While there were few recyclables in trash, there was a larger proportion of contaminants in recycling.

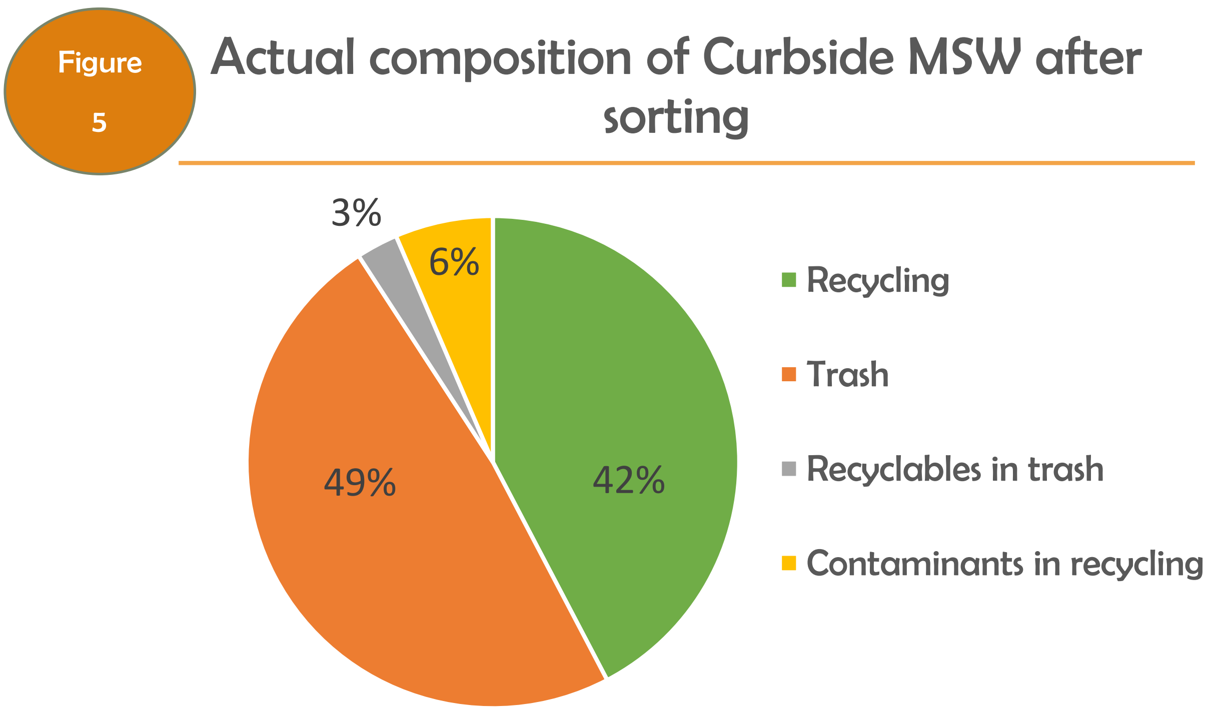

Figure 5: Actual composition of curbside Municipal Solid Waste after sorting

While the trash stream did have more recyclable materials, most of them were too contaminated to be considered as recoverable recyclables. Thus, those were regarded as true trash, and only the recyclables in the trash stream that were not contaminated and that had the potential to be processed by a facility were counted as recoverable recyclables.

Table 6 represents the weights of each of these categories as they were recorded after the sorting process.

Table 6

Composition of Municipal Solid Waste after sorting

Post-sort category	Weight (lbs.)
Recycling	367.6
Trash	421.3
Recyclables in trash	23.8
Contaminants in recycling	55.9
Total Municipal Solid Waste	**868.6**

Table 6: Composition of Municipal Solid Waste after sorting

The Recycling Stream

Looking at the recycling stream which constitutes 423.5 lbs of the 868.6 lb sample, about 13% of this stream contained contaminants, as shown by Figure 6.

