2019-2022 Food Waste Generation and Composition Study Analysis

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Contents

EXECUTIVE SUMMARY

The Minnesota Pollution Control Agency (MPCA) contracted with Resource Recycling Systems (RRS) and GRG Analysis to measure the proportion of food in Minnesota's Mixed Municipal Solid Waste (MMSW), including residential and commercial streams. RRS and GRG Analysis completed thirteen sorts as a part of this study, separating food (edible, inedible, and liquid) and food-related packaging 'compostable paper and packaging' and residual packaging removed from edible food) from the MMSW stream and sorting into more granular categories. The remaining sample material in the MMSW stream outside of these categories was not sorted into individual categories. Quantifying and monitoring trends on the proportion of food in Minnesota's MMSW is important for making adjustments to programs and targeting the needs identified to reduce food waste.

Throughout the report, the thirteen sorts are grouped into six sort events based on the year in which they were conducted – 2019 Sort Event (with three sorts), 2020 Sort Event (with two sorts), 2021 Spring Sort Event (with two sorts), 2021 Fall Sort Event (with two sorts), 2022 Spring Sort Event (with two sorts), and 2022 Fall Sort Event (with two sorts). Sorts were conducted in the Metro and Greater MN as well as the Spring and Fall to account for variations.

Five categories of organic material were sorted from the MMSW: inedible food, edible food, 'compostable paper and packaging', liquids, and non-compostable packaging removed from edible food during the sort. Overall, approximately 27% of the sorted residential and commercial MMSW in the study was food & 'compostable paper and packaging' and 73% was Remaining Sample Material.' [1] (Figure 1).

Of the food & 'compostable paper and packaging' category, edible food was the largest subcategory and made up nearly half of the material (48.4%). The next largest category was inedible food (24.5%), followed closely by 'compostable paper and packaging' (23.9 %), liquid (3.2%) and non-compostable packaging removed from edible food (2.6%) of the Food and food Packaging in the waste stream portion sorted.(Figure 2).

Figure 1: Overall Sort Composition

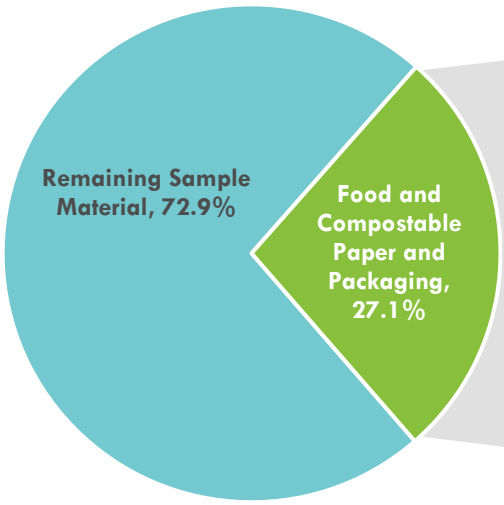
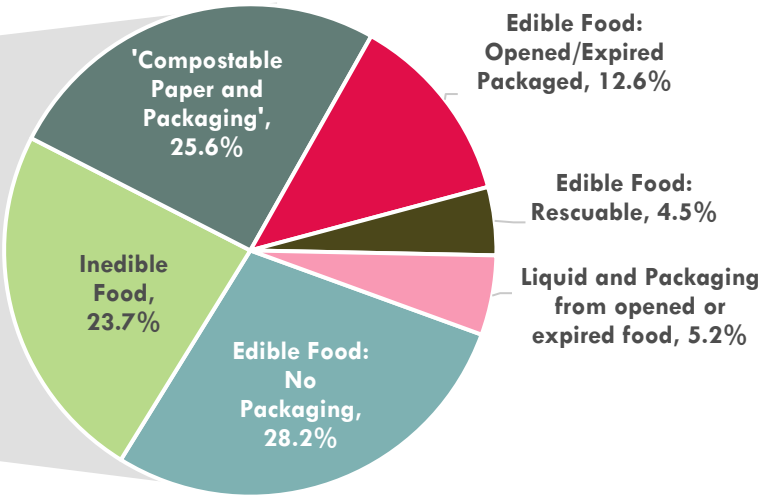


Figure 2: Food & 'Compostable Paper and Packaging'



[1] Edible food waste includes unpackaged food, opened, or expired packaged food, and donatable food.

DEFINITIONS

Metro MN: Metro Minnesota refers to the seven-county metropolitan region around Minneapolis and St. Paul (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington Counties)

Greater MN: Greater Minnesota refers to the area outside the seven counties of the Twin Cities region that is centered on the state's two largest cities of Minneapolis and St. Paul, or the state's non-urban areas more generally.

Food, No Packaging: Any food that could have been consumed by humans but was not disposed of within a package. Includes anything spoiled, moldy, half-eaten, or otherwise makes it unfit for consumption

Opened or Expired Packaged Food (Prior to the Date of the Sort): Food that has packaging and the container has been opened but still contains food

Rescuable Whole or Unopened Packaged Food: Food which is fit for human consumption and meets criteria for suitability for rescue/donation, generally limited to pre-consumer surplus food; may include inedible parts as parts of food products donated

Food Scraps: The portion of food remaining after consumption; may include edible food as well as inedible parts, though ideally includes only inedible parts (I.e., could be a core that has some apple flesh on it that others would eat but the majority of it is the core)

Compostable Paper Products: Paper towels, napkins, and unlined paper bags only

Compostable Food Service Ware Products: Include in this category any food service ware or products that are clearly not plastic lined, BPI labeled, PLA labeled, or marked as compostable; any item that is solely marked as biodegradable will not be included

Liquid Waste: Liquid captured from emptying beverage containers

Packaging of Opened or Expired Packaged Food (Prior to the Date of the Sort): Packaging removed from opened or expired depackaged food

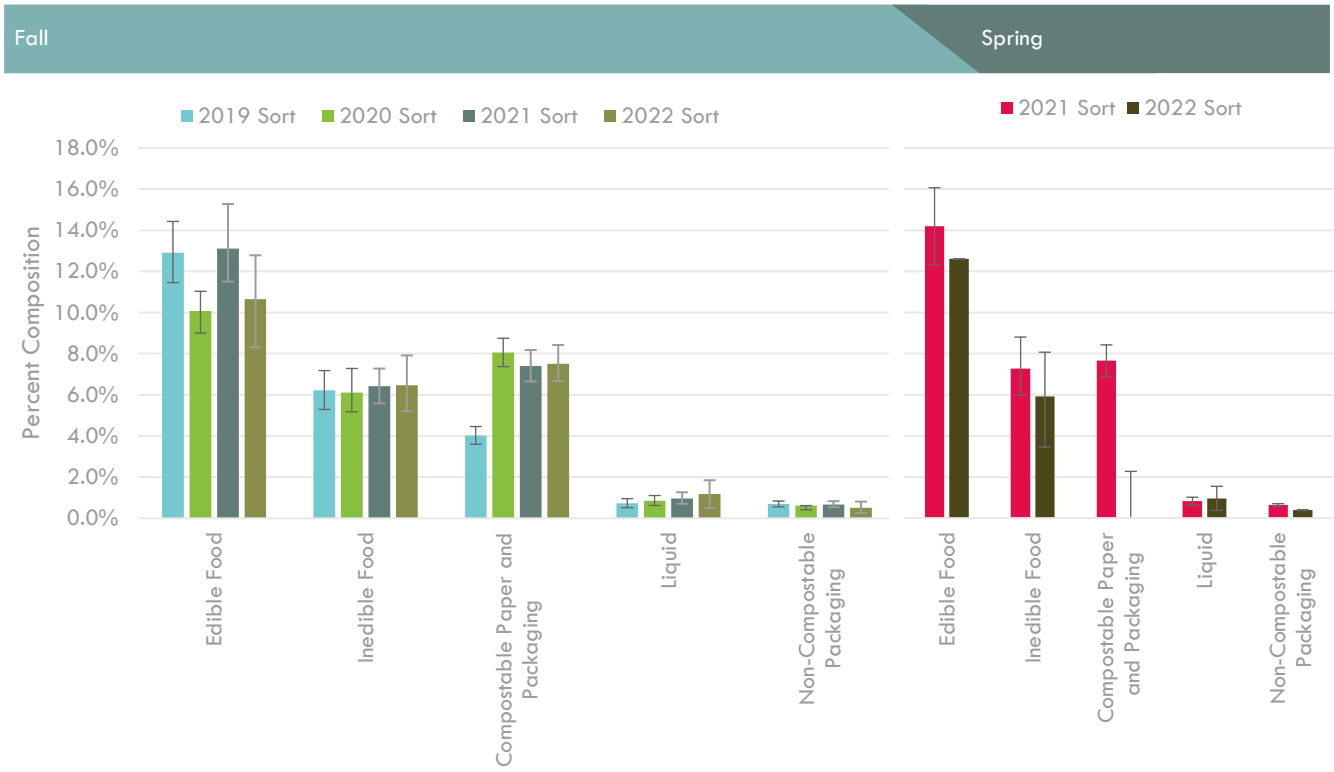
Packaging of Rescuable Whole or Unopened Packaged Food: Packaging removed from rescuable depackaged food

Remaining Sample Material: Any material in the sample that does not fit into the below categories

In comparing sort events between seasons, across years, and between Metro and Greater MN, several findings stand out. For example, the 2020 Sort Event had nearly twice the proportion of 'compostable paper and packaging' than the 2019 Sort Event. Additionally, the 2019 Sort Event found a greater proportion of edible food in the MMSW stream than the 2020 Sort Event (Figure 3). The data from 2021 and 2022 showed no significant difference. Greater Minnesota and the Metro had comparable compositions when aggregated across sort years in all categories except 'compostable paper and packaging'. The Metro had a slightly greater proportion of 'compostable paper and packaging' in the MMSW stream than Greater MN (Figure 4).

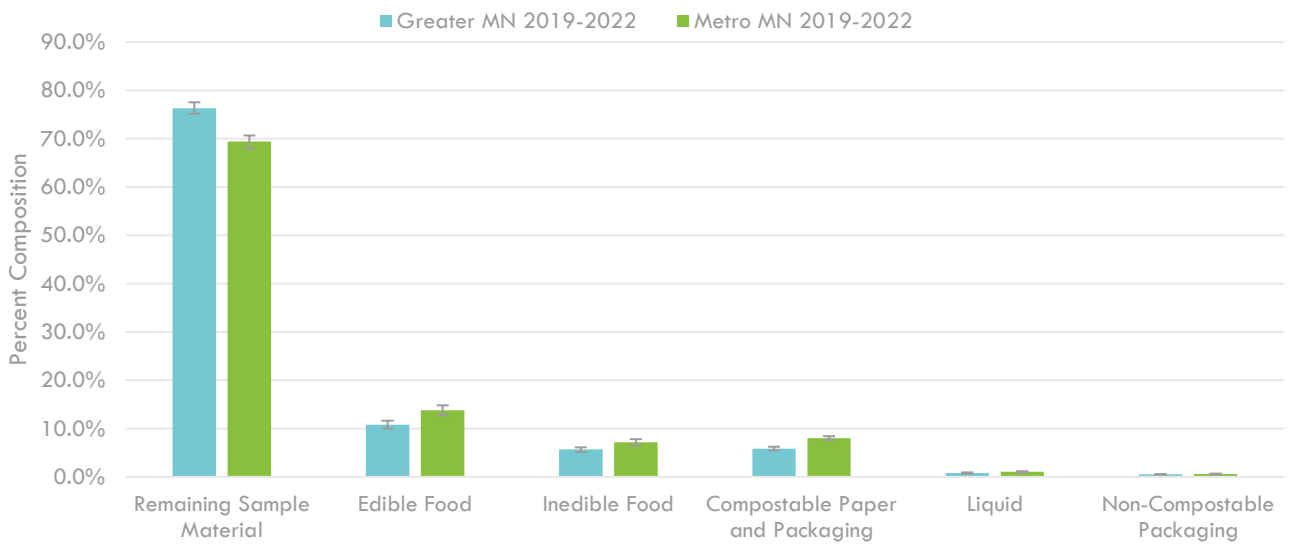
To assist with focusing on smaller categories the Figure 3 does not include "Remaining Sample Material"

Figure 3: Comparison of the Fall and Spring Sort Events: 2019-2022 without showing the Remaining Material Category



All error bars are based on a 90% Confidence Interval.

Figure 4: Comparison of Greater and Metro MN Sorts



All error bars are based on a 90% Confidence Interval

Strategies to reduce food waste fall into three categories: Prevent, Rescue, and Compost:

- **Prevent** (41%) may include education around knowledge of packaging expiration dates, conscience volume purchases, portions, and pantry rotation. This falls under the "upstream" stage of focusing on education initiatives for food waste prevention.

- **Rescue** (4%) may include food bank food waste prevention, restaurant collaboration, and food pantry education and outreach programs. This falls under the "midstream" stage of focusing on rescuable food initiatives.

- **Compost** (50%) may include compost facilities certified to handle food waste such as inedible scraps and compostable food service ware. This falls under the "downstream" stage of focusing managing the food waste that does not fall under the "upstream" and "midstream" stages.

- Other (5%) is not categorized under any of the "upstream, midstream, and downstream" stages as liquids and non-compostable packing are not material categories which food waste prevention program may focus on.

Moving forward, RRS would recommend increased policy and programming focusing on prevention of wasted food and food rescue. This is in line with the waste management hierarchy[2] which highlights the greater environmental benefits of food waste prevention and rescue. Secondarily, RRS recommends the MPCA focus on increased composting when prevention of wasted food and food rescue is not possible. This study shows there is ample opportunity to target reduction and expand investment and support of both the great MN and metro MN areas as wells focusing on the different types of food categories.

[2] Minnesota Statue. 2022. 115A.02 Legislative Declaration of Policy; Purposes. https://www.revisor.mn.gov/statutes/cite/115A.02.

From this data, 95% of food categorized from the waste stream has the potential to be diverted from the landfill. The following figure has broken down the Food & 'Compostable Paper and Packaging' sub sort into the three categories: Prevent, Rescue, and Compost.

Figure 5 Food & 'compostable paper and packaging' sort percentages

Note: The remaining 5% not accounted for in the graphic above includes non-compostable packaging removed from food and liquid waste. The sorted organics stream includes food, 'compostable paper and packaging', liquids, and non-compostable packaging.

INTRODUCTION

In order to gain an understanding and measurement of the proportion of food in Minnesota's Mixed Municipal Solid Waste (MMSW), Minnesota Pollution Control Agency (MPCA) contracted with Resource Recycling Systems (RRS) and GRG Analysis to conduct a wasted food generation and composition study. The study consisted of six food sort events in the state. To capture a representative sample for the state, five of the sorts sampled MMSW from the Metro Minnesota region, and the remaining four sampled MMSW from Greater Minnesota[3]. The study will serve to inform MPCA's strategies towards wasted food reduction, food donation, and composting in Minnesota.

STUDY RESULTS AND ANALYSIS

SORT METHODOLOGY

Between 2019 and 2022, six sort events were conducted to measure the amount of food & 'compostable paper and packaging' in MMSW from both Minnesota's Metro and Greater regions. Table 1 shows the sort events grouped by sort year.

All sorts in this study were conducted in accordance with ASTM standards for sorting methodology – ASTM D523-92, reapproved in 2016 which is a Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste. Each sort was performed over three days with the goal of sorting 30 total samples for each sort. The sample size was ideally between 190 to 310 pounds each (99.2% of samples met this ideal weight).

Table 1: Sort Event Descriptions and Number of Samples

Year	Season	Sort Date	Location	Target Region	Number of Samples
2019	Fall	September 2019	Lyon County Transfer Station	Greater MN	30
		November 2019	Pine Bend Landfill	Metro MN	7
		December 2019	Newport Transfer Station	Metro MN	23
2020	Fall	September 2020	Lyon County Transfer Station	Greater MN	29
		October 2020	Newport Transfer Station	Metro MN	30
2021	Spring	April 2021	Lyon County Transfer Station	Greater MN	30
		April 2021	Newport Transfer Station	Metro MN	30
	Fall	November 2021	Lyon County Transfer Station	Greater MN	30
		November 2021	Newport Transfer Station	Metro MN	30
2022	Spring	April 2022	Lyon County Transfer Station	Greater MN	30
		April 2022	Newport Transfer Station	Metro MN	30
	Fall	October 2022	Lyon County Transfer Station	Greater MN	30
		October 2022	Newport Transfer Station	Metro MN	30

[3] Metro Minnesota refers to the seven-county metropolitan region around Minneapolis and St. Paul (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington Counties)

Initially, the 2019 and 2020 Sort Events were planned over two seasons, fall 2019 and spring 2020, with sorting occurring twice at Greater MN and Metro MN. The 2019 Sort Event was conducted at Lyon County Transfer Station and a combination of Pine Bend Landfill and Newport Transfer Station in the fall and winter of 2019. Seven samples were sorted at Pine Bend Landfill in November of 2019 until weather limitations prevented the sort from being completed. The remaining 23 samples were sorted at Newport Transfer Station a month later. The samples from the Pine Bend Landfill and Newport Transfer Station were combined to represent the Metro MN sort in fall 2019. The 2020 Sort Event was scheduled for the spring of 2020. However, due to the COIVD-19 pandemic and the Minnesota state shutdown in the spring and summer of 2020, the Sort Event was postponed to the fall of 2020. The fall 2020 Sort Event was conducted at both the Lyon County and Newport Transfer Stations.

