King County Solid Waste Division

Organics Characterization Report

June 2012

King County
Department of
Natural Resources and Parks
Solid Waste Division

CASCADIA
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1. Introduction and Summary

In 2011, the King County Solid Waste Division (SWD) completed a characterization study of the single-family organics collection program as part of the county's ongoing waste monitoring program.

The composition and quantity data in this report provide the following information:

- The baseline composition of material collected from organics routes throughout King County.
- The proportion of subscribers setting out an organics cart for collection.
- The proportion of carts that contain food scraps.
- The average quantity of food scraps set out by each household.

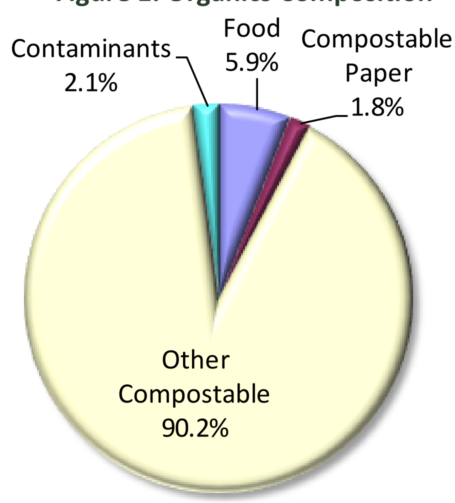
To meet these goals, the SWD contracted with Cascadia Consulting Group, Inc. (Cascadia) to collect and hand-sort 739 samples of organics over three seasons (April, June, and November) from King County single-family collection programs. Cascadia sorted samples into 18 material types (described in detail in Appendix A: Material Type Definitions).

Approximately 151,372 tons of organics were collected for composting from single-family residences in King County. Additional results of the characterization study are summarized in Figure 1 and Figure 2.

Key Findings

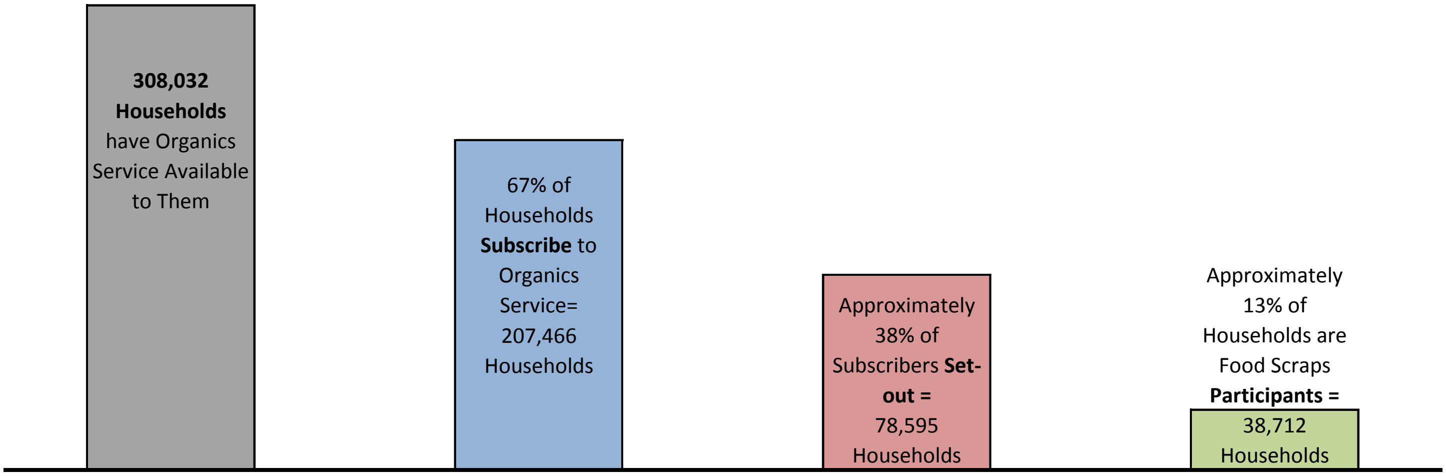
- **Composition**
  - The majority of material collected (approximately 90%) is *yard debris.*
  - **Food** and **Compostable Paper** combined are approximately 8% of curbside single-family organics.
- **Set-outs**
  - Approximately 38% of households that subscribe to organics service set out organics carts.
  - Almost half (49%) of set-outs contain food scraps.
- **Participation**
  - About 19% of subscribing households, or 13% of all King County households, place food scraps their organics carts.

Figure 1. Organics Composition



- **Quantities**
  - The average food scraps participant places nearly 42 pounds of food scraps and compostable paper in their organics cart each month.
- **Capture rates**
  - The overall King County capture rate for food scraps and compostable paper is slightly more than 13%.
  - An estimated 86% of the food scraps and compostable paper generated by food scraps participants are collected in their organics service cart instead of being disposed.

Figure 2. Summary of Key Findings and Definitions



A **household** is a single family customer to whom organics service is available.

A **subscriber** is a household that pays an additional fee for organics service or is in a city where organics service is embedded in the garbage rate.

A **set-out** is an organics service container placed at the curb/alley for pick up by the collection company.

A food scraps **participant** is a household that includes food scraps in their organics service container.

The rate data as well as the food scraps and compostable paper collection data detailed throughout the report is summarized in Table 1.

Table 1. Rate and Collection Data Summary

	Subscription Rate	Set-out Rate	Food Scraps Participation Rate	Lbs. of Food Scraps and Compostable Paper/Month	Capture Rate
Household	67%	26%	13%	6.3	13.1%
Subscriber	100%	38%	19%	9.4	19.4%
Set-out	100%	100%	49%	24.8	51.3%
Food Scraps Participant	100%	100%	100%	41.7	86.3%

The remainder of this report describes the study methodology and findings, and is organized as follows:

- **Section 2. Summary of Methodology,** explains the methodology used to design and implement the data collection portion of this study.
- **Section 3. Findings**, presents the organics composition and rates results.
- **Appendices** follow the main body of the report. They provide definitions for all material types, a complete explanation of the methodology, the formulas used in the characterization calculations, and copies of field forms.

2. Summary of Methodology

The following section summarizes the three main steps of the study methodology and highlights the revisions in the methodology from previous studies.

Develop Plan

Before scheduling the fieldwork, the consultant team met with key staff at the SWD, representatives from the haulers, and sampling facility staff to define the study universe, schedule field seasons, and develop route survey and sampling protocols.

The study "universe" included all King County cities and unincorporated areas (excluding Seattle) where combined food scraps and yard debris collection service is offered. The list of included cities is shown in Table 2. The universe includes only routes serving primarily single family residences.

Table 2. Cities and Regions With and Without Organics Service

Has Organics Service		
Algona	Issaquah	SeaTac
Auburn	Kenmore	Shoreline
Beaux Arts	Kent	Snoqualmie
Bellevue	Kirkland	Tukwila
Black Diamond	Lake Forest Park	Woodinville
Bothell	Maple Valley	Yarrow Point
Burien	Medina	Unincorporated County (except as
Carnation	Mercer Island	noted below)
Clyde Hill	Newcastle	
Covington	Normandy Park	
Duvall	North Bend	**Does Not Have Organics Service**
Des Moines	Pacific	Town of Skykomish
Enumclaw	Redmond	Unincorporated County-Vashon Island,
Federal Way	Renton	Snoqualmie Pass, and Skykomish area
Hunts Point	Sammamish	

This study includes several unique terms and definitions. Definitions for these terms are provided below.

- **King County—**Refers to King County, excluding Seattle.
- **Organics Service—**For the purposes of this study, organics service only includes franchised curbside/alley programs where residents are permitted to include food scraps in the organics service cart.
- **Households—**A household is a single family customer to whom organics service is available. Ninety nine percent of all single family residences in King County have organics service available to them.
- **Subscriber—**A subscriber is a household that pays an additional fee for organics service or is a household in a city where organics service is embedded in the garbage collection rate.

- **Set-out—**A set-out is an organics service container placed at the curb/alley for pick-up by the collection company. It is important to distinguish between a subscriber (a household that pays an additional fee for organics service or has organics service embedded in their garbage collection rates) and a set-out (where the resident uses the service and literally "sets out" the container for collection).
- **Food Scraps Participant—**A food scraps participant is a household that places at least some food scraps in their organics service container.

