2018 WASTE CHARACTERIZATION STUDY
REGIONAL DISTRICT OF FRASER-FORT GEORGE

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Executive Summary

Characterization of solid waste provides important information about the composition of waste generated by residential, commercial, industrial and institutional sources and is a useful tool for the Regional Waste Management Planning. The studies conducted are useful for managing waste flows, understanding waste generation, and aid in the development and implementation of waste reduction strategies. The RDFFG is responsible for managing the solid waste produced within its boundaries and recognizes the value of conducting a waste characterization study in assessing the effectiveness of the current Solid Waste Management Plan.

A waste characterization study was conducted to create an interpretation of the overall composition of waste generated within the RDFFG and was undertaken at the Foothills Boulevard Regional Landfill in the City of Prince George, BC. The results from the study are presented in two (2) reports, one covers the entire Regional District and one that focused on the City of Prince George's automated curbside collection of single family residential garbage. The results from this report summarizes the data for the entire RDFFG that was conducted in 2018. The 2018 Waste Characterization Study of the RDFFG provides an update to the previous studies completed in 2007 and 2013.

The Study was completed at the Foothills Boulevard Regional Landfill between 11 and 22 June 2018. A total of fifty-six (56) waste samples, each weighing approximately 100 kg were collected and analyzed. Each sample was classified according to one of the five (5) following sources: Single Family Residential curbside, Rural Transfer Station, Self-haul Residential, Self-haul Commercial, Industrial, Commercial and Institutional. All samples were weighed and sorted into twelve (12) Primary categories, forty-five (45) Secondary categories and fifty-eight (58) Tertiary categories. The mass of each category was recorded and used to calculate the sample composition. The data was subjected to statistical analysis to determine the mean and standard deviations.

The Primary category constituting the greatest mass was compostable organics with a mass percent representing 30.21% of the total waste sorted. The second largest Primary category was plastic, comprising a mean composition of 16.88%, followed by paper at 15.84%. Collectively, organics, plastic and paper represented over half of the waste delivered to the Foothills Boulevard Regional Landfill. The next largest waste constituents were non-compostable organics comprising a mean composition of 10.91% followed by building materials with a mean composition of 9.59%. The remainder of the Primary categories (i.e. glass, metals, electronic waste, household hazardous waste, household hygiene, bulky objects and fines) each comprised approximately 4% or less of the total waste stream.

The three largest waste categories from single-family residential waste were compostable organics, paper and plastics. Compostable organics made up the largest quantity at 46.40%, followed by plastic at 18.08% and paper at 15.96%. In total, compostable organics, paper and plastics made up 80.43% or over three-quarters of single-family residential waste entering the Foothills Boulevard Regional Landfill.

Due to the expansive area for which the RDFFG has waste collection responsibility for rural transfer stations and are recognized as a significant source of waste delivered to the landfill. In general, paper, plastics, and compostable organics collectively made up the largest portion of waste for single-family

residential, transfer station, institution, commercial, and industrial sources. Self-haul residential or commercial wastes contained significant quantities of building material and non-compostable organics as they typically are associated with renovation and construction activities.
The RDFFG maintains an extensive system for collecting recyclables. A sub-group of the recyclable waste products is regulated under the Recycling Regulation and is subject to specific BC Product Stewardship Programs (currently referred to as the Extended Producer Responsibility (EPR) programs) which direct the responsibility for reuse, recycling and disposal of specific consumer products to manufacturers and their customers. In this Study, electronic waste, small appliances and refundable beverage containers constituted the majority of product waste delivered to the landfill. Combined, all EPR waste categories comprise approximately 2.73% of the total mass of waste sorted.

The Primary and Secondary category data was subjected to statistical analysis using the provincial waste characterization tool to determine the means and standard deviations of each of the categories. The standard deviations of waste within each of the Primary categories calculations indicated a fairly good consistency for the residential samples. The residential waste samples were from all five garbage collection zones in the City of Prince George, each of which would be expected to have a similar waste composition.

The waste composition for the ICI sector shows a higher standard deviation for all Primary waste categories than the residential sector. Higher standard deviations are expected for the ICI sector because the Primary sources can be vastly different. In addition, each delivery may contain waste from several Primary sources, but the load is not necessarily well mixed.

The standard deviations for the majority of categories from the self-haul waste are large. This is due to having a significant number of the samples from the self-haul sector containing waste from only a few Primary categories. A large confidence interval does not necessarily indicate that the data is unreliable; instead, it can indicate that the data from a particular sector is highly variable depending on the source with different sub-sectors producing different types of waste.

When the data was compared to the 2013 study, the greatest changes in waste composition were observed in plastic waste which saw an increase of almost 3.67% since the 2013 study and building materials had a significant decrease of 3.05%. Paper saw a decrease of 2.08% from the 2013 17.50% to 15.42%.

NOTE TO THE READER

The samples collected and audited for this study are “snapshots” in time, meaning the reported quantities are estimates and only represent the conditions for the period of time in which they were collected. Seasonal and annual variability, weather, and other factors can affect the amount and composition of waste and recyclables generated by the various sectors at any given time.

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1.0 Introduction

TRI Environmental Consulting Inc. (TRI), a Canadian Construction Materials Engineering & Testing Inc. (CCMET) company, is pleased to present the findings of the Waste Characterization Study ("the Study") conducted at the Foothills Boulevard Regional Landfill (the "FBR Landfill"), located at 6595 Foothills Boulevard, Prince George, BC. ("the Site"). The project was completed for the Regional District of Fraser-Fort George (RDFFG) and the results are presented in this report as well as a report on the City of Prince George's automated curbside collection of the single family residential garbage.

The assessment of the overall composition of waste generated within the RDFFG was undertaken with samples collected at the FBR Landfill which serves a population of approximately 106,000 residents across four (4) municipalities and seven (7) electoral areas. The FBR landfill receives materials from municipal and commercial collection services, outlying rural transfer stations, the general public, and regional area contractors.

1.1 Objective

The purpose of the Study was to provide current data on the composition of the Municipal Solid Waste (MSW) within the RDFFG in order to extrapolate and determine the overall waste composition for the FBR Landfill and determine the effectiveness of the present waste diversion and reduction strategies.

The Study will also be used as a tool for Solid Waste Management Planning, including determining any changes in the waste composition since the implementation of expanded stewardship programs in the region, and to identify the improvements and changes in recycling behaviour.

1.2 Definitions / Terminology

During the waste composition analysis, the "as received" wet mass of the waste samples and compositions were recorded.

In this report, "hauler" refers to the vehicle delivering the waste, "load" refers to the total amount of waste contained in a hauler truck, "sample" refers to the portion of the load that was sorted and weighed, and "load source" refers to the origin of a specific sample.

2.0 Methodology

The Waste Characterization Reports prepared by TRI in 2007 and 2013 were used as a baseline for comparison and the methodology used was derived from the new draft "Waste Characterization Tool" developed by the Ministry of Environment in 2012.

2.1 Design of the Sampling Program

The sampling program for the waste composition monitoring was based on industry accepted techniques, [1,2,3] previous experience gained by TRI, with modifications made according to the requirements of the

[1] SENES Consultants Ltd., April 30, 1999. *Recommended Waste Characterization Methodology for Direct Waste Analysis Studies in Canada*, 39 pp.

[2] Ministry of Environment, Lands and Parks, November, 1991. *Procedural Manual for Municipal Solid Waste Composition Analysis*.

[3] TRI Environmental Consulting Inc., May 14, 2012. Solid Waste Characterization Studies: Standardized Spreadsheet Tool For Assisting In The Planning, Execution And Reporting For Solid Waste Characterization Studies (Draft Version) prepared for the BC Ministry of Environment.

present Study. The design of the sampling program was consistent with the proposal[4] prepared by TRI, which provided a work plan and a detailed waste source allocation list identifying the number of waste samples to be sorted by source category at the FBR Landfill. Samples were collected from five (5) different sources of municipal waste.

2.2 Load Source and Sample Acquisition

Municipal solid waste received at the FBR Landfill is classified as originating from one (1) of the following five (5) sectors:

- Single-family residential curbside collection (SFRES)
- Rural transfer stations (RTS)
- Self-haul; residential (SHRES)
- Self-haul; commercial (SHICI)
- Commercial ICI (ICI)

Collection of SFRES, RTS, and ICI loads are sent directly to the landfill face, while self-haul loads are delivered either to the landfill face or to a series of forty-yard bins for self-hauled drop-off. To obtain a sample from SFRES, RTS, and ICI waste, the hauler would unload as a received source at the landfill face. The team of auditors collected a sample portion of the load that was dropped at the landfill face and brought it to the sort area. The sort supervisor confirmed the truck number and the source of a given load with the driver of the load and randomly selected samples from the dropped material. A ticket indicating the net mass of the load was collected from the scale house operator at the end of the day.

In order to safely sample self-haul residential, the scale house arranged for all self-haul loads to be transported to the landfill face where samples were collected by the sort supervisor. The sort supervisor randomly selected a sample from each self-haul load once permission to analyze the waste was obtained from the customer. The load mass was recorded at the scale house, and this information was obtained by the sort supervisor at the end of each day.

Every effort was made to randomly select loads for sampling; however, at times when only a small number of vehicles were arriving at the facility, any available load was selected for sampling. A description of the waste source, including originating sector, and how the samples were obtained from the waste haulers is outlined in Table 1.

[4] TRI Environmental Consulting Inc., March 26, 2018. *Response to Request for Proposal ES-18-04 2018 Waste Characterization Study (RFP ES-18-04).*

Table 1 – Solid Waste Source Definition and Methodology for Sampling

Solid Waste Source	Category Description and Sampling Method
Single Family Residential	**Description** • The city of Prince George hauled municipal loads from regular residential curbside pick-up routes where waste is collected using roll off carts • Primarily detached single-family and duplex homes **Sample Collection** • Haulers identified to meet the definition above were sampled randomly • Haulers identified what coloured zone was serviced during sample collection SFRES waste is collected from the curbside residential sector and is delivered to the landfill by garbage trucks as part of the automated collection system. There are five (5) separate garbage collection areas or zones (Appendix I). Pickup is scheduled such that each area is serviced once every week. An equal number of samples from SFRES waste were collected each day resulting in samples uniformly sourced from all zones of the City garbage collection plan.
Rural transfer stations	**Description** • Transfer stations included: Bear Lake, Berman Lake, Buckhorn, Chief Lake, Summit Lake, West Lake, Willow River, Hixon, McLeod, Miworth, Cummings Road, Dunster, McBride, Shelley, Valemont and Vanway • Waste is collected in a self-drop-off Transtor or PL6 bins located at the transfer stations **Sample Collection** Scale operators were asked to notify the TRI Site Supervisor when haulers carrying waste from RTS arrived. Once the truck emptied the load at the landfill face, the waste team sampled a portion of the waste.
Self-haul Residential and Self-haul Commercial	**Description** • Load < (less than) 1,000 kg • Pick-up trucks or vehicles with trailers • Non-account residential AND non-account commercial drop-off **Sample Collection** Haulers were identified by random selection at the scale house. The selected drop-off customers were asked the following questions: Hi, I'm conducting a survey to help the RDFFG implement better waste management programs. Is it okay if I ask you two (2) short questions? 1. Was this waste generated at a single-family residential, multi-family residential, or commercial property? 2. What kind of activity generated the waste (e.g., renovation/demolition, bulky object clean-up, moving clean-up, or special social event/party)? The scale house at the landfill arranged for all self-haul and commercial loads to be dumped into 40-yard containers which were then transported to the landfill face where samples were collected by the waste team. The sort supervisor randomly selected a sample from each self-haul load once permission to analyze the waste was obtained from the customer. The load mass was recorded at the scale house, and this information was obtained by the sort supervisor at the end of each day.
Industrial, Commercial, and Institutional	**Description** Waste delivered to the landfill face by contractors collecting garbage from bins or dumpsters located at light industrial, commercial and institutional facilities. **Sample Collection** Haulers identified to meet the definition above were sampled randomly.

