



# **Contamination in source-separated municipal and business recyclate in the UK 2013**

## **Final Project Report**

March 2014

## Acknowledgements

A large team was involved in carrying out the work that enabled this report to be produced. Zero Waste Scotland would like to thank:

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  - the members of the steering group, including the Resource Association and Smurfit Kappa, SESA, governments in Wales and Northern Ireland, regulators and local government in England, Scotland and Wales, and finally WRAP and Zero Waste Scotland staff;
  - WRc plc and RPS Ireland Limited (RPS), who designed and delivered the work;
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  - the local authorities, site operators, waste management companies and reprocessors who generously gave their time and resources to enable us to sample, sort and weigh recycle.
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## Executive Summary

### Background

The Scottish Government is committed to creating high quality closed-loop recycling systems that maintain and enhance the value of materials that flow through the Scottish economy. Poor quality recyclate is regarded as a key issue by the waste management and reprocessing industries.

The Waste (Scotland) Regulations 2012 introduce a duty for five key recyclates (paper, card, glass, metals and plastics) to be collected in a source-separated manner, unless it can be demonstrated that the amount of recyclate collected would not be significantly less, and the quality of the material not significantly lower, by collecting materials co-mingled.

To address the lack of robust data on the quality of source-separated dry recyclate, Zero Waste Scotland was asked by the Scottish Government to manage a UK-wide compositional analysis programme focused on determining the typical quality of the five key source-separated recyclates. While the work was required for the Scottish Government to inform policy development and implementation, it was recognised that sampling in Scotland alone would not yield enough data due to the relatively small number of source-separated collections there. The sampling and analysis work programme was therefore carried out UK-wide and the research designed to produce results at a UK level.

### Aims and objectives

The aim of the project was to determine within reasonable bounds of confidence the typical levels of contamination in dry recyclate separately collected from households by local authorities ('municipal recyclate') and from the commercial and industrial sector by local authorities, reprocessors or third-party waste management companies ('business recyclate'). The five recyclate materials as defined in the Waste Scotland Regulations are paper, card, glass, metal and plastics.

For the purposes of the sampling and analysis programme, contamination was defined as any non-target or non-recyclable material present in the recyclate stream. Contamination was defined with specific reference to the recycling scheme in place within a given local authority or business.

### Methods

The approach consisted of visiting recyclate bulking sites, sampling pre-agreed loads of recyclate and quantifying contaminants in them. Site visits were carried out between July and November 2013 with data collation and statistical analysis carried out in November and December 2013.

Overall, 860 municipal recyclate samples were collected from 59 sites; the ten recyclate streams sampled were paper/card (paper; card; mixed paper & card), glass (clear; green; brown; mixed brown & green; mixed glass), metals and plastics. In addition, 225 business recyclate samples were taken across 18 sites; the six recyclate streams sampled were paper/card (paper; card; mixed paper & card), mixed glass, metals and plastics.

Three measures of typical contamination were calculated, along with associated confidence intervals at the 95% probability level. The choice of which measure to use should be made carefully, taking account of the circumstances and context within which it will be applied. Readers should note that the geometric mean cannot be calculated in cases where no contamination was found in at least one sample; this is represented by 'n/a' in the data tables.

## Contamination levels in source-separated recyclate

Contamination levels in source-separated *municipal* recyclate were generally low. The metals recyclate stream was the most heavily contaminated, followed by card, plastics and brown glass.

**Table 1.1 Sample summary statistics – contamination in municipal recyclate**

| Recyclate      |                     | Arithmetic mean | Geometric mean | Median |
|----------------|---------------------|-----------------|----------------|--------|
| Paper and card | Paper               | 1.6%            | 1.0%           | 1.1%   |
|                | Card                | 8.1%            | 3.9%           | 4.1%   |
|                | Mixed paper & card  | 1.7%            | 1.0%           | 0.9%   |
| Glass          | Clear               | 1.8%            | n/a            | 1.2%   |
|                | Green               | 3.0%            | 1.8%           | 1.9%   |
|                | Brown               | 4.2%            | n/a            | 2.7%   |
|                | Mixed brown & green | 3.6%            | 2.2%           | 2.3%   |
|                | Mixed               | 0.7%            | n/a            | 0.4%   |
| Metals         |                     | 9.1%            | 5.6%           | 6.2%   |
| Plastics       |                     | 5.5%            | 3.3%           | 2.9%   |

Contamination levels in source-separated *business* recyclate were also generally low, although caution should be exercised in using these figures due to the low sample size obtained. As observed with municipal recyclate, the metals stream was the most heavily contaminated followed by the paper and plastics streams.

**Table 1.2 Sample summary statistics – contamination in business recyclate**

| Recyclate      |                    | Arithmetic mean | Geometric mean | Median |
|----------------|--------------------|-----------------|----------------|--------|
| Paper and card | Paper              | 5.4%            | n/a            | 3.3%   |
|                | Card               | 3.3%            | n/a            | 0.5%   |
|                | Mixed paper & card | 3.4%            | n/a            | 1.0%   |
| Glass          | Mixed              | 1.7%            | 1.3%           | 1.5%   |
| Metals         |                    | 3.1%            | n/a            | 3.3%   |
| Plastics       |                    | 7.1%            | n/a            | 2.5%   |

For both municipal and business recyclate, it should be noted that the level of contamination for each material stream includes contamination by similar physical materials (i.e. paper in card collections, card in paper collections and glass of the wrong colour in glass collections). Depending on the purpose for which the information is being used, this may lead to some distortion of the overall contamination rate, particularly for paper & card and glass recyclates. In practical terms, materials of the same physical composition, though not targeted for recycling by a scheme, would often be deemed acceptable by the reprocessor and not counted as contamination, whereas material of a different physical characteristic would be considered contamination. This is worth bearing in mind when determining how schemes are regulated in future. It is recommended that the information on typical contaminants present in each recyclate (detailed in subsections for each recyclate group in Chapter 3) should also be considered.

When using the data, it is also important to bear in mind the confidence intervals around it. Confidence intervals reflect sampling error; so the smaller the sample obtained, the more the sampling error and the wider the confidence intervals. The confidence intervals are calculated at a 95% probability level; in simple terms this means that on average 19 times out of 20 the level of contamination would fall within this range if you had the resources to weigh all recyclate in the UK. It is important to remember that any individual measure of recyclate may fall well outside these bounds. Confidence intervals for the three measures of typical contamination are shown in Table 3.3 and Table 3.4 on p.28.

## Factors that influence contamination

The data collected as part of the project lends itself to an analysis of the factors that influence contamination. This analysis will be published separately by Zero Waste Scotland.

## Recommendations

Although contamination is generally low in source-separated recyclate streams, improvements can still be made. Metal streams are the most heavily contaminated, so work could be done with crews to ensure contamination is removed more effectively.

Plastics appear to be a significant contaminant in many recyclate streams. People find it difficult to determine which plastics are recyclable due to the range of plastic polymers and differences between schemes. Further efforts should be made to educate waste producers – both householders and businesses – as to what is accepted in each stream.

Taking into account the evidence from this study that local authorities are moving away from source-separated collections, the study should be repeated, if possible, in a few years' time when the Scottish regulations have had time to take effect. Any future study should take account of the methodological lessons set out in Chapter 4.

In repeating this study, consideration should be given to capturing and reporting the weights of each type of contamination. This was not possible in this project but if data was available it would allow a distinction to be made between contaminants that are readily recyclable and normally accepted, and contaminants that are recyclable in theory but not normally accepted.