The consultant team also worked with SWD staff to identify material types and definitions for this study. The material types are grouped into four material classes: **Food, Compostable Paper, Other Compostable,** and **Contaminants**. See Appendix A: Material Type Definitions for a complete list of the material types and detailed definitions.

Material Designations

Throughout this report **Material Classes** such as **Food**, and **Compostable Paper** are bolded and capitalized, while specific material types such as *meat,* and *pizza boxes* are italicized.

Five routes per day were randomly selected for sampling. In most cases the same routes were used for all three seasons. A significant portion of one route included a gated community and was replaced after the first season due to the difficulty in gaining access to the community. One route was replaced after the hauler cancelled the route and split its service area among several nearby routes. For each of the selected routes, the haulers provided the subscriber count and a map showing the route boundaries. The selected routes are summarized in Table 3.

Table 3. Routes Selected for Sampling

Monday	
Hauler	**Jurisdiction**
Allied	Mercer Island
Allied	Renton
Waste Management	Redmond
Waste Management	Burien
Waste Management	Kirkland

Tuesday	
Hauler	**Jurisdiction**
Waste Management	County
Allied (replaced)	Des Moines
Allied	Sammamish
Allied	Kirkland
Allied	Bellevue
Allied (replacement)	County

Thursday	
Hauler	**Jurisdiction**
Allied (replaced)	Kent
Allied	Covington
Waste Management	Renton
Waste Management	Redmond
Waste Management	Fed Way
Allied (replacement)	Kent

Friday	
Hauler	**Jurisdiction**
Allied	Bellevue
Waste Management	Issaquah
Waste Management	County
CleanScapes	Shoreline
Waste Management	Bothell

Collect Data

On Monday, Tuesday, Thursday, and Friday during each of the field seasons, route surveyors, using route maps provided by the haulers, traversed the selected routes ahead of the regular collection vehicles to count the number of set-outs on each route and collect samples. The route surveyors counted more than 15,000 set-outs over three seasons and collected 739 samples. The route surveyors transported collected samples to Cedar Grove in Maple Valley for sorting.

At Maple Valley, the field crew hand sorted all 739 samples. The average sample weighed approximately 61 pounds. The field crew sorted and weighed each sample into 18 material types. The crew leader recorded the weight for each sorted material type on the sampling form, reviewed the form, and later entered the data into a custom database for analysis. A full description of the hand sort procedure is included in Appendix B: Study Design.

Analyze Data

Following on-site data collection, the consultant team entered all data recorded on field forms into a customized database and reviewed it for data entry errors. The team calculated organics composition and quantity estimates using the methods described in Appendix D: Calculations.

Changes to the Methodology from Previous Studies

The objectives and methodologies of the current study and the 2009 study are very similar. There are two changes to note. In 2009 sampling and sorting occurred over two weeks, one in April and one in August. For this study sampling occurred three times, once in early March, once in early June, and once in November. The change was made to better capture any seasonal variation in set-out rate, food scraps participation rate, sample size, and sample composition.

The material list for this study includes one additional material type compared to the 2009 study. In previous seasons the material definitions were unclear as to whether fruits and vegetables grown at home should be included with the material type *fruits and vegetables* (as an apple, for example, is a fruit) or with the material type *yard debris* (since the homegrown apple could be considered yard debris along with the leaves and prunings from the apple tree). The 2009 material type *fruits and vegetables* is now divided into *purchased fruits and vegetables* and *homegrown fruits and vegetables* to provide clarity when sorting.

3. Findings

Interpreting the Results

How Data Is Presented

Organics characterization data are presented in two ways:

- An overview of organics composition, by **Material Class,** in a pie chart, and
- A detailed table that lists the full composition and quantity results for the 18 *material types*. Please refer to Appendix A: Material Type Definitions for a detailed list of definitions for material types used in the study.

Means and Error Ranges

The data from the sorting process were treated with a statistical procedure that provided two kinds of information for each of the *material types*:

- Estimates of composition, by weight.
- The degree of precision of the composition estimates.

All estimates of precision were calculated at the 90% confidence level. The equations used in these calculations appear in Appendix D: Calculations.

The example below illustrates how the results can be interpreted. In this example, the best estimate of the amount of *yard debris* present in the samples is 90.0%. The figure 1.2% reflects the precision of the estimate. When calculations are performed at the 90% confidence level, we are 90% certain that the true amount of *yard debris* is between 90.0% plus 1.2% and 90.0% minus 1.2%. In other words, we are 90% certain that the mean lies between 88.8% and 91.2%.

Material Type	Est. Pct.	+ / -
Yard Debris	90.0%	1.2%

Rounding

To keep the organics composition tables and figures readable, estimated tonnages are rounded to the nearest ton, and estimated percentages are rounded to the nearest tenth of a percent. Due to this rounding, the tonnages presented in the report, when added together, may not exactly match the subtotals and totals shown. Similarly, the percentages, when added together, may not exactly match the subtotals or totals shown. Percentages less than 0.05% are shown as 0.0%.

It is important to recognize that the tons shown in the report were calculated using the more precise (not rounded) percentages. Using the rounded percentages to calculate tonnages yields quantities that are different than the rounded numbers shown in the report.

For example, the rounded percentage for *yard debris* in Table 4 is shown as 90.0%, while the more precise number, 90.0319647038085%, was used in calculations. If the rounded numbers (90.0%, 151,372 tons) had been used in the calculations *yard debris* would be 136,235 tons. Using the more precise numbers, *yard debris* is calculated to be 136,283 tons as shown in Table 4, a difference of 48 tons.

Characterization and Rate Results

This section describes the single family residential organics characterization and rate results in four subsections:

1. Composition of material set out in organics service carts.
2. Organics set-outs and food scraps participation rates.
3. Capture rates for food scraps and compostable paper.
4. A comparison among the various service types and collection schedules.

Organics Service Composition

From January 2011 through December 2011 single family residents in King County set out more than 151,000 tons of material in their organics service carts. Figure 3 summarizes composition by material class for organic materials collected in King County. Table 4 presents the detailed material composition for organics from King County.

Key Findings

- The two most prevalent material types are *yard debris* (90.0%, 136,283 tons) and *purchased fruits and vegetables* (3.7%, 5,579 tons). Together these two materials comprise nearly 94% of the organics service material.
- **Food** and **Compostable Paper** combined are about 8% (11,689 tons) of organics service material.
- **Contaminants** (3,132 tons) account for approximately two percent of the collected material.

Figure 3. Composition by Material Class

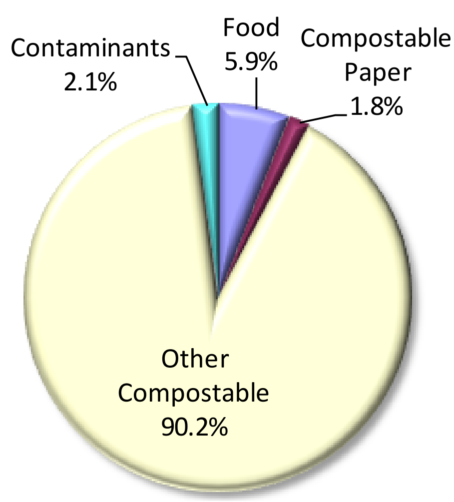


Table 4. Detailed Composition

Material	Estimated Percent	+ / -	Estimated Tons
Food	**5.9%**		**8,987**
Purchased Fruits and Vegetables	3.7%	0.5%	5,579
Homegrown Fruits and Vegetables	0.1%	0.1%	211
Meat	0.6%	0.1%	888
Dairy	0.0%	0.0%	19
Mixed/Other Food Scraps	1.5%	0.3%	2,290
Compostable Paper	**1.8%**		**2,702**
Uncoated Paper Bags	0.3%	0.2%	493
Pizza Boxes	0.4%	0.1%	637
Other Compostable Paper	1.0%	0.2%	1,572
Other Compostable	**90.2%**		**136,551**
Yard Debris	90.0%	1.2%	136,283
Biodegradable Plastic Bags	0.2%	0.2%	249
Other Compostables	0.0%	0.0%	18
Contaminants	**2.1%**		**3,132**
Difficult to Compost Materials	0.5%	0.4%	785
Milk/Ice Cream Cartons	0.0%	0.0%	30
Paper Cups	0.0%	0.0%	30
Other Plastic Coated Papers	0.1%	0.0%	95
Other Recyclable Materials	0.3%	0.1%	491
Plastic Bags	0.0%	0.0%	34
Other Materials	1.1%	0.4%	1,667
Totals	**100.0%**		**151,372**
Sample Count: 739			

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

The material type *other materials* includes all materials not defined elsewhere that do not belong in organics service carts. Examples of *other materials* include: animal waste, kitty litter, treated wood, construction materials, Styrofoam, and plastic trash bags.

