Seattle Public Utilities

2016

Organics Stream

Composition Study:

Final Report

prepared by

Cascadia Consulting Group

May 2018

Table of Contents

Table of Tables

Table of Figures

1 Overview

1.1 Introduction and Background

Seattle Public Utilities (SPU) has conducted composition studies since 1988 to better understand the types and quantities of municipal solid waste (MSW) and recyclable materials collected, to assess Seattle's recycling potential, and to aid in the evaluation of existing programs. These studies have analyzed the residential, commercial, and self-haul waste streams and the residential recycling stream at intervals of about four years.

In 2012, Seattle conducted the first in-depth evaluation of the city's organics stream. The objective of this study was two-fold. The first objective was to evaluate how accurately the chosen sampling methodology could depict the composition of the organics stream over a year, in general and when compared to previous composition estimate techniques. The second objective was to determine the composition of Seattle's combined organics stream that the City's two contracted haulers collect for composting in plastic carts.

Until 2012, SPU used a statistical regression technique to estimate the portion of **food waste** in the collected organics. After the 2012 study, SPU determined that the sampling methodology used for the 2012 study was preferable to depict organics composition over a year. Additionally, haulers, organics processing facilities, city staff, and SPU staff are increasingly interested in details of the composition of the material placed in the organics containers, including the amount and type of contaminants. The methodology used for the 2012 study (and, subsequently, for the 2016 study) provided these composition details.

The objective of the 2016 organics composition study was to update the 2012 organics characterization data for single-family residential, multifamily residential, and commercial streams that are collected in carts by the City's two contracted haulers. This data will help the City understand differences among substreams so that targeted organics diversion programs can be designed and implemented or improved.

This document details the sample collection and sorting methodology for the 2016 study. This study includes only material collected under Seattle's contracts for organics collection services. Private non-contracted haulers collect a significant amount of material from commercial customers, and that material is not included in this study.

This report presents the results of the 2016 organics composition study in five sections. Section 1 briefly introduces the project and the study methodology; Section 2 summarizes the 2016 sampling methodology; Section 3 compares key results from the 2016 study to results from the 2012 study; Section 4 presents detailed composition results by substream. Appendices follow the main body of the report and contain definitions of organics components, the complete sampling methodology, comments on sampling events, organics composition calculations, and copies of field forms.

1.2 Seattle's Organics

For any specific geographic area, the organics stream is composed of various substreams. A "substream" is determined by the particular generation, collection, or composition characteristics that make it a unique portion of the total organics stream. For this study, the three substreams are defined as follows:

- ***Single-family residential:*** Organic materials that are generated by residential customers with cart organics collection service. These are customers who typically also have their garbage collected in carts. They are primarily residents of single-family detached homes, duplexes, triplexes, and four-plex buildings.
- ***Multifamily residential:*** Organic materials that are generated by residential customers with cart organics collection service and dumpster collection for garbage. These customers typically reside in apartment buildings with five or more units.
- ***Commercial:*** Organic materials that are generated by businesses and institutions with cart organics collection service.

These three organics substreams are collected by two contracted haulers, each serving two of four distinct "zones" (Figure 1) in the City of Seattle. One of the contracted haulers handles Zones 1 and 4; the other hauler handles Zones 2 and 3. The contents of the carts are collected and transported to either one of the two City-owned transfer stations or to Eastmont transfer station, after which they are transported to Cedar Grove for composting. All organics that were placed in plastic carts, including carts collected both at the curb and from on-site locations (such as in an enclosure or parking garage), were eligible for sampling. Organics placed in metal containers were excluded from the study.[1]

This study did not sample any organics collected by private organics composting firms that are not under contract with Seattle Public Utilities. Also excluded from this study are organics that are self-hauled.

[1] There are about 48 commercial customers who receive dumpster service for organics. Those were excluded from sampling due to accessibility issues for the field crew. The field methodology involved dumping container contents onto a tarp and sampling at a central location. One-cubic-yard and larger dumpsters could not be easily sampled in the field.

Figure 1. Seattle's Collection Zones

1.3 Study Methodology

This organics stream composition study consisted of four distinct steps: develop a sampling plan, collect organics samples, sort samples, and analyze the data and prepare the report. Each of these steps is outlined in detail below.

Step 1: Develop Sampling Plan

A total of 600 organics samples were allocated among the three substreams (single-family residential, multifamily residential, and commercial) and four seasons.

For the single-family residential substream:

Single-family residential samples were collected at the South Disposal Station from incoming trucks carrying pure loads (organics collected from single-family residences that do not contain organics cart contents from multifamily or commercial properties). A total of 200 single-family residential samples were collected over four sampling seasons (50 samples per season). The single-family samples were evenly distributed across the four collection zones.

For the multifamily residential and the commercial substreams:

Multifamily residential and commercial samples were collected directly from organics carts set out for pick-up on their regularly scheduled collection day. A total of 200 multifamily samples and 200 commercial samples were characterized. Samples were distributed equally across collection zones and seasons.

The dates for sampling events for all substreams were randomly selected to assure a representative distribution of the days of the week and weeks of the month.

Refer to Appendix B for the full Sampling Methodology.

Step 2: Collect Organics Samples

Organics samples for the 2016 study were collected using the following methodologies.

For single-family samples:

- Vehicles arriving at the South Disposal Station were randomly selected for each sampling day.
- For each selected vehicle, the collection crew:

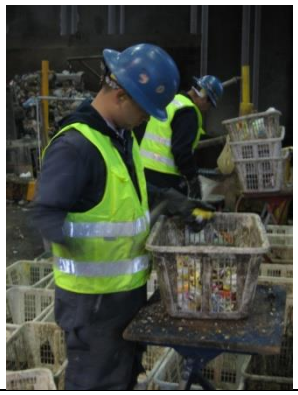
1. Coordinated with the loader operator at the facility to scoop a 200-250 pound sample of organics from each selected vehicle as it dumped its load on the ground.
2. Placed each sample on a clean tarp and labeled it with a sample placard for sorting.

For multifamily and commercial samples:

- For the selected zone for a particular sampling day, lists of all of the multifamily and commercial accounts were obtained from the hauler that serviced that zone. The lists of accounts were randomly ordered and the top accounts were selected for sampling until the target for that day, plus contingencies, had been reached.
- The selected accounts were mapped and routed for the sample collection crews.
- Following the route of selected accounts, the collection crew:
    1. Emptied the entire contents from selected carts on a tarp, sealed the tarps, and labeled them with sample placards.
    2. Delivered collected samples to the South Transfer Station for sorting.

Refer to Appendix B for the full Sampling Methodology, Appendix C for Sampling Event Progress Reports, and Appendix E for sample Field Forms.

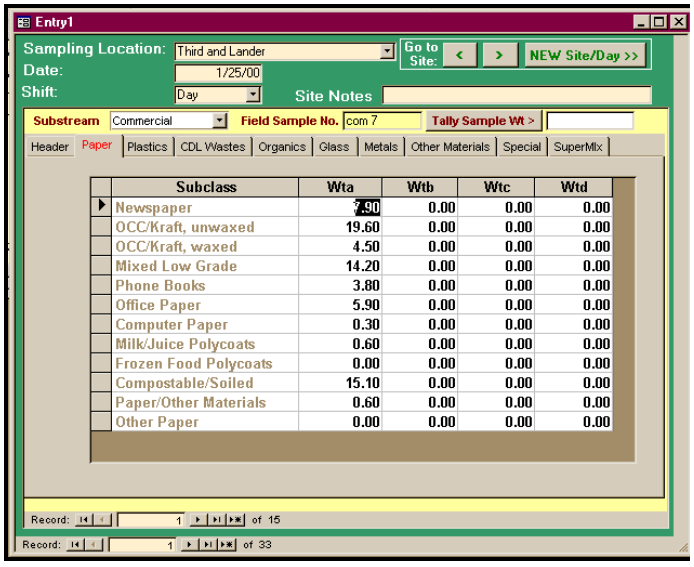
Step 3: Sort Samples



- Following sample collection, field crew members hand-sorted samples at the South Transfer Station.
- For this study, 604 samples were sorted into 25 distinct material components. Refer to Appendix A for component definitions.
- Field crew members weighed the sorted components of each sample and recorded the weights. At the conclusion of each sorting day, the field crew manager conducted a quality control review of the recorded data. Refer to Appendix E for field forms.

Step 4: Analyze Data and Prepare Report

- Following each sampling event, all sort data was entered into a customized database.
- Entered data was re-checked against the paper forms to eliminate data entry errors.
- At the conclusion of the study organics composition estimates were calculated. Refer to Appendix D for a description of the calculation methodology.



Subclass	Wta	Wtb	Wtc	Wtd
Newspaper	7.90	0.00	0.00	0.00
OCC/Kraft, unwaxed	19.60	0.00	0.00	0.00
OCC/Kraft, waxed	4.50	0.00	0.00	0.00
Mixed Low Grade	14.20	0.00	0.00	0.00
Phone Books	3.80	0.00	0.00	0.00
Office Paper	5.90	0.00	0.00	0.00
Computer Paper	0.30	0.00	0.00	0.00
Milk/Juice Polycoats	0.60	0.00	0.00	0.00
Frozen Food Polycoats	0.00	0.00	0.00	0.00
Compostable/Soiled	15.10	0.00	0.00	0.00
Paper/Other Materials	0.60	0.00	0.00	0.00
Other Paper	0.00	0.00	0.00	0.00

2 Summary of 2016 Sampling Results

Table 1 shows the compositions of material components greater than 5%, by weight, overall and by substream. For all substreams, *compostable paper, vegetative food,* and *grass/leaves* were among the most prevalent components in the organics stream. *Grass/leaves* are a significantly larger portion of single-family organics (74% of the stream) than multifamily and commercial organics (19% and 5% of the stream, respectively).

Only material types that are more than 5 percent by weight of the stream are shown in the table below. No contaminant material components (such as *polycoated paper, glass, pet waste,* or *disposable diapers*) made up more than 5 percent of the material in any substream.

Table 1. Summary of Composition Estimates by Substream

	Comp. Paper	Veg. Food	Other Food	Grass/ Leaves
Substream				
Single-family	5.8%	8.6%		73.6%
Multifamily	10.7%	36.3%	20.3%	18.8%
Commercial	11.7%	33.6%	38.8%	5.3%
Overall	**8.5%**	**20.3%**	**19.3%**	**42.6%**

2.1 Overall Organics

Figure 2 below summarizes composition by material class for Seattle's collected organics overall, including single-family, multifamily, and commercial organics collected by the city's two contracted haulers. As shown, **yard waste** makes up the largest portion of the overall organics stream at over 45 percent of the total stream. **Food waste** is also a significant portion of the stream, at 41 percent, followed by compostable paper at just over 9 percent. Almost 3 percent of the stream is made up of **contaminants**.