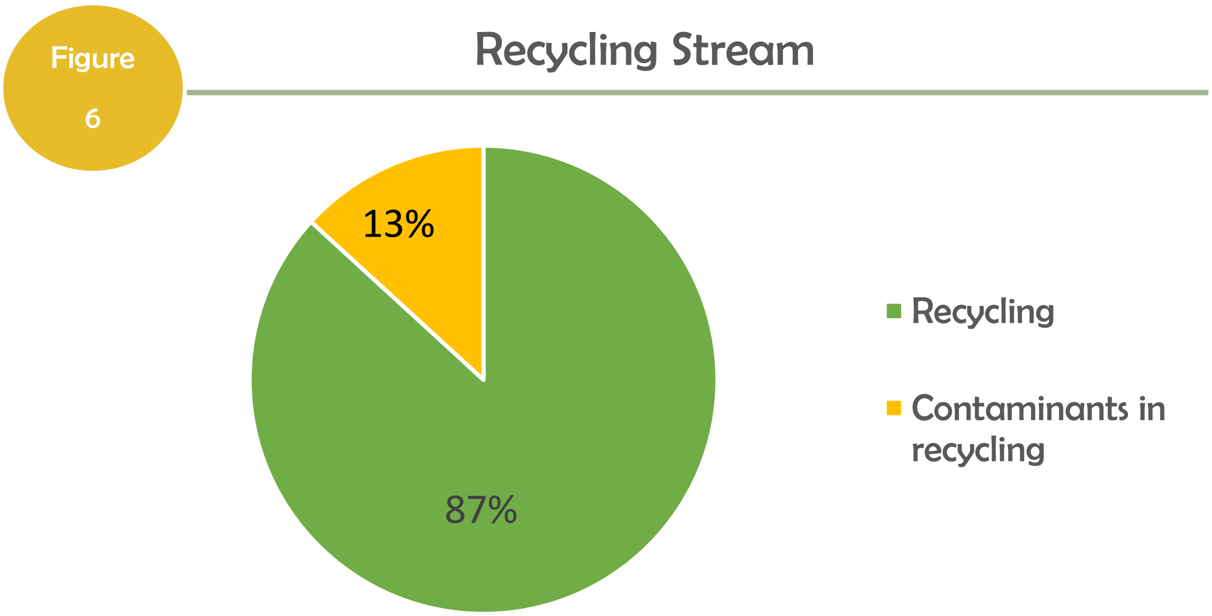

Figure 6: Recycling Stream

True Recyclables

Among the true recyclables within the recycling stream, fibrous recyclables emerged as the most recycled material (Figure 7). Fibrous recyclables include paper, corrugated cardboard, boxboard, newspapers, magazines, office paper/mail, and other types of paper.

The second largest chunk of this stream was occupied by glass food and beverage containers, most of which were containers for alcoholic beverages.

Among the plastics, PET bottles or Plastic #1 had the highest composition by weight. Table 7 depicts the breakdown, by weight, of the true recyclables in the recycling stream.

Although we had included “Books” as one of the categories, there were no books in our sample, although there were several newspapers and magazines.