2.3 Waste Characterization Categories

Waste was characterized into twelve (12) Primary categories, forty-five (45) Secondary categories, and fifty-eight (58) Tertiary categories. Refer to Table 4 for the waste categories and characterization.

- Primary categories included paper, plastics, compostable organics, non-compostable organics, metals, glass, building materials, electronic waste, household hazardous waste (HHW), household hygiene, bulky objects and fines (used for items that were aggregates of several categories of waste but were too small or indistinguishable to separate).

- Secondary categories further divided the Primary categories into materials that are commonly found in municipal waste.

- Tertiary categories were used to further segregate the waste into more specific categories.

2.4 Waste Sorting Methodology

Waste material from source loads were sampled by the waste team and brought to the waste sorting area. The sorting station was set up under a portable canopy tent to protect the samples from any added water content due to precipitation. The sorting was performed by two (2) waste technicians and the sort supervisor, all of whom were trained in the sorting method to identify and separate waste items into the various waste categories and place them in the appropriate categorized 26-litre plastic bins.

The waste pile was first visually inspected by the sort supervisor to confirm the source of waste and to ensure no cross-contamination from other waste had occurred. Materials were randomly collected using 77-litre plastic garbage cans from all sides of the waste pile to acquire the most representative sample. Large items in a sample were weighed directly on a calibrated electronic weigh scale and then discarded back onto the waste pile. The filled garbage cans were weighed to confirm 100 kg ± 5kg of sample acquisition.

The bins were arranged around the sort table such that they were readily accessible. The sort supervisor watched for items placed into incorrect bins and assisted in categorizing unusual items. When possible, food waste in containers was separated and sorted accordingly. Items that contained multiple components that could not be separated, such as metal and plastic, were placed into bins representing the material with the highest weight content.

After the contents of the sample were sorted, each bin was weighed individually using the electronic scale and the data recorded on the waste categorization field sheet.

Selected photographs taken during the waste sorting operations are provided in Appendix III.

2.5 Health and Safety

TRI developed a Health and Safety Plan (HASP) specifically for the Study at the FBR Landfill and ensured that the sort supervisor and all waste technicians received health and safety training to manage hazards associated with sorting waste as well as site-specific hazards.

The most important safety issue at the facilities was vehicular traffic. Visual contact with drivers was maintained when working around vehicles. Workers at the site were provided with appropriate personal protective equipment (PPE).

Other specific health and safety measures implemented included:

- All workers were required to have up-to-date tetanus shots.
- Sharp objects (i.e. straight razors, syringes and broken glass) in the waste presented a significant hazard which was occasionally hidden and mixed with other wastes.
- Tongs were used to sort through waste if medical waste or signs of sharps were identified in the samples.
- Syringes and needles were immediately placed in a medical waste container upon discovery.

2.6 Data Analysis

Data entry and data analysis for the Study was performed at the TRI office.

Raw data was entered into a British Columbia Ministry of Environment spreadsheet tool for facilitating waste characterization studies.

The weighted mean compositions for all categories (Primary, Secondary, and Tertiary) for each waste category and source were calculated for the waste, including determining standard deviations about the means. Additionally, TRI employed basic statistical methods to derive quantitative information from the data.

Appendix II provides a detailed description of the calculations used to arrive at the results presented in this report.

2.7 Quality Assurance and Quality Control Procedures

In addition to the methods described above, a quality control program was undertaken during the Study to ensure accurate results.

In the field, raw waste composition data was reviewed on a daily basis following the sorts. This review allowed the sort supervisor to determine if items had been omitted from the data sheets. All samples were weighed at the beginning before any sorting occurred, and then again at the end to ensure all material was accounted for.

In the office, staff reviewed the accuracy of 100% of the data that was transcribed into spreadsheet format. The accuracy of all data was reviewed by calculating the difference between the sum of the sorted category masses and the unsorted sample mass. Data entry corrections were made as necessary for the samples exhibiting discrepancies greater than 5% of the unsorted sample mass.

3.0 Results

The results of the analysis of the data collected in this Study are presented in the sections below, including the composition of waste from all sectors coming into the FBR Landfill by waste category and a breakdown for each waste generating sector.

3.1 Sample Source and Distribution

Fifty-six (56) waste samples, with an approximately combined mass of 6,003 kg, were sorted between 11 and 22 June 2018 as part of the Study. The samples were comprised of the following:

- twenty (20) SFRES
- thirteen (13) RTS
- six (6) SHRES
- five (5) SHICI
- twelve (12) ICI

The mean sample size was approximately 107.31 kg, consistent with the recommended sample size of 100 kg.

The data presented below is based on the waste source categories outlined in the following table:

Table 2 – Number of Samples and Total Mass Sorted

Waste Source	Number of Samples Sorted	% of Samples	Total Mass Sorted (kg)	Tonnes Total Waste Buried in 2017
Single-family residential	20	36%	2,189	15,505
Rural transfer stations	13	23%	1,362	7,800
Self-haul; residential	6	9%	657	6,425
Self-haul; ICI	5	21%	529	15,578
Commercial (ICI)	12	11%	1,272	27,715
Total	**56**	**100%**	**6,009**	**73,023**

3.2 Overall Waste Composition by Category

The average waste composition was calculated using the tonnage that each waste sector contributed to the total tonnes of waste buried at the FBR Landfill in 2017. All averages were calculated by taking into account the mass percentage of waste buried that contributed to the overall waste stream characterization. Two (2) averages were calculated and are presented in Table 3 and Table 4:

- The first average is based on the tonnage percentage each sector contributed to the total tonnage of waste buried in 2017.
- The second average excluded the contributions from the SHICI sector, as this sector is primarily demolition and land clearing (DLC) waste and this waste source is expected to be highly variable depending on the season. Therefore, the samples completed during this study do not fully characterize this waste stream.

The Primary category constituting the greatest mass was compostable organics with a mass percent representing 30.21% of the total waste sorted. The second largest Primary category was plastics, comprising a mean composition of 16.88%, followed by paper at 15.84%. Collectively, paper, plastic and organics make up over half of the waste delivered to the FBR Landfill.

The next largest waste constituents were non-compostable organics comprising a mean composition of 10.91% followed by household hygiene and building material with a mean composition of 4.91% and 9.5%, respectively.

The remainder of the Primary categories (i.e. glass, metals, electronic waste, household hazardous waste, bulky objects and fines) each comprised approximately 4% or less of the total waste stream.

The data is summarized below in Table 3 and presented graphically in Figure 1.

Table 3 – Mean Primary Category Distribution

Category	All Sources[5]	All Sources[6]	Kg waste generated/capita[7]
Compostable Organics	30.21%	32.83%	208.27
Plastic	16.88%	17.97%	116.04
Paper	15.84%	15.42%	109.14
Non-Compostable Organics	10.91%	11.06%	75.21
Building Materials	9.59%	5.15%	66.17
Household Hygiene	4.91%	5.36%	33.85
Metals	3.18%	3.31%	21.92
Electronic Waste	2.58%	2.82%	17.75
Glass	2.14%	1.97%	14.71
Bulky Objects	1.95%	2.14%	13.47
Household Hazardous (HHW)	0.91%	1.00%	6.23
Fines	0.90%	0.97%	6.19
	100.00%	**100.00%**	**688.95**

[5] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2017 at the Foothills Boulevard Regional Landfill

[6] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2017 at the Foothills Boulevard Regional Landfill, excluding tonnage from the SHICI sector

[7] Kg/capita is based on the population estimate of 106,000 in the RDFFG in 2017

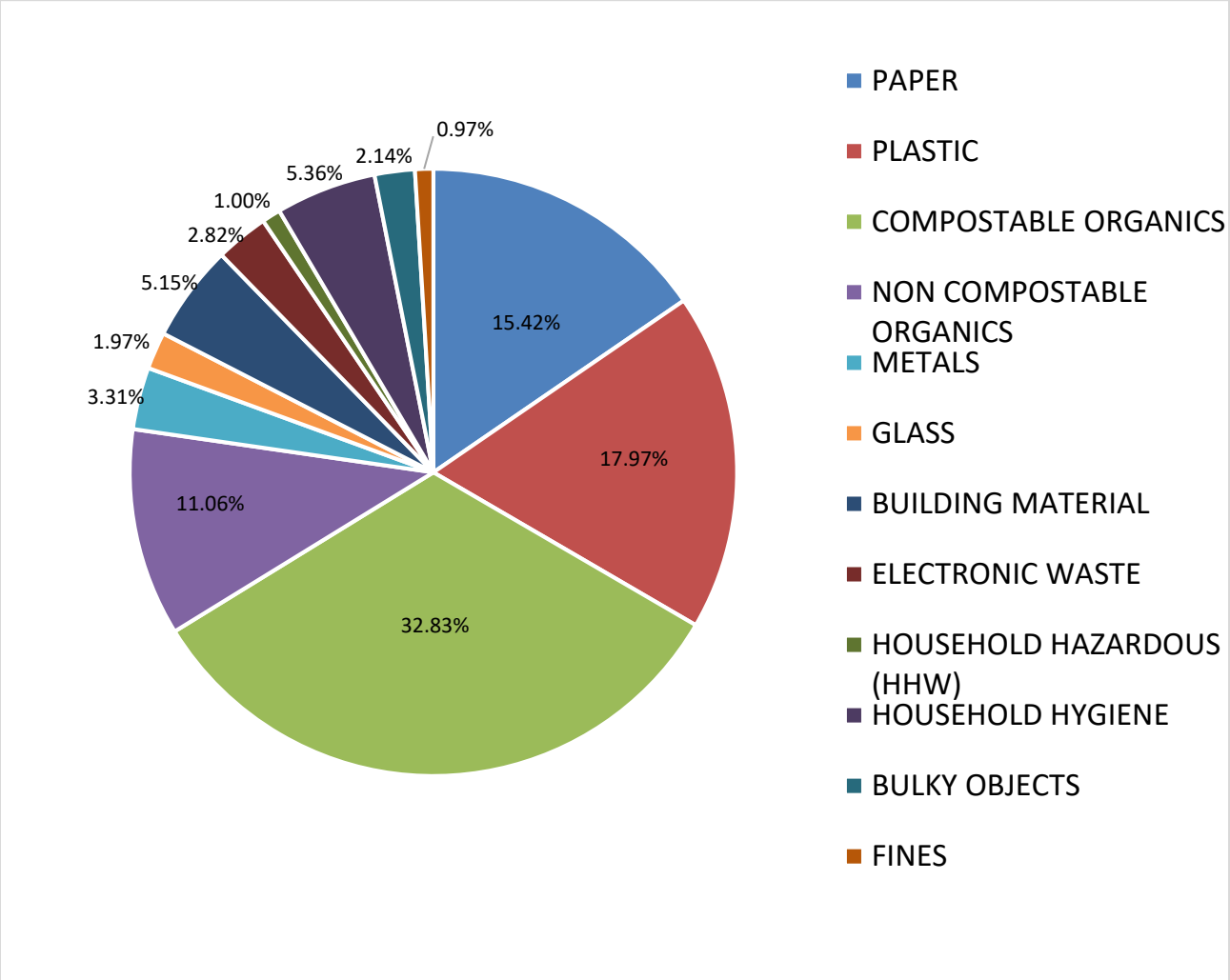

Figure 1: Mean Primary Waste Category Composition - All Sectors Excluding SHICI

3.3 Waste Composition by Sector

Table 4 presents the waste composition as a percentage of all categories for the SFRES, RTS, SHRES, SHICI and ICI sectors. The average compositions are based on the tonnage each sector contributed to overall waste buried at the FBR Landfill in 2017.