## Contents

|          |                                                                                                                      |           |
|----------|----------------------------------------------------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Introduction</b>                                                                                                  | <b>9</b>  |
| 1.1      | Background                                                                                                           | 9         |
| 1.2      | Aims                                                                                                                 | 9         |
| 1.3      | Objectives                                                                                                           | 10        |
| 1.4      | This report                                                                                                          | 11        |
| <b>2</b> | <b>Methodology</b>                                                                                                   | <b>12</b> |
| 2.1      | Key definitions                                                                                                      | 12        |
| 2.2      | Development of a sampling framework                                                                                  | 13        |
| 2.3      | Recruiting the sites                                                                                                 | 15        |
| 2.4      | Compositional analysis                                                                                               | 18        |
| 2.5      | Results collation and statistical analysis                                                                           | 22        |
| <b>3</b> | <b>Levels of contamination in source-separated recyclate</b>                                                         | <b>25</b> |
| 3.1      | Summary results                                                                                                      | 25        |
| 3.2      | Paper and Card                                                                                                       | 29        |
| 3.3      | Glass                                                                                                                | 35        |
| 3.4      | Metals                                                                                                               | 40        |
| 3.5      | Plastics                                                                                                             | 42        |
| <b>4</b> | <b>Conclusions</b>                                                                                                   | <b>46</b> |
| 4.1      | Levels of contamination in source-separated recyclate                                                                | 46        |
| 4.2      | Constraints and caveats                                                                                              | 46        |
| 4.3      | Methodology                                                                                                          | 46        |
| 4.4      | Recommendations                                                                                                      | 50        |
|          | <b>Appendix A: Examples of contaminants in source-separated recyclate material (as described by the reprocessor)</b> | <b>51</b> |
|          | <b>Table A0.1 Contaminants in source-separated recyclate</b>                                                         | <b>51</b> |
|          | <b>Appendix B: Summary of the peer reviewer's comments</b>                                                           | <b>52</b> |

## Tables

|                                                                                                                          |    |
|--------------------------------------------------------------------------------------------------------------------------|----|
| Table 1.1 Sample summary statistics – contamination in municipal recycle                                                 | 4  |
| Table 1.2 Sample summary statistics – contamination in business recycle                                                  | 4  |
| Table 2.1 Profile of local authority municipal recycle samples used in the data analysis                                 | 20 |
| Table 2.2 Profile of sampled municipal collections by UK nation                                                          | 20 |
| Table 2.3 Profile of sampled local authorities by round size                                                             | 21 |
| Table 2.4 Profile of sampled local authorities by key characteristics                                                    | 21 |
| Table 2.5 Profile of business recycle samples used in the data analysis                                                  | 22 |
| Table 2.6 Profile of samples from commercial collections by UK nation                                                    | 22 |
| Table 2.7 Contextual factors                                                                                             | 23 |
| Table 2.8 Alternative measures of ‘typical’ contamination                                                                | 24 |
| Table 3.1 Sample summary statistics – contamination in municipal recycle                                                 | 27 |
| Table 3.2 Sample summary statistics – contamination in business recycle                                                  | 27 |
| Table 3.3 Confidence intervals (CIs) – contamination in municipal recycle                                                | 28 |
| Table 3.4 Confidence intervals (CIs) – contamination in business recycle                                                 | 28 |
| Table 3.5 Sample summary statistics – paper and card                                                                     | 31 |
| Table 3.6 Confidence intervals (CIs) – paper and card                                                                    | 31 |
| Table 3.7 Percentage of samples containing recyclable and non-recyclable contaminants – municipal paper and card recycle | 34 |
| Table 3.8 Percentage of samples containing recyclable and non-recyclable contaminants – business paper and card recycle  | 35 |
| Table 3.9 Sample summary statistics – glass recycle                                                                      | 37 |
| Table 3.10 Confidence intervals – glass recycle                                                                          | 37 |
| Table 3.11 Percentage of samples containing recyclable and non-recyclable contaminants – municipal glass recycle         | 39 |
| Table 3.12 Percentage of samples containing recyclable and non-recyclable contaminants – business glass recycle          | 40 |
| Table 3.13 Sample summary statistics – metals recycle                                                                    | 41 |
| Table 3.14 Confidence intervals – metals recycle                                                                         | 41 |
| Table 3.15 Recyclable and non-recyclable contaminants in the samples – municipal metals recycle                          | 42 |
| Table 3.16 Sample summary statistics – plastics recycle                                                                  | 43 |
| Table 3.17 Confidence intervals – plastics recycle                                                                       | 43 |
| Table 3.18 Recyclable and non-recyclable contaminants in the samples – municipal plastics recycle                        | 44 |
| Table 3.19 Recyclable and non-recyclable contaminants in the samples – business plastics recycle                         | 44 |
| Table A0.1 Contaminants in source-separated recycle                                                                      | 51 |

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## Figures

|                                                                                                            |    |
|------------------------------------------------------------------------------------------------------------|----|
| Figure 2.1 Methodology for sampling and analysis                                                           | 13 |
| Figure 3.1 Variability in contamination in the samples – paper                                             | 32 |
| Figure 3.2 Variability in contamination in the samples – card                                              | 32 |
| Figure 3.3 Variability in contamination in the samples – mixed paper & card                                | 33 |
| Figure 3.4 Variability in contamination in the samples – clear, brown, green and mixed brown & green glass | 38 |
| Figure 3.5 Variability in contamination in the samples – mixed glass                                       | 38 |
| Figure 3.6 Variability in contamination in the samples – metals recyclate                                  | 41 |
| Figure 3.7 Variability in contamination in the samples – plastics recyclate                                | 43 |

Zero Waste Scotland works with businesses, individuals, communities and local authorities to help them reduce waste, recycle more and use resources sustainably.

Find out more at  
[www.zerowastescotland.org.uk](http://www.zerowastescotland.org.uk)

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# 1 Introduction

## 1.1 Background

In line with the requirements of the revised European Waste Framework Directive (WFD) and following introduction of the Waste (Scotland) Regulations 2012, the Scottish Government is committed to creating high quality closed-loop recycling systems that maintain and enhance the value of materials that flow through the Scottish economy. Much of that ambition is delivered through Zero Waste Scotland.

Not only does high quality recyclate mean higher prices, but its production is also necessary to improve market confidence and promote investment in the expansion of the UK reprocessing sector. Poor quality recyclate is regarded as a key issue by the waste management industry. The level of contamination in recyclate is the most important determinant of its quality.

The Waste (Scotland) Regulations 2012 introduced a duty for five key recyclates (paper, card, glass, metals and plastics) to be collected in a source-separated manner, unless it can be demonstrated that the amount of recyclate collected would not be significantly less, and the quality of the material not significantly lower, by collecting materials co-mingled. No recent and robust information on levels of contamination in source-separated recyclate could be identified.

To address the lack of robust data on the quality of source-separated dry recyclate, Zero Waste Scotland was asked by the Scottish Government to manage a UK-wide compositional analysis programme exclusively focused on determining the typical quality of the five key source-separated recyclates. The work started in November 2012.

While the work was required for the Scottish Government to inform policy development and implementation, it was recognised that sampling in Scotland alone would not yield enough data due to the relatively small number of source-separated collections there. The sampling and analysis work programme was therefore carried out UK-wide.

The research was designed to produce results at a UK level and not for each nation separately; subsequent analysis has indicated that the results are applicable to each of the four UK nations.

## 1.2 Aims

The principal aim of the project was to determine within reasonable bounds of confidence the typical levels of contamination in dry recyclate:

- a. separately collected from households by local authorities (hereafter referred to as 'municipal recyclate'); and
  - b. separately collected from the commercial and industrial sector by local authorities, reprocessors or third-party waste management companies (hereafter referred to as 'business recyclate').
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The five recyclate materials, as defined in the Waste Scotland Regulations, were:

- paper;
- card;
- glass;
- metals; and
- plastics.

Additionally, information on the different material grades would be collected where the recycling scheme required separation at grade level (for example, paper into newspapers and magazines, plastics into HPDE and PE, and glass into the different colours).

For the purposes of the sampling and analysis programme, contamination was defined as any non-target or non-recyclable material present in the recyclate stream. This was applied only to loads that were accepted at the point of delivery; rejected loads were excluded on the basis that they would either go for disposal or for sorting so would never make it to a reprocessor. Contamination was defined with specific reference to the recycling scheme in place within a given local authority or business; for example, although foil is accepted by some schemes and therefore would not be regarded as a contaminant, it was classified as contamination for schemes that did not accept it.

A general guide on items that should be classified as contamination was developed (see Appendix A). This was used by RPS for analysing the recyclate and gave guidance on, for example: envelopes with plastic window flaps, wet paper, a drinking straw inside a beer bottle (not contamination); food containers with food residues, candle wax in glass, oil-stained pizza boxes (contamination).

The goal of the work programme was to estimate typical levels of contamination to a precision of  $\pm 1$  percentage point at a 95% confidence level for each recyclate stream, both municipal and business.

In addition, it was decided that the study should attempt to analyse the relationship between some key variables and the level of contamination measured in order to draw some tentative conclusions about the kinds of factor that might lead to more and less contamination in source-separated recyclate.

