MAKE EVERY BITE COUNT:

Study to Estimate the Greenhouse Gas (GHG) Footprint of Household Food Waste in Oakville

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Executive Summary

The purpose of this study was to establish a defendable estimate of the amount of food loss and waste (FLW) and resulting CO_2E (carbon dioxide emissions equivalent) generated by households in Oakville, and identify causal factors that result in avoidable FLW. The study's results will guide the development of public and private initiatives that will lead to reduced FLW and less CO_2E emissions through prevention and the improved management of organic waste streams.

Sixty-five Oakville households, 26 of which participated in a post-study interview, measured their FLW over seven consecutive days. In addition, an online survey was completed by 280 individuals, the majority of whom live in Oakville or the surrounding area. Quantitative and qualitative data captured during the study was triangulated to produce statistically robust conclusions. The study did not include food purchased and eaten at hotels, restaurants, institutions, or take-outs.

The 65 households represented 172 individuals, the average household therefore comprised 2.9 people. The total FLW reported by households was 282 kg. Reported as unavoidable (i.e. preparation waste) and avoidable (i.e. plate and spoiled waste), this amounted to an average of 4.2kg FLW per household and 1.7 kg per individual, respectively. A correlation existed between households with children, households located in particular wards, household income, and higher FLW. A correlation was also established between three merchandizing practices and increased household FLW, namely 1) pack size, 2) bulk buying, and 3) best before dates. Across all respondents, the highest daily FLW occurred on a Sunday. The meal occasion that experienced the highest FLW by volume was dinner. Fruits and vegetables (fresh) represented the highest total FLW by volume when categorized by food type; the majority of this FLW occurred during meal preparation and was therefore deemed unavoidable. Avoidable FLW represented 42 percent of total FLW.

Total household FLW in Oakville was estimated to be 16,370 tonnes. This represents 43,035 metric tonnes of CO_2E ($MtCO_2E$). Emissions were estimated by equating FLW volumes recorded by the 65 households to CO_2E for each kilogram of food by type, then extrapolating that data across Oakville's population. Landfilling FLW increases total emissions, composting FLW slightly reduces total emissions: +0.6 vs. -0.2 $MtCO_2E$ per tonne of FLW, respectively. When current waste management practices are factored into the analysis, total FLW emissions equate to 41,988 $MtCO_2E$. Composting all Oakville households' FLW would reduce CO_2E emissions by 2,227 tonnes.

The largest reduction in CO_2E emissions by food type would come from reducing avoidable FLW in meat and poultry. Avoidable household FLW currently equates to 23,675 $MtCO_2E$. Under current waste management practices, reducing avoidable FLW by 50 percent would lessen Oakville's annual food waste related emissions by 11,620 $MtCO_2E$. Reducing avoidable FLW by 50 percent, combined with the composting of all remaining FLW, would reduce total household FLW emissions to 28,608 $MtCO_2E$. This is 32 percent below the current baseline. This reduction of 13,380 $MtCO_2E$ emissions is equivalent to taking 3,345 cars off the road for a year. For reasons cited in the report, this potential reduction in CO_2E emissions is conservative.

By identifying the key drivers of household FLW, the study found that the majority of Oakville residents would benefit from more guidance on strategies to reduce FLW by improving their food purchasing, storage, and usage practices. Changes to merchandizing and date coding practices would enable and motivate further changes in consumers' purchasing and at-home decisions, leading to further reductions in FLW. Consumer messaging on food disposal practices and extending organic programs to all households, particularly those living in multi-unit complexes, would play an important role in further reducing CO_2E emissions by enabling a greater proportion of FLW to be composted.

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1 Introduction

Commissioned by the Halton Environmental Network[1] (HEN), and generously funded by the Ontario Trillium Foundation, this project's objective was to establish a defendable estimate of the amount of food loss and waste (FLW) and resulting wasted CO_2E[2] generated by households in Oakville. To guide the development of public and private initiatives that lead to reduced FLW and the environmental impact of FLW, the project also: 1) identified causal factors that lead to FLW, and, 2) estimated the comparative CO_2E footprints of FLW that is landfilled versus composted. The study did not include food purchased and eaten at hotels, restaurants, institutions or take-outs.

The research required the volume of FLW generated by homes across Oakville to be determined. This was achieved via households measuring their FLW and completing a seven-day food waste diary, completing an online survey, and participating in post-measurement interviews. Data produced by the household level research was extrapolated against secondary data to estimate the CO_2E footprint of households' FLW.

To assist in completing the research, we reviewed information and data sourced from the Region of Halton and Statistics Canada pertaining to:

1. Current population of Oakville;
2. Total number of households in Oakville — that is, owned houses, rented apartments, owned condominium apartments, as well as public housing;
3. Total number of households that may participate in the green bin organics recovery program;
4. Percentage of the population participating in the organic green bin program;
5. Composition of edible and inedible food compiled from green bin audits; and
6. Tonnes of organics typically recovered in Oakville over a recent 12-month period.

Findings from prior household food waste and municipal organic waste studies, such as those completed in the city of Guelph, were also reviewed.

2 Methodology – Data Collection

Based on the national estimations of FLW completed by Value Chain Management International[3] (VCMI) in 2019, the foods consumed by Canadians and the food waste associated with the consumption of these foods were categorized into six types.[4] The purpose of the granular research was to establish how representative this national statistic was in Oakville, then use the findings to estimate CO_2E emissions associated with Oakville households' FLW. Establishing a FLW and CO_2E profile for Oakville required the researchers to survey an adequate number of representative households.

To enable the research to produce robust conclusions through having triangulated quantitative and qualitative data, the FLW data and feedback on factors that lead to FLW were collected from three sources:

[1] https://www.haltonenvironet.ca/
[2] Carbon dioxide emissions equivalent
[3] https://vcm-international.com/
[4] The six primary food types chosen for the study were 1) dairy/eggs; 2) meat/poultry; 3) fish/seafood; 4) grains/rice/ bread, etc.; 5) fruit/vegetables; and 6) sugar/syrups.

1) A household measurement study, where households were asked to weigh and record their preparation (unavoidable) food waste, and plate/spoilt (avoidable) food waste for the six chosen primary food types over a seven-day period
    a. Instructions, scales, recording sheets, and assistance were provided to participants
    b. Out of a targeted 100 households, we received 65 completed studies
2) An online survey
    a. Our target was 250 responses; actual responses totalled 280
3) Telephone interviews of 26 households

Households were invited to participate in the study and online survey through HEN and VCMI contacts,[5] as well as media outreach conducted by HEN.

A misconception that the measurement of FLW would be more daunting and time consuming than it actually was proved to be a challenge when recruiting participants. In total, 104 households received kits containing kitchen scales, instructions, and record sheets. The measurement reporting process ensured respondents' anonymity. The only personal information sought from all respondents in the form of a short survey was their postal code, household size, whether they lived in a house, condo, etc., and if any household member was aged under 13 years. The survey also asked whether the household had and used a green (organic) bin, and how they most commonly disposed of FLW. A challenge faced during the study was the level of anonymity given to participants. This limited the degree to which participating households could be motivated and reminded to complete the study and to return their records in a timely fashion.

In the measurement kit, respondents were asked if they were willing to participate in a short follow-up telephone interview. Twenty-six interviews were completed. During the interview, respondents were asked whether the experience had altered their perspectives of FLW compared to those that they had possessed prior to participating in the study. They were also asked if they were surprised by the findings and/or causal factors that had impacted the volume and types of FLW they had experienced. Causal factors explored during the interviews included those related to the food purchasing process and drivers of choice, meal preparation, and general in-home behaviours.

In addition to the FLW measurement and follow-up interviews, an online survey that explored individuals' FLW related behaviours and attitudes was randomly distributed by HEN and VCMI to their networks and via social media. The retail grocer Longo's[6] also supported the survey, with HEN staff and Longo's Director of Sustainability promoting the study in a North Oakville store. Among the topics investigated in the survey were: 1) household location and demographics; 2) whether respondents had purposely modified their food purchasing or at-home behaviours in an effort to reduce FLW; 3) the extent to which they perceived a direct link to exist between FLW, financial, socio-economic, and environmental considerations; 4) the perceived importance of best before dates for different types of foods; and 5) those foods in which they experienced comparatively less/more avoidable food waste.

[5] The majority of the 65 households who participated in the study were direct HEN and VCMI contacts. This may have affected the randomness of the type of household that participated in the study versus the wider Oakville populous.
[6] Longo Brothers Fruit Markets Inc. (https://www.longos.com)

3 Summary of Data

For the purpose of this study, the term "food loss" was applied to food (and beverages) discarded during the preparation and cooking of meals. This included fruit or vegetable peelings and animal bones, which are also commonly referred to as unavoidable waste. The term "food waste" was applied to food (and beverages) that were prepared and not eaten and food that spoils. These occurrences, such as plate waste and foods that spoil due to their quality degrading or from having reached their best-before date, are often termed "avoidable waste." While almost all waste is avoidable to a degree, avoidable FLW offers the greatest opportunities to minimize the economic and environmental impact of food and beverages. This is because it typically results from individual behaviour, such as consumers purchasing beyond their needs or not keeping leftovers.

As mentioned previously, a total of 65 households in Oakville participated in the food waste measurement challenge. Each household measured (weighed) and recorded the amount of preparation and plate waste for every meal that was prepared/consumed in their home over a seven-day period. Uneaten foods that were stored for a later occasion were not waste and therefore not included in the measurement/reporting. Food discarded during the seven days' measurement period due to spoilage was recorded. All food was measured in grams. To avoid the weighing of water, the number of tea and coffee beverages was recorded by participants, and these were converted into dry weight: 3g per cup of tea and 6g per cup of coffee. The dry weight of tea and coffee was added to fruit and vegetable preparation waste.[7]

3.1 Household Composition

Two-person households made up 42 percent of participants. Forty-five percent of participating households had three or more members. The measurement studies took place from mid-November 2019 to mid-February 2020, with the majority of households participating in December 2019 and January 2020.

Within the 65 households, there were 143 adults and 29 children, totalling 172 individuals. The average household size was 2.9 people. Sixteen of the households had children under 13. Children represented 16.9 percent of the participant households, which tracks closely to Statistics Canada 2016 data[8] that indicates children aged 14 and under represent 18.9 percent of the Oakville population.

While the distribution of household size from the study was similar to that which is seen in the Oakville population, there was a moderate over representation of two-person households and a moderate under representation of five or more person households (Table 3-1).