The calculation method is given in Appendix II.

Note: all percentages in the following sections are of cumulative total sample weight content.

Table 4 – Composition of Primary, Secondary, and Tertiary Categories from all Sectors

Primary	Secondary	Tertiary	Average[8]	Average[9] (excl. SHICI)	SFRES	RTS	SHRES	SHICI	ICI
PAPER		Subtotal	15.8%	15.4%	16.0%	17.0%	7.3%	20.2%	17.0%
	Fine, computer, office		4.6%	4.9%	4.3%	4.0%	2.6%	2.0%	7.9%
	OCC	Clean OCC	1.5%	1.5%	1.4%	2.2%	0.6%	2.1%	1.3%
		Waxed and other non-recyclable OCC	0.2%	0.2%	0.0%	0.1%	0.0%	0.0%	0.7%
	Boxboard		4.3%	3.2%	3.7%	4.2%	1.2%	15.7%	2.5%
	Bound paper products (books)		1.0%	1.1%	2.0%	0.6%	0.2%	0.0%	0.5%
	Beverage containers - Drink Box / Aseptic Containers (Tetra)	Dairy or Dairy Substitute	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
		Non-Dairy (refundable)	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
	Tissue / Paper Towels, other paper (food contaminated paper, paper plates, etc.)		4.0%	4.4%	4.3%	5.6%	2.6%	0.4%	4.1%
PLASTIC		Subtotal	16.9%	18.0%	18.1%	19.4%	9.7%	5.6%	20.5%
	Film		6.6%	6.8%	6.3%	6.7%	1.8%	4.3%	10.5%
	Textiles	Clothing (natural fibers, blends, polyester, Gore-Tex, fleece, nylon, etc.)	2.6%	2.9%	4.3%	2.5%	3.5%	0.1%	0.4%
	Rigid Beverage Containers	Deposit Containers (juice, pop, alcohol)	0.2%	0.2%	0.2%	0.3%	0.1%	0.2%	0.3%
		Non-Deposit (milk/milk substitute)	0.2%	0.2%	0.2%	0.3%	0.1%	0.0%	0.3%
	Rigid containers - All others	#1 PETE; #2 HDPE; #3 PVC; #4 LDPE; #5 PP; #6 Non-Foam/Foam; #7 Mixed Resin Plastic	4.0%	4.3%	4.6%	5.3%	1.7%	0.8%	4.0%
	Other Plastics	Durable products, toys, etc.	3.2%	3.5%	2.5%	4.3%	2.5%	0.2%	5.0%

[8] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2017 at Foothills Boulevard Regional Landfill

[9] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2017 at Foothills Boulevard Regional Landfill, excluding tonnage from the SHICI sector

Table 4 – Composition of Primary, Secondary, and Tertiary Categories from all Sectors

Primary	Secondary	Tertiary	Average[8]	Average [9] (excl. SHICI)	SFRES	RTS	SHRES	SHICI	ICI
COMPOSTABLE ORGANICS		Subtotal	30.2%	32.8%	46.4%	28.0%	15.9%	3.1%	23.4%
	Yard and Garden	Small yard waste (leaves, branches, grass clippings	12.9%	14.0%	23.6%	6.4%	9.6%	1.1%	8.0%
	Food Waste	Compostable (e.g. fruits, vegetables). Backyard Non-compostable (Meat, bones, breads, non-liquid dairy, fats)	17.3%	18.8%	22.8%	21.5%	6.3%	1.9%	15.3%
	Clean Wood		0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
NON-COMPOSTABLE ORGANICS		Subtotal	10.9%	11.1%	2.0%	9.5%	15.6%	9.3%	25.9%
	Treated/Painted Wood/Composite Wood		9.4%	9.5%	1.0%	7.2%	13.5%	9.1%	24.3%
	Rubber		0.3%	0.4%	0.0%	0.6%	0.0%	0.1%	0.9%
	Multiple/Composite organic materials (footwear, etc.)		1.1%	1.2%	1.0%	1.8%	2.1%	0.2%	0.7%
METALS		Subtotal	3.2%	3.3%	3.5%	4.4%	2.1%	1.9%	2.4%
	Beverage Containers	Alcoholic	0.2%	0.2%	0.1%	0.6%	0.0%	0.2%	0.0%
		Non-alcoholic	0.1%	0.1%	0.1%	0.3%	0.0%	0.0%	0.2%
	Food Containers, Trays or Foil Wraps		1.1%	1.2%	1.5%	1.8%	0.5%	0.0%	0.1%
	Other Metals		1.8%	1.8%	1.8%	1.7%	1.5%	1.7%	2.1%
GLASS		Subtotal	2.1%	2.0%	1.7%	3.0%	4.0%	3.8%	0.4%
	Beverage containers	Refundable alcoholic	0.2%	0.2%	0.2%	0.5%	0.2%	0.0%	0.0%
		Refundable non-alcoholic	0.1%	0.1%	0.0%	0.2%	0.0%	0.0%	0.0%
		Non-refundable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Food containers		0.7%	0.8%	0.8%	1.4%	0.2%	0.0%	0.2%
	Other glass		1.2%	0.9%	0.5%	0.9%	3.6%	3.8%	0.1%

Table 4 – Composition of Primary, Secondary, and Tertiary Categories from all Sectors

Primary	Secondary	Tertiary	Average[8]	Average [9] (excl. SHICI)	SFRES	RTS	SHRES	SHICI	ICI
BUILDING MATERIAL		Subtotal	9.6%	5.1%	0.4%	2.7%	20.5%	55.7%	7.9%
	Gypsum/drywall, plaster		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Masonry (bricks, blocks, concrete, etc.)		2.5%	2.0%	0.0%	0.7%	0.0%	7.5%	7.7%
	Rock, sand, dirt, ceramic, porcelain		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Rigid Asphalt Products		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Carpet Waste (and underlay)		0.3%	0.3%	0.2%	0.9%	0.0%	0.0%	0.0%
	Other Inorganics (linoleum, etc.)		6.9%	2.9%	0.2%	1.1%	20.5%	48.2%	0.2%
ELECTRONIC WASTE		Subtotal	2.6%	2.8%	2.2%	3.5%	7.6%	0.0%	0.7%
	Computers and peripherals		0.2%	0.2%	0.1%	0.3%	0.8%	0.0%	0.0%
	TV & Audio/video equipment		0.5%	0.6%	0.4%	1.4%	0.5%	0.0%	0.0%
	Telephones & Equipment		0.1%	0.2%	0.0%	0.1%	0.0%	0.0%	0.6%
	Small appliances & floor care appliances		1.2%	1.3%	1.1%	1.1%	5.3%	0.0%	0.0%
	Electronic or electrical tools		0.2%	0.2%	0.1%	0.4%	0.3%	0.0%	0.0%
	Electronic toys		0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
	Lighting equipment and light bulbs		0.3%	0.3%	0.4%	0.2%	0.6%	0.0%	0.1%
	Smoke/CO detectors		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Other e-waste		0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%

Table 4 – Composition of Primary, Secondary, and Tertiary Categories from all Sectors

Primary	Secondary	Tertiary	Average[8]	Average[9] (excl. SHICI)	SFRES	RTS	SHRES	SHICI	ICI
HOUSEHOLD HAZARDOUS (HHW)		Subtotal	0.9%	1.0%	0.9%	2.2%	0.5%	0.0%	0.2%
	Batteries		0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
	HHW (product &/or container)	Paint	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Fertilizers/Pesticides	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Automotive	0.5%	0.6%	0.4%	1.6%	0.0%	0.0%	0.0%
		Pharmaceuticals	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%
		Solvents	0.1%	0.1%	0.1%	0.0%	0.2%	0.0%	0.0%
		Cosmetics	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
	Mercury Containing Items	Thermostats and switches	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Other (old thermometers)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Other HHW		0.2%	0.2%	0.1%	0.4%	0.3%	0.0%	0.1%
HOUSEHOLD HYGIENE		Subtotal	4.9%	5.4%	7.7%	7.5%	3.3%	0.3%	0.2%
	Biological	Diapers, feminine hygiene products	2.9%	3.2%	5.8%	3.2%	0.8%	0.0%	0.0%
		Pet Waste (kitty litter, dog waste)	2.0%	2.1%	1.9%	4.3%	2.5%	0.2%	0.2%
BULKY OBJECTS		Subtotal	2.0%	2.1%	0.2%	1.9%	13.2%	0.0%	0.0%
	Furniture		2.0%	2.1%	0.2%	1.9%	13.2%	0.0%	0.0%
FINES		Subtotal	0.9%	1.0%	1.1%	0.8%	0.2%	0.1%	1.4%

3.3.1 Single-Family Residential (SFRES)

A total of twenty (20) waste samples were sorted from the SFRES sector. The percent composition for Primary waste categories identified in these samples is provided in descending order in Table 5 and Figure 2.

The largest quantity of the SFRES waste stream was compostable organics representing 46.40% of the total weight sampled. Yard and garden waste represented over half the compostable organics making up 50.83%, with food waste at 49.09% and, clean wood at 0.07%, respectively. It should be noted that pictures and a visual inspection were completed before samples were taken of the load prior to sorting – yard and garden waste was a large visual contributor to the sample.

Plastics was the next largest category contributing 18.08%. Within the plastics category non-recyclable; films were the largest contributors.

The largest contribution to plastics are:

- Plastic films at 6.27%
- Synthetic textiles at 4.33%
- Rigid containers – all other at 4.58%
- Other plastics at 2.51%

Paper made up 15.96% of the SFRES sample with fine, computer, office paper being the largest category with 4.33% and tissue/papers representing 4.31%.

The higher standard deviation for the compostable organics was caused by the variable amount of yard waste in some of the waste samples. All samples would have a consistent amount of food waste; however, some samples did have a large quantity of yard waste, while others would have less yard waste, which leads to the larger standard deviation observed.

Table 5 – Mean Primary Category Distribution for the Single Family Residential Sector

Category	Percent Total Mass	Standard Deviation
Compostable Organics	46.40%	11.22%
Plastic	18.08%	5.23%
Paper	15.96%	5.34%
Household Hygiene	7.65%	4.59%
Metals	3.50%	2.74%
Electronic Waste	2.20%	2.24%
Non-Compostable Organics	2.02%	2.23%
Glass	1.67%	1.13%
Fines	1.06%	1.35%
Household Hazardous (HHW)	0.87%	2.25%
Building Material	0.41%	1.19%
Bulky Objects	0.17%	0.62%
Total	100%	