Figure 7

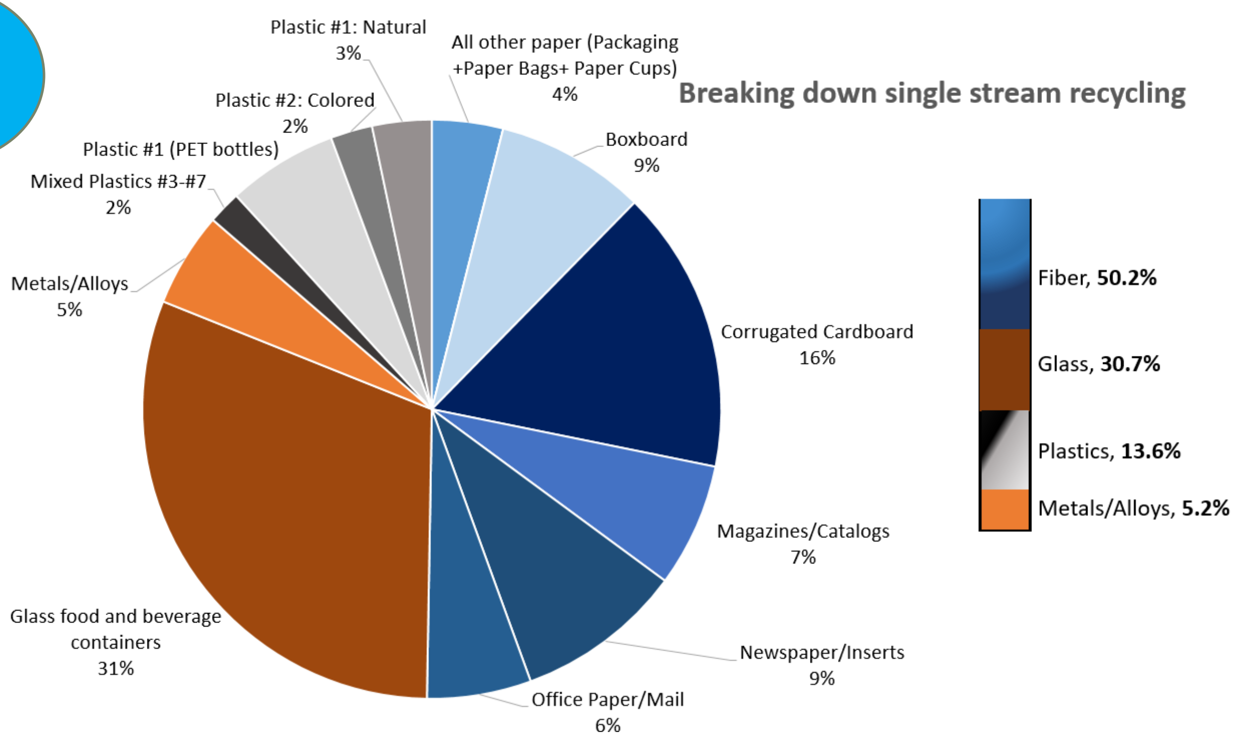

Figure 7: Breaking down single stream recycling

Table 7

Composition of true recyclables in the recycling stream

Recycling Category	Weights (lbs.)	Percentage
Fiber	**184.8**	**50.27%**
All other paper (packaging+ paper bags + paper cups)	14.6	3.97%
Books	0	0.00%
Boxboard	30.8	8.38%
Corrugated cardboard	58.2	15.83%
Magazine/Catalog	25.4	6.91%
Newspaper/Inserts	34.4	9.36%
Office Paper/Mail	21.4	5.82%
Glass	**113.2**	**30.79%**
Glass food and beverage containers	113.2	30.79%
Metals/Alloys	**19.4**	**5.28%**
Steel/Tin + Aluminum beverage cans	19.4	5.28%
Plastic	**50.2**	**13.66%**
Mixed plastics: #3- #7	6.8	1.85%
Plastic #1 (PET bottles+screw top caps)	22.6	6.15%
Plastic #2 Colored (milk and water bottles)	8.6	2.34%
Plastic #2 Natural (milk and water bottles)	12.2	3.32%
Grand Total	**367.6**	**100.00%**

Table 7: Composition of true recyclables in the recycling stream

Contaminants in Recycling

Figure 8

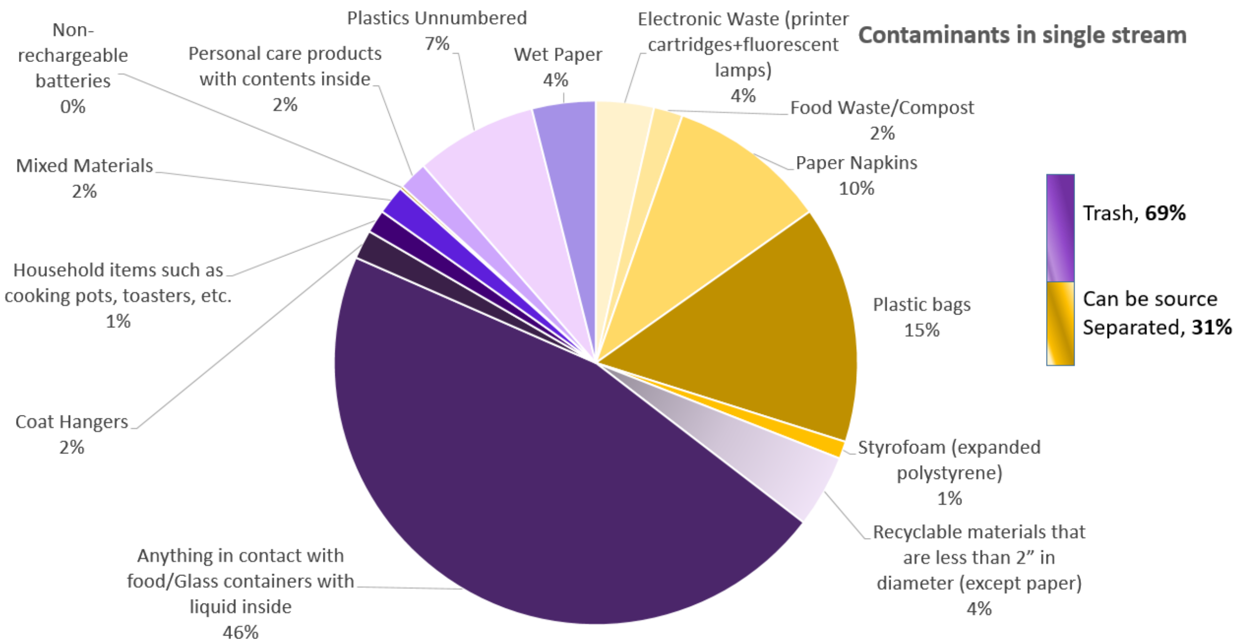

Figure 8: Contaminants in single stream recycling

Among all the contaminants in the recycling stream, we found that 31% of the contaminants can be source separated (Figure 8). These are considered contaminants because MRFs cannot recycle these mixed materials, however, there are other opportunities to source separate them. These include Styrofoam (which can be mailed to a Styrofoam recycling company), plastic bags (which can be dropped off at the grocery store), food and paper napkins (which can be composted), and electronic waste (which can be dropped off at Public Works).