In 2021, spring sorts were in April and fall sorts were in November. In 2022, spring sorts remained in April but fall sorts were in October. The spring and fall sort events were conducted at both the Lyon County and Newport Transfer Stations.

The goal of the waste sorts was to measure the quantity and type of food & 'compostable paper and packaging' in Minnesota's MMSW. To accomplish the goal, the sort team categorized food into seven categories described in Table 2. The categories were determined to ensure the sort team identified wasted food that could have been consumed (food with no packaging, plus opened or expired food), food that could potentially be eligible for donation, though consumable food was given a distinct category (rescuable food), liquid organic waste that may be suitable for anaerobic digestion, food that could be readily diverted to compost (food scraps), compostable paper such as paper napkins, and finally compostable food service products and packaging. Combined, these seven categories represent the total food & 'compostable paper and packaging' stream.

Edible food was sorted into three categories. Two of these categories, "food no packaging" and "opened or expired packaged food" represent food that could have been consumed but was wasted. The third category, "unopened and not expired" represents food that could be rescued.

To differentiate whether unopened food should be in the "opened" or the "expired packaged food category" or the "unopened and not expired" category, the sort team looked for an expiration date.

- If the expiration date was equal to the day of the sort or a later date, the unopened food was considered "Rescuable Whole or Unopened Packaged Food".
- If the expiration date was before the date of the sort, the food was considered "Opened or Expired Packaged Food". In the case that the expiration date was not found or unreadable, the sort team assumed the unopened food container was "Opened or Expired Packaged Food".

In general, the sort team depackaged food, weighed the food and the packaging separately. The weight of the packaging was recorded within the category the food was sorted into. For example, if the sort team encountered a bag half full of chips, the food was considered "opened or expired food" and the accompanying packaging was weighed separately as packaging from "opened or expired food." The purpose of the measured category-specific packaging from depackaged food was to gauge how much effort a composter would need to exert to capture that particular stream. The sort team also encountered some food that was still in the container and was difficult to depackage, such as canned vegetables or peanut bar jars. In those cases, the sort team weighed each can or jar separately and noted the size and type of the container. By recording the total container weight along with the size and type of the container (ex: 8 oz glass jar), an estimate of the packaging weight was calculated post sort and subtracted from the total weight.

Table 2: Food Sort Categories

Category	Definition	Rationale	Examples
Other Material			
Remaining Sample Material	Any material in the sample that does not fit into the below categories		Recyclables, refuse, yard waste
Edible Food			
Food, No Packaging	Any food that could have been consumed by humans but was not disposed of within a package. Includes anything spoiled, moldy, half-eaten, or otherwise makes it unfit for consumption	Measure of food stream that could have been consumed in the home but was not	Spoiled food, plate waste, leftovers (not in a container), half-eaten hamburger/sandwich, produce (with bites or visibly spoiled)
Opened or Expired Packaged Food (Prior to the Date of the Sort)	Food that has packaging and the container has been opened but still contains food	Food that would require the individual to remove packaging or a de-packaging machine to be composted	Any open container with food still inside, any unopened package that is past the expiration sort date or severely dented/mangled so that it wouldn't be sold in a grocery store
Rescuable Whole or Unopened Packaged Food	Food which is fit for human consumption and meets criteria for suitability for rescue/donation, generally limited to pre-consumer surplus food; may include inedible parts as parts of food products donated	Measure portion of food would be eligible for donation	Any shelf stable product in an unopened, minimally damaged package with an expiration date from that day or before; any produce item that has a peel or skin intact that could still be eaten; unopened milk or snack items from schools
Inedible Food			
Food Scraps	The portion of food remaining after consumption; may include edible food as well as inedible parts, though ideally includes only inedible parts (I.e., could be a core that has some apple flesh on it that others would eat but the majority of it is the core)	Measure of food that is ideal for composting	Outer peelings, stems, leaves, cores, large seeds, fat trimmings, bones
Compostable Paper and Packaging			
Compostable Paper Products	Paper towels, napkins, and unlined paper bags only	Additional compostable stream that can be readily diverted from landfill or incineration to an industrial sized composting facility	Does not include any food service ware or items
Compostable Food Service Ware Products	Include in this category any food service ware or products that are clearly not plastic lined, BPI labeled, PLA labeled, or marked	Additional compostable stream that can be readily diverted from landfill or incineration to an industrial sized composting	Clamshells, compostable plastics, compostable molded fiber products, toothpicks,

Category	Definition	Rationale	Examples
	as compostable; any item that is solely marked as biodegradable will not be included	facility; consumers tend to encounter these materials in on-the-go environments presenting an additional challenge to capture	popsicle, chopsticks, and other food related wooden sticks
Liquid			
Liquid Waste	Liquid captured from emptying beverage containers	Food that is generally unsuitable for backyard or composting or curbside composting programs but could be utilized in an anerobic digestion system	Water bottles and pop bottles that contain leftover liquid
Non-Compostable Packaging			
Packaging of Opened or Expired Packaged Food (Prior to the Date of the Sort)	Packaging removed from opened or expired depackaged food	Measure percentage of food that would require individuals or a machine to remove packaging before composting or digesting	Chip bags, glass jars, clamshells that contained left over food
Packaging of Rescuable Whole or Unopened Packaged Food	Packaging removed from rescuable depackaged food	Measure percentage of food that would require individuals or a machine to remove packaging before composting or digesting	Chip bags, glass jars, clamshells that contained left over food

SAMPLING APPROACH

Trucks that collected MMSW were selected at random for sampling such that a sampling bias was not introduced in the truck selection. Additionally, the total number of sampled trucks was roughly equally divided between the three sort days as much as possible. For each sampled truck, the scale house at the facility provided GRG Analysis with the outbound ticket recording the date, time, truck number, hauler name, type of load (residential, commercial, or mixed), origin of load, and net weight of the load.

Once a truck was selected for sampling, the MMSW was dumped at a designated, flat area such that the load was as evenly spread out as possible. The load was then divided into even sections that represent approximately three times the required sample size. The sort team selected which divided section to draw the sample from (aiming for 190 to 310 pounds each) by rotating through the different sections on the truck load systematically. For example, the sort team started by taking a portion of the materials to make up the sample from the left most section, followed by second to the left most section for the next truck materials' divided sections, etc. Since the sampled trucks were random, a systematic sampling approach avoided bias. The sort team advised against mixing the load due to the likelihood of spreading out potentially hazardous material such as improperly disposed of sharps, household hazardous waste, etc. The sample material was then moved using a front loader (with a one cubic yard capacity or greater) to the sorting location. The front loader dumped the sample into large buckets for the initial weighing. The material was then pulled out of the large buckets for sorting. Each sort had a sample size of 30.

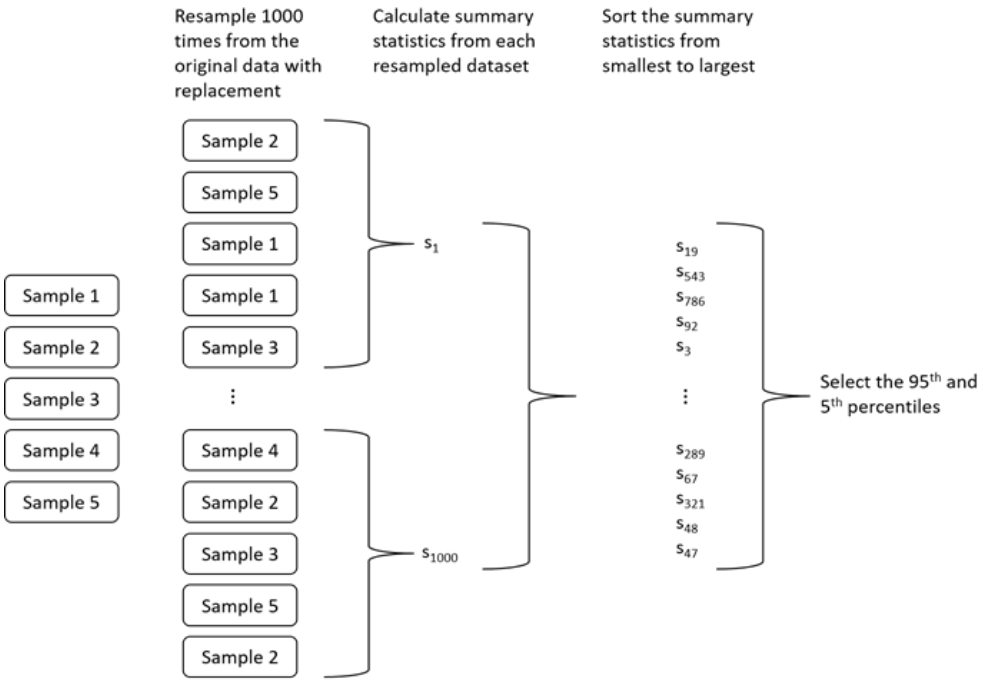
The samples were sorted by hand into the categories described above. Material that did not fit into the designated categories was negatively sorted into the category "remaining sample material." Sorted material was placed into buckets or bins and individually weighed.

The weight of sorted categories was recorded with pen and paper by the GRG team. See Appendix B for a copy of the data sheet. The preference for relying on a lower tech method is its durability in a high stress environment. RRS transferred all written data to Excel for analysis.

DATA ANALYSIS

Determination of the 90% confidence interval was achieved using bootstrapping, a statistical technique which utilizes resampling from the existing data with replacement to achieve an estimate of the possible range of values for the sample statistic. In this study, all material weights and associated sample weights were resampled to create 1,000 possible variations of material compositions. These material compositions are then sorted from smallest to largest and the 95th and 5th percentiles are selected to create the 90% confidence interval for the estimated composition percent. Figure 6 shows how the bootstrapping process is used to create the confidence intervals and the R code used to perform the calculations is presented in Appendix D: Bootstrap R Code.

Figure 6: Illustration of Bootstrapping to Calculate the 90% Confidence Interval for a Specific Summary Statistic



Bootstrapping works well when there are a large number of samples, and the samples were selected to be representative of the population at large. It has the added benefit of being a non-parametric method which means no additional assumptions (e.g. data are normally distributed) are needed to estimate the 90% confidence interval.

The sections below present the measurement of the proportion of food & 'compostable paper and packaging' in MMSW as well as a more detailed analysis of the food & 'compostable paper and packaging' stream. Further detail of the composition data is found in Appendix A.

MIXED MUNICIPAL SOLID WASTE STREAM FINDINGS

This section presents the findings of the fraction of MMSW that is comprised of food & 'compostable paper and packaging' in the MMSW samples. For ease of reading and key data takeaways, the findings are grouped per main categories described in Table 2.

FOOD & 'COMPOSTABLE PAPER AND PACKAGING' COMPOSITION IN MMSW

Edible food, inedible food, 'compostable paper and packaging', liquid waste, and non-compostable packaging make up approximately 27.1% of the sorted residential and commercial MMSW from all sorts combined. Food alone (edible and inedible) comprises 18.7%, and 'compostable paper and packaging' comprises 6.9%. A small portion of the waste stream is non-compostable packaging removed from edible food, comprising 0.6% of the total composition, and liquid waste is 0.9%. The remaining approximately three-quarters of the sample material is categorized as any material not fitting into the defined food & 'compostable paper and packaging' categories. This remaining material was not sorted into further categories, but generally includes metals, plastics, paper, non-food related organics such as yard waste, and any other material in the MMSW stream (Figure 7 and Table 4).

Figure 7: Food & 'Compostable Paper and Packaging' Composition in MMSW

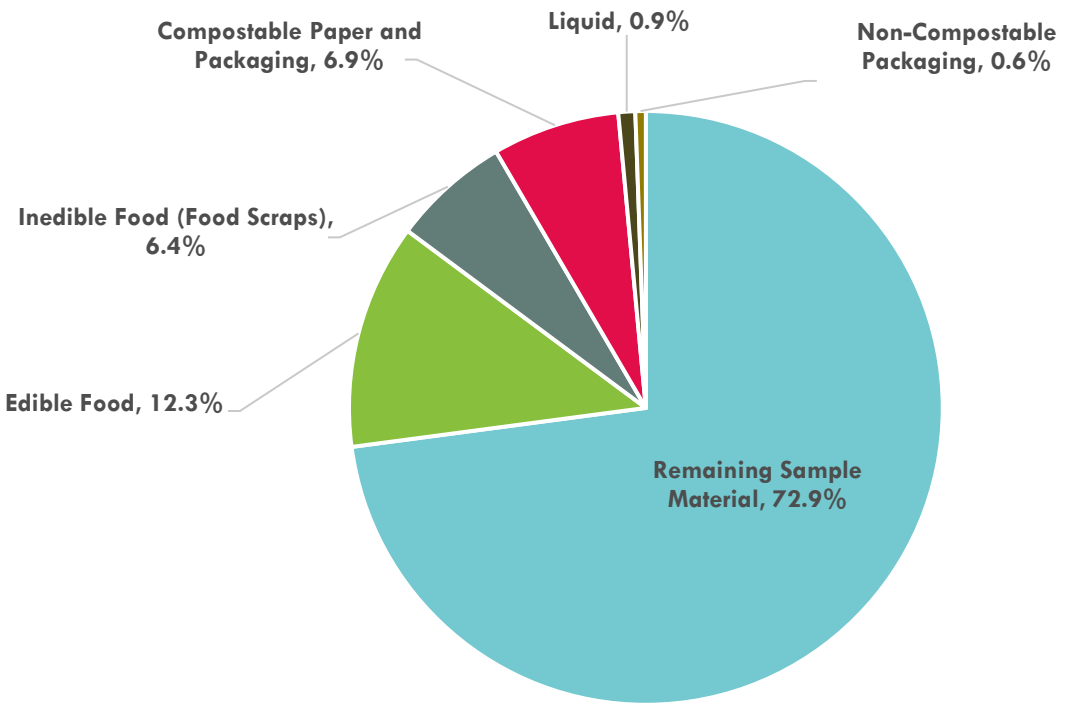


Table 3: Food & 'Compostable Paper and Packaging' Composition in MMSW

	Statewide	Lower Bound	Upper Bound
Remaining Sample Material	**72.90%**	**71.98%**	**73.89%**
Edible Food	**12.27%**	**11.65%**	**12.93%**
• ***Food, no packaging***	*7.64%*	*7.19%*	*8.15%*
• ***Opened or expired packaged food prior the date of the sort***	*3.42%*	*3.14%*	*3.71%*
• ***Rescuable unopened and unexpired packaged food***	*1.21%*	*0.98%*	*1.45%*
Inedible Food (Food Scraps)	**6.41%**	**6.04%**	**6.80%**
'Compostable Paper and Packaging'	**6.93%**	**6.62%**	**7.22%**
• ***Compostable food service products***	*1.90%*	*1.77%*	*2.04%*
• ***Compostable paper products***	*5.03%*	*4.79%*	*5.30%*
Liquid	**0.92%**	**0.82%**	**1.02%**
Non-Compostable Packaging	**0.57%**	**0.52%**	**0.62%**
• ***Packaging from opened or expired food***	*0.50%*	*0.46%*	*0.54%*
• ***Packaging from rescuable food***	*0.07%*	*0.05%*	*0.09%*

SORT EVENTS ANALYSIS OF MMSW

The 2019-2022 Sort Events (Table 1) were compared to one another to identify any statistically significant differences. While there are some small variations of sort composition between the sort events, conducted approximately one year apart, the variations are generally not statistically significant, meaning that any differences between composition does not fall outside the margin of error of the study. The only exception to this is seen in the category of 'compostable paper and packaging', which represented 4.0% of the sampled composition in the 2019 Sort Event and 8.1% of the sampled composition in the 2020 Sort Event. The difference between the 'compostable paper and packaging' composition in the Sort Events is statistically significant between 2019 and 2020 but not between the additional sorts in 2021 and 2022 (

Figure 8 and Table 4 and Table 4).