Table 3-1: Distribution of participants by household size compared with Oakville population

	Study Participants		Oakville Census Data	
Household size	**# of households**	**% of households**	**# of households**	**% of households**
1 person	9	14%	11,760	18%
2 people	27	42%	18,715	28%
3 people	11	17%	12,170	18%
4 people	15	23%	15,560	23%
5 or more	3	5%	8,070	12%
TOTAL	**65**		**66,270**	

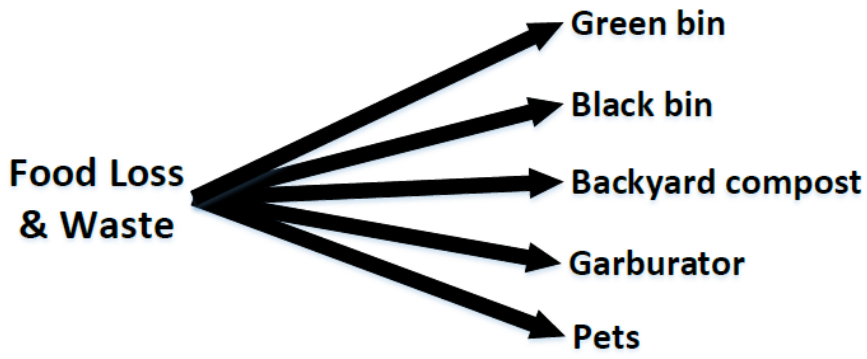
[7] Tea is a leaf and coffee is from a berry, hence the allocation to this food category, as per previous classification in VCMI research.
[8] Statistics Canada 2016 data – Oakville population

3.2 Food Waste Overview

The analysis found that study participants discarded approximately 1.7kg of FLW person/week. This is 40 percent less than the national average estimated by VCMI in 2019 (based on 2016 data), which was 2.8kg/person/week[a] (Section 5). Based on the average household being 2.9 persons, this equates to an average weekly food waste per household of 4.2kg. This figure of 4.2kg is 40 percent higher than average weekly household waste data sourced from Halton Region.

One major reason that the figure of 1.7kg of FLW per person is 40 percent lower than the national estimate is that the national estimate comprised food service (dine-in and take-out). Reasons for the difference between the study's findings and data sourced from Halton Region include the fact that the study measured all FLW regardless of its method of disposal. As illustrated below in Figure 3-1, five disposal routes for FLW were identified during the research. These were: organic (green) bins, regular (black) garbage bins, garden composting, garburators, and leftovers being fed to pets.

Figure 3-1: Food loss and waste disposal routes



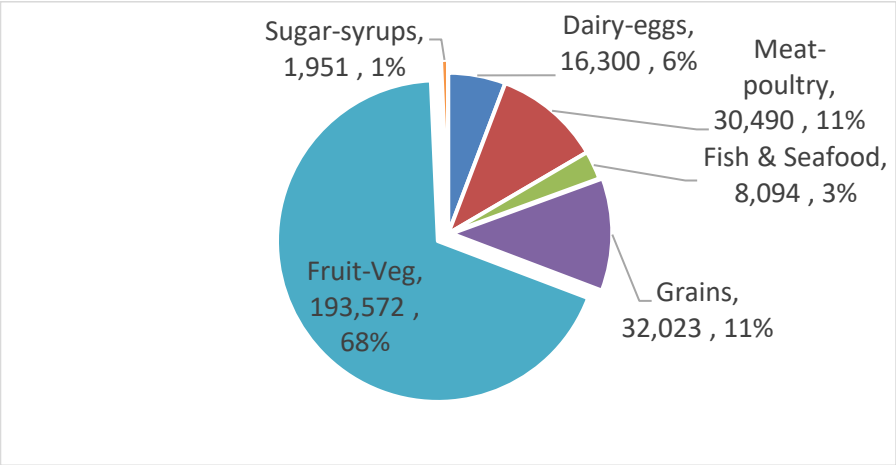
Halton region's data was captured from green bin audits, which is one of five FLW disposal routes. This study's data was captured in the home, so it encapsulated all five disposal routes.

4 Household Food Loss and Waste

4.1 Total Household Food Loss and Waste

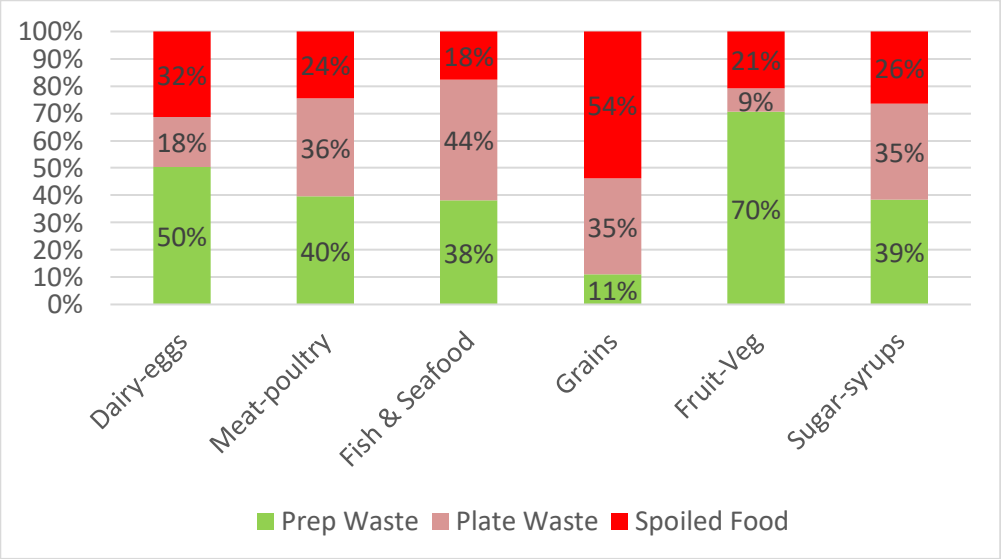
The 65 participating households reported a total of 282kg of food waste occurring over a seven-day period. The charts below provide a summary of the total weekly food waste. We regard preparation waste as largely unavoidable food loss, whereas plate waste and spoiled food is largely avoidable food waste. Figure 4-1 illustrates that the majority of FLW is in the produce (fruit and vegetable) category; and the majority of this is unavoidable (preparation) waste.

Figure 4-1: Weekly total food waste reported by food type (grams)



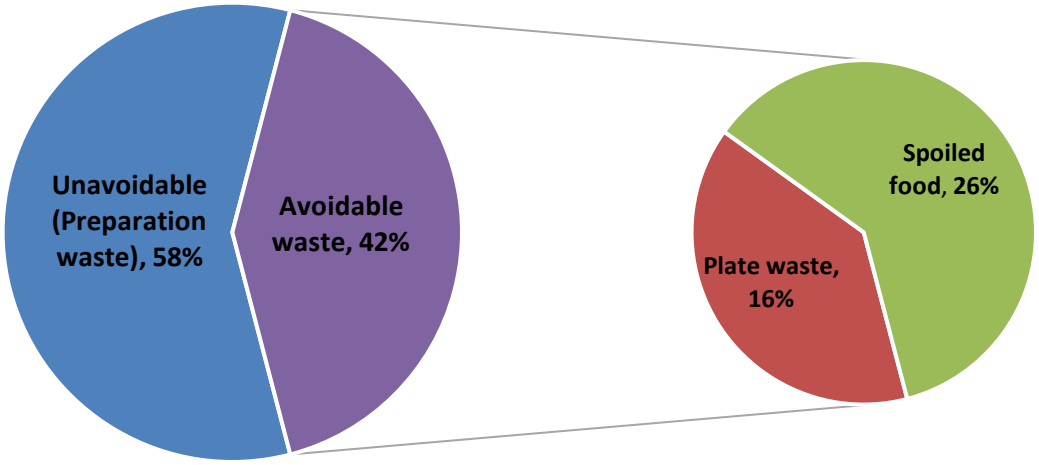
As shown below in Figure 4-2, at 89 percent, grains had the highest proportion of avoidable (plate and spoiled combined) food waste. In all categories, except produce, avoidable food waste accounted for 50 percent or more of the total waste. With all FLW being avoidable to a degree, the findings illustrate the full extent of opportunities to reduce FLW related greenhouse gas (GHG) emissions. Reducing avoidable FLW has a direct effect on the occurrence of unavoidable FLW. An example is vegetables, where reducing plate waste by preparing a smaller volume of food would reduce the volume of unavoidable waste (e.g. broccoli stalks or potato peelings) that result from the meal's preparation. In the same way, reducing the amount of bread that is avoidably wasted in the home would result in less bread needing to be manufactured. It would also reduce manufacturing waste occurring further up the chain. This includes less grain needing to be milled in the production of the flour, and, in turn, less flour used in the manufacturing of bread. Less associated wastes that also result in GHG emissions, such as energy and transportation emissions, would also occur.[b]

Figure 4-2: Type of food loss and waste for each food category



In its 2019 national analysis of FLW, VCMI had estimated that household waste was 50 percent avoidable (plate and spoiled waste) and 50 percent unavoidable (preparation waste). The data from the household participants suggests food waste is 42 percent avoidable and 58 percent unavoidable. Figure 4-3 shows the breakdown of total FLW from the household study, of which 26 percent is spoiled food and 16 percent is food this is not eaten and thrown away. Spoiled food includes that which has reached its best before date or its quality has deteriorated to a point that it is not considered fit to eat. The latter includes items such as overripe fruit and stale bread.

Figure 4-3: Unavoidable vs avoidable waste



Of the 26 individuals who participated in the FLW measurement and post-study interviews, all had learned from their experience — some in unexpected ways. Eleven (42%) of the 26 interviewees stated that the results were reasonably close to what they expected. Of the 15 respondents who were surprised by the findings, five (33%) had expected their total FLW to be higher than the results showed, while seven (47%) were surprised by the amount of waste. Eight (53%) of the 15 respondents were surprised by the amount of preparation waste and the types of waste they experienced; the most common reference made by interviewees being for fruits and vegetables, followed by meat.