The rest of the contaminants were not ones that can be source separated. Among these, the largest category by percentage was paper and glass containers stained with food. Unnumbered plastics formed the second largest category amongst the contaminants that do not have a potential for source separation.

Figure 9

Contaminants in the recycling stream: L-R: Coat hangers, unnumbered plastics, greasy food, packaging

Table 8

Composition of contaminants in the recycling stream

Categories	Weights (lbs.)	Percentage Composition
Source Separated	**17.3**	**30.95%**
Electronic waste (printer cartridges + fluorescent lamp)	2	3.58%
Food waste/Compost	1	1.79%
Paper napkins	5.5	9.84%
Plastic bags	8.2	14.67%
Styrofoam (expanded polystyrene)	0.6	1.07%
Trash	**38.6**	**69.05%**
Any recyclable materials, or pieces of recyclable materials, less than 2” in size in any dimension (except for paper)	2.5	4.47%
Anything in contact with food (or glass containers with liquids inside them)	25.8	46.15%
Coat hangers	1	1.79%
Household items such as cooking pots, toasters, etc.	0.8	1.43%
Mixed Materials	1	1.79%
Non-Rechargeable Batteries	0.1	0.18%
Personal care products with contents inside them	1	1.79%
Plastics unnumbered	4.2	7.51%
Wet paper	2.2	3.94%
Grand Total	**55.9**	**100.00%**

Table 8: Composition of contaminants in the recycling stream

Trash stream

Looking at the trash stream which constitutes 445.1 lbs. out of 868.6 lbs. of curbside MSW, there is a potential for recovering 5% of its contents into the recycling stream (Figure 10).