### 1.3 Objectives

To deliver the project aims, the following specific objectives were identified:

1. Understand more about the causes of contamination in separately collected recyclate in order to develop a robust sample frame that maximises sample size where it is expected that there would be more variation. This needed to be tackled separately for municipal and business recyclate as the sources and levels of contamination were thought to be different.
  2. Devise a robust but affordable sampling framework, individual or combined, for:
    - i. local authority waste collections (both municipal and business recyclate) taken to waste transfer/bulking stations; and
    - ii. business waste collections where recyclate may be taken to waste transfer/bulking stations or directly to reprocessors.
  3. Determine the level of certainty acceptable to key stakeholders, in particular the regulators.
  4. Determine the optimal amounts of recyclate to be sampled at each waste transfer/bulking station.
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5. Recruit waste transfer/bulking stations, sample and weigh the contamination in each recycle stream, and collate the data.
6. Analyse the data to generate estimates of typical contamination levels.
7. Analyse the data to investigate factors that might be related to more or less contamination being present.
8. Prepare a UK-level report.

## 1.4 This report

This report brings together the results all the activities undertaken. It has been subject to external peer review by a respected expert, Dr Robin Curry of SRI Consulting. The summary of the peer review feedback is included in Appendix B. Interim reports were also prepared throughout the study and are available on request from [research@zerowastescotland.org.uk](mailto:research@zerowastescotland.org.uk), including:

- a report on the pilot studies;
- a factual report on the compositional study by RPS; and
- a technical report on the outcome of the data analysis by WRc.

The remainder of the report presents the methodology (Chapter 2 starting on p.12) and then the results, firstly overall and then for each material (Chapter 3 starting on p.25). Finally, the conclusions and recommendations are presented in Chapter 3 starting on p.46.

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## 2 Methodology

The work programme involved three primary activities:

- developing the sampling framework – this was undertaken by WRc between February and April 2013;
- UK-wide compositional analysis – this was carried out by RPS, with the work undertaken between June and the beginning of November 2013; and
- results collation and statistical analysis – this was conducted by WRc between November and December 2013 following completion of the waste compositional analysis, with additional analysis carried out by WRAP and Zero Waste Scotland in January and February 2014.

Figure 2.1 below summarises the project methodology for all the activities undertaken. The remainder of this chapter sets out the intended approach to the study. Chapter 4 (starting on p.46) discusses the extent to which the intended approach was achieved in practice and makes recommendations for future studies.

### 2.1 Key definitions

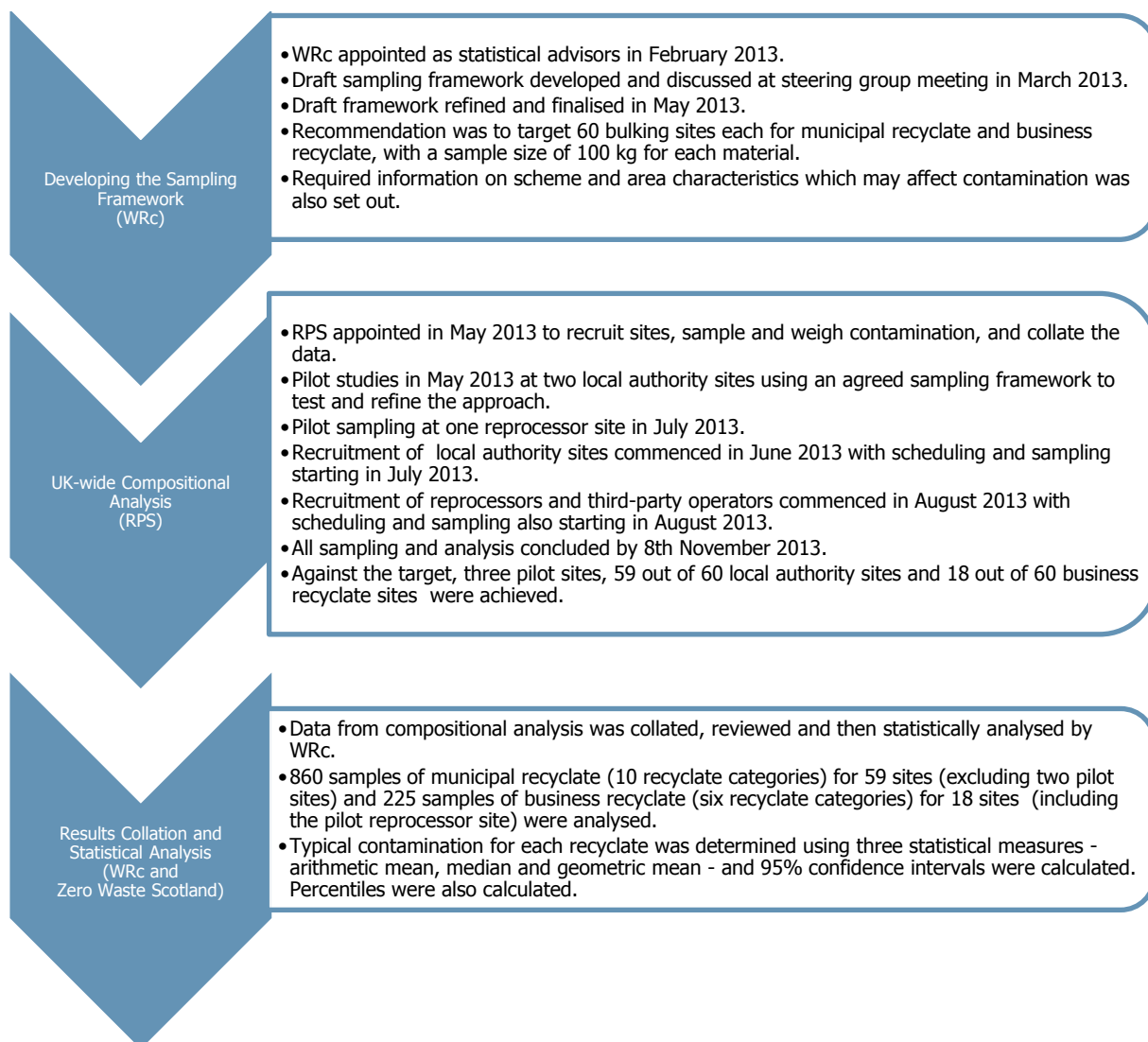
To ensure consistency of the work programme, the following definitions were applied. Where possible, the definitions were aligned with those in the consultation on the Recyclate Quality Action Plan.

- **Separately collected material**  
This includes both source-separated and kerbside-sorted material collected from households and businesses by local authorities, reprocessors, waste management companies or other third parties. It excludes co-mingled collections with the exception of co-mingled paper & card.
  - **Target material**  
This is any material that the collector has identified as needing to be separated from other types of material by virtue of the fact that separation is required by the intended reprocessor of the material. 'Target material' may be defined at a more granular level than the five broad categories (paper, card, glass, metals and plastics) requiring separate collection and could be defined as the range of 'grades' of recyclable material output by the waste collector (e.g. clear, brown and mixed glass). For the purposes of this study, 'target material' included only the materials specified as needing separate collection by the Waste (Scotland) Regulations 2012, namely paper, card, glass, metals and plastics.
  - **Non-target material**  
This is material that is capable of being recycled but is not being targeted by the collector for separation and sale. This may be because they do not have a buyer (e.g. for liquid packaging) or because the reprocessor excludes it from the specification (e.g. card in a consignment of newspapers which can cause problems in paper mills).
  - **Non-recyclable material**  
This is material that is not widely recycled. The range of materials that are recycled will change over time as technology improves and market conditions alter.
  - **Contamination**  
This is defined as any non-target material present in the dry recyclate stream when the load is accepted at the point of delivery, which may be at a waste transfer station, a bulking station or the reprocessor. For the purposes of this study, materials rejected at the kerbside were excluded as were whole loads rejected at the point of delivery.
  - **Sampling unit**  
The sampling unit is 100 kg of each recyclate material that is to be sorted to determine the types and percentage of contamination.
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▪ **Statistical significance / level of certainty**

This is taken to be the level of statistical confidence that can be applied to the data or the standard deviation from the mean level of contamination at a given confidence interval. For this work programme, the desired level of certainty was set at  $\pm 1\%$  at 95% confidence.