Figure 2. 2016 Organics Composition by Broad Material Class – Overall

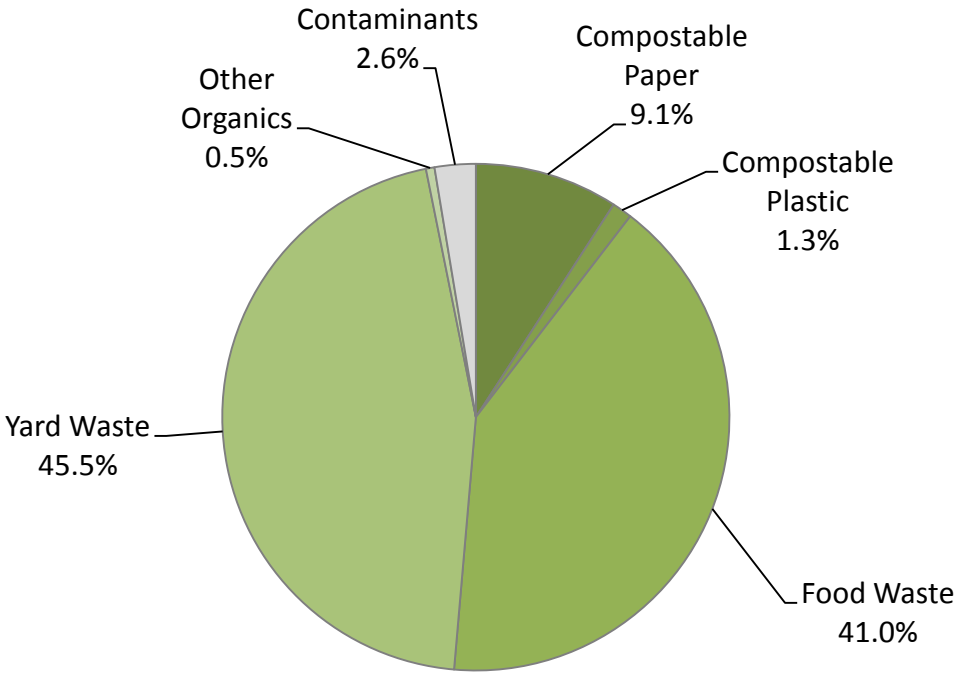


Table 2 below lists the top five materials in the overall organics stream, by weight. When summed, they accounted for 93.5% of the stream. *Grass/leaves* was the most prevalent material component in the stream (42.6%) followed by *vegetative food* (20.3%) and *other food* (19.3%).

Table 2. 2016 Top Five Organics Material Components – Overall

Material	Est. Percent	Cumulative Percent	Est. Tons
Grass/Leaves	42.6%	42.6%	67,146
Vegetative Food	20.3%	62.8%	31,965
Other Food	19.3%	82.1%	30,427
Compostable Paper	8.5%	90.6%	13,380
Prunings	2.9%	93.5%	4,584
Total	***93.5%***		***147,502***

Table 3, below, presents the detailed composition of the overall organics stream.

Table 3. 2016 Detailed Organics Material Composition – Overall

Material	Est. Tons	Est. Percent	Low	High
Compostable Paper	**14,431**	**9.1%**		
Compostable Paper	13,380	8.5%	7.6%	9.3%
Mixed Recyclable Paper	1,051	0.7%	0.5%	0.8%
Compostable Plastic	**2,011**	**1.3%**		
Compostable Plastic	2,011	1.3%	1.1%	1.4%
Organics	**137,193**	**87.0%**		
Vegetative Food	31,965	20.3%	18.4%	22.1%
Vegetative Food, Packaged	299	0.2%	0.1%	0.3%
Other Food	30,427	19.3%	17.1%	21.5%
Other Food, Packaged	1,910	1.2%	0.6%	1.8%
Grass/Leaves	67,146	42.6%	41.0%	44.1%
Prunings	4,584	2.9%	2.3%	3.5%
Other Compostable Organics	862	0.5%	0.4%	0.7%
Contaminants	**4,122**	**2.6%**		
Recyclable Polycoated Paper	465	0.3%	0.2%	0.4%
Other Paper	592	0.4%	0.2%	0.5%
Non-compostable Plastic Film	1,029	0.7%	0.5%	0.8%
Non-compostable Plastic Containers	387	0.2%	0.2%	0.3%
Other Plastic	221	0.1%	0.1%	0.2%
Recyclable Glass	239	0.2%	0.1%	0.2%
Recyclable Metal	164	0.1%	0.1%	0.1%
Pet Waste	181	0.1%	0.0%	0.2%
Disposable Diapers	68	0.0%	0.0%	0.1%
Hazardous	45	0.0%	0.0%	0.1%
Other Materials	732	0.5%	0.4%	0.6%
Total	**157,757**	**100.0%**		
Sample Count	*604*			

3 Comparison of Results to Previous Studies

Both the amount and composition of single-family residential organics varies by month, largely due to fluctuations in yard waste. Table 4 compares single-family residential organics composition in 2012 (by sampling month) to the 2016 composition (for the year). Table 5 is a similar comparison of multifamily residential organics composition (by sampling month) to the 2016 composition (for the year).[2] While the compositions by month cannot be directly compared to the weighted annual average composition, for

[2] Organics samples in 2016 were collected in April, July, October, and December.

either single-family or multifamily residents, the 2016 organics composition falls within the range of previously observed values for single-family in 2012 and multifamily in 2013 with a few exceptions:

- For single-family residential organics, the percentage of **other organics** in 2016 (0.8%) is on the high end of what was observed in 2012, which may indicate that the composition of Other Organics in the stream has increased overall.
- For multifamily residential organics, the percentage of **compostable paper** (11.8%) and **compostable plastic** (2.6%) in 2016 exceeds what was observed in any month in 2013, which may indicate that the relative amount of these two material classes in multifamily organics has increased.

Table 4. Changes in Percents of Single-family Residential Organics: 2012 vs. 2016

	March 2012	May 2012	August 2012	September 2012	November 2012	December 2012	2016
Yard Waste	27.4%	88.0%	66.9%	62.9%	80.8%	70.9%	78.6%
Food Waste	57.1%	8.9%	24.1%	30.0%	15.4%	21.7%	12.7%
Compostable Paper	11.5%	1.9%	4.2%	6.0%	2.6%	3.9%	6.2%
Compostable Plastic	1.1%	0.1%	0.5%	0.5%	0.1%	0.4%	0.8%
Other Organics	0.8%	0.5%	0.0%	0.0%	0.3%	0.6%	0.8%
Contaminants	2.2%	0.5%	4.3%	0.7%	0.8%	2.5%	0.9%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100.0%**

Table 5. Changes in Percents of Multifamily Residential Organics: 2013 vs. 2016

	June 2013	October 2013	February 2014	2016
Food Waste	49.2%	41.5%	62.0%	59.4%
Yard Waste	34.9%	37.2%	18.6%	20.3%
Compostable Paper	8.7%	9.0%	10.8%	11.8%
Compostable Plastic	1.9%	1.7%	2.1%	2.6%
Other Organics	0.6%	0.2%	0.2%	0.2%
Contaminants	4.6%	10.4%	6.3%	5.7%
Total	100.0%	100.0%	100.0%	100.0%

Table 6 compares the per-unit amount of organics by zone and season collected from multifamily residents in 2013 and 2016. Overall, multifamily residents set out 2.1 pounds per unit of organics for collection in 2013 and 4.1 pounds per unit—nearly doubling—in 2016. The pounds per unit collected increased in every zone from 2013 to 2016, with the amount doubling or more in Zones 1 and 4. By season, the largest observed increases from 2013 to 2016 amounts were in spring and summer.

Table 6. Pounds per Unit by Zone and Season: 2013 vs. 2016

	2013	2016
Zone		
Zone 1	2.50	6.54
Zone 2	1.55	2.88
Zone 3	2.02	2.37
Zone 4	2.69	5.42
Season		
Spring	2.88	4.53
Summer	1.69	5.27
Fall	N/A	3.18
Winter	2.10	3.49
Overall	**2.14**	**4.10**

4 Composition Results

4.1 Overview

For this study, Cascadia collected and sorted over 600 organics samples averaging 116 pounds. Table 7 summarizes the number of samples collected and average sample weights by substream and zone. The average sample weights for single-family residential organics samples were 227 to 245 pounds (collected from incoming trucks at the transfer station), while average samples weights for multifamily and commercial organics ranged from 28 to 86 pounds (collected directly at the multifamily property or business).

Table 7. Sampling Data by Substream

Substream	Zone	Sample Count	Average Sample Weight
Single-family			
	1	53	240.8
	2	55	244.6
	3	38	235.9
	4	51	227.1
Multifamily			
	1	44	28.4
	2	62	53.0
	3	54	53.4
	4	49	51.7
Commercial			
	1	47	64.2
	2	38	44.9
	3	63	85.8
	4	50	62.4
Overall		**604**	**115.8**

4.2 Residential Organics Composition

4.2.1 Single-Family Residential Substream

Figure 3 below summarizes single-family organics composition by material class. As shown, **yard waste** makes up the largest portion of the multifamily organics stream at almost 80 percent of the total stream. **Food waste** is also a significant portion of the stream, at almost 13 percent of the stream's composition. Less than 1 percent of the stream is made up of **contaminants**.