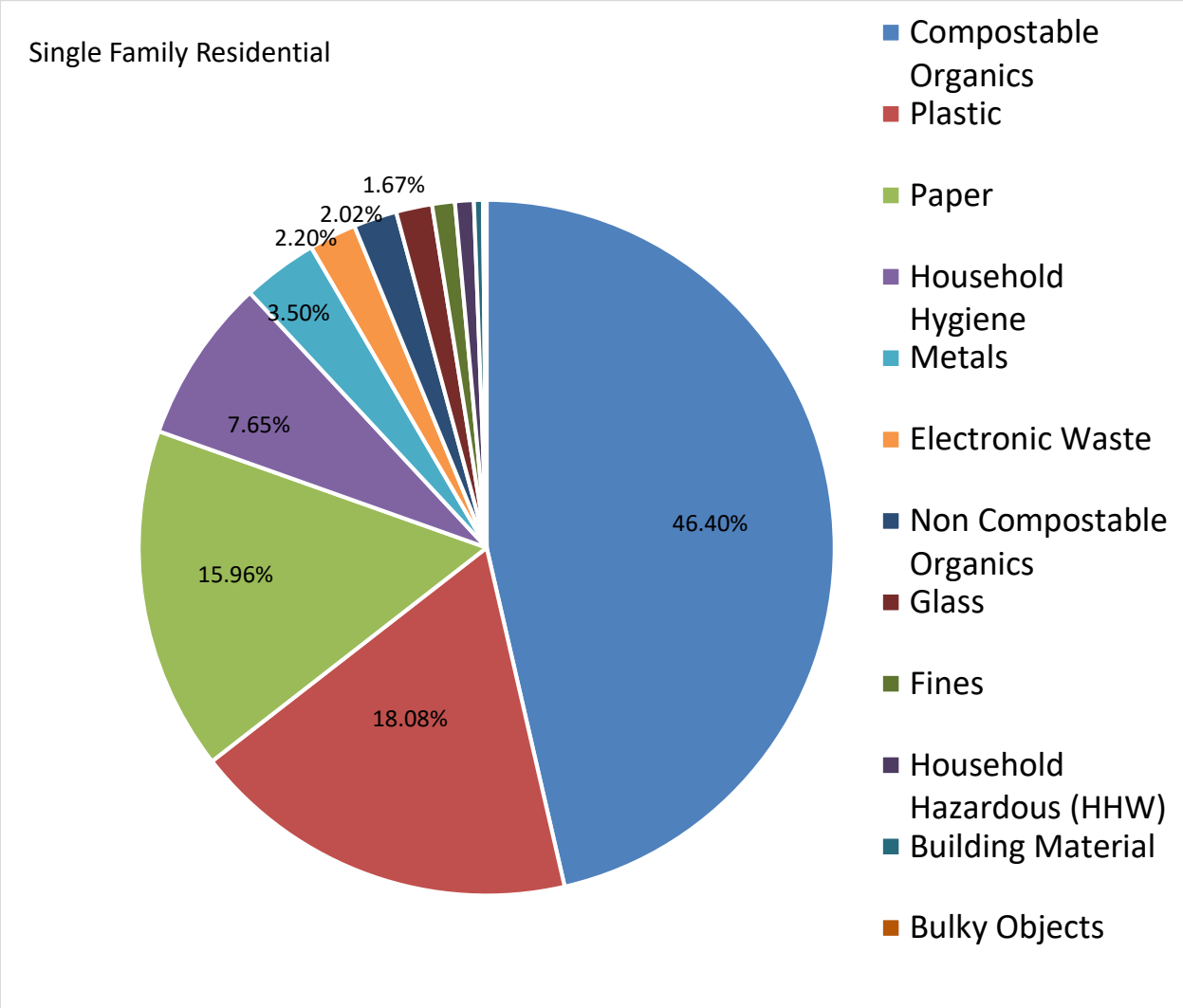

Figure 2: Mean Primary Waste Category Composition of the Single Family Residential Sector

3.3.2 Rural Transfer Station (RTS)

For this Study, a total of thirteen (13) waste samples were sorted from the RTS. The percent composition for Primary waste categories identified in these samples is provided in descending order in Table 6 and Figure 3.

It should be noted that there may be bias in the sampling results for RTSs due to the following:

- Of the thirteen (13) RTSs, loads were only available from Valemount/McBride, Miworth, Buckhorn, Bear Lake, Summit, McLeod, Hixon, Cummings Road, West Lake, and Vanway.

- Loads collected from the Dunster and Valemount/McBride RTSs were comingled, the amount collected from each transfer station unknown. Therefore, it should be noted that the load sampled to represent the Dunster Transfer Station was collected from Valemount/McBride.

- Loads collected from the Bear Lake, Summit and McLeod transfer stations were comingled. The amount collected from each transfer station was 10% Bear Lake, 50% Summit and 40% McLeod. Sampling bias for this load was reduced by completing sampling in the order in which waste would have been retrieved from each transfer station.

The largest quantity of the RTS waste stream is compostable organics representing 27.98% of the total weight sampled. Of the total compostable organic content within the RTS samples, food waste was 77% and, yard and garden waste was 22.78% and clean wood were at 0.22%, respectively.

Plastic comprised the second largest waste category with 19.4%. Within the plastic category, plastic films contributed 6.74%, recyclable plastic containers with 5.87% and the rest being synthetic textile material and other durable plastic products 2.51% and 4.29%, respectively.

Paper was the next largest category at 17%, with tissues/paper towels being the largest contributor with 5.59%.

Table 6 – Mean Primary Category Distribution for the Rural Transfer Station Sector

Category	Percent Total Mass	Standard Deviation
Compostable Organics	27.98%	13.61%
Plastic	19.41%	6.34%
Paper	17.00%	7.07%
Non-Compostable Organics	9.52%	11.02%
Household Hygiene	7.49%	4.66%
Metals	4.41%	3.33%
Electronic Waste	3.52%	4.06%
Glass	2.97%	2.32%
Building Material	2.74%	4.27%
Household Hazardous (HHW)	2.17%	3.06%
Bulky Objects	1.95%	5.15%
Fines	0.84%	0.73%
Total	100%	

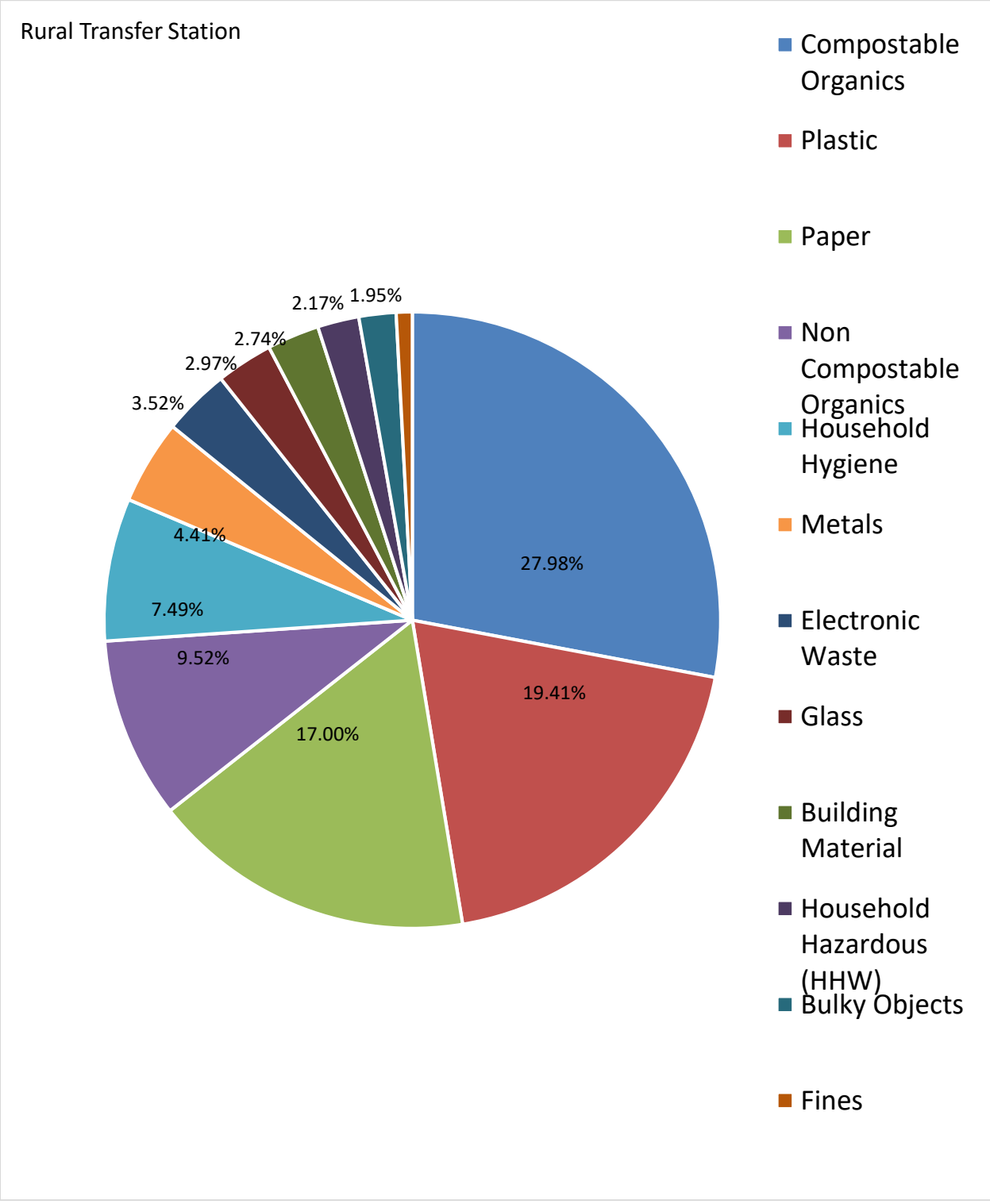

Figure 3: Mean Primary Waste Category Composition of Rural Transfer Station Sector

3.3.3 Self-Haul Residential

For this Study, a total of six (6) waste samples were sorted from the self-haul residential sector. The percent composition for Primary waste categories identified in these samples is provided in descending order in Table 7 and Figure 4.

The waste composition was highly variable for the self-haul residential sector; however, there were occurrences of common trends in each of the samples sorted. Variability is due to residents unloading waste that is household waste or home renovations debris. In the samples, the common trend was that there was mixture of household waste within the home renovations.

Building material constituted the largest portion at 20.48% and the large standard deviation suggests the high variability of building material as a constituent to the self-haul residential waste stream. Of the 20.48%, 100% of the building material sample was other inorganics generated from renovation activities such as shingles and insulation.

Compostable organics generation made up a large portion of the waste stream at approximately 15.93%. Yard and garden was the largest portion of the category contributing 9.62%, with food waste at 6.30% and clean wood at 0.01%.

Non-compostable organics was a large portion at 15.64% of the waste, with treated or painted wood contributing 13.54% and multiple/composite organic materials contributing 2.10%.

According to responses to the questions asked of self-haul residential customers, renovation, clean-up, and construction activities were the most common activities that generated the waste. SHRES samples are also highly variable, as activities such as construction, renovations and bulky object clean-up can generate many different types of waste. Notably, the waste is heavily weighted by the three (3) main categories: building materials, compostable and non-compostable organics. Building material comprised of other inorganics, compostable organics consisted mainly of yard and garden while non-compostable organics mainly consisted of painted wood.