Set-out and Food Scraps Participation Rates

The set-out and food scraps participation rates were calculated using the subscriber, set-out, and composition data collected by the route surveyors and the sort crew. The set-out rate is the proportion of subscribers with a set-out. The food scraps participation rate is the proportion of set-outs or subscribers who include food in their cart. As shown in Table 5, nearly half of all set-outs contained food scraps but, because not all subscribers set out carts, the food scraps participation rate for subscribers is much lower (19%).

Table 5. Set-out and Food scraps participation Rate Data

	Set-out Rate	Food Scraps Participation Rate
Subscriber	38%	19%
Set-out	100%	49%

Capture Rate

The food scraps and compostable paper capture rate is the proportion of total food scraps and compostable paper generated in King County that is collected in single-family organics programs. King County residents generate an estimated 48 pounds of food scraps and compostable paper per household per month.[1] The average food scraps participant sets out for collection approximately 42 pounds per month per household, thus the capture rate among food scraps participants is estimated to be 86%. The food scraps and compostable paper capture rate analysis is summarized in Table 6.

Table 6. Capture Rates

	Lbs. of Food Scraps and Compostable Paper Collected/Month	Lbs. of Food Scraps and Compostable Paper Generated/Month	Capture Rate
Household	6.3	48.3	13.1%
Subscriber	9.4	48.3	19.4%
Set-out	24.8	48.3	51.3%
Food Scraps Participant	41.7	48.3	86.3%

Comparisons Among Service Types and Collection Schedules

Using information provided by the hauler every sampled routes can be classified by its service type and collection schedule. The two service types are:

- **Subscription Service—**Cities where households have the option to pay an extra fee for organics service in addition to their regular garbage service.
- **Embedded Service—**Cities where the cost of organics service is embedded the regular service fee households pay for their garbage service. In embedded programs, households receive organics service automatically.

Depending on the jurisdiction, organics service may be provided either weekly (W) or every other week (EOW). Some jurisdictions have weekly service during the summer months (typically April through October) then switch to an every other week service for the winter months. For this study, jurisdictions with this split service were considered weekly. Table 7 summarizes the service type and collection schedule information for each jurisdiction included in the study.

[1] Per household generation figure is calculated from data in this report and the *2011 King County Waste Characterization and Customer Survey Report*.

Table 7. Service Type and Collection Schedules

Jurisdiction	Schedule	Service Type
Bellevue	W	Embedded
Bothell	W	Embedded
Burien	W	Subscription
Covington	EOW	Subscription
Des Moines	EOW	Subscription
Federal Way	W	Subscription
Issaquah	W	Embedded
Kent	EOW	Subscription
Kirkland	W	Embedded
Mercer Island	EOW	Embedded
Redmond	W	Embedded
Renton	EOW	Embedded
Sammamish	W	Subscription
Shoreline	EOW	Subscription
Unincorporated North County	W	Subscription
Unincorporated South County	EOW	Subscription
Unincorporated South County	W	Subscription

Table 8 compares service types. The set-out rate appears to be higher for households with subscription service, as is the average cart weight. The food scraps participation rate and average pounds of food and compostable paper seem to be higher for households with embedded service.

Table 8. Comparison of Key Metrics by Service Type

	Number of Samples	Set-out Rate	Food Scraps Participation Rate	Average Cart Weight	Average Pounds Food & Compostable Paper per Set-out*
Embedded	369	37%	54%	59.2	9.5
Subscription	370	40%	44%	63.5	8.7
Combined	739	38%	49%	61.3	9.2

**Calculated using only set-outs from participants, the average excludes non participating set outs.*

Table 9 compares results for weekly and every other week collection. The set-out rate, average cart weight, and average pounds of food and compostable paper tend to be higher for subscribers with every other week service; weekly subscribers on average appear to have a higher food scraps participation rate.

Table 9. Comparison of Key Metrics by Collection Schedule

	Number of Samples	Set-out Rate	Food Scraps Participation Rate	Average Cart Weight	Average Pounds Food & Compostable Paper per Set-out*
Weekly	486	35%	51%	61.0	9.1
Every Other Week	253	52%	47%	61.9	9.2
Combined	739	38%	49%	61.3	9.2

**Calculated using only set-outs from participants, the average excludes non participating set outs.*

Comparisons to Previous Studies

There have been marked changes to curbside organics service throughout King County since the 2007 organics study. Residents in nearly every jurisdiction within the county can now include food scraps in their carts (99% of households in 2011 compared to 57% in 2007). Programs have also had many years to mature and attract new users. Methodological changes between the 2007 study and the current are significant including a switch from collecting samples from route trucks as they complete their route to collecting samples directly from carts at the curbside and an increase from a single season to three seasons. Because of these reasons direct comparisons of the results between 2007 and the two subsequent studies (2009 and 2011) are difficult. However, the methodology changes from 2009 to 2011 are minor so the results are more comparable.

For comparison purposes, where the methodology allows, the same measures are reported for each study. Some of the differences are methodological, some are programmatic, and some are due to behavior changes on the part of King County residents.

Rate Comparisons

Table 10 compares several key measures between the two studies. As shown the set-out food scraps participation rate held steady between 2009 and 2011. The set-out rate, subscriber food scraps participation rate, and capture rate show larger changes.

Table 10: Comparison of Key Data between 2007 and 2009

	2007	2009	2011
Subscription Rate	68%	63%	67%
Set-out Rate	38%	49%	38%
Set-out Food Scraps Participation Rate	*	50%	49%
Subscriber Food Scraps Participation Rate	*	24%	19%
Capture Rate	*	77%	86%

**Methodology changes since 2007 prevent comparisons between years for this measure.*

The decrease in the subscription rate from 2007 to 2009 may be due to an increase in jurisdictions implementing paid subscription based rather than embedded organics service programs. The total number of King County residents with organics service available to them has increased faster than the number of residents who subscribe to the service. Between 2009 and 2011 the trend appears to have reversed and the subscription rate increased.

In addition to changes in the utilization of organics service carts by households, the changes in the set-out rate may be influence by external factors such as:

- **General weather patterns-**A late spring or an early winter may influence the frequency of set-outs.
- **Weather in the week immediately preceding the sample collection-**If the weather is good then the set-out rate may increase due to an increase in the amount of time spent doing yard work by subscribers. Conversely, if the weather is bad the set-out rate may decrease.

- **Holidays-**If sampling occurs during a holiday week the set-out rate may decrease. The study intentionally avoids all major holidays. Summer season sampling when families go on summer vacation may influence the summer set-out rate.

As shown in Table 11 the set-out rate is seasonally variable. The 2011 set-out rate (38%) is lower than the 2009 rate (49%) at least partly due to the inclusion of the March field season in 2011 when the set-out was 26%.

Table 11. 2009 and 2011 Set-out Rate by Field Season

	March	April	June	August	November	Overall
2009		54%		44%		**49%**
2011	26%		50%		37%	**38%**

The food scraps participation rate for set-outs is nearly unchanged from 2009 (50%) to 2011 (49%). The food scraps participation rate for all subscribers, however, is lower in 2011 (19%) than in 2009 (24%). This is primarily due to the method in which this rate is calculated as it is dependent on the set-out rate. The subscriber food scraps participation rate is the product of the set-out food scraps participation rate (49%) and the set-out rate (38%).