Figure 3. 2016 Organics Composition by Broad Material Class – Single-family

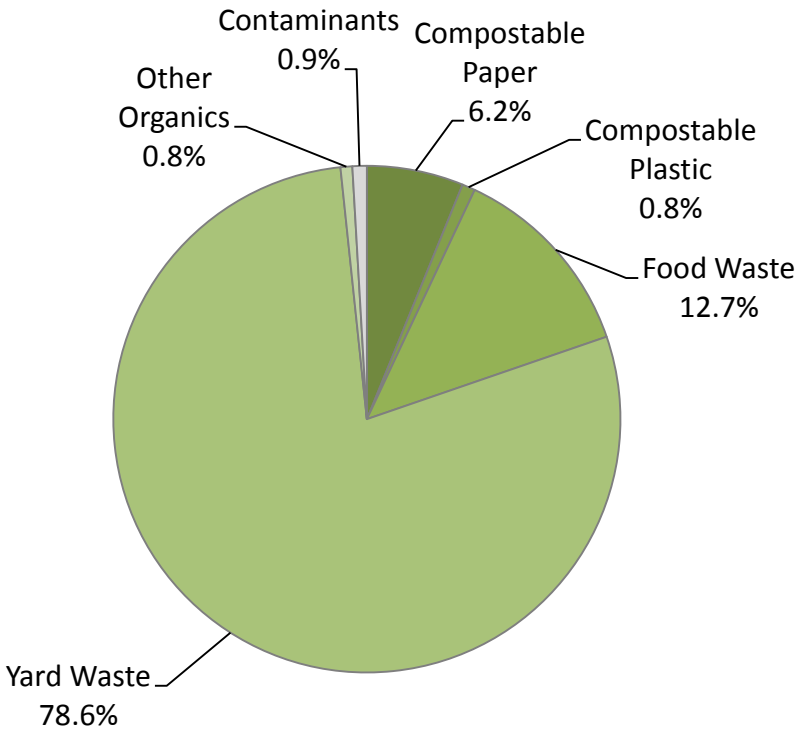


Table 8 below lists the top five materials in the single-family organics stream, by weight. When summed, they accounted for nearly 97 percent of the stream. *Grass/leaves* was the most prevalent material component in the stream (73.6%) followed by *vegetative food* (8.6%) and *compostable paper* (5.8%).

Table 8. 2016 Top Five Organics Material Components – Single-family

Material	Est. Percent	Cumulative Percent	Est. Tons
Grass/Leaves	73.6%	73.6%	62,384
Vegetative Food	8.6%	82.2%	7,275
Compostable Paper	5.8%	88.0%	4,909
Prunings	5.0%	93.0%	4,225
Other Food	3.9%	96.9%	3,299
Total	***96.9%***		***82,091***

Table 9, below, presents the detailed composition of the single-family organics stream.

Table 9. 2016 Detailed Organics Material Composition – Single-family

Material	Est. Tons	Est. Percent	Low	High
Compostable Paper	**5,224**	**6.2%**		
Compostable Paper	4,909	5.8%	5.3%	6.2%
Mixed Recyclable Paper	314	0.4%	0.3%	0.5%
Compostable Plastic	**701**	**0.8%**		
Compostable Plastic	701	0.8%	0.7%	0.9%
Organics	**78,033**	**92.1%**		
Vegetative Food	7,275	8.6%	7.8%	9.4%
Vegetative Food, Packaged	55	0.1%	0.0%	0.1%
Other Food	3,299	3.9%	3.2%	4.6%
Other Food, Packaged	159	0.2%	0.1%	0.3%
Grass/Leaves	62,384	73.6%	71.7%	75.5%
Prunings	4,225	5.0%	3.8%	6.1%
Other Compostable Organics	636	0.8%	0.6%	0.9%
Contaminants	**775**	**0.9%**		
Recyclable Polycoated Paper	94	0.1%	0.1%	0.1%
Other Paper	111	0.1%	0.1%	0.2%
Non-compostable Plastic Film	120	0.1%	0.1%	0.2%
Non-compostable Plastic Containers	68	0.1%	0.1%	0.1%
Other Plastic	23	0.0%	0.0%	0.0%
Recyclable Glass	22	0.0%	0.0%	0.0%
Recyclable Metal	20	0.0%	0.0%	0.0%
Pet Waste	30	0.0%	0.0%	0.1%
Disposable Diapers	33	0.0%	0.0%	0.1%
Hazardous	7	0.0%	0.0%	0.0%
Other Materials	248	0.3%	0.2%	0.4%
Total	**84,733**	**100.0%**		
Sample Count	*197*			

4.2.2 Multifamily Residential Substream

Figure 4 below summarizes multifamily organics composition by material class. As shown, **food waste** makes up the largest portion of the multifamily organics stream at almost 60 percent of the total stream. **Yard waste** is also a significant portion of the stream, at over 20 percent of the stream's composition, followed by compostable paper at almost 12 percent. Almost 6 percent of the stream is made up of **contaminants**.

Figure 4. 2016 Organics Composition by Broad Material Class – Multifamily

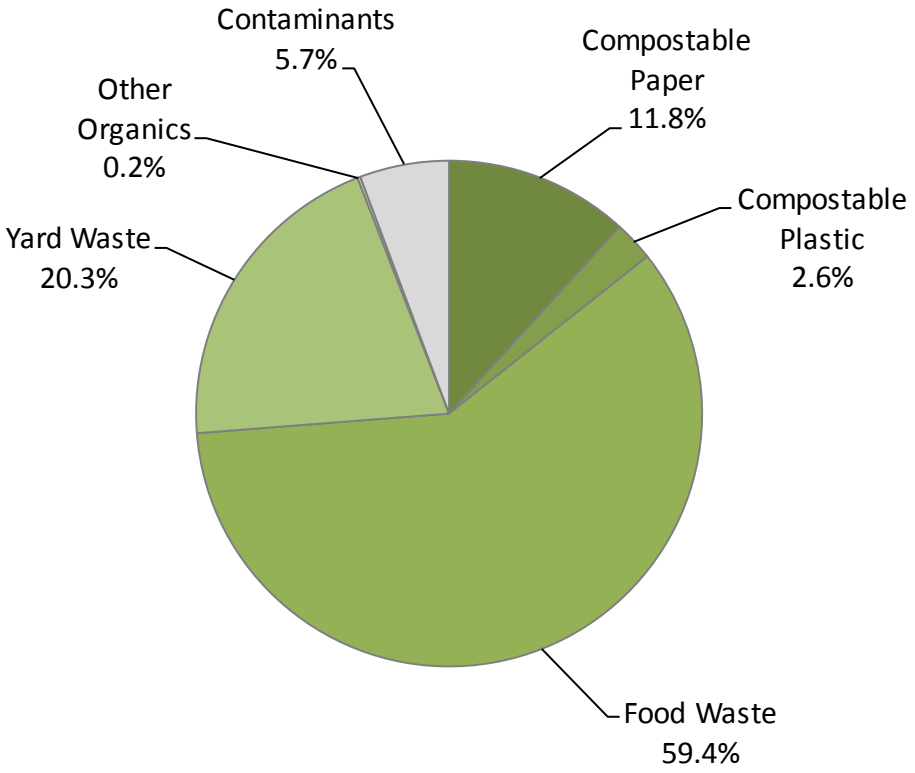


Table 10 below lists the top five materials in the multifamily organics stream, by weight. When summed, they accounted for nearly 87 percent of the stream. *Vegetative food* was the most prevalent material component in the stream (36.3%) followed by *other food* (20.3%), *grass/leaves* (18.8%), and *compostable paper* (10.7%).

Table 10. 2016 Top Five Organics Material Components – Multifamily

Material	Est. Percent	Cumulative Percent	Est. Tons
Vegetative Food	36.3%	36.3%	2,408
Other Food	20.3%	56.6%	1,348
Grass/Leaves	18.8%	75.4%	1,249
Compostable Paper	10.7%	86.1%	710
Compostable Plastic	2.6%	88.6%	170
Total	***88.6%***		***5,885***

Table 11, below, presents the detailed composition of the multifamily organics stream.

Table 11. 2016 Detailed Organics Material Composition – Multifamily

Material	Est. Tons	Est. Percent	Low	High
Compostable Paper	**782**	**11.8%**		
Compostable Paper	710	10.7%	9.5%	11.9%
Mixed Recyclable Paper	71	1.1%	0.8%	1.4%
Compostable Plastic	**170**	**2.6%**		
Compostable Plastic	170	2.6%	2.2%	2.9%
Organics	**5,310**	**80.0%**		
Vegetative Food	2,408	36.3%	33.3%	39.3%
Vegetative Food, Packaged	43	0.6%	0.4%	0.9%
Other Food	1,348	20.3%	17.0%	23.6%
Other Food, Packaged	148	2.2%	1.3%	3.2%
Grass/Leaves	1,249	18.8%	14.3%	23.4%
Prunings	102	1.5%	0.3%	2.8%
Other Compostable Organics	12	0.2%	0.1%	0.3%
Contaminants	**379**	**5.7%**		
Recyclable Polycoated Paper	22	0.3%	0.2%	0.5%
Other Paper	17	0.3%	0.2%	0.3%
Non-compostable Plastic Film	98	1.5%	0.8%	2.1%
Non-compostable Plastic Containers	36	0.5%	0.4%	0.7%
Other Plastic	17	0.2%	0.1%	0.4%
Recyclable Glass	35	0.5%	0.3%	0.8%
Recyclable Metal	15	0.2%	0.1%	0.3%
Pet Waste	62	0.9%	0.2%	1.6%
Disposable Diapers	23	0.3%	0.1%	0.6%
Hazardous	3	0.1%	0.0%	0.1%
Other Materials	52	0.8%	0.4%	1.1%
Total	**6,641**	**100.0%**		
Sample Count	*209*			

4.2.2.1 Multifamily Organics Metrics

To help the city monitor progress of the multifamily substream towards greater diversion of organics, this section presents data that normalize diversion on a per unit basis. Table 12 summarizes the per-unit amount of food and contaminants in the multifamily organics stream by zone and season. Multifamily residents set out the least food for collection in Zone 3 (0.78 pounds of food per unit) and the most food in Zone 1 (1.65 pounds of food per unit). The amount of food set out for collection did not vary by season.

Contaminants per unit similarly varied by zone but did not vary significantly by season. Zone 4 multifamily residents set out the most contaminant material (0.24 pounds per unit), while Zone 3 residents set out the least contaminant material (0.07 pounds per unit).

Table 12. Average Pounds per Multifamily Unit by Zone and Season

	Pounds of Food Per Unit Per Sample	Pounds of Contaminants Per Unit Per Sample
Zone		
1	1.65	0.11
2	1.13	0.14
3	0.78	0.07
4	1.21	0.24
Season		
Spring	1.01	0.11
Summer	1.11	0.12
Fall	0.99	0.13
Winter	1.10	0.15

4.3 Commercial Organics Composition

Figure 5 below summarizes commercial organics composition by material class. As shown, **food waste** makes up the largest portion of the multifamily organics stream at over 75 percent of the total stream. **Compostable paper** is also a significant portion of the stream, at almost 13 percent of the stream's composition. Over 4 percent of the stream is made up of **contaminants**.