Table 7 – Mean Primary Category Distribution for the Self Haul Residential Sector

Category	Percent Total Mass	Standard Deviation
Building Material	20.48%	33.40%
Compostable Organics	15.93%	11.51%
Non-Compostable Organics	15.64%	13.00%
Bulky Objects	13.25%	13.14%
Plastic	9.74%	4.97%
Electronic Waste	7.61%	8.14%
Paper	7.26%	5.67%
Glass	4.04%	4.42%
Household Hygiene	3.29%	5.49%
Metals	2.06%	1.85%
Household Hazardous (HHW)	0.51%	0.72%
Fines	0.20%	0.37%
Total	100%	

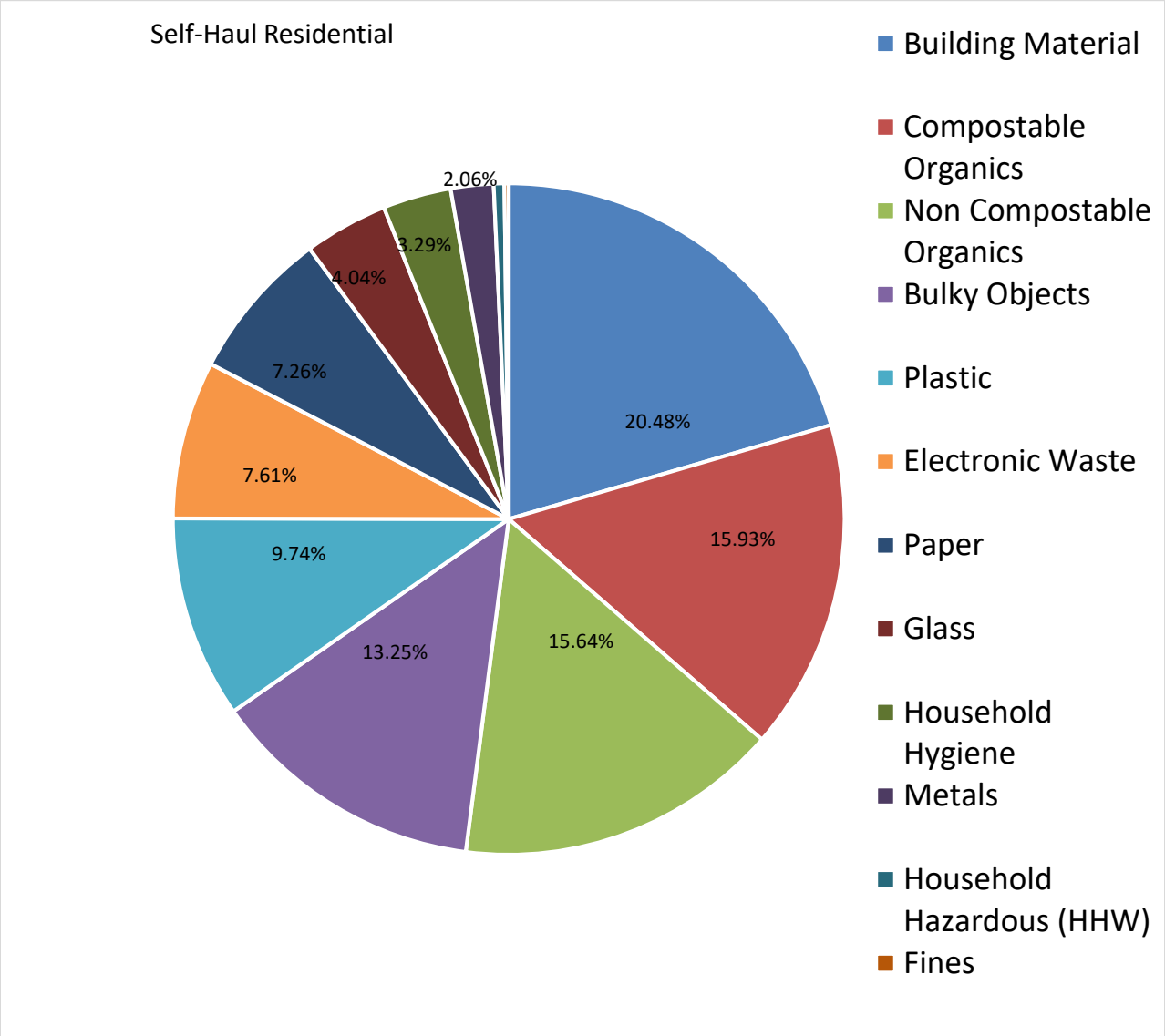

Figure 4: Mean Primary Waste Category Composition of the Self Haul Residential Sector

3.3.4 Self-Haul Commercial

For this Study, a total of five (5) waste samples were sorted from the self-haul commercial sector. The percent composition for Primary waste categories identified in these samples is provided in descending order in Table 8 and Figure 5.

Like the self-haul residential sector, the waste composition for the self-haul commercial sector was highly variable, however similar common trends occurred. Building materials generated from renovation activities made up the largest portion of the waste stream at 55.67%. Other inorganics was the largest partition of this waste category at 48.19% followed by masonry (bricks, blocks, concrete) at 7.48%, respectively. The next largest contributing category is paper at 20.17%. Boxboard comprised 15.72% of the sample with clean OCC at 2.09%, fine paper at 1.98%, tissue/paper towel at 0.37% and aseptic containers at 0.01%.

The large standard deviation suggests the high variability of waste as a constituent to the self-haul commercial waste stream, attributable to the fact that many self-haul commercial loads may be contaminated with household waste. It should be noted that the waste team noticed varying amounts of household waste contamination within each self-haul loads.

Household hygiene and fines were the lowest of any other waste sectors at 0.29% and 0.13%, respectively. Pet waste made up the vast majority of the weight contributing 0.46% of the total sample. A large number of the samples from this sector contained waste from only a few of the waste categories.

In the samples taken from the self-haul commercial sector bulky objects were not encountered; however, it is highly likely that items such as furniture and other bulky waste would enter the landfill through this waste stream.

Table 8 – Mean Primary Category Distribution for the Self Haul Commercial Sector

Category	Percent Total Mass	Standard Deviation
Building Material	55.67%	39.83%
Paper	20.17%	38.54%
Non-Compostable Organics	9.33%	13.60%
Plastic	5.57%	1.27%
Glass	3.82%	7.00%
Compostable Organics	3.07%	3.98%
Metals	1.94%	2.35%
Household Hygiene	0.29%	0.53%
Fines	0.13%	0.24%
Electronic Waste	0.00%	0.00%
Household Hazardous (HHW)	0.00%	0.00%
Bulky Objects	0.00%	0.00%
Total	100%	

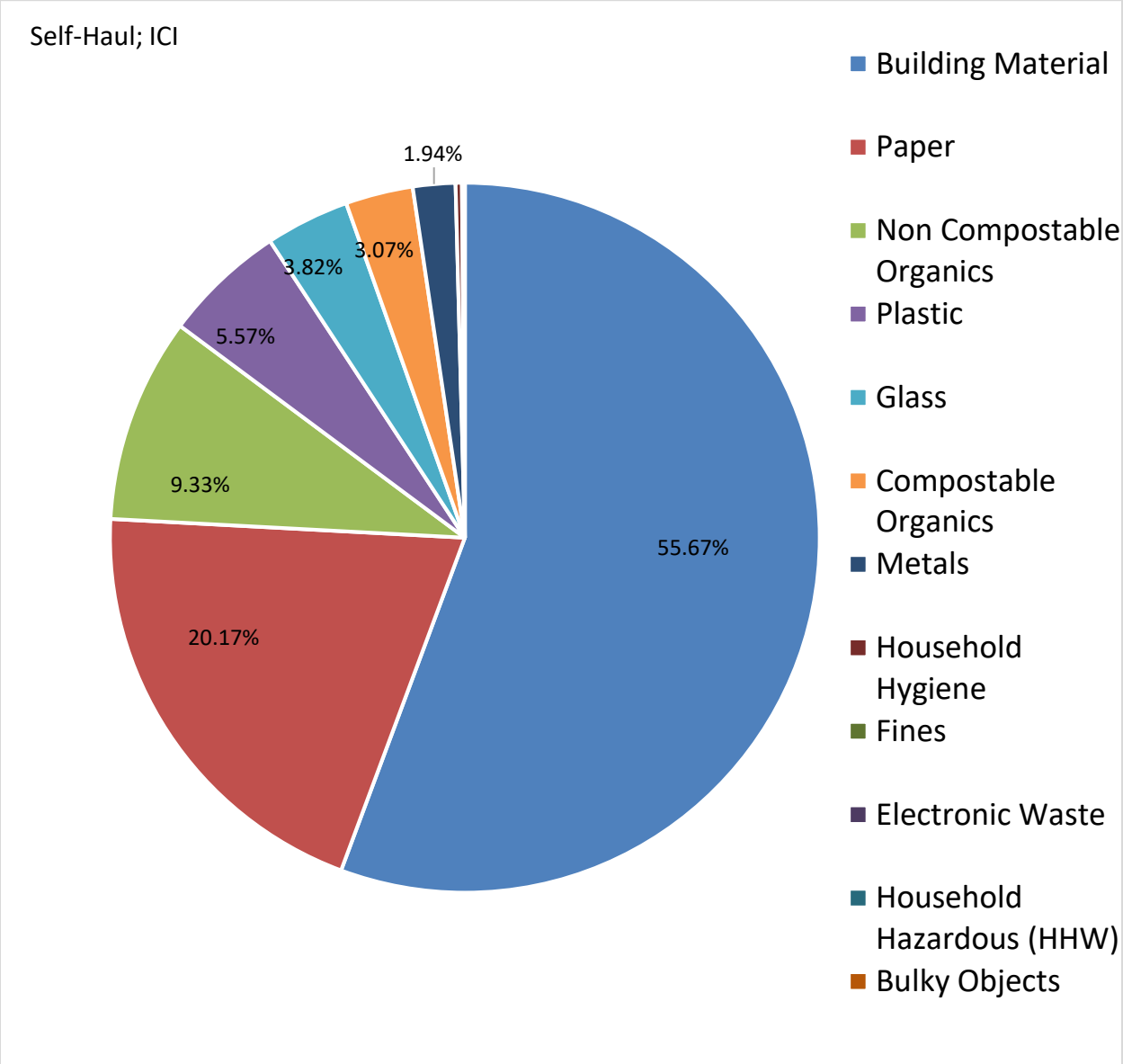

Figure 5: Mean Primary Waste Category Composition of the Self Haul Commercial Sector

3.3.5 Commercial (ICI)

For this Study, a total of twelve (12) waste samples were sorted from the commercial ICI sector. The percent composition for Primary waste categories identified in these samples is provided in descending order in Table 9 and Figure 6.

Non-compostable organics made up the largest portion of the waste representing 25.90%. Treated or painted wood represented 24.31% of the non-compostable organics followed by rubber at 0.90% and leather/multiple/composite organics materials at 0.69%, respectively.

Compostable organics was the next largest portion of the waste stream at 23.38%. Food waste comprised over half of the compostable organics within the ICI sample at 65.60%, yard and garden at 34.30% and

clean wood at 0.10%. Plastics was the next largest contributor with 20.51% and followed by paper with 17.04%.

The waste composition for the ICI sector shows a higher standard deviation for all Primary waste categories than the residential sector. The higher standard deviations may reflect the more diverse individual source sites, e.g. office buildings, grocery stores, restaurants, repair shops, institutions, etc. Generally, in ICI samples the contents are variable, depending on the samples origin as one ICI sample was often shown to have a vastly different waste composition compared to another.