Composition Comparisons

Using a t-test the 2011 composition data can be checked for statistically significant changes since 2009 because of the similarity in methods between the 2009 and 2011 studies. One example of the null hypothesis tested is "There is no statistically significant difference, between the 2009 and 2011 study periods, in the percentage of food scraps composted." The t-test results are summarized in Table 12; **Contaminants** is the only material class to have shown a statistically significant change, decreasing from 3.7% in 2009 to 2.1% in 2011. The calculations and a discussion of the t-test are included in Appendix D: Calculations.

Table 12. T-test Results

	Composition		Change in			Statistically
Material Class	**2009**	**2011**	**Composition**	**t-Statistic**	**p-Value**	**Significant Change***
Food	5.8%	5.9%	0.1% ⬆	0.1111	0.9115	No
Compostable Paper	1.4%	1.8%	0.3% ⬆	1.1322	0.2578	No
Other Compostable	89.0%	90.2%	1.2% ⬆	1.0548	0.2917	No
Contaminants	3.7%	2.1%	-1.7% ⬇	2.6721	0.0076 *	**Yes**
Total	**100%**	**100%**				
Number of Samples	402	739				

**(Cut-off for statistically significant difference = 0.025)*

Appendix A: Material Type Definitions

Food

1. **Purchased Fruits and Vegetables—**food that comes from a plant but does not appear to have grown on the subscriber's property. Examples include apples, bananas, cucumbers, and other vegetables and fruit. Many purchased fruits and vegetable have adhesive stickers, labels, or other branding marks still on them and are generally larger, of higher quality, and discarded in smaller quantities than homegrown fruits and vegetables. Includes fruit and vegetables in the original or another container when the container weight is less than 10% of the total weight.
2. **Homegrown Fruits and Vegetables—**food that comes from a plant that is growing on or has been cleared from the subscribers' property. Examples will include apples, pears, cucumbers, etc. that have been disposed of in the set-out as a result of falling or pruning from trees and gardens. Homegrown fruits and vegetables do not have labels or other branding marks adhered to them and are frequently discarded in greater quantities than purchased fruits and vegetables. Includes fruit and vegetables in a container when the container weight is less than 10% of the total weight.
3. **Meat—**non-dairy food that comes from an animal. Examples include eggs, fresh meat, bones, cooked meat, and meat scraps. Does not include dairy products such as cheese and milk. Includes meat in the original or another container when the container weight is less than 10% of the total weight.
4. **Dairy—**food that comes from an animal's milk. Examples include cheese, milk, and yogurt. Includes dairy products in the original or another container when the container weight is less than 10% of the total weight.
5. **Mixed/Other Food Scraps—**any food that cannot be put in the above categories. Examples include food items that are a combination of the above categories, as well as coffee grounds, tea packets, grains, crackers, bread, and cereal. Includes food in the original or another container when the container weight is less than 10% of the total weight.

Compostable Paper

6. **Uncoated Paper Bags—**any uncoated bag made of paper. Examples include paper grocery bags, soiled and unsoiled fast food bags, and department store bags if made entirely from paper.
7. **Pizza Boxes—**boxes without a plastic or foil liner that have been used for carrying pizza.
8. **Other Compostable Paper—**includes paper products, not included above, that do not contain a plastic coating. Examples include waxed cardboard boxes, uncoated or waxed paper plates, uncoated or waxed paper containers (such as for fast food), napkins, coffee filters, shredded paper, newspaper (if used to contain food scraps), and paper towels.

Other Compostables

9. **Yard Debris—**includes leaves, grass clippings, sod, garden debris, brush, prunings, logs, soil, and rocks.
10. **Biodegradable Plastic Bags—**plastic bags that are made of materials such as corn starch or soy and are designed to biodegrade or compost. The bags will most likely have the companies' logo including BioBag, Biocorp, Natu-Ur, BioSource, Eco Film/Eco Works, and Bio Tuf.
11. **Other Compostables—**other compostable organic materials, not included above, such as hair, Popsicle sticks, and toothpicks.

12. **Difficult to Compost Materials—**organic items whose durability makes them hard to compost. Examples include wine corks, burlap sacks, pallets, wood crates, and rope.

Contaminants

13. **Milk/Ice Cream Cartons—**bleached polycoated paperboard cartons of various sizes and shapes that contained milk, ice cream, or other liquids. Does not include paper containers with a foil liner or aseptic containers (these will be considered *other recyclable materials)*.
14. **Paper Cups—**all cups designed to be used for beverages or food. Examples include to-go coffee cups, fast food soda cups, and paper picnic cups.
15. **Other Plastic Coated Papers—**food service papers coated with plastic. Examples include some types of fast food wrapping, plastic coated take-out containers, and plastic coated paper plates and bowls.
16. **Other Recyclable Materials—**includes materials normally recycled in curbside collection programs that are not significantly contaminated. Examples include newspapers (not used to contain food waste), newspaper inserts, corrugated cardboard, magazines, phone books, junk mail, chipboard, boxboard, egg cartons, printing and writing paper, scrap iron, aluminum cans, tin cans, plastic tubs, plastic bottle and jars, and glass bottles.
17. **Plastic Bags—**plastic bags that are not made of materials that compost or biodegrade.
18. **Other Materials—**any material that does not fit into the above categories. Examples include textiles, grease, foil lined paper products, Styrofoam, gypsum waste, treated wood, pet waste, stumps, demolition debris, hazardous wastes, plastic cups; and non-recyclable metals, glass, and plastics.

Appendix B: Study Design

This section presents the study plan as it was written prior to collecting and characterizing organics samples.

Objectives

The objective of the 2011 study is to replicate the methodology employed in the 2009 study and compare results with the baseline composition of material collected from organics routes throughout King County established in 2007. This study will also measure set-out and food scrap participation levels.

Summary

Composition, set-out, and food scraps participation data will be collected over three seasons of field work—March, June, and November, 2011. Each field season will last approximately one week and cover 20 randomly selected routes from around the county.

Each season's fieldwork can be broken into two broad elements, with separate work crews dedicated to each: sample collection and sample sorting. Using route data provided by local haulers, 20 random routes will be selected from within King County. Route surveyors will traverse the selected routes recording set-out information for the route as well as collecting material from 12 organics carts for hand sorting. The entire contents of each collected cart constitute a single sample, 12 samples per route, and 20 routes per season for a total of 240 samples per season.

The route surveyors will deliver the samples to the Cedar Grove facility in Maple Valley for hand sorting by a trained sorting crew. Following the sorts, the data will be analyzed to determine the composition of the organics material collected, the number of households that set out the bin for collection, the number that place food in the bin, and the quantity of food scraps set out by each participating household.

This document provides a detailed description of the proposed study methodology. The sampling plan is organized into five sections.

- **Section 1: Study Terms and Definitions—**a list of several unique terms used throughout this document.
- **Section 2: Route Selection—**a description of the method used to define the universe of routes and the random selection process.
- **Section 3: Sample Collection—**the method used to collect random, representative samples.
- **Section 4: Route Data Collection—**a description of the method in which data will be collected along each of the selected routes.
- **Section 5: Sorting Procedures—**a description of the method used to characterize samples.

Section 1: Study Terms and Definitions

This plan includes several unique terms and definitions. Definitions for these terms are provided below.

King County—Refers to King County, excluding Seattle.