Figure 5. 2016 Organics Composition by Broad Material Class – Commercial

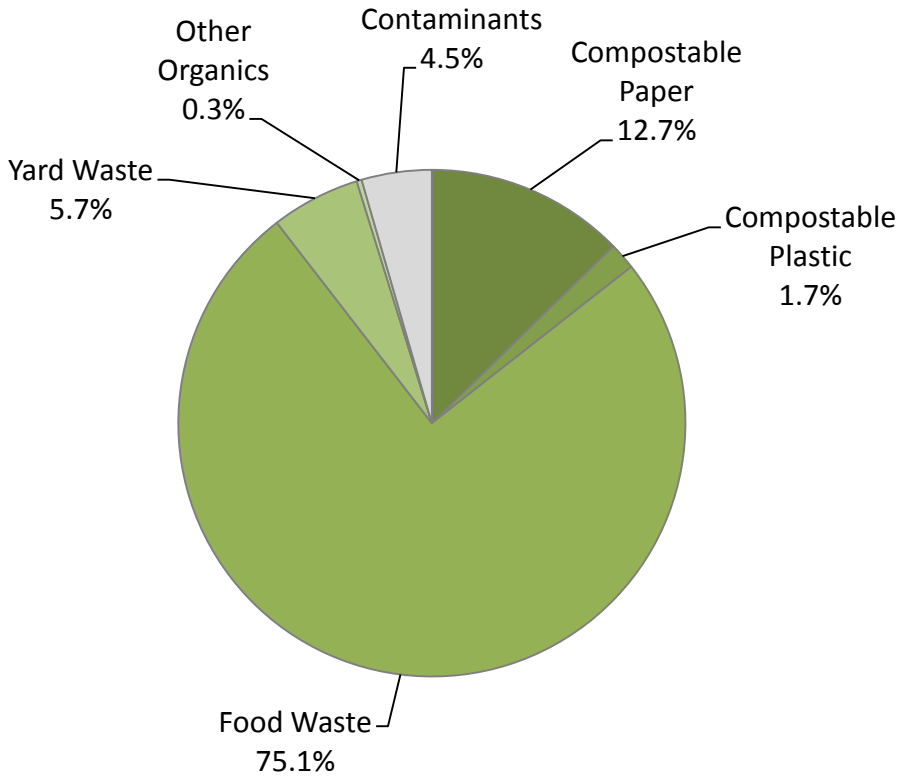


Table 13 below lists the top five materials in the commercial organics stream, by weight. When summed, they accounted for nearly 92 percent of the stream. *Other food* was the most prevalent material component in the stream (38.8%) followed by *vegetative food* (33.6%), and *compostable paper* (11.7%).

Table 13. 2016 Top Five Organics Material Components – Commercial

Material	Est. Percent	Cumulative Percent	Est. Tons
Other Food	38.8%	38.8%	25,781
Vegetative Food	33.6%	72.4%	22,282
Compostable Paper	11.7%	84.1%	7,760
Grass/Leaves	5.3%	89.4%	3,513
Other Food, Packaged	2.4%	91.8%	1,602
Total	***91.8%***		***60,939***

Table 14, below, presents the detailed composition of the commercial organics stream.

Table 14. 2016 Detailed Organics Material Composition – Commercial

Material	Est. Tons	Est. Percent	Low	High
Compostable Paper	**8,425**	**12.7%**		
Compostable Paper	7,760	11.7%	9.7%	13.7%
Mixed Recyclable Paper	665	1.0%	0.7%	1.3%
Compostable Plastic	**1,139**	**1.7%**		
Compostable Plastic	1,139	1.7%	1.4%	2.0%
Organics	**53,849**	**81.1%**		
Vegetative Food	22,282	33.6%	29.2%	37.9%
Vegetative Food, Packaged	201	0.3%	0.1%	0.5%
Other Food	25,781	38.8%	33.7%	44.0%
Other Food, Packaged	1,602	2.4%	1.0%	3.9%
Grass/Leaves	3,513	5.3%	2.5%	8.1%
Prunings	257	0.4%	0.1%	0.7%
Other Compostable Organics	213	0.3%	0.1%	0.6%
Contaminants	**2,968**	**4.5%**		
Recyclable Polycoated Paper	349	0.5%	0.3%	0.8%
Other Paper	464	0.7%	0.3%	1.1%
Non-compostable Plastic Film	812	1.2%	0.9%	1.5%
Non-compostable Plastic Containers	283	0.4%	0.3%	0.6%
Other Plastic	182	0.3%	0.2%	0.4%
Recyclable Glass	182	0.3%	0.1%	0.4%
Recyclable Metal	129	0.2%	0.1%	0.3%
Pet Waste	89	0.1%	0.0%	0.3%
Disposable Diapers	12	0.0%	0.0%	0.0%
Hazardous	35	0.1%	0.0%	0.1%
Other Materials	432	0.7%	0.5%	0.9%
Total	**66,382**	**100.0%**		
Sample Count	*198*			

5 Analysis of Single-family Composition Data

This section discusses whether the study methodology produced results that are representative of a full year's worth of organics collection.

An analysis by SPU and Cascadia of 2012 study data concluded that the results were "too inconsistent to be representative of Seattle's single-family organics stream for a full year." Sources of inconsistency included 1) the variation in amounts of organics generated due to seasonal fluctuations in yard waste; 2) monthly and weekly variation in weather patterns that affect yard work and the amounts of organics set out for collection; and 3) unexpectedly variable amounts of food waste.

Analyses of the results for the single-family substream in the current study conclude that they are representative of Seattle's single-family organics stream for a full year. This conclusion is based on three analyses: an analysis of temperature and precipitation prior to sampling, a comparison of food waste capture rates by season, and a sample size analysis.

5.1 Representativeness of Temperature and Precipitation Preceding Sampling

Given that temperature and precipitation impact plant growth and gardening activities, we would expect weather to impact the amount of yard waste placed in residential organics bins. A summary of temperature and precipitation conditions for the month of and the week prior to each sampling event is shown in Table 15. Both the average temperature and precipitation for the week prior to each sampling event are within one standard deviation of the mean for the month. In other words, this analysis indicates that weather leading up to sampling, in terms of temperature and precipitation, was representative of the month that sampling took place.

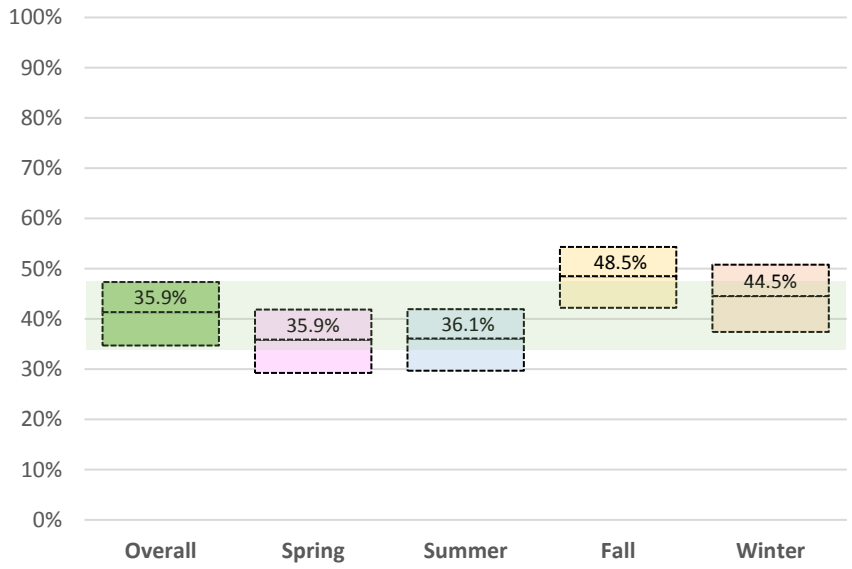
Table 15. Temperature and Precipitation Leading up to Sampling

	Temperature			Precipitation		
Sampling Dates	**Monthly Daily Avg. Temp**	**Prior Week Daily Avg. Temp**	**Within 1 St. Dev. of mean?**	**Monthly Daily Avg. Precipitation (inches)**	**Prior Week Avg. Daily Precipitation (inches)**	**Within 1 St. Dev. of mean?**
4/18/2016	56.5	54.3	yes	0.04	0.10	yes
4/19/2016	56.5	57.8	yes	0.04	0.04	yes
7/19/2016	66.9	66.2	yes	0.02	0.00	yes
7/20/2016	66.9	66.7	yes	0.02	0.00	yes
10/17/2016	55.1	54.4	yes	0.35	0.74	yes
10/18/2016	55.1	54.8	yes	0.35	0.76	yes
12/13/2016	38.3	36.7	yes	0.13	0.13	yes
12/14/2016	38.3	36.9	yes	0.13	0.13	yes

5.2 Capture Rate Comparison

If the organics composition data is representative of the year, we would anticipate that the food waste capture rate is relatively similar across seasons. In other words, single-family residents should capture a similar percentage of their food in organics bins across the seasons, regardless of the amount of total material (including yard waste) they place in their organics bins. Figure 6 presents the food capture rate for each season. The capture rates range from almost 36% in the spring to a high of almost 49% in the fall. However, when considering confidence intervals, at least three of the seasons (spring, summer, and fall) are quite close, nearing 40% at the high end of the confidence interval for spring and summer and the low end for winter, with the low end of the confidence interval for fall at slightly more than 45%. Further, portions of the range for all four seasons fall within the overall annual composition confidence interval band.

Figure 6. Comparison of Food Capture Rates, by Season
(Mean Composition Percentages with Confidence Intervals)



5.3 Sample Size Analysis

The sample size analysis calculated the minimum number of samples required, given seasonal variance in the weight of residential organics set out for collection, to obtain representative data. The methodology for this analysis is provided in more detail in Appendix D Organics Composition Calculations. The results of this analysis appear below in Table 16.