Table 9 – Mean Primary Category Distribution for the ICI Sector

Category	Percent Total Mass	Standard Deviation
Non-Compostable Organics	25.90%	37.80%
Compostable Organics	23.38%	34.16%
Plastic	20.51%	25.12%
Paper	17.04%	17.02%
Building Material	7.94%	23.04%
Metals	2.43%	4.17%
Fines	1.36%	3.73%
Electronic Waste	0.67%	1.97%
Glass	0.36%	0.54%
Household Hazardous (HHW)	0.21%	0.38%
Household Hygiene	0.20%	0.61%
Bulky Objects	0.00%	0.00%
Total	100%	

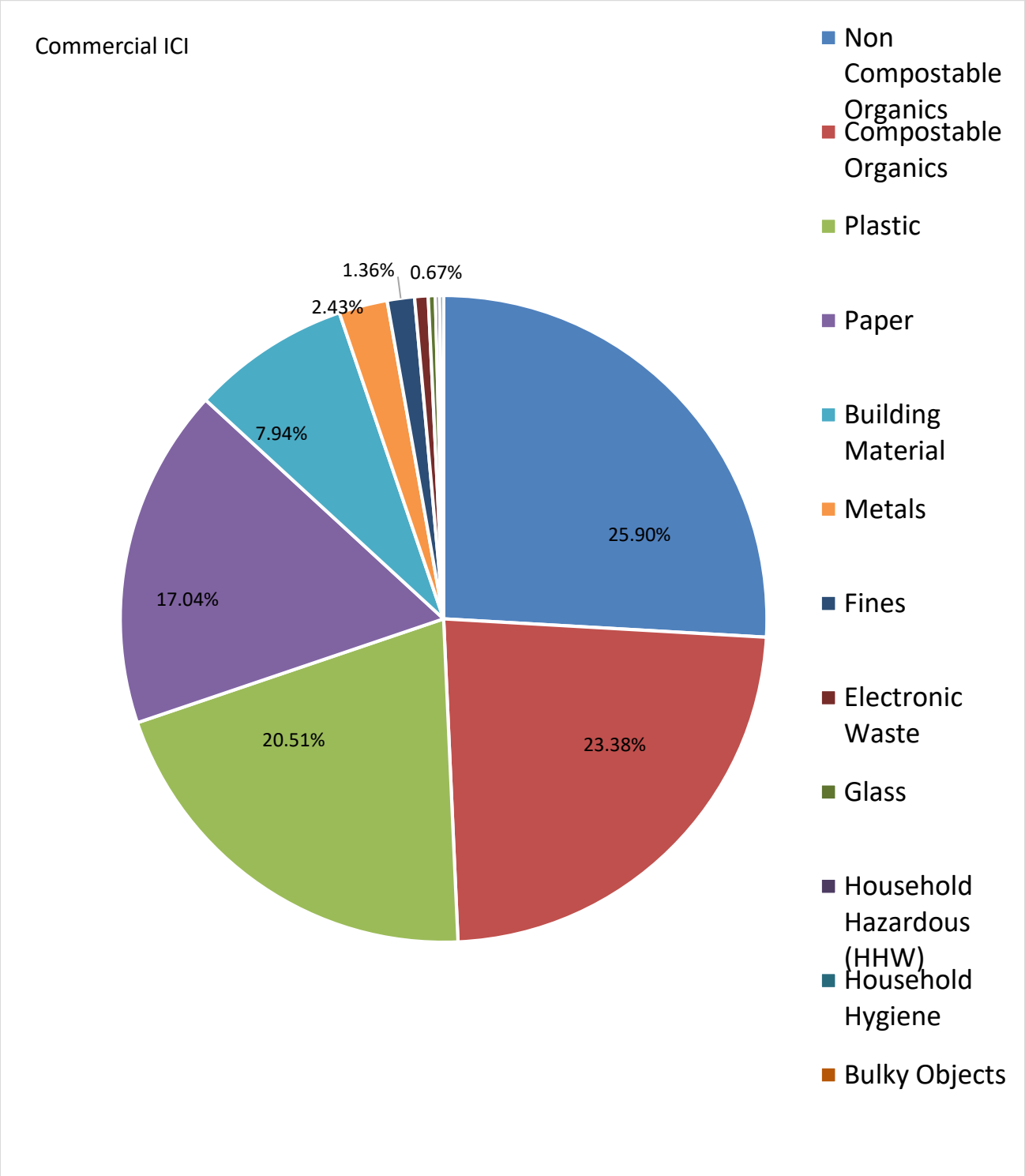

Figure 6: Mean Primary Waste Category Composition Commercial ICI

3.4 Extended Producer Responsibility (EPR) Materials

Table 10 below summarizes the waste characterized under the Extended Producer Responsibility (EPR) category.

Small appliances and tools were the EPR category with the largest proportion at 1.22% of all waste sorted, SHRES was the largest contributor with 5.28% and SFRES with 1.09% and RTS with 1.07%.

Refundable beverage containers were the second largest contributor with 0.91%, RTS was the largest contributor of 1.92%, SFRES with 0.77%, ICI with 0.59%, SHICI with 0.39% and SHRES with 0.31%.

Other EPR categories contribution:

- Used oil/antifreeze with 0.51%
- Non-deposit beverage with 0.28%
- Fluorescent lights, lighting equipment with 0.26%
- Batteries with 0.06%

Table 10 – Number of Samples and Total Mass Sorted

EPR Category	Average[10]	Average[11] (excluding SHICI)	SFRES	RTS	SHRES	SHICI	ICI
Refundable Beverage Containers	0.91%	0.96%	0.77%	1.92%	0.31%	0.39%	0.59%
Non-Deposit Beverage Containers	0.28%	0.30%	0.26%	0.41%	0.15%	0.01%	0.31%
Small Appliances and Tools	1.22%	1.34%	1.09%	1.07%	5.28%	0.00%	0.00%
Fluorescent Lights, Lighting Equipment	0.26%	0.28%	0.36%	0.16%	0.61%	0.00%	0.11%
Smoke and CO Alarms	0.00%	0%	0.00%	0%	0%	0%	0%
Batteries	0.06%	0.07%	0.13%	0.06%	0.01%	0.00%	0.01%
Other E-waste	0.02%	0.02%	0.00%	0.00%	0.17%	0.00%	0.00%
Paint	0.01%	0.01%	0.00%	0.03%	0.00%	0.00%	0.03%
Used Oil/ Antifreeze	0.51%	0.56%	0.43%	1.56%	0.00%	0.00%	0.00%
Thermostats	0.01%	0.01%	0.00%	0.02%	0.01%	0.00%	0.00%
Pharmaceuticals	0.05%	0.05%	0.07%	0.02%	0.00%	0.00%	0.06%
Total by Sector	**3.32%**	**3.60%**	**3.12%**	**5.26%**	**6.55%**	**0.39%**	**1.11%**

3.5 Overall Waste Composition

Compostable organics comprised the largest percentage of waste across all sectors, excluding SHICI.

SFRES contributed approximately 46%, RTS at approximately 27%, SHRES at approximately 15%, SHICI at approximately at 3% and ICI at approximately at 23%.

[10] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2017 at Foothills Boulevard Regional Landfill

[11] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2017 at Foothills Boulevard Regional Landfill, excluding tonnage from the SHICI sector

Collectively, compostable organics accounted for 30.21% of the total waste entering the FBR Landfill. Compostable organics, paper and plastics are the top three (3) Primary categories comprising over half of the overall waste disposed-of (approximately 62%).

Plastic was the second largest contributor with 16.88%, each sector contributed the following to the total plastic percentage:

- SFRES with 18.08%
- RTS with 19.41%
- SHRES with 9.74%
- SHICI with 5.57%
- ICI with 20.51%

The compostable organics was the main component of SFRES which comprised mostly of food waste (49.09%) and yard and garden (50.83%) and the remaining was clean wood. Plastic was the second largest contributor (18.08%) with over half being non-recyclable plastics.

Breakdown of the Non-recyclable plastics (72.57%) within the SFRES:

- Plastic films at 34.71%
- Textiles at 23.96%
- Other plastics at 13.90%

The next largest categories of waste from SFRES, in descending order, was paper (15.96%), household hygiene (7.65%), metals (3.50%), electronic waste (2.20%), non-compostable organics (2.02%), glass (1.67%), fines (1.06%) and HHW, building material and bulky objects (>1%).

Within the RTS the largest contributor was compositable organics with 27.98% and the second largest contributor is plastic with 19.4%. Paper contributed 17%, the highest contributing Secondary Categories for paper are:

- Tissue/paper towels at 32.89%
- Boxboard at 24.90%
- Fine, computer, office paper at 23.34%

The percentage of hazardous by-products in the waste stream from RTS was much higher than from any other waste source. Specifically, 2.1% of waste from the transfer stations was reported as hazardous by-products, significantly greater than the 0% to 1% range reported for all other waste sources.

Over half of the waste from the self-haul commercial sector was building materials, 55.67%. The second highest contributor was paper (approximately 20%). Within the paper category, boxboard contributed 15.7%, clean OCC at 2%, fine paper at 1.9%, tissue/paper towel at 0.3% and remaining categories >1%.

The data shows that non-compostable organics is the largest contributor to the commercial ICI waste (approximately 25%). Compostable organics was the second largest category; together these organics account for approximately 49% of the waste from this sector.

As can be seen in the figure below, the SFRES contributes the largest quantity of compostable organics in the total waste stream closely followed by rural transfer stations.

The greatest amount of electronic waste came from SHRES, the electronic waste was made up of small appliances (1.2%) such as a coffee maker. SHRES represented the highest contribution in other glass (4%) this represents ceramic and glass cups, mugs, plates and bowls.

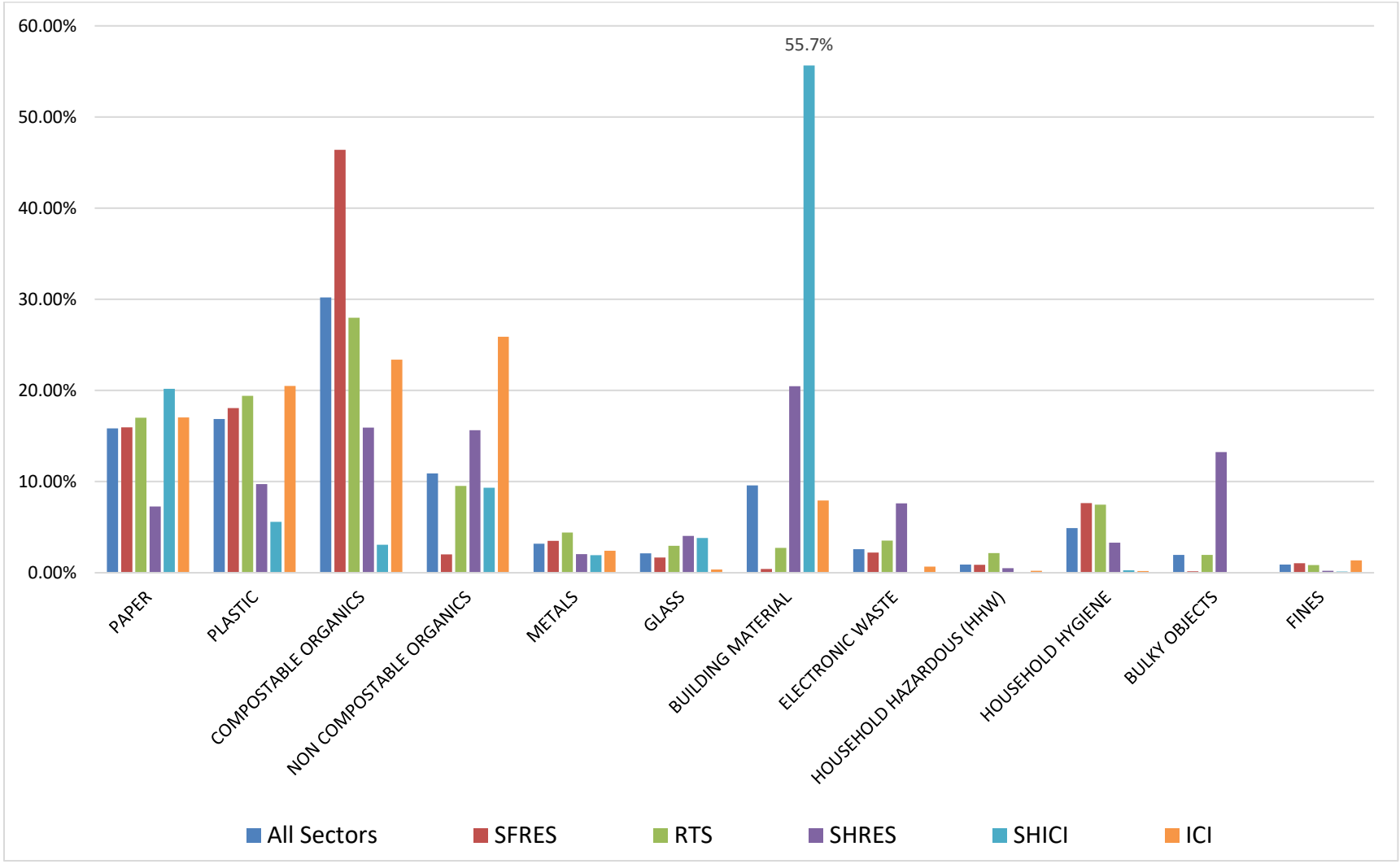

Figure 7: Overall Waste Composition by Sector and Primary Category

3.6 Comparison with 2007 and 2013 Waste Characterization Results

Table 11 includes data from the 2007 data, the 2013 data and the 2018 data for all the Primary categories at the FBR Landfill.