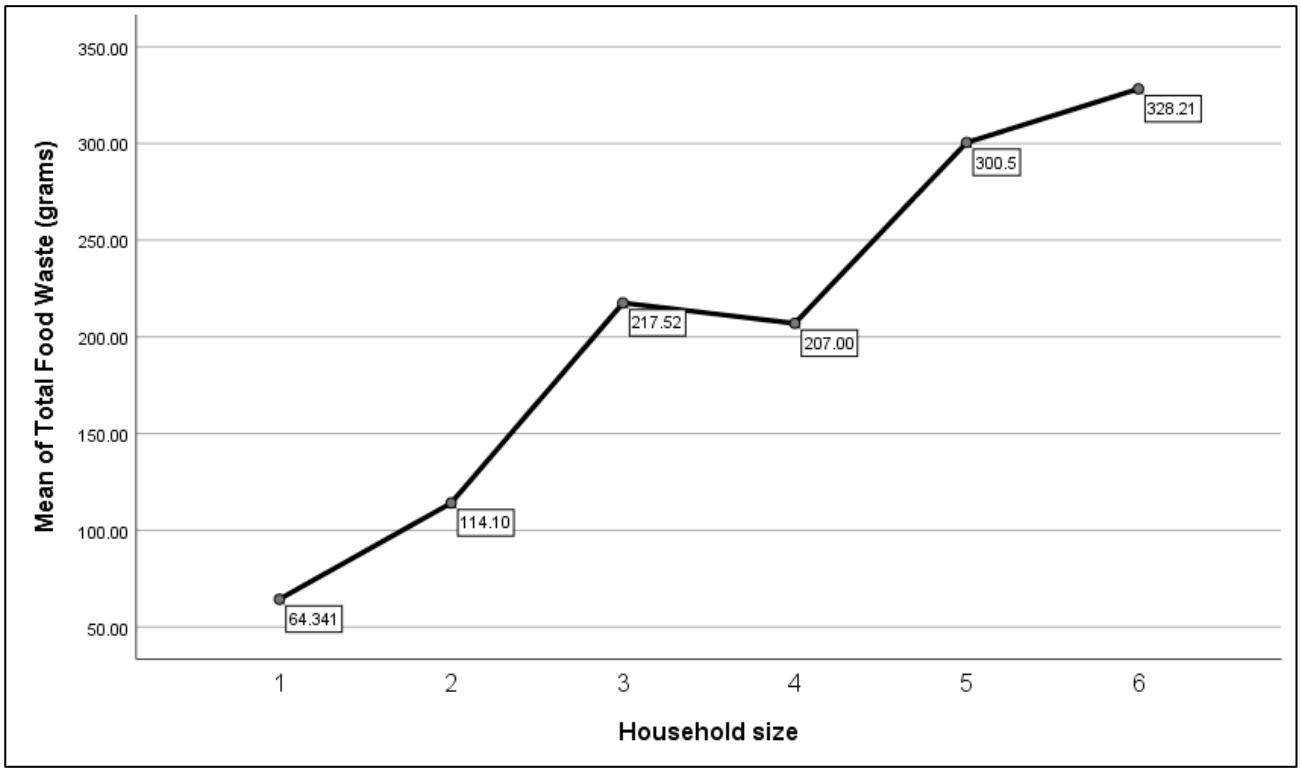
Out of all 26 respondents, 58 percent (n=15) stated that the study had markedly increased their awareness of FLW, and expected that what they had learnt would either moderately or significantly influence their purchasing and/or at-home behaviours going forward. The most common responses were related to realizing the need to reduce FLW by better managing the contents of their fridge, and more proactively using foods before they reached their best before date. Two respondents stated how pack size led to avoidable FLW: an example given was purchasing three heads of romaine lettuce in a single package, which invariably led to waste in a single-person household. Another respondent stated that the avoidable FLW they experienced was influenced by whether they had completed a bulk buy.

4.2 Household Size and Waste

A one-way ANOVA of analysis of total food waste identified a significant correlation between household size and total food waste. This is not a surprising finding, as it would be expected that the greater the number of individuals in a household, the greater the total amount of food waste (Figure 4-4). That said, no significant difference was found to occur between the total food waste produced by three- and four-person

households. Sections 5 and 6 describe the detailed extrapolations that were conducted to identify differences in per person food waste and causal factors.

Figure 4-4: Average total food waste by household size

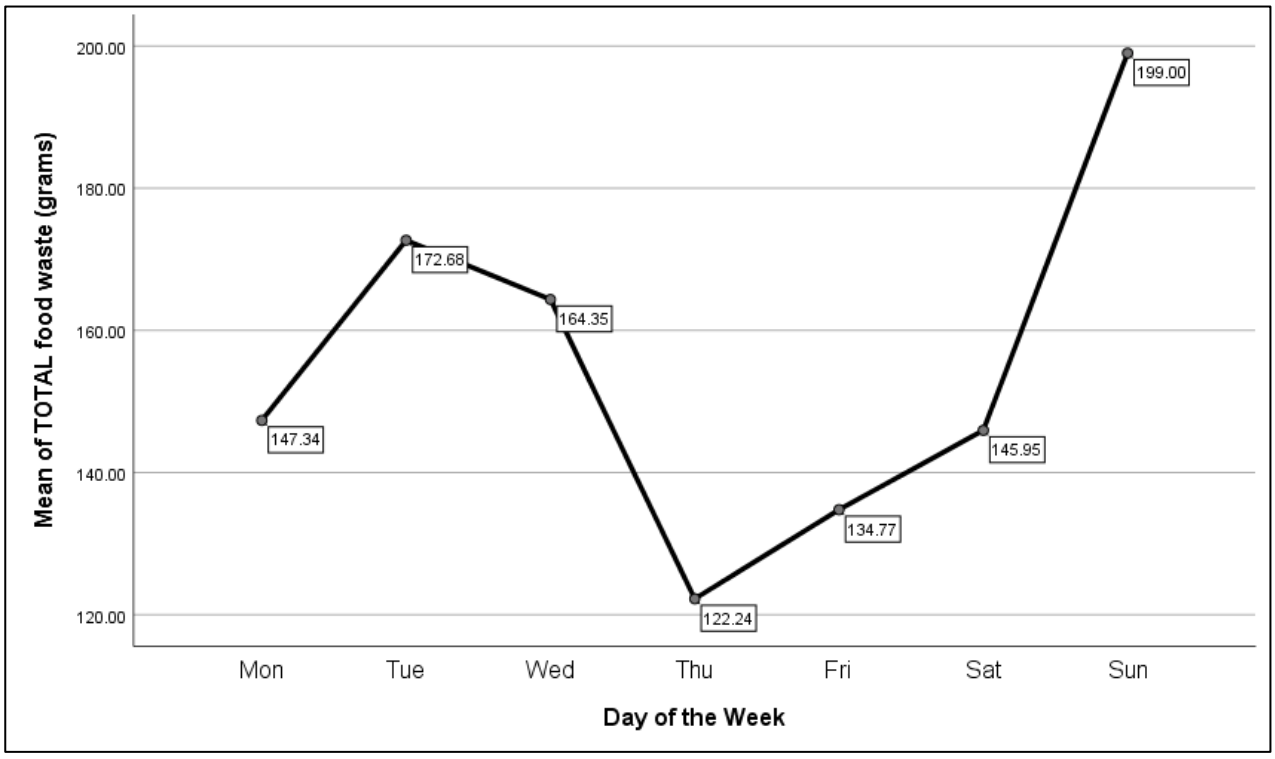


Analysis was subsequently conducted to assess whether any differences occurred in the food waste reported for particular days of the week, specific meal occasions, geographic location, and if children (<13 years) are members of the household.

4.3 Day of the Week

A statistical difference was observed in the amount of waste that occurred on a particular day of the week. Figure 4-5 presents the means from the one-way ANOVA analysis. The highest average food waste occurred on a Sunday (~200gms). The lowest average food waste occurred on a Thursday (~122gms).

Figure 4-5: Average total food waste by day of the week

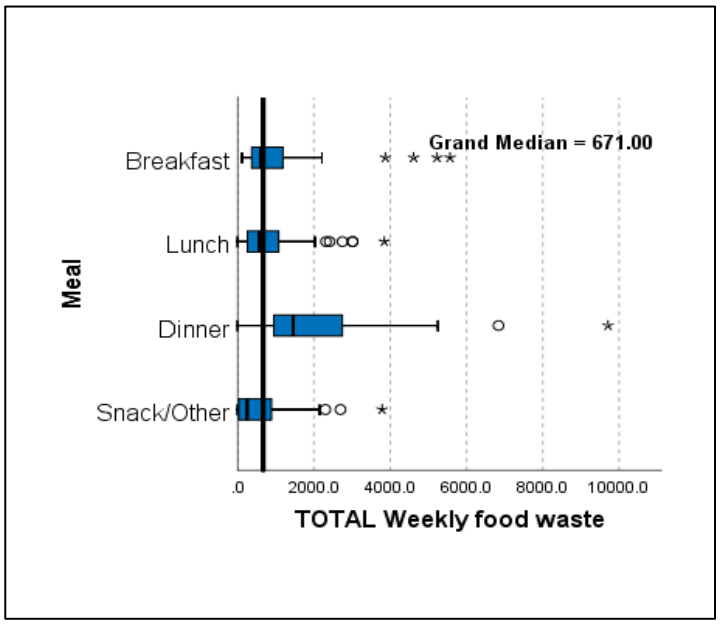


Two factors in particular appeared to lie behind why the highest volume of FLW occurred on a Sunday. The first was due to the preparation of a large family meal. Large meals may also lead to higher plate waste and also leftovers. The second was due to families cleaning out the fridge prior to the working week. As described previously, a number of those who participated in the study had come to recognize how they could reduce FLW by better managing the contents of their fridge. The foods most commonly mentioned in relation to fridge management were vegetables.

4.4 Meal Occasion

There was a statistical difference in the amount of waste that occurred by meal (breakfast, lunch, dinner or snack/other). Dinner was found to result in significantly higher waste than any other meal (Figure 4-6). The median total weekly waste that occurred in Oakville households from the dinner meal was 1.46kg. This compared to 0.62kg for breakfast and 0.58kg for lunch.

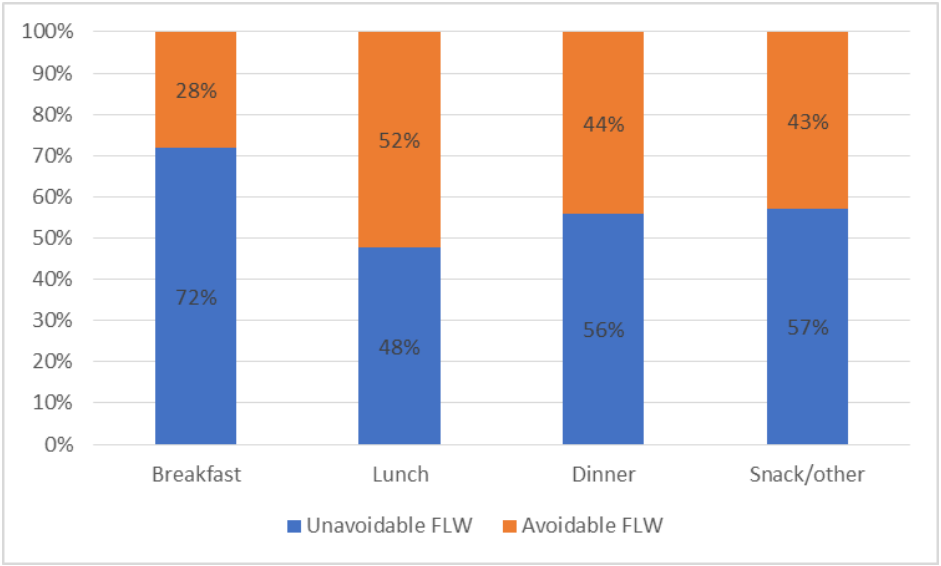
Figure 4-6: Weekly food waste by meal (grams)



The above box plot shows the distribution of responses. The single thick black line that runs through all four meal occasions is the overall median for all meals (0.67kg). The thick black line within each of the four individual boxes gives the median response for that meal occasion — 50 percent of responses were above this point and 50 percent were below this point. The box gives the quartiles above and below the median (a quartile is 25% of the responses); therefore, this is the middle 50 percent of responses. The bars that extend outside of the box give the first and fourth quartile, while the dots indicate outliers in the data.

As shown in the bar chart that forms Figure 4-7, the majority of the food waste produced at dinner was unavoidable preparation waste (56%), while lunch meals resulted in a comparatively higher proportion of avoidable waste (52%). The lowest occurrence of avoidable food waste was associated with breakfast (28%). Snacks/other resulted in a similar percentage of avoidable waste to that associated with dinner (44%).