Organics Service—For the purposes of this study, *organics service* only includes franchised curbside/alley programs where residents are permitted to combine food scraps and yard debris in a single cart. Table 13 shows the King County cities and regions that are considered to have *organics service*, and those that are not:

Table 13. Cities and Regions with and without Organics Service[2]

Has Organics Service		
Algona	Issaquah	SeaTac
Auburn	Kenmore	Shoreline
Beaux Arts	Kent	Snoqualmie
Bellevue	Kirkland	Tukwila
Black Diamond	Lake Forest Park	Woodinville
Bothell	Maple Valley	Yarrow Point
Burien	Medina	Unincorporated County (except as
Carnation	Mercer Island	noted below)
Clyde Hill	Newcastle	
Covington	Normandy Park	
Duvall	North Bend	**Does Not Have Organics Service**
Des Moines	Pacific	Town of Skykomish
Enumclaw	Redmond	Unincorporated County-Vashon Island,
Federal Way	Renton	Snoqualmie Pass, and Skykomish area
Hunts Point	Sammamish	

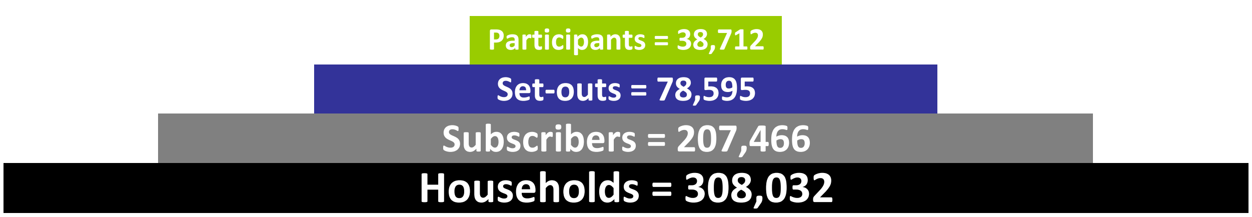
Subscriber—A *subscriber* is a King County household that pays an additional fee for *organics service* or is a household in a city where *organics service* is embedded in the garbage collection service.

Set-Out—A *set-out* is an *organics service* container actually placed out on the curb/alley for pick up by the collection company, regardless of whether is contains food. It is important to distinguish between a subscriber (a household that has *organics service* available to them) and a *set-out* (where the resident uses the service and literally sets out the container for collection).

Food Scraps Participant—A *food scraps participant* is a household that places at least some food scraps in the *organics service* container.

The relationship between the households, subscribers, set-outs, and food scraps participants is shown in Figure 4.

Figure 4. Relationship between Defined Terms



[2]Between the 2009 and 2011 studies, Duvall and Seatac implemented combined organics service collections.

Section 2: Route Selection

All organics service routes in King County are included in the sampling universe. Waste Management, Allied Waste, City of Enumclaw, and CleanScapes provided complete route lists for their respective service areas. The 310 routes were sorted by collection day and five routes per day were randomly selected for sampling using the *=rand()* function in Microsoft Excel.

The routes selected for sampling are listed in Table 14.

Table 14. Randomly Selected Routes for Sampling in 2011

Monday	
Hauler	**Jurisdiction**
Allied	Mercer Island
Allied	Renton
Waste Management	Redmond
Waste Management	Burien
Waste Management	Kirkland

Tuesday	
Hauler	**Jurisdiction**
Waste Management	County
Allied	Des Moines
Allied	Sammamish
Allied	Kirkland
Allied	Bellevue

Thursday	
Hauler	**Jurisdiction**
Allied	Kent
Allied	Snoqualmie
Waste Management	Renton
Waste Management	Redmond
Waste Management	Fed Way

Friday	
Hauler	**Jurisdiction**
Allied	Bellevue
Waste Management	Issaquah
Waste Management	County
CleanScapes	Shoreline
Waste Management	Bothell

Section 3: Route Data Collection

At the start of every sampling day, each route surveyor will receive a route map, driving directions, the route start location, and the count of subscribers along the route. The route surveyors will traverse each of the five routes, one surveyor per route, counting set-outs. An example of the set-out count form is included in Appendix E: Example Field Forms. The route surveyor will begin traversing the route 30 minutes before the hauler begins collection and will run the route in the same order as the hauler. This ensures that the sampler will be sufficiently ahead of the hauler to prevent any disruptions to the collection operations while allowing residents the maximum amount of time to set out their organics containers for counting and collection. Each house along the route with organic material placed at the curb will be considered a set-out, whether the material is in a standard service cart or bundled and bagged in accordance with the hauler's collection guidelines. A household will be considered a single set-out regardless of the actual amount of material set out (multiple carts or bundles at a single address will be considered a single set-out).

Section 4: Sample Collection

The route surveyor will also be responsible for selecting carts for sampling. Using a predetermined sampling interval each route surveyor will collect all material in 12 set-outs each day. The sampling interval is determined using the following procedure:

1. For each sampling day and route, the expected number, *L*, of set-outs will be estimated using route data provided by the haulers. The number *L* is then reduced by one-fifth (producing 0.8 x *L*). This will be done in order to ensure that the targeted number of carts will be selected on each sampling day, even if there are fewer set-outs than expected.
2. Next, the interval *n* will be determined to ensure systematic sampling of carts. If *r* represents the number of samples needed, and .8 x *L* represents the number of expected set-outs, then $n = (.8 \times L) \div r$. Every n^{th} cart will be selected for sampling. To help facilitate this process, the sampling interval will be noted on the set-out count form.

All the material from each cart constitutes a sample. Each sample will be stored and labeled separately. An example sample label is included in Appendix E: Example Field Forms.

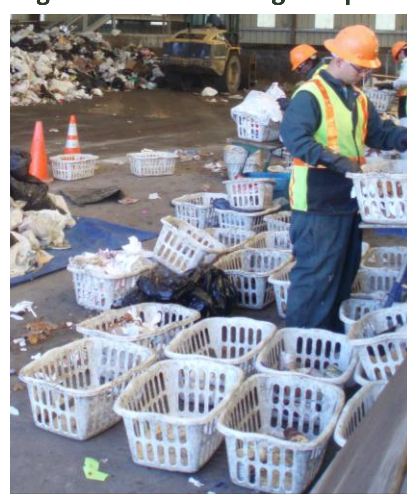
After the route surveyor completes their route they will transport the samples to Cedar Grove for sorting.

Section 5: Sorting Procedures

The consultants will hand-sort samples at the Cedar Grove compost facility in Maple Valley. Approximately 240 samples will be sorted over two days each season. The sorting procedure includes the following four steps.

Step 1: Review methodology and sorting categories with the crew. To provide consistent sorting, Cascadia will use highly trained crewmembers throughout the project. Before the sorting begins all crewmembers will review the procedures, forms, and material definitions in detail.

Figure 5. Hand Sorting Samples



Step 2: Sort Sample. The field crew will sort each sample by hand into the material types defined for the study. See Appendix A: Material Type Definitions, for the complete list of material types. The sorters will place sorted materials in plastic laundry baskets for weighing and recording, one material type per basket. Open laundry baskets will allow the field supervisor to see the material at all times, and to monitor the homogeneity of the baskets as material accumulated, rejecting items that might be improperly classified. Figure 5 shows the sort crew and the laundry baskets.

Step 3: Weigh the Sample. The field crew manager will verify the purity of each material as it is weighed and record the data on the sample tally sheet.

Step 4: Review Data and Clean Site. At the conclusion of each sorting day, the field crew manager will conduct a quality control review of the data recorded while the field crew cleans and organizes the sorting area, returning it to its pre-sort state.

Appendix C. Greenhouse Gas and Cost Implications of Organics Diversion

Cities and counties around Puget Sound have implemented organics service for many reasons including reductions in greenhouse gas (GHG) emissions and costs. This appendix quantifies current and potential GHG reductions and cost savings associated with organics diversion. It is divided into two sections, the first covering current organics programs and the second covering future programs with increased diversion of organics from the disposed waste stream. Each section considers the estimated GHG reductions and cost savings. All GHG reduction calculations are performed using MEBCalc™, a life cycle assessment (LCA) model for measuring the environmental footprint of a community's solid waste management system, from collection through final disposition of each discarded product or packaging material.

Current Organics Service

Greenhouse Gas Emissions Estimates

Measuring or calculating GHG reductions is complicated, however the United Nations Intergovernmental Panel on Climate Change (IPCC) provides some methodological guidelines. This analysis follows the IPCC guidelines and takes into account local conditions (such as local landfill gas management practices and the local power grid) when data are available. Factors incorporated in the GHG analysis include the following:

- Emissions from organics collection vehicles compared to garbage collection vehicles. This assumes a 70%/30% mix between diesel/CNG powered collection equipment.
- Emissions from equipment used to handle materials at compost facilities and landfills.
- Emissions from hauling organics to Cedar Grove composting facility compared to hauling garbage to Cedar Hills landfill. This assumes an average 36 mile round trip for both organics and yard debris. That number is the weighted average distance between the transfer stations and Cedar Hills landfill or Cedar Grove composting.
- Carbon storage in landfills.[3]
- Emissions from petroleum-based fertilizers. (Compost provides a replacement for these fertilizers, decreasing demand and associated embodied emissions.)
- Carbon storage in compost and from applications of compost.
- Ten percent methane oxidation rate of fugitive emissions from landfills.
- Emissions from landfill gas (LFG) to energy projects. This assumes a 90% capture rate for methane at the landfill and energy production at the landfill.