Generally, waste in all categories showed a significant reduction compared to the 2013 study. The greatest reduction was observed in metal waste which saw a drop of almost 2.2% and plastic waste increased by 3.7% since the 2013 study. Organic content (compostable and non-backyard compostable) saw an increase of 3.9%.

Figure 8 shows the overall span of the three studies, there is an overall decline in the results.

It should be noted that "Composite Products" has been divided into "Electronic Waste" and "Household Hygiene" in the 2013 and 2018 studies, while the graph reflects the combined average of the two for comparison to the 2007 data. For electronic waste there was a decrease of 0.6% from 2013 to 2018 and household hygiene there was an increase of 1.3% from 2013 to 2018. Overall, there was a 2.1% decrease from 2007 to 2018, from 10.2% in 2007, to 7.5% in 2013 with an increase to 8.2% in 2018.

Other noticeable results from the comparison of the 2007 and the 2013 data:

- Overall there has been a decline in the categories, paper had the largest decline of 11.3%, from 26.70% in 2007, to 17.50% in 2013 to 15.42% in 2018.
- Glass had a large decline from 2007 to 2013 from 4.70% to 1.70 % with the amount of glass increasing slightly in 2018 to 1.97% (as 2013 and 2018 as so close we could say this number is fairly steady).
- Metals had an overall decline of 1.4% with an increase of 0.8% in 2013 from 2007 and then a decline of 2.2% in 2018.
- Non-Compostable organics had the largest increase overall, in 2007 at 24.6%, 2013 at 30.70% and 2018 at 32.83%, an 8.6% increase. Between 2007 to 2013 there was a 6.1% increase and between 2013 to 2018 a 1.8% increase.
- The second largest overall increase was compostable organics, at 8.2%, in 2007 organics was at 24.60%, 2013 at 30.70% and 2018 at 32.83%.

Table 11 – Comparison of Data between 2007, 2013 and 2018 Studies

Primary Category	2007 Study Foothills Boulevard Regional Landfill (N=60)		Primary Category	2013 Study Foothills Boulevard Regional Landfill (N=55)		Primary Category	2018 Study Foothills Boulevard Regional Landfill (N=56)	
	Mean[12]	(+/-)		Mean[13]	(+/-)		Mean[14]	(+/-)
Paper & Paperboard	26.70%	9.90%	Paper	17.50%	7.20%	Paper	15.42%	4.73%
Glass	4.70%	3.80%	Glass	1.70%	1.70%	Glass	1.97%	1.59%
Plastic	14.00%	4.00%	Plastic	14.30%	6.80%	Plastic	17.97%	4.90%
Ferrous Metals	3.60%	2.40%	Metals	5.50%	5.90%	Metals	3.31%	1.07%
Non-Ferrous Metals	1.10%	1.30%						
Organic Matter	24.60%	10.50%	Compostable Organics	30.70%	22.60%	Compostable Organics	32.83%	12.97%
Wood Products	2.50%	5.10%	Non-Compostable Organics	9.30%	14.30%	Non-Compostable Organics	11.06%	10.10%
Construction and Demolition Materials	2.90%	6.30%	Building Material	8.20%	25.30%	Building Material	5.15%	8.96%
Hazardous By-Products	1.50%	2.60%	Household Hazardous (HHW)	2.00%	1.60%	Household Hazardous (HHW)	1.00%	0.86%
Composite Products	10.20%	8.30%	Electronic Waste	3.40%	5.80%	Electronic Waste	2.82%	2.98%
			Household Hygiene	4.10%	4.80%	Household Hygiene	5.36%	3.59%
Other	0.00%	0.20%	Bulky Objects	2.80%	6.10%	Bulky Objects	2.14%	6.33%

[12] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2006 in RDFFG, excluding the SHICI sector

[13] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2012 in RDFFG, excluding the SHICI sector

[14] Average is based on the percentage tonnage each sector contributed to the total tonnage of waste buried in 2017 in RDFFG, excluding the SHICI sector

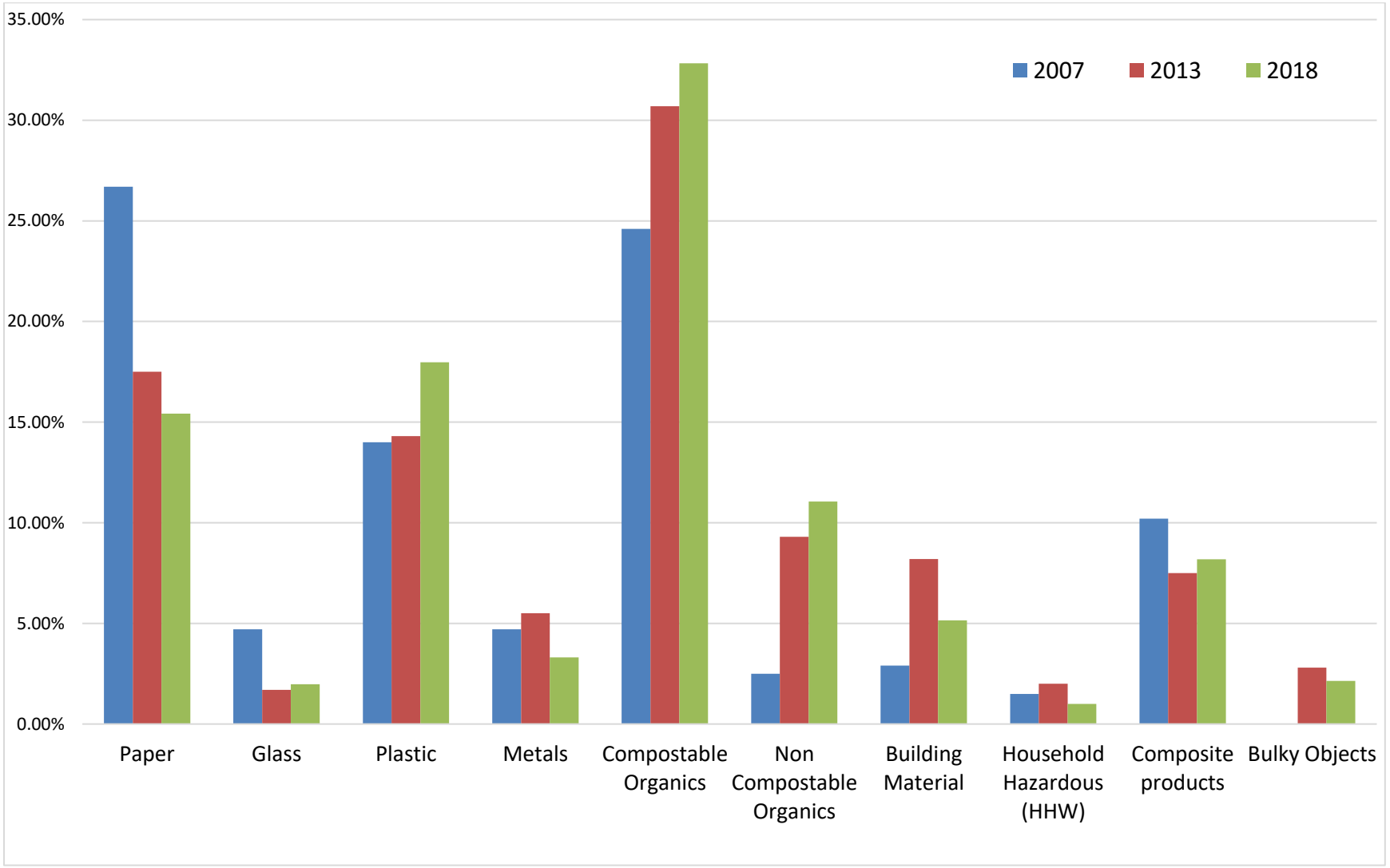

Figure 8: Comparison of 2007, 2013 and 2018 Data

4.0 Limitations and Sources of Error

Small discrepancies between the total sample mass and the sum of the sorted category masses can occur at the end of sorting a sample. Sample material falling to the floor and changes in moisture content during the sort would result in a sorted category mass that was different than the total sample mass. Additionally, errors in the recording of field data are possible reasons for the sum of the category masses being different from the total sample mass. Such errors were minor and are controlled by our QA/QC procedures for error checking the data.

To keep the waste composition tables and figures readable, percentages are rounded to the nearest tenth of a percent. Due to rounding in the data presented in the report, when added together the percentages may not exactly match the subtotals and totals shown, as the results are not rounded in the Excel data tables.

5.0 Conclusions

Analysis of the overall waste composition from all sectors coming into the landfill demonstrates that compostable organics make up the largest portion of the waste at 30.21%. This includes yard and garden waste, food waste and clean wood. Paper and plastic were second and third largest categories at 15.84% and 16.88%, respectively.

Non-compostable organics was the next largest contributor at 10.91% followed by building material at 9.59%. However, large quantities of building material were recovered from several samples taken from the self-haul commercial, self-haul residential and ICI sectors and this may be expected to be seasonal waste, as most construction such as roofing projects and outdoor renovations take place in the summer months. Building materials made up a large portion of the waste generated from renovation activities.

Electronic waste was found in all waste streams, except self-haul ICI, the greatest quantity came from self-haul residential where 7.61% of the total mass sorted was electronic waste. Bulky electronics such as vacuum cleaners, lawn mowers, and other electronic appliances are examples of electronic items that were observed.

The Primary and Secondary category data was subjected to statistical analysis using the provincial waste characterization tool to determine the means and standard deviations of each of the categories. The standard deviations of waste within each of the Primary categories calculations indicated a fairly good consistency for the SFRES samples.

The waste composition for the ICI sector shows a higher standard deviation for all Primary waste categories than the residential sector. Higher standard deviations are expected for the ICI sector due to the variety of Primary sources can be vastly different. In addition, each delivery may contain waste from several Primary sources, but the load is not necessarily well mixed.

A large confidence interval does not necessarily indicate that the data is unreliable; instead, it can indicate that the data from a particular sector is highly variable depending on the source, with different sub-sectors producing different types of waste.

When the data was compared to the 2013 study, the greatest changes in waste composition were observed in plastic waste which saw an increase of almost 3.6% and building material saw a decrease of 3% from 8.20% to 5.15% since the 2013 study.

Overall change since 2007 that has been a decline in waste, the largest decline was in paper, 11.3%, followed by glass and composite products (electronic waste and household hygiene in 2013 and 2018). The largest increase was in non-compostable organics 8.6%, followed by compostable organics.

6.0 Closure and Professional Statement

TRI Environmental Consulting Inc. prepared the foregoing report for the exclusive use and information of the Regional District of Fraser-Fort George.

The information and data were collected and compiled in accordance with the general level of care and skill normally exercised by environmental science and engineering professionals practicing under similar circumstances.

During the preparation of this report, TRI has relied on reports, data, studies, specifications, documents and other information provided by others.

TRI has taken care to verify the information provided where possible but makes no warranty as to the accuracy of the reports, data, studies, specifications, documents and other information prepared by others and accepts no responsibility for information contained in them.

Any use by a third party of the foregoing report, or any reliance upon or decisions made by a third party based upon them, are the sole responsibility of such third parties. TRI Environmental Consulting Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on the foregoing report.

Thank you for choosing TRI for this project. Should you have questions concerning this report, or if you require additional information, please contact the undersigned at (604) 436-3384.