Figure 4-7: Weekly food waste by meal — unavoidable vs avoidable waste



Examples of specific FLW per meal occasion included:

1) Breakfast
    a. Unavoidable: banana peels, apple cores, egg shells
    b. Avoidable: yogurt that had reached its best before date
2) Lunch
    a. Unavoidable: banana peels
    b. Avoidable: uneaten sandwiches (some of which returned home in lunchboxes)
3) Dinner
    a. Unavoidable: vegetable peelings, meat trimmings
    b. Avoidable: excess rice, bagged salads that had reached their best before date
4) Snack/other
    a. Unavoidable: orange peelings, apple cores
    b. Avoidable: uneaten sandwiches, stale bread

The most common time of the day for households to dispose of spoiled food was during the preparation of the evening meal.

4.5 Oakville Wards

Of the seven wards in the community of Oakville, the population of one (Ward 3, n=24) was particularly engaged in the research. Ward 3 and the next most engaged ward (Ward 6, n=11) are situated in East Oakville. The distribution of households that participated in the measurement study, across each of the seven wards, is presented in Table 4-1 below. A geographic map of the wards forms the Appendix.

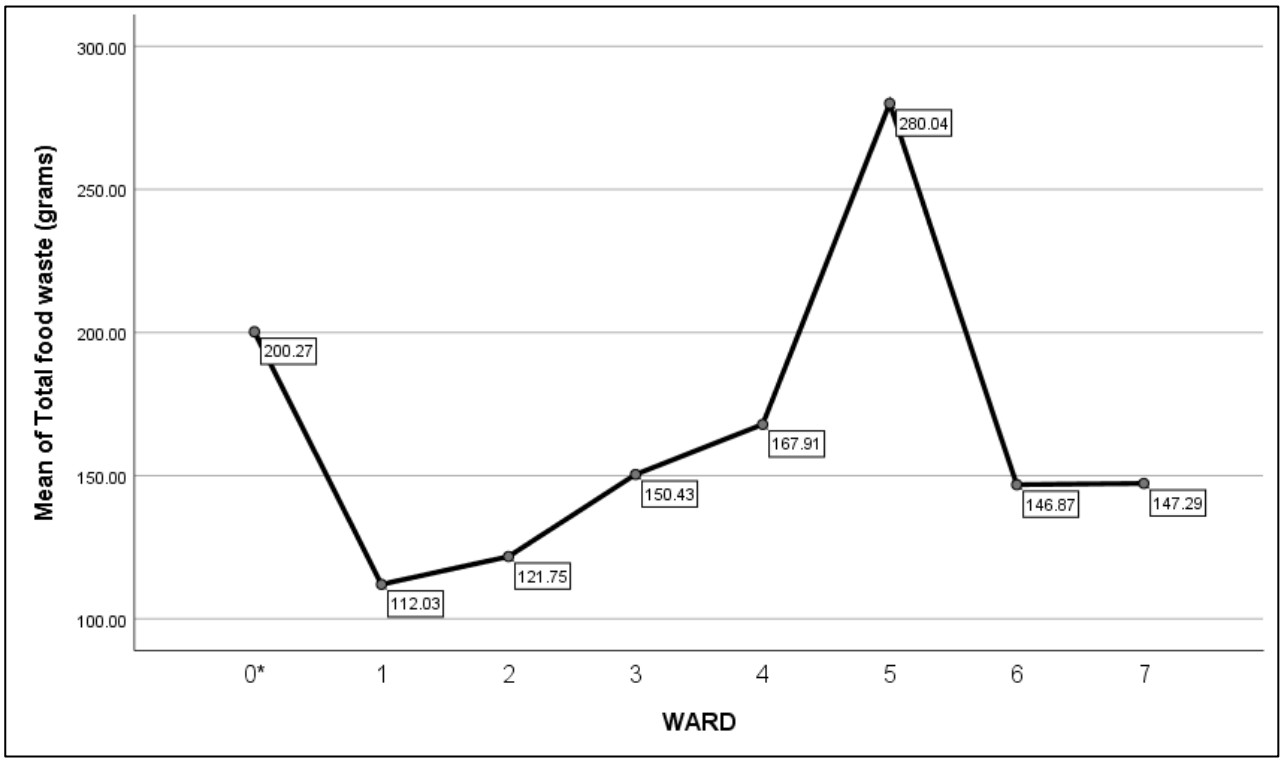
Table 4-1: Respondents by ward

Ward	Respondents
0*	2
1	7
2	8
3	24
4	6
5	5
6	11
7	2
Total	**65**

**These two respondents could not be allocated to a ward and therefore were given the ward number of "0."*

The analysis identified that there was a significant difference in total food waste reported within each of the seven wards that together comprise the community of Oakville. As shown in Figure 4-8 below, ward 5 represented a significantly higher total food waste than the other six wards.

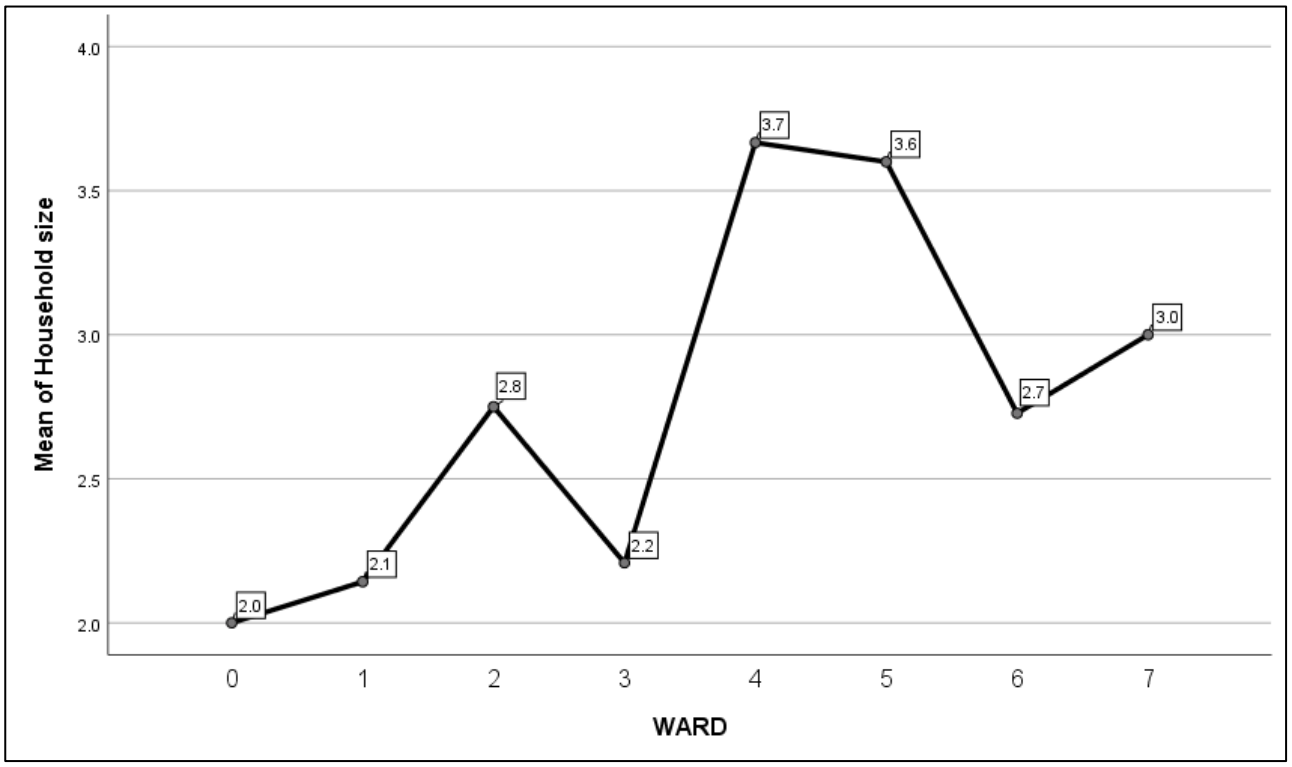
Figure 4-8: Average total food waste by ward



**Two households were not allocated to a ward due to lack of correct location data; these two households were given the ward number of "0."*

While the comparatively low number of responses from five of the seven wards means that the granulated ward level extrapolation of results should be considered directional, significant differences in total food waste were identified within those households with children versus those without children. Despite the fact that this is likely a function of household size, and the fact that, as can be seen below in Figure 4-9, the average household size of participants from wards 4 and 5 was higher than the other wards (3.7 and 3.6 people, respectively), this does not explain why the total food waste reported per household in ward 4 was significantly less than that reported in ward 5 (~160gm and ~280gm, respectively).

Figure 4-9: Average household size in each ward



Further analysis identified that whether households contain children aged under 13 has a measurable impact on the volume of household FLW. The interviews supported findings from prior VCMI studies, which identified that the finicky eating habits of younger children—which includes the refusal to eat leftovers at a later date (such as for lunch the next day)—partly explain the correlation between child age and household FLW. The interviews also tended to support results produced by the online survey (Section 7) that pertain to the fact that those households with children are more likely to definitively discard food due to it nearing or reaching its best before date. These factors help to explain why a significant difference in FLW was reported by families with children, particularly those with young children, versus those families without children.

4.6 Socio-Economic Status to Income Quintiles

Canada Post and Statistics Canada produce the Postal Code Conversion File Plus (PCCF+). The PCCF+ allows geographic postal code data to be extrapolated against 2016 Census data. The income data provides insight into the economic situation of households within a neighbourhood based on postal code. The income variables in the PCCF+ are provided on the basis of a single person's income, modified to account for the fact that it generally costs less (on a per person basis) for two or more individuals living together than it does for an individual living alone. The quintiles presented below are based on distribution of income at the metropolitan (local) area level, not nationally. In so doing, it provides a regional focus. As shown below in Table 4-2, the majority of respondents (n=47, 72%) were identified as being in the highest income quintile.

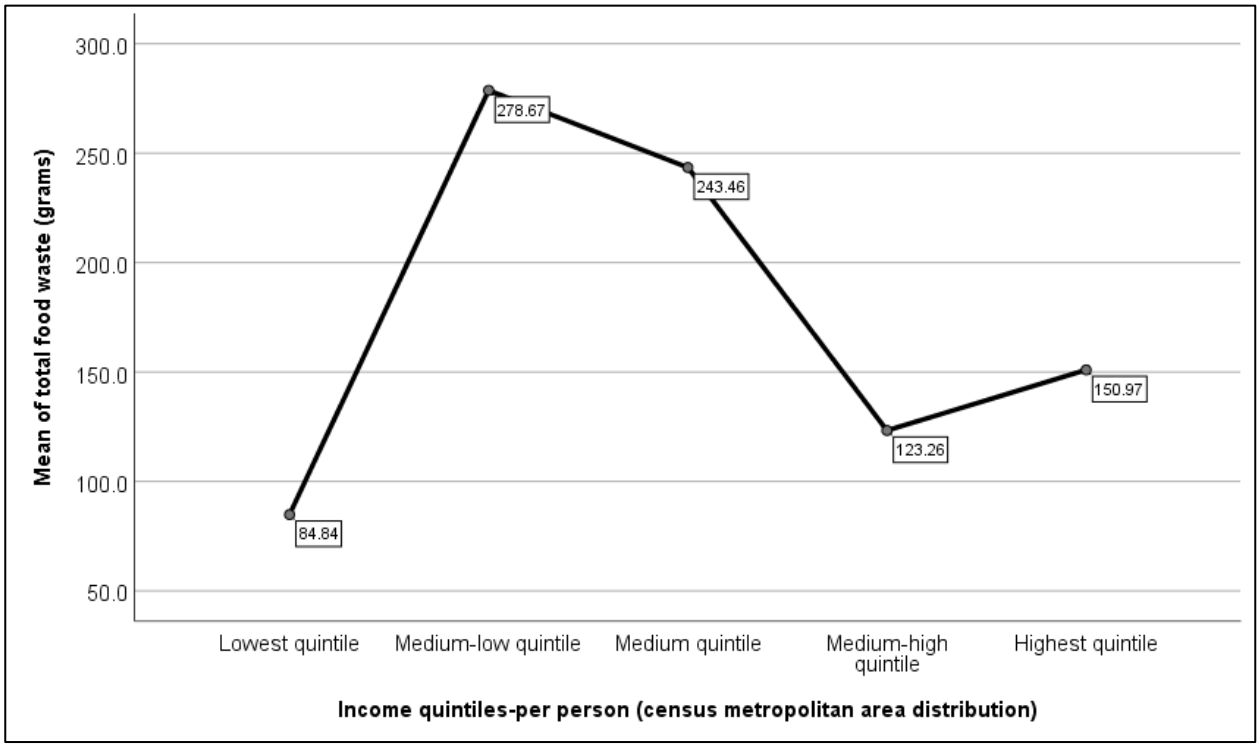
Table 4-2: Oakville respondents by income quintile

Income Quintile	Respondents
1: lowest	2
2: medium-low	3
3: medium	2
4: medium-high	9
5: highest	47
Not available	2*
TOTAL	**65**

* *Two households did not provide their postal codes*

Analysis of the FLW measurement data based on income and postal code data found no significant direct correlation of food waste and income. For example, total FLW or FLW by food type did not increase or decrease with income. However, a significant difference in mean food waste was found when incomes were classified by quintile. Figure 4-10 shows that respondents from neighbourhoods that are in the medium-low and medium quintiles of income have higher average food waste than those in the lowest and highest income quintiles.

Figure 4-10: Mean total food waste by income quintile



The small number of responses received for three of the five socio-economic quintiles mean that the results should be considered directional, not quantitative. An assumption that low-medium and medium income segments of the population may experience higher FLW, due to having responded to promotions or buying in bulk as a result of price incentives, is supported by insights captured by the follow-up interviews. Fully quantifying the causal factors that lie behind differences in overall FLW by socio-economic quintile, and the full extent of these differences, would require further research.

4.7 Influence of Weather and Retail Promotions on FLW

Throughout the period of time that households were weighing and reporting FLW, VCMI monitored daily weather and retail promotions. Weather was tracked by recording Oakville's average daily temperatures and overall weather patterns, reported online by the Weather Channel. Retail promotions were tracked by collecting and monitoring retail fliers on a weekly basis.

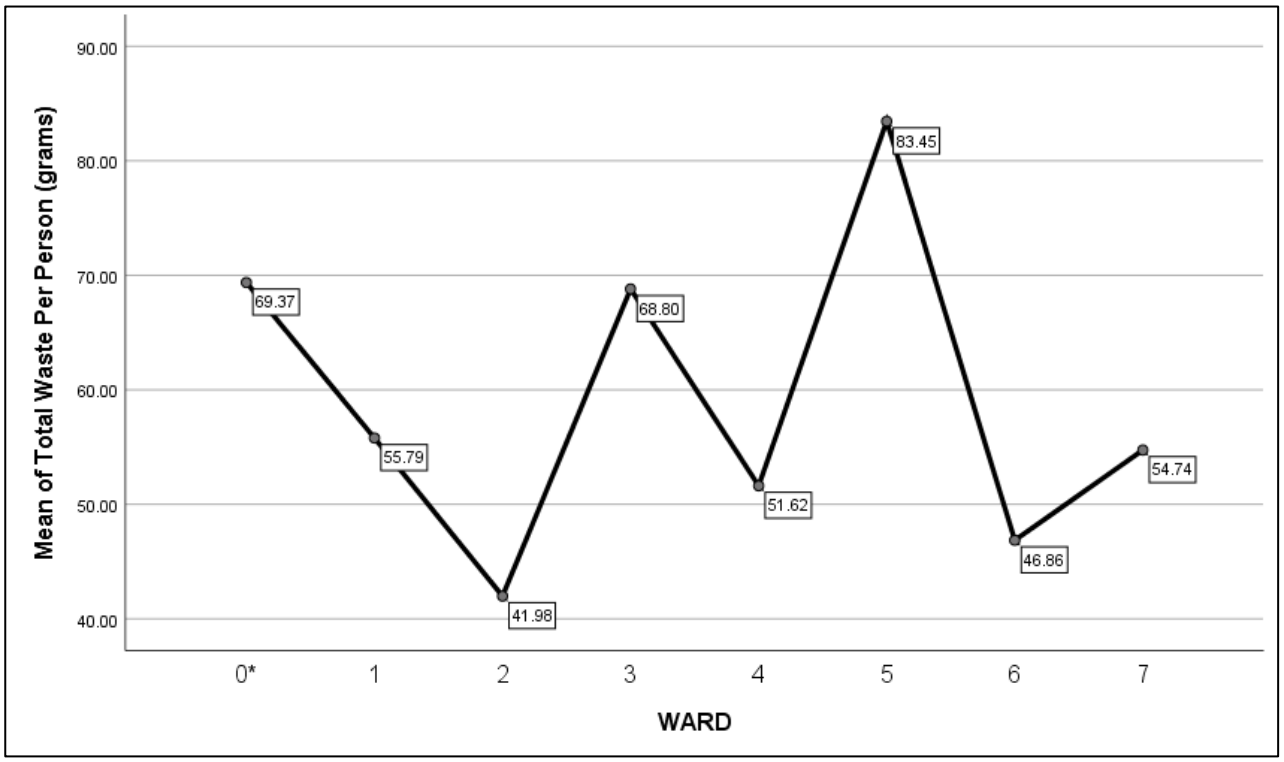
No correlations were identified to exist between the FLW reported by the 65 participating households and weather events or retail promotions in the form of fliers. The measurement of household FLW and the post-study interviews did, however, see a correlation established between three retail merchandising practices and avoidable FLW. These three practices were 1) pack size, 2) bulk sales, and 3) best before dates. Pack size and bulk sales encourage shoppers to purchase beyond their needs. Best before dates can lead to consumers unnecessarily disposing of food that is safe to eat. That each of these factors have the potential to significantly influence avoidable household FLW is supported by prior studies.[c]

5 FLW per Person

Total waste per household was calculated and then divided by the number of people in that household to establish the total waste per person. The average waste per person for each meal was totalled to calculate the per person waste for the week. The average waste from the participants was 1,666 grams (~1.7kg) per person per week. Based on 2016 statistics, in 2019 VCMI estimated that the Canada-wide average household waste stood at 2.8kg per person per week.[d] Expected reasons for differences between VCMI's national estimate and this study of Oakville residents were highlighted in Section 3.2.

Analysis was conducted to assess if correlations existed between an average total waste per person and 1) household size, 2) if children were in the household, and 3) location (ward). There was no statistically significant difference in the average per person waste when the data was grouped by household size or if children were present. Despite the fact that households containing children aged under 13 years does statistically impact household level results, it does not have a statistically significant impact on per person waste. However, reflecting the findings presented in section 4.3, a statistically significant difference was identified in total average per person waste between locations. Figure 5-1 shows total average waste per person per ward.

Figure 5-1: Average total waste per person by ward



**As mentioned previously, two households were not allocated to a ward due to lack of correct location data; these two households were given the ward number of "0."*

As can be seen, the average per person total food waste ranged from ~42gms (ward 2) to ~83gms (ward 5). Ward 5 is an outlier, meaning that the results are materially different to the other wards. The average per person total food waste in the other five wards was between ~48gms (ward 6) and ~69gms (ward 3).

6 Food Loss and Waste CO_2E Emissions

The per person food waste identified in this study was 40 percent lower than the national average previously estimated by VCMI in 2019. On a per household basis, the study was 40 percent higher than food waste data provided by Halton Region. Reasons for these differences are described in Section 3.2. The measurement of food waste per person was used as the basis to extrapolate the food waste volume to CO_2E footprint. This was because the study identified that the average total food waste on a per person basis did not vary significantly by household size, rather the biggest difference was by ward.

As mentioned previously, for the extrapolation, preparation waste is considered unavoidable food waste; plate waste and spoiled food are considered avoidable.

6.1 Total FLW CO_2E Emissions

Previous work by VCMI established a ratio of CO_2E emissions per tonne of food for the six categories of food from production along the food chain.[e] This includes emissions produced by primary production, processing, manufacturing, distribution, retail, and transportation along the value chain. The CO_2E ratios for each of the six foods are shown in Table 6-1 (total food waste) and Table 6-2 (avoidable food waste) below. These values

enabled the estimation and extrapolation of CO_2E from the food waste reported for the community of Oakville.

From left to right, each of the tables shows 1) the total volume of FLW recorded for each of the six food types over a seven-day (one week) period; 2) the aggregated CO_2E emissions of each 1kg of that food type; and 3) total CO_2E emissions that the total volume of FLW in each type of food represents. This figure is then extrapolated across the broader Oakville population on a weekly and yearly basis.

Table 6-1: Total food waste and estimated CO_2E

Food Type	**Study Participants (n=172)**			**Extrapolated for Oakville Population (191,720[9])**	
TOTAL WASTE	**kg FLW/ week**	**kg CO_2E/ kg FLW**	**kg CO_2E/ week**	**MTCO_2E/ week**	**MTCO_2E/ year**
Dairy & eggs	16.3	4.05	66.00	74	3,825
Meat & poultry	30.49	15.01	457.71	510	26,529
Fish & seafood	8.09	4.68	37.90	42	2,197
Grains, rice etc.	32.02	1.16	37.24	42	2,158
Fruit & vegetables	193.57	0.73	142.02	158	8,231
Sugar & syrups	1.95	0.82	1.60	2	93
TOTAL	**282.43**		**742.47**	**828**	**43,034**

6.2 Avoidable FLW CO_2E Emissions

The extrapolation concluded that Oakville's total food waste accounts for 43 thousand MT (metric tonnes) of CO_2E emissions per year. Of this, avoidable waste accounts for 23.6 thousand MTCO_2E per year, or 55 percent of the total CO_2E from food waste.

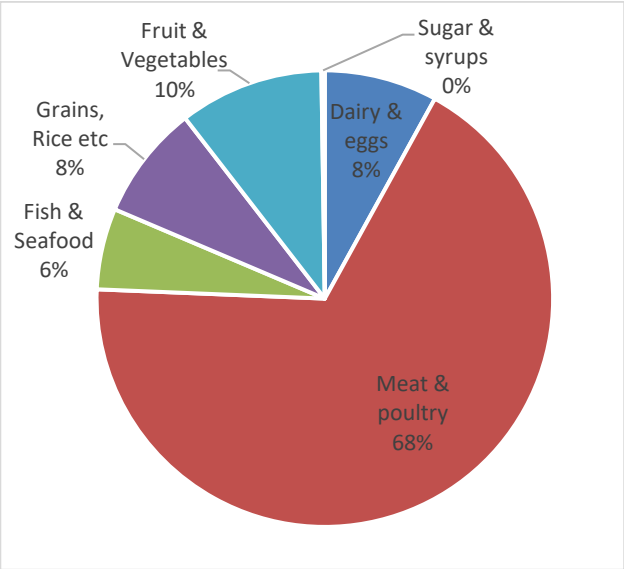
Table 6-2: Avoidable food waste and estimated CO_2E

	Study Participants (n=172)			**Extrapolated for Oakville Population (191,720)**	
Avoidable waste	**kg FLW/ week**	**kg CO_2E/ kg FLW**	**kg CO_2E/ week**	**MTCO_2E/ week**	**MTCO_2E/ year**
Dairy & eggs	8.1	4.05	32.72	37	1,896
Meat & poultry	18.4	15.01	276.32	308	16,016
Fish & seafood	5.0	4.68	23.48	26	1,360
Grains, rice etc.	28.5	1.16	33.17	37	1,922
Fruit & vegetables	57.0	0.73	41.83	47	2,424
Sugar & syrups	1.2	0.82	0.99	1	57
TOTAL	**118.3**		**408.51**	**456**	**23,675**

[9] Number of people in private households – according to 2016 Census data

Figure 6-1 below illustrates that, although the produce (fruit and vegetable) category had the highest mass, it accounted for 10 percent of Oakville's avoidable food waste related CO_2E emissions. The GHG footprint associated with meat and poultry accounted for 68 percent of the avoidable food waste CO_2E emissions.

Figure 6-1: Percentage of avoidable waste CO_2E by food category



6.3 Impact of Destination on CO_2E Emissions

FLW CO_2E emissions are less when FLW is composted versus landfilled. The majority of Oakville's FLW is composted through the regional green bin program. The emissions calculation assumed that multi-unit dwellings/apartment buildings typically do not have access to the green bin program. Green bins are difficult to implement in these households due to issues around storage of the organic waste. Statistics Canada data suggests that 17 percent of (private) dwellings in Oakville are apartment buildings. Based on the average household size of 2.9, it is estimated that 32,671 people do not have access to the green bin program. This is 17 percent of the population in private dwellings. Therefore, an estimated 17 percent of the CO_2E per person from FLW is landfilled rather than composted.

The United States Environmental Protection Agency online interactive Waste Reduction Model (WARM)[f] provides a means to establish the difference in CO_2E emissions that result from different waste management streams. WARM provides data on the comparative carbon footprints of multiple foods, as well as identifying how different management methods (incl. compost, landfill) affect the total volume of CO_2E for FLW.

The WARM model suggests that for every tonne of food waste sent to landfill, there is an extra 0.6 metric tonnes of CO_2E emitted; and for every tonne of food waste that is composted, CO_2E is reduced by 0.2 tonnes. Based on this data, Table 6-3 below shows the results of the calculation. It found that the total GHG emissions from FLW in Oakville would be approximately 42 thousand metric tonnes per year. Emissions are reduced by 2.4 percent due to 83 percent of FLW being composted. Enabling Oakville's apartment buildings to participate in the green bin program would allow all FLW to be composted. Full participation in the green bin program would see Oakville's food waste related CO_2E emissions reduced by 2,227 $MTCO_2E$ to 39.8 thousand metric tonnes per year. This is 5.3 percent below the current baseline of 41,988 $MTCO_2E$.

Table 6-3: Comparative estimate of CO_2E emissions and waste management practices

	Tonnes of FLW	$MTCO_2E$ from food waste	$MTCO_2E$ effects of waste management stream	Resulting $MTCO_2E$ Total	Variance to current CO_2E emission baseline (%)
FLW sent to landfill (~17%)	2,783	7,334	1,670	9,004	
FLW composted (~83%)	13,587	35,701	- 2,717	32,984	
FLW CO_2E Emission Baseline	**16,370**	**43,035**	**- 1,047**	**41,988**	
Full participation in green bin — all FLW composted	**16,370**	**43,035**	**- 3,274**	**39,761**	- **5.3%**

Actual CO_2E emissions could be greater than this estimate, given that the research identified that 1) some households who do have and use green bins also place organics in the regular (black) garbage stream; and 2) some households do not use the green bins provided; instead, they potentially place all organics in the regular (black) garbage stream. Not making full use of organic bins leads to a higher proportion of organic waste going to landfill than necessary, and therefore additional CO_2E emissions.

6.4 Potential Reduction in CO_2E Emissions

A calculation was made of the reduction in CO_2E emissions that would result from avoidable FLW being reduced by 50 percent. This halving of consumer food waste is in line with Canada's commitment to the Paris Climate Agreement and the United Nation's Sustainability Development Goals.[g] The results are presented below in Table 6-4. Halving avoidable food waste and composting all occurring waste would result in total annual CO_2E emissions of 28,608 metric tonnes ($MTCO_2E$). This is 32 percent below current emissions of 41,988 $MTCO_2E$. Based on the typical annual emissions of each passenger vehicle being 4 $MTCO_2E$ per year,[h] this reduction is the equivalent of taking 3,345 cars off the road for a year.

Table 6-4: Result of 50 percent reduction of avoidable FLW and all FLW composted

	$MTCO_2E$	Variance (%)
Current baseline (83% of current FLW is composted)	**41,988**	
Reduction in emissions from reducing avoidable FLW by 50%	11,620	
Reduction in emissions from composting all remaining FLW	1,760	
Resulting total reduction in emissions	**13,380**	
TOTAL EMISSION (50% reduction in avoidable FLW, all FLW composted)	**28,608**	**- 32%**

Reducing avoidable FLW, by preparing less food which subsequently goes to waste, would in turn reduce the volume of unavoidable FLW created during meals' preparation. The fact that a reduction in the CO_2E emissions associated with unavoidable FLW has not been factored into the above calculations speaks to the conservative nature of this estimate.

7 Behavioural and Attitudinal Analysis

To enable an assessment of individuals' attitudes towards FLW, and the extent to which they explicitly sought to reduce food waste by adopting certain practices when purchasing food or in the home, an online survey was circulated via social media and HEN's network. The survey was also promoted in a Longo's store in North Oakville, and circulated to VCMI's network in the Oakville and surrounding area.

7.1 Distribution of Online Survey

Two thirds of 280 respondents to the online survey were from the community of Oakville. One third were from outside Oakville, but generally lived in the surrounding area (predominantly Burlington and Mississauga). Of the Oakville respondents, there was a similar distribution of household size to that seen within the Oakville population who participated in the measurement study.

Table 7-1: Distribution of responses to the online survey by household size

	Online Survey Participants		Oakville Census Data (2016)	
Household size	**# of households**	**% of households from Oakville**	**# of households**	**% of households**
1 person	29	16%	11,760	18%
2 people	83	45%	18,715	28%
3 people	35	19%	12,170	18%
4 people	29	16%	15,560	23%
5 or more	10	5%	8,070	12%
TOTALS				
Total – Oakville	186	66%	66,270	
Outside of Oakville	94	34%		
TOTAL	**280**			

Compared to census data sourced from Statistics Canada, the online survey population included an over representation of two-person households and an under representation of four-person and five plus-person households.

7.2 Attitudes and Behaviour

The charts on the following pages provide a summary of the responses received to the online survey.

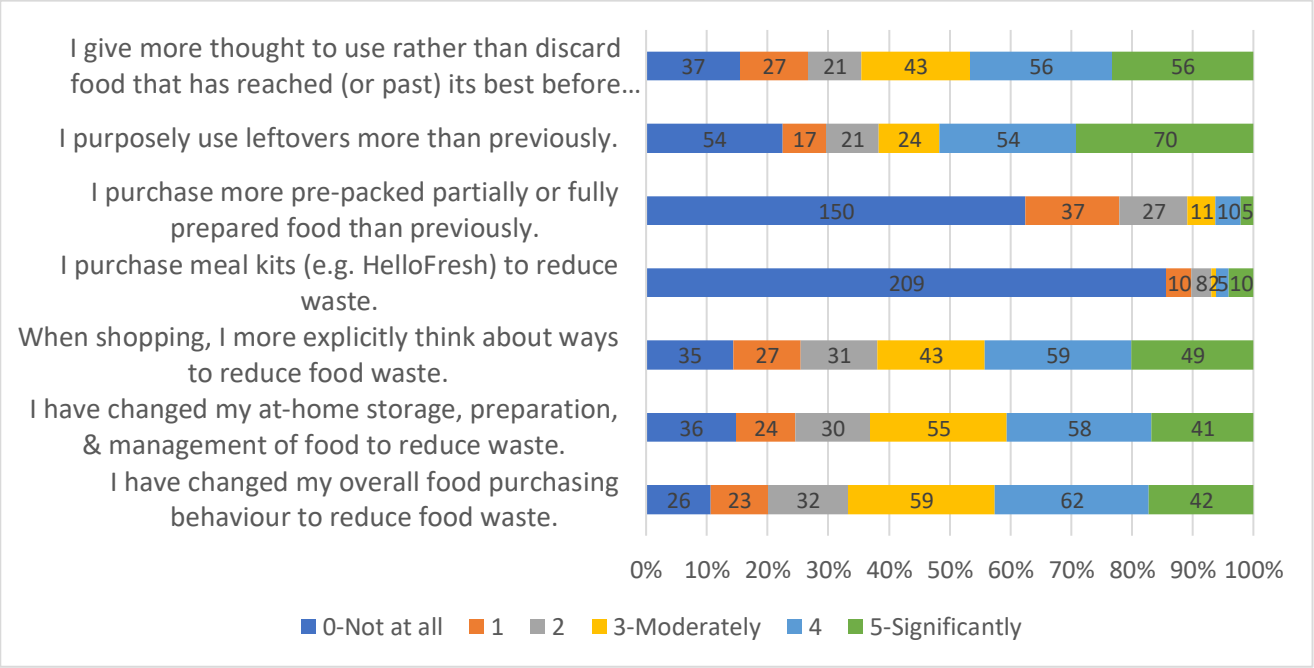
To assess the extent to which respondents' behaviours are aligned to purposely seeking to reduce food waste, they were asked to indicate the extent to which the statements in Figure 7-1 reflect their behaviour.[10] While the survey did not seek to quantify over what period of time respondents' attitudes towards food waste have changed, an analysis of the responses revealed:

[10] Survey question: On a scale of 0-5 (where 0 = not at all, 3 = moderately; 5 = significantly) to what extent do the following statements reflect your behavior?

- The majority of respondents (52%) indicated that they purposely consume meal leftovers more than previously.
- Eighty-six percent of respondents indicated that they do not purchase meal kits to reduce food waste, and 63 percent said they do not purchase more pre-packaged partially or fully prepared food than previously.
- Forty-three percent of respondents have changed their purchasing behaviour to reduce food waste, and 41 percent have changed their at-home storage, preparation, and management of food to reduce waste.
- Forty-four percent of respondents factored food waste considerations in their purchasing decisions when shopping.
- Almost 50 percent of respondents (47%) stated they give more thought to using rather than discarding food that has reached (or past) its best before date.

The range and pattern of responses are identified by layering the number of individual 0 to 5 Likert[11] scores expressed by the respondents onto the bar charts (Figures 7-1, 7-2, and 7-3).

Figure 7-1: To what extent do these statements reflect your behaviour?

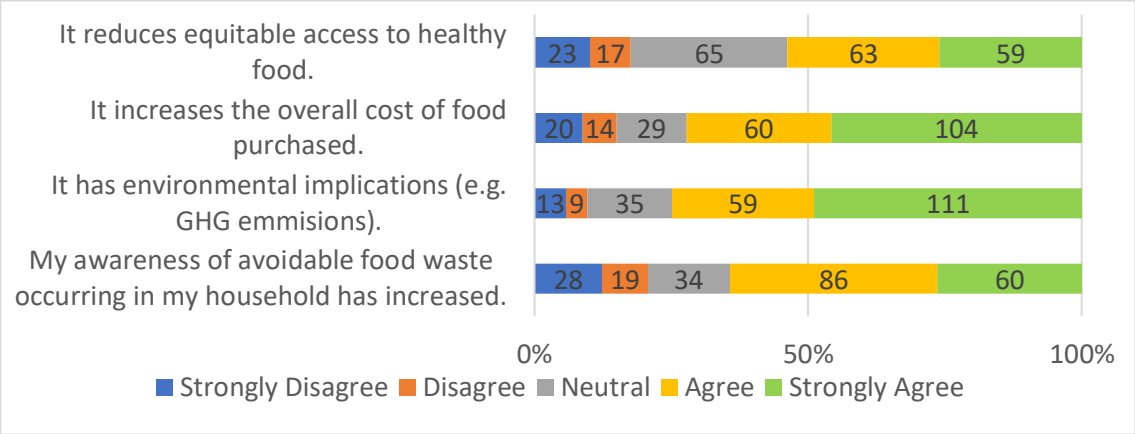


The results showed that the majority of respondents moderately or strongly agreed that their awareness of avoidable food waste has increased. In an effort to reduce FLW, the majority of the 280 respondents stated that they have made moderate to significant changes to their purchasing and at-home behaviours. The least likely change that consumers reported to have made in an effort to reduce FLW was the purchasing of meal kits, followed by purchasing more partially or fully pre-prepared foods.

[11] Likert scales quantify the strength of relationship that exists between an individual's opinion and the question being asked.

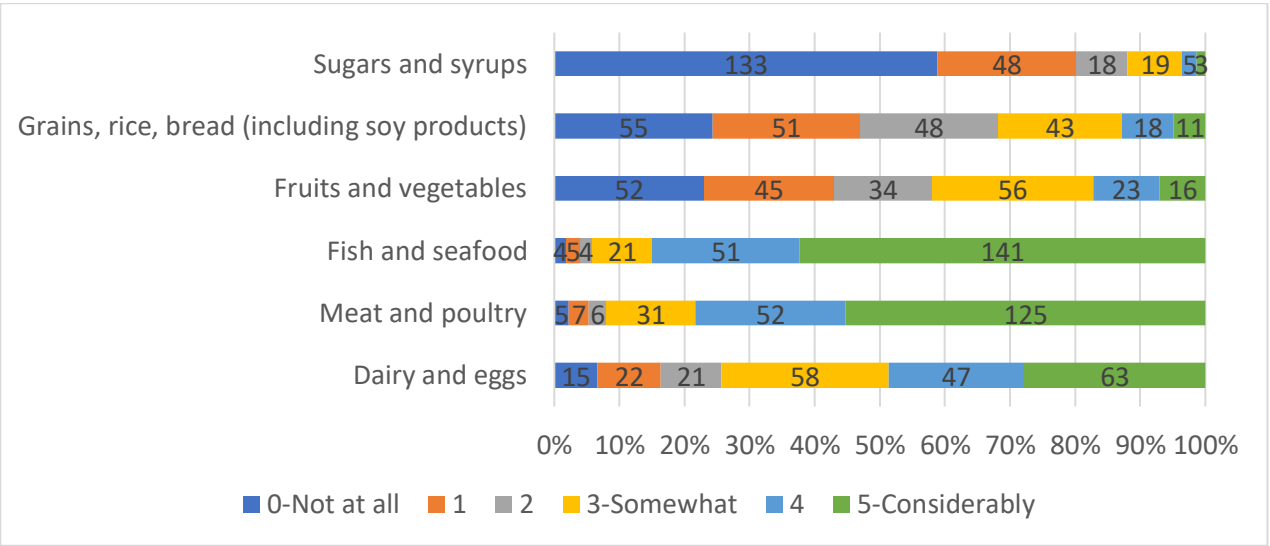
The majority of respondents agreed with the statements that FLW has environmental implications, increases overall cost of food, and reduces equitable access to healthy food (Figure 7-2). Overall, the most important factors voiced by respondents are the environmental implications associated with FLW, followed by the extent to which FLW increases the overall costs of food.

Figure 7-2: To what extent do you agree or disagree with the following statements regarding avoidable food waste? (N=227)



Respondents were also asked about the perceived importance of best before dates, and whether that perception differed by food type. The majority of respondents indicated that best before dates are considerably important for proteins, particularly fish and seafood, followed by meat and poultry. The responses were more divided with respect to dairy and eggs, while best before dates for sugars, grains, fruits, and vegetables were not felt to be very important (Figure 7-3). No respondents identified that it was considerably important to include best before dates on sugars and syrups.

Figure 7-3: How important do you feel best before dates are for each of the following types of fresh foods? (N=226)



Few respondents considered that it is particularly important to include best before dates on grain and rice products (e.g. bread and pasta), and fruits and vegetables.

7.3 Most Commonly Wasted Foods and Beverages

Respondents were asked to identify which foods and beverages were most likely to be avoidably wasted in their household, and to rank them in terms of comparative volumes. The most to least ranking of household avoidable food waste reported by survey respondents matched the quantities reported by households who participated in the measurement of food waste. Figure 7-4 shows the ranking requested in the online survey, while Figure 7-5 presents the total kg of avoidable food waste that was reported by the 65 households in the food waste measurement study.

Figure 7-4: What foods make up your household's avoidable food waste? Please rank these food types from most to least amount of food that is thrown away.

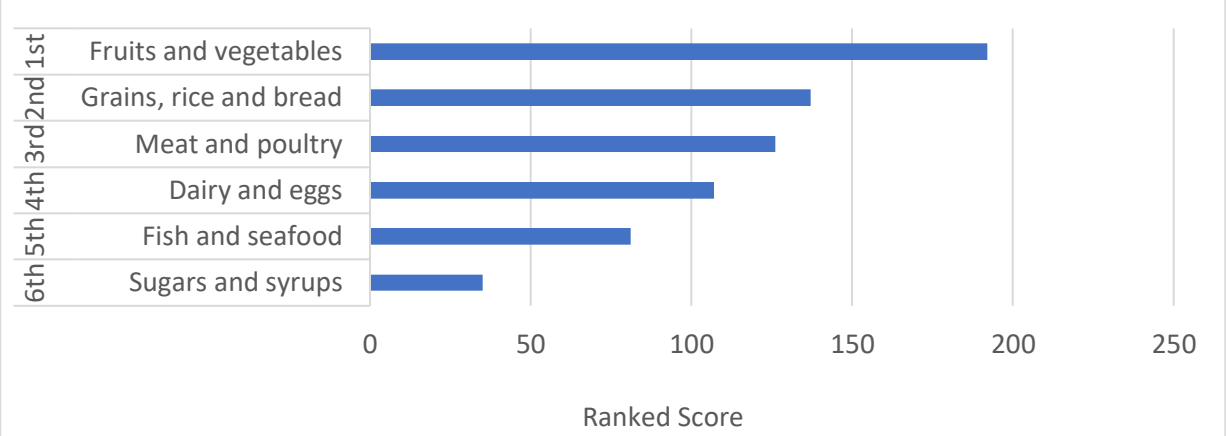
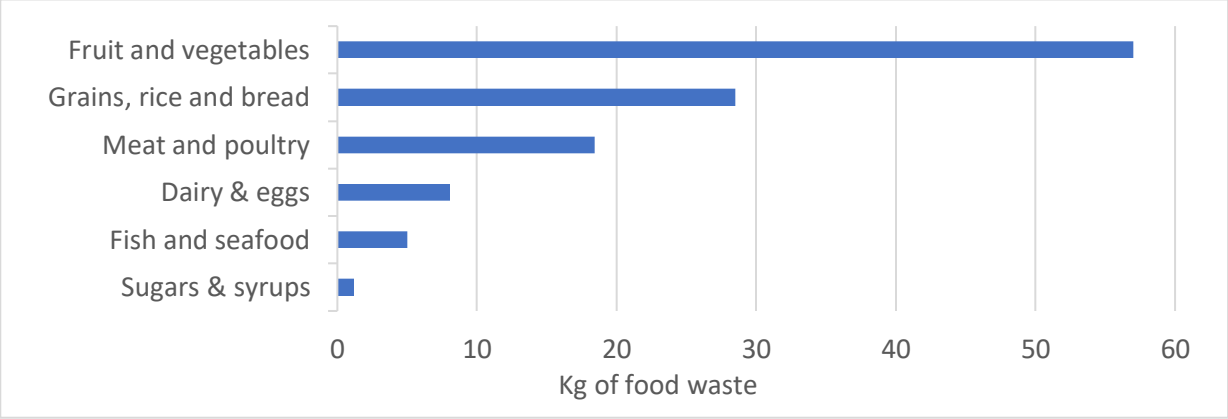


Figure 7-5: Avoidable food waste (plate & spoiled waste) recorded and reported in the study by 65 households in Oakville



This suggests that individuals are generally aware of the types of FLW that occur in their home, if not the volumes. This assumption is supported by approximately 50 percent of the post-survey interviewees expressing that they were not surprised by the types of foods that they reported, though they were surprised by the volume (weight).

7.4 Segmentation by Demographic Group

Non-parametric tests were conducted to assess if there was any statistical difference in the responses from various groups: location (e.g. wards within Oakville, Oakville versus surrounding region), household size,

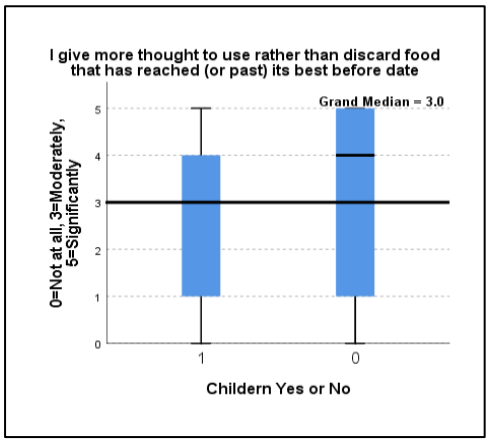
socio-economic status,[12] and if children were household members or not. Respondents' location, household size, and socio-economic status did not have any significant impact on the responses that were given. However, the responses to three questions were significantly different for those households with children versus those without.

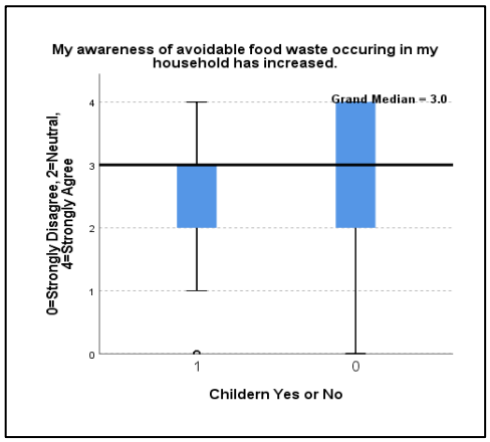
Firstly, households with children appeared to have a greater propensity to discard food that has reached (or past) its best before date than households without children, presumably due to parents' concern about their children's health. This aligns with the results of the household study and interviews, where households with even one child experienced significantly more food waste than those without. A driver of that is parents approaching the disposal of food due to best before dates as being a binary (straight yes/no) versus a more nuanced decision.

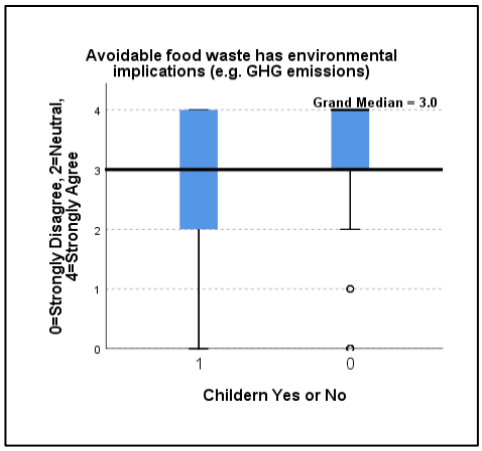
Secondly, households without children were more likely to say they agree or strongly agree with the statement "my awareness of food waste occurring in my household has increased." Households with children were more likely to be neutral/disagree with this statement.

Finally, households without children tended to consider avoidable food waste to have more environmental implications than households with children. The graphical representation of the statistical test (Figure 7-6) illustrates the differences between households with and households without children.

Figure 7-6: Independent samples median test — households with and without children







Note: On the x=axis
1 = Yes children
0 = No Children

[12] Based on income statistics linked to postal code data

Of the differing perceptions held towards avoidable FLW and environmental implications of FLW, the greatest statistically significant difference between the perceptions held by respondents with children versus those without children pertained to their awareness of avoidable FLW. Without further research, the reasons for these differences can only be surmised. It may be that respondents with children have less time and inclination to consider ways to reduce avoidable FLW. The same may hold true for why respondents with children see less connection between FLW and any environmental implications. Differences could also partly stem from socio-economic perspectives, with younger working respondents having more disposal income than older, possibly retired respondents.

8 Conclusions

The study produced a defendable estimate of the amount of food loss and waste (FLW) and resulting CO_2E (carbon dioxide emissions equivalent) generated by households in Oakville by engaging 65 households to measure their unavoidable and avoidable FLW over a seven-day period. The study did not include food purchased and eaten at hotels, restaurants, institutions, or take-outs. Twenty-six households subsequently participated in a post-study interview that explored causal factors resulting in FLW. The attitudes and behaviours of individuals residing in Oakville and the surrounding region was investigated via an online survey that was completed by 280 individuals.

Total FLW reported by households amounted to 282 kg, which translates to 4.2kg of FLW per household and 1.7 kg per individual, respectively. The highest daily FLW was found to occur on a Sunday. The meal occasion that experienced the highest FLW by volume was dinner. Fruits and vegetables was the food type that represented the highest total FLW by volume. Avoidable FLW represented 42 percent of total FLW. The food type that experienced the highest percentage of avoidable FLW (89% of total FLW) was grains such as bread, rice, pasta. A correlation existed between households with children, households located in particular wards, household income, and higher FLW. A correlation was also established between three merchandizing practices and increased household FLW, namely 1) pack size, 2) bulk buying, and 3) best before dates.

Purchasing in excess of needs, suboptimum storage of foods (particularly perishable foods that are kept in the fridge), preparing foods that are not consumed, and the disposal of foods that have reached their best before date were the four primary drivers of avoidable FLW. Families with children appeared least conscious about the FLW that occurred in their home and its environmental impact. These households were also more likely to adhere to date codes. For them, decisions around the disposal of foods and beverages were more binary (yes/no) and less nuanced than in households without children.

Based on current waste management practices, the environmental emissions associated with Oakville households' current total FLW is conservatively estimated to be 41,988 metric tonnes of CO_2E ($MtCO_2E$). Avoidable household FLW equates to 23,675 $MtCO_2E$. The largest reduction in CO_2E emissions by food type can be achieved by reducing avoidable FLW in meat and poultry. Under the current waste management system, reducing avoidable FLW by 50 percent would reduce Oakville's annual FLW related GHG emissions by 11,620 tonnes of CO_2E. Composting all remaining FLW would reduce total CO_2E emissions by a further 1,760 tonnes.

Reducing avoidable FLW by 50 percent and composting all remaining FLW would result in the total annual household FLW emissions for the community of Oakville being 28,608 $MtCO_2E$. This is 32 percent below the current baseline and equates to taking 3,345 cars off the road for a year. That all FLW can be reduced to a degree by 1) reducing the amount of food prepared *(the primary source of unavoidable waste)* and plate

waste *(the primary source of unavoidable waste)*, 2) better aligning purchasing decisions with needs, and 3) improving food storage and handling practices, emphasizes the conservative nature of the above estimates. It also underlines the scale of the opportunities that exist to reduce Oakville's FLW related CO_2E emissions.

The majority of Oakville residents would benefit from more guidance on strategies to reduce FLW by improving their food purchasing, storage, and usage practices. Changes to merchandizing and date coding practices would enable and motivate further changes in consumers' purchasing and at-home decisions, thus leading to further reductions in FLW. Consumer messaging on food disposal practices and extending organic programs to all households, particularly those living in multi-unit complexes, would play an important role in further reducing CO_2E emissions by enabling a greater proportion of FLW to be composted. These efforts would lead to reduced FLW and lessen the CO_2E emissions of remaining FLW through the improved management of organic waste streams.

9 Halton Environmental Network

Established in 2004, Halton Environmental Network (HEN) strives to make the community of Halton a region with educated citizens, engaged stakeholders, and best practice policies for climate change mitigation and adaptation and environmental sustainability.

HEN is an incorporated, non-profit organization operating in Halton Region (Oakville, Burlington, Milton, Halton Hills). HEN supports and enhances the capacity for local climate action and environmental sustainability across the community. HEN brings together relevant parties to drive change and facilitates communication, cooperation, resources and alignment with community members, conservation authorities, non-profits, faith-based organizations, government, and the educational sector.

HEN has successfully implemented several programs including Greening Sacred Spaces Halton-Peel, OakvilleReady, and Halton Green Screens. HEN is also the backbone agency of the Halton Climate Collective.

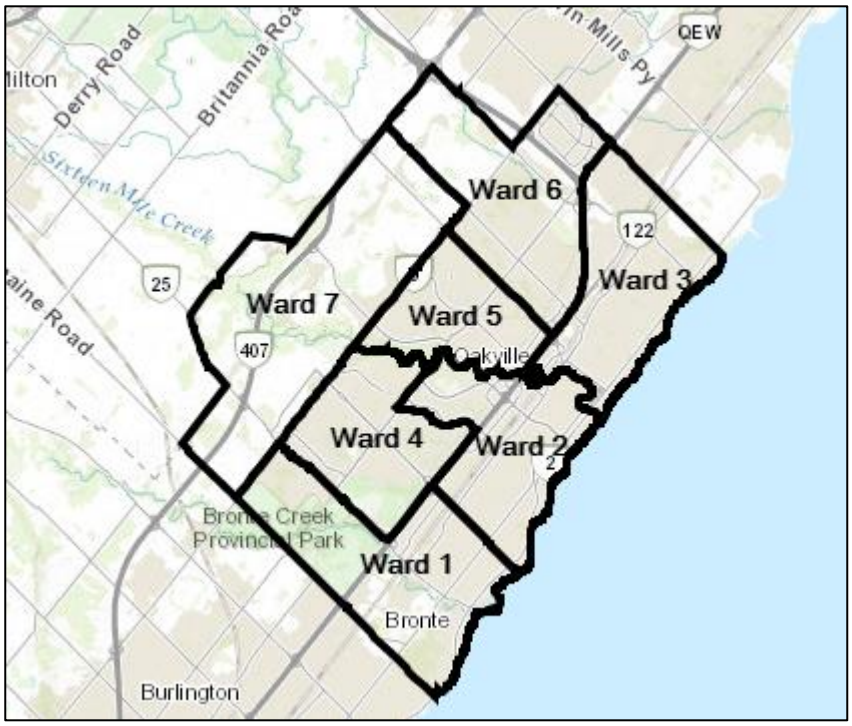
10 Value Chain Management International

VCMI has authored/co-authored several publications on food loss and waste (FLW), and is a leading public and industry voice in bringing awareness to the opportunities and solutions surrounding food waste reduction, traceability, and the environment. VCMI's most recent FLW research "The Avoidable Crisis of Food Waste" was completed in partnership with Second Harvest.

VCMI measures waste within the overall analysis of food systems to create pragmatic and sustainable solutions for businesses and industry organization along the value chain. VCMI applies specialized value chain diagnostic tools to detect where waste occurs and to determine how to eliminate it. VCMI then participates in the implementation of new practices to solve the issues and ensure successful outcomes.

VCMI's global consulting team is located in Canada, Europe, and Australasia, and comprises world leaders in quality management, experiential management training, commercial-focused environmental sustainability, and value chain innovation. The team's expertise in lean thinking, six sigma, sales processes, management systems, consumer research, and value chain analysis techniques has resulted in highly measurable improved profitability for their clients in the agri-food, aeronautical, automotive, pharmaceutical, and service sectors.

11 Appendix — Map of Oakville Wards



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[b] Gooch et al, 2019: Page 5

[c] Examples include: 1) Gooch et al, 2019; 2) Goldring, N. 2020. The Relationship Between Fresh Produce Packaging, Food Waste And Recycling In The Home; Australian Fresh Produce Alliance. Accessible from: http://www.freshproduce.org.au/resources/; 3) Verghese, K., Lewis, H., Lockrey, S., Williams, H. 2015. Packaging's Role in Minimizing Food Loss and Waste Across the Supply Chain; Packaging Technology and Science; DOI: 10.1002/pts.2127. Accessible from: https://www.worldpackaging.org/Uploads/SaveTheFood/Packagingroleminimisingwaste.pdf

[d] Gooch et al, 2019

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[h] Based on total annual per capita Halton transportation emissions equating to 2.6 $MTCO_2E$, an average Oakville household comprising 2.9 people and 1.5 vehicles, and Canadian vehicular emissions being less than the 4.7 $MTCO_2E$ calculated by EPA.
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