Some of these factors tend to support the case for increasing diversion of organics to compost (increased diversion reduces the use of petroleum based fertilizers, for instance) and some support

[3] MEBCalc™ accounts for carbon storage using data and techniques developed and outlined in Morris, Jeffery. "Bury or Burn North America MSW? LCAs Provide Answers for Climate Impacts & Carbon Neutral Power Potential." *Environmental Science & Technology* 44 (2010): 7944-7949

reduced diversion of organics to compost (landfilling organics can increase electricity generation from captured LFG thus displacing other petroleum based fuels in the power grid).

As shown in Table 15, organics service programs collected nearly 11,700 tons of food and compostable paper and more than 136,000 tons of yard debris during the study period. Compared to landfilling the material, curbside organics service programs reduce emissions by nearly 59,000MTCO2e with current landfill operations (LFG is collected for energy generation).

Table 15. Estimated GHG Reductions from Organics Service

	Curbside Tons Collected	GHG Reduction (MTCO2e)
Yard Waste	136,283	52,601
Food Scraps/Compostable Paper	11,689	6,383
Total	147,972	58,984

Notes: Assumes 90% landfill gas capture

For perspective, more practical measures of the importance of composting include the following:[4]

- The average food scrap participant household sent approximately 1,848 pounds of organics to Cedar Grove in 2011 which reduces their GHG emissions by an estimated 810 pounds for the year. The GHG reductions from this are equivalent to an average King County household reducing vehicle fuel consumption by 4%.
- Each full 96-gallon cart from a food scraps participant reduces GHG emissions by approximately 32 pounds CO2e.

Cost Savings Estimates

Calculating the costs of garbage service and organics service is another very complicated task with a variety of complex variables including subsidies, penalties, incentives, hauling costs, transfer costs, disposal costs, material management costs, product revenues, moisture content, and a host of other factors. A simplified model comparing the tipping costs of organics and garbage makes the following assumptions:

- Hauling costs are the same for both organics and garbage. Whether the material is placed into an organics service cart or a garbage cart, the same total volume and weight of material needs to be hauled requiring the same amount of labor, equipment, and driving.
- Transfer costs, disposal costs, material management costs, and product revenues for the garbage and organics are captured in the different tipping fees charged for those materials.
- The tipping fee for garbage is $117.82 per ton; the tipping fee for organics varies between $60/ton and $82.50/ton. At the time of this report $82.50 per ton is the gate rate for mixed organics at Cedar Grove. Haulers may pay an amount much lower than the gate rate, estimated for this study to be around $60 per ton.
- The effects of subsidies, penalties, and incentives are marginal.

[4] Calculations for these two comparisons can be found in Appendix C: Calculations and are based on data contained in this report, other Solid Waste Division reports, from the U.S. Census, and MEBCalc™, an LCA model for measuring the environmental footprint of a community's solid waste management system, from collection through final disposition of each discarded product or packaging material.

Under these assumptions the cost savings to the solid waste system of the current organics service program vary between $5.3 million if a user pays an $82.50/ton organics tip fee and $8.7 million if a user pays a $60/ton organics tip fee. That is to say users of the solid waste system pay up to $8.7 million less per year with the current level of organics service than they would if there were no curbside organics service. These results are shown in Table 16.

Table 16. Current Organics Program System-wide Cost Savings

	Organics Tip Fees	
	$60.00	**$82.50**
Current program cost savings	$8,752,323	$5,346,455

Future Potential

In 2011 King County single family households landfilled nearly 82,200 tons of yard waste, food, and compostable paper.[5] If subscription rates, set out rates, and food scraps participation rates increase, the quantity of these materials captured in curbside organics programs will likely increase as well. Table 17 shows the additional quantities of these materials composted at Cedar Grove assuming an additional 25%, 50% or 75% of these materials can be diverted from curbside single family residential garbage. Cascadia estimated the additional GHG reductions and costs savings from diverting these additional quantities of materials in the following sections.

Table 17. Single Family Residential Disposed Tons, 2011[6]

	Tons Disposed	Tons Diverted at 25% Diversion	Tons Diverted at 50% Diversion	Tons Diverted at 75% Diversion
Yard Debris	4,572	1,143	2,286	3,429
Food Scraps/Compostable Paper	77,621	19,405	38,811	58,216
Total	**82,193**	**20,548**	**41,096**	**61,645**

Greenhouse Gas Emissions Estimates

Under current landfill operations (LFG to energy), diverting additional quantities from the landfill will reduces GHG emissions and higher levels of diversion lead to greater GHG reductions. As shown in Table 18 diverting to compost an additional 25% of the currently disposed organics results in an estimated GHG reduction of 9,918MTCO2e. Diverting 75% of the currently disposed organics results in an estimated GHG reduction of 29,753MTCO2e. These reductions are on top of the reductions already achieved through current diversion levels. These calculations are based on the same assumptions used in the current program GHG estimates.

[5] From the *2011 King County Waste Characterization and Customer Survey report.*

[6] Food scraps is the sum of *packaged vegetative items*, *unpackaged/scrap vegetative items*, *packaged non-vegetative items*, and *unpackaged/scrap non-vegetative items* from the 2011 waste characterization study. Yard debris is the sum of *yard wastes* and *large prunings* from the 2011 waste characterization study. Compostable paper is the sum of *waxed corrugated cardboard, single use food service compostable paper* and *other compostable paper* in the 2011 waste characterization study.

Table 18. Estimated GHG Reductions from Diverting Additional Materials from the Landfill

	GHG Reduction (MTCO2e)		
	25% Diversion	50% Diversion	75% Diversion
Yard Debris	392	784	1,175
Food Scraps/Compostable Paper	9,526	19,052	28,577
Total	**9,918**	**19,835**	**29,753**

Notes: Assumes 90% landfill gas capture

Cost Savings Estimates

Using the same assumptions as noted in the current program cost savings, if additional organics material is captured from the garbage and diverted to compost the system-wide cost savings may increase by $1.3 million to $6.6 million, depending on organics tipping fees and the amount of increased diversion. That is to say users of the solid waste system may save up to an additional $6.6 million per year with increased level of organics diversion over the current level organics diversion. See Table 19 for a summary of these results.

Table 19. System-wide Cost Savings at Various Levels of Increased Organics Diversion

	Organics Tip Fees	
	$60.00	**$82.50**
Cost savings at 25% increased diversion	$2,188,081	$1,336,614
Cost savings at 50% increased diversion	$4,376,161	$2,673,228
Cost savings at 75% increased diversion	$6,564,242	$4,009,841

Appendix D: Calculations

Estimating Organics Composition

Organics composition estimates were calculated using a method that gave equal weighting or "importance" to each sample. Confidence intervals (error ranges) were calculated based on assumptions of normality in the composition estimates.

In the descriptions of calculation methods, the following variables are used frequently:

- i denotes an individual sample;
- j denotes the material type;
- c_j is the weight of the material type j in a sample;
- w is the weight of an entire sample;
- r_j is the composition estimate for material j (r stands for *ratio*);
- s denotes a particular sector or subsector of the organics stream; and
- n denotes the number of samples in the particular group that is being analyzed at that step.

Estimating the Composition

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

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

where:

- c = weight of particular component;
- w = sum of all component weights;
- for i = 1 to n, where n = number of selected samples; and
- for j = 1 to m, where m = number of components.

For example, the following simplified scenario involves three samples. For the purposes of this example, only the weights of the material type *meat* are shown.