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APPENDICES

APPENDIX I
CITY OF PRINCE GEORGE WASTE COLLECTION SCHEDULE AND ZONES

CITY OF PRINCE GEORGE

2018-2019 AUTOMATED GARBAGE COLLECTION SCHEDULE

Find the colour of your garbage collection area on the map (on reverse), the corresponding colour on the calendar indicates your garbage collection day.

On Statutory Holidays, there will be no garbage collection

March 2018						
Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

April 2018						
Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

May 2018						
Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

June 2018						
Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

July 2018						
Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

August 2018						
Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

September 2018						
Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

October 2018						
Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

November 2018						
Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

December 2018						
Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

January 2019						
Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

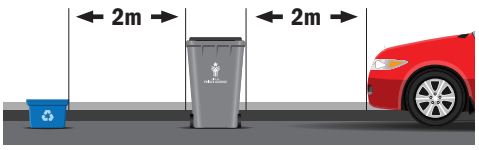
February 2019						
Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

RESIDENTIAL GARBAGE COLLECTION

The City of Prince George will **NOT** collect any carts that are overflowing with garbage. Please make sure all garbage is contained inside your cart, and the lid is completely closed.

Give It Space

Provide at least 2m of clearance on all sides, including from your recycling bins.



RECYCLING

For information about the curbside recycling schedule for your address and what items can be recycled, visit **recyclinginbc.ca/prince-george**.
For other recycling information, visit the website for the Recycling Council of BC: **rcbc.ca**.

REGIONAL DISTRICT TRANSFER STATIONS AND LANDFILL

For information about hours of operation, fees, and regulations for the Quinn Street Recycling Depot, Vanway Transfer Station, and Foothills Boulevard Regional Landfill, visit **rdffg.bc.ca** or call 250-960-4400.

BE BEAR AWARE

Each year, many bears are attracted into Prince George city limits in search of food. Unfortunately, many "problem bears" have to be destroyed by Conservation Officers. There are a number of simple things we can all do to make a difference and maybe save a bear's life:

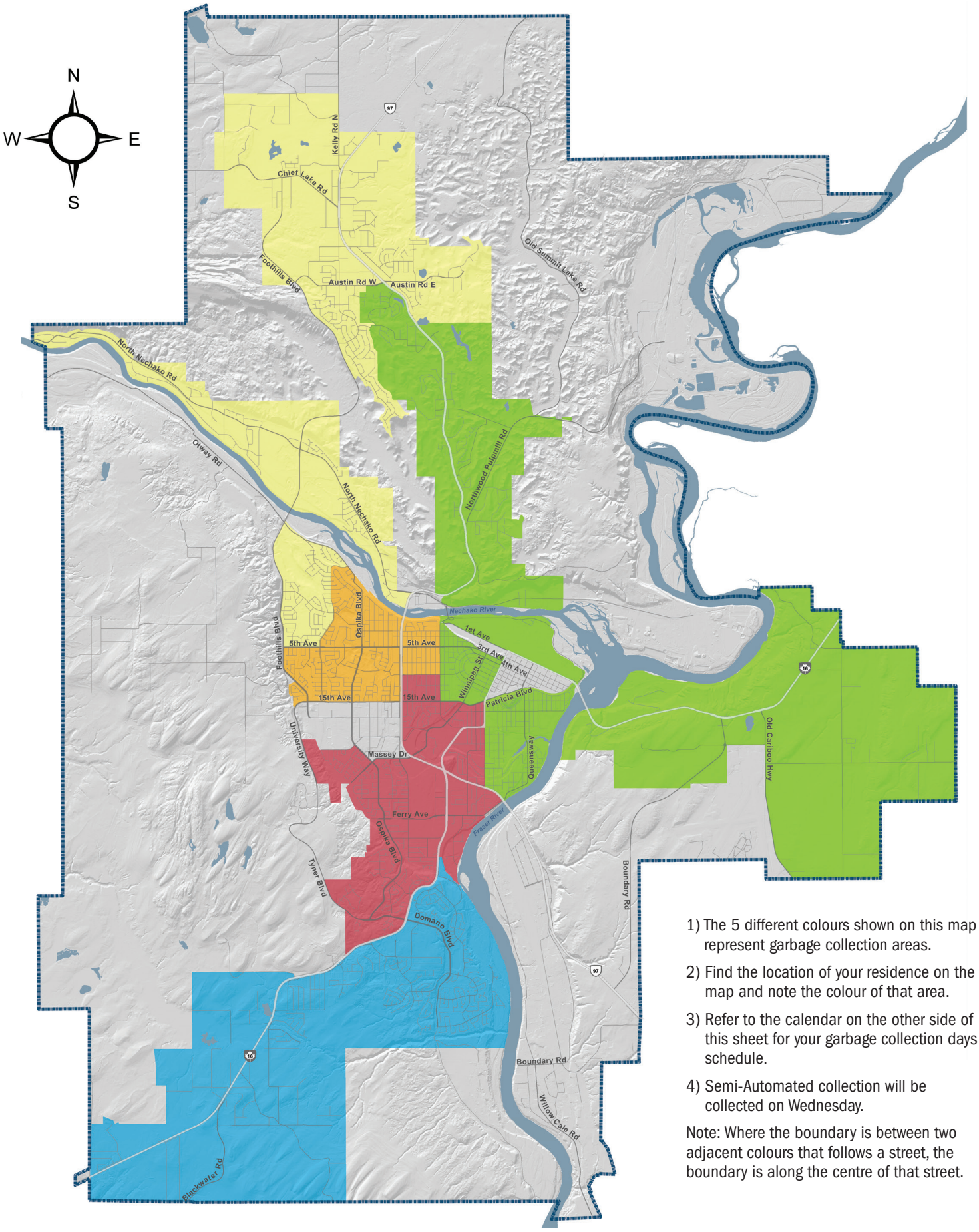
- Secure your garbage in a bear-resistant location such as your garbage or shed
- Place your garbage at the curb on the day of collection after 4:00am and before 8:00am.
- Clean your garbage cart to reduce odors.
- Take your bird feeder down from April to November.
- Keep your BBQ clean.

For more information please visit the City of Prince George's website at **www.princegeorge.ca** or call the Service Centre at 250-561-7600

PLEASE REMEMBER TO HAVE YOUR CART TO THE CURB NO EARLIER THAN 4:00 AM AND BEFORE 8:00 AM THE DAY OF YOUR COLLECTION

CITY OF PRINCE GEORGE

AUTOMATED GARBAGE COLLECTION AREAS



1) The 5 different colours shown on this map represent garbage collection areas.
2) Find the location of your residence on the map and note the colour of that area.
3) Refer to the calendar on the other side of this sheet for your garbage collection days schedule.
4) Semi-Automated collection will be collected on Wednesday.

Note: Where the boundary is between two adjacent colours that follows a street, the boundary is along the centre of that street.

APPENDIX II
CALCULATION METHODOLOGY

Waste Composition Estimation

1. The weighted mean of a particular category or subcategory was calculated by first summing the weights of that particular category across all the samples.

2. Next, the weights of each sample were summed to obtain the total weight for all samples within that set (e.g. Round 1 of SF-RES sector).

3. The weighted mean is finally calculated by dividing the first sum by the second.

This method was chosen to calculate the mean compositions because not every sample is exactly the same weight. This method ensures that the average gives more emphasis to those samples that contain a greater weight.

A simple illustration is provided for the sample calculation for the weighted mean of newsprint.

	RES-1	RES-2	RES-3	RES-4
Newsprint (weight)	2	1.5	1.4	3
Boxboard (weight)	1.1	2	3	1.2
Total Weight of Sample	3.1	3.5	4.4	4.2

Following Step 1, the sum is of the weights is taken across all samples of newsprint.

2 + 1.5 + 1.4 + 3 = **7.9**

Step 2 entails summing the total weights of each sample across all samples.

3.1+ 3.5 + 4.4 + 4.2 = **15.2**

Finally, the weighted mean of newsprint is calculated by dividing the two sums.

7.9 / 15.2 = **0.52**

Mathematically, the calculations of the weighted mean can be shown as follows:

Let

i represent an individual sample
j represents the waste category
k_{ij} represent the weight of waste category *j* in sample *i*
w_i represent the weight of sample *i*

Then,

Weight Mean of Waste Category *j* = $\Sigma_i k_{ij} / \Sigma_i w_i$

Standard Deviation Calculations

The non-biased standard deviation method was applied to the Study to estimate how much the waste in a particular category varies about the average from sample to sample.

1. All data was converted from weight in kilograms to percentage of sample weight. For example, Sample 1 has a total mass is 100.2 kg. Suppose 1.65 kg out of 100.2 kg consisted of Fine Office Paper then in terms of percentages, 1.65/100.2 or 1.65 percent of Sample 1 consisted of Fine Office Paper.

2. The non-biased, or "n-1" equation for standard deviation was then applied to the percentages of a particular waste category across all samples.

Using the above example, the weights are converted to percentages to obtain the following table.

	RES-1	RES-2	RES-3	RES-4
Newsprint (%)	65%	43%	32%	71%
Boxboard (%)	35%	57%	68%	29%
Total % of Sample	100%	100%	100%	100%

Then, applying the non-biased equation for standard deviation to newsprint,
(values 65%, 43%, 32%, and 71%) the standard deviation of newsprint is obtained to be 18.47%.

$SD_{newsprint}$ = sqrt((4((65%)^2 + (43%)^2 + (32%)^2 + (71%)^2) – (65% + 43% + 32% + 71%)^2) / 4(3)) = 18.34 %

Mathematically, the calculations of the standard deviation can be shown as follows:

$$SD_j = \sqrt{\frac{n\sum_i x_{ij}^2 - (\sum_i x_{ij})^2}{n(n-1)}}$$

Where i represents an individual sample
j represents the waste category
n is the number of samples
x_{ij} is the percentage waste in the waste category j of sample i

***Note**

The standard deviations for Primary Waste Categories were calculated by first calculating the standard deviations for Secondary Categories using the above method, and then summing those standard deviations to obtain standard deviations for the Primary Categories.

For the Study, the same methods for calculating weighted averages and standard deviations of waste categories in one particular facility have been extended to calculating weighted averages and standard deviations across data sets of an entire sector or round.

APPENDIX III
SELECTED SITE PHOTOS

Rigid Plastic Containers

Rural Transfer Station Load

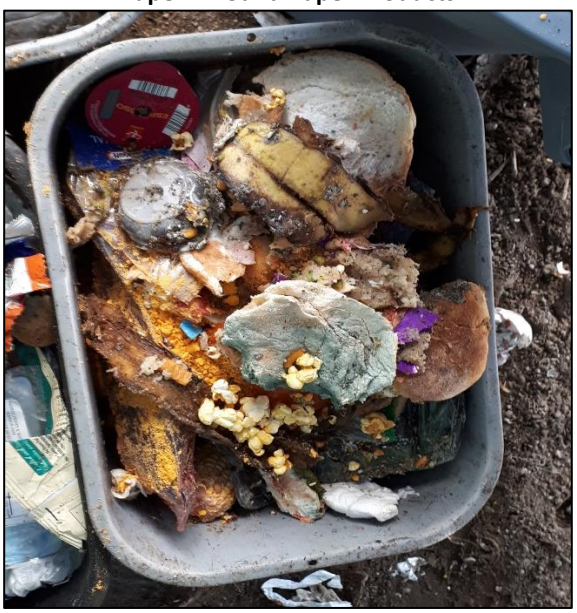
Household Hygiene – Pet Waste

Plastic Film

Paper – Fine, Computer, Office

Paper – Bound Paper Products

Other Plastics – Straws, Utensils



Compostable Organics – Food Waste

Electronic Waste – Audio/Video equipment

Paper – Tissues/paper towels

Beverage Containers – Non-Dairy

Textiles

Paper - Boxboard

Self-Haul; Commercial Load

Other Glass - Ceramics

Paper - OCC