**Figure 2.1 Methodology for sampling and analysis**



## 2.2 Development of a sampling framework

A quota-based sampling framework was developed with the intention that RPS would recruit sites in a specific order from a list which had been created by WRc to ensure the authorities appeared in a random order. The purpose behind this was to ensure there was no deliberate or accidental bias in the way authorities were selected for the study. The aim was for RPS to move on to the next one only when a refusal was obtained or the site was deemed unsuitable, until the quota of 60 local authority and 60 business recyclate sites was filled. This is different to truly random sampling where the 60 local authority and business sites would be identified in advance from a random list and they would not be replaced if a refusal was obtained.

The sampling framework could not take account of temporal differences as there was no provision to repeat sampling over an extended period. However, the adopted approach combined individual survey results from a large number of locations at UK level over a period of four months and therefore provides some coverage of temporal variation, although the influence of this has not been specifically investigated.

### *2.2.1 Local authority sampling – municipal and business recycle*

The sampling list for local authority collected municipal and business recycle was generated from a WRAP database which contains details of all UK local authority recycling schemes. This database is collated from an annual audit of local authorities administered through a self-reporting questionnaire. The results are published on the WRAP Local Authority Recycling Scheme portal<sup>1</sup>. Based on the in-house database for 2011/12, 156 local authorities across the UK were thought to be collecting at least three recycles in a source-separated fashion. Only authorities that collected at least three recycles were included to maximise cost-effectiveness by ensuring as many samples as possible were taken in each area visited.

Based on analysis of the likely variability in results, and bearing in mind the objective of producing results to 1% precision, a target of obtaining samples from 60 out of the possible 156 local authorities was set. During the early phases of the project, an additional four local authorities were identified as having separate collection schemes for municipal recycle and were included in the sampling population list, bringing this to a total of 160.

The recommended sampling approach was to select a sample of local authorities that were as representative as possible for a broad range of factors, ensuring that the data could be analysed at the end of the survey to identify which, if any, of these factors had a significant bearing on levels of contamination. If need be, these factors could then be used to adjust (or 'weight') the results to (i) remove any bias caused by differential response rates and (ii) improve the precision of the results.

The 160 local authorities were randomly assigned to an ordered list, which included some local authorities that had indicated they had source-separated dry recycling collections from business as well as households. During the recruitment for municipal recycle sites, the local authorities were asked if they had a separate business recycle collection. This was to identify the true sampling population for local authority business recycle. The target from this shortlist was 30 local authorities for business recycle sampling.

The requirements for the local authority samples were that they should include:

- a. authorities that collect three or more of the target materials separately (at least 20); and
- b. authorities operating schemes that have elements of both co-mingling and source separation (at least 20).

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<sup>1</sup> WRAP Local Authority Recycling Scheme <http://laportal.wrap.org.uk> . The database has now been updated to take account of recycling scheme practices in UK local authorities for 2012/13.

The local authority samples taken should also specifically include the following sub-categories:

- authorities that specify source separation of materials into grades – for example: clear, brown and green glass; paper and cardboard; aluminium and steel cans and foil; different grades of plastic to include HDPE, PPE and 'other' (at least 10);
- authorities that collect both household and business recyclate (at least 30 to satisfy the business waste work-stream approach);
- authorities with collections that include communal recycling (for flatted properties) (at least five); and
- authorities that operate compulsory recycling schemes such as those which are operated in a number of the London boroughs (two).

### *2.2.2 Reprocessors and third-party collectors sampling – business recyclate*

In addition to the target of 30 local authorities collecting source-separated business recyclate, reprocessors and third-party collectors that separately collect the target recyclate materials were included. A list of reprocessors and third-party operations was collated through web searches and information from relevant trade bodies<sup>2</sup>. An initial list of 35 third-party collectors and 213 reprocessors across all five recyclates was collated by Zero Waste Scotland and issued to RPS. RPS added seven third-party collectors and nine reprocessors to the list, making 42 third-party collectors and 222 reprocessors in total. This list was divided according to the five target material grades and randomised in a similar manner to the local authority sampling population list.

The target population was at least 30 sites for reprocessors (six sites per recyclate stream) and additional numbers of third-party collectors (at least five), as required depending on the number of local authority collected business samples achieved.

## **2.3 Recruiting the sites**

A two-phase recruitment programme was conducted. Recruitment of local authorities for municipal and business recyclate collections commenced at the beginning of June 2013, while recruitment of reprocessors, waste management companies and other third parties for business recyclate collections commenced in late August 2013.

### *2.3.1 Local authority recruitment*

For recruitment of local authorities, RPS were provided with a spreadsheet listing the local authorities that had been selected as being suitable to take part in the study, each of which had a random number assigned to it for the purposes of ensuring a randomised sampling approach. RPS was tasked with recruiting each local authority in ascending numerical order and with ensuring that the range of characteristics identified in section 2.2.1 was covered.

Each local authority was initially contacted by telephone to ascertain a named contact and to obtain their contact details. WRAP and Zero Waste Scotland staff also helped in providing contacts. Within one week of making initial contact, RPS followed up with an emailed letter that invited the local authority to take part. All 160 local authorities were contacted in the order provided, but in four batches as follows:

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<sup>2</sup> Confederation of Paper Industries (CPI), Independent Waste Paper Producers Ltd (IWPP), British Plastics Federation (BPF), British Glass, British Metals Recycling Association (BMRA), Bureau of International Recycling and the Recycling Association.

- Batch 1: local authority numbers 1 to 60 were contacted on 6th June 2013;
- Batch 2: local authority numbers 61 to 90 were contacted on 23rd July 2013;
- Batch 3: local authority numbers 91 to 110 were contacted on 6th August 2013; and
- Batch 4: local authority numbers 115 to 160 were contacted on 22nd August 2013.

If no reply was received to the email, two working days later a senior member of RPS contacted the local authority to provide further information on the study and ascertain their level of interest in taking part. The local authorities contacted were asked if they separately collected business recycle and those that responded in the affirmative were subsequently asked whether they would also participate in the business recycle study.

When RPS began the local authority recruitment stage, a number of issues became evident in relation to the available data for the year 2011/12, including:

- **Change to co-mingled collections**  
A significant number of local authorities had changed from kerbside sort collections to co-mingled collections between the WRAP survey in June 2011 (for 2011/12 schemes) and the start of the project in May 2013. The data for the 2012/13 schemes which were surveyed in late 2012 had also not been collated. In total, 38 local authorities were not eligible to participate in the study for this reason.
- **Did not collect three or more of the key recyclates**  
To maximise the cost-effectiveness of the study by taking as many samples as possible from each site, a prerequisite was that local authorities recruited had to collect at least three of the five key recyclates. This was factored into the collation of the sampling population. Once recruitment began, it became apparent that the number of local authorities that separately collected at least three of the waste streams was lower than anticipated; in total, 26 authorities did not have the prerequisite of three source-separated recyclates and therefore were not initially eligible to participate in the study. In many cases this was due to cans and plastics being collected co-mingled and cardboard being mixed with green waste.

The prerequisite to select only authorities that collected three or more of the materials in a source-separated manner was removed towards the end of the study<sup>3</sup> in order to increase the number of potential participants. A number of local authorities initially discounted were re-contacted to participate in the project. Of these, nine were recruited and participated with either one or two waste streams. Therefore a total of 17 local authorities were not sampled due to not separately collecting enough streams.

Section 4.3.2 includes some recommendations as to how these problems might be avoided in any future study.

Out of the 160 local authorities that were identified as collecting three or more recyclates in a source-separated manner, 55 were found to have changed to co-mingled collections or reduced the number of separately collected recycle materials below the threshold level of three which had been set to achieve economies of scale in the sampling programme. This resulted in a sample population of 105, significantly lower than first envisaged. Following contact by RPS, an additional 39 local authorities did not wish to participate in the study, leaving just 66 authorities against a target of 60 for recruitment. Subsequently, in the final phase of sampling between September and November 2013, the initially discounted authorities that collected one or two separate recycle streams rather than three were re-contacted to achieve the target number of local authorities and representative number for each key recycle, particularly plastics and metals.

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<sup>3</sup> 24<sup>th</sup> September 2013

In total, 62 local authorities were recruited for the study. Of these, 61 were sampled; one which was scheduled right at the end of the fieldwork period was missed due to storm damage at the site and there was no time left in the schedule to rearrange. The 61 included two local authorities who participated in the pilot survey, which was intended to test the practical and operational parameters of the sampling framework. There was a spread of recycle collection schemes across these 61 local authorities:

- six separately collect four key recycles and additional sub-categories of recycle, typically clear or coloured glass;
- eight separately collect the five key recycles;
- 18 separately collect four of the target recycles;
- 20 separately collect three target recycles, most commonly paper, card and glass, with plastics and metals co-mingled and so excluded from this study;
- three separately collect two target recycles; and
- six separately collect one target recycle.

### *2.3.2 Recruitment of reprocessors, waste management companies and other third parties*

For recruitment of organisations that collect commercial and industrial recycle, the sampling population was collated (see section 2.2.2 on p.15), randomised, ordered in the same manner as the local authorities list and provided to RPS. The list contained reprocessors and third-party waste collectors identified as collecting each of the key recycle streams, in addition to a separate list for third-party operators collecting a mixture of the key recycles.

Where the details were not already available, the organisation was initially contacted via a phone call in order to ascertain a named contact and obtain up to date contact details. Within one week this initial contact was followed up with an emailed letter which invited them to take part. In total, 42 third-party collectors / waste management companies and 222 reprocessors were contacted. Due to the tight timescales towards the end of the project (August to October 2013), the sequential contact approach was discarded and all organisations were emailed in a single batch, with follow-up calls subsequently made in the numbered order by senior RPS personnel.

When RPS began the commercial & industrial recruitment stage, a number of issues became evident in relation to the sampling population:

- **Company not suitable to participate**  
Several companies on the list were either brokers or exporters and did not physically handle recycle material. Others did not receive recycle directly from business sources and instead bought baled recycle or cullet from waste management companies which had collected these from business sources. In those instances, the name of the company from whom the reprocessor received business recycle was sought by RPS and sometimes made available. RPS staff were then able to approach the waste management company with regard to participation in the project, but this was a protracted process and given the tight timescales of the project was generally unfruitful.
  - **Did not reprocess recycles**  
A number of companies contacted stated that they did not process recycles, only virgin raw materials, and were therefore out of scope.
  - **Did not receive recycle from business sources**  
A number of companies received recycle from local authority municipal collections only. As the sampling plan already addressed local authority collected municipal recycle, these companies were unsuitable to participate in the study.
-

- **Unsuitable type of recyclate**

The study was concerned with five key recyclate streams commonly found in mainstream municipal and business recycling. Specialist recyclates, or those generated by specialised manufacturing processes, were out of scope. For example, rather than glass bottles and jars, window pane glass might be accepted and, rather than steel and aluminium cans, metals from end-of-life vehicles, waste electrical and electronic equipment or building demolitions might be accepted. A number of companies contacted accepted only such recyclates and were therefore deemed unsuitable for this study.

Out of the sampling population of 42 third-party collectors contacted, only three agreed to participate in the study. Of the 39 that did not participate, 17 declined to participate, 10 had unsuitable waste streams and 11 did not respond. One company was interested but could not be scheduled within the project timescales.

Of 222 reprocessors contacted, 109 were found to be unsuitable for the study due to the type and/or source of their recyclate material. A further 63 did not respond and 31 did not wish to participate. Just 19 were recruited and, of these, four could not be sampled for various reasons. Three reprocessors subsequently cancelled the scheduled site visits and so only 10 reprocessors were recruited and sampled for a range of recyclates including paper, card, plastics and glass. No metals reprocessors were sampled. Three of the reprocessors processed two of the target recyclates while one reprocessor processed three of the target recyclates. For each of these reprocessors, all available samples of each recyclate were collected.

Out of the 152 local authorities that the WRAP database implied had a form of source-separated collection for business recyclate, only 24 actually collected business recyclate separately. The majority (128) were, on further discussion, found to have either outsourced their collection to a reprocessor / third party or co-mingled the recyclate; they were therefore ineligible for the study. Five of these 24 local authorities agreed to participate.

In total, five local authorities, three third-party collectors and 10 reprocessors were recruited and sampled. These included the reprocessor site that participated in the pilot survey intended to test the practical and operational parameters of the sampling framework; however, by this point in the study the on site approach had been finalised and the data was considered to be of suitable quality. No metals reprocessors were surveyed so all metal samples collected have been derived from local authority or third-party business recyclate collections.

## 2.4 Compositional analysis

In general terms, the process involved the development of a site-specific sampling plan followed by a day spent at each site diverting loads of recyclate for sampling and analysis. This was carried out under tight health and safety controls.

The site-specific sampling plan included details of the materials considered to be contamination in each case. As discussed above, whether an item counted as contamination was dictated by whether the scheme in question considered it to be contamination, based on what would be accepted by the end market for the recyclate.

Sampling was undertaken at the point of acceptance of the target load at a waste transfer station, a bulking station or the reprocessor. For municipal recyclate, the target of sampling at least four different loads of all recyclate streams received at the site was achieved. For business recyclate, the target of sampling at least 10 loads or bales of the target recyclate material was also achieved.

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The aim was to sample a target number of loads across one sampling day, collecting and sorting a representative sub-sample of each recycle delivered on site and linked to known collection round(s) or business type. For each recycle, 100 kg of material had to be sorted for each load sampled.

For the compositional analysis, a negative pick was carried out whereby each contaminant was extracted from the sampled pile of recycle. The combined contaminants were weighed, a note was made of what they consisted of, and the total weight (kg) of the sample was also taken. Following sorting, the record of the total sample weight was divided into three components:

- the weight of **target** material;
- the weight of recyclable **non-target** material; and,
- the weight of **non-recyclable non-target** material.

Additional information was also collected and recorded, for example information about the nature of the collection route (urban, rural or mixed), vehicle registration and an approximation of the socio-economic make-up of the collection route.

#### *2.4.1 Source-separated municipal recycle*

A total of 1008 samples of municipal recycle were collected from 61 local authorities including the two pilot sites. 10 samples were excluded from the data analysis because they were not the relevant target recycle (liquid packaging and mixed plastics and cans). Ultimately, the data from the two pilot sites was also discarded because it was felt to be unreliable; in several instances the total sample sizes were too small and recorded significantly higher levels of contaminant variability in the data which is not thought to be typical.

The samples for 59 local authorities (860 samples), excluding the pilot sites, have been used for the data analysis. Of the 860 samples, total sample weights ranged from 12 to 190 kg with an average of 99 kg, and all but 40 samples had a total weight of at least 40 kg. Where samples fell below the target 100 kg, this was normally because the vehicle had collected less than 100 kg rather than due to any problems on site with the sampling process.

For three of the five target materials, information on contamination was collected at a lower level of detail, by material grade rather than material (e.g. 'clear glass' rather than 'glass'). This included glass (clear, brown, green, mixed brown & green and mixed glass) and paper/card (paper, card, and mixed paper & card). This gave a total of 10 material categories of recycle that have been reported on. The sample quantities and local authorities from which samples were collected are summarised in Table 2.1 below.

**Table 2.1 Profile of local authority municipal recycle samples used in the data analysis**

| Recyclate      |                     | Number of local authorities | Number of samples collected |
|----------------|---------------------|-----------------------------|-----------------------------|
| Paper and card | Paper               | 42                          | 182                         |
|                | Card                | 23                          | 95                          |
|                | Mixed paper & card  | 16                          | 60                          |
| Glass          | Clear               | 19                          | 82                          |
|                | Green               | 5                           | 20                          |
|                | Brown               | 5                           | 20                          |
|                | Mixed brown & green | 14                          | 62                          |
|                | Mixed               | 33                          | 135                         |
| Metals         |                     | 30                          | 128                         |
| Plastics       |                     | 19                          | 76                          |
| <b>TOTAL</b>   |                     | <b>59<sup>4</sup></b>       | <b>860</b>                  |

Overall there was a good spread of samples by region and nation, more or less proportional to the target population.

In terms of UK nations, most of the samples were collected in England but that reflects the fact that most of the local authorities that collect materials in a source-separated manner are to be found there. This information is presented in Table 2.

**Table 2.2 Profile of sampled municipal collections by UK nation**

| UK nation        | Population of eligible authorities | Local authorities actually sampled |
|------------------|------------------------------------|------------------------------------|
| England          | 125                                | 43                                 |
| Northern Ireland | 7                                  | 5 (+1 pilot)                       |
| Scotland         | 16                                 | 4 (+1 pilot)                       |
| Wales            | 13                                 | 7                                  |
| <b>TOTAL</b>     | <b>161</b>                         | <b>59 (+2 pilots)</b>              |

The sampling framework set out the number of local authorities to be sampled by their size, measured as the number of households served. The local authorities actually sampled and included in the analysis broadly matched the framework (Table 2.3).

<sup>4</sup> The numbers in this column do not sum because local authorities collected more than one recyclate

**Table 2.3 Profile of sampled local authorities by round size**

| Household size                                       | Target number of local authorities | Number of local authorities sampled |
|------------------------------------------------------|------------------------------------|-------------------------------------|
| Small rounds (up to 30,000 households)               | 15                                 | 11<br>+1 pilot                      |
| Medium rounds (between 30,001 and 60,000 households) | 32                                 | 33<br>+1 pilot                      |
| Large rounds (60,001 households or more)             | 13                                 | 15                                  |
| <b>TOTAL</b>                                         | <b>60</b>                          | <b>59<br/>+2 pilots</b>             |

The sampling framework also identified the target number of local authorities to be sampled based on selected characteristics. The local authorities actually sampled and included in the analysis broadly met the requirements to capture sites that fell within a given set of characteristics (Table 2.4).

**Table 2.4 Profile of sampled local authorities by key characteristics**

| Local authority characteristics sought                                                             | Target number of local authorities | Number of local authorities meeting criteria |
|----------------------------------------------------------------------------------------------------|------------------------------------|----------------------------------------------|
| Collect all the five survey target materials separately                                            | 20                                 | 13                                           |
| Operate a mixed co-mingled and source-separated recyclate scheme                                   | 20                                 | 46                                           |
| Specify source separation of materials into grades                                                 | 10                                 | 21                                           |
| Collect both household and business recyclate (to satisfy the business waste work-stream approach) | 30                                 | 5                                            |
| Operate collections that include communal recycling (for flatted properties)                       | 5                                  | 7                                            |
| Operate compulsory recycling schemes such as those operated in a number of London boroughs         | 2                                  | 0                                            |

#### 2.4.2 Source-separated business recyclate

For business recyclate the aim was to sample as many vehicle loads as possible on each day of sampling, taking into account the target sample size requirement of 100 kg each.

The samples from 18 sites (225 business waste samples = 201 samples from 13 commercial companies and 24 samples from five local authorities) have been used for the data analysis. Total sample weights ranged from 14 to 762 kg with an average sample weight of 108 kg and all but eight samples had a total weight of at least 40 kg. The sample numbers were much lower than for municipal waste, and very low for business waste collected at local authority sites.

Three sub-categories for paper and card were used – paper, card and mixed paper & card. This gave a total of six reporting categories for business recyclate contamination. The sample quantities and sites from which samples were collected are summarised in Table 2.5.

**Table 2.5 Profile of business recyclate samples used in the data analysis**

| Recyclate             |                    | Number of sites       | Number of samples collected |
|-----------------------|--------------------|-----------------------|-----------------------------|
| <b>Paper and card</b> | Paper              | 8                     | 34                          |
|                       | Card               | 11                    | 105                         |
|                       | Mixed paper & card | 5                     | 12                          |
| <b>Glass</b>          | Mixed              | 6                     | 43                          |
| <b>Metals</b>         |                    | 4                     | 8                           |
| <b>Plastics</b>       |                    | 7                     | 23                          |
| <b>TOTAL</b>          |                    | <b>18<sup>5</sup></b> | <b>225</b>                  |

Samples were collected from sites in three out of the four UK nations (England, Northern Ireland and Scotland). There were no targets set for how many samples should be collected in each nation, and no samples were collected from Wales due to reluctance of businesses to participate. The information is presented in Table 2.6.

**Table 2.6 Profile of samples from commercial collections by UK nation**

| UK nation        | Number of sites |
|------------------|-----------------|
| England          | 11              |
| Northern Ireland | 1               |
| Scotland         | 7               |
| Wales            | 0               |
| <b>TOTAL</b>     | <b>18</b>       |

## 2.5 Results collation and statistical analysis

Overall, the fieldwork element of the study successfully achieved the target sampling population for municipal recyclate (59 local authorities against the target of 60 were included in the analysis) but fell far short of the target for business recyclate (18 sites against the target of 60). The main reasons for this were fewer eligible local authorities and businesses than expected and a lack of engagement from those that were eligible. Some reasons for this and issues encountered with the recruitment are identified in section 2.3. Data on the samples achieved was collated by RPS and provided to Zero Waste Scotland and WRc for analysis.

Individual datasets were created for 860 samples of municipal recyclate and 225 samples of business recyclate and these were then used for all subsequent analysis. Data from the two local authority pilot studies was excluded, although the business recyclate pilot site was included.

### 2.5.1 General information

The following information was included in the dataset for each sample:

- nation of sample origin (England, Northern Ireland, Scotland, Wales);

<sup>5</sup> The numbers in this column do not sum because sites receive more than one recyclate

- the name of the local authority or company that supplied the sample;
- an anonymous identifier for the recycle receiving site; and
- the date(s) the sample was collected and sorted.

### 2.5.2 Contextual factors

In addition, a variety of contextual information covering things that could conceivably influence the level of contamination was included in the dataset, including:

- scheme type (kerbside or householder separation<sup>6</sup>);
- details of the vehicle from which the sample was taken;
- type of collection route (rural, urban, mixed); and
- indicative level of deprivation of households on the collection route based on socio-economic category).

These were used in the assessment of external factors that might be influencing levels of contamination in municipal and business recycle.

The data was first checked for internal consistency, e.g. to check that the combined weight of target and non-target material equalled the total sample weight and that the identity of non-target materials had been described. The level of contamination in each sample was defined as the weight of all non-target material as a percentage of the total sample weight. Contamination (non-target material) was further broken down according to the percentage of recyclable material and non-recyclable material in the sample.

**Table 2.7 Contextual factors**

| Data field                   | Household waste                                                                | Business waste                                                                            |
|------------------------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| Collection type              | Not applicable                                                                 | Reprocessor vehicle, council vehicle or waste management company (third-party collection) |
| Scheme type                  | Household or kerbside sorted                                                   | Business or kerbside sorted                                                               |
| Location/area collected from | City, town or other description                                                | Commercially sensitive, not provided                                                      |
| Location/route               | A number of routes were sampled at each receiving site                         | Not applicable                                                                            |
| Urban/rural/mixed            | Associated with route. Urban, rural or mixed                                   | Not populated                                                                             |
| Socio-economic category      | Associated with route. Lower, lower-mid, mid, mid-upper, upper, mixed, unknown | Not populated                                                                             |
| Origin/business type         | Not applicable                                                                 | Text description                                                                          |
| Total load                   | Not applicable                                                                 | Tonnes. Not fully populated.                                                              |
| Target material              | Glass, paper, card, metals, plastics (with material grades)                    | Mixed glass, paper, card, mixed paper & card, metals, plastics                            |
| Grade                        | Not applicable                                                                 | Subdivision of target material                                                            |
| Other information            | Not applicable                                                                 | Bagged, baled, loose or in bins                                                           |

<sup>6</sup> Householder sort involves separation of target recyclates into the relevant boxes by the householder; during the collection round, the recycle is tipped straight into the vehicle with no further separation. Kerbside sort involves manual separation by the collection crew of target recycle placed inside recycling box(es) or bags into individual compartments on the collection vehicle. Many collection schemes operated mixed sorting, with some materials sorted by the householder and others sorted at the kerbside. Scheme type information was not available for business recycle, although it is assumed that this would predominantly be a business owner segregation/sorting scheme.

The materials which made up the recyclable and non-recyclable contaminants were described in the dataset for each sample, although individual weights were not recorded. Keyword searches on the dataset were used to determine the typical contaminants observed and their relative proportions in each recycle stream. A detailed summary of this information is presented for each recycle in Chapter 3.

### 2.5.3 Measures of typical contamination

Three different measures of 'typical' contamination were calculated and compared. All three provide a measure of the central value in a set of data but they can be useful in different contexts.

For each measure, confidence intervals were also calculated. The confidence intervals show that there is a 95% chance that the true average level of contamination for source-separated recycle in the UK lies between the lower and upper bounds. More precisely, they indicate that if the study were to be repeated 20 times, 19 times out of the 20 the average would lie within the lower and upper confidence interval but on one occasion it would not. Confidence intervals tend to narrow as the sample size increases and widen as the variability between the samples increases.

Detailed findings are presented in Chapter 3 for each recycle stream sampled from both municipal and business sources.

**Table 2.8 Alternative measures of 'typical' contamination**

| Statistic                                                   | Definition                                                                                                                                    | Example                                                                                                                                                                    |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Arithmetic mean</b>                                      | What most people think of as 'the average': the sum of the values, divided by the number of values                                            | The arithmetic mean of 2, 4 and 8 is: $(2+4+8) / 3 = 4.67$                                                                                                                 |
| <b>Median</b> (or 50 <sup>th</sup> percentile) <sup>7</sup> | The middle value when the values are ranked from smallest to largest                                                                          | The median of 2, 4 and 8 is 4 (the middle value)                                                                                                                           |
| <b>Geometric mean</b>                                       | The $n^{\text{th}}$ root of the product of $n$ values (or, alternatively, the back-transformed arithmetic mean of $n$ log-transformed values) | The geometric mean of 2, 4 and 8 is: $\sqrt[3]{2 \times 4 \times 8} = \sqrt[3]{64} = 4$ . Note that the geometric mean cannot be calculated if any of the values are zero. |

Users of the data should ensure they use the most appropriate measure of typical contamination based on their specific needs.

<sup>7</sup> The median can be calculated either parametrically, which requires the data to conform to a specified probability distribution, or non-parametrically, which makes no assumption about the distribution of the data. In practice, both methods tend to produce very similar results but the non-parametric method is easier to calculate and more robust to outliers. This is the method used in this report.

### 3 Levels of contamination in source-separated recycle

In this chapter, we present the typical levels of contamination found in source-separated recycle. Three measures of typical contamination are presented – the arithmetic mean, median and geometric mean, each of which may be appropriate to use in different circumstances (see section 2.5.3). We also present the variability in the data, including confidence intervals for each of measure of typical contamination.

The levels of contamination in both municipal and business recycle are presented for each material sampled. Although we present the data for business recycle, the small sample size means that caution should be exercised when using the figures as it is likely that the results are an unreliable representation of the situation in the UK. The same does not apply to municipal recycle, the results of which can be relied on as being representative of the situation in the UK in 2013.

For both municipal and business recycle it should be noted that the level of contamination for each material stream includes contamination by similar physical materials (i.e. paper in card collections, card in paper collections and glass of the wrong colour in glass collections). Depending on the purpose for which the information is being used, this may lead to some distortion of the overall contamination rate, particularly for paper & card and glass recycles. In practical terms, materials of the same physical composition, though not targeted for recycling by a scheme, would often be deemed acceptable by the reprocessor and not counted as contamination whereas material of a different physical characteristic would be considered contamination. This is worth bearing in mind when determining how schemes are regulated in future. It is recommended that the information on typical contaminants present in each recycle (detailed in subsections for each recycle group within this chapter) also be considered.

#### 3.1 Summary results

Table 3.1 and Table 3.2 below summarise the data for all the recycles, the range of values obtained and the measures of typical contamination (arithmetic mean, geometric mean and median). Table 3.3 and Table 3.4 set out the confidence intervals around the data.

For municipal recycle (Table 3.1), the most heavily contaminated materials were card and metals. Contamination was generally lowest for mixed collections (mixed glass and mixed paper & card); this is because much of the contamination in the individual streams comes from items of the same category, for example clear glass in the brown glass, or paper in the card. Paper and clear glass also show low levels of contamination. However, brown glass, mixed brown & green glass and plastics had at least one sample with 20% contamination or more.

For business recycle (Table 3.3), contamination varied across the sampled loads. It was quite low in mixed glass and card and slightly higher for paper and plastics. It is much more difficult to draw definitive conclusions about typical levels of contamination in business recycle (particularly mixed paper & card and metals) due to the very low sample numbers obtained.

Comparing the recycles from both sources:

- contamination in the paper stream was much higher in business recycle than in municipal recycle, although levels were similar for mixed paper & card from both sources;
  - the contamination in business card recycle was lower than in municipal card;
  - municipal mixed glass was less contaminated than business mixed glass;
  - contamination in plastics from both sources was very similar; and
  - contamination in business-sourced metals was much lower than for municipal-sourced metals.
-

Contamination in business mixed paper & card, card and plastics is low, as would be expected because these materials tend to derive from less contaminating sources (e.g. card from retailer packaging). Conversely, higher levels of contamination would be expected from business glass and metals as these tend to be predominantly from hospitality establishments and typically would not be subject to the requirement of cleaning/rinsing out as commonly expected from municipal recycle.

Geometric means could not be calculated where the minimum value for typical contamination was zero. This is because geometric means are calculated using log-transformed values and there is no equivalent value for a log transformation of zero.

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**Table 3.1 Sample summary statistics – contamination in municipal recyclate**

| Recyclate             |                     | Minimum | Maximum | Arithmetic mean | Geometric mean | 25 <sup>th</sup> percentile | Median (50 <sup>th</sup> percentile) | 75 <sup>th</sup> percentile |
|-----------------------|---------------------|---------|---------|-----------------|----------------|-----------------------------|--------------------------------------|-----------------------------|
| <b>Paper and card</b> | Paper               | 0.1%    | 11.0%   | 1.6%            | 1.0%           | 0.5%                        | 1.1%                                 | 2.0%                        |
|                       | Card                | 0.3%    | 47.5%   | 8.1%            | 3.9%           | 1.6%                        | 4.1%                                 | 10.8%                       |
|                       | Mixed paper & card  | 0.03%   | 16.8%   | 1.7%            | 1.0%           | 0.6%                        | 0.9%                                 | 1.8%                        |
| <b>Glass</b>          | Clear               | 0%      | 8.2%    | 1.8%            | n/a            | 0.5%                        | 1.2%                                 | 2.8%                        |
|                       | Green               | 0.2%    | 9.7%    | 3.0%            | 1.8%           | 1.3%                        | 1.9%                                 | 3.5%                        |
|                       | Brown               | 0%      | 22.8%   | 4.2%            | n/a            | 1.5%                        | 2.7%                                 | 5.2%                        |
|                       | Mixed brown & green | 0.2%    | 21.8%   | 3.6%            | 2.2%           | 1.3%                        | 2.3%                                 | 4.6%                        |
|                       | Mixed               | 0%      | 5.7%    | 0.7%            | n/a            | 0.2%                        | 0.4%                                 | 0.9%                        |
| <b>Metals</b>         |                     | 0.4%    | 70.1%   | 9.1%            | 5.6%           | 2.7%                        | 6.2%                                 | 12.3%                       |
| <b>Plastics</b>       |                     | 0.4%    | 29.9%   | 5.5%            | 3.3%           | 2.0%                        | 2.9%                                 | 5.4%                        |

**Table 3.2 Sample summary statistics – contamination in business recyclate**

| Recyclate             |                    | Minimum | Maximum | Arithmetic mean | Geometric mean | 25 <sup>th</sup> percentile | Median (50 <sup>th</sup> percentile) | 75 <sup>th</sup> percentile |
|-----------------------|--------------------|---------|---------|-----------------|----------------|-----------------------------|--------------------------------------|-----------------------------|
| <b>Paper and Card</b> | Paper              | 0%      | 24.4%   | 5.4%            | n/a            | 0.3%                        | 3.3%                                 | 5.9%                        |
|                       | Card               | 0%      | 62.1%   | 3.3%            | n/a            | 0.0%                        | 0.5%                                 | 3.2%                        |
|                       | Mixed paper & card | 0%      | 19.2%   | 3.4%            | n/a            | 0.6%                        | 1.0%                                 | 3.0%                        |
| <b>Glass</b>          | Mixed              | 0%      | 4.5%    | 1.7%            | 1.3%           | 0.9%                        | 1.5%                                 | 2.1%                        |
| <b>Metals</b>         |                    | 0%      | 5.3%    | 3.1%            | n/a            | 2.9%                        | 3.3%                                 | 3.5%                        |
| <b>Plastics</b>       |                    | 0%      | 56.1%   | 7.1%            | n/a            | 0.4%                        | 2.5%                                 | 6.4%                        |

**Table 3.3 Confidence intervals (CIs) – contamination in municipal recyclate**

| Recyclate      |                     | Median   |          | Arithmetic mean |          | Geometric mean |          |
|----------------|---------------------|----------|----------|-----------------|----------|----------------|----------|
|                |                     | Lower CI | Upper CI | Lower CI        | Upper CI | Lower CI       | Upper CI |
| Paper and Card | Paper               | 0.9%     | 1.3%     | 1.3%            | 1.9%     | 0.8%           | 1.1%     |
|                | Card                | 2.8%     | 5.6%     | 6.0%            | 10.2%    | 3.0%           | 5.1%     |
|                | Mixed paper & card  | 0.7%     | 1.4%     | 1.0%            | 2.3%     | 0.7%           | 1.3%     |
| Glass          | Clear               | 1.0%     | 1.7%     | 1.5%            | 2.2%     | n/a            | n/a      |
|                | Green               | 1.2%     | 3.4%     | 1.7%            | 4.3%     | 1.1%           | 3.1%     |
|                | Brown               | 1.3%     | 5.0%     | 1.7%            | 6.7%     | n/a            | n/a      |
|                | Mixed brown & green | 1.7%     | 2.8%     | 2.6%            | 4.7%     | 1.7%           | 2.9%     |
|                | Mixed               | 0.3%     | 0.6%     | 0.5%            | 0.8%     | n/a            | n/a      |
| Metals         |                     | 4.0%     | 8.6%     | 7.4%            | 10.8%    | 4.7%           | 6.8%     |
| Plastics       |                     | 2.4%     | 3.8%     | 3.9%            | 7.0%     | 2.7%           | 4.2%     |

**Table 3.4 Confidence intervals (CIs) – contamination in business recyclate**

| Recyclate      |                    | Median   |          | Arithmetic mean |          | Geometric mean |          |
|----------------|--------------------|----------|----------|-----------------|----------|----------------|----------|
|                |                    | Lower CI | Upper CI | Lower CI        | Upper CI | Lower CI       | Upper CI |
| Paper and Card | Paper              | 1.0%     | 4.0%     | 3.0%            | 7.7%     | n/a            | n/a      |
|                | Card               | 0.3%     | 1.6%     | 1.9%            | 4.8%     | n/a            | n/a      |
|                | Mixed paper & card | n/a      | n/a      | 0.0%            | 7.0%     | n/a            | n/a      |
| Glass          | Mixed              | 1.3%     | 1.9%     | 1.4%            | 2.1%     | 0.9%           | 1.7%     |
| Metals         |                    | n/a      | n/a      | 1.9%            | 4.3%     | n/a            | n/a      |
| Plastics       |                    | 0.3%     | 5.3%     | 1.6%            | 12.6%    | n/a            | n/a      |

## 3.2 Paper and Card

Although paper and card are separate categories within the Waste (Scotland) Regulations 2012, they are grouped together in this report because many collection schemes currently collect them in a co-mingled form.

Within paper and card, three sub-categories have been sampled – paper, card and mixed paper & card. The tables below show the data for typical contamination in paper and card recyclate (Table 3.5) and confidence intervals around the data (Table 3.6). The variability in the data is graphically illustrated in Figure 3.1, Figure 3.2 and Figure 3.3.

### 3.2.1 Paper

In total, 216 samples of paper were collected (182 municipal, 34 business) across 50 sites (42 local authority, eight business).

Contamination in paper from municipal sources ranged from 0.1% to 11% with a typical contamination level of:

- 1.1% (median; lower CI = 0.9%, upper CI = 1.3%);
- 1.6% (arithmetic mean; lower CI = 1.3%, upper CI = 1.9%); and
- 1.0% (geometric mean; lower CI = 0.8%, upper CI = 1.1%).

Contamination in paper from business sources ranged from 0% to 24.4% with a typical contamination level of:

- 3.3% (median; lower CI = 1.0%, upper CI = 4.0%); and
- 5.4% (arithmetic mean; lower CI = 3.0%, upper CI = 7.7%).

### 3.2.2 Card

In total, 200 samples of card were collected (95 municipal, 105 business) across 34 sites (23 local authority, 11 business).

Contamination in card from municipal sources ranged from 0.3% to 47.5% with a typical contamination level of:

- 4.1% (median; lower CI = 2.8%, upper CI = 5.6%);
- 8.1% (arithmetic mean; lower CI = 6.0%, upper CI = 10.2%); and
- 3.9% (geometric mean; lower CI = 3.0%, upper CI = 5.1%).

Card was one of the most heavily contaminated waste streams and also highly variable.

Contamination in card from business sources ranged from 0% to 62.1% with a typical contamination level of:

- 0.5% (median; lower CI = 0.3%, upper CI = 1.6%); and
- 3.3% (arithmetic mean; lower CI = 1.9%, upper CI = 4.8%).

### 3.2.3 Mixed paper & card

72 samples of mixed paper & card (60 municipal, 12 business) were also collected across 21 sites (16 local authority, five business).

Contamination in mixed paper & card from municipal sources ranged from 0% to 16.8% with a typical contamination level of:

- 0.9% (median; lower CI = 0.7%, upper CI = 1.4%);
  - 1.7% (arithmetic mean; lower CI = 1.0%, upper CI = 2.3%); and
  - 1.0% (geometric mean; lower CI = 0.7%, upper CI = 1.3%).
-

Contamination in mixed paper & card from business sources ranged from 0% to 19.2% with a typical contamination level of:

- 1.0% (median; lower CI = could not be calculated, upper CI = could not be calculated); and
- 3.4% (arithmetic mean; lower CI = 0%, upper CI = 7.0%).

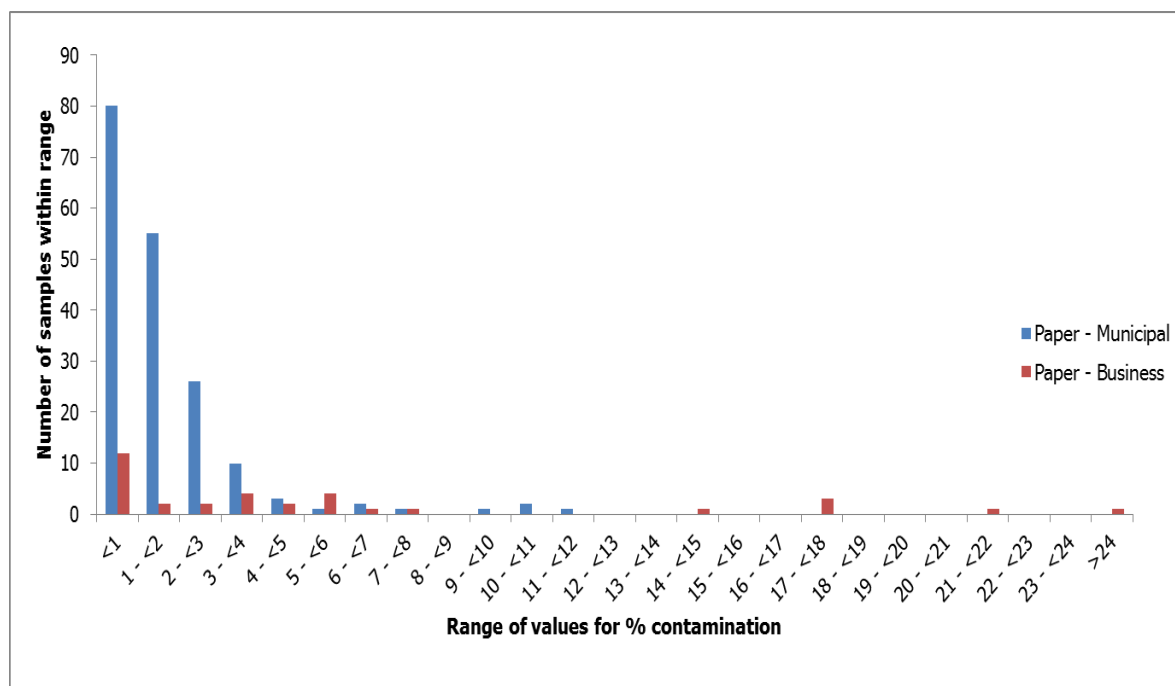