Table 16. Calculated Sample Sizes by Season

Season	Month	Residential Curbside Single-family Collection (lbs)	Mean by season	Std. Dev. by season	Coefficient of Variation (Std. Dev./Mean)	Calculated minimum # of samples	Actual # of Samples
Winter	Dec	10,069,682	9,702,528.4	259,634.6	2.7%	1	48
	Jan	9,515,247					
	Feb	9,522,656					
Spring	Mar	14,363,552	16,963,819.7	1,842,419.3	10.9%	18	50
	Apr	18,120,007					
	May	18,407,900					
Summer	Jun	16,214,720	14,479,814.9	1,248,157.0	8.6%	11	47
	Jul	13,894,180					
	Aug	13,330,544					
Fall	Sep	12,847,846	15,342,751.9	2,768,094.6	18.0%	50	52
	Oct	13,977,715					
	Nov	19,202,695					

As shown in Table 16, the minimum sample size increases with the coefficient of variation, a measure of the variability in the weight of the residential curbside collection in each season. The calculated minimum sample size for each study season in 2016 ranged from 1 to 50. Cascadia collected 47 to 52 samples each season, meeting or exceeding the minimum sample size needed in each season. These results suggest that the sample size (approximately 50 samples per season) used in the 2016 study is adequate to obtain representative data (with a margin of error of 5%) for each season of the study.

Appendix A **Organics Components**

Organics samples were sorted by hand into 25 material components. The list below is organized by compostable, questionable, and non-compostable materials within the broad categories of paper, plastic, organics, and other. The sorting crewmembers utilized this list in the field to guide the sorting process.

	Class	Component Category	Definition
Paper	Compostable	1 Universal Compostable Paper	Cedar Grove-labeled cups and other clearly compostable paper, such as pizza boxes, paper towels, napkins, egg and berry cartons, shredded paper, uncoated paper plates, uncoated paper bags, coffee filters, drink carriers, coffee sleeves, and take-out paper bags.
		2 Mixed Recyclable Paper	Office paper, newspaper, boxboard, and other recyclable papers not listed in other categories.
		3 Compostable Paper Currently Accepted from Commercial Accounts[3]	BPI-labeled paper clamshells, waxed cups, and waxed cardboard. Though approved compostable, SPU does not currently encourage their discard in residential organics service.
	Questionable	*4* Potentially Compostable Paper[4]	Bakery boxes, deli sheets, plates, bowls, wax-coated portion cups, non-BPI labeled clamshells, food trays, hot cups, deli containers, paper or bagasse meat trays. This category also includes items that are marked compostable or biodegradable, but are not Cedar Grove-approved. Examples include compostable-labeled bagasse or coffee cups that are not Cedar Grove-approved.
	Non-compostable	5 Polycoated Paper	Milk cartons, juice cartons, and ice cream cartons; Starbucks or other non-compostable hot cups, TetraPak containers.
		6 Other Non-compostable Paper	Photographs, carbon copy paper, hardcover books, and other predominantly paper items with other attached materials, such as spiral notebooks.

[3] For the analysis, *compostable paper currently accepted from commercial accounts* and *potentially compostable paper*, were combined with *universal compostable paper.*
[4] Ibid.

	Class	Component Category	Definition
Plastic	Compostable	7 Universal Compostable Plastic	Cedar-Grove-labeled food service ware, tan-colored compostable meat trays, and BPI-labeled kitchen compost bags currently on accepted list.
		8 Compostable Plastic Currently Accepted from Commercial Accounts[5]	BPI-labeled food service ware. Though approved compostable, SPU does not currently encourage their discard in residential organics service.
	Questionable	9 Potentially Compostable Plastic[6]	Utensils, straws, cups, food-handling gloves, cold cups, deli containers, and meat trays. This category includes items that are marked compostable or biodegradable, but are not Cedar Grove-approved.
	Non-compostable	10 Non-compostable Film	Bags not approved by Cedar Grove and other film. Includes all merchandise and take-out bags.
		11 Recyclable Plastic Containers	Plastic bottles, jars, tubs, cups, and other rigid containers not marked as compostable or biodegradable. Includes lids 3 inches in diameter or larger.
		12 Other Non-compostable, Non-recyclable Plastic	All other items that are entirely or predominantly composed of plastic.
Organics	Compostable	13 Vegetative Food, Unpackaged	Whole fruits and vegetables and scraps. Examples include loose vegetables and fruits, tree fruit, peelings, fruits and vegetables in storage bags, opened tea bags, and coffee grounds. Includes the food container when the container weight is not appreciable compared to the food inside.
		14 Vegetative Food, Packaged	Fruit and vegetables. Examples include packaged salad, frozen vegetables in their original box, container or plastic package from the point of sale, and bags of coffee beans. Includes the food container when the container weight is not appreciable compared to the food inside.

[5] For the analysis, *compostable plastic currently accepted from commercial accounts* and *potentially compostable plastic* were combined with *universal compostable plastic.*
[6] Ibid.

	Class	Component Category	Definition
		15 Other Food, Unpackaged	Non-vegetative food, such as breads, meats, pastas, dairy products, etc., not packaged or not in its original package or container. Examples include food in plastic wrap, aluminum foil, or sandwich bags, and food in takeout containers. Includes the food container when the container weight is not appreciable compared to the food inside.
		16 Other Food, Packaged	Non-vegetative food, such as breads, meats, pastas, dairy products, etc., disposed in the original package (i.e., how the food was packaged at the point of sale). Includes the food container when the container weight is not appreciable compared to the food inside.
		17 Grass/Leaves	Grass, leaves, evergreen needles, and soil.
		18 Prunings	Prunings that are at least 2 inches in diameter at their largest point.
		19 Other Compostable Organics	Toothpicks, chop sticks, untreated wood (including dimensional lumber), and indoor florals.
Other	Non-compostable	20 Recyclable Glass	Glass containers.
		21 Recyclable Metal	Aluminum cans, aluminum foil/containers, steel food cans, and other ferrous metal.
		22 Disposable Diapers	Diapers made from a combination of fibers, synthetic and/or natural, and made for single use. This includes disposable baby diapers and adult protective diapers.
		23 Pet Waste	Bagged or unbagged pet waste. Includes kitty litter and animal bedding.
		24 Hazardous	Mercury-containing light bulbs, paint, motor oil, etc.
		25 Other Non-compostable, Non-recyclable Items	All other items not included in the categories above, such as mirrors.

Appendix B **Sampling Methodology**

Overview

Seattle Public Utilities (SPU) has conducted material composition studies since 1988 to better understand the types and quantities of municipal solid waste (MSW) and recyclable materials collected, to assess the City of Seattle's recycling potential, and to support the evaluation of existing programs. In 2012, Seattle conducted the first in-depth evaluation of the city's organics stream. The objective of this study was to determine the composition of Seattle's single-family, multifamily, and commercial organics stream that the City's two contracted haulers collect for composting in plastic carts.

The objective of the 2016 organics composition study was to update the organics characterization data for single-family residential, multifamily residential, and commercial streams that are collected in carts by the City's two contracted haulers. This data will help the City understand differences among substreams so that targeted organics diversion programs can be designed and implemented or improved and evaluated. This document details the sample collection and sorting methodology for the 2016 study.

Substream Definitions

For any specific geographic area, the organics stream is composed of various substreams. A "substream" is determined by the particular generation, collection, or composition characteristics that make it a unique portion of the total organics stream. For this study, the three substreams are defined as follows:

- ***Single-family residential:*** Organic materials that are generated by residential customers with cart organics collection service. These are customers who typically also have their garbage collected in carts and are primarily residents of single-family detached homes, duplexes, triplexes, and four-plex buildings.
- ***Multifamily residential:*** Organic materials that are generated by residential customers with cart organics collection service and dumpster collection for garbage. These customers typically reside in apartment buildings with five or more units.
- ***Commercial:*** Organic materials that are generated by businesses and institutions with cart organics collection service.

These three organics substreams are collected by two contracted haulers, each serving two of four distinct "zones" (Figure 7) in the City of Seattle. One of the contracted haulers handles Zones 1 and 4; the other hauler handles Zones 2 and 3. The organics targeted by this study are typically collected and transported to either the two city-owned transfer stations or Eastmont transfer station, after which they are transported to Cedar Grove for composting. All organics that are placed in plastic carts, including carts collected both at the curb and from on-site locations, were eligible for sampling. Organics placed in metal containers were excluded.

This study did not sample any organics collected by private organics composting firms that are not under contract with Seattle Public Utilities.

Figure 7. Seattle's Collection Zones

Sample Allocation

A total of 600 organics samples—200 from single-family, 200 from multifamily, and 200 from commercial properties—were obtained for this study. Samples were collected seasonally, once each season beginning in April, so that data would be representative of the types of organics collected throughout the year. All samples were allocated equally across Seattle's four collection zones. For this study, single-family residential samples were collected at the South Disposal Station from incoming trucks. Multifamily residential and commercial samples were obtained directly from organics carts set out for pick-up. The process for allocating samples to each of the three substreams and four collection zones is described below.

Single-family Residential Samples

For this study, single-family residential samples were obtained at the South Disposal Station from incoming trucks carrying pure loads (organics collected from single-family residences that do not contain organics cart contents from multifamily or commercial properties). A total of 200 single-family residential samples over four sampling seasons (50 samples per season) were collected. The single-family samples were evenly distributed across the four collection zones.

Single-family residential sample allocations by collection zone appear below in Figure 8.

Figure 8. Single-family Residential Sample Targets by Zone

Zone	Single-family
1	50
2	50
3	50
4	50
Total Target	**200**

Multifamily Residential and Commercial Samples

Multifamily residential and commercial samples were obtained directly from organics carts that were set out for pick-up on their regularly scheduled collection day. A total of 200 multifamily samples and 200 commercial samples were characterized. Samples were distributed equally across the four collection zones.

The resulting target allocations by zone appear below in Figure 9.

Figure 9. Multifamily and Commercial Sample Targets by Zone

Zone	Multifamily	Commercial
1	50	50
2	50	50
3	50	50
4	50	50
Total Target	**200**	**200**

Sampling Calendar

Sampling took place seasonally beginning in April 2016, with a total of four sampling events over the four seasons. During each sampling event, 50 samples were obtained from each substream for a total of 150 samples (and 600 samples over the entire study). The start dates for all sampling events each season were selected using a random number generator. The sampling dates for both the single-family and commercial/multifamily substreams were scheduled contiguously from the selected start dates. Each sampling event was planned for four days: two days to collect single-family samples and two days to collect multifamily and commercial samples.

Scheduling Single-family Sampling

The daily sampling target for single-family organics was 25, so eight sampling days (two days each season for four seasons to obtain 200 samples) were assigned to the single-family substream. The sample collection crew was sized to meet the daily targets.

Scheduling Commercial and Multifamily Sampling

Cascadia used four collection crews to obtain samples from the commercial and multifamily substreams. Each crew could collect 12 to 13 samples per day, for a total of 50 samples each sampling day. Therefore, two collection days during each of four seasonal sampling events were required to obtain a total of 200 samples each from the commercial and multifamily substreams. Each collection crew

obtained samples from one randomly selected route each day; one route from each zone was sampled on each of the two sampling days.

Scheduling Sampling Events

The starting sampling date within each season was selected randomly using the procedure described below. The remainder of the sampling dates in each season were scheduled contiguously.

- First, the number of available weeks (weeks starting Monday or Tuesday that did not include holidays) was determined for each month. The random number function in Excel was used to select the starting week for each month of the study.
- Sampling was scheduled to take place over four continuous days not interrupted by weekends or holidays. Therefore, sampling could start only on a Monday or Tuesday. The starting day of the week for each seasonal sampling event was chosen randomly using a random number generator.

The resulting sampling calendar is shown in Table 17 below.

Table 17. Sampling Calendar

Season	Month	Start Day (Monday or Tuesday)	Day 1	Day 2	Day 3	Day 4
Q1	April	Monday	18-Apr	19-Apr	20-Apr	21-Apr
Q2	July	Tuesday	19-Jul	20-Jul	21-Jul	22-Jul
Q3	October	Monday	24-Oct	25-Oct	26-Oct	27-Oct
Q4	December	Tuesday	6-Dec	7-Dec	8-Dec	9-Dec

SF days
MF/COM days

Hauler and Transfer Station Participation

For each of the scheduled organics sampling events, the South Transfer Station provided a sorting site for the collection and sorting crew. Affected transfer station staff were notified both the week and the day prior to sampling to ensure that all staff were aware of the sampling event and that no conflicting circumstances had arisen. For all sampling, the two contracted haulers were asked to provide daily collection schedules and route information. Hauler participation is described in more detail below.

Single-family Residential Sampling

Haulers were sent reminders the week prior to each sampling event. Several days prior to each sampling day, Cascadia sent the collection schedule and route information for the sampling days to each hauler. The hauler verified that route numbers were correct; added truck numbers, driver names, and vehicle arrival times; and returned the list. From the lists of routes, the target number of routes was randomly selected to correspond to the number of samples required on each sampling day. The list of vehicles selected for sampling was forwarded to the hauler and verified verbally. In addition, the haulers were

reminded to notify drivers of selected vehicles that they were expected to participate in the sampling activities.

Multifamily Residential and Commercial Sampling

To assist with the daily routing of Cascadia organics collection vehicles, the two contracted haulers were asked to provide feedback on accessibility to the organics carts at selected commercial and multifamily sites in Seattle. Sites with carts that were inaccessible (e.g., carts in locked enclosures) were removed from the list of possible customers to sample. This final list was used to randomly select customers for sampling and to construct collection routes for use by Cascadia's sample collection personnel as described in Multifamily Residential and Commercial Organics Sample Selection below.

Load and Sample Selection

Single-family Residential Loads

To select which loads would be sampled on a given sampling day, a random number was assigned to every load that was expected to arrive at the sampling facility from each zone that day. These random numbers were sorted, and the loads with the lowest random number were selected in sequence until the target number of samples was achieved for each collection zone. For subsequent sampling days, a new random number was assigned to each load, and the process was repeated.

An additional single-family route was added to the list of routes scheduled on each sampling day. The additional route provided "contingency samples" that were obtained and sorted in the event that one of the vehicles for the regularly-planned collection route failed to arrive on time or was not intercepted in time to obtain a sample.

Multifamily Residential and Commercial Organics Sample Selection

Prior to each sampling day, one route from each of the four collection zones was selected for sampling using a random number generator. The contracted haulers were asked to provide a starting location, regular driver starting time, and a list of multifamily and commercial accounts for each selected route. Accounts were randomly selected from the list for sampling, including contingencies in the event that a selected customer did not set out their bin that week. To randomly select accounts, each account was assigned a random number. The accounts with the lowest random number were selected in sequence until the target number of accounts from which to sample was achieved.

Field Procedures

Sample Collection

SINGLE-FAMILY RESIDENTIAL SAMPLES

The field crew manager coordinated all logistics involving truck selection, sample extraction, sorting area, and disposal of sorted materials with the South Transfer Station staff. As the selected truck dumped at the transfer station, a loader operator scooped into material dumped from the truck to capture a sample of approximately 200 to 250 pounds of organics. Each sample was placed on a clean tarp and labeled with a *Sample Placard* for sorting.

MULTIFAMILY RESIDENTIAL AND COMMERCIAL ORGANICS SAMPLES

Prior to each commercial or multifamily sampling day, a mapped route of the accounts to be sampled was given to Cascadia's collection crews. Each collection crew drove the preselected route and collected samples from the organics carts of the first 12 to 13 accounts on their list. When the collection crew reached the multifamily or commercial property selected for sampling, a collection crew member took the organics cart, emptied its entire contents onto a tarp, and sealed it. If more than one cart had been set out, or if extra organics were left next to carts for collection, the collection crew collected all material set out for collection unless there were several carts with similar material, in which case the crew collected material from a randomly selected cart. The driver then labeled each sample with a *Sample ID*.

The collection crew collected samples prior to the normal pick-up time for the contracted hauler. In the event that a customer did not set out their bin that day, the crew continued on the route to the contingency samples until they met their sample quota. After each crew had collected the designated number of samples, they delivered the collected samples to the South Transfer Station for sorting.

Sample Sorting

Cascadia staff hand-sorted samples at the South Transfer Station. Approximately 150 samples were sorted over four days each season. The sorting procedure included the following four steps:

Step 1: Review methodology and sorting categories with the crew. To ensure consistent sorting, Cascadia used highly trained crewmembers throughout the duration of the project. Before the sorting began, all crewmembers reviewed the procedures, forms, and material definitions in detail. The material definitions are included in Appendix A.

Step 2: Sort Sample. Once the samples were placed on the floor for sorting, a crewmember photographed the sample clearly showing the sample placard. The sorting crewmembers then sorted each sample by hand into the 24 prescribed material component categories. The crewmembers typically started each sample with three or four sorting baskets for the most commonly found components and set up more as needed. Each sample was sorted to the greatest reasonable level of detail.

Step 3: Weigh the Sample. The field crew manager verified the purity of each material as it was weighed using a pre-tared scale, and recorded the data on the *Sample Tally Sheet* (Appendix E).

Step 4: Review Data. At the conclusion of each sorting day, the Field Crew Manager conducted a quality control review of the data recorded.

Appendix C Sampling Event Progress Reports

Cascadia produced brief reports to track progress towards study goals after each season of field work was complete. The four reports (one report per season) are presented below.

April (Q1) Organics Sampling Event Progress Report

This memo presents a summary of the 2016 Seattle Residential and Commercial Organics Composition Study sampling event that occurred in April 2016. Sampling took place from April 18 through April 21. Table 18 compares the number of samples that were actually sorted to the number originally planned by date and zone. The goal for each substream for the sampling event was 50 samples. In total, 50 single-family, 48 commercial, and 52 multifamily organics samples were collected and sorted. By zone, sampling was one short for Zone 1 and one over for Zone 4 over the sampling days, while the targets were met for Zone 2 and Zone 3.

Table 18. Summary of Planned vs. Actual Samples Completed by Date and Zone

		4/18/2016	4/19/2016	4/20/2016	4/20/2016	4/21/2016	4/21/2016	
		Single-family	**Single-family**	**Commercial**	**Multifamily**	**Commercial**	**Multifamily**	**Total**
Planned	Zone 1	7	6	0	5	12	0	30
	Zone 2	6	6	0	6	6	7	31
	Zone 3	6	7	12	7	7	12	51
	Zone 4	6	6	13	7	0	6	38
	Total Planned	**25**	**25**	**25**	**25**	**25**	**25**	**150**
Actual	Zone 1	7	6	0	5	11	0	29
	Zone 2	6	6	0	5	5	9	31
	Zone 3	6	6	13	7	6	13	51
	Zone 4	6	7	13	7	0	6	39
	Total Actual	**25**	**25**	**26**	**24**	**22**	**28**	**150**
	Difference	**0**	**0**	**1**	**(1)**	**(3)**	**3**	

July (Q2) Organics Sampling Event Progress Report

This memo presents a summary of the 2016 Seattle Residential and Commercial Organics Composition Study sampling event that occurred in July 2016. Sampling took place from July 19 through July 22. Table 19 compares the number of samples that were actually sorted to the number originally planned by date and zone. The goal for each substream for the sampling event was 50 samples. In total, 47 single-family, 51 commercial, and 50 multifamily organics samples were collected and sorted. By zone, sampling resulted in four more samples than planned for Zone 1, two more samples for Zone 2, five fewer samples than planned for Zone 3, and three fewer for Zone 4 over the sampling days.

Table 19. Summary of Planned vs. Actual Samples Completed by Date and Zone

Planned		Zone 1	Zone 2	Zone 3	Zone 4	Total
7/19/2016	Single-family	6	7	6	6	**25**

7/20/2016	Single-family	6	6	6	7	**25**
7/21/2016	Commercial	0	13	12	0	**25**
7/21/2016	Multifamily	0	12	13	0	**25**
7/22/2016	Commercial	13	0	0	12	**25**
7/22/2016	Multifamily	12	0	0	13	**25**
	Total Planned	**37**	**38**	**37**	**38**	**150**
Actual						
7/19/2016	Single-family	6	7	5	7	**25**
7/20/2016	Single-family	5	6	4	7	**22**
7/21/2016	Commercial	0	18	13	0	**31**
7/21/2016	Multifamily	0	9	10	0	**19**
7/22/2016	Commercial	11	0	0	9	**20**
7/22/2016	Multifamily	19	0	0	12	**31**
	Total Actual	**41**	**40**	**32**	**35**	**148**
	Difference	**4**	**2**	**(5)**	**(3)**	**(2)**

As shown in Table 20 sampling to date was within two of the overall goal. By zone, all zones other than Zone 3 were between one and five samples below the target. Eight samples more than the target were completed for Zone 3. By zone and substream, sampling targets were exceeded for Zone 3 commercial and multifamily substreams while Zone 3 single-family was below the target. The actual number of samples completed for Zone 1 and Zone 4 commercial substreams were each below the target by three samples.