Figure 8: Comparison of Sort Events of MMSW

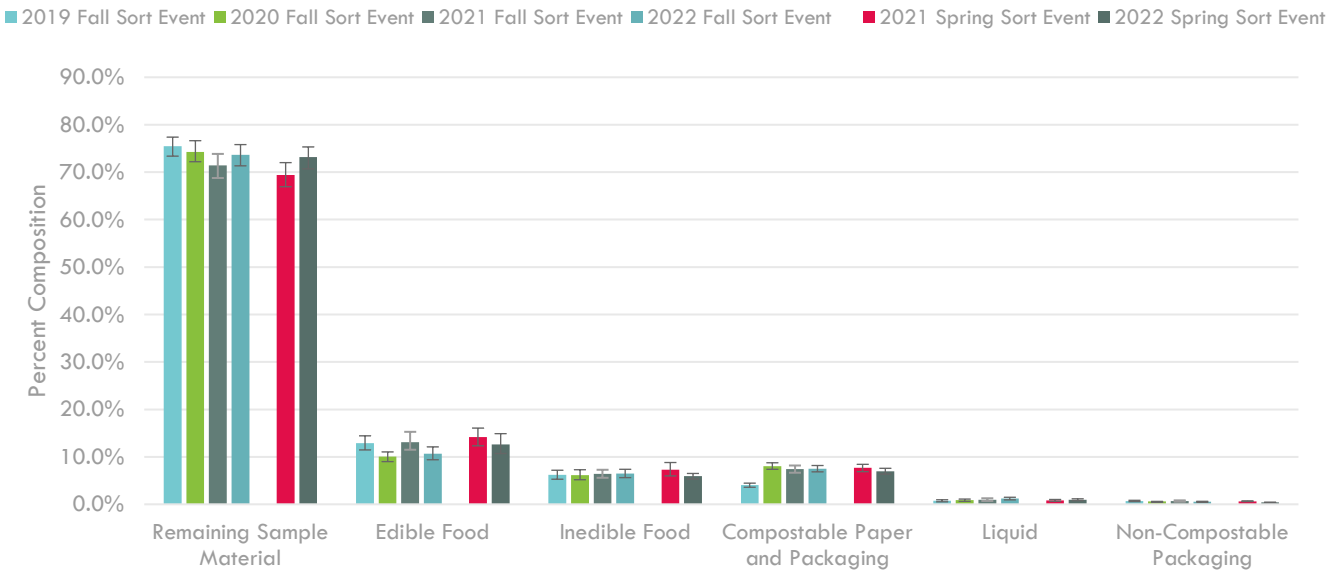

2019 Fall Sort Event
2020 Fall Sort Event
2021 Fall Sort Event
2022 Fall Sort Event
2021 Spring Sort Event
2022 Spring Sort Event
Percent Composition
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Remaining Sample Material
Edible Food
Inedible Food
Compostable Paper and Packaging
Liquid
Non-Compostable Packaging

Table 4: Comparison of Sort Events of Full Waste Stream - Fall

	2019 Fall Sort Event			2020 Fall Sort Event			2021 Fall Sort Event			2022 Fall Sort Event		
	Mean	LB	UB	Mean	LB	UB	Mean	LB	UB	Mean	LB	UB
Remaining Sample Material	75.4%	73.4%	77.4%	74.4%	72.2%	76.6%	71.4%	69.1%	73.6%	73.7%	71.3%	75.8%
Edible Food	12.9%	11.5%	14.4%	10.0%	9.0%	11.0%	13.1%	11.4%	15.1%	10.6%	9.4%	12.1%
• ***Food, no packaging***	*7.1%*	*6.2%*	*8.0%*	*6.6%*	*5.8%*	*7.5%*	*8.3%*	*7.3%*	*9.3%*	*7.0%*	*6.1%*	*7.8%*
• ***Opened or expired packaged food prior the date of the sort***	*3.5%*	*3.0%*	*4.1%*	*2.6%*	*2.2%*	*3.0%*	*3.7%*	*3.0%*	*4.6%*	*2.9%*	*2.4%*	*3.5%*
• ***Rescuable unopened and unexpired packaged food***	*2.3%*	*1.6%*	*3.1%*	*0.8%*	*0.5%*	*1.1%*	*1.1%*	*0.6%*	*1.7%*	*0.8%*	*0.4%*	*1.3%*
Inedible Food (Food Scraps)	6.2%	5.3%	7.2%	6.2%	5.2%	7.3%	6.4%	5.5%	7.3%	6.5%	5.6%	7.4%
'Compostable Paper and Packaging'	4.0%	3.6%	4.5%	8.1%	7.4%	8.8%	7.4%	6.7%	8.2%	7.5%	6.8%	8.2%
• ***Compostable food service products***	*1.6%*	*1.3%*	*1.8%*	*0.7%*	*0.5%*	*0.9%*	*2.2%*	*1.9%*	*2.6%*	*2.5%*	*2.1%*	*2.9%*
• ***Compostable paper products***	*2.5%*	*2.2%*	*2.8%*	*7.4%*	*6.7%*	*8.0%*	*5.2%*	*4.6%*	*5.8%*	*5.0%*	*4.5%*	*5.6%*
Liquid	0.7%	0.5%	1.0%	0.9%	0.6%	1.1%	1.0%	0.7%	1.3%	1.2%	0.9%	1.5%
Non-Compostable Packaging	0.7%	0.6%	0.8%	0.5%	0.4%	0.6%	0.7%	0.5%	0.8%	0.5%	0.4%	0.6%
• ***Packaging from opened or expired food***	*0.5%*	*0.4%*	*0.6%*	*0.5%*	*0.4%*	*0.6%*	*0.6%*	*0.5%*	*0.7%*	*0.5%*	*0.4%*	*0.6%*
• ***Packaging from rescuable food***	*0.2%*	*0.1%*	*0.3%*	*0.0%*	*0.0%*	*0.1%*	*0.1%*	*0.0%*	*0.1%*	*0.1%*	*0.0%*	*0.1%*

Note: LB = Lower Bound, UB = Upper Bound

Table 5: Comparison of Sort Events of Full Waste Stream - Spring

	2021 Spring Sort Event			2022 Spring Sort Event		
	Mean	LB	UB	Mean	LB	UB
Remaining Sample Material	69.4%	66.9%	72.0%	73.2%	70.7%	75.3%
Edible Food	14.2%	12.3%	16.1%	12.6%	10.7%	14.9%
• ***Food, no packaging***	*8.7%*	*7.4%*	*10.2%*	*8.1%*	*6.6%*	*9.9%*
• ***Opened or expired packaged food prior the date of the sort***	*3.9%*	*3.0%*	*4.9%*	*3.9%*	*3.1%*	*4.6%*
• ***Rescuable unopened and unexpired packaged food***	*1.6%*	*0.9%*	*2.5%*	*0.7%*	*0.4%*	*1.0%*
Inedible Food (Food Scraps)	7.3%	6.0%	8.8%	5.9%	5.3%	6.5%
'Compostable Paper and Packaging'	7.7%	6.9%	8.4%	7.0%	6.4%	7.6%
• ***Compostable food service products***	*2.1%*	*1.8%*	*2.5%*	*2.2%*	*1.9%*	*2.6%*
• ***Compostable paper products***	*5.5%*	*4.9%*	*6.2%*	*4.8%*	*4.4%*	*5.2%*
Liquid	0.8%	0.6%	1.0%	1.0%	0.8%	1.1%
Non-Compostable Packaging	0.6%	0.6%	0.7%	0.4%	0.3%	0.5%
• ***Packaging from opened or expired food***	*0.6%*	*0.5%*	*0.7%*	*0.3%*	*0.3%*	*0.4%*
• ***Packaging from rescuable food***	*0.0%*	*0.0%*	*0.1%*	*0.0%*	*0.0%*	*0.1%*

REGIONAL ANALYSIS OF MMSW

Looking to the regional analysis, MMSW sorted in Metro MN had a lower proportion of the remaining sample material in the waste stream and a greater proportion of 'compostable paper and packaging' than Greater MN (Figure 9 and Table 6).

Figure 9: Comparison of Regions of Full Waste Stream

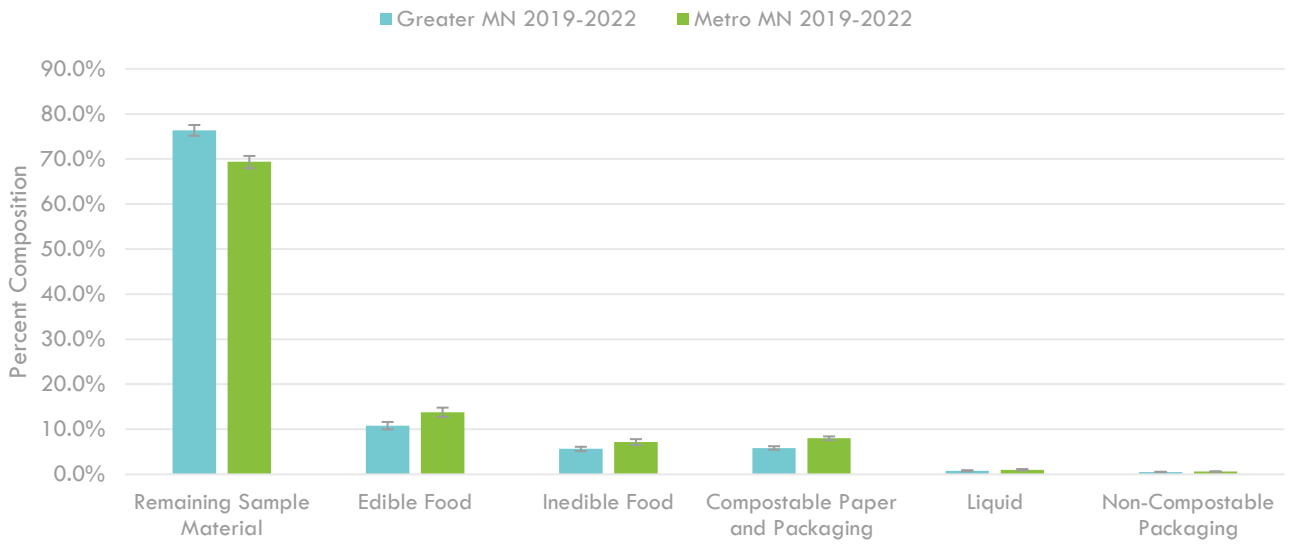


Table 6: Comparison of Regions of Full Waste Stream

	Greater MN	Lower Bound	Upper Bound	Metro MN	Lower Bound	Upper Bound
Remaining Sample Material	76.32%	75.16%	77.54%	69.42%	67.95%	70.67%
Edible Food	10.81%	10.00%	11.63%	13.76%	12.76%	14.81%
• ***Food, no packaging***	*6.74%*	*6.20%*	*7.26%*	*8.55%*	*7.76%*	*9.33%*
• ***Opened or expired packaged food prior the date of the sort***	*2.88%*	*2.55%*	*3.22%*	*3.98%*	*3.56%*	*4.44%*
• ***Rescuable unopened and unexpired packaged food***	*1.20%*	*0.85%*	*1.61%*	*1.22%*	*0.93%*	*1.53%*
Inedible Food (Food Scraps)	*5.68%*	*5.18%*	*6.12%*	*7.16%*	*6.52%*	*7.82%*
'Compostable Paper and Packaging'	*5.85%*	*5.47%*	*6.25%*	*8.02%*	*7.60%*	*8.43%*
• ***Compostable food service products***	*1.77%*	*1.58%*	*1.99%*	*2.03%*	*1.87%*	*2.20%*
• ***Compostable paper products***	*4.08%*	*3.77%*	*4.41%*	*6.00%*	*5.62%*	*6.40%*
Liquid	0.81%	0.68%	0.94%	1.03%	0.89%	1.18%
Non-Compostable Packaging	0.52%	0.47%	0.59%	0.61%	0.54%	0.68%
• ***Packaging from opened or expired food***	*0.48%*	*0.43%*	*0.53%*	*0.52%*	*0.46%*	*0.58%*
• ***Packaging from rescuable food***	*0.05%*	*0.03%*	*0.08%*	*0.10%*	*0.07%*	*0.12%*

FOOD & 'COMPOSTABLE PAPER AND PACKAGING' COMPOSITION IN WASTE STREAM

This section of the study provides more granular analysis of food & 'compostable paper and packaging' in the MMSW stream with the purpose of gaining insight into what food management methods would best achieve reduction in food sent to landfills or incinerators. This analysis helps to define the amount of wasted food that could be prevented in the first place, donated, or sent to composting facilities.

ANALYSIS OF FOOD & 'COMPOSTABLE PAPER AND PACKAGING' COMPOSITION

In all conducted sorts, approximately 70% of the sorted material was either edible or inedible food. Edible food, which includes food without packaging, open or expired food and rescuable food, comprised the largest category at 46.0%, and 'compostable paper and packaging' was the second largest category encompassing 24.7%. The third largest category was inedible food such as vegetable and fruit peelings at 23.8% of the sorted organics. Finally, liquid waste accounted for 3.1% and non-compostable packaging removed from edible food made up 2.4% of the sorted food composition (Figure 10 and

Table 7).

Figure 10: Food & 'Compostable Paper and Packaging' Composition

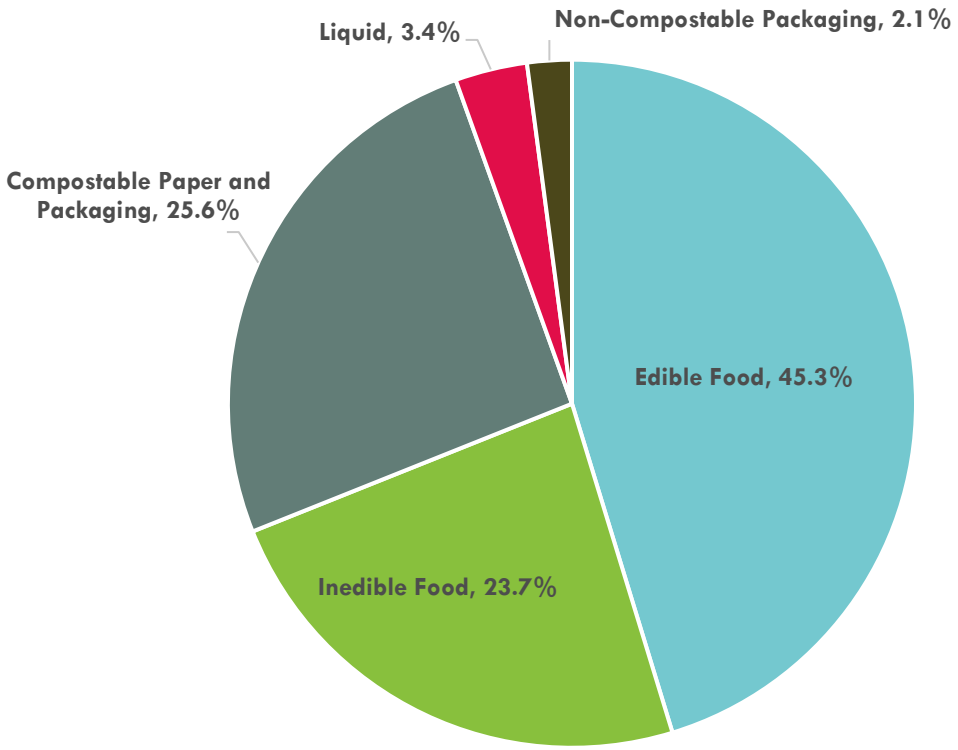


Table 7: Food & 'Compostable Paper and Packaging' Composition

	Statewide	Lower Bound	Upper Bound
Edible Food	45.28%	43.73%	46.79%
• ***Food, no packaging***	*28.18%*	*26.91%*	*29.61%*
• ***Opened or expired packaged food prior the date of the sort***	*12.63%*	*11.76%*	*13.56%*
• ***Rescuable unopened and unexpired packaged food***	*4.46%*	*3.61%*	*5.31%*
Inedible Food (Food Scraps)	23.66%	22.51%	24.94%
'Compostable Paper and Packaging'	25.57%	24.60%	26.56%
• ***Compostable food service products***	*7.01%*	*6.55%*	*7.46%*
• ***Compostable paper products***	*18.56%*	*17.69%*	*19.44%*
Liquid	3.39%	3.04%	3.74%
Non-Compostable Packaging	2.09%	1.93%	2.26%
• ***Packaging from opened or expired food***	*1.83%*	*1.70%*	*1.97%*
• ***Packaging from rescuable food***	*0.27%*	*0.20%*	*0.35%*

SORT EVENTS ANALYSIS OF FOOD & 'COMPOSTABLE PAPER AND PACKAGING'

The 2019-2022 Sort Events (Table 1) were compared to one another to identify any statistically significant differences for the food composition of the sorted MMSW. The 2019 Sort Event had a significantly greater proportion of opened or expired packaged food and rescuable unopened and unexpired packaged food while the 'edible food, no packaging' category was comparable between the Sort Events. Finally, the 2020 Sort Event had a much greater proportion of compostable paper products than the 2019 Sort Event (Figure 11, Table 8, and Table 9). The 2019 Sort Event occurred prior to any impacts from the COVID-19 pandemic whereas the 2020 Sort Event occurred during the COVID-19 pandemic. The 2021 and 2022 Sort Events have only significant differences for the rescuable unopened and unexpired packaged food.