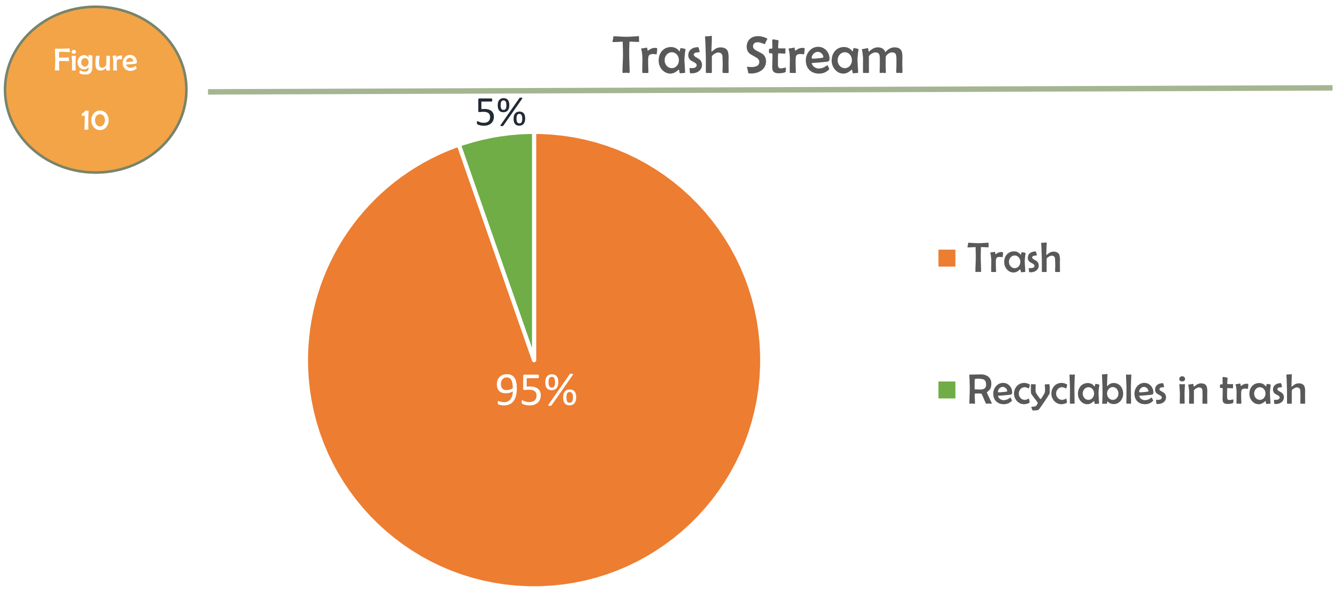

Figure 10: The Trash Stream

Recyclables in trash

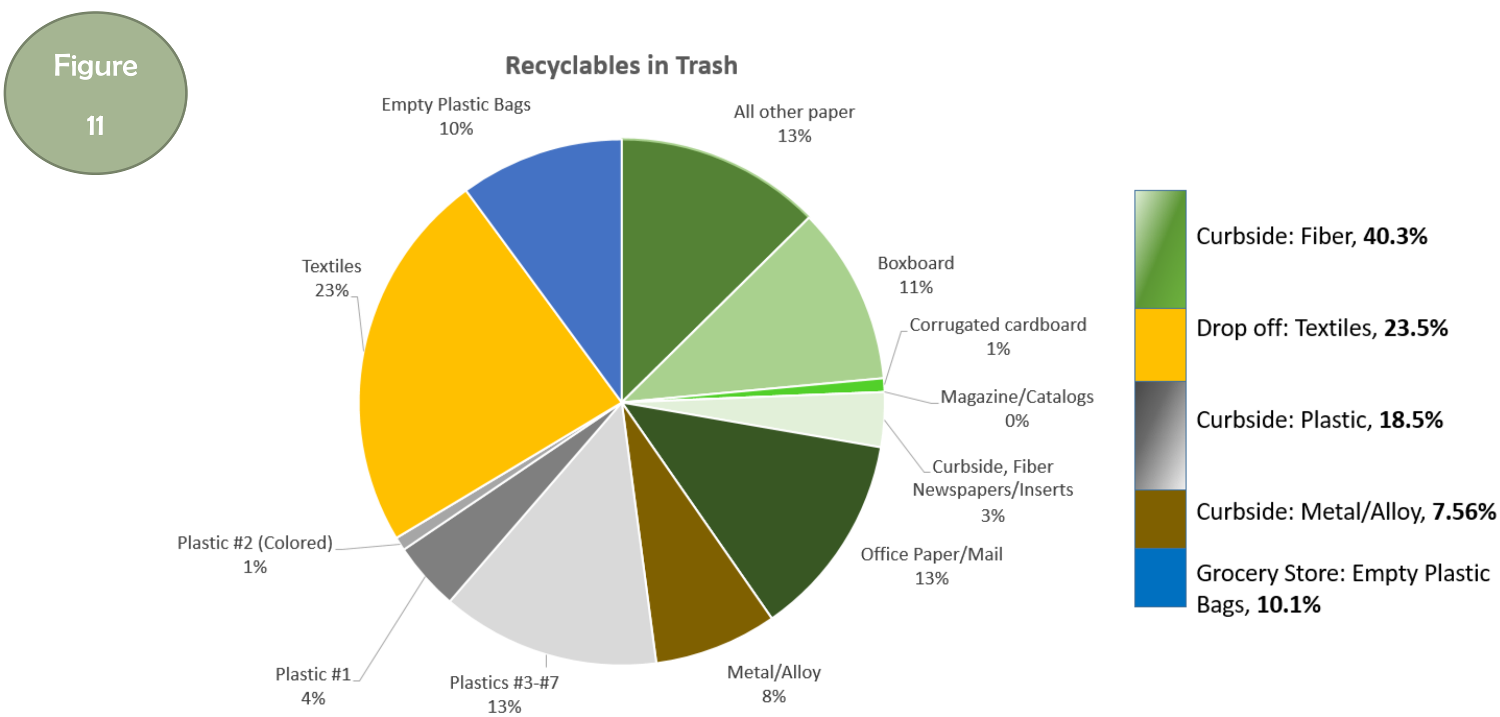

Figure 11: Recyclables in Trash

Since one of the goals of this study was to identify opportunities for improvement, we counted plastic bags and textiles as recoverable recyclables even though they are not part of the curbside recycling program. Empty plastic bags, though not recyclable by Public Works, can be recycled at the local grocery and department stores. Textiles can be dropped off at the clothing collection boxes around town including the recycling center at Public Works. Interestingly, textiles formed the second largest category of recoverable recyclables in the trash stream.

The composition of recoverables in the trash stream echo, in some ways, the composition of the true recyclables (Figure 11). Among the true recyclables, fiber formed the largest category by weight, and the same is seen in the recoverables from trash. One major difference is that there was virtually no glass present as a recoverable recyclable in the trash stream. There was, however, some glass in the trash stream, but it was too contaminated to meet the criteria to be a recoverable.

While plastic #1 dominated the plastics in the true recyclables, plastics #3-#7 dominate the plastics in the recoverables. This is an interesting find, and indicates that some people may still not be aware that plastics #3-#7 can, in fact, be recycled.