Table 20. Summary of Overall Sampling Progress

	Overall Target by Substream				Actual Samples Sorted by Substream						
Zone	Single-Family	Commercial	Multifamily	Total	Single-Family	Commercial	Multifamily	Total	% Complete	Expected Number of Samples	Difference
Zone 1	50	50	50	150	24	22	24	70	50%	75	**(5)**
Zone 2	50	50	50	150	25	23	23	71	50%	75	**(4)**
Zone 3	50	50	50	150	21	32	30	83	50%	75	**8**
Zone 4	50	50	50	150	27	22	25	74	50%	75	**(1)**
Total	**200**	**200**	**200**	**600**	**97**	**99**	**102**	**298**	**50%**	**300**	**(2)**

***Note**: Orange denotes substreams/zones for which sampling is more than two below the planned number of samples. Green denotes substreams/zones for which sampling has exceeded the target by more than two samples.*

October (Q3) Organics Sampling Event Progress Report

This memo presents a summary of the 2016 Seattle Residential and Commercial Organics Composition Study sampling event that occurred in October 2016. Sampling took place from October 17 through October 20. Table 21 compares the number of samples that were actually sorted to the number

originally planned by date and zone. The goal for each substream for the sampling event was 50 samples. In total, 52 single-family, 50 commercial, and 50 multifamily organics samples were collected and sorted. By zone, sampling in this event resulted in 14 fewer samples than planned for Zone 1, one fewer sample for Zone 2, 13 more samples than planned for Zone 3, and four more than planned for Zone 4.

Table 21. Summary of Planned vs. Actual Samples Completed by Date and Zone

Planned		Zone 1	Zone 2	Zone 3	Zone 4	Total
10/17/2016	Single-family	6	6	7	6	**25**
10/18/2016	Single-family	7	6	6	6	**25**
10/19/2016	Commercial	0	13	12	0	**25**
10/19/2016	Multifamily	0	12	13	0	**25**
10/20/2016	Commercial	13	0	0	12	**25**
10/20/2016	Multifamily	12	0	0	13	**25**
	Total Planned	**38**	**37**	**38**	**37**	**150**
Actual						
10/17/2016	Single-family	7	7	6	5	**25**
10/18/2016	Single-family	7	7	4	9	**27**
10/19/2016	Commercial	0	0	11	14	**25**
10/19/2016	Multifamily	4	8	6	7	**25**
10/20/2016	Commercial	6	5	13	1	**25**
10/20/2016	Multifamily	0	9	11	5	**25**
	Total Actual	**24**	**36**	**51**	**41**	**152**
	Difference	**(14)**	**(1)**	**13**	**4**	**2**

As shown in Table 22, the total samples completed to date matches the target. By zone, Zones 2 and 4 were within five and three samples of the target, respectively. Sampling to date resulted in 19 fewer samples than planned for Zone 1 and 21 more samples than planned for Zone 3. By zone and substream, sampling targets were exceeded for Zone 2 multifamily, Zone 3 commercial and multifamily, and Zone 4 single-family substreams. Sampling was below the targets for Zone 1 commercial and multifamily, Zone 2 commercial, and Zone 3 single-family substreams.

Table 22. Summary of Overall Sampling Progress

Zone	Overall Target by Substream				Actual Samples Sorted by Substream				% Complete	Expected Number of Samples	Difference
	Single-Family	Commercial	Multifamily	Total	Single-Family	Commercial	Multifamily	Total			
Zone 1	50	50	50	150	38	28	28	94	75%	113	**(19)**
Zone 2	50	50	50	150	39	28	40	107	75%	112	**(5)**
Zone 3	50	50	50	150	31	56	47	134	75%	113	**21**
Zone 4	50	50	50	150	41	37	37	115	75%	112	**3**
Total	**200**	**200**	**200**	**600**	**149**	**149**	**152**	**450**	**75%**	**450**	**0**

***Note**: Orange denotes substreams/zones for which sampling is more than two below the planned number of samples. Green denotes substreams/zones for which sampling has exceeded the target by more than two samples.*

December (Q4) Organics Sampling Event Progress Report

This memo presents a summary of the 2016 Seattle Residential and Commercial Organics Composition Study sampling event that occurred in December 2016. Sampling took place from December 13 through December 16. Table 23 compares the number of samples that were actually sorted to the number originally planned by date and zone. The goal for each substream for the sampling event was 50 samples. In total, 51 single-family, 49 commercial, and 57 multifamily organics samples were collected and sorted. By zone, sampling in this event resulted in 13 more samples than planned for Zone 1, 12 more samples for Zone 2, 17 fewer samples for Zone 3, and one fewer for Zone 4.

Table 23. Summary of Planned vs. Actual Samples Completed by Date and Zone

Planned		Zone 1	Zone 2	Zone 3	Zone 4	Total
12/13/2016	Single-family	6	6	7	6	**25**
12/14/2016	Single-family	7	6	6	6	**25**
12/15/2016	Commercial	0	13	12	0	**25**
12/15/2016	Multifamily	0	12	13	0	**25**
12/16/2016	Commercial	13	0	0	12	**25**
12/16/2016	Multifamily	12	0	0	13	**25**
	Total Planned	**38**	**37**	**38**	**37**	**150**
Actual						
12/13/2016	Single-family	8	9	2	6	**25**
12/14/2016	Single-family	8	8	5	5	**26**
12/15/2016	Commercial	0	10	7	0	**17**
12/15/2016	Multifamily	8	22	7	0	**37**
12/16/2016	Commercial	19	0	0	13	**32**
12/16/2016	Multifamily	8	0	0	12	**20**
	Total Actual	**51**	**49**	**21**	**36**	**157**
	Difference	**13**	**12**	**-17**	**-1**	**7**

As shown in Table 24, the total samples completed to date matched the target. Looking at targets by zone, Zone 1 was six samples below the target. Sampling to date resulted in six more samples than planned for Zone 2 and five more samples than planned for Zone 3. Zone 4 sampling resulted in the same number of samples as planned. By zone and substream, sampling targets were exceeded for Zone 2 single-family and multifamily and Zone 3 commercial and multifamily. Sampling was below the targets for Zone 1 multifamily, Zone 2 commercial, and Zone 3 single-family substreams. Overall, five more samples than planned were completed.

Table 24. Summary of Overall Sampling Progress

	Overall Target by Substream				Actual Samples Sorted by Substream						
Zone	Single-Family	Commercial	Multifamily	Total	Single-Family	Commercial	Multifamily	Total	% Complete	Expected Number of Samples	Difference
Zone 1	50	50	50	150	52	48	44	144	100%	150	**(6)**
Zone 2	50	50	50	150	56	38	62	156	100%	150	**6**
Zone 3	50	50	50	150	38	63	54	155	100%	150	**5**
Zone 4	50	50	50	150	51	50	49	150	100%	150	**0**
Total	**200**	**200**	**200**	**600**	**197**	**199**	**209**	**605**	100%	**600**	**5**

***Note**: Orange denotes substreams/zones for which sampling is more than two below the planned number of samples. Green denotes substreams/zones for which sampling has exceeded the target by more than two samples.*

Appendix D **Organics Composition Calculations**

Composition Calculations

The composition estimates represent the **ratio of the components' weight to the total waste** for each noted substream. They are derived by summing each component's weight across all the selected records and dividing by the sum of the total weight of waste, as shown in the following equation:

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

where:

c = weight of particular component
w = sum of all component weights

for i = 1 to n

where n = number of selected samples

for j = 1 to m

where m = number of components

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

$$\hat{V}_{r_j} = \left(\frac{1}{n}\right) \cdot \left(\frac{1}{\overline{w}^2}\right) \cdot \left(\frac{\sum_i \left(c_{ij} - r_j w_i\right)^2}{n-1}\right)$$

where:

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

Second, **confidence intervals** at the 90% confidence level are calculated for a component's mean as follows:

$$r_j \pm \left(t \cdot \sqrt{\hat{V}_{r_j}}\right)$$

where:

t = the value of the t-statistic (1.645) corresponding to a 90% confidence level

For more detail, please refer to Chapter 6 "Ratio, Regression and Difference Estimation" of *Elementary Survey Sampling* by R.L. Scheaffer, W. Mendenhall and L. Ott (PWS Publishers, 1986).

Weighted Averages

The overall commercial waste composition estimates were calculated by performing a weighted average across the relevant substreams: each zone, vehicle type, and shift.

Seattle provided the estimate of tonnage disposed by the commercial substream for the study period (January thru December 2016). The composition estimates for each substream and subpopulation were applied to the relevant tonnages to estimate the amount of waste disposed for each component category.

The **weighted average for an overall composition estimate** is performed as follows:

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

where:

p = the proportion of tonnage contributed by the noted substream

r = ratio of component weight to total waste weight in the noted substream

for

j = 1 to m

where

m =number of components

The **variance of the weighted average** is calculated:

$$VarO_j = ({p_1}^2 * \hat{V}_{r_{j1}}) + ({p_2}^2 * \hat{V}_{r_{j2}}) + ({p_3}^2 * \hat{V}_{r_{j3}}) + \ldots$$

The weighting percentages that were used to perform the composition calculations are listed below in Table 25 through Table 28. Weighting percentages were not used to perform composition calculations on sampling data by zone.