Figure 11: Comparison of Sort Events of Food & 'Compostable Paper and Packaging'

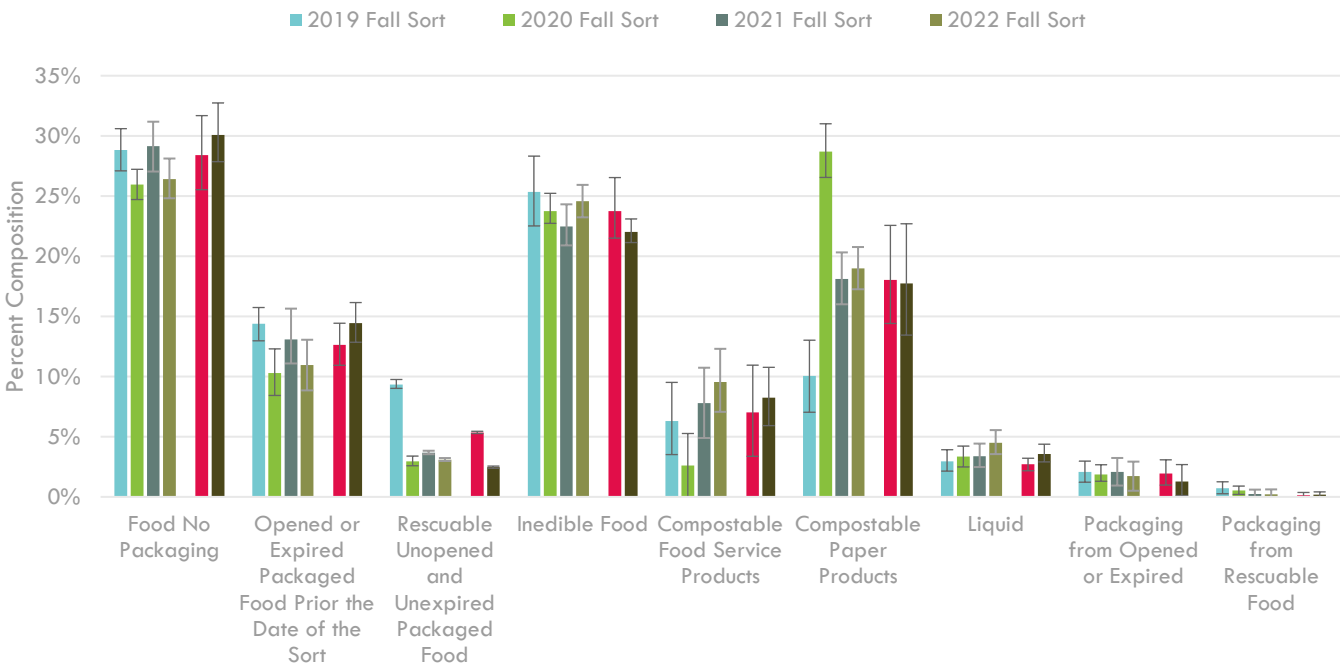


Table 8: Comparison of Sort Events of Food & 'Compostable Paper and Packaging' - Fall

	2019 Sort Event			2020 Sort Event			2021 Fall Sort Event			2022 Fall Sort Event		
	Mean	LB	UB	Mean	LB	UB	Mean	LB	UB	Mean	LB	UB
Edible Food	28.8%	25.8%	31.8%	26.0%	23.8%	28.3%	29.1%	27.0%	31.3%	26.4%	24.7%	28.2%
• ***Food, no packaging***	*14.4%*	*12.6%*	*16.2%*	*10.3%*	*9.0%*	*11.6%*	*13.1%*	*11.0%*	*15.1%*	*11.0%*	*9.4%*	*12.7%*
• ***Opened or expired packaged food prior the date of the sort***	*9.3%*	*6.5%*	*12.3%*	*3.0%*	*1.9%*	*4.4%*	*3.7%*	*2.1%*	*5.5%*	*3.1%*	*1.7%*	*4.4%*
• ***Rescuable unopened and unexpired packaged food***	*25.3%*	*22.5%*	*28.3%*	*23.8%*	*20.9%*	*26.7%*	*22.5%*	*19.8%*	*25.4%*	*24.6%*	*22.1%*	*27.2%*
Inedible Food (Food Scraps)	16.4%	14.6%	18.2%	31.3%	29.6%	33.2%	25.9%	23.4%	28.6%	28.5%	26.5%	30.9%
'Compostable Paper and Packaging'	6.3%	5.4%	7.2%	2.6%	2.0%	3.4%	7.8%	6.7%	9.0%	9.6%	8.3%	10.8%
• ***Compostable food service products***	*10.0%*	*8.6%*	*11.4%*	*28.7%*	*26.9%*	*30.7%*	*18.1%*	*16.1%*	*20.7%*	*19.0%*	*16.9%*	*21.1%*
• ***Compostable paper products***	*3.0%*	*2.1%*	*3.9%*	*3.3%*	*2.5%*	*4.2%*	*3.4%*	*2.5%*	*4.4%*	*4.5%*	*3.6%*	*5.6%*
Liquid	2.8%	2.3%	3.4%	2.4%	1.9%	2.9%	2.3%	1.9%	2.7%	1.9%	1.6%	2.4%
Non-Compostable Packaging	2.1%	1.6%	2.6%	1.9%	1.5%	2.2%	2.1%	1.8%	2.4%	1.7%	1.4%	2.2%
• ***Packaging from opened or expired food***	*0.7%*	*0.4%*	*1.1%*	*0.5%*	*0.2%*	*1.0%*	*0.3%*	*0.1%*	*0.4%*	*0.2%*	*0.1%*	*0.3%*
• ***Packaging from rescuable food***	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*

Table 9: Comparison of Sort Events of Food & 'Compostable Paper and Packaging' - Spring

	2021 Spring Sort Event			2022 Spring Sort Event		
	Mean	LB	UB	Mean	LB	UB
Edible Food	28.4%	24.8%	32.9%	30.1%	25.8%	35.0%
• ***Food, no packaging***	*12.6%*	*9.8%*	*15.9%*	*14.4%*	*12.2%*	*17.1%*

• *Opened or expired packaged food prior the date of the sort*	*5.4%*	*3.1%*	*8.1%*	*2.5%*	*1.6%*	*3.5%*
• *Rescuable unopened and unexpired packaged food*	*23.8%*	*20.0%*	*27.8%*	*22.0%*	*19.7%*	*24.3%*
Inedible Food (Food Scraps)	25.0%	22.9%	27.1%	26.0%	23.7%	28.6%
'Compostable Paper and Packaging'	7.0%	6.1%	8.2%	8.3%	7.1%	9.7%
• *Compostable food service products*	*18.0%*	*16.3%*	*19.8%*	*17.8%*	*16.2%*	*19.5%*
• *Compostable paper products*	*2.7%*	*2.2%*	*3.2%*	*3.6%*	*2.9%*	*4.4%*
Liquid	2.1%	1.9%	2.3%	1.4%	1.2%	1.7%
Non-Compostable Packaging	1.9%	1.7%	2.2%	1.3%	1.1%	1.5%
• *Packaging from opened or expired food*	*0.1%*	*0.1%*	*0.2%*	*0.2%*	*0.1%*	*0.3%*
• *Packaging from rescuable food*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*

REGIONAL ANALYSIS OF FOOD & 'COMPOSTABLE PAPER AND PACKAGING'

Regionally, the food & 'compostable paper and packaging' stream is generally comparable between Greater MN and Metro MN in all but one category (Figure 12 and Table 10). The percent of compostable paper products is statistically different ($\alpha = 0.1$) in Metro MN (19.6%, 18.3% to 20.8%) vs Greater MN (17.2%, 16.0% to 18.5%).

Figure 12: Comparison of Regions of Food & 'Compostable Paper and Packaging'

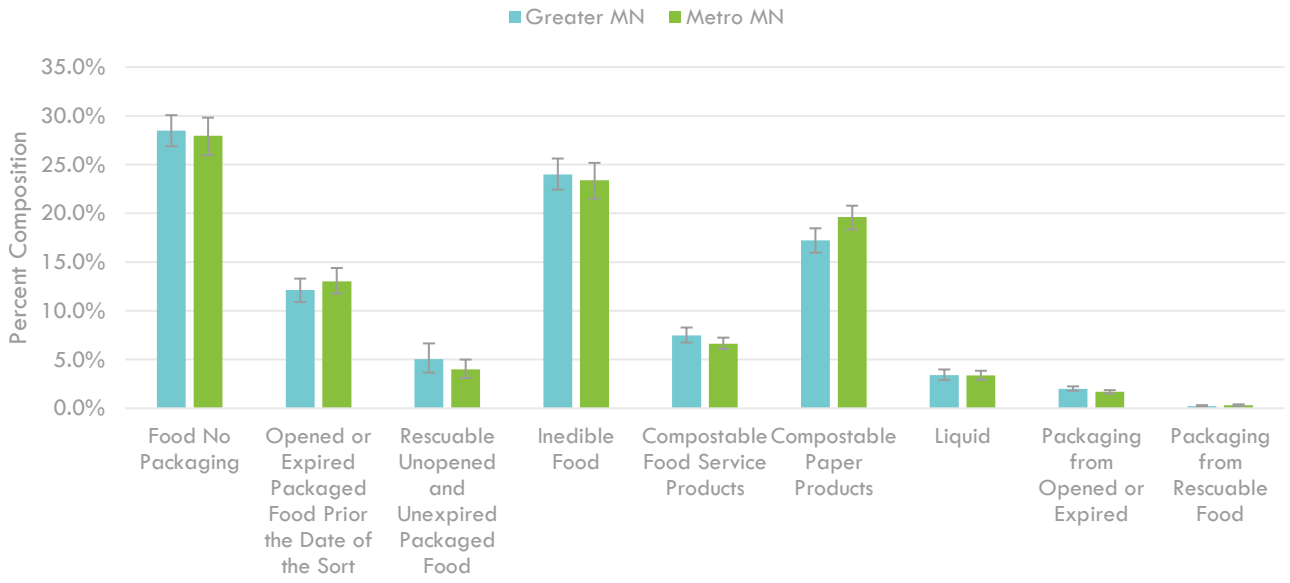


Table 10: Comparison of Regions of Food & 'Compostable Paper and Packaging'

	Greater MN	Lower Bound	Upper Bound	Metro MN	Lower Bound	Upper Bound
Edible Food	**45.7%**	**43.7%**	**47.6%**	**45.0%**	**42.7%**	**47.2%**
• *Food, no packaging*	*28.5%*	*26.9%*	*30.1%*	*28.0%*	*26.0%*	*29.8%*
• *Opened or expired packaged food prior the date of the sort*	*12.2%*	*10.9%*	*13.3%*	*13.0%*	*11.8%*	*14.4%*
• *Rescuable unopened and unexpired packaged food*	*5.0%*	*3.7%*	*6.7%*	*4.0%*	*3.1%*	*5.0%*
Inedible Food (Food Scraps)	**24.0%**	**22.4%**	**25.7%**	**23.4%**	**21.5%**	**25.3%**
'Compostable Paper and Packaging'	**24.7%**	**23.1%**	**26.3%**	**26.2%**	**25.0%**	**27.5%**
• *Compostable food service products*	*7.5%*	*6.7%*	*8.3%*	*6.6%*	*6.1%*	*7.3%*
• *Compostable paper products**	*17.2%*	*16.0%*	*18.5%*	*19.6%*	*18.3%*	*20.8%*
Liquid	**6.8%**	**5.8%**	**8.0%**	**6.8%**	**5.9%**	**7.7%**
Non-Compostable Packaging	**2.2%**	**2.0%**	**2.5%**	**2.0%**	**1.8%**	**2.2%**
• *Packaging from opened or expired food*	*2.0%*	*1.8%*	*2.3%*	*1.7%*	*1.5%*	*1.9%*
• *Packaging from rescuable food*	*0.2%*	*0.1%*	*0.3%*	*0.3%*	*0.2%*	*0.4%*

* denotes statistically significant difference at $\alpha = 0.1$

COMPARISON TO THE 2013 MN STATEWIDE WASTE COMPOSITION STUDY

MPCA conducted a statewide waste composition analysis in 2013 where food from the MMSW stream was sorted into a category that encompassed food scraps, spoiled food, kitchen waste, liquid food, parts from butchered animals, and dead animals. In that study the state found 17.8% of the overall MMSW was food. In this study 20.0% of the overall composition was food[4] and liquid waste, which was within the 90% confidence interval of the 2013 study. Since these two studies have overlapping 90% confidence intervals, the difference between the overall food plus liquid waste composition of the study, and the food composition of the 2013 statewide waste characterization study is not statistically significant ($\alpha = 0.1$)(Figure 13 and Table 11).

Figure 13: Figure Comparison of Food Composition Between this Study and the 2013 MN Statewide Waste Characterization

[4] Here food waste is referring to the edible food waste and inedible food.

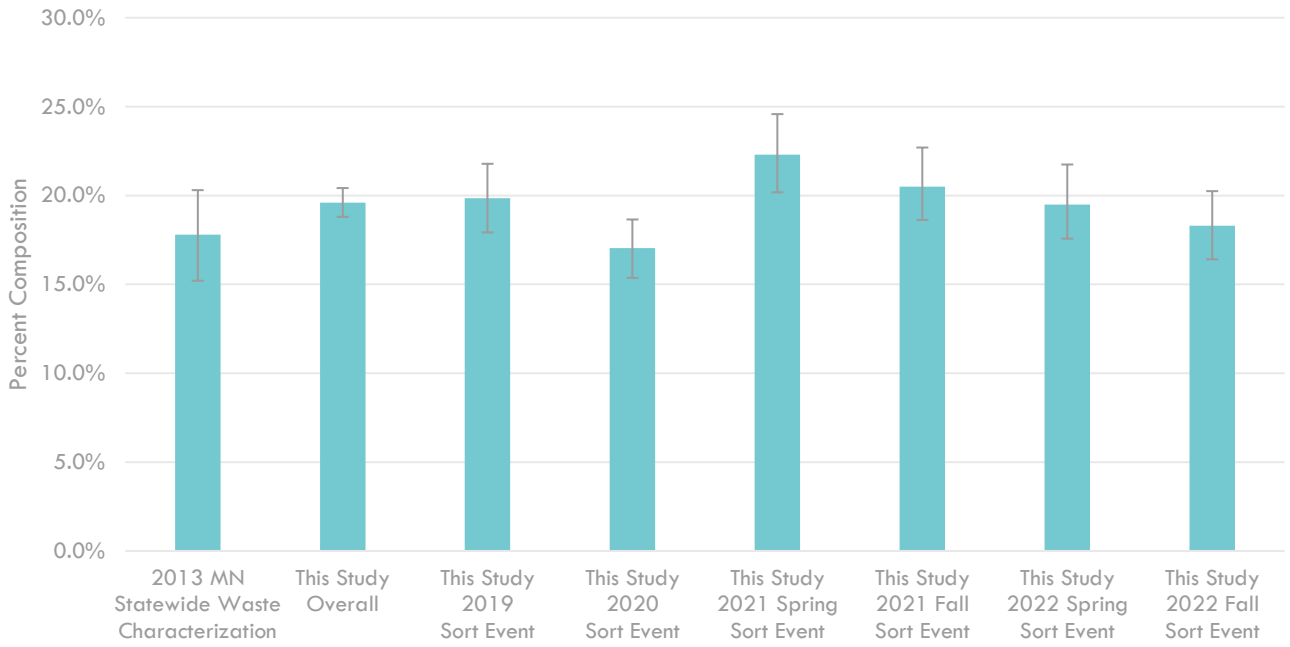


Table 11: Table Comparison of Food Composition Between this Study and the 2013 MN Statewide Waste Characterization

	Average	Lower Bound	Upper Bound
2013 MN Statewide Waste Characterization[5]	17.8%	15.2%	20.3%
This Study Overall	18.5%	17.3%	19.7%
This Study 2019 Sort Event	19.8%	19.7%	21.8%
This Study 2020 Sort Event	17.0%	15.4%	18.6%
This Study 2021 Spring Sort Event	22.3%	20.2%	24.6%
This Study 2021 Fall Sort Event	20.5%	18.6%	22.7%
This Study 2022 Spring Sort Event	19.5%	17.6%	21.7%
This Study 2022 Fall Sort Event	18.3%	16.4%	20.2%

One challenge of comparing percent composition of studies that are several years apart is that the overall composition of the waste stream changes overtime, and the proportion of food in the disposal stream depends not only on the amount of food discarded but also on the proportion of other materials in the stream. Notably, from 1990 to 2017 heavier items such as newspaper, glass containers, steel containers, and paper have decreased in prevalence in the stream while lighter items such as plastic containers and plastic film have increased (Figure 14). As a result, disposed food is mixed in with lighter materials such as plastics, so that food encompasses a greater proportion of the weight of the sample even if the absolute weight of food being disposed of remains unchanged or even declines.

Figure 14: The Evolving Waste Stream

[5] 2013 MN Statewide Waste Characterization study lower and upper bounds are reported on a 90% confidence interval

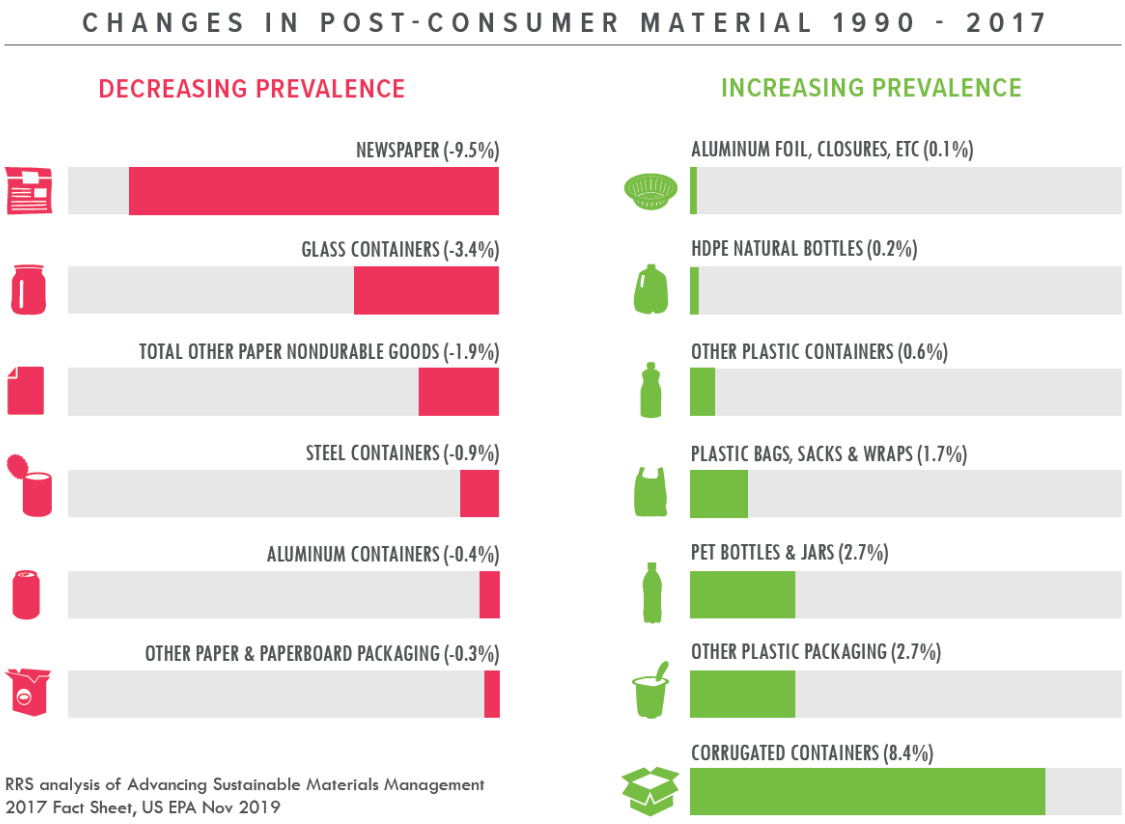
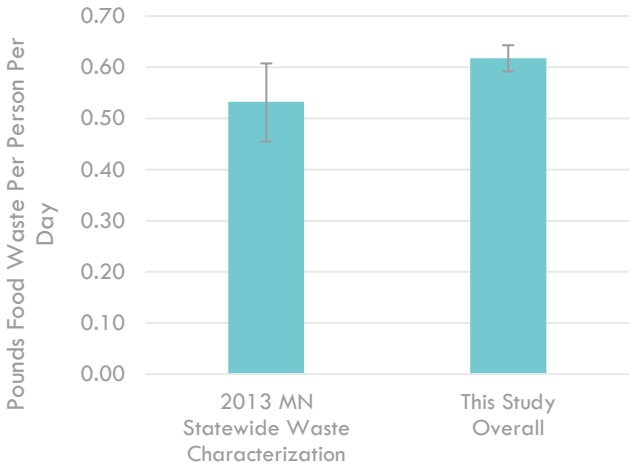


Figure 15: Per Capita Food Waste Disposal Comparison



Comparing food disposal per capita is a way to address the potential for the evolving waste stream to impact the percent composition comparisons from 2013 to 2019-2022. In 2013, Minnesota residents disposed of 2.99 pounds per person per day of MMSW of which 0.53 pounds per person per day was food. In 2019 Minnesota residents disposed of 3.15 pounds per person per day of MMSW and 0.63 pounds per person per day was food. However, the slight difference in per capita food disposal between 2013 and 2019 is not outside of the estimated range of the margin of errors of the waste sort studies (Figure 15).

CONCLUSION

The 2019-2022 food sort showed that the percent composition of disposed food & 'compostable paper and packaging' in MMSW and the per capita disposal rate in Minnesota (19.6% and 0.58 pounds per person per day respectively) are comparable to the average found from an analysis of many similar waste characterization studies performed across the U.S. (18.9% and 0.62 pounds per person per day respectively). Furthermore, no significant change was found in either the proportion of food in the disposal stream or the per capita food disposal in Minnesota from 2013 to 2019-2022.

One point of interest in the 2019 and 2020 Sort Events was that the 2019 Sort Event was conducted prior to the COVID-19 pandemic and the 2020 Sort Event captured a mid-pandemic look at Minnesota's waste stream. When examining the food & 'compostable paper and packaging' categories alone, a much larger proportion of compostable paper was found in the 2020 Sort Event compared to 2019 Sort Event (Figure 11). It is possible this difference is reflecting a change in consumer behavior and disposal patterns during the pandemic; however, this study is not equipped to determine a definite connection. With the addition of 2021 and 2022 Spring and Fall Sort Events, the data is more balanced between pre- and post-pandemic behaviors.

According to ReFED, a national non-profit organization working to end food loss and waste in the U.S., 35% of all food produced in the U.S. was unsold or uneaten which represents a $408 billion economic loss and contributes to 4% of the total U.S. greenhouse gas emissions[6]. The food & 'compostable paper and packaging' sort data collected in this study provides MPCA with a detailed understanding of how much food in the MMSW could have been eaten or could be rescued, which together accounts for 45.3% of the sorted organics stream. This allows MPCA to direct resources to target opportunities such as preventing food waste and rescuing edible food.

Based on the aggregated data collected over six waste sorts and 4 years, there are opportunities to significantly reduce wasting of edible food and increase composting of inedible food & 'compostable paper and packaging'. (Figure 16). Sorted organic materials are broken down to compare different "upstream, midstream, and downstream" stages and approaches to fighting food waste (Figure 17).

Strategies to reduce food waste fall into three categories: Prevent, Rescue, and Compost:

- **Prevent** (41%) may include education around knowledge of packaging expiration dates, conscience volume purchases, portions, and pantry rotation. This falls under the "upstream" stage of focusing on education initiatives for food waste prevention.

- **Rescue** (4%) may include food bank food waste prevention, restaurant collaboration, and food pantry education and outreach programs. This falls under the "midstream" stage of focusing on rescuable food initiatives.

- **Compost** (50%) may include compost facilities certified to handle food waste such as inedible scraps and compostable food service ware. This falls under the "downstream" stage of focusing managing the food waste that does not fall under the "upstream" and "midstream" stages.

- Other (5%) is not categorized under any of the "upstream, midstream, and downstream" stages as liquids and non-compostable packing are not the focus of food waste prevention programs.

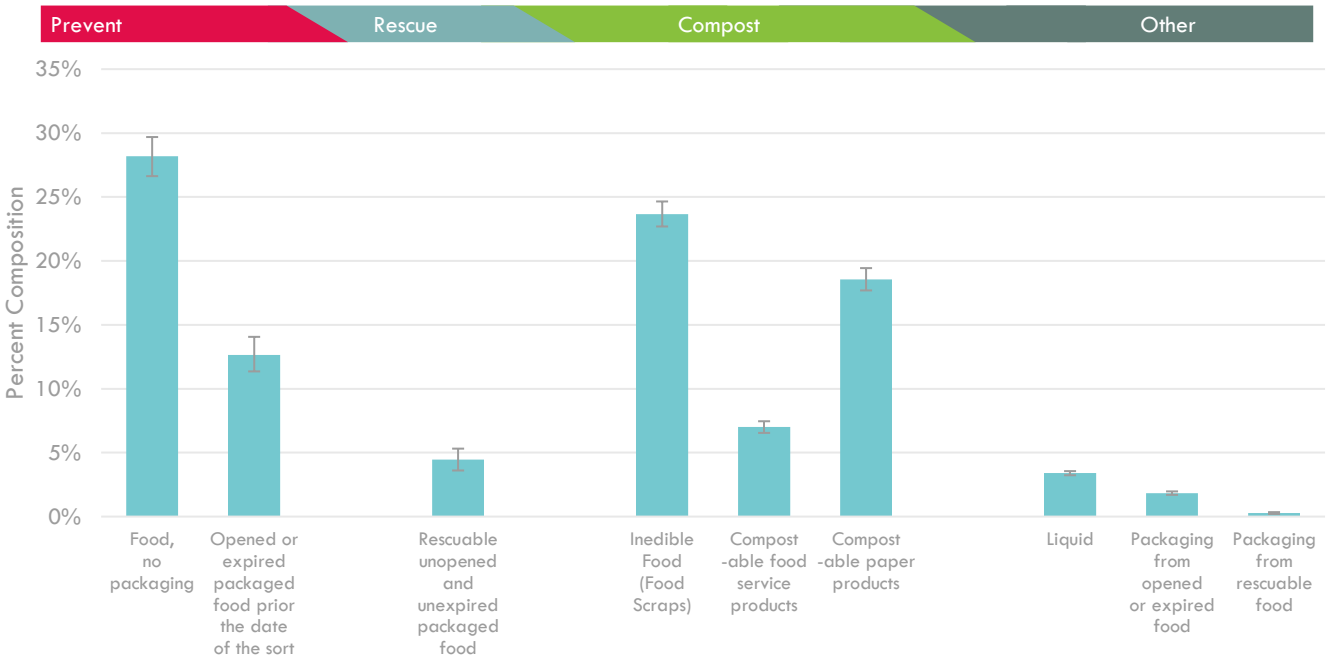
From this data, 95% of food categorized from the waste stream has the potential to be diverted from the landfill. The following figure has broken down the Food & 'Compostable Paper and Packaging' sub sort into the three categories: Prevent, Rescue, and Compost.

Figure 16: Food & 'compostable paper and packaging' sort percentages

[6] Source to ReFED: https://refed.com/

Note: The remaining 5% not accounted for in the graphic above includes non-compostable packaging removed from food and liquid waste. The sorted organics stream includes food, 'compostable paper and packaging', liquids, and non-compostable packaging.

Figure 17: Comparison of Food & 'Compostable Paper and Packaging' Material Percentages



All error bars are based on a 90% Confidence Interval

Recommendations

Moving forward, RRS would recommend increased policy and programming focusing on prevention of wasted food and food rescue. This is in line with the waste management hierarchy[7] which highlights the greater environmental benefits of food waste prevention and rescue. Secondarily, RRS recommends the MPCA focus on increased composting when prevention of wasted food and food rescue is not possible. This study shows there is ample opportunity to target reduction and expand investment and support of both the great MN and metro MN areas as wells focusing on the different types of food categories.

[7] Minnesota Statue. 2022. 115A.02 Legislative Declaration of Policy; Purposes. https://www.revisor.mn.gov/statutes/cite/115A.02.

APPENDIX A: COMPOSITION DATA

All sort data is presented in detail in the tables below.

Table 12 Overall Sort Composition of Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	6.5%	6.0%	7.1%
Food, No Packaging	7.7%	7.2%	8.3%
Opened or Expired Packaged Food Prior the Date of the Sort	3.5%	3.1%	3.8%
Rescuable Unopened and Unexpired Packaged Food	1.4%	1.1%	1.8%
Compostable Paper Products	5.1%	4.8%	5.5%
Compostable Food Service Products	1.7%	1.5%	1.8%
Packaging from Opened or Expired	0.5%	0.5%	0.6%
Packaging from Rescuable Food	0.1%	0.1%	0.1%
Liquid	0.8%	0.7%	1.0%
Remaining Sample Material	72.6%	71.3%	73.8%

Table 13 2019 Sort Event Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	6.2%	5.4%	7.2%
Food, No Packaging	7.1%	6.2%	8.1%
Opened or Expired Packaged Food Prior the Date of the Sort	3.5%	3.0%	4.0%
Rescuable Unopened and Unexpired Packaged Food	2.3%	1.6%	3.0%
Compostable Paper Products	2.5%	2.1%	2.8%
Compostable Food Service Products	1.6%	1.3%	1.8%
Packaging from Opened or Expired	0.5%	0.4%	0.6%
Packaging from Rescuable Food	0.2%	0.1%	0.3%
Liquid	0.7%	0.5%	1.0%
Remaining Sample Material	75.4%	73.4%	77.5%

Table 14 2020 Sort Event Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	6.1%	5.1%	7.1%
Food, No Packaging	6.7%	5.9%	7.5%
Opened or Expired Packaged Food Prior the Date of the Sort	2.6%	2.3%	3.1%
Rescuable Unopened and Unexpired Packaged Food	0.8%	0.5%	1.1%
Compostable Paper Products	7.4%	6.7%	8.0%
Compostable Food Service Products	0.7%	0.5%	0.9%
Packaging from Opened or Expired	0.5%	0.4%	0.6%
Packaging from Rescuable Food	0.1%	0.0%	0.2%
Liquid	0.9%	0.6%	1.1%
Remaining Sample Material	74.3%	72.1%	76.5%

Table 15 2021 Spring Sort Event Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	7.3%	5.9%	8.9%
Food, No Packaging	8.7%	7.4%	10.1%
Opened or Expired Packaged Food Prior the Date of the Sort	3.9%	3.0%	4.9%
Rescuable Unopened and Unexpired Packaged Food	1.6%	0.9%	2.5%
Compostable Paper Products	5.5%	4.9%	6.2%
Compostable Food Service Products	2.1%	1.9%	2.5%
Packaging from Opened or Expired	0.6%	0.5%	0.6%
Packaging from Rescuable Food	0.0%	0.0%	0.1%
Liquid	0.8%	0.7%	1.0%
Remaining Sample Material	69.4%	66.7%	71.8%

Table 16 2021 Fall Sort Event Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	6.4%	5.5%	7.3%
Food, No Packaging	8.3%	7.4%	9.3%
Opened or Expired Packaged Food Prior the Date of the Sort	3.7%	3.0%	4.6%
Rescuable Unopened and Unexpired Packaged Food	1.1%	0.6%	1.7%
Compostable Paper Products	5.2%	4.6%	5.8%
Compostable Food Service Products	2.2%	1.9%	2.6%
Packaging from Opened or Expired	0.6%	0.5%	0.7%
Packaging from Rescuable Food	0.1%	0.0%	0.1%
Liquid	1.0%	0.7%	1.3%
Remaining Sample Material	71.4%	68.8%	73.8%

Table 17 2022 Spring Sort Event Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	5.9%	5.3%	6.5%
Food, No Packaging	8.1%	6.6%	9.9%
Opened or Expired Packaged Food Prior the Date of the Sort	3.9%	3.1%	4.6%
Rescuable Unopened and Unexpired Packaged Food	0.7%	0.4%	1.0%
Compostable Paper Products	4.8%	4.4%	5.2%
Compostable Food Service Products	2.2%	1.9%	2.6%
Packaging from Opened or Expired	0.3%	0.3%	0.4%
Packaging from Rescuable Food	0.0%	0.0%	0.1%
Liquid	1.0%	0.8%	1.1%
Remaining Sample Material	73.2%	70.7%	75.3%

Table 18 2022 Fall Sort Event Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	6.5%	5.6%	7.4%
Food, No Packaging	7.0%	6.1%	7.8%
Opened or Expired Packaged Food Prior the Date of the Sort	2.9%	2.4%	3.5%
Rescuable Unopened and Unexpired Packaged Food	0.8%	0.4%	1.3%
Compostable Paper Products	5.0%	4.5%	5.6%
Compostable Food Service Products	2.5%	2.1%	2.9%
Packaging from Opened or Expired	0.5%	0.4%	0.6%
Packaging from Rescuable Food	0.1%	0.0%	0.1%
Liquid	1.2%	0.9%	1.5%
Remaining Sample Material	73.7%	71.3%	75.8%

Table 19 Great MN Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	7.2%	6.5%	7.8%
Food, No Packaging	8.6%	7.8%	9.3%
Opened or Expired Packaged Food Prior the Date of the Sort	4.0%	3.6%	4.4%
Rescuable Unopened and Unexpired Packaged Food	1.2%	0.9%	1.5%
Compostable Paper Products	6.0%	5.6%	6.4%
Compostable Food Service Products	2.0%	1.9%	2.2%
Packaging from Opened or Expired	0.5%	0.5%	0.6%
Packaging from Rescuable Food	0.1%	0.1%	0.1%
Liquid	1.0%	0.9%	1.2%
Remaining Sample Material	69.4%	67.9%	70.7%

Table 20 Metro MN Full Waste Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	7.2%	6.5%	7.8%
Food, No Packaging	8.6%	7.8%	9.3%
Opened or Expired Packaged Food Prior the Date of the Sort	4.0%	3.6%	4.4%
Rescuable Unopened and Unexpired Packaged Food	1.2%	0.9%	1.5%
Compostable Paper Products	6.0%	5.6%	6.4%
Compostable Food Service Products	2.0%	1.9%	2.2%
Packaging from Opened or Expired	0.5%	0.5%	0.6%
Packaging from Rescuable Food	0.1%	0.1%	0.1%
Liquid	1.0%	0.9%	1.2%
Remaining Sample Material	69.4%	67.9%	70.7%

Table 21 Overall Sort Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	23.7%	22.4%	24.9%
Food, No Packaging	28.2%	26.9%	29.6%
Opened or Expired Packaged Food Prior the Date of the Sort	12.6%	11.8%	13.6%
Rescuable Unopened and Unexpired Packaged Food	4.5%	3.6%	5.3%
Compostable Paper Products	18.6%	17.7%	19.4%
Compostable Food Service Products	7.0%	6.5%	7.5%
Packaging from Opened or Expired	1.8%	1.7%	2.0%
Packaging from Rescuable Food	0.3%	0.2%	0.3%
Liquid	3.4%	3.0%	3.7%

Table 22 2019 Sort Event Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	25.3%	22.5%	28.5%
Food, No Packaging	28.8%	25.8%	31.8%
Opened or Expired Packaged Food Prior the Date of the Sort	14.4%	12.6%	16.2%
Rescuable Unopened and Unexpired Packaged Food	9.3%	6.5%	12.3%
Compostable Paper Products	10.0%	8.6%	11.4%
Compostable Food Service Products	6.3%	5.4%	7.2%
Packaging from Opened or Expired	2.1%	1.6%	2.6%
Packaging from Rescuable Food	0.7%	0.4%	1.1%
Liquid	3.0%	2.1%	3.9%

Table 23 2020 Sort Event Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	23.8%	20.8%	26.4%
Food, No Packaging	26.0%	23.8%	28.3%
Opened or Expired Packaged Food Prior the Date of the Sort	10.3%	9.0%	11.6%
Rescuable Unopened and Unexpired Packaged Food	3.0%	1.9%	4.4%
Compostable Paper Products	28.7%	26.9%	30.7%
Compostable Food Service Products	2.6%	2.0%	3.4%
Packaging from Opened or Expired	1.9%	1.5%	2.2%
Packaging from Rescuable Food	0.5%	0.2%	1.0%
Liquid	3.3%	2.5%	4.2%

Table 24 2021 Spring Sort Event Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	23.8%	19.8%	27.5%
Food, No Packaging	28.4%	24.6%	32.4%
Opened or Expired Packaged Food Prior the Date of the Sort	12.6%	10.0%	15.6%
Rescuable Unopened and Unexpired Packaged Food	5.4%	3.0%	8.3%
Compostable Paper Products	18.0%	16.4%	19.7%
Compostable Food Service Products	7.0%	6.1%	8.2%
Packaging from Opened or Expired	1.9%	1.7%	2.2%
Packaging from Rescuable Food	0.1%	0.1%	0.2%
Liquid	2.7%	2.2%	3.2%

Table 25 2021 Fall Sort Event Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	22.5%	19.4%	25.4%
Food, No Packaging	29.1%	27.0%	31.2%
Opened or Expired Packaged Food Prior the Date of the Sort	13.1%	11.0%	15.4%
Rescuable Unopened and Unexpired Packaged Food	3.7%	2.1%	5.7%
Compostable Paper Products	18.1%	15.9%	20.5%
Compostable Food Service Products	7.8%	6.7%	9.0%
Packaging from Opened or Expired	2.1%	1.8%	2.4%
Packaging from Rescuable Food	0.3%	0.1%	0.4%
Liquid	3.4%	2.5%	4.4%

Table 26 2022 Spring Sort Event Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	22.0%	19.7%	24.5%
Food, No Packaging	30.1%	25.8%	35.0%
Opened or Expired Packaged Food Prior the Date of the Sort	14.4%	12.2%	17.1%
Rescuable Unopened and Unexpired Packaged Food	2.5%	1.6%	3.5%
Compostable Paper Products	17.8%	16.2%	19.5%
Compostable Food Service Products	8.3%	7.1%	9.7%
Packaging from Opened or Expired	1.3%	1.1%	1.5%
Packaging from Rescuable Food	0.2%	0.1%	0.3%
Liquid	3.6%	2.9%	4.4%

Table 27 2022 Fall Sort Event Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	24.6%	22.1%	27.3%
Food, No Packaging	26.4%	24.7%	28.2%
Opened or Expired Packaged Food Prior the Date of the Sort	11.0%	9.4%	12.7%
Rescuable Unopened and Unexpired Packaged Food	3.1%	1.7%	4.4%
Compostable Paper Products	19.0%	16.9%	21.1%
Compostable Food Service Products	9.6%	8.3%	10.8%
Packaging from Opened or Expired	1.7%	1.4%	2.2%
Packaging from Rescuable Food	0.2%	0.1%	0.3%
Liquid	4.5%	3.6%	5.6%

Table 28 Greater MN Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	24.0%	22.4%	25.6%
Food, No Packaging	28.5%	26.9%	30.1%
Opened or Expired Packaged Food Prior the Date of the Sort	12.2%	10.9%	13.3%
Rescuable Unopened and Unexpired Packaged Food	5.0%	3.7%	6.7%
Compostable Paper Products	17.2%	16.0%	18.5%
Compostable Food Service Products	7.5%	6.7%	8.3%
Packaging from Opened or Expired	2.0%	1.8%	2.3%
Packaging from Rescuable Food	0.2%	0.1%	0.3%
Liquid	3.4%	2.9%	4.0%

Table 29 Metro MN Composition Food & 'Compostable Paper and Packaging' Stream Detailed Data

Material	Average	Lower Bound	Upper Bound
Inedible Food	23.4%	21.5%	25.2%
Food, No Packaging	28.0%	26.0%	29.8%
Opened or Expired Packaged Food Prior the Date of the Sort	13.0%	11.8%	14.4%
Rescuable Unopened and Unexpired Packaged Food	4.0%	3.1%	5.0%
Compostable Paper Products	19.6%	18.3%	20.8%
Compostable Food Service Products	6.6%	6.1%	7.3%
Packaging from Opened or Expired	1.7%	1.5%	1.9%
Packaging from Rescuable Food	0.3%	0.2%	0.4%
Liquid	3.4%	2.9%	3.9%

APPENDIX B: DATA COLLECTION SHEET

Below is an example data sheet used to collected data for this sort.

Time:		Sort Location:		Sample Number:	
Truck Material Type (Residential, Commercial, R&C):		County of Origin:		Truck Number:	
Category	**Weight 1**	**Weight 2**	**Weight 3**	**Weight 4**	**Weight 5**
Food Scraps					
Food, No Packaging					
Opened or Expired Packaged Food (Prior the Date of the Sort)					
Packaging From Above Category					
Total Weight of Un-Depackaged Item					
Package Size					NA
Package Type					NA
Rescuable Unopened and Unexpired Packaged Food					
Packaging From Above Category					
Total Weight of Un-Depackaged Item					
Package Size					NA
Package Type					NA
Compostable Paper Products					
Compostable Food Service Products					
All Other Material From Sort					
Liquid Waste					

APPENDIX C: LITERATURE REVIEW

A literature review of historical waste characterization studies was conducted that examined a total of 49 waste characterization studies and compared those studies to the 2019/2020/2021/2022 sort results presented here. The methodology of each study was examined to ensure the study was conducted in a comparable way to the MPCA food sorts. Table 30 outlines the required components for each study to be considered comparable to this waste sort.

Table 30: Components of Waste Characterization Studies

	Requirement for Study
Study Sector	Residential and Commercial (ICI) sectors. Excluded self-haul and C&D data from analysis.
Sample Type	Municipal Solid Waste.
Sort Method	Samples must be hand sorted.
Sampling Method	Samples must be randomly selected.
Sample Size	Samples must be 200-300 pounds in size.
Study Confidence	At least 90% confidence interval with lower and upper range bounds provided for study results.
Food Sort Category	Study must include a food only category.

From the original list of 49 studies, 36 waste studies were included in the analysis described below and 13 studies were excluded because the studies did not meet the qualifications as outlined in Table 30. The included studies encompassed statewide, countywide, city/municipal-wide, and facility-based estimates, and ranged in time from 2002 to 2018. In the analysis of these studies, differences such as time, population density, policy, and seasonality were analyzed.

STATEWIDE WASTE CHARACTERIZATION ANALYSIS

Out of the 36 waste studies included in this analysis, 23 studies encompassed statewide estimates. Table 31 and Figure 18 show the estimated percent of food in each study along with the lower and upper bounds of each measurement. If there were multiple studies over multiple years, the percent change over time and indication if change was statistically significant was also included in the right-most columns. These data show that on average 18.9% of residential and commercial MSW was comprised of food, with a range of 13.3% to 26.7%. For the states with multiple studies:

- No change detected - The changes in the proportion of food measured in six states, CA, MN, OR, WA, and WI, are not statistically significant.
- Increase detected – The proportion of food measured in the waste stream showed a statistically significant increase in four states, CT, IA, IL, and VT, across one or more years.
- Decrease detected – No states showed a statistically significant decrease in food from any multi-year data.

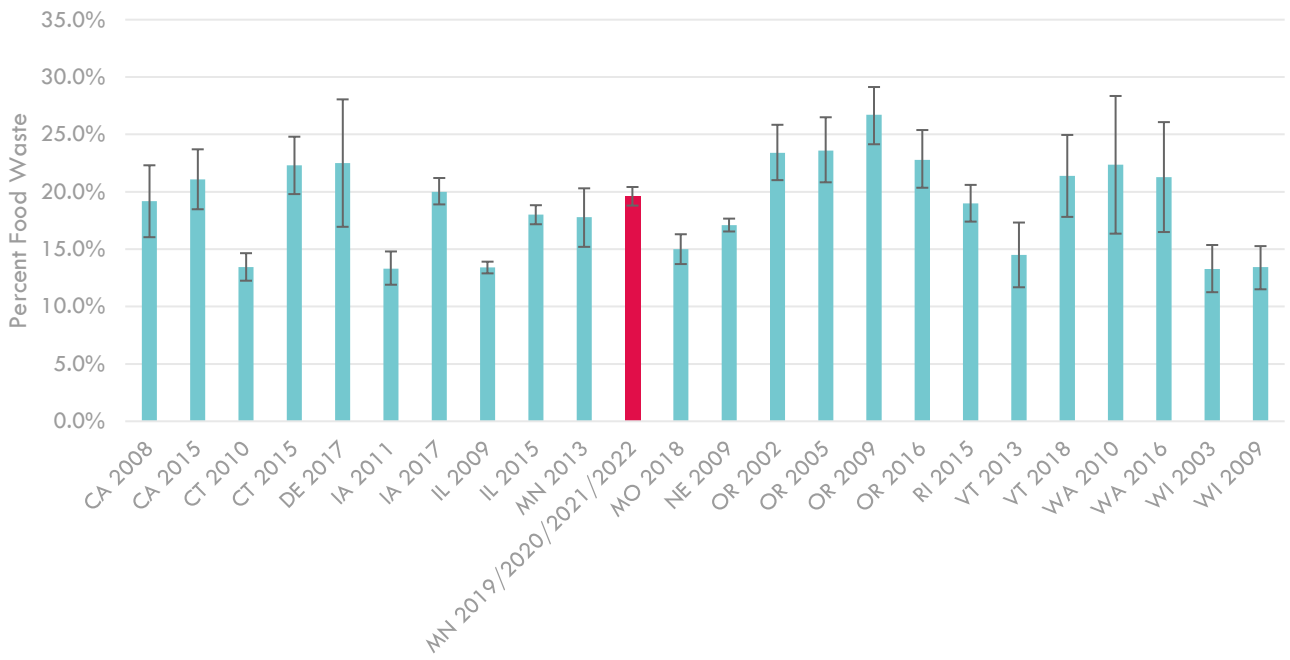
Table 31: Percent Food Measured in Waste Composition Studies Statewide

State	Year	Percent Food	Lower Bound	Upper Bound	Percent Change	Statistically Significant Change
CA	2008	19.2%	16.0%	22.3%		
CA	2015	21.1%	18.5%	23.7%	1.9%	No
CT	2010	13.5%	12.3%	14.7%		
CT	2015	22.3%	19.8%	24.8%	8.8%	Yes
DE	2017	22.5%	16.9%	28.1%		
IA	2011	13.3%	11.9%	14.8%		
IA	2017	20.0%	18.9%	21.2%	6.7%	Yes
IL	2009	13.4%	12.9%	13.9%		
IL	2015	18.0%	17.2%	18.8%	4.6%	Yes
MN	2013	17.8%	15.2%	20.3%		
MN[8]	2019/2020/2021/2022	19.6%	18.8%	20.4%	1.8%	No
MO	2018	15.0%	13.7%	16.3%		
NE	2009	17.1%	16.5%	17.7%		
OR	2002	23.4%	21.0%	25.8%		
OR	2005	23.6%	20.8%	26.5%	0.2%	No
OR	2009	26.7%	24.1%	29.1%	3.1%	No
OR	2016	22.8%	20.4%	25.4%	-3.9%	No
RI	2015	19.0%	17.4%	20.6%		
VT	2013	14.5%	11.7%	17.3%		
VT	2018	21.4%	17.8%	25.0%	6.9%	Yes
WA	2010	22.4%	16.4%	28.4%		
WA	2016	21.3%	16.5%	26.1%	-1.1%	No
WI	2003	13.3%	11.2%	15.4%		
WI	2009	13.4%	11.5%	15.3%	0.1%	No

All studies reported a 90% confidence interval. A reference sheet to waste composition studies is provided in Appendix C: Literature Review .

[8] The estimated percent food waste for the MN 2019/2020/2021 sort includes edible food, food scraps, and liquid waste.

Figure 18: Percent Food Measured in Waste Composition Studies Statewide

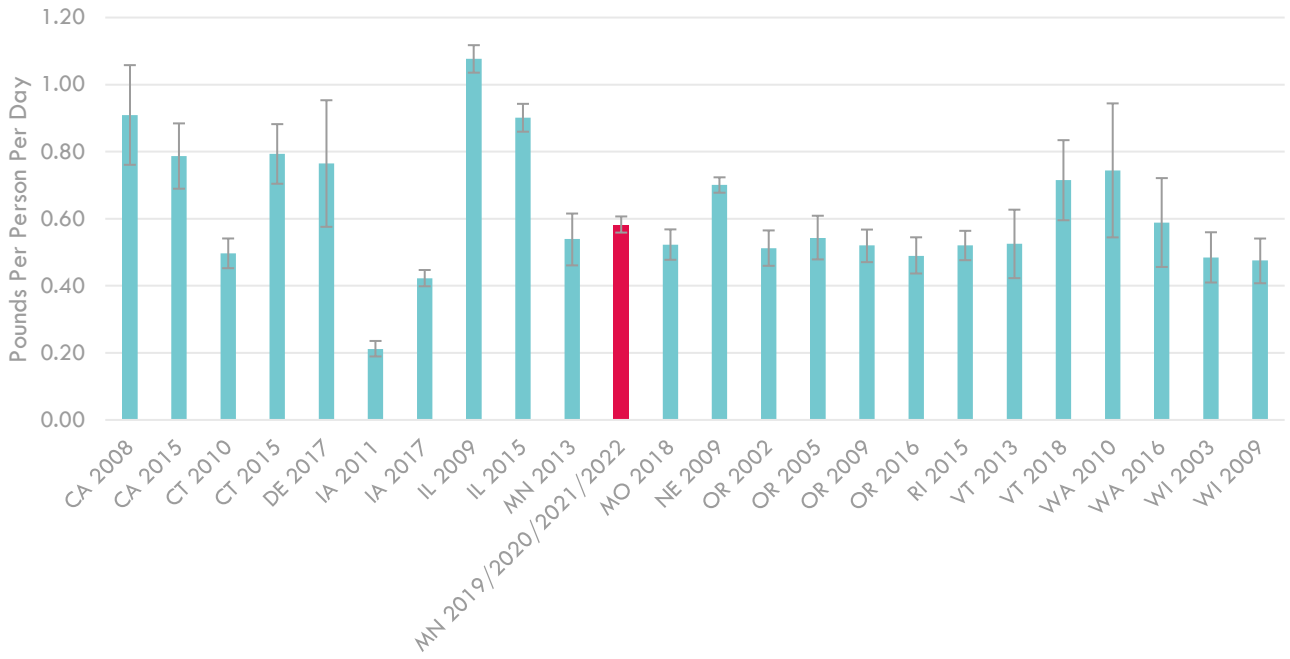


While the data seem to suggest in some states with studies conducted over multiple years that food is increasing in the stream, there are always challenges to comparing waste sorts to each other due to the evolving waste stream discussed in the previous section. A more apt comparison between waste composition studies conducted in different years may be the per capita food disposal rate shown in Table 32 and Figure 19Figure 19. Reexamining the four states that showed a percent increase in food when comparing an earlier and later waste characterization study – CT, IA, IL, and VT – two of those states, CT and IA, also showed a per capita increase in food. The per capita food disposal actually dropped in Illinois between studies, even though the percent composition of food in the disposal stream increased. The per capita change in VT was not statistically significant.

Table 32: Per Capita Food Disposal in Waste Composition Studies

State	Year	Per Capita Food Disposal (Pounds Per Person Per Day)	Percent Change
CA	2008	0.91	
CA	2015	0.79	-13.5%
CT	2010	0.50	
CT	2015	0.79	59.7%
DE	2017	0.76	
IA	2011	0.21	
IA	2017	0.42	99.3%
IL	2009	1.08	
IL	2015	0.90	-16.3%
MN	2013	0.54	
MN[8]	2019/2020/2021/2022	0.58	7.5%
MO	2018	0.52	
NE	2009	0.70	
OR	2002	0.51	
OR	2005	0.54	6.0%
OR	2009	0.52	-4.0%
OR	2016	0.49	-6.1%
RI	2015	0.52	
VT	2013	0.52	
VT	2018	0.71	36.2%
WA	2010	0.74	
WA	2016	0.59	-20.9%
WI	2003	0.48	
WI	2009	0.48	-1.6%

Figure 19: Per Capita Food Disposal in Waste Composition Studies



To further examine notable waste characterization studies, a state specific analysis of select waste characterization studies is provided below.

California – Two statewide waste composition studies conducted in California were analyzed here. The studies, conducted in 2008 and 2015, did not find a significant change in percent food in the municipal and commercial disposal stream nor the per capita food disposal rate.

In 2014, the Governor of California signed a law requiring businesses to recycle their organic waste starting on and after April 1, 2016, depending on the amount of waste they generate per week. In addition, the law required that local jurisdictions implement an organic waste recycling program to divert organic waste generated by businesses and multifamily residential dwellings consisting of five or more units. As mentioned, the date in which a business was required to divert food depended on their generation rate. Starting in April 2016, businesses generating 8 cubic yards of organics per week were the first group of businesses that were required to recycle their organic waste. In January 2017, businesses generating 4 cubic yards of organics per week were required to have organics recycling services. Finally in January 2019 businesses generating 4 cubic yards of solid waste per week were required to established organics diversion programs. Throughout this timeframe, CalRecycle monitored and reviewed implementation of the law to determine if the desired goal of decreasing statewide disposal of organics by 50% of 2014 levels in 2020. If the state does not meet this goal, businesses generating 2 cubic yards of organics per week would be required to recycle their organic waste, and in September 2020 CalRecycle's Acting Director approved the lower threshold requirements. Given the timing of the waste characterization studies analyzed here, any impacts of the organic diversion law would not be reflected in the waste characterization studies.

There have also been local initiatives to divert organics occurring in the state. For example, San Francisco has had a mandatory recycling and composting ordinance in place since 2009, requiring all persons located in San Francisco to separate recyclables, organics, and trash and participate in recycling and composting programs.

While the San Francisco ordinance clearly contributes to a higher diversion rate for the City, it is not possible for this analysis to determine if the San Francisco ordinance or any local ordinance has an impact on food disposal at the overall state level.

Connecticut – From 2010 to 2015 food increased 8.9% in the disposal stream. While the proportion of food increased, there are some differences between the two studies. In the 2010 study, sampling was from suburban and rural areas, coming from facilities in Bristol, Bridgeport, New Haven, Preston, and Hartford. In the 2015 study, 192 out of 235 total samples came from urban areas. Additionally, the food categories were slightly different. In the 2010 study, "Food" was the only category, while in 2015, food was split into two categories, "Food, loose" and "Food, emptied from packaging." When adding the "Food, emptied from packaging" category, food was separated from packaging when it was practical to do so. In this study, foods that could be easily emptied with the help of gravity were removed and foods that were viscous and not easily removed (e.g., peanut butter, mayonnaise) would remain in their packaging. This category was added because of the increased interest in removing organics from the waste stream through anaerobic digestion, composting, and other organics recovery programs. The 2010 study does not indicate how packaged food or packaged beverages were sorted. Looking at the specific food categories in 2015, 2.8% (2.0% to 3.6%) of food was unpackaged and 19.5% (17.8% to 21.2%) was loose food. Comparing the 2015 study results to the 2010 findings of 13.5% food (12.3% to 14.7%) even if the unpackaged food measured in 2015 were discounted, the percent of loose food is significantly greater in the 2015 waste characterization than 2010. Additionally, per capita disposal of food was significantly higher in 2015 (0.79) compared to 0.5 in 2010.

As food is a large portion of Connecticut's waste stream, in 2011, the state passed PA 11-217, which requires the recycling of food residuals by certain commercial generators of organics if they have a projected annual generation rate of 104 tons per year of source separated organics and are within 20 miles of a licensed facility that is able and willing to accept it. In 2020 the law expanded requirements to an annual generation rate of 52 tons per year. While this policy change occurred, the waste characteristic studies are not showing a decrease in disposed food.

Iowa – A 2017 statewide waste characterization study in Iowa found that food in the disposal stream increased from comprising 13.3% of waste statewide in 2011 to 20.0% in 2017. Although there was an increase in the proportion of food in the waste stream, there are several differences between the 2011 study and the 2017 study. The 2011 study and the 2017 study were conducted by two different consultation groups which potentially impacted the methodology used in each study. There were also additional facilities included in the 2017 study that were not included in the 2011 study which may have increased the range of data included to previously unmeasured parts of Iowa. There were also differences in the time of year when data was collected, with waste sorting occurring from the second week of May to the end of July in 2017 versus the previous study in 2011, which began fieldwork at the end of April and continued until the beginning of July. The later starting date of data collection in 2017 could have resulted in data collection during months of higher food disposal than the earlier data collection in 2011. Finally, the most notable difference between the 2017 study and the 2011 study was the methodology for measuring food waste. In 2011, food waste was a single item under the organic waste category, whereas the 2017 study classified food waste into two separate types: loose food waste and packaged food waste. The loose food waste classification accounted for 13.3% (12.7% to 14.0%) of waste in Iowa in 2017, similar to the 13.3% (11.9% to 14.8%) found by the 2011 study for the general food waste classification, while the packaged food waste classification accounted for 6.7% (6.2% to 7.2%) of the waste stream. As the 2011 study does not specify how food waste contained inside of packaging was handled, it is possible that the increase in food waste found in 2017 results from the change in how packaged food waste is measured.

While there are some university level initiatives to reduce food disposal in Iowa, there are currently few policy initiatives at the local or state level addressing the issue of food disposal in Iowa. One initiative currently

operational to address Iowa's food disposal increase is a curbside composting program in Iowa City that provides residents with 95-gallon compost carts for a monthly fee. While not required by the city, Iowa City's composting program helps increase its food diversion rate.

Oregon – The state of Oregon was found to have performed the most statewide waste characterizations, conducting studies in 2002, 2005, 2009, and 2016, and has also kept the sampling, sorting methodology, and categories generally consistent between years. The waste characterization studies include sampling of route truck collection, self-haul, and drop boxes. In this examination, only data from the residential, commercial, and mixed (combination of residential and commercial) route collection trucks were considered so that the data is most comparable to the waste composition performed in Minnesota. In the four studies examined, the percent composition food upper and lower bounds overlap between all years, and the same is true for the per capita analysis.

Looking into the future, the Metro Council adopted a policy that large food generating businesses, such as grocery stores, restaurants, lodging and hotels, hospitals, nursing and residential care facilities, correctional facilities, educational facilities, and food and beverage manufacturers must compost back-of-house food scraps. The original start date was for March 30, 2020, but the implementation was delayed until March 30, 2022, due to the impact of COVID-19.

Vermont – A waste composition study in 2013 found 14.5% of the state's MSW was food. In 2018, a follow up study found 21.4% food in the disposal stream, a 6.9% increase. While food increased as a percent of the overall disposal stream from 2013 to 2018, there are also important factors between the 2013 study and the 2018 study that should be noted. First, the generating sectors are not a one-to-one comparison. In 2013, the generating sectors were split 60% and 40% between residential and ICI whereas in 2018, the residential and commercial split was 54% and 46% respectively. Also, the authors of the study noted that there was no significant change in residential food from 2013 to 2018, and that in 2018 less total residential MSW was disposed of so that denser food became a higher percentage of overall MSW disposal. More telling than the percent of food in the disposal stream is that the per capita food disposal remained unchanged from 2013 to 2018.

Vermont has implemented aggressive policy aimed at decreasing food between the two waste study years. In 2012, Vermont passed the Universal Recycling Law (Act 148). This law targeted food scraps, as one of the major categories to remove from Vermont's trash bins. In 2014, this law requires food scrap generators of 104 tons/year to divert their materials to a certified facility within 20 miles from their operation. Overtime, this law's requirements become stricter so that:

- 2015: food scrap generators of 52 tons/year have to divert materials to a certified facility within 20 miles
- 2016: food scrap generators of 26 tons/year have to divert materials to a certified facility within 20 miles
- 2017: food scrap generators of 18 tons/year have to divert materials to a certified facility within 20 miles.
- 2020: food scraps are banned from the landfill, and it is mandatory that haulers offer food scrap collection to both nonresidential customers and apartment buildings with four or more residential units.

In addition to commercial food diversion, the Castleton Polling Institute results shared in the 2018 study estimated that Vermont in 2018 diverted about 40% or 27,600 tons of residential food through backyard composting, feed for animals/livestock, and other activities like composting at drop-off sites.

Washington – The state of Washington performed two statewide waste characterization studies in 2010 and 2016 and found no significant change in the proportion of food measured in the disposal stream when comparing the two studies. While the proportion of food disposed remained similar, the overall residential and commercial tonnage disposed declined from 2010 to 2016 despite adding approximately 0.5 million residents to the state.

There is no statewide organics collection mandate in Washington, however there are some local ordinances in place within the state. Seattle started curbside food collection in 2005, and in 2009, Seattle made it mandatory for all residential properties to compost either through subscribing to food and yard waste collection or through backyard composting. Seattle's ordinance expanded in 2011such that all multi-family property managers were required to provide compost collection services to residents. Starting January 2015, Seattle prohibited food scraps, compostable paper, yard waste, and recyclables from disposal. Washington's state capital Olympia offers pay-as-you-throw cart-based garbage services, no fee recycling, and $21.18 bi-monthly fee for either a 35- or 95-gallon organics cart. Residents can put yard waste, pizza boxes, and food including food scraps, meat, bones, dairy products into their carts for bi-weekly year-round collection.

One of the challenges in documenting changes in the waste stream over time is that studies are often not conducted frequently enough, methodologies and categories are slightly changed from year to year, and there are many variables at play in disposal patterns such as economic and technological changes. Other variables such as seasonality and population differences can have an impact on food, and as a result it is difficult to parse out if policy changes around food have an impact on the municipal and commercial disposal streams.

RURAL AND URBAN WASTE CHARACTERIZATION ANALYSIS

The waste characterization data collected in this study encompassed measurement of food at both an urban and rural site in Minnesota. To provide a comparison, an analysis of available waste characterization studies from historical urban and rural studies was performed and is presented below.

RURAL ANALYSIS

Table 33 and Figure 20 display the percent food results with lower and upper bounds for rural waste characterization studies. In several instances, results are taken from a statewide study that reported rural and urban results separately. On average, rural MMSW is composed of 19.0% food and ranges from 13.0% (HI 2006) to 30.0% (WA 2012). The data from the rural portion of this study found 23.1% (20.2% to 26.1%) food in rural MMSW.

Table 33: Data on the Percent Food in Rural Regions

Reference Study	Population Density of Study Region (per square mile)	Percent Food Rural	Rural Lower Bounds	Rural Upper Bounds
HI 2006	1,461	13.0%	9.5%	16.5%
CO 2010	450	14.1%	12.4%	15.8%
TN 2018	1,326	14.1%	12.9%	15.3%
VA 2014	1,200	14.2%	Not Provided	Not Provided
IL 2009	Rural Statewide	14.3%	12.3%	16.3%
MO 2018	Rural Statewide	15.2%	12.7%	17.7%
WA 2009	368	16.7%	Not Provided	Not Provided
MN 2013	239	18.3%	16.9%	19.7%

Reference Study	Population Density of Study Region (per square mile)	Percent Food Rural	Rural Lower Bounds	Rural Upper Bounds
IL 2015	Rural Statewide	19.2%	17.1%	21.3%
CT 2015	Rural Statewide	20.7%	11.3%	30.2%
WA 2014	368	21.1%	14.8%	27.5%
MN 2019/2020/2021/2022	36	23.2%	20.8%	25.6%
ID 2014	370	23.0%	15.8%	30.1%
WA 2008	1,034	23.0%	Not Provided	Not Provided
NC 2017	336	25.5%	23.1%	28.1%
WA 2012	717	30.0%	24.7%	35.3%

A reference sheet to waste composition studies is provided in Appendix C: Literature Review .

Figure 20: Data on the Percent Food in Rural Regions

Studies without error bars indicated did not provide upper and lower bounds in data reporting.
MN 2019 refers to the study sorts conducted in Lyon County, MN for this study.

URBAN ANALYSIS

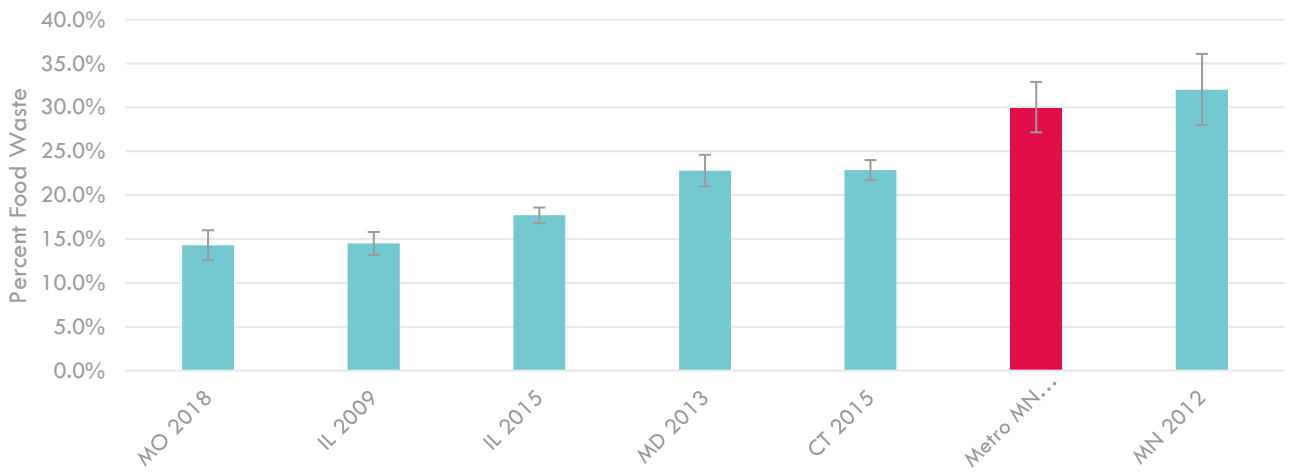
Table 34 and Figure 21 display the percent food results with lower and upper bounds for urban waste characterization studies. As in the rural analysis, some results are taken from statewide studies that reported rural and urban results separately. On average, urban MMSW is composed of 21.7% food and ranges from 14.3% (MO 2008) to 32.0% (MN 2012). The data from the urban portion of this study found 27.7% (23.7% to 32.0%) of the municipal disposal stream was composed of food. Overall, the average food disposal is slightly greater in urban regions over rural although the ranges of food between the rural and urban studies are comparable.

Table 34: Data on the Percent Food in Urban Regions

Reference Study	Population Density of Study Region (per square mile)	Percent Food Urban	Urban Lower Bounds	Urban Upper Bounds
MO 2018	Urban Statewide	14.3%	12.6%	16.0%
IL 2009	Urban Statewide	14.5%	13.2%	15.8%
IL 2015	Urban Statewide	17.7%	16.8%	18.6%
MD 2013	1,900	22.8%	21.0%	24.6%
CT 2015	Urban Statewide	22.9%	21.7%	24.0%
Metro MN 2019/2020/2021/2022	2,082	30.0%	27.2%	32.9%
MN 2013	2,082	32.0%	28.0%	36.1%

A reference sheet to waste composition studies is provided in Appendix C.

Figure 21: Data on the Percent Food in Urban Regions



CONCLUSION

For any policy maker looking to reduce their community's dependency on disposal and reduce landfill greenhouse gas emissions, a necessary question is whether access to organics diversion and/or organics diversion requirements impacts the level of organics in the disposal stream. Ideally, if residents and businesses can access organics recycling – and in particular, when disposal is discouraged through structures such as pay-as-you-throw programs – the proportion of organics in the waste stream should decline. While intuitively this makes sense, it is challenging to observe impacts of organics policy changes to organics in the waste stream for several reasons:

- Margin of error tends to be large on waste characterization studies due to limitations in sampling for budgetary and time constraints.
- Studies may not be conducted frequently enough or at the right time points to detect the impact of a policy change.
- There are a number of factors influencing behavior in a community that could all impact organics disposal, and it is challenging to separate the many confounding factors within the data.

DATA SOURCES

Table 35 below provides source data for the studies analyzed in the desktop analysis of this report.

Table 35: Reference to waste composition studies analyzed

Study Name	Location	State	Year Published
California 2008 Statewide Waste Characterization Study	CA	CA	2008
2014 Disposal-Facility-Based Characterization of Solid Waste in California Significant Tables and Figures	CA	CA	2015
2010 Waste Composition Study	Boulder County, CO	CO	2010
Connecticut State-wide Solid Waste Composition and Characterization Study, Final Report	CT	CT	2010
Connecticut Department of Environmental Protection 2015 Statewide Waste Characterization Study	CT	CT	2015
Delaware Solid Waste Authority Statewide Waste Characterization Study, FY 2016	DE	DE	2017
2006 Waste Characterization Study City and County of Honolulu	Honolulu, HI	HI	2006
2011 Iowa Statewide Waste Characterization Study	IA	IA	2011
2017 Iowa Statewide Waste Characterization Study	IA	IA	2017
ADA County Waste Stream Analysis	Ada County, ID	ID	2014
Illinois Commodity/Waste Generation and Characterization Study	IL	IL	2009
Illinois Commodity/ Waste Generation and Characterization Study Update	IL	IL	2015
Hennepin Energy Resource Company Waste Characterization Study	Hennepin County, MN	MN	2012
Montgomery County Waste Composition Summary of Result	Montgomery County, MD	MD	2013
2013 Statewide Waste characterization, MN	MN	MN	2013
Olmsted Waste-to-Energy (OWEF) Solid Waste Characterization Study	Olmsted County, MN	MN	2014
Statewide Waste Composition, MO	MO	MO	2018
Orange County Waste Composition Study	Orange County, NC	NC	2017
Final Report State of Nebraska Waste Characterization Study	NE	NE	2009
2002 Oregon Solid Waste Characterization and Composition	OR	OR	2002
2005 Oregon Solid Waste Characterization and Composition	OR	OR	2005
2009 Oregon Solid Waste Characterization and Composition	OR	OR	2009
Statewide 2016 Waste Composition Study: Excel results files Updated June 20, 2018	OR	OR	2016
Rhode Island Solid Waste Characterization Study FINAL REPORT – December 31, 2015	RI	RI	2015
Metro Nashville and Davidson County, TN Waste Stream and Recycling Characterization Study	Davidson County, TN	TN	2018
Waste Composition Study Summary of 2013-2014 Results	Prince William County, VA	VA	2014
State of Vermont Waste Composition Study Final Report May, 2013	VT	VT	2013
2018 Vermont Waste Characterization Study	VT	VT	2018
King County Monitoring Program 2007 Waste Characterization Study	King County, WA	WA	2008
Thurston County Waste Composition Study 2008-2009	Thurston County, WA	WA	2009
2009 Washington Statewide Waste Characterization Study	WA	WA	2010

Study Name	Location	State	Year Published
2012 Waste Stream Analysis for Clark County, Washington	Clark County, WA	WA	2012
Thurston County Waste Composition Study 2013-2014	Thurston County, WA	WA	2014
2015-2016 Washington Statewide Waste Characterization Study	WA	WA	2016
Wisconsin Statewide Waste Characterization Study Final Report May 2003	WI	WI	2003
2009 Wisconsin State-Wide Waste Characterization Study	WI	WI	2009

APPENDIX D: BOOTSTRAP R CODE

```
# these are all the packages that you'll need prior to running the script
# if you don't have them, uncomment out the install.packages section
# and run those first. You only need to install packages once

# install.packages("tidyverse")
# install.packages("readxl")
# install.packages("janitor")
# install.packages("lubridate")
# install.packages("data.table")
library(tidyverse)
library(readxl)
library(janitor)
library(lubridate)
library(data.table)
library(openxlsx)

#set seed for reproducibility
set.seed(20210111)

# Bootstrapping and helper functions ----------------------------

#function for calculating the composition of material
comp <- function(data, lbs_col_name, sample_weights_col_name){
  return(sum(data[[lbs_col_name]])/
           sum(data[[sample_weights_col_name]]))
}

#Function for creation of 90% confidence intervals
#using bootstrap methodology
  bootstrap_ci <- function(data, n = 1000,
                           lbs_col_name, sample_weights_col_name){
  reps <- replicate(n, data[sample(1:nrow(data), replace = TRUE),],
                    simplify = F)
  ratio <- sapply(reps, comp, lbs_col_name, sample_weights_col_name)
  return(tibble(mean = comp(data, lbs_col_name, sample_weights_col_name),
                ci_lower = quantile(ratio, 0.05),
                ci_upper = quantile(ratio, .95)))
}

# Loading and cleaning the data ---------------------------------

# file location for the sort data, edit this path with where you have
# saved the file. You need to merge all the data into one data table and that
# might be easier to do by hand but I wanted make sure I kept all the original
# information so I read in each sheet and then bound the rows together

path <- "Data Deliverable Fall 2019 and 2020 sorts.xlsx"
```

```
sort_2019_2020 <- path %>%
  excel_sheets() %>%
  set_names() %>%
  map_dfr(read_excel, path = path, range = "A2:L33", .id = "sheet") %>%
  clean_names() %>%
  filter(!is.na(sample_number)) %>%
  # cleaning up the names to be more universal, creating a column for
  # total sample weights to be used in calculating the percent of total
  rowwise() %>%
  mutate(sample_weights = sum(c_across(where(is.numeric))))

names(sort_2019_2020) <- c("sheet" , "sample_number", "type", "food_scraps",
"food_no_packaging",

"opened_or_expired_packaged_food_prior_the_date_of_the_sort",
                           "packaging_from_opened_or_expired",
                           "rescuable_unopened_and_unexpired_packaged_food",

"packaging_from_rescuable_food","compostable_paper_products",

"compostable_food_service_products","all_other_material_from_sort",
                           "liquid", "sample_weights")

path <- "Data Deliverable Spring and Fall 2021.xlsx"

sort_2021 <- path %>%
  excel_sheets() %>%
  set_names() %>%
  .[c(1:4)] %>%
  map_dfr(., read_excel, path = path, range = "A1:L31", .id = "sheet") %>%
  # cleaning up the names to be more universal, creating a column for
  # total sample weights to be used in calculating the percent of total
  clean_names() %>%
  rowwise() %>%
  mutate(sample_weights = sum(c_across(where(is.numeric))))

names(sort_2021) <- c("sheet" , "sample_number", "type", "food_scraps",
"food_no_packaging",
                      "opened_or_expired_packaged_food_prior_the_date_of_the_sort",
                      "packaging_from_opened_or_expired",
                      "rescuable_unopened_and_unexpired_packaged_food",
                      "packaging_from_rescuable_food","compostable_paper_products",

"compostable_food_service_products","all_other_material_from_sort",
                      "liquid", "sample_weights")

path <- "Data Deliverable Spring and Fall 2022.xlsx"

sort_2022 <- path %>%
  excel_sheets() %>%
```

```
  set_names() %>%
  .[c(1:4)] %>%
  map_dfr(., read_excel, path = path, range = "A1:L31", .id = "sheet") %>%
  # cleaning up the names to be more universal, creating a column for
  # total sample weights to be used in calculating the percent of total
  clean_names() %>%
  rowwise() %>%
  mutate(sample_weights = sum(c_across(where(is.numeric))))

names(sort_2022) <- c("sheet" , "sample_number", "type", "food_scraps",
"food_no_packaging",
                      "opened_or_expired_packaged_food_prior_the_date_of_the_sort",
                      "packaging_from_opened_or_expired",
                      "rescuable_unopened_and_unexpired_packaged_food",
                      "packaging_from_rescuable_food","compostable_paper_products",

"compostable_food_service_products","all_other_material_from_sort",
                      "liquid", "sample_weights")

sort_data <- bind_rows(sort_2019_2020, sort_2021, sort_2022) %>%
  # filtering out those samples that are greater than 310 and less than
  # 190lbs based on discussion with RRS
  dplyr::filter(sample_weights <= 310, sample_weights >= 190) %>%
  dplyr::mutate(facility = str_extract(sample_number, "Lyon|New Port|Pine
Bend|Newport|Marshall"),
         facility = case_when(facility %in% c("New Port", "Newport") ~ "Newport",
                              facility %in% c("Lyon", "Marshall") ~ "Lyon",
                              TRUE ~ facility),
         region = ifelse(str_detect(sheet, "Metro"),
                         "Metro", "Greater MN"),
         year = case_when(str_detect(sheet, "2019") ~ 2019,
                          str_detect(sheet, "2020") ~ 2020,
                          str_detect(sheet, "21") ~ 2021,
                          str_detect(sheet, "22") ~ 2022),
         sort = case_when(str_detect(sheet, "2019") ~ 1,
                          str_detect(sheet, "2020") ~ 2,
                          str_detect(sheet, "Spring 21") ~ 3,
                          str_detect(sheet, "Fall 21") ~ 4,
                          str_detect(sheet, "Spring 22") ~ 5,
                          str_detect(sheet, "Fall 22") ~ 6),
         edible_food = food_no_packaging +
           opened_or_expired_packaged_food_prior_the_date_of_the_sort +
           rescuable_unopened_and_unexpired_packaged_food,
         inedible_food = food_scraps,
         compostable_paper_and_packaging = compostable_paper_products +
           compostable_food_service_products,
         non_compostable_packaging = packaging_from_opened_or_expired +
           packaging_from_rescuable_food,
         sorted_food_and_compostable_paper_and_packaging = food_scraps +
           food_no_packaging +
           opened_or_expired_packaged_food_prior_the_date_of_the_sort +
```

```
            rescuable_unopened_and_unexpired_packaged_food +
            compostable_paper_products +
            compostable_food_service_products,
          edible_food_inedible_food_liquid_waste = food_scraps +
            food_no_packaging +
            opened_or_expired_packaged_food_prior_the_date_of_the_sort +
            rescuable_unopened_and_unexpired_packaged_food +
            liquid)

sort_data$sample <- seq(1, nrow(sort_data))

# All Material ------------------------------------------------


#transform the data from wide to long by using pivot_longer()
id_vars = c("sheet","sample_number", 'facility', 'region',
            'type', 'sample', 'sort', 'year', 'sample_weights')

data_pivot <- pivot_longer(sort_data,
                           cols = -all_of(id_vars),
                           names_to = "material",
                           values_to = "lbs")

# below are the different cuts of the data so that we can calculate
# confidence intervals for each of the different levels of detail
# Statewide, region by region, and sort by sort.
# These are done by adding additional variables to the group_by statement
statewide <- data_pivot %>%
  group_by(material) %>%
  group_modify(~bootstrap_ci(.x, n = 1000, "lbs","sample_weights"))

region <- data_pivot %>%
  group_by(region, material) %>%
  group_modify(~bootstrap_ci(.x, n = 1000, "lbs","sample_weights"))

sorts <- data_pivot %>%
  group_by(sort, material) %>%
  group_modify(~bootstrap_ci(.x, n = 1000, "lbs","sample_weights"))

# Writing the data to excel -----------------------------------

tables <- list("Statewide Composition" = statewide,
               "Material Composition by Region" = region,
               "Material Composition by Sort" = sorts)

# you will need to specify the file path for your finished file
all_material_table_filepath = "All_Material_Breakdown.xlsx"
write.xlsx(tables,
           file = all_material_table_filepath)
```

```
# Sorted Material Only ----------------------------------------


# creating a subset of the data that is only representing the sorted
# portion of the material (excluding the "All Other Material" category)
# new sample weight is only the material sorted
data_food_only <- sort_data %>%
  mutate(sample_weight_food_only = food_scraps + food_no_packaging+
           opened_or_expired_packaged_food_prior_the_date_of_the_sort+
           packaging_from_opened_or_expired+
           rescuable_unopened_and_unexpired_packaged_food+
           packaging_from_rescuable_food+compostable_paper_products +
           compostable_food_service_products+liquid) %>%
  select(-sample_weights)

id_vars = c("sheet", "sample_number", 'facility', 'region',
            'type', 'sample', 'sort', 'year', 'sample_weight_food_only')

data_pivot_food_only <- pivot_longer(data_food_only,
                                     cols = -all_of(id_vars),
                                     names_to = "material",
                                     values_to = "lbs") %>%
  filter(material != 'all_other_material_from_sort')

statewide_food_only <- data_pivot_food_only %>%
  group_by(material) %>%
  group_modify(~bootstrap_ci(.x, n = 1000, "lbs", "sample_weight_food_only"))

region_food_only <- data_pivot_food_only %>%
  group_by(region, material) %>%
  group_modify(~bootstrap_ci(.x, n = 1000, "lbs", "sample_weight_food_only"))

sorts_food_only <- data_pivot_food_only %>%
  group_by(sort, material) %>%
  group_modify(~bootstrap_ci(.x, n = 1000, "lbs", "sample_weight_food_only"))


# Writing the Food Only to Excel ------------------------------


tables_food_only <- list("Statewide Composition" = statewide_food_only,
                "Material Composition by Region" = region_food_only,
                "Material Composition by Sort" = sorts_food_only)

# you will need to specify the file path for your finished file
food_only_table_filepath = "Food_Only_Breakdown.xlsx"

write.xlsx(tables_food_only,
           file = food_only_table_filepath)
```