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

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

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

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

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

where:

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

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

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

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

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

Subscription Rate

The subscription rate is calculated by dividing the monthly average number of King County residents with garbage service in the included jurisdictions by the monthly average number of organic service customers in the included jurisdictions. The King County Solid Waste Division (SWD) provided customer number data for the period from January 20011 through December 2011.

$$\textit{average monthly organics customers} \div \textit{average monthly garbage customers} = \textit{subscription rate}$$

$$207{,}353 \div 309{,}505 = 67\%$$

Set-out Rate

The set-out rate is calculated by dividing the total number of subscribers along surveyed routes by the total number of carts set out for collection along surveyed routes. The haulers provided the number of subscribers on a route and the Route Surveyors counted the number of set-outs on a route.

$$\textit{number of set outs on routes} \div \textit{number of subscribers on routes} = \textit{set out rate}$$

$$15{,}015 \div 39{,}635 = 38\%$$

Food Scraps Participation Rate

The subscriber food scraps participation rate is a measure of the people who have signed up for organics service (not all households subscribe to organics service even if it's available) that place food scraps in their cart. The set-out food scraps participation rate is a measure of the number of carts set out for collection that contain food scraps.

The set-out food scraps participation rate is calculated by dividing the total number of samples collected by the number that contained food scraps.

$$364(\textit{samples with food}) \div 739(\textit{total samples}) = 49\%$$

The subscriber food scraps participation rate is calculated by multiplying the set-out food scraps participation rate by the set-out rate. The premise is that we know what percent of set-outs have food scraps and we know what percent of subscribers set-out so the percent of subscribers who participate is the product of those two numbers.

$$38\%(\textit{set out rate}) \times 49\%(\textit{set out participaton rate}) = 19\%$$

Capture Rate

The capture rate is a measure of the amount of food scraps and compostable paper collected per food scraps participant per month in their organics service divided by the amount of food scraps and compostable paper generated per participant per month. The amount of food scraps and compostable paper generated is the sum of food scraps and compostable paper disposed in the garbage and food scraps and compostable paper collected in organics service programs.

The amount of food scraps and compostable paper collected per participant per month in their organics service is calculated from this study's composition data and tonnage. The amount of food scraps and compostable paper disposed per participant per month is provided by the SWD.

The capture rate is

$$c \div (c + d)$$

where:

- c = food scraps and compostable paper collected in organics service programs per participant per month
- d = food scraps and compostable paper disposed per participant per month

Evaluating Changes in the Composition Between Studies

Comparisons examined the changes in the in composition percentages for each of the four material classes. In order to control for population changes and other factors that may influence the total amount of material composted from year to year, the tests described in this appendix measure material proportions, not actual tonnage. For example, say that **Food** accounts for 10% of composted material each year, and that a total of 1,000 tons of material was composted in one year and 2,000 tons composted in the next. While the amount of **Food** increased from 100 to 200 tons, the percentage remained the same. Therefore, the tests would indicate that there had been no change.

The purpose of conducting these comparisons is to identify trends within the organics stream in the percentage of selected types of waste disposed over time. One specific example is stated as follows:

Hypothesis: "There is no statistically significant difference, between the 2009 and 2011 study periods, in the percentage of **Food** composted."

Statistics are then employed to look for evidence disproving the hypothesis. A "significant" result means that there is enough evidence to disprove the hypothesis and it can be concluded that there is a true difference across years. "Insignificant" results indicate that either a) there is no true difference, or b) even though there may be a difference, there is not enough evidence to prove it.[7]

The purpose of these tests is to identify changes across years. However, the study did not attempt to investigate *why* or *how* these changes occurred. The changes may be due to a variety of factors. Future studies could be designed to test the influence of various potential sources of the increase/decrease of specific materials in the disposed waste stream.

Statistical Considerations

The analyses were based on the component percentages, by weight. As described in Appendix D: Calculations, these percentages are calculated by dividing the sum of the selected component weights by the sum of the corresponding sample weights. T-tests (modified for ratio estimation) were used to examine the variations from year-to-year.

[7] Please see the "Power Analysis" discussion on page 27.

Normality

The distributions of some of the material types may be skewed and may not follow a normal distribution. Although t-tests assume a normal distribution, they are very robust to departures from this assumption, particularly with large sample sizes. In addition, the material classes are sums of the material types, which improve our ability to meet the assumptions of normality.

Dependence

There may be dependence between material types (if a person disposes of material A, they always dispose of material B at the same time).

There is certainly a degree of dependence between the calculated percentages. Because the percentages sum to 100 (in the case of year-to-year comparisons) or near 100 (in the case of subpopulation comparisons), if the percentage of material A increases, the percentage of some other material must decrease.

Multiple T-Tests

In all statistical tests, there is a chance of incorrectly concluding that a result is significant. The year-to-year comparison required conducting several t-tests (one for each material class) **each** of which carries that risk. However, we were willing to accept only a 10% chance, **overall**, of making an incorrect conclusion. Therefore, each test was adjusted by setting the significance threshold to $\frac{0.10}{w}$ (*w* = the number of t-tests).

The adjustment can be explained as follows:

For each test, we set a $1-\frac{0.10}{w}$ chance of not making a mistake, which results in a $\left(1-\frac{0.10}{w}\right)^w$ chance of not making a mistake during all *w* tests.

Since one minus the chance of not making a mistake equals the chance of making a mistake, by making this adjustment, we have set the overall risk of making a wrong conclusion during any one of the tests at $\left(1-\left(1-\frac{0.10}{w}\right)^w\right)=0.10$.

The chance of a "false positive" for the year-to-year comparisons made in this study is restricted to 10% overall, or 2.5% for each test (10% divided by the four tests equals 2.5%).

For more detail regarding this issue, please refer to Section 11.2 "The Multiplicity Problem and the Bonferroni Inequality" of *An Introduction to Contemporary Statistics* by L.H. Koopmans (Duxbury Press, 1981).

Power Analysis

As the number of samples is increased, so is the ability to detect differences. In the future, an a *priori* power analysis might benefit this research by determining how many samples would be required to detect a particular minimum difference of interest.

Interpreting the Calculation Results

For the purposes of this study, only those calculation results with a p-value of less than 2.5% are considered to be statistically significant. As described above, the threshold for determining statistically significant results (the "alpha-level") is conservative, accounting for the fact that so many individual tests were calculated. An asterisk notes the statistically significant differences.

The t-statistic is calculated from the data. According to statistical theory, the larger the absolute value of the t-statistic the less likely that the two populations have the same mean. The p-value describes the probability of observing the calculated t-statistic if there were no true difference between the population means.

GHG Calculations

The following several tables illustrate the calculations and sources used in Appendix C. Greenhouse Gas and Cost Implications of Organics Diversion.

As shown in Table 20 the average food scraps participant composts approximately 604 pounds of food scraps and compostable paper per year. The data in this table is compiled from elsewhere in this report.

Table 20. Annual Pounds of Food Scraps and Compostable Paper per Food Scraps Participant

Annual tons food scraps and paper composted	11,689
Number of participants	38,712
Annual pounds food scraps and paper composted per participant	**604**

As shown in Table 21 the average organics service subscriber composts approximately 1,244 pounds per year of yard debris. The data in this table is compiled from elsewhere in this report.

Table 21. Annual Pounds of Yard Waste per Subscriber

Tons yard debris composted annually	136,283
Number of subscribers	207,466
Pounds yard debris composted annually per subscriber	**1,244**

Table 22 shows the sum of materials composted per participant per year, 1,848 pounds. This is the sum of the composted food scrap, compostable paper, and yard debris amounts.

Table 22. Annual Pounds of Diverted Compostables per Food Scraps Participant

Annual pounds of compostables per food scraps participant	**1,848**

Table 23 illustrates the pounds of emitted CO_2e avoid by organics participants each year. Data used in this calculation is from Table 20, Table 21, and MEBCalc^{TM}, an LCA model for measuring the environmental footprint of a community's solid waste management system, from collection through final disposition of each discarded product or packaging material.

Table 23. Pounds of CO2e Avoided Annually from Composting

	Pounds Composted per Household per Year	Pounds CO2e Avoided per Ton Composted	Pounds CO2e Avoided Annually from Composting
Yard Debris	1,244	772	480
Food Scraps and Compostable Paper	604	1,092	330
Totals	**1,848**		**810**

As shown in Table 24 the average King County family emits nearly 9.2MTCO2e annually from their vehicles. This converts to nearly 20,300 pounds CO2e annually. Data in this table come from the U.S. Census and MEBCalc™.