Table 25. Weighting Percentages: Overall Organics

Substream Season	Tons Disposed	Percent of Total
Single-family		
Spring	25,445.73	16.13%
Summer	21,719.72	13.77%
Fall	23,014.13	14.59%
Winter	14,553.79	9.23%
Multifamily		
Spring	1,764.79	1.12%
Summer	1,782.64	1.13%
Fall	1,726.09	1.09%
Winter	1,367.84	0.87%
Commercial		
Spring	16,103.46	10.21%
Summer	16,573.82	10.51%
Fall	17,531.88	11.11%
Winter	16,172.74	10.25%
Overall	**157,756.64**	**100.00%**

Table 26. Weighting Percentages: Single-family

Season	Tons Disposed	Percent of Total
Spring	25,445.73	30.03%
Summer	21,719.72	25.63%
Fall	23,014.13	27.16%
Winter	14,553.79	17.18%
Overall	**84,733.37**	**100.00%**

Table 27. Weighting Percentages: Multifamily

Season	Tons Disposed	Percent of Total
Spring	1,764.79	26.57%
Summer	1,782.64	26.84%
Fall	1,726.09	25.99%
Winter	1,367.84	20.60%
Overall	**6,641.37**	**100.00%**

Table 28. Weighting Percentages: Commercial

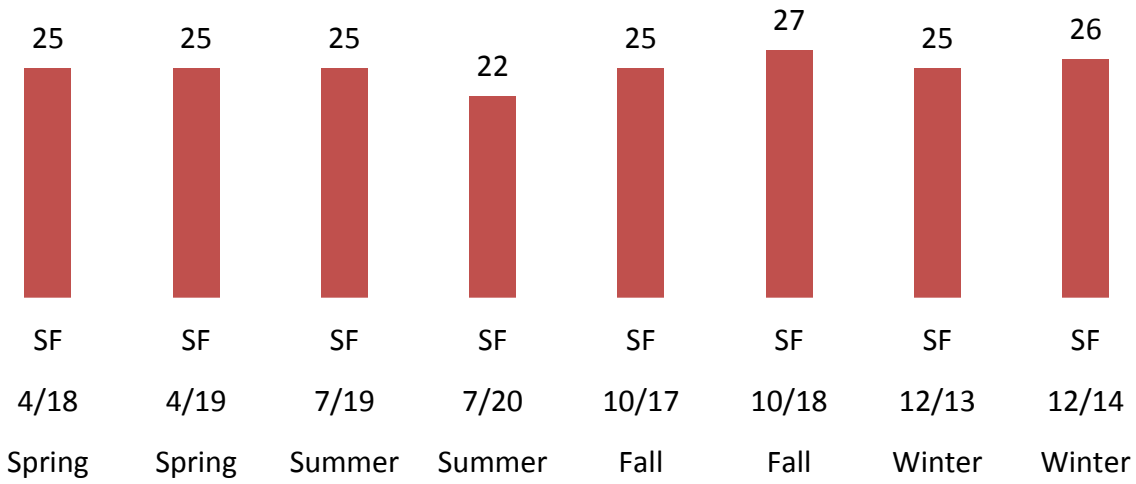
Season	Tons Disposed	Percent of Total
Spring	16,103.46	24.26%
Summer	16,573.82	24.97%
Fall	17,531.88	26.41%
Winter	16,172.74	24.36%
Overall	**66,381.90**	**100.00%**

Sample Size Analysis

Objective: Determine if the sample size for 2016 single-family organics sampling was adequate given the variability of organic quantities within each season.

The number of residential samples from single-family households taken during the 2016 study are shown in Figure 10.

Figure 10: Number of samples taken during 2016 study (single-family households only)[7]



It can be said from the figure that the number of samples taken were mostly uniform across the four seasons of the study.

A posteriori number of samples were calculated for the four seasons in 2016 based on the standard deviation (a measure of variability around the mean) for a desired margin of error using the following formula:

$$N = \frac{Z^2 \cdot s^2}{e^2}$$

[7] The field team collected and sorted 200 single-family samples over the course of the study, but not all samples were included in the final analysis.

Where:

- N = sample size
- Z = Z-score for a 95% confidence interval = 1.96
- s = Standard deviation calculated around the seasonal mean weight of the residential curbside collection. The seasonal mean (and the standard deviation) is calculated from the monthly residential curbside collection weights for each month grouped within a given season.
- e = margin of error (expressed in decimals) = 0.05

Table 29 shows the number of samples calculated using the above formula, as well as the actual number of samples taken during the 2016 study.

Table 29: Sample sizes

Season	Month	Residential Curbside Single-family Collection (lbs.)	Mean by season (A)	Std. Dev. by season (B)	Coeff. of Variation (B/A)	Estimated # of samples	Actual # of Samples
Winter	Dec	10,069,682	9,702,528.4	259,634.6	2.7%	1	48
	Jan	9,515,247					
	Feb	9,522,656					
Spring	Mar	14,363,552	16,963,819.7	1,842,419.3	10.9%	18	50
	Apr	18,120,007					
	May	18,407,900					
Summer	Jun	16,214,720	14,479,814.9	1,248,157.0	8.6%	11	47
	Jul	13,894,180					
	Aug	13,330,544					
Fall	Sep	12,847,846	15,342,751.9	2,768,094.6	18.0%	50	52
	Oct	13,977,715					
	Nov	19,202,695					

It can be seen from the table that the actual number of single-family samples taken during the study exceeded or equaled the number of samples estimated using the above formula for all four seasons.

As a rule of thumb, the sample size increases with the increase in the heterogeneity in the targeted population. The variability in the residential curbside collection for each season is indicated by the coefficient of variation (the ratio of the standard deviation to its mean). In 2016, the residential curbside collection showed highest variation in fall (CV=18%), followed by spring (CV=10.9%), and summer (CV=8.6%). The lowest variability was seen in winter season (CV=2.7%). Accordingly, the number of samples estimated ranged from 50 to 18 to 11 and to 1 for fall, spring, summer, and winter seasons respectively.

As can be seen from the table, each season in 2016 requires a varied number of samples (from 50 to 1). The number of samples (rounded to the nearest ten) that were taken during the study was 50. This established parity among different sampling efforts across different seasons and facilitates comparative analysis among different seasons by balancing the sample sizes.

Appendix E **Field Forms**

This appendix includes examples of the following field forms.

- Organics Sample Tally Sheet
- Single-family Organics Sample Placard
- Commercial/Multifamily Organics Sample Placard

Figure 11: Organics Sample Tally Sheet

2016 Seattle Organics Composition Study
Sample Tally Sheet

*PHOTO TAKEN ☐

Sample ID: _____

Date: _____

Zone: _____

Hauler: Waste Mangement

(circle one) Recology

Cart Liner? ☐

Sampler: _____

Paper	Wt.1	Wt.2	Wt.3	Wt.4
1 Universal Compostable Paper				
2 Mixed Recyclable Paper				
3 Compostable Paper Currently Accepted				
4 Potentially Compostable Paper				
5 Polycoated paper				
6 Other Non-compostable Paper				

Plastic	Wt.1	Wt.2	Wt.3	Wt.4
7 Univesral Compostable Plastic				
8 Compotable Plastic Currently Accepted				
9 Potentially Compostable Plastic				
10 Non-compostable Film				
11 Recyclable Plastic Containers				
12 Other Non-compostable, Non-recyclable Paper				

Organics	Wt.1	Wt.2	Wt.3	Wt.4
13 Vegetative Food				
14 Vegetative Food, Packaged				
15 Other Food				
16 Other Food, Packaged				
17 Grass/Leaves				
18 Prunings				
19 Other Compostable Organics				

Other	Wt.1	Wt.2	Wt.3	Wt.4
20 Recyclable Glass				
21 Recyclable Metal				
22 Disposable Diapers				
23 Pet Waste				
24 Hazardous				
25 Other Materials				

Notes

Figure 12: Single-family Organics Sample Placard

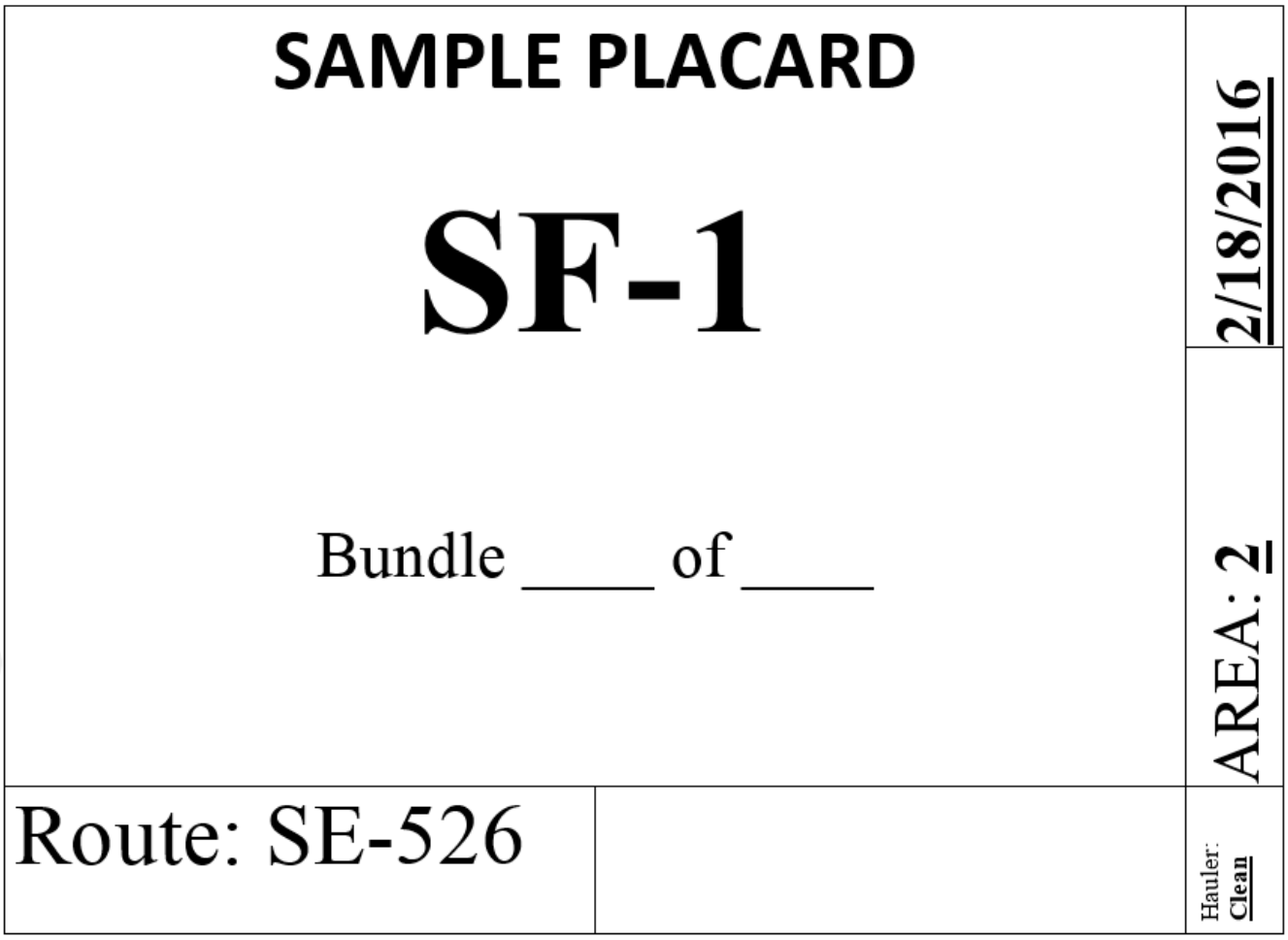


Figure 13: Commercial/Multifamily Organics Sample Placard