Figure 12

Recoverable recyclables in the trash stream: L-R: Office paper, boxboard, plastic

Figure 12: Recoverable recyclables in the trash stream

Table 9

Recoverable recyclables in the trash stream

Categories	Weight (lbs.)	Percentage Composition
Curbside, Fiber	**9.6**	**40.34%**
All other paper (paper bags+paper cups+paper plates)	3	12.61%
Books	0	0.00%
Boxboard	2.6	10.92%
Corrugated cardboard	0.2	0.84%
Magazine/Catalogs	0	0.00%
Newspapers/Inserts	0.8	3.36%
Office Paper/Mail	3	12.61%
Curbside, Glass	**0**	**0.00%**
Glass food and beverage containers	0	0.00%
Curbside, Metal/Alloy	**1.8**	**7.56%**
Aluminum beverage cans/Steel/Tin	1.8	7.56%
Curbside, Plastic	**4.4**	**18.49%**
Mixed plastics: #3- #7	3.2	13.45%
Plastic #1 (PET bottles+screw top caps)	1	4.20%
Plastic #2 Colored (milk and water bottles)	0.2	0.84%
Plastic #2 Natural (milk and water bottles)	0	0.00%
Drop-off (DPW)	**5.6**	**23.53%**
Textiles	5.6	23.53%
Drop-off (grocery store)	**2.4**	**10.08%**
Empty plastic bags	2.4	10.08%
Total	**23.8**	**100.00%**

Table 9: Composition of recoverable recyclables in the recycling stream

Recovery Rates by material

The following are individual recovery rates calculated for select materials. For glass, there was insufficient data to calculate its individual recovery rate. This is because a lot of the glass in the trash stream was too contaminated with food to be considered as a recoverable recyclable as defined by this study. However, that data would still be necessary to calculate the recovery rate for glass as a separate material.

Table 10

Material	Trash (lbs.)	Recycling (lbs.)	Total (lbs.)	Recovery Rate
Fiber (including drop-off textiles)	15.2	184.8	200	**92%**
Plastic	4.4	19.4	23.9	**81%**
Metals/Alloys	1.8	50.2	52	**97%**

Table 10: Recovery Rates by Material

Key Takeaways

Curbside Recycling Rate

The recycling rate is a measure of how much of the overall municipal curbside stream is recycled. The maximum achievable recycling rate is a measure of how much of the overall curbside MSW *could potentially* be recycled.

Portsmouth's curbside recycling rate currently stands at 42% out of a maximum achievable recycling rate of 44.1%.

Curbside Recovery Rate

The recovery rate is a measure of how much of all the recycling in the MSW stream was actually recovered as recycling.

Portsmouth's curbside recovery rate currently stands at 95.8%.

Contamination in the recycling stream

The recycling stream was contaminated by about 13%. Out of these, unclean food containers were the dominant contaminants. Recycling enclosed within plastic bags was also found in abundance, although for the purposes of this study, only the plastic bags themselves were labeled a contaminant while the recyclables inside weren't included in calculating the contamination rate.

Within the overall curbside MSW stream, the proportion of recycling contaminants was found to be 6%.

Potential for additional recovery

Further source separation can occur in order to decrease contamination rates and increase recovery rates. 31% of the recycling contaminants could be source separated, and 3% of the trash stream could be diverted from the landfill.

Within the overall curbside MSW stream, the potential for source separation was found to be 4.7%.

Conclusions

Recommendations – Outreach Strategies

- **Bagged recycling** formed 19% of the recycling stream, and 51% of the contaminants in recycling. This is a grey area, because the contents of the bags are recyclable but the plastic bag is not. Thus, conveying this information to residents and asking them to avoid putting their recyclables in bags could help improve the recycling rate.
- **Plastic bags** formed the third largest category of contaminants (15%). Although plastic bags cannot be recycled in the single stream recycling program, grocery stores accept plastic bags for recycling. Diverting plastic bags away from the recycling stream could reduce the rate of contamination, even though it is not quantitatively detectable because of its negligible weight.
- From field observations, we were able to gather that residents who had **covered bins** for recycling were less likely to bag their recycling than residents who had the regular open bins. Covered bins also provided protection to the recycling materials from wind and rain, thus making them easier to process.
- The second largest category of contaminants was **food-stained or greasy containers** (22.6%). The containers were either made of glass, fiber, or numbered plastic. While food-stained glass isn't as big an issue, food-stained fiber causes problems during processing because the fiber is made into a slurry with large quantities of water. This causes the oil on the surface of the fiber to leech out to the top of the slurry, making it difficult for the paper fibers to separate out [8]. Thus, an emphasis on cleaning containers with food/grease in them before disposing them into the recycling stream could improve the recycling rate.
- **Personal care products** with contents inside them formed 2% of the contaminants within the recycling stream. Educating residents to empty out these tubes or bottles before disposal could potentially reduce the occurrence of these contaminants.
- **Mixed materials** posed a conundrum. Some parts of the material were recyclable, while other parts were not. The only way to handle this is through source separation: taking the material apart, and placing the appropriate parts in their respective stream. Figure 13 is one such example.

Figure

13

Mixed Materials Box

Figure 13: Mixed materials

- **Materials less than 2" in any dimension**: this includes shredded paper, broken glass, and other plastic odds and ends (Figure 14). Tiny bits of recycling are likely to fall through the screen at the Material Recovery Facility (MRF), and eventually end up in the landfill. Broken glass can be recycled, however, it poses a hazard to those who manually handle or sort through the waste, and could be avoided where possible.

Figure

14

Materials less than 2" in any dimension

Figure 14: Materials less than 2" in any dimension

Opportunities to streamline and improve future studies

- If time allows, perform a pilot run in order to ensure that your time of collection does not interfere with the regular trash and recycling collection. The pilot run will also help assess whether you have the right resources for collection, and will familiarize you with the sorting procedure.

- Aggregate the data from this study and subsequent studies in order to have a cohesive picture of curbside recycling. If the same study is conducted during a different season, the data from both studies would be an accurate representation of Portsmouth’s curbside recycling.

- Set aside a special stratum for sampling households which only set out their trash (and not recycling). This would help clarify whether the percentage of recyclables in trash shown by this study is an accurate reflection of recyclables in trash even amongst those who do not actively recycle, while also avoiding the set-out bias (because this stratum will be analyzed separately as a satellite study, and the results from the two cases can be compared).

- This study used “Newspapers/Glossy Inserts” as a single category, and “Magazines” as a separate category. However, it would be useful if future studies looked at “Newsprint” and “Magazines/Glossy Inserts” to get a better idea of how much of the paper is colored vs. non-colored.

- This study did not separate office paper from office paper with wax liners, the latter being a contaminant. Future studies could separately identify office paper with wax liners and quantify those as a contaminant.

- If resources allow, a more sensitive digital scale would help improve the accuracy of the results.

- Check the weights of each of the bins before weighing. If possible, label each bin with their respective weights because not all bins are likely to have the same weight.

- Establish a procedure to identify recyclables in trash. For this study, the procedure was to check which surface was contaminated. If it was the outside surface, it was classified as a recoverable recyclable. If it was the inside surface, it was considered as belonging to the trash stream.

- It might also be useful to classify ALL the glass in the trash stream as recoverable recyclables (even if they were too contaminated) in order to generate data on how much of the glass can be recovered.
- Check weather and schedule a backup week in case the collected waste for the day is wet.
- Attempt representation of data by volume/density in addition to weight.
- Attempt to project an economic value, and create a metric for contaminants or trash or even recyclables in terms of kgCO2eq. This would then yield information that says "*with every load of recyclables, there's X amount of carbon from those materials, and this could have saved x% CO2 if there were no contaminants.*"[9]

Appendix A: Metric Calculations and Definitions

1) Curbside Recycling Rate [10] = $\dfrac{\text{Weight of waste recycled}}{\text{Total Municipal Solid Waste Generated}}$

2) Rate of contamination in the recycling stream = $\dfrac{\text{Weight of contaminants}}{\text{Weight of recycling stream before sorting}}$

3) Maximum Achievable Recycling Rate [10] = $\dfrac{\text{Weight of recyclables + Recyclables in trash}}{\text{Total Municipal Solid Waste Generated}}$

4) Recyclable Recovery Potential [10]= $\dfrac{\text{Weight of curbside recoverable recyclables in the trash stream}}{\text{Weight of trash stream before sorting}}$

5) Recovery Rate [10] = $\dfrac{\text{Weight of recycling}}{\text{Weight of recycling + Weight of recyclables in trash}}$

6) True Recyclables: Refers to the recyclable materials that were correctly put into the recycling stream.

7) Contaminants: Refers to materials in the recycling stream that cannot be recycled.

8) True Trash: Refers to materials that were correctly put into the trash stream (i.e., materials that cannot be recycled)

9) Recoverable recyclables: Refers to materials in the trash stream that were eligible to be recycled.

10) Source separation: A self-explanatory term which involves sorting of waste into their appropriate categories by the user before disposal into their respective streams.

Appendix B: Sample Data Sheet

Portsmouth Recycling Recovery Rate Analysis		
Date	11th July 2016	
Day	Monday	
Route	1	
Time of Collection	8 AM - 9 AM	
Weather	Drizzly, cloudy	
State of Samples	Slightly damp	
Number of Samples	7	
Total Weight of Pre-sorted trash collected	96.4	
Total Weight of Pre-sorted Recyclables collected	117.6	
Total MSW Generated=Total MSW Recycled+Total MSW in trash		
Recycling recovery rate= Total MSW Recycled/Total MSW Generated * 100		
Maximum achievable recovery rate for the day= Tons reycled+ Recyclables in trash/ Total tons of waste generated		
Rate of contamination in the recycling stream= Weight of Contaminants * 100 /Total weight of Pre-Sort Recycling		
Pictures		

Recyclables sorting categories	Weight in pounds (bin weight subtracted)	Weight of bin used for measuring= 3.6 lbs
Actual recyclables		
Newspaper/Inserts	8.4	
Magazine/Catalogs	6.6	
Books		
Office Paper/Mail	4.2	
All other paper	0.6	
Corrugated cardboard	35.2	
Boxboard	9	
Steel/Tin + Aluminum beverage cans	6.6	
Glass food and beverage containers	29.8	
Plastic #1 (PET bottles+screw top caps)	3.6	
Plastic #2 Natural (milk and water bottles)	1.6	
Plastic #2 Coloured (milk and water bottles)	1	
Mixed plastics: #3- #7	1.8	
Contaminants		
Bagged materials (even if containing Recyclables)	14.4	**Subtract this amount from the total recycling because it gets counted twice since bags are also opened and sorted**
Mirrors	9.2	
Light Bulbs		
Porcelain		
Plastic bags, expanded polystyrene		
Glass cookware/bakeware		
Flexible packaging and multi-laminated materials		
Excluded Materials		
Any recyclable materials, or pieces of recyclable materials, less than 2" in size in any dimension (except for paper)		
Microwave trays		
Window or auto glass		
Ceramics		
Plastics unnumbered		
Coat hangers		
Household items such as cooking pots, toasters, etc.		
Wet fiber+ Fiber containing, or that has been in contact with, food debris		
Materials: (a) that contain chemical or other properties deleterious, or capable of causing material damage, to any part of Company's property, its personnel or the public; and/or (b) that may materially impair the strength or the durability of the Company's structures or equipment.		
Specialty items meant for drop off		
Rechargeable Batteries		
Electronic waste		
Food waste/Compost		
Empty plastic bags (can go to grocery store)		
Antifreeze		
Clothing		
Cooking oil		
Vegetable oil		
Tires		
Eyeglasses		
Fluorescent light bulbs		
Oil & oil filters		
Propane tanks (empty)		
Freon waste		

Trash sorting categories	Weight in pounds
Actual trash	91.2
Non-organic trash	
Organic Trash	
Recyclables thrown in trash	5.2
Potential curbside	
Newspaper/Inserts	
Magazine/Catalogs	
Books	
Office Paper/Mail	
All other paper	
Corrugated cardboard	
Boxboard	
Steel/Tin	
Aluminium beverage cans	
Glass food and beverage containers	
Plastic #1 (PET bottles+screw top caps)	
Plastic #2 Natural (milk and water bottles)	
Plastic #2 Coloured (milk and water bottles)	
Mixed plastics: #3- #7	
Potential drop off	
Rechargeable Batteries	
Electronic waste	
Food waste/Compost	
Empty plastic bags (can go to grocery store)	
Antifreeze	
Clothing	
Cooking oil	
Vegetable oil	
Tires	
Eyeglasses	
Fluorescent light bulbs	
Oil & oil filters	
Propane tanks (empty)	
Freon waste	
Household Hazardous Waste	

References

1. Levenson, J., *Recycling & Solid Waste Program*, Department of Public Works, Editor. 2016, City of Portsmouth: Portsmouth, New Hampshire.
2. James, S. and T. Lahti, *The Natural Step for Communities: How Cities and Towns Can Change to Sustainable Practices*. 2004: New Society Publishers.
3. California Department of Resources Recycling and Recovery. *Collecting Your Own Solid Waste Characterization Data: CalRecycle Uniform Waste Disposal Characterization Method*. 2016; Available from: http://www.calrecycle.ca.gov/wastechar/yourdata.htm.
4. Harvey Abramowitz, Y.S., *Municipal Solid Waste Characterization Study for Indiana*. 2012, Purdue University Calumet: Hammond, Indiana. p. 3.
5. Siegler, T., *Recovery Rates A Better Way to Measure Recycling Performance At Your Transfer Station*. 2015, DSM Environmental Services: Windsor, Vermont.
6. Sustainable Cities Institute. *Conducting a Waste Characterization Study: Overview*. 2013 [cited 2016; Available from: http://www.sustainablecitiesinstitute.org/topics/materials-management/conducting-a-waste-characterization-study-overview.
7. Tim Goodman & Associates, *Suburban Recycling Recovery Rate Study for St. Louis Park and Minnetonka*. 2009, Tim Goodman & Associates: St. Louis Park, Minnetonka.
8. McNatt, M. *What Not to Put in the Bin*. [Webpage] 2016; Available from: http://earth911.com/home-garden/what-not-to-put-in-the-bin/.
9. Hellebusch, B., *Presentation feedback*, V. Balasubramanyam, Editor. 2016.
10. Siegler, T., *Waste Composition Studies: Understanding the Results*. 2015, DSM Environmental Services: Windsor, Vermont. p. 40-44.