Table 24. Average CO2e Emitted from Vehicle Fuel Consumption

Per capita annual MTCO2e emitted from vehicle fuel consumption	4.0
Average King County household size	2.3 people
Average per household MTCO2e emitted from vehicle fuel consumption	**9.2**

The conversion from MTCO2e to pounds CO2e is shown in Table 25.

Table 25. Conversion Factor from Metric Tons to Pounds

Pounds per metric ton	2,204.6
Average per household pounds CO2e emitted from vehicle fuel consumption	**20,283**

As shown in Table 26 the CO2e emissions avoided through composting by the average participant are equivalent to a household reducing their annual motor vehicle fuel consumption by four percent. Data in this table is compiled from Table 23 and Table 25.

Table 26. Vehicle Emission Reduction Equivalency

Pounds CO2e avoided by composting	810
Average per family pounds CO2e emitted from vehicle fuel consumption	20,283
Percent emissions reduction equivalent	**4%**

As shown in Table 27 each food scraps participant's full organics service cart avoids more than 32 pounds CO2e. Data in this table is compiled from elsewhere in this report and from MEBCalc™.

Table 27. Pounds CO2e Avoided per Organics Service Cart

	Average Weight in Full Organics Cart (pounds)	Pounds CO2e Avoided per Ton Composted	Pounds CO2e Avoided per Full Organics Cart
Yard Debris	65.3	772	25.2
Food Scraps and Compostable Paper	13.4	1,092	7.3
Totals	**78.8**		**32.6**

Appendix E: Example Field Forms

This appendix contains examples of the field forms used throughout the study, including:

- Route count form
- Sample placard
- Sample tally sheet

Scalehouse Vehicle Selection Sheet

King County Waste Monitoring Study
Set Out and Participant Count Form

Day: ______________________ **Route:** ______________

Hauler: ______________________ ***n*=** ______________

Jurisdiction: ________________________________

1. Cross off one number from the set out column for each set out
2. Once the circled interval is reached, cross off the number and take the entire set out as a sample.
3. Once all 12 samples are collected, continue counting set outs until the entire route has been driven.

Set Outs																			
1	2	3	4	5	6	7	8	9	10	451	452	453	454	455	456	457	458	459	460
11	12	13	14	15	16	17	18	19	20	461	462	463	464	465	466	467	468	469	470
21	22	23	24	25	26	27	28	29	30	471	472	473	474	475	476	477	478	479	480
31	32	33	34	35	36	37	38	39	40	481	482	483	484	485	486	487	488	489	490
41	42	43	44	45	46	47	48	49	50	491	492	493	494	495	496	497	498	499	500
51	52	53	54	55	56	57	58	59	60	501	502	503	504	505	506	507	508	509	510
61	62	63	64	65	66	67	68	69	70	511	512	513	514	515	516	517	518	519	520
71	72	73	74	75	76	77	78	79	80	521	522	523	524	525	526	527	528	529	530
81	82	83	84	85	86	87	88	89	90	531	532	533	534	535	536	537	538	539	540
91	92	93	94	95	96	97	98	99	100	541	542	543	544	545	546	547	548	549	550
101	102	103	104	105	106	107	108	109	110	551	552	553	554	555	556	557	558	559	560
111	112	113	114	115	116	117	118	119	120	561	562	563	564	565	566	567	568	569	570
121	122	123	124	125	126	127	128	129	130	571	572	573	574	575	576	577	578	579	580
131	132	133	134	135	136	137	138	139	140	581	582	583	584	585	586	587	588	589	590
141	142	143	144	145	146	147	148	149	150	591	592	593	594	595	596	597	598	599	600
151	152	153	154	155	156	157	158	159	160	601	602	603	604	605	606	607	608	609	610
161	162	163	164	165	166	167	168	169	170	611	612	613	614	615	616	617	618	619	620
171	172	173	174	175	176	177	178	179	180	621	622	623	624	625	626	627	628	629	630
181	182	183	184	185	186	187	188	189	190	631	632	633	634	635	636	637	638	639	640
191	192	193	194	195	196	197	198	199	200	641	642	643	644	645	646	647	648	649	650
201	202	203	204	205	206	207	208	209	210	651	652	653	654	655	656	657	658	659	660
211	212	213	214	215	216	217	218	219	220	661	662	663	664	665	666	667	668	669	670
221	222	223	224	225	226	227	228	229	230	671	672	673	674	675	676	677	678	679	680
231	232	233	234	235	236	237	238	239	240	681	682	683	684	685	686	687	688	689	690
241	242	243	244	245	246	247	248	249	250	691	692	693	694	695	696	697	698	699	700
251	252	253	254	255	256	257	258	259	260	701	702	703	704	705	706	707	708	709	710
261	262	263	264	265	266	267	268	269	270	711	712	713	714	715	716	717	718	719	720
271	272	273	274	275	276	277	278	279	280	721	722	723	724	725	726	727	728	729	730
281	282	283	284	285	286	287	288	289	290	731	732	733	734	735	736	737	738	739	740
291	292	293	294	295	296	297	298	299	300	741	742	743	744	745	746	747	748	749	750
301	302	303	304	305	306	307	308	309	310	751	752	753	754	755	756	757	758	759	760
311	312	313	314	315	316	317	318	319	320	761	762	763	764	765	766	767	768	769	770
321	322	323	324	325	326	327	328	329	330	771	772	773	774	775	776	777	778	779	780
331	332	333	334	335	336	337	338	339	340	781	782	783	784	785	786	787	788	789	790
341	342	343	344	345	346	347	348	349	350	791	792	793	794	795	796	797	798	799	800
351	352	353	354	355	356	357	358	359	360	801	802	803	804	805	806	807	808	809	810
361	362	363	364	365	366	367	368	369	370	811	812	813	814	815	816	817	818	819	820
371	372	373	374	375	376	377	378	379	380	821	822	823	824	825	826	827	828	829	830
381	382	383	384	385	386	387	388	389	390	831	832	833	834	835	836	837	838	839	840
391	392	393	394	395	396	397	398	399	400	841	842	843	844	845	846	847	848	849	850
401	402	403	404	405	406	407	408	409	410	851	852	853	854	855	856	857	858	859	860
411	412	413	414	415	416	417	418	419	420	861	862	863	864	865	866	867	868	869	870
421	422	423	424	425	426	427	428	429	430	871	872	873	874	875	876	877	878	879	880
431	432	433	434	435	436	437	438	439	440	881	882	883	884	885	886	887	888	889	890
441	442	443	444	445	446	447	448	449	450	891	892	893	894	895	896	897	898	899	900

Totals: SO ________ Samples ________

Sampler ________ Day ________ Route ________

Sample Placard

DAY: **M** HAULER: **KM** ROUTE: **1342**	SAMPLE ID: 181 Bundle ____ of ____	SAMPLER: GV
JURISDICTION: **Unincorporated South County**		

Hand-sort Data Entry Sheet

King County Waste Monitoring Study
Sample Tally Sheet

Food	Wt.1	Wt.2	Wt.3	Wt.4
Fruits and Vegetables				
Homegrown Fruits and Vegetables				
Meat				
Dairy				
Mixed/Other Food Scraps				

Compostable Paper	Wt.1	Wt.2	Wt.3	Wt.4
Uncoated Paper Bags				
Pizza Boxes				
Other Compostable Paper				

Other Compostable	Wt.1	Wt.2	Wt.3	Wt.4
Yard Debris				
Biodegradable Plastic Bags				
Other Compostables				
Difficult to Compost Materials				

Contaminants	Wt.1	Wt.2	Wt.3	Wt.4
Milk/Ice Cream Cartons				
Paper Cups				
Other Plastic Coated Papers				
Other Recyclable Materials				
Plastic Bags				
Other Materials				

Sample ID: ______________________________

Day: ______________________________

Hauler: ______________________________

Jurisdiction: ______________________________

Route: ______________________________

Sampler: ______________________________

Volume: ______in. x ______ in. x ______ in.

Notes: