North London Waste Authority

Residual waste composition analysis 2016

Final report

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Document revisions

No.	Details	Date
1	Draft report	15 September 2016
2	Second Draft report	30 September 2016
3	Final report	12 October 2016

Executive summary

Purpose of this report

This report has been produced for the purpose of reporting the results of the North London Waste Authority (NLWA) Residual waste composition analysis 2016.

NLWA commissioned Amec Foster Wheeler to undertake a residual waste compositional analysis to identify the main kerbside collected waste materials arising by weight within the Energy from Waste (EfW) Facility feedstock. Residual waste was sampled in two season exercises in January/February and August 2016. In the January/February exercise Amec Foster Wheeler sub-contracted the waste sampling and sorting to Axion Consulting Limited. In the August exercise Amec Foster Wheeler undertook the sampling and sub-contracted Waste Research Limited (WRL) to sort the waste at their dedicated waste analysis facility.

In total 70 samples (approx. 100 kg each) were collected over both seasonal exercises and used to:

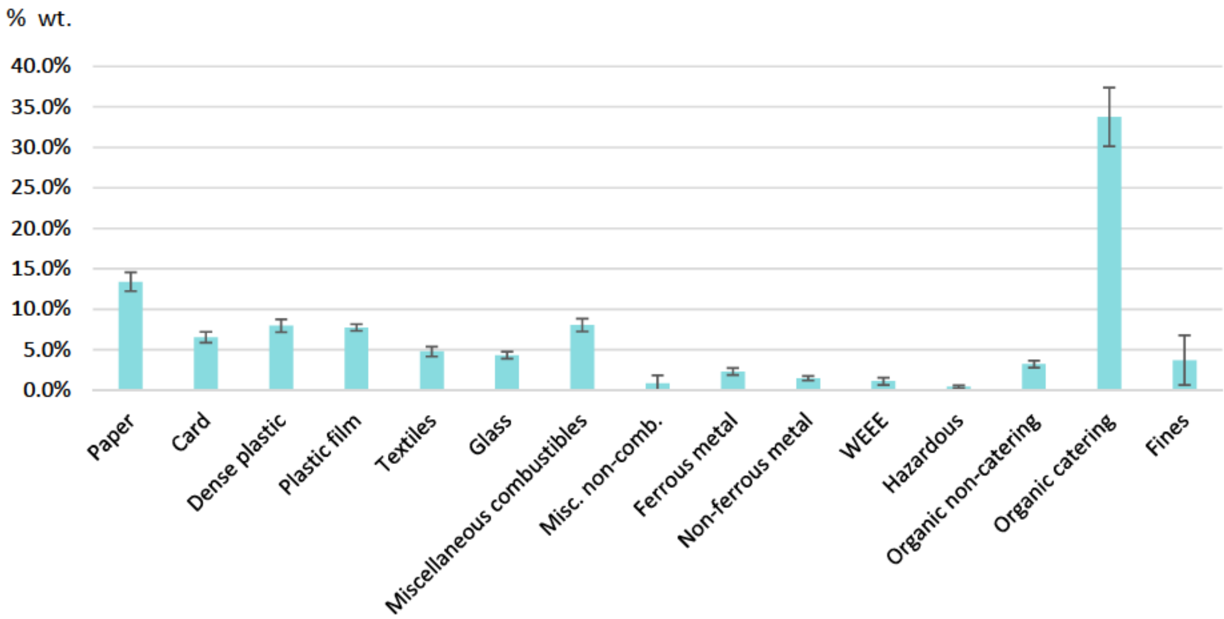
- To determine the composition of residual waste on a North London area basis;
- To estimate the composition of residual waste arising from each of the seven Boroughs in NLWA; and
- To estimate the composition of residual waste collected from high and low rise dwellings within the North London area.

The compositional data was then used in three ways:

- To calculate the Calorific Value (CV) to determine the theoretical energy yield when the material is used for energy from waste;
- To inform the constituent Boroughs and NLWA as to which potentially recyclable materials are still present in the household residual waste stream; and
- Undertake modelling on potential higher rates of recycling in the North London area.

Figure A shows the average residual waste composition result for the North London area with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories. Organic catering (food waste) accounted for the largest proportion of the residual waste stream in NLWA area at 33.8%. Paper was the second most prominent material category at 13.4% followed by miscellaneous combustibles at 8.1% (which includes sanitary waste including nappies at 6.4% of the residual waste).

Figure A Residual waste composition result with 90% confidence intervals - NLWA

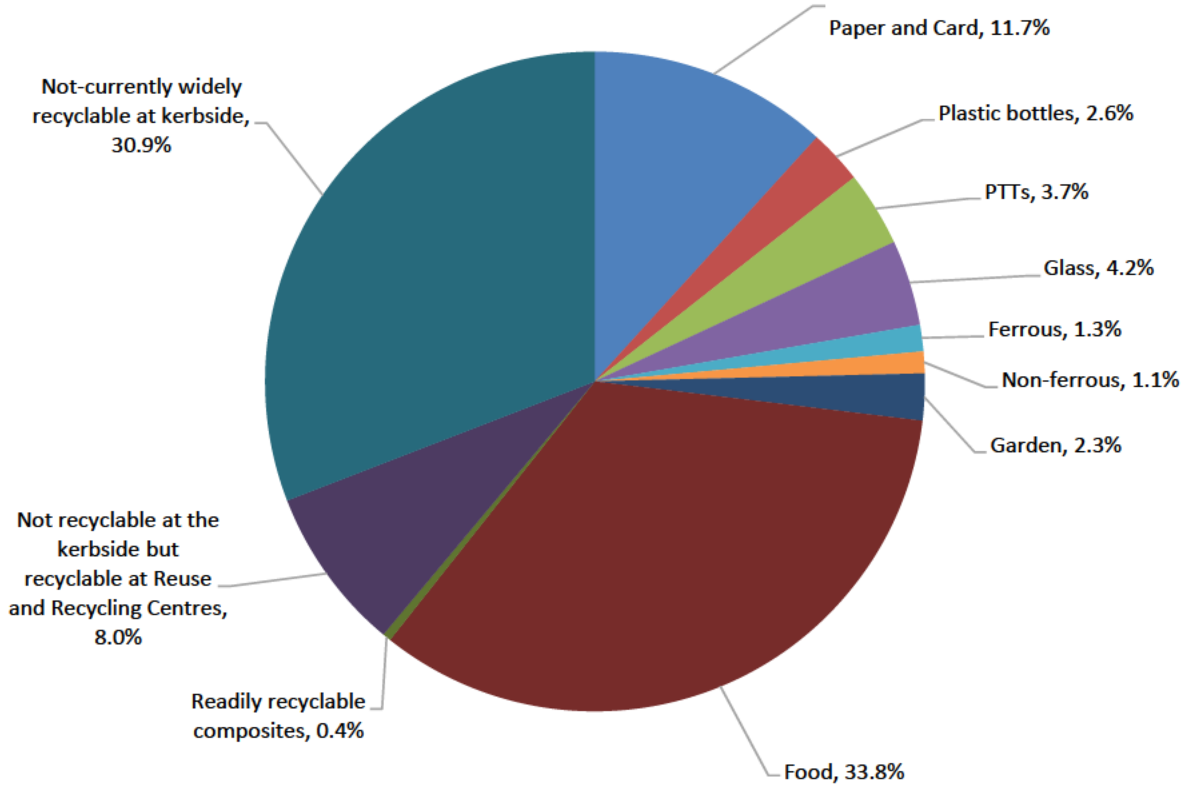


The pie chart below (Figure B) highlights that approximately 61% of NLWA area's residual waste stream consists of materials which are widely recyclable at the kerbside. The largest component of the widely recyclable material is food waste, which accounts for approx. 34% of the residual waste stream[1]. This is particularly telling as households in NLWA Boroughs are provided with a food waste collection service. The data suggests that many of households are not fully utilising the food collection service and/or that food waste from commercial premises is entering the Municipal stream. Similarly, the presence of the remaining recyclable materials[2], which accounts for 25% of the residual waste stream, suggests that households are also not fully utilising the recyclable waste collection service. The level of other recyclable materials within the residual waste (i.e. materials which can be collected at Recycling and Reuse Centres or using the bring bank network) is relatively low) at 8.0%. Textiles was the main component of the materials categorised as 'not recyclable at the kerbside but recyclable at Reuse and Recycling Centres' composing approximately 4.8% of the kerbside residual waste.

[1] Food waste also accounts for approximately 57% of the potentially recyclable materials

[2] Paper, card, plastic bottles, PTTs, Glass, readily recyclable composites, ferrous metals (packaging) and non-ferrous metals (packaging)

Figure B Composition of NLWA waste by recyclability



The net CV for residual waste calculated from the residual waste composition for the North London area in 2016 was 8.74 MJ/kg[3]. The net CV in 2016 is slightly lower than the estimate for 2010 which was 9.13 MJ/kg. This is likely to be a result of the higher organics content found within the 2016 sample compared with that of the 2010 sample. The reduction in the proportions of paper, card and plastic in the residual waste will also be a factor in the lower net CV estimate.

The residual waste composition result obtained by this study has also been used to model waste flows for a number of future recycling rate scenarios. The results of this modelling have been reported in a separate technical note 35180-47_REA_CO54_Maximim Recycling Rate_i1.

The main conclusion of the study is that food waste is the most prominent material in the residual waste and diversion of this material from the residual waste would have benefits for NLWA's recycling and composting rate and also help to increase the theoretical energy content (net calorific value (CV)) of the (kerbside)[4] residual waste stream which is the main EfW feedstock.

[3] Reported values for European MSW are in the range 9 to 11 MJ/kg (AEA Technology report to the European Commission (2001) *Waste Management Options and Climate Change*. ISBN 92-894-1733-1, pp 116). ***Note, this range is for non-segregated waste with low / no recycling***.

[4] This study sampled household residual waste collected from the kerbside by RCVs. Other household residual wastes (e.g. bulky waste) were not included in the analysis.

Contents

1. Introduction

This section describes the project background, project aims and objectives, and the structure of the report.

1.1 Project background

North London Waste Authority (NLWA) arranges the disposal, recycling and composting of waste collected by the seven London Boroughs of Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest.

Figure 1.1 North London Waste Authority

Source: Letsrecycle.com, http://www.letsrecycle.com/news/latest-news/north-london-waste-plan-consultation-resumes/

Residual waste that is not suitable for recycling or composting is either disposed to landfill or treated at the LondonWaste Ltd energy from waste (EfW) facility located at the Edmonton EcoPark. This facility has a nominal annual throughput capacity of 550,000 tonnes per annum and generates electricity for export to the grid. Waste that is not processed at the Edmonton EcoPark is deposited in landfill elsewhere in the UK.

NLWA commissioned Amec Foster Wheeler to undertake a residual waste composition analysis to identify the main waste kerbside collected materials arising by weight within the Energy from Waste (EfW) Facility feedstock. Residual waste was sampled in two season exercises in January/February and August 2016. In the January/February exercise Amec Foster Wheeler sub-contracted the waste sampling and sorting to Axion Consulting Limited. In the August exercise Amec Foster Wheeler undertook the sampling and sub-contracted Waste Research Limited (WRL) to sort the waste at their dedicated waste analysis facility.

The analysis of waste is an important source of information for local authorities. By determining the composition of the waste being collected, it is possible to target materials remaining in residual waste streams in order to enhance existing kerbside recycling schemes. Furthermore, information on waste types and amounts can also be used to calculate the theoretical Calorific Value (CV) of a waste stream to determine the theoretical energy yield when the material is sent to an EfW.

1.2 Aim and objectives

NLWA commissioned a residual waste composition analysis study with the following aims:

- To determine the composition of residual waste on a North London area basis;
- To estimate the composition of residual waste arising from each of the seven Boroughs in NLWA; and
- To estimate the composition of residual waste collected from high and low rise dwellings within the North London area.

The compositional data was then used in three ways:

- To calculate the net calorific value (CV) to determine the theoretical energy yield when the material is used for energy from waste (EfW);
- To inform the constituent Boroughs and NLWA as to which potentially recyclable materials are still present in the household residual waste stream; and
- Undertake modelling on potential higher rates of recycling in the North London area.

Figure 1.2 shows an overview of the waste composition project and outputs.

Figure 1.2 Project overview

1.3 Structure of this report

This report presents the results on the two waste analysis exercises undertaken in 2016 and combines this data to estimate the overall composition of residual collected household waste. The report is structured as follows:

- Introduction;
- Methodology;
- Compositional analysis results;
- Calorific value (CV) estimation; and
- Conclusion.

2. Methodology

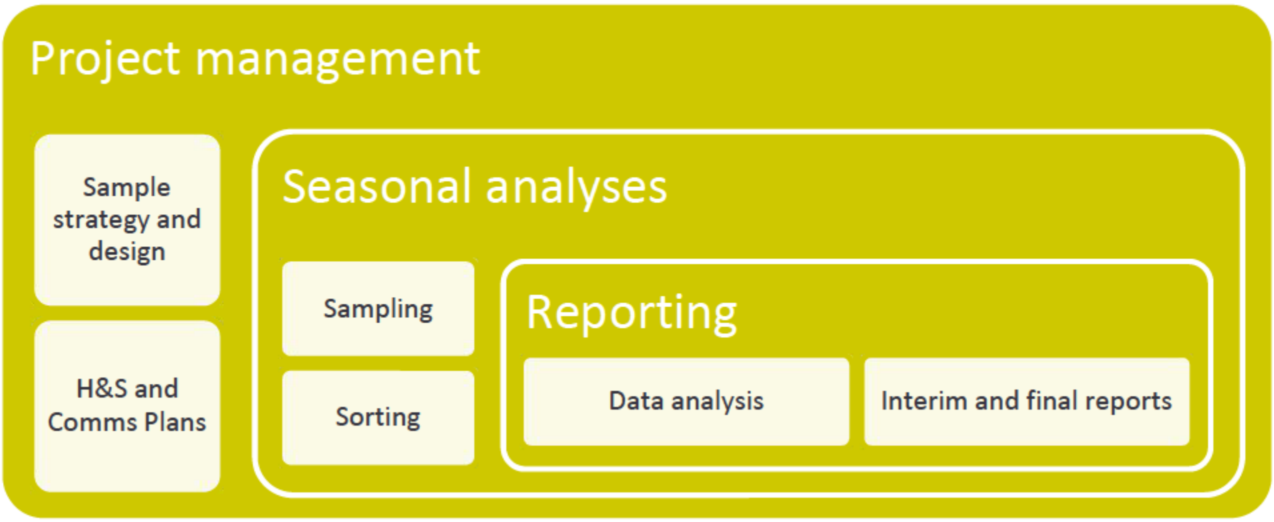
This section outlines the methodology used to undertake the two seasonal residual waste analyses performed for North London Waste Authority.

Over the course of two seasons – January/February[5] and August – two waste composition studies were carried out. Sample collections were carried out at the following sites: Hendon Rail Waste Transfer Station, Edmonton EcoPark and Hornsey Street Waste Transfer Station. Each of these waste transfer stations are operated by LondonWaste Ltd (LWL).

2.1 Methodology overview

An overview of the project methodology is shown in Figure 2.1.

Figure 2.1 Project methodology



A project inception meeting was hosted by NLWA in London on 15 December 2015. At the meeting, the proposed methodology was discussed and relevant data was secured from NLWA. Also, a sampling approach was agreed upon for obtaining materials directly from each Borough's Refuse Collection Vehicles (RCVs). Site visits were organised prior to each seasonal analyses to undertake a risk assessment of the areas where the residual waste samples would be collected from. In addition arrangements were agreed for the locations where the samples were to be sorted – Hendon Rail Waste Transfer Station for the first study and Waste Research Limited's Rotherham facility for the second study. Amec Foster Wheeler produced health and safety plans, and communications plans. These documents were disseminated to all parties involved in the composition study.

2.2 Sample design

Working in partnership, the North London Boroughs, NLWA and Amec Foster Wheeler produced a sampling schedule for both of the waste composition analysis exercises. A total of five RCVs from each Borough were sampled in each season. As NLWA manages the residual waste for seven Boroughs, each sampling

[5] Some additional sampling was undertaken in March 2016 to collect samples from Boroughs which had been missed in January/February.

exercise required the collection of 35 samples. A total of ten samples were collected over both seasons for each Borough. A total of 70 samples were collected over both seasons for NLWA.

The target RCVs were identified for high rise and low rise properties (the Boroughs defined the number of high and low rise samples collected), to provide a sample which was representative of the residual waste generated by the mixture of housing in each Borough and hence NLWA.

Table 3.1 shows the waste samples which were collected for each Borough and housing type (high and low rise dwellings).

2.3 Sample collection

The sampling exercises were carried out by a sample team comprising a sampling supervisor and up to two operatives. The sampling team was equipped with all the necessary personal protective equipment indicated in the health and safety plan.

For the January/February season, the cone and quarter method of sampling was not used due to the limited space available within the Hendon Rail WTS site used for the study. Hence, an alternative sampling approach was used - the RCV sampling method, indicated in Figure 2.2[6]. This method involved tipping the majority of a load down a chute into a waste compactor as per the usual procedure, but to retain a small amount of waste to be sampled from. The remaining material that was not put down the chute was picked up with a front end loader and the material was dropped within the sorting area. The sampling team then took samples from random areas of the pile to collect a sub-sample of 50 – 100 kg.

For the August season, the RCV sampling method was also used. Once the sampling team had set up at the sampling site and had received the list of the expected RCVs from NLWA, the RCVs were diverted to the sampling area by LWL operatives and the sampling supervisor where their load was safely tipped and randomly sampled. The target weight for each Borough's sample was a minimum of 100 kg. The tipped residual waste was manually collected and deposited into sample bags. After each sample was collected, the sample bags were clearly labelled so as to enable the identification of the source[7] of the residual waste during the sorting stage. With sampling completed, the site operator was signalled by the sampling supervisor and any surplus waste was disposed of.

[6] At the Edmonton Ecopark and at Hornsey Street space was severely restricted which meant the shovel operator was unable to collect a shovel load of material from which the team sampled the waste. Therefore sample material collected at these sites was taken directly from the accessible areas of the tipped RCV load.
[7] This included information about the Borough of the sample, whether it was from high rise or low rise properties and the registration number of the RCV.

Figure 2.2 RCV sampling

2.4 Sample sorting

At the sorting stage, the collected samples of residual waste were hand-sorted[8] by a sorting team. The sorting process followed an agreed method statement for waste sorting which was included in the health and safety plan. This included appropriate measures for the use of personal protective equipment and the methodology for sorting the samples into categories. The sorting team was composed of sorting supervisors and operatives. The sorting supervisors were responsible for ensuring that the sorting method statement was followed, including the weighing operation and quality assurance. The operatives were responsible for hand sorting and weighing. The importance of treating the data obtained from the sorting process as confidential was communicated to the sorting team during the waste sort operative induction and training. Prior to sorting the residual waste samples, their weights were recorded.

For the January/February season, Axion was responsible for sample sorting at Hendon rail waste transfer station. The 50 – 100 kg sub-sample was manually sorted into 35 different material categories described in Appendix A. Material was spread onto a sorting table with a 20 mm mesh. The different types of material were picked out with the aid of mechanical grabbers. Any material <20 mm was classed as fines, collected and weighed. The collected category weights were recorded on an Excel spreadsheet.

In the August season, Waste Research Limited was subcontracted to sort the samples at their dedicated sorting facility in Rotherham. The sorting process involved the screening of each sample on a sorting table with a 20 mm mesh to remove fines; these were weighed and recorded. Subsequently, the remaining sample contents were hand sorted into 38 material categories[9], also described in Appendix A. Upon completion of the material classification stage, each category was weighed using calibrated scales and their weights were recorded on an Excel spreadsheet.

[8] Primary using mechanical grabbers. It is sometimes necessary to manually handle waste materials where items are very large/heavy (large rocks or stones) or very small (e.g. household batteries).
[9] Three additional categories for ‘composites’ were included in Season 2.

2.5 Data analysis

All of the waste sort data from each sample was entered into Excel spreadsheets. The data was then examined for outliers and, where necessary, excluded from the analysis (see Table 3.2). The sample data was then used to estimate the composition of the residual waste across the whole NLWA area, from each individual Borough and from high and low rise dwellings.

In addition to calculating the mean composition, the standard deviation, standard error and confidence limits were also calculated, as well as minimum and maximum values.

The confidence limits can be used to estimate the range in which the true population mean lies based on the data obtained from the samples. The confidence limits are calculated as follows:

$$Li \qquad (\pm) = \frac{S \qquad\qquad d}{\sqrt{nı} \qquad\qquad o \quad sa} \times Z$$

Where Z depends upon the confidence level. A confidence level of 90% was used for the limit calculations.

The aim of the study was to calculate the composition with the following confidence intervals:

- Confidence limits of ±10% in the primary material categories at the North London level at a confidence level of 90%; and
- Confidence limits of ±20% in the primary material categories at an individual Borough level at a confidence level of 90%.

Using the composition results an estimate of the Calorific Value (CV) of the kerbside residual waste was calculated. This was done using a model designed to estimate the CV of waste based on its composition[10].

2.6 Project limitations

It should be noted that any study of this type, regardless of the sample strategy or design, is a snapshot in time of waste composition and that other local and national factors, such as changes to collection policies through to legislative changes, could lead to significant differences in compositional make-up over time.

Other limitations associated with this study include:

- After the first sampling exercise it was necessary to undertake some additional sampling to collect the required number of samples for each Borough. It should be noted that this resampling exercise took place approximately one month after the original exercise[11];
- The study has been designed to produce robust compositional results for the residual waste stream at NLWA area level. We recommend that the NLWA area level composition results be used as they have a higher level of confidence than that for the Borough level and high and low rise composition results.

Any small discrepancies in totals and sub-totals within the data are due to cumulative rounding errors in Microsoft Excel as multiple spreadsheet calculations are used and rounded down to 1 or 2 decimal places as appropriate in the reporting process.

[10] The reference values used are derived from the UK National Household Waste Composition Study conducted in 1994. These are the reference values used in Defra's 'WRATE' waste management scenario modelling tool.
[11] The additional samples were obtained from Waltham Forest, Enfield, Haringey and Hackney.

3. Compositional analysis results

This section contains an analysis of the data obtained from the two residual waste sampling exercises.

3.1 Samples collected

Across both sampling exercises, a total of 70 samples were collected from NLWA Boroughs. Table 3.1 contains a breakdown of the number of samples collected for each of the Boroughs and also includes the number of samples sourced purely from high rise and low rise properties (a small number were from mixed or unknown sources).

Table 3.1 Samples taken during study (combined Seasons 1 & 2)

Area	Number of Samples Analysed
NLWA area	70
Barnet	10
Camden	10
Enfield	10
Hackney	10
Haringey	10
Islington	10
Waltham Forest	10
High rise properties	21
Low rise properties	33

In the first sampling exercise a small number (four) of samples were rejected. These rejected samples are described in Table 3.2.

Table 3.2 Samples rejected from analysis[12]

Date	Description
Camden	Contained large amount of wet cardboard boxes, which appeared upon inspection to be "Commercial & Industrial" in nature.
Islington	Contained a high level of garden furniture and carpet which was abnormal compared to the other material collected, however this could have been from a household renovation which is likely to be common in the London area.
Haringey	Contained material which appeared to be from an office clear out. The sample contained >30% WEEE and <1% food waste.
Haringey	Contained a high level of uncooked fish heads and so could not be sorted. This was distributed throughout the load and so a representative sample could not be taken.

[12] January/February exercise only

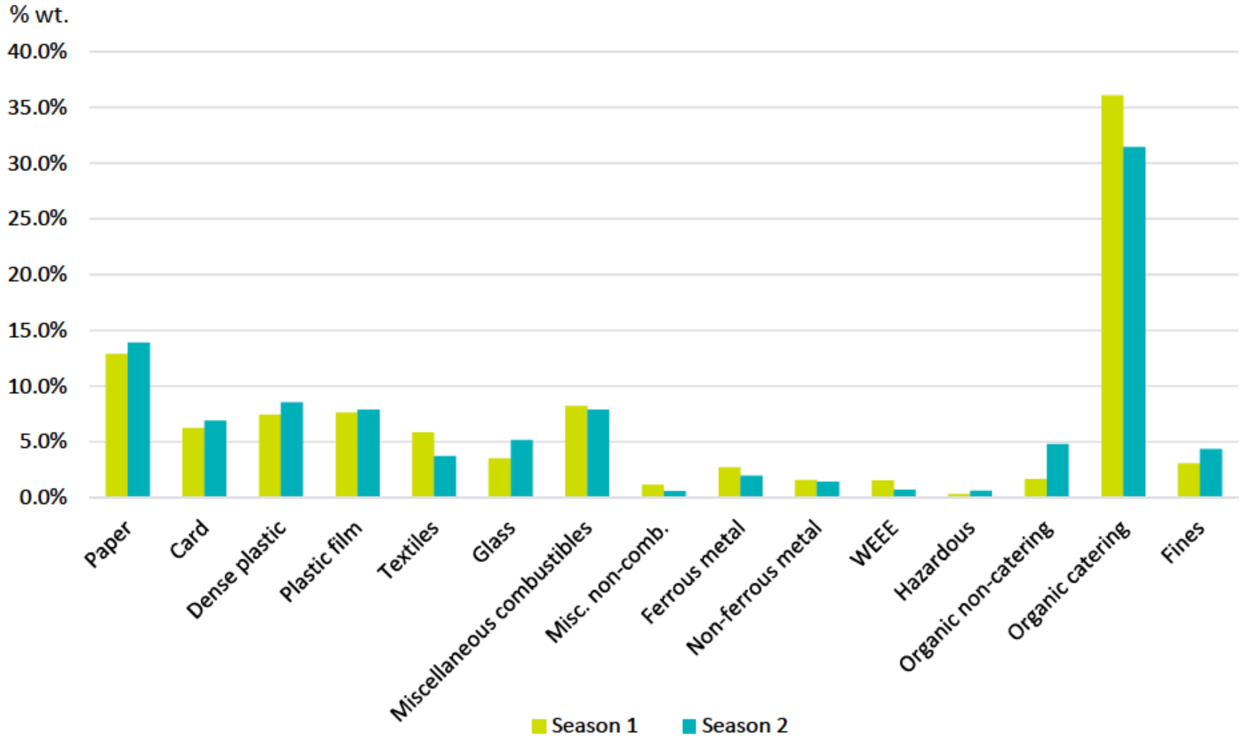
3.2 NLWA results

Composition

Seasonal waste composition results

Figure 3.1 compares NLWA's residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). The main differences between the seasonal results are in the organic catering (food waste) category, which composed approximately 5% less of the residual waste in Season 2 compared to Season 1, and the organic non-catering waste category, which composed approximately 3% more of the residual waste in Season 2 compared to Season 1. Organic non-catering (specifically garden waste) has been proven to vary by season. The increase in garden waste partially explains the decrease in the proportion of food waste. This is because food waste is the most prominent category and will therefore (all other things being equal) be the material category which changes the most to accommodate the increase in garden waste. This rebalancing of the relative proportion of materials does not necessarily explain all the variance in the proportion of food waste in the residual waste, or other differences in the materials such as paper, glass and textiles, however there is no conclusive evidence from other studies that materials other than garden waste vary significantly by season[13], therefore the observed differences in the samples are likely to be a function of 'normal' variance.

Figure 3.1 Season 1 and Season 2 residual waste stream composition results (% wt.)



[13] There is limited evidence from other studies for a Christmas "peak" in food waste. The types of food waste bought by households is known to vary by season (e.g. salads in summer, root vegetables in winter) but no evidence this influences the quantity of food waste produced.

Average waste composition result

Table 3.3 presents the seasonal and average waste composition results for the whole NLWA area. Upper and lower confidence limits are presented for the average waste composition result.

- Organic catering (food waste) accounted for the largest proportion of the residual waste stream in NLWA area at 33.8%; and
- Paper was the second most prominent material category at 13.4% followed by miscellaneous combustibles at 8.1% (which included sanitary waste including nappies at 6.4% of the residual waste).

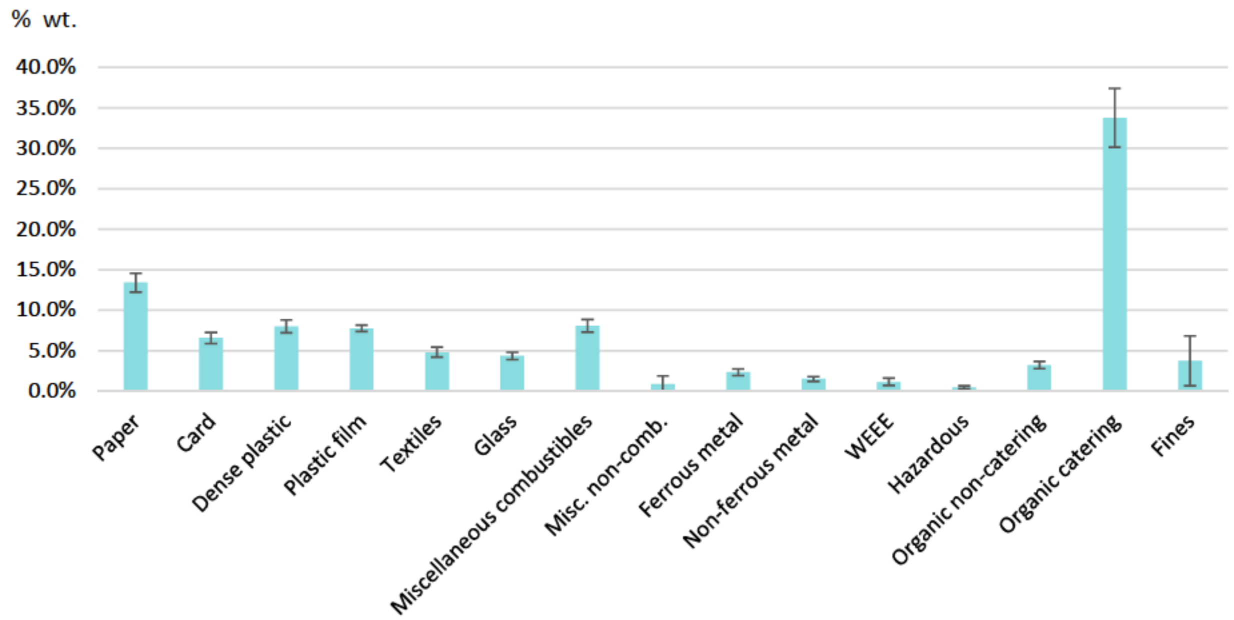
Table 3.3 Residual waste stream composition results (% wt.) – NLWA Boroughs

	Season 1	Season 2	Average	LCL	UCL
Paper	12.9%	13.9%	13.4%	12.2%	14.6%
Card	6.2%	6.9%	6.6%	5.9%	7.2%
Dense plastic	7.5%	8.5%	8.0%	7.2%	8.8%
Plastic film	7.6%	7.9%	7.8%	7.4%	8.2%
Textiles	5.9%	3.7%	4.8%	4.2%	5.4%
Glass	3.5%	5.2%	4.4%	3.9%	4.8%
Miscellaneous combustibles	8.2%	7.9%	8.1%	7.3%	8.9%
Miscellaneous non-combustibles	1.2%	0.6%	0.9%	0.0%	1.9%
Ferrous metal	2.7%	2.0%	2.3%	1.9%	2.8%
Non-ferrous metal	1.6%	1.4%	1.5%	1.2%	1.8%
WEEE	1.6%	0.7%	1.1%	0.7%	1.6%
Hazardous	0.3%	0.6%	0.5%	0.3%	0.6%
Organic non-catering	1.7%	4.8%	3.2%	2.8%	3.7%
Organic catering	36.1%	31.4%	33.8%	30.1%	37.4%
Fines	3.1%	4.4%	3.7%	0.7%	6.8%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.2 highlights the average results for the residual waste composition study with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.2 Residual waste composition result with 90% confidence intervals - NLWA



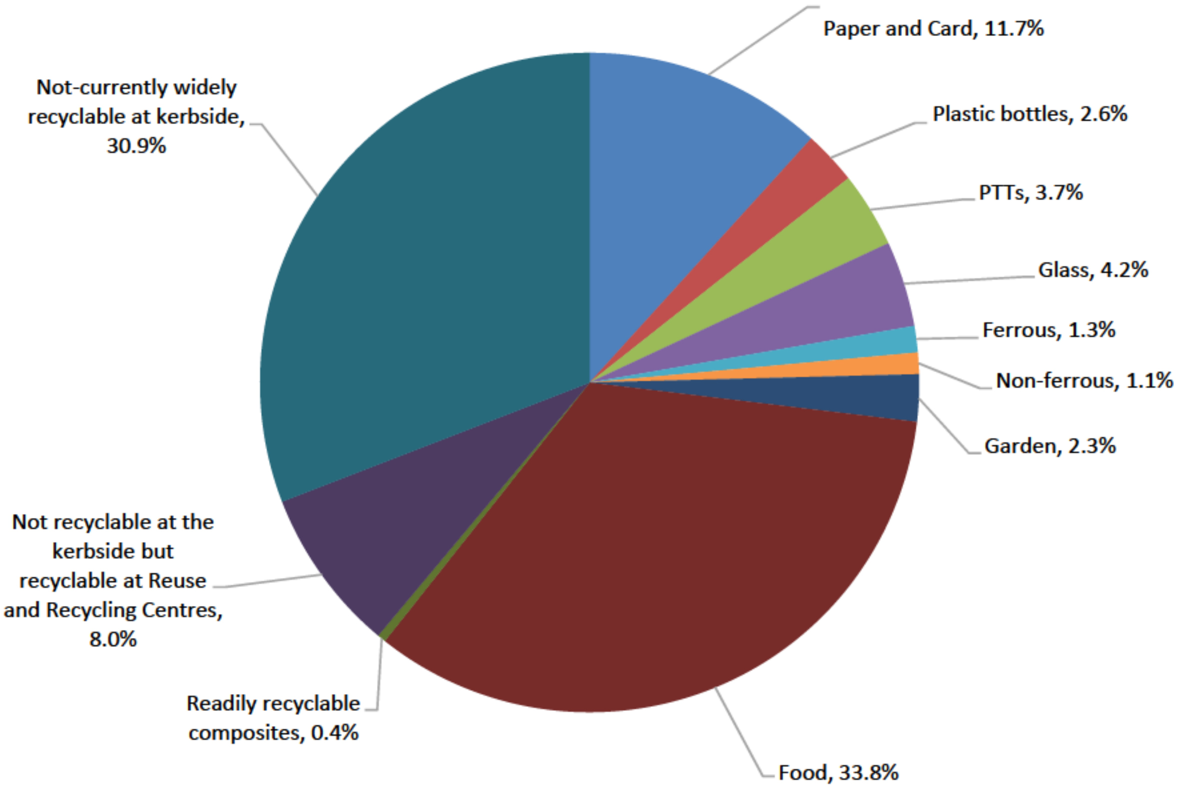
The margin of error within the results obtained for NLWA area is low, with relatively small confidence limits. This suggests that the data is robust. The confidence intervals are less than 10%, which was the target interval for the study. The confidence limits range from as low as ±0.2% (for hazardous) to as high as ±3.6% (for organic catering waste). Overall this indicates that the data for NLWA area is sufficiently robust to be used to estimate the CV of the residual waste and waste modelling/forecasting purposes.

Potentially recyclable material

The pie chart presented in Figure 3.3 presents the composition of the residual waste from NLWA according to its recyclability. Materials such as paper and card, and glass were categorised according to their recyclability[14], plastic bottles were categorised by polymer and dense plastic and plastic film were categorised to enable the proportion of recyclable material to be estimated (e.g. dense plastic were broken down into pots, tubs and trays with separate category for black plastics and plastic film included the category polyethylene film to identify potentially recyclable plastic films). The pie chart only suggests a theoretical maximum for the potentially recyclable materials in NLWA area. This is due to the fact that it is likely that some of the potentially recyclable materials could be significantly contaminated or damaged and, thus, not suitable for recycling in practice[15].

The pie-chart includes the material category "readily recyclable composites". In this context "readily recyclable composites" refer to Tetra Paks and similar beverage cartons made of a card-plastic-aluminium composite.

Figure 3.3 Composition of NLWA waste by recyclability



The pie chart highlights that approximately 61% of NLWA area's residual waste stream consists of materials which are widely recyclable at the kerbside. The largest component of the widely recyclable material is food waste, which accounts for 34% of the residual waste stream[16]. This is particularly telling as households in NLWA Boroughs are provided with a food waste collection service. The data suggests that many of households are not fully utilising the food collection service and/or that food waste from commercial premises is entering the Municipal stream. Similarly, the presence of the remaining recyclable materials[17], which accounts for 25% of the residual waste stream, suggests that households are also not fully utilising the recyclable waste collection service. The level of other recyclable materials within the residual waste is

[14] Note, heavily contaminated or very wet paper or card was categorised as non-recyclable.
[15] An example is a newspaper which has been used to wrap food waste.
[16] Food waste also accounts for approximately 57% of the potentially recyclable materials
[17] Paper, card, plastic bottles, PTTs, Glass, readily recyclable composites, ferrous metals (packaging) and non-ferrous metals (packaging)

relatively low suggesting the mechanical recovery of these materials from the kerbside residual waste stream prior to sending to energy from waste (EfW) may be economically and technically challenging, and a continued focus on source-separation by householders is likely to yield better quality materials.

Figure 3.4 shows the proportion of NLWA area's residual waste stream that are not recyclable at the kerbside but could be recycled at the Re-use and Recycling Centres (RRCs). These materials include textiles, waste electrical and electronic equipment (WEEE), wood and non-packaging (scrap) metals and account for approximately 8% of the residual waste stream.

Figure 3.4 Percentage of residual waste recyclable at RRCs

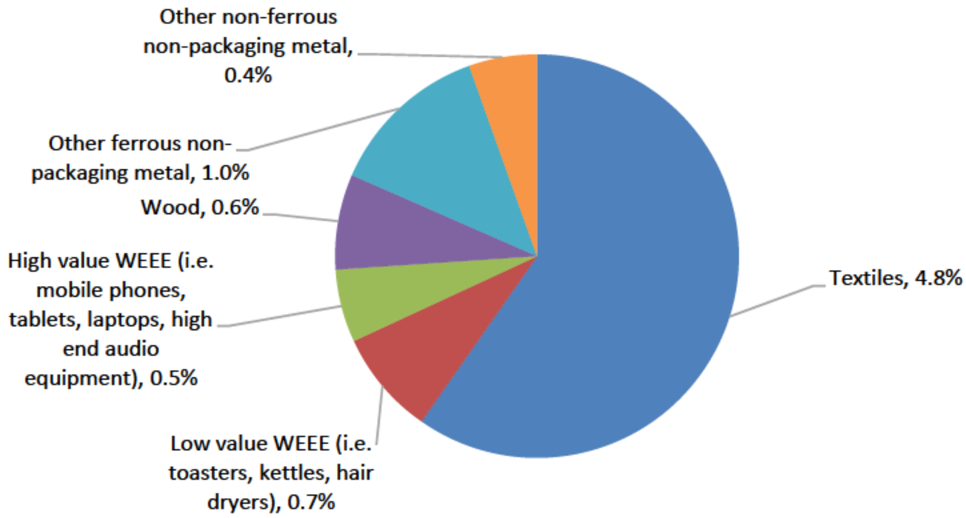
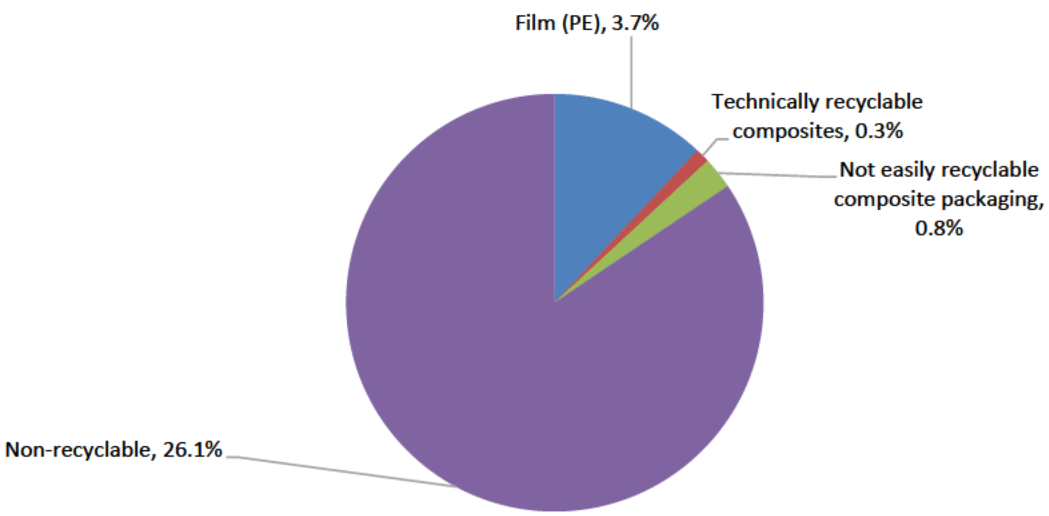


Figure 3.5 highlights the proportion of the residual waste stream (approx. 31%) that consists of materials that currently do not have established recycling routes. The key materials within this category which could potentially be collected and recycled by NLWA were identified as being "PE film", "technically recyclable composites" and "not easily recyclable composite packaging". Though film recycling in the UK is in its infancy, there are a small number of recycling facilities processing post-consumer PE films. Similarly there are composites composing over 1% if the residual waste which could potentially be recyclable in future, if various practical and/or technical barriers could be overcome. The types of composite packaging present in NLWA's residual waste stream are discussed in more detail in the next section.

Figure 3.5 Percentage of residual waste not recyclable



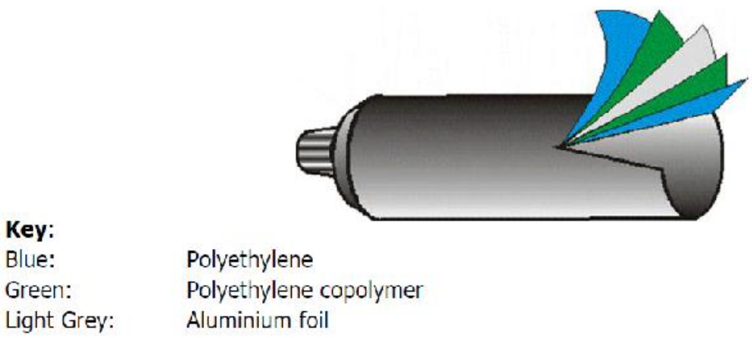
An overall assessment of the data suggests that NLWA's Boroughs could improve their recycling rates by investing in avenues to divert more food waste, paper and card from the residual waste stream into recycling or composting. This will require addressing the obstacles that impede the full utilisation of separate food waste collections and recycling waste collections by residents. Furthermore, the increase in recycling rates, especially the reduction of food waste from the residual waste stream, could contribute to an increase in the net CV of the residual material, which could affect the thermal throughput of the EfW process.

Composites

Today the main trend in packaging is towards composite packaging which uses various materials together to increase durability, increase elasticity and to combine the materials' unique properties. Composite packaging is most commonly seen in cartons (fruit juice and soup), pouches (pet foods, ready meals such as soups and coffee grounds) and toothpaste tubes. There are many types of composite packaging including:

- Plastic-aluminium composite packaging (e.g. blister packs and tooth paste tubes see Figure 3.6);
- Paper or cardboard-polyethylene composite packaging (e.g. soup cartons);
- Plastic-paper/card-aluminium composite packaging (e.g. Tetra Paks); and
- Paper-aluminium composite packaging.

Figure 3.6 Different layers present in a typical toothpaste tube



Source: WRAP (2011) Recycling of laminated packaging

This shift towards composite is likely to accelerate over the next 10-20 years[18] and is likely to pose an even greater technical challenge than mixed plastics recycling (whose financial viability is still not fully proven). At present, with the exception of the new Tetra Pak facility[19], most composite products can only be recycled through specialist programmes. The Terracycle website[20] gives a good overview of current programmes for difficult to recycle waste streams which may be the target materials for local authority recycling collections (kerbside, bring or RRC) in the future.

Therefore, in Season 2, NLWA requested the inclusion of categories to identify the composite materials in the residual waste stream. The composites, highlighted in Figure 3.7, were categorised as follows:

- Readily recyclable composites: this category only includes Tetra Paks which are widely recycled in the UK;
- Technically recyclable composites: the category includes items such as disposable coffee cups and card-plastic-aluminium tubes used for packaging retail items such as *Pringles* and custard powder. The

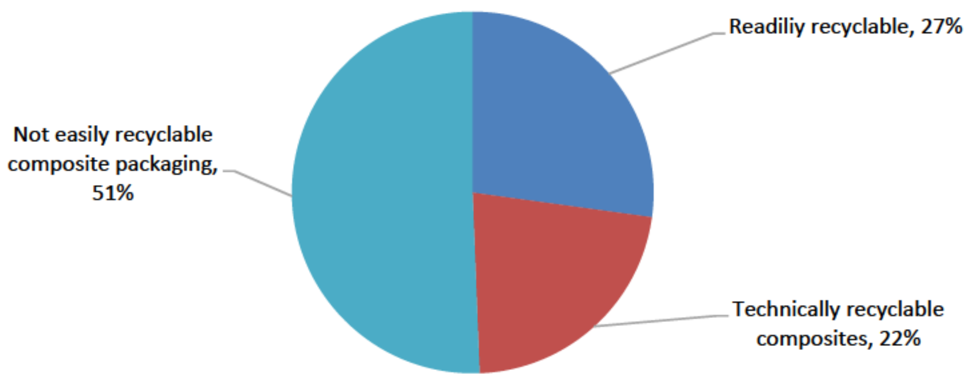
[18] Some laminated packaging formats are estimated to be growing by between 10% and 15% per year.
[19] http://www.foodmanufacture.co.uk/Packaging/New-centre-to-recycle-40-of-UK-food-and-drink-cartons [accessed 30th August 2016]
[20] http://www.terracycle.co.uk/en-UK/brigades

technology to recycle these materials exists[21] however they are not currently widely recycled as there are barriers to effective collection[22] and there is little or no capacity to reprocess these materials in the UK; and

- Not easily recyclable composite packaging: this category includes items such as toothpaste tubes, blister packs, metallised films (crisp packets), coffee capsules or pods, paper-plastic composites and some types of card-plastic packaging. The recycling these materials has a number of technical challenges: they are difficult to extract from mixed dry (commingled) recycling but are not produced in sufficient quantities to justify separate, source-separated collections. Also the technology to recycle these materials is still in its infancy, and it is uncertain when large scale recycling of these materials will be economically viable.

In total composites were estimated to compose 1.5% of NLWA's residual waste[23]. Around 30% of these composites are readily recyclable (Tetra Paks) and approx. 20% are technically recyclable (a category which includes items such as disposable coffee cups and other card-plastic-aluminium packaging). Over 50% of the composites are not easily recyclable – this includes paper/card-plastic composites and multi-layered packaging including plastic-aluminium pouches and toothpaste tubes.

Figure 3.7 Types of composites



[21] Approximately 1 in 400 disposable coffee cups are recycled in the UK (Daily Telegraph). The most complex part of other card-aluminium-plastic composites, for example a *Pringles* tube, is the card-aluminium tube element. Assuming the metal base and plastic top can be removed it is assumed the tube could be recycled using similar processes to those used to recycle Tetra Paks.
[22] For example, separation of card-plastic composite disposable coffee cups from other types of card by residents or at material recovery facilities is both impractical and technically challenging.
[23] This estimate is based on the Season 2 results only. Composites were not categorised separately in Season 1. The season 1 results have therefore been adjusted to account for the additional categories included in the Season 2 analysis.

Comparisons with other studies

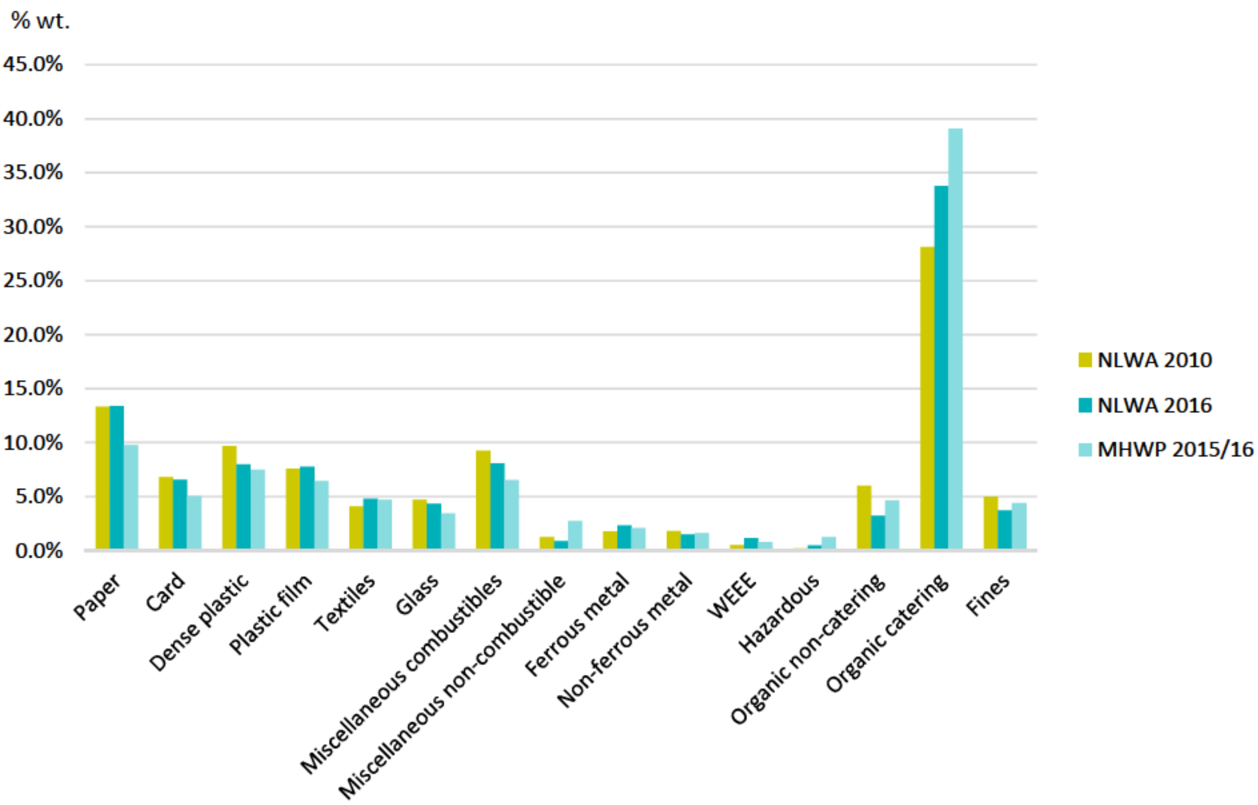
The data obtained from this study was compared with that from a prior NLWA residual waste composition study in 2010 and a residual waste composition study for the Merseyside and Halton Waste Partnership (MHWP) which was undertaken in 2015/16. There was a significant difference in the methodologies used in the studies: whereas this study involved the sampling of residual waste that had been mixed and compacted in RCVs prior to sorting, the other two comparator studies involved sampling residual waste directly at the kerbside and, hence, the residual waste had not been compacted. The effect of compaction is that materials can get broken up or can become more easily contaminated by food or liquid wastes.

Table 3.4 and Figure 3.8 present the residual waste compositions for the three studies. The comparison of the two NLWA studies also allows for an assessment of the changes in the residual waste stream within NLWA area.

Table 3.4 Comparison of the residual waste stream composition results (% wt.)

	NLWA 2010	NLWA 2016	MHWP 2015/16
Paper	13.3%	13.4%	9.8%
Card	6.8%	6.6%	5.1%
Dense plastic	9.7%	8.0%	7.5%
Plastic film	7.6%	7.8%	6.4%
Textiles	4.1%	4.8%	4.7%
Glass	4.7%	4.4%	3.4%
Miscellaneous combustibles	9.2%	8.1%	6.6%
Miscellaneous non-combustibles	1.2%	0.9%	2.7%
Ferrous metal	1.8%	2.3%	2.1%
Non-ferrous metal	1.8%	1.5%	1.6%
WEEE	0.5%	1.2%	0.8%
Hazardous	0.2%	0.5%	1.2%
Organic non-catering	6.0%	3.2%	4.6%
Organic catering	28.1%	33.8%	39.1%
Fines	5.0%	3.7%	4.4%
Total	100.0%	100.0%	100.0%

Figure 3.8 Comparison of residual waste composition study results



The waste stream compositions across the three studies are relatively similar. The largest differences are in the organic catering waste category. In this study for NLWA organic catering (food) waste has been estimated to compose approximately 5.6% more of the residual waste stream, when compared to the similar study in 2010. A composition project in Merseyside and Halton which was undertaken in 2015/16 estimated that food waste composed almost 40% of the residual waste stream, some 5% higher than in the NLWA area.

Overall, these studies indicate that food waste is increasing as a proportion of the residual waste stream. This may be linked to increases in the recycling of dry recyclables however it may also indicate that the quantities of food waste generated by households may be increasing – The Waste Recycling Action Programme (WRAP) food waste studies in 2007 and 2012 showed that food waste had decreased during this period, however this coincided with the 2008/09 recession and subsequent recovery. It is possible that the recovery from the recession may be a factor in the increase in food waste as a proportion of the residual waste between NLWA study in 2010 and 2016.

3.3 London Borough of Barnet results

Composition

Seasonal waste composition results

Figure 3.9 compares Barnet's residual waste composition results obtained from the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). In a pattern that is similar across all Boroughs, the main differences between the seasonal results are in the organic catering (food waste) and the organic non-catering waste (garden waste). In Barnet the proportion of organic non-catering waste (garden waste) in the residual waste reduced in Season 2 in comparison to Season 1. This is unexpected (and counter to the change observed at the NLWA level and in other seasonal waste composition studies) and perhaps illustrates the lower level of confidence associated with Borough level results and why they are considered to be indicative. There are also differences in the paper, glass and miscellaneous combustibles composition however there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.9 Season 1 and Season 2 residual waste stream composition results (% wt.) – Barnet

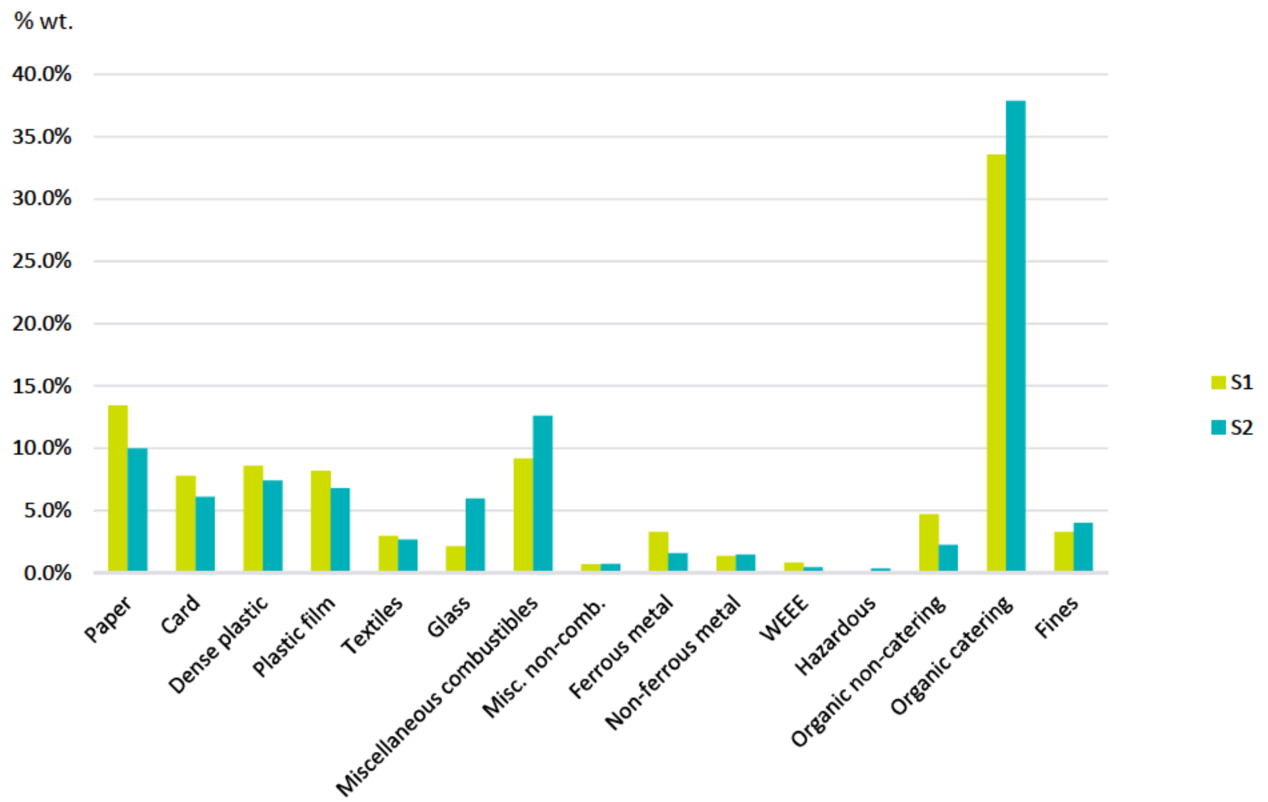


Table 3.5 presents the seasonal and average waste composition results for Barnet. Upper and lower confidence limits are presented for the average waste composition result.

- Food waste accounted for the largest proportion of the residual waste stream in Barnet at 35.7% - this suggests an under-utilisation of the separate food waste collection service; and
- Paper was the second most prominent material category at 11.7% followed by miscellaneous combustibles at 10.9% (which included sanitary waste including nappies at 7.9% of the residual waste).

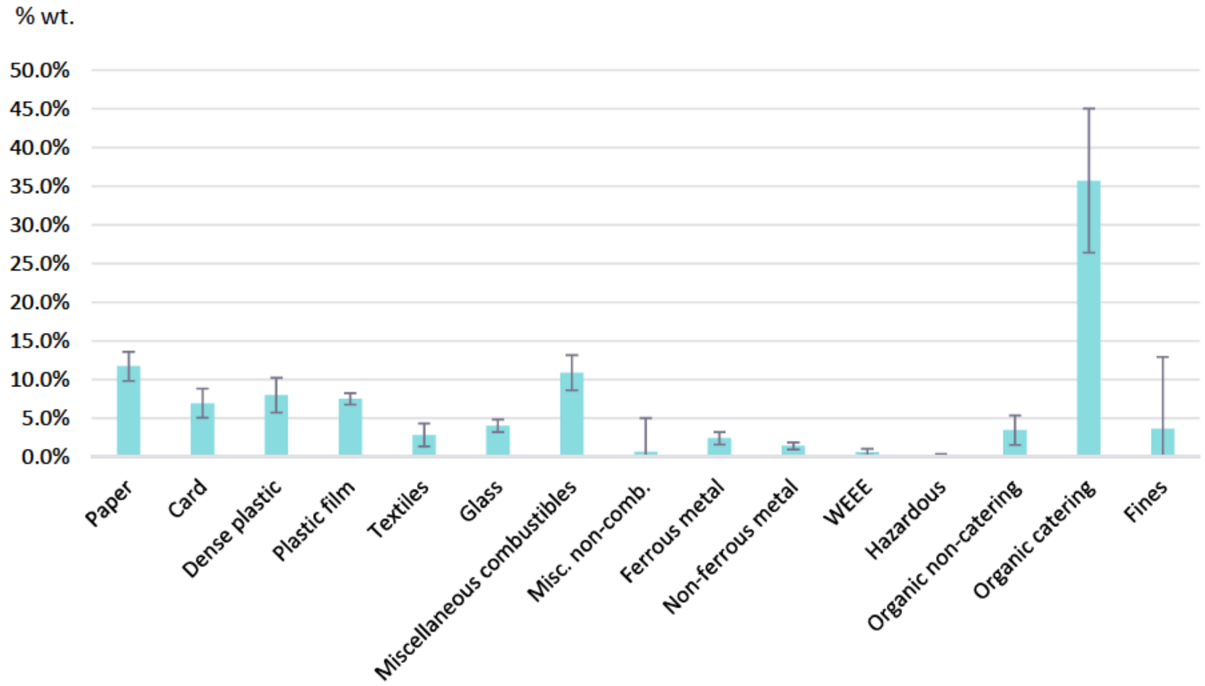
Table 3.5 Residual waste stream composition results (% wt.) – Barnet

	Season 1	Season 2	Average	LCL	UCL
Paper	13.4%	10.0%	11.7%	9.8%	13.6%
Card	7.8%	6.1%	6.9%	5.1%	8.8%
Dense plastic	8.6%	7.4%	8.0%	5.7%	10.2%
Plastic film	8.2%	6.8%	7.5%	6.7%	8.3%
Textiles	3.0%	2.7%	2.8%	1.3%	4.3%
Glass	2.1%	5.9%	4.0%	3.2%	4.9%
Miscellaneous combustibles	9.2%	12.6%	10.9%	8.6%	13.2%
Miscellaneous non-combustibles	0.7%	0.7%	0.7%	0.0%	5.0%
Ferrous metal	3.3%	1.5%	2.4%	1.6%	3.2%
Non-ferrous metal	1.4%	1.4%	1.4%	0.9%	1.9%
WEEE	0.8%	0.4%	0.6%	0.2%	1.0%
Hazardous	0.1%	0.3%	0.2%	0.0%	0.4%
Organic non-catering	4.7%	2.2%	3.5%	1.6%	5.4%
Organic catering	33.5%	37.9%	35.7%	26.4%	45.1%
Fines	3.3%	4.0%	3.6%	0.0%	12.9%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.10 highlights the average results for the residual waste composition study for Barnet with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.10 Residual waste composition result with 90% confidence intervals – Barnet



3.4 London Borough of Camden results

Composition

Seasonal waste composition results

Figure 3.11 compares the Camden's residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). The main differences between the seasonal results are in the organic catering (food waste) which decreases and the organic non-catering waste (garden waste) which increases in line with expectations. There were also notable differences in the paper, glass, miscellaneous combustibles and dense plastic. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.11 Season 1 and Season 2 residual waste stream composition results (% wt.) – Camden

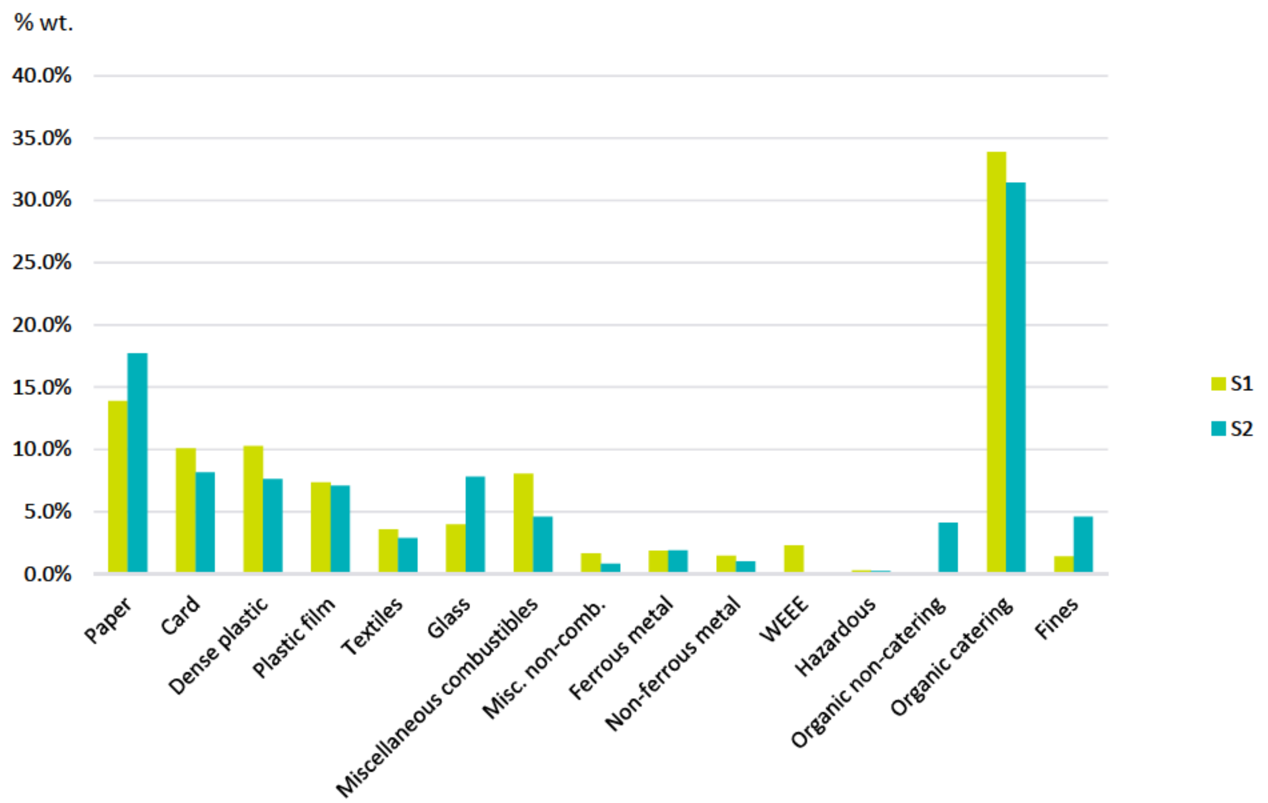


Table 3.6 presents the seasonal and average waste composition results for Camden. Upper and lower confidence limits are presented for the average waste composition result.

- Food waste accounted for the largest proportion of the residual waste stream in Camden at 32.7%; and
- Paper was the second most prominent material category at 15.8% followed by card at 9.1% of the residual waste.

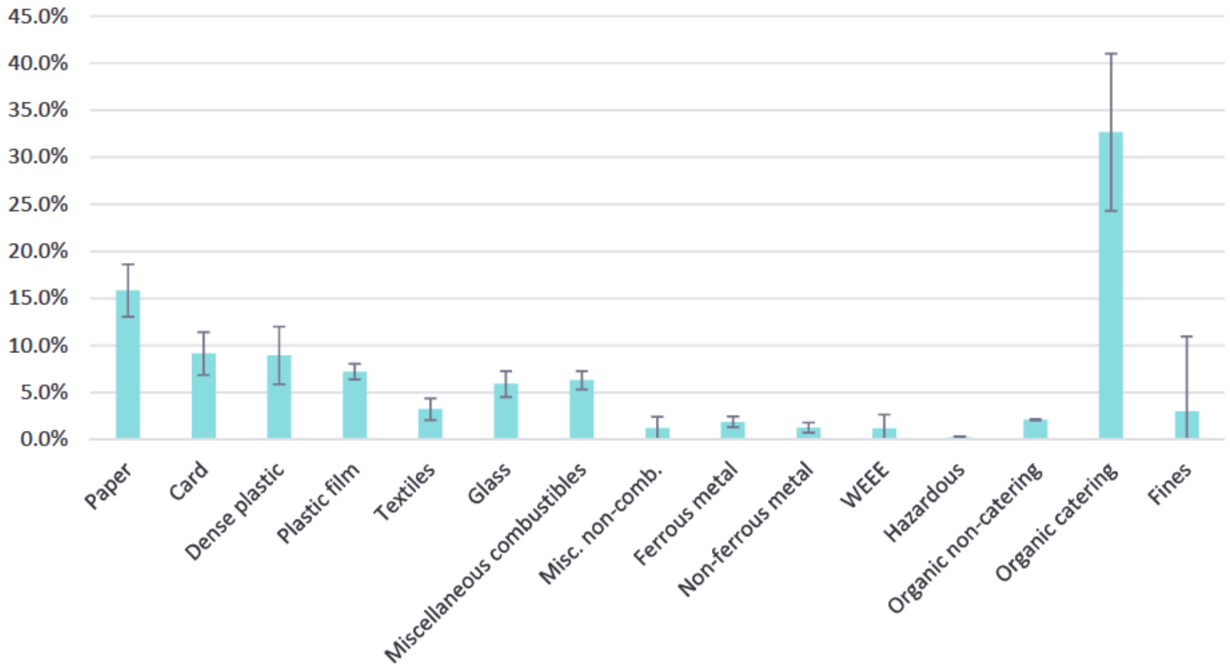
Table 3.6 Residual waste stream composition results (% wt.) – Camden

	Season 1	Season 2	Average	LCL	UCL
Paper	13.9%	17.7%	15.8%	13.0%	18.6%
Card	10.1%	8.2%	9.1%	6.9%	11.4%
Dense plastic	10.3%	7.6%	8.9%	5.9%	12.0%
Plastic film	7.3%	7.1%	7.2%	6.4%	8.0%
Textiles	3.6%	2.9%	3.2%	2.0%	4.4%
Glass	4.0%	7.8%	5.9%	4.5%	7.3%
Miscellaneous combustibles	8.0%	4.6%	6.3%	5.3%	7.3%
Miscellaneous non-combustibles	1.6%	0.8%	1.2%	0.0%	2.4%
Ferrous metal	1.9%	1.9%	1.9%	1.3%	2.4%
Non-ferrous metal	1.5%	1.0%	1.2%	0.7%	1.8%
WEEE	2.3%	0.1%	1.2%	0.0%	2.7%
Hazardous	0.3%	0.2%	0.2%	0.1%	0.3%
Organic non-catering	0.1%	4.1%	2.1%	2.0%	2.2%
Organic catering	33.9%	31.4%	32.7%	24.3%	41.0%
Fines	1.4%	4.6%	3.0%	0.0%	10.9%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.12 highlights the average results for the residual waste composition study for Camden with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.12 Residual waste composition result with 90% confidence intervals – Camden



3.5 London Borough of Enfield results

Composition

Seasonal waste composition results

Figure 3.13 compares the Enfield's residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). The main differences between the seasonal results are in the organic catering (food waste) which decreases and the organic non-catering waste (garden waste) which increases in line with expectations. There are also notable differences in the card, dense plastic, miscellaneous combustibles and hazardous. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.13 Season 1 and Season 2 residual waste stream composition results (% wt.) – Enfield

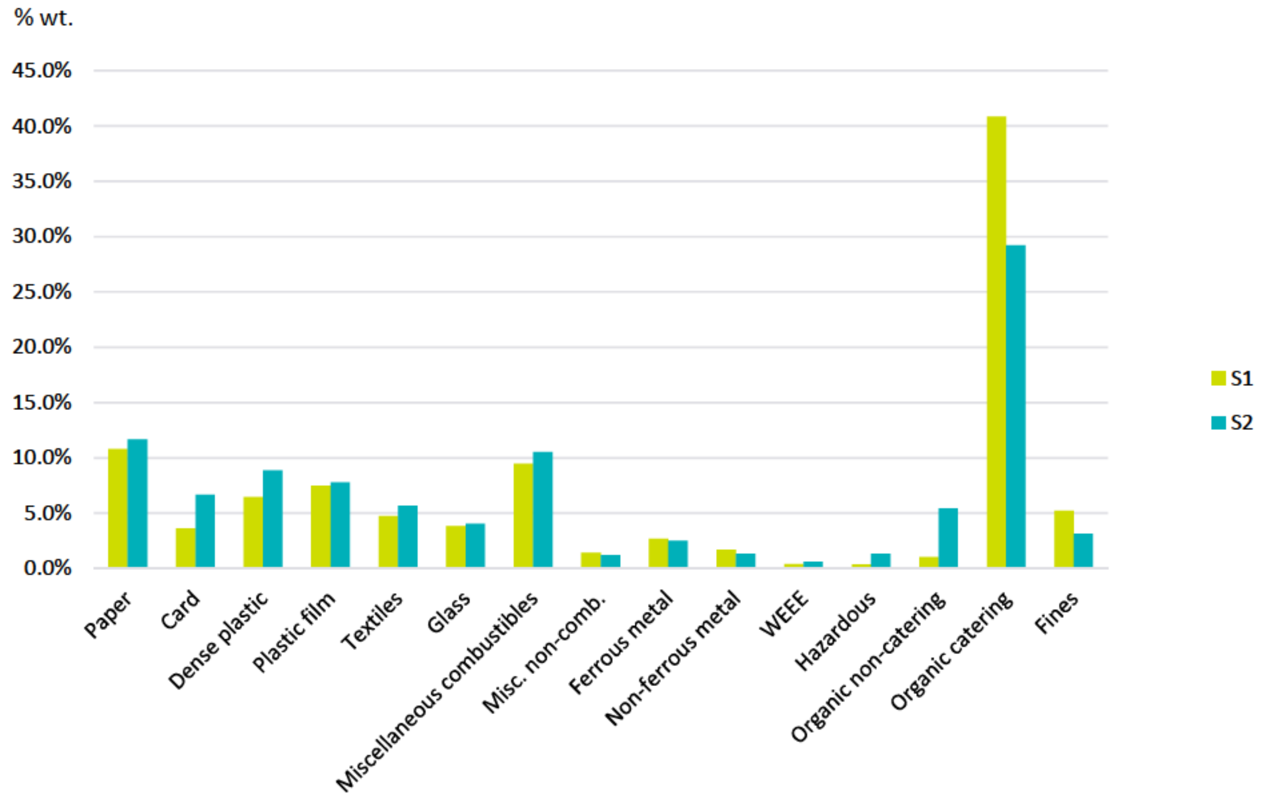


Table 3.7 presents the seasonal and average waste composition results for Enfield. Upper and lower confidence limits are presented for the average waste composition result.

- Food waste accounted for the largest proportion of the residual waste stream in Enfield at 35.0%; this suggests an under-utilisation of the separate food waste collection service; and
- The second most prominent material was paper at 11.2% following by miscellaneous combustibles at 10.0% (the main component of which was nappies and sanitary waste at 8.6% of the residual waste).

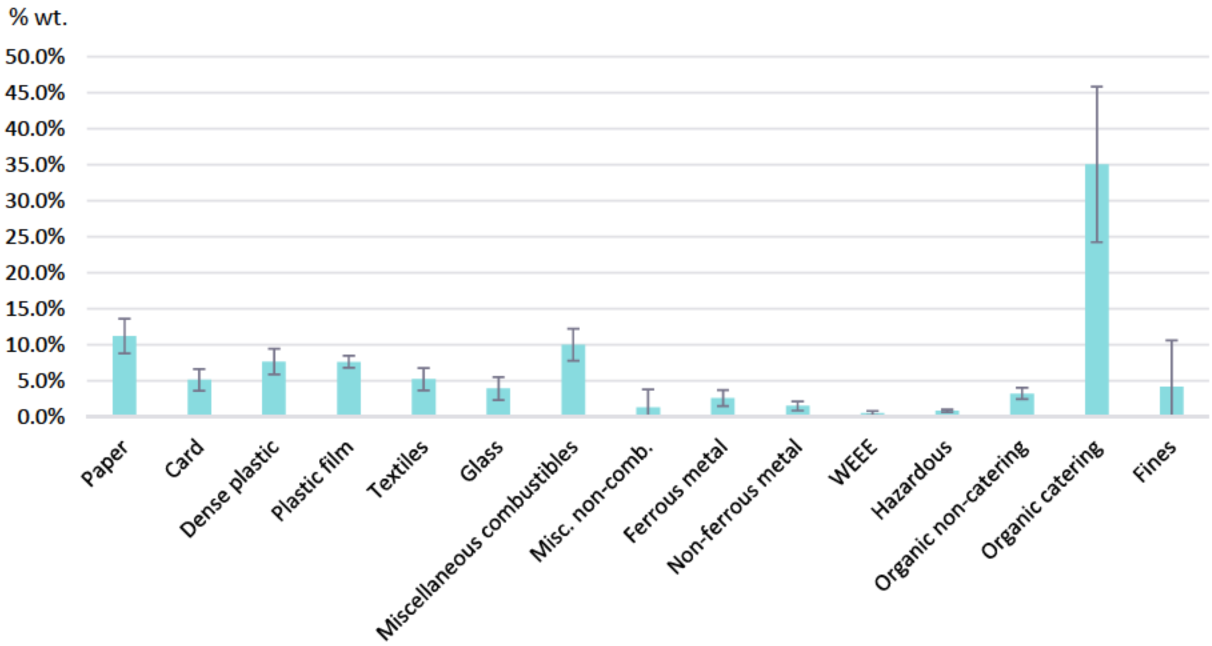
Table 3.7 Residual waste stream composition results (% wt.) – Enfield

	Season 1	Season 2	Average	LCL	UCL
Paper	10.8%	11.7%	11.2%	8.8%	13.6%
Card	3.6%	6.7%	5.1%	3.6%	6.7%
Dense plastic	6.4%	8.9%	7.6%	5.9%	9.4%
Plastic film	7.5%	7.8%	7.6%	6.8%	8.5%
Textiles	4.8%	5.7%	5.2%	3.7%	6.8%
Glass	3.8%	4.0%	3.9%	2.3%	5.5%
Miscellaneous combustibles	9.5%	10.6%	10.0%	7.8%	12.2%
Miscellaneous non-combustibles	1.4%	1.2%	1.3%	0.0%	3.8%
Ferrous metal	2.7%	2.5%	2.6%	1.5%	3.7%
Non-ferrous metal	1.7%	1.3%	1.5%	0.9%	2.2%
WEEE	0.4%	0.6%	0.5%	0.2%	0.8%
Hazardous	0.4%	1.3%	0.8%	0.7%	1.0%
Organic non-catering	1.0%	5.4%	3.2%	2.4%	4.0%
Organic catering	40.8%	29.2%	35.0%	24.2%	45.8%
Fines	5.2%	3.1%	4.2%	0.0%	10.6%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.14 highlights the average results for the residual waste composition study for Enfield with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.14 Residual waste composition result with 90% confidence intervals – Enfield



3.6 London Borough of Hackney results

Composition

Seasonal waste composition results

Figure 3.15 compares the Hackney's residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). The main differences between the seasonal results are in the organic catering (food waste); though the organic non-catering waste (garden waste) difference is important (as the change in relative proportions is counter to expectations), it is relatively small and perhaps reflects the relative lack of gardens in the Borough of Hackney. There are also notable differences in the paper, dense plastic, miscellaneous non-combustibles and textiles. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.15 Season 1 and Season 2 residual waste stream composition results (% wt.) – Hackney

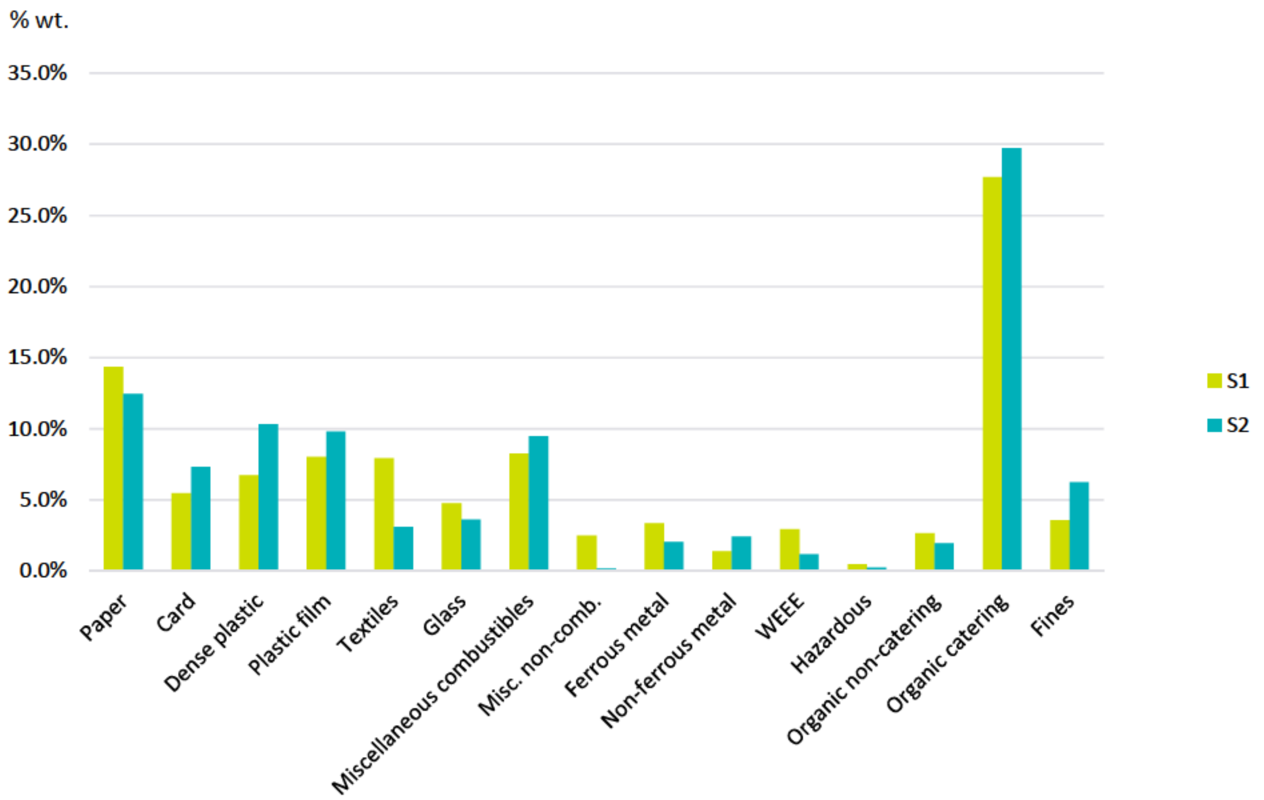


Table 3.8 presents the seasonal and average waste composition results for Hackney. Upper and lower confidence limits are presented for the average waste composition result.

- Food waste accounted for the largest proportion of the residual waste stream in Hackney at 28.7%; this suggests an under-utilisation of the separate food waste collection service; and
- The second most prominent material was paper at 13.4% following by miscellaneous combustibles at 8.9% (the main component of which was nappies and sanitary waste at 7.2% of the residual waste).

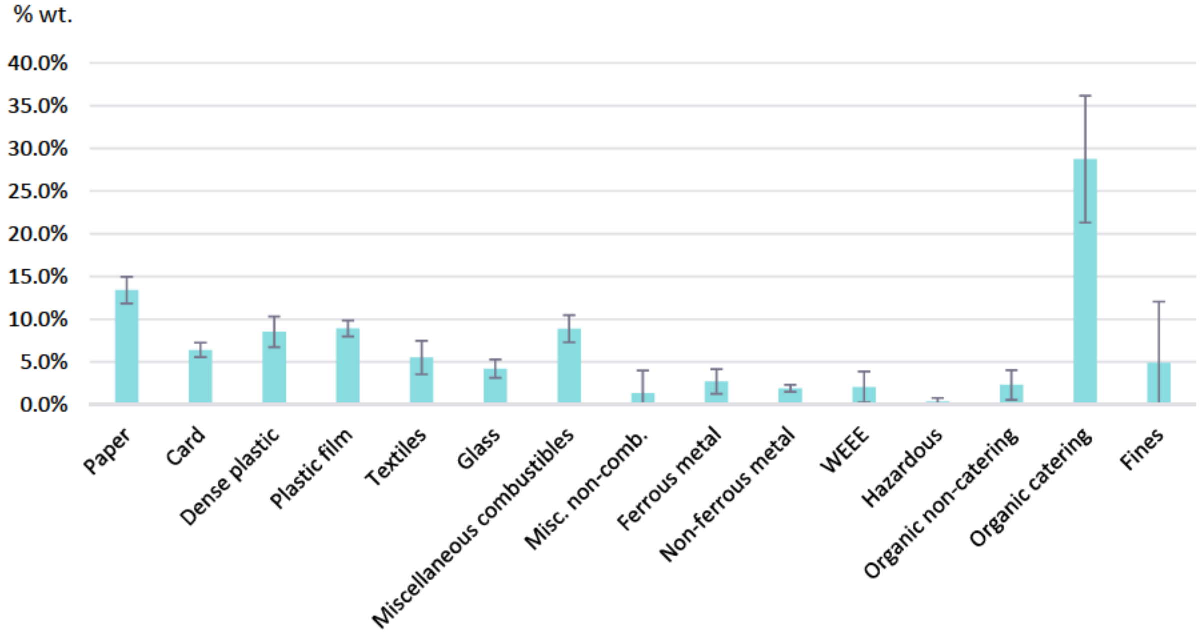
Table 3.8 Residual waste stream composition results (% wt.) – Hackney

	Season 1	Season 2	Average	LCL	UCL
Paper	14.3%	12.5%	13.4%	11.8%	15.0%
Card	5.5%	7.3%	6.4%	5.6%	7.2%
Dense plastic	6.7%	10.3%	8.5%	6.7%	10.3%
Plastic film	8.0%	9.8%	8.9%	8.0%	9.8%
Textiles	7.9%	3.1%	5.5%	3.6%	7.5%
Glass	4.8%	3.6%	4.2%	3.1%	5.3%
Miscellaneous combustibles	8.3%	9.5%	8.9%	7.3%	10.5%
Miscellaneous non-combustibles	2.5%	0.2%	1.3%	0.0%	4.0%
Ferrous metal	3.3%	2.1%	2.7%	1.3%	4.1%
Non-ferrous metal	1.4%	2.4%	1.9%	1.5%	2.3%
WEEE	2.9%	1.2%	2.1%	0.2%	3.9%
Hazardous	0.5%	0.2%	0.3%	0.0%	0.8%
Organic non-catering	2.7%	1.9%	2.3%	0.6%	4.0%
Organic catering	27.7%	29.7%	28.7%	21.3%	36.2%
Fines	3.6%	6.2%	4.9%	0.0%	12.1%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.16 highlights the average results for the residual waste composition study for Hackney with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.16 Residual waste composition result with 90% confidence intervals – Hackney



3.7 London Borough of Haringey results

Composition

Seasonal waste composition results

Figure 3.17 compares the Haringey's residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). The main differences between the seasonal results are in the organic catering (food waste) which decreases and the organic non-catering waste (garden waste) which increases as would be expected. There are also notable differences in the paper, dense plastic, miscellaneous combustibles, non-ferrous metal and textiles. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.17 Season 1 and Season 2 residual waste stream composition results (% wt.) – Haringey

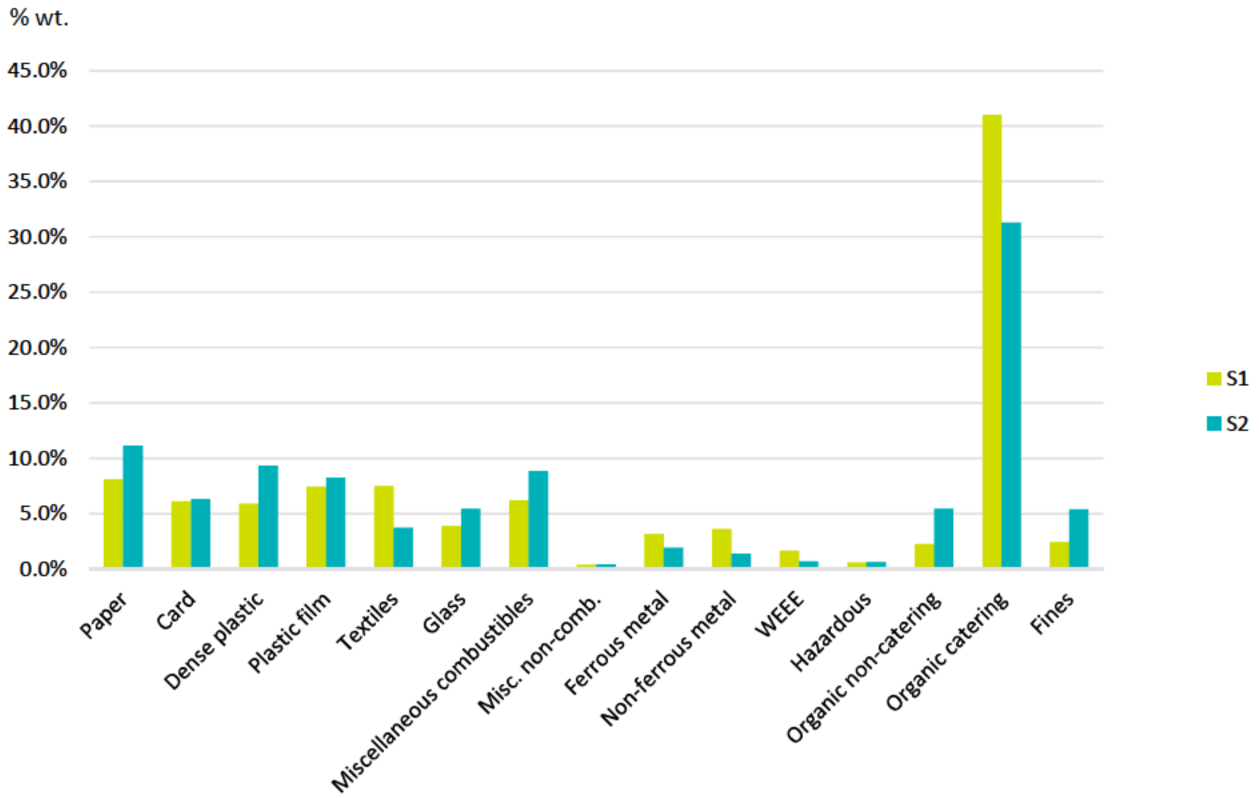


Table 3.9 presents the seasonal and average waste composition results for Haringey. Upper and lower confidence limits are presented for the average waste composition result.

- Food waste accounted for the largest proportion of the residual waste stream in Haringey at 36.2%; this suggests an under-utilisation of the separate food waste collection service; and
- The second most prominent material was paper at 9.6% following by plastic film at 7.8%.

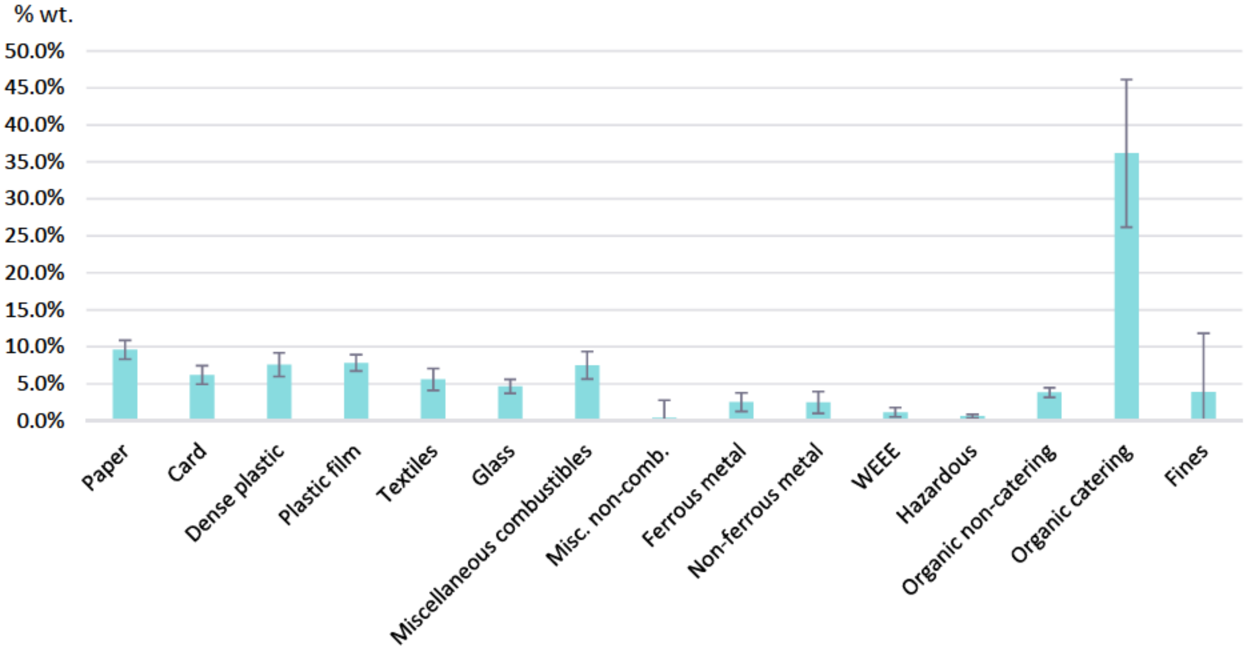
Table 3.9 Residual waste stream composition results (% wt.) – Haringey

	Season 1	Season 2	Average	LCL	UCL
Paper	8.1%	11.1%	9.6%	8.3%	10.9%
Card	6.1%	6.3%	6.2%	4.9%	7.4%
Dense plastic	5.9%	9.3%	7.6%	6.0%	9.2%
Plastic film	7.4%	8.2%	7.8%	6.7%	8.9%
Textiles	7.5%	3.7%	5.6%	4.1%	7.1%
Glass	3.9%	5.4%	4.6%	3.7%	5.6%
Miscellaneous combustibles	6.2%	8.8%	7.5%	5.7%	9.4%
Miscellaneous non-combustibles	0.4%	0.4%	0.4%	0.0%	2.8%
Ferrous metal	3.1%	1.9%	2.5%	1.3%	3.8%
Non-ferrous metal	3.6%	1.4%	2.5%	1.0%	3.9%
WEEE	1.6%	0.7%	1.2%	0.5%	1.8%
Hazardous	0.6%	0.6%	0.6%	0.4%	0.9%
Organic non-catering	2.2%	5.4%	3.8%	3.2%	4.5%
Organic catering	41.0%	31.3%	36.2%	26.2%	46.1%
Fines	2.4%	5.4%	3.9%	0.0%	11.8%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.18 highlights the average results for the residual waste composition study for Haringey with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.18 Residual waste composition result with 90% confidence intervals – Haringey



3.8 London Borough of Islington results

Composition

Seasonal waste composition results

Figure 3.19 compares the Islington's residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). The main differences between the seasonal results are in the organic catering (food waste) which decreases and the organic non-catering waste (garden waste) which increases (which is in line with expected seasonal variation). There are also notable differences in the paper, card, miscellaneous combustibles and textiles. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.19 Season 1 and Season 2 residual waste stream composition results (% wt.) – Islington

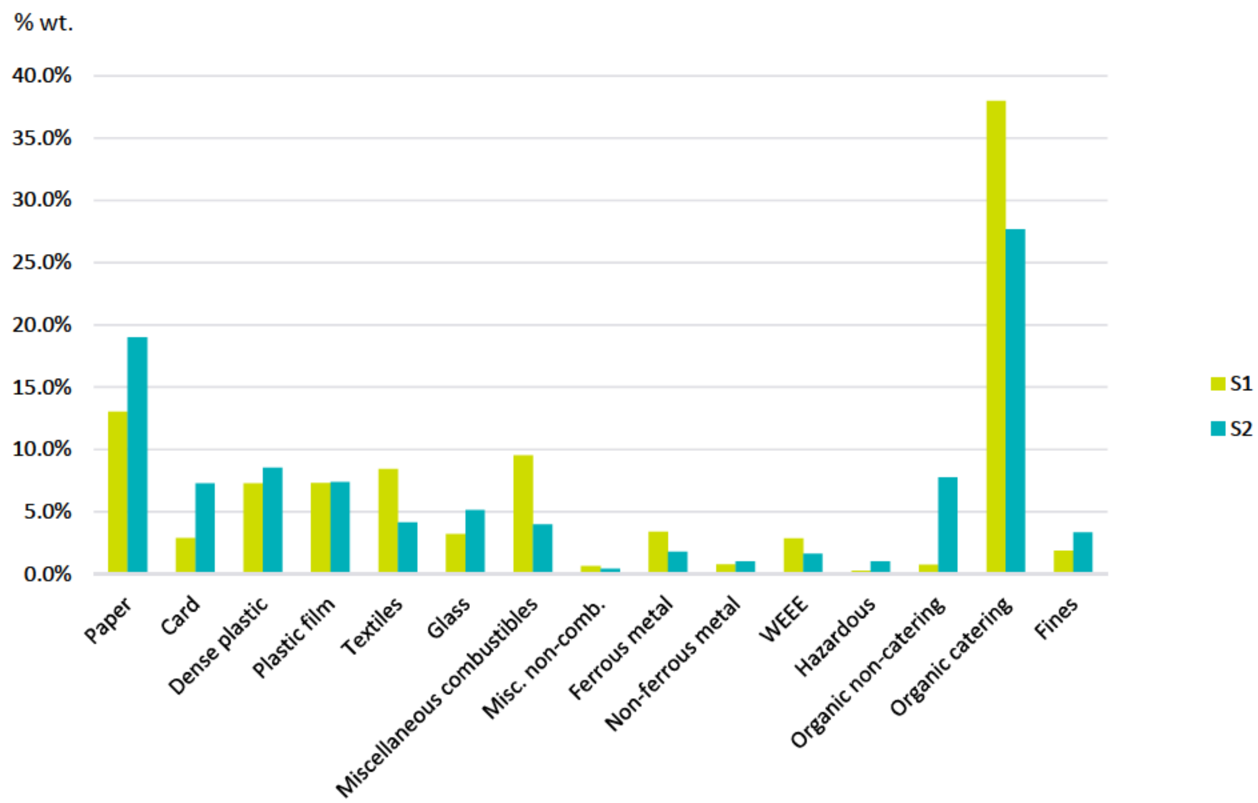


Table 3.10 presents the seasonal and average waste composition results for Islington. Upper and lower confidence limits are presented for the average waste composition result.

- Food waste accounted for the largest proportion of the residual waste stream in Islington at 32.8%; and
- The second most prominent material was paper at 16.0% followed by dense plastic at 7.9%.

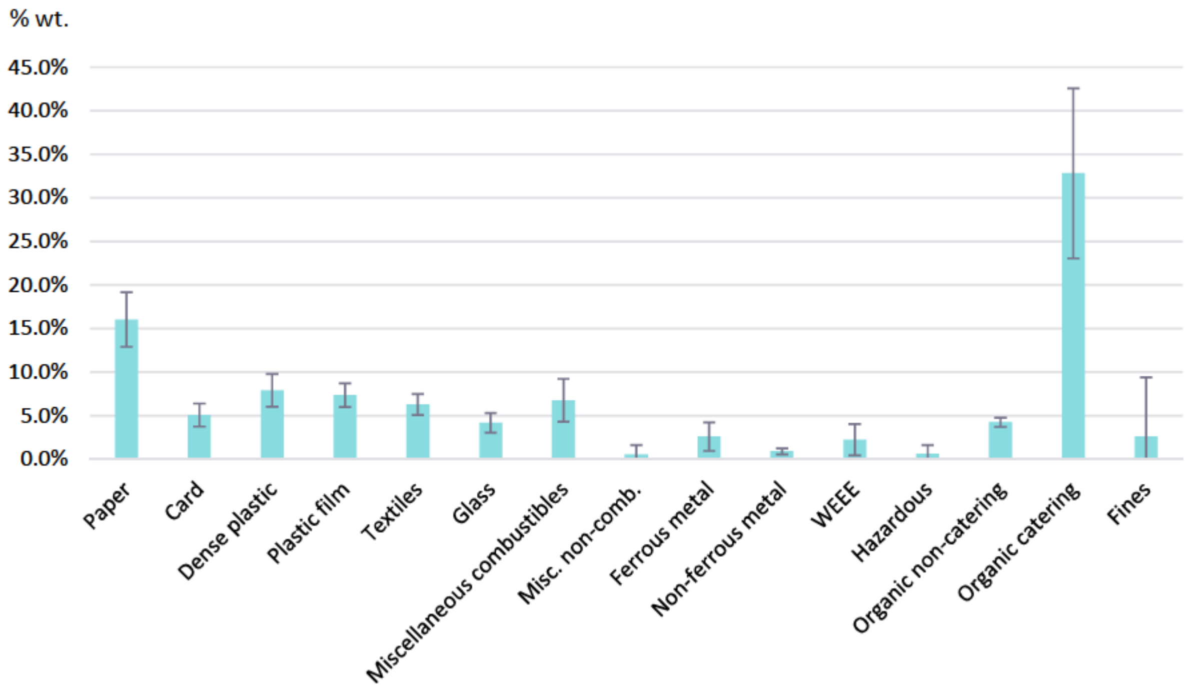
Table 3.10 Residual waste stream composition results (% wt.) – Islington

	Season 1	Season 2	Average	LCL	UCL
Paper	13.0%	19.0%	16.0%	12.9%	19.2%
Card	2.9%	7.3%	5.1%	3.7%	6.4%
Dense plastic	7.3%	8.5%	7.9%	6.0%	9.8%
Plastic film	7.3%	7.4%	7.3%	6.0%	8.7%
Textiles	8.4%	4.1%	6.3%	5.1%	7.5%
Glass	3.2%	5.1%	4.2%	3.0%	5.3%
Miscellaneous combustibles	9.5%	4.0%	6.8%	4.3%	9.2%
Miscellaneous non-combustibles	0.6%	0.4%	0.5%	0.0%	1.6%
Ferrous metal	3.4%	1.8%	2.6%	1.0%	4.2%
Non-ferrous metal	0.8%	1.0%	0.9%	0.5%	1.3%
WEEE	2.8%	1.6%	2.2%	0.4%	4.0%
Hazardous	0.3%	1.0%	0.6%	0.0%	1.6%
Organic non-catering	0.7%	7.8%	4.2%	3.7%	4.8%
Organic catering	38.0%	27.7%	32.8%	23.1%	42.6%
Fines	1.9%	3.3%	2.6%	0.0%	9.4%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.20 highlights the average results for the residual waste composition study for Islington with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.20 Residual waste composition result with 90% confidence intervals – Islington



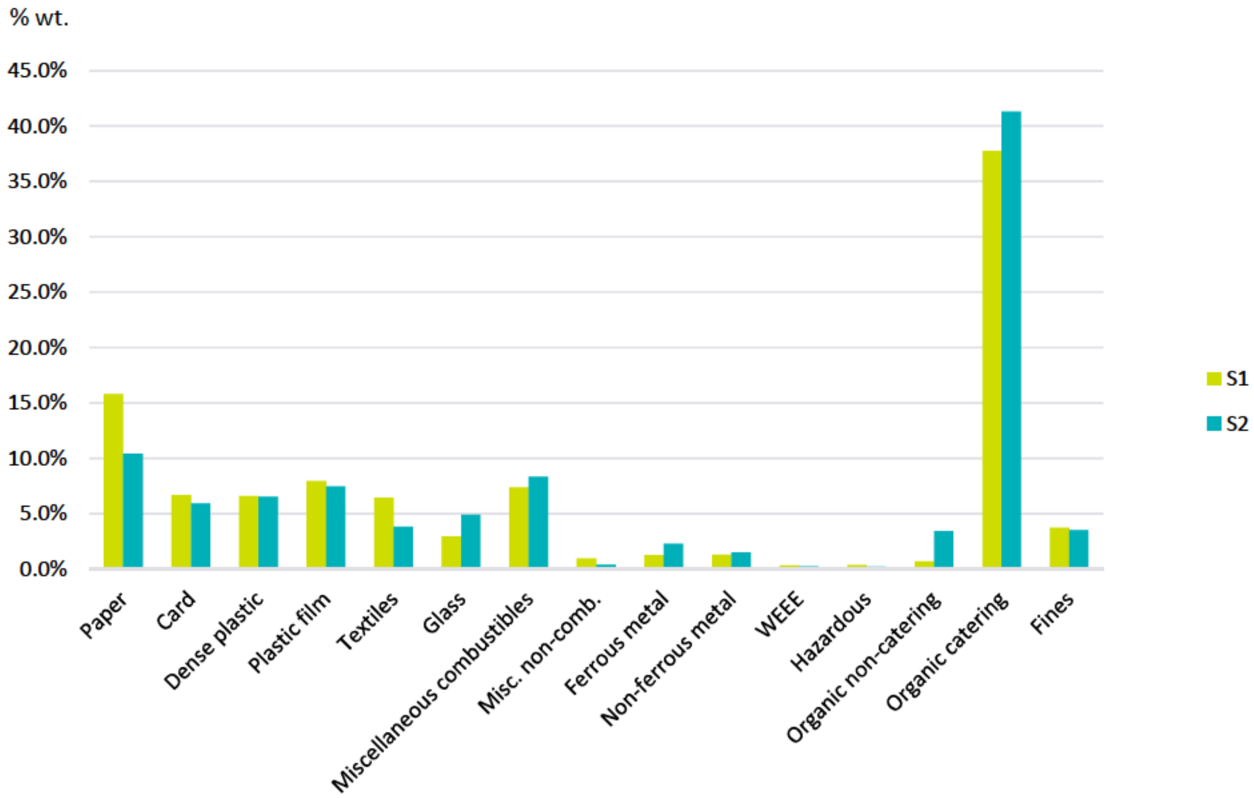
3.9 London Borough of Waltham Forest results

Composition

Seasonal waste composition results

Figure 3.21 compares the Waltham Forest's residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2). The main differences between the seasonal results are in the organic catering (food waste) which increases (counter to expectations[24]) and the organic non-catering waste (garden waste) which increases (in line with expectations). There are also notable differences in the paper, glass and textiles. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.21 Season 1 and Season 2 residual waste stream composition results (% wt.) – Waltham Forest



[24] Again, this emphasises the indicative nature of Borough level results however it may also indicate that seasonal variations in garden waste arisings may be less pronounced in London than elsewhere in the country. This could be linked to lower prevalence or gardens in London and, where houses have gardens, the possibility that gardens may also tend to be smaller than elsewhere in the UK.

Table 3.11 presents the seasonal and average waste composition results for Waltham Forest. Upper and lower confidence limits are presented for the average waste composition result.

- Food waste accounted for the largest proportion of the residual waste stream in Waltham Forest at 39.5%; and
- The second most prominent material was paper at 13.1% following by miscellaneous combustibles at 7.8% (with nappies and sanitary waste composing 6.4% of the residual waste).

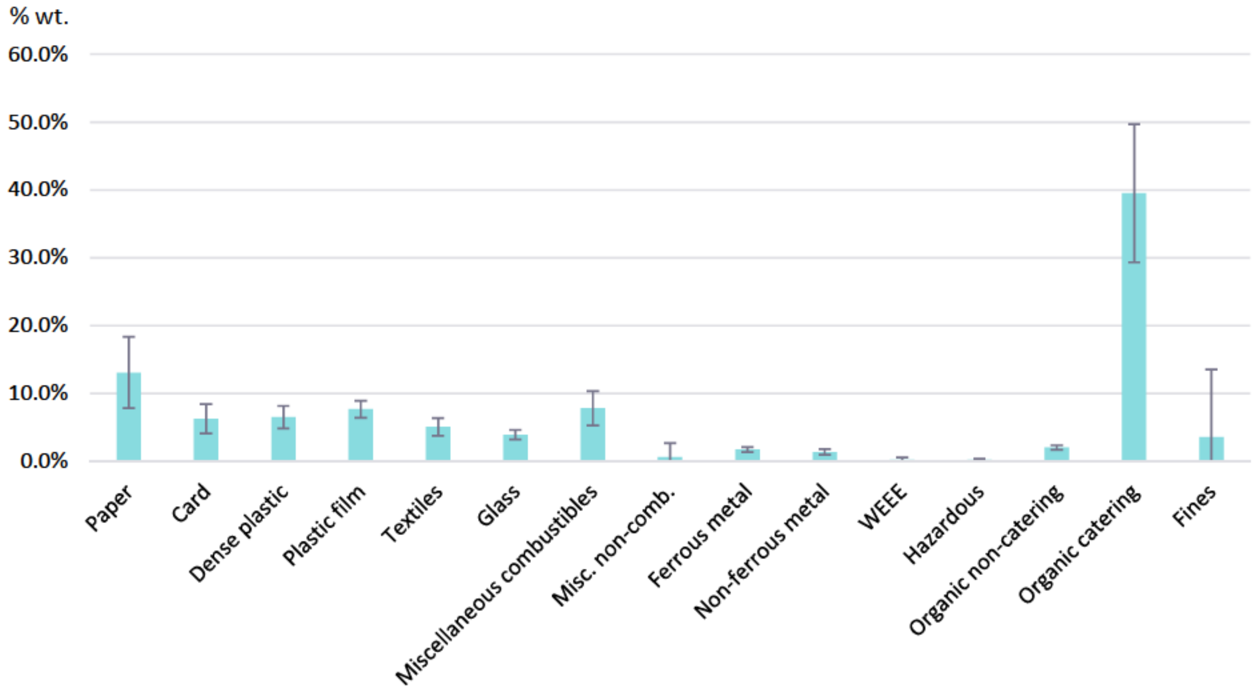
Table 3.11 Residual waste stream composition results (% wt.) – Waltham Forest

	Season 1	Season 2	Average	LCL	UCL
Paper	15.8%	10.4%	13.1%	7.8%	18.3%
Card	6.7%	5.9%	6.3%	4.1%	8.5%
Dense plastic	6.6%	6.5%	6.5%	4.9%	8.2%
Plastic film	7.9%	7.4%	7.7%	6.4%	8.9%
Textiles	6.4%	3.8%	5.1%	3.8%	6.4%
Glass	2.9%	4.9%	3.9%	3.2%	4.6%
Miscellaneous combustibles	7.4%	8.3%	7.8%	5.3%	10.4%
Miscellaneous non-combustibles	0.9%	0.4%	0.7%	0.0%	2.7%
Ferrous metal	1.2%	2.3%	1.8%	1.4%	2.1%
Non-ferrous metal	1.3%	1.5%	1.4%	1.0%	1.8%
WEEE	0.3%	0.2%	0.3%	0.0%	0.6%
Hazardous	0.3%	0.2%	0.3%	0.1%	0.4%
Organic non-catering	0.7%	3.4%	2.1%	1.7%	2.4%
Organic catering	37.8%	41.3%	39.5%	29.4%	49.7%
Fines	3.7%	3.5%	3.6%	0.0%	13.6%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.22 highlights the average results for the residual waste composition study for Waltham Forest with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

Figure 3.22 Residual waste composition result with 90% confidence intervals – Waltham Forest



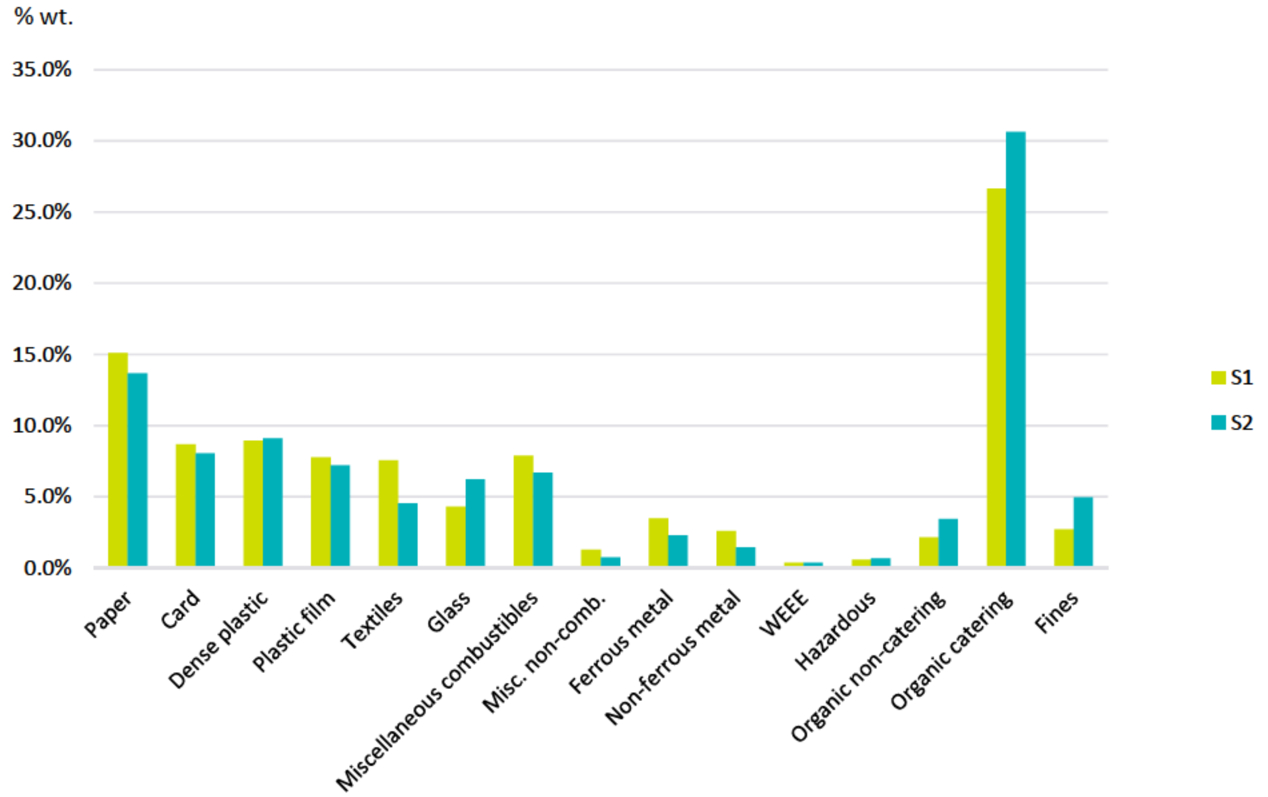
3.10 Composition of residual waste from high and low rise dwellings

Composition

Seasonal waste composition results

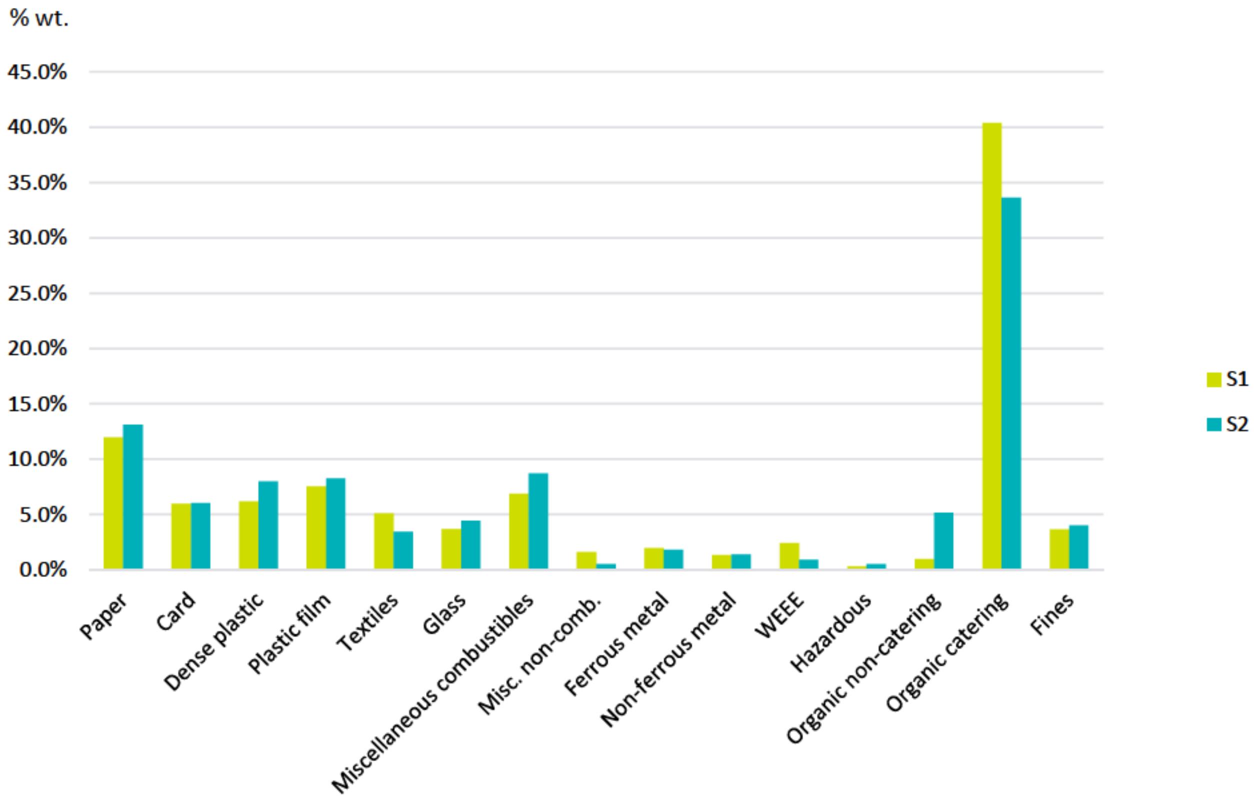
Figure 3.23 and Figure 3.24 compare the residual waste composition results obtained for the January/February sampling exercise (Season 1) and the August sampling exercise (Season 2) for high rise dwellings and low rise dwellings, respectively.

Figure 3.23 Season 1 and Season 2 residual waste stream composition results (% wt.) – high rise



For high rise dwellings, the main differences between the seasonal results are in the organic catering (food waste) and the organic non-catering waste (garden waste). For high-rise properties both organic non-catering waste (garden waste) and organic catering waste (food waste). Although this is not in line with expectations it is probably unremarkable because high rise properties are unlikely to have gardens. There are also notable differences in the paper, glass and textiles. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Figure 3.24 Season 1 and Season 2 residual waste stream composition results (% wt.) – low rise



For low rise dwellings, the main differences between the seasonal results are in the organic catering (food waste) which decreases and the organic non-catering waste (garden waste) which increases. This is in line with expectations for seasonal variation and perhaps indicates the (obvious) relative prevalence of gardens in low rise properties when compared to high rise. There are also notable differences in the dense plastic, miscellaneous combustibles and textiles. Nonetheless, there is no conclusive evidence for seasonal variations in the quantities of these waste materials and therefore it is likely to be a function of 'normal' variance.

Table 3.12 and Table 3.13 present the seasonal and average waste composition results for high rise dwellings and low rise dwellings, respectively. Upper and lower confidence limits are presented for the average waste composition results.

- Food waste accounted for the largest proportion of the residual waste stream in high rise dwellings and low rise dwellings at 28.6% and 37.0% respectively; and
- Paper is the second most prominent category (at 14.4% for high rise and 12.5% for low rise properties) followed by dense plastic for high rise properties at 9.0% and by plastic film for low rise properties at 7.9%.

Table 3.12 Residual waste stream composition results (% wt.) – high rise

	Season 1	Season 2	Average	LCL	UCL
Paper	15.1%	13.7%	14.4%	11.4%	17.4%
Card	8.7%	8.0%	8.4.%	7.3%	9.4%
Dense plastic	8.9%	9.1%	9.0%	7.3%	10.8%
Plastic film	7.8%	7.2%	7.5%	6.8%	8.1%
Textiles	7.5%	4.5%	6.0%	5.1%	7.0%
Glass	4.3%	6.2%	5.3%	4.3%	6.2%
Miscellaneous combustibles	7.9%	6.7%	7.3%	6.1%	8.5%
Miscellaneous non-combustibles	1.3%	0.7%	1.0%	0.0%	2.2%
Ferrous metal	3.5%	2.3%	2.9%	2.0%	3.8%
Non-ferrous metal	2.6%	1.5%	2.0%	1.3%	2.8%
WEEE	0.4%	0.4%	0.4%	0.0%	0.7%
Hazardous	0.6%	0.7%	0.6%	0.5%	0.7%
Organic non-catering	2.2%	3.4%	2.8%	1.9%	3.7%
Organic catering	26.6%	30.6%	28.6%	24.1%	33.1%
Fines	2.7%	5.0%	3.8%	0.0%	8.8%
Total	100.0%	100.0%	100.00%		

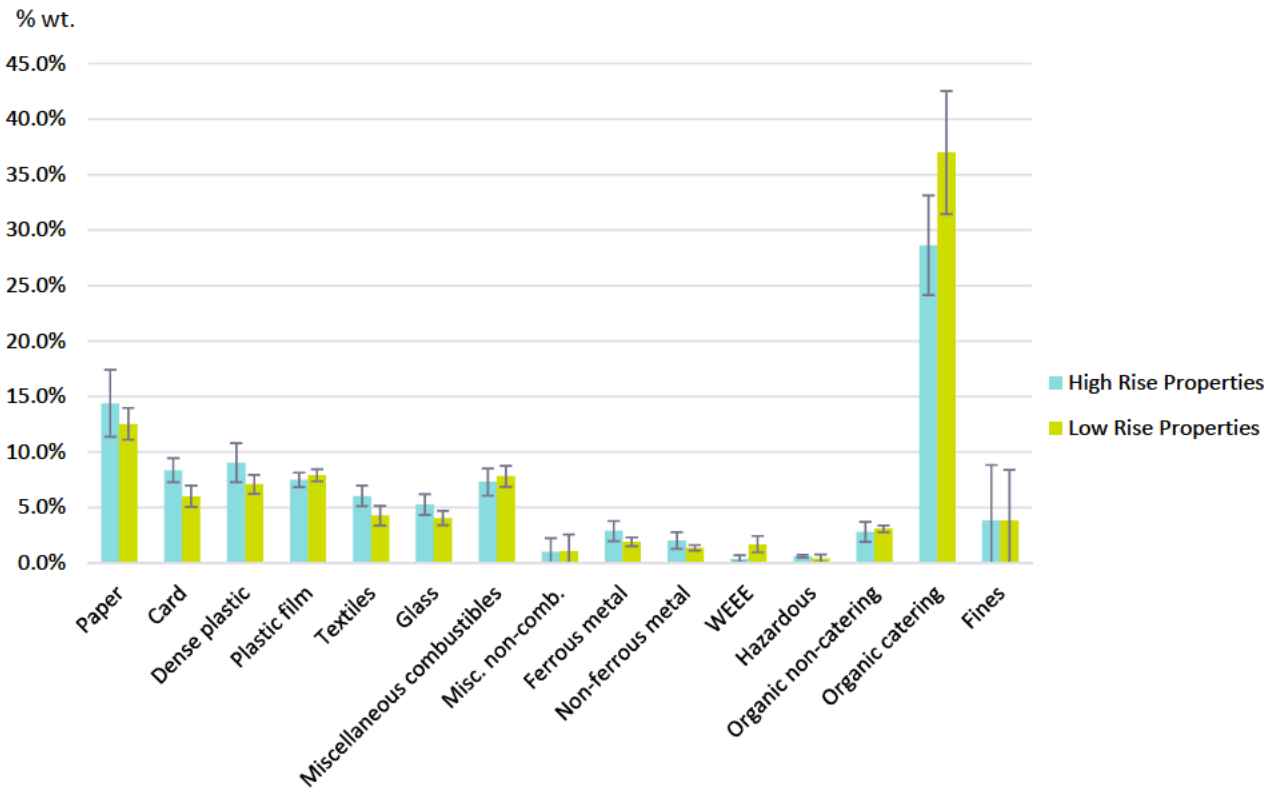
Table 3.13 Residual waste stream composition results (% wt.) – low rise

	Season 1	Season 2	Average	LCL	UCL
Paper	12.0%	13.1%	12.5%	11.1%	14.0%
Card	6.0%	6.1%	6.0%	5.1%	7.0%
Dense plastic	6.2%	8.0%	7.1%	6.2%	7.9%
Plastic film	7.5%	8.3%	7.9%	7.4%	8.5%
Textiles	5.1%	3.4%	4.3%	3.4%	5.1%
Glass	3.7%	4.4%	4.0%	3.4%	4.7%
Miscellaneous combustibles	6.9%	8.7%	7.8%	6.9%	8.8%
Miscellaneous non-combustibles	1.6%	0.5%	1.1%	0.0%	2.6%
Ferrous metal	2.0%	1.8%	1.9%	1.5%	2.3%
Non-ferrous metal	1.3%	1.4%	1.4%	1.1%	1.6%
WEEE	2.4%	0.9%	1.7%	1.0%	2.4%
Hazardous	0.3%	0.5%	0.4%	0.1%	0.8%
Organic non-catering	1.0%	5.2%	3.1%	2.8%	3.4%
Organic catering	40.4%	33.6%	37.0%	31.5%	42.5%
Fines	3.6%	4.0%	3.8%	0.0%	8.4%
Total	100.0%	100.0%	100.00%		

Confidence

Figure 3.25 highlights the average results for the residual waste composition study for both high rise and low rise dwellings with indicative 90% confidence intervals to illustrate the level of uncertainty associated with the results for the primary material categories.

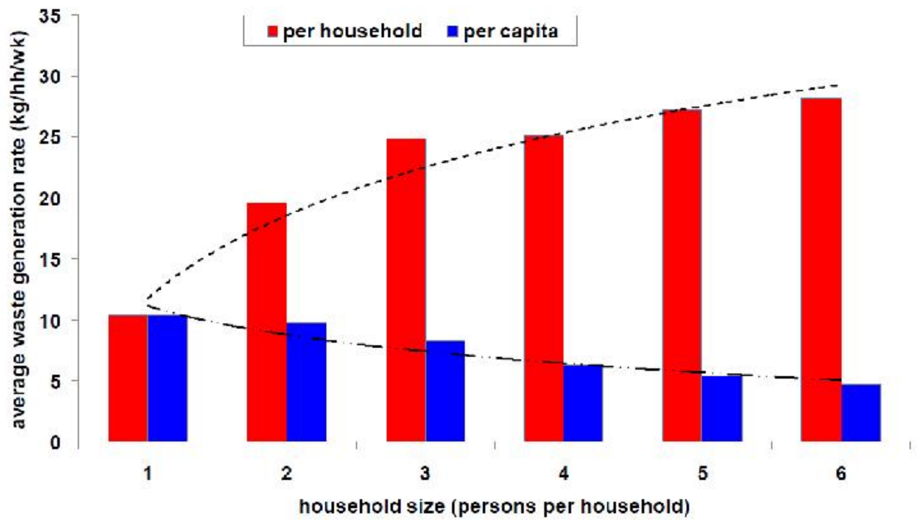
Figure 3.25 Residual waste composition result with 90% confidence intervals – high rise and low rise



Analysis of high and low rise results

According to a number of studies residents in high rise properties tend to put more recyclable waste in their residual waste stream[25]. This has been linked to less convenient systems for the separate capture of recyclable waste, socio-demographics and also the fact that households with fewer occupants, tend to generate more waste and recycling per capita[26] (see Figure 3.26). The residual waste composition for high rise and low rise properties obtained from the study is consistent with this assertion; high rise properties tended to have a higher proportion of recyclables in its residual waste stream in comparison with the residual waste from low rise properties.

Figure 3.26 The effect of household size on waste generation rate



Source: Defra / The Open University (2008) The Open University Household Waste Study

The larger proportion of recyclables in residual waste from low-rise properties is the main reason that the proportion of the food waste is lower in the residual waste from high rise properties than in the residual waste from low rise properties. We must note, however, that this difference in the proportion of food waste does not imply a reduction in the quantity of food waste generated by high rise properties. As high-rise properties would tend to be associated with a lower number of occupants[27] in reality, high rise properties are likely to generate a greater quantity of food waste per person than residents living in low rise properties[28]. Figure 3.27 shows that as the number of occupants in a household decreases the waste produced per person increases.

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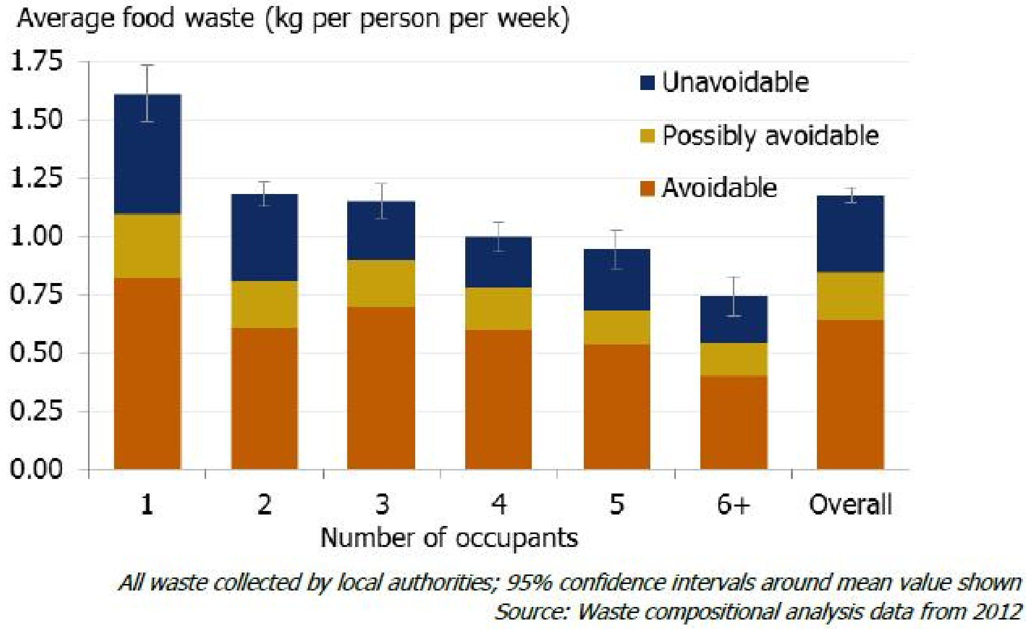
[25] Amec Foster Wheeler (2011) Greater Manchester Householder Survey and Waste Composition Analysis showed that flats (and other high-density housing i.e. terraces) tended to recycle less and therefore tended to have a higher proportion of recyclable materials in their residual waste. See Appendix B.
[26] Defra / The Open University (2008) The Open University Household Waste Study.
[27] Amec Foster Wheeler (2011) Greater Manchester Householder Survey and Waste Composition Analysis showed that housing type and number of occupants was correlated i.e. detached housing tended to have more occupants than semi-detached housing, which in turn tends to have more occupants than terraces which similarly tend to have more occupants than flats. Whilst there are special circumstances in London we would still expect this relationship to hold.
[28] WRAP (2014) Household food and drink waste: a people focus

Figure 3.27 Average quantity of food and drink waste per person for different household sizes



Source: WRAP (2014) Household food and drink waste: a people focus

4. Calorific Value estimation

This section contains a description of the methodology used for calculating the net CV estimation for the collected residual waste samples. It also highlights the elemental composition of the collected residual waste samples.

4.1 Method

The results from NLWA area's residual waste compositional exercises have been used to estimate the net CV[29] for the residual waste stream[30] using an Amec Foster Wheeler model developed for this purpose. The model uses reference values the waste constituents. The reference values used are derived from the UK National Household Waste Composition Study conducted in 1994. These are the reference values used in 'WRATE' the waste management lifecycle modelling tool originally developed for the Environment Agency and now owned and supported by Golders Associates (UK) Ltd.

The original reference data were determined by laboratory analysis of materials extracted from waste bins. As may be anticipated, these materials would have been contaminated with other waste constituents while in the bin. Hence, absorbent materials such as paper, card and textiles would have absorbed moisture from wet materials such as kitchen and garden waste, and become contaminated. Likewise, kitchen and garden waste would have lost moisture. Values for each of the key constituents of the waste materials are also provided in the reference data; these include ash, hydrogen, carbon, nitrogen, oxygen, sulphur and chlorine. These reference values were determined by destructive testing of waste materials.

4.2 Results

Table 4.1 presents the estimated net CV for the residual waste collected from the whole NLWA area.

Table 4.1 Net CV estimation

	Net CV (MJ/kg)	Moisture (wt %)	Ash (wt %)
Season 1	8.69	38.13	17.40
Season 2	8.82	39.03	17.26
Average	8.76	39.08	17.17

[29] Gross calorific value is the quantity of heat released when all combustible material is fully burnt, the theoretical maximum energy available, determined using a bomb calorimeter. In practical situations energy recovery facilities cannot recover all of the energy implied by a gross calorific value. There are two main reasons for this: water produced by the oxidation of hydrogen in the fuel is not condensed, but escapes from the system in the stack gas as steam, and other residues leave the system at a higher temperature than they enter, so removing heat. In addition, water present in the waste will consume energy in the process of evaporation and reduce the amount of heat that can be recovered. Also non-combustible materials will absorb heat and remove it from the system on discharge. Net calorific value is viewed as a useful parameter for estimating the energy input to combustion processes, since it takes into account these potential losses

[30] The compositional analysis sampled RCV delivered waste only. The study did not examine other residual waste streams such as residual waste from RRCs, fly-tipped waste, bulky waste or street cleansing wastes. Therefore the CV estimate is only applicable to RCV delivered residual waste only.

The net CV for residual waste calculated from the 2010 data for the North London area was 9.13 MJ/kg[31]. The net CV estimate in 2016 is slightly lower at 8.74 MJ/kg. This is likely a result of the higher organics content found within the 2016 samples compared with that of the 2010 samples. The reduction in paper, card and plastic will also be a factor. One of the most fruitful areas of focus in future would be the high food waste content of the residual waste. Increased diversion of this faction at source would benefit both recycling rates and increase the CV of the residual fraction.

Table 4.2 gives the elemental composition of the sample with reference to the components most relevant to treatment via energy from waste.

Table 4.2 Elemental composition of North London samples

Chemical Elements	Results (wt %) - Season 1	Results (wt %) - Season 2	Results (wt %) - Average
Hydrogen	3.4	3.5	3.5
Carbon	23.9	24.2	24.0
Nitrogen	0.8	0.7	0.7
Oxygen	14.8	14.5	14.7
Sulphur	0.1	0.1	0.1
Chlorine	0.8	0.7	0.8

[31] Reported values for European MSW are in the range 9 to 11 MJ/kg (AEA Technology report to the European Commission (2001) *Waste Management Options and Climate Change*. ISBN 92-894-1733-1, pp 116). ***Note, this range is for non-segregated waste with low / no recycling***.

5. Conclusions

This section summarises the key points highlighted in the study in relation to its stated objectives.

A significant proportion of North London's residual waste stream still consists of recyclable waste[32] which indicates that the kerbside dry recycling, food waste and garden waste collection services and the area's RRCs are not being fully exploited. Organic catering or food waste was the most significant component of North London's residual waste composition. The diversion of this material from the residual waste would have benefits for NLWA's recycling and composting rate and also help to increase the theoretical energy content (net CV) of the kerbside residual waste stream which is the main EfW feedstock. Additionally, over 20% of North London's composite waste arising in its residual waste stream could potentially be recycled (technically recyclable composites such as disposable coffee cups), but will require an assessment of the viability of recycling these waste materials as new technologies emerge.

Likewise, across the seven Boroughs in NLWA area, organic food waste accounts for the largest proportion of residual waste arising. This indicates that the Boroughs may not be effectively capturing food waste for recycling at the current time. Furthermore, each Borough may not be capturing the levels of dry recyclables which could potentially be captured for recycling (capture rates and future recycling rate scenarios have been examined in a separate technical note 35180-47_REA_CO54_Maximim Recycling Rate_i1). Also, consistent with the analyses of the results at both the North London and Borough level, high rise and low rise dwellings food waste was the most prominent material in their residual waste arisings.

The most significant seasonal difference identified was the increase in the proportion of organic non-catering waste (garden waste) in Season 2 (in line with expectations i.e. more garden waste in the residual waste in the summer). As a consequence the proportion of food waste in the residual waste tended to decrease in Season 2 because it is the most prominent category[33].

The net CV estimate for NLWA's residual waste arisings decreased by 0.39 MJ/kg to 8.74 MJ/kg when compared to the residual waste composition from 2010 (9.13 MJ/kg). This reduction in the net CV estimate is attributed to the increase in the proportion of organic waste materials within the residual waste stream. Reductions in the proportions of paper, card and plastic in the residual waste between 2010 and 2016 may also have contributed to the reduction in net CV. Hence, the increase in the theoretical energy yield from the incineration of North London's residual waste at its EfW plant would benefit from an increased diversion of food waste away from the residual waste stream.

[32] 71.5% of the residual waste stream.

[33] We acknowledge the anticipated seasonal differences in garden waste (and as a consequence food waste) was not present in all Borough and property-type subsets – however the inverse relationship is clear in the most robust results at the NLWA level. On one hand this emphasises the indicative nature of Borough level results however the relative prevalence of gardens in different Boroughs may also be a factor.

Appendix A
Waste sort categories

The table below highlights the primary and secondary material categories that were targeted during both residual waste sampling exercises. Though the primary categories were consistent over both seasons of sampling, there additional secondary categories were included in the Season 2 study[34].

Primary Category	Season 1 Secondary Category	Season 2 Secondary Category
Paper	Recyclable paper	Recyclable paper
	Non-recyclable paper	Composite paper
		Non-recyclable paper
Card	Recyclable card	Recyclable card
	Non-recyclable card	Non-recyclable card
	Beverage cartons	Technically recyclable composites
		Composite Card - not recyclable
		Beverage cartons
Not easily recyclable composite packaging	N/A	Not easily recyclable composite packaging
Dense plastic	PET bottles	PET (1) bottles
	HDPE bottles	HDPE (2) bottles
	PP bottles	PP (5) bottles
	Pots, Tubs and Trays	Pots, Tubs and Trays
	Other non-packaging plastic	Other non-packaging plastic
Plastic film	Refuse sacks	Refuse sacks
	PE film	Polyethylene (PE) film
	Non-PE film	Non-PE film
Textiles	All textiles (including shoes)	All textiles (including shoes)
Glass	Recyclable (bottles and jars) glass	Packaging glass
	Non-recyclable glass	Non-packaging glass
Miscellaneous combustibles	Wood	Wood
	Sanitary waste	Sanitary waste
	Other	Other
Miscellaneous non-combustible	All miscellaneous non-combustibles	All miscellaneous non-combustibles

[34] These additional entries covered different types of composites-related categories: Composite paper - not recyclable, technically recyclable composites, composite card – not recyclable, and not easily recyclable composite packaging.

Primary Category	Season 1 Secondary Category	Season 2 Secondary Category
Ferrous metal	Ferrous metal packaging	Ferrous metal packaging
	Ferrous compounded metal	Ferrous compounded metal
	Other ferrous non-packaging metal	Other ferrous metal
Non-ferrous metal	Non-ferrous metal packaging	Non-ferrous metal packaging
	Non-ferrous compounded metal	Non-ferrous compounded metal
	Other non-ferrous non-packaging metal	Other non-ferrous
WEEE	Low value WEEE (i.e. toasters, kettles, hair dryers)	Low value WEEE
	High value WEEE (i.e. mobile phones, tablets, laptops, high end audio equipment)	High value WEEE
Hazardous	Batteries	Batteries
	Clinical waste	Clinical waste
	Other	Other
Organic non-catering	Garden waste	Garden waste
	Other organic waste	Other organic waste
Organic food	Food waste	Food waste
Fines	<20 mm	<20 mm

Since additional categories for composites were included in Season 2, Amec Foster Wheeler adjusted the Season 1 results to reconcile the different material categories used in both exercises.

To achieve this, the following assumptions were applied:

- The proportions of composites determined to be present in the residual waste in Season 2 were assumed to be the present in the same proportions in Season 1; and
- The proportion of residual waste assigned to the new categories for composites was subtracted from the category the material would have been sorted into in Season 1. For example, paper composites would have been categorised as non-recyclable paper in Season 1 and card composites as non-recyclable card. The main difficulty during the reconciliation exercise was determining what the material categorised as "not easily recyclable composites" would have been sorted into in Season 1. These materials are composed of multiple materials and would have been categorised in a variety of ways depending upon the individual item. In addition there is uncertainty about the proportion of different types of items present in this category. Therefore the "other miscellaneous combustibles" category was adjusted in the Season 1 results to account for the present of materials categorised as "not easily recyclable composites" in Season 2. Whilst we recognise this is not an ideal solution, it is a practical solution.

Appendix B
Waste composition information by housing types

A study for the Greater Manchester Waste Disposal Authority (GMWDA) in 2011 identified some clear differences in the composition (% wt.) and arisings (kg/hh/wk) between the kerbside waste and recycling collected from different housing types.

Capture of pulpable recyclables (paper, card and Tetra Pak) and co-mingled recyclables (glass, plastic bottles, metal cans, aerosols and foil) was found to higher in detached and semi-detached housing in comparison to terraced housing and flats. There was an inverse relationship in terms of contamination with detached and semi-detached housing associated with lower levels of contamination than terraced housing and flats. Finally, although the difference was not found to be statistically significant, there was also a clear difference in the proportion of potentially recyclable material in the residual waste (RW) from flats in comparison to other housing types.

Although the housing categories used in the GMWDA study do not directly match with those used for the NLWA study (i.e. high and low rise) we still consider this to be evidence which supports the conclusions that the residual waste from high density housing tends to contain more recyclables.

	Detached	**Semi-detached**	**Terraced**	**Flats**
Pulpable capture of target materials	78.9%	73.9%	68.3%	53.4%
Pulpable non-target material	2.9%	3.3%	5.1%	12.8%
Co-mingled capture of target materials	85.0%	82.4%	70.3%	45.4%
Co-mingled non-target material	10.4%	10.4%	13.4%	23.0%
Potentially recyclable in RW including organic catering waste	56.9%	53.8%	52.5%	64.2%
Potentially recyclable in RW excluding organic catering waste	25.4%	20.3%	19.8%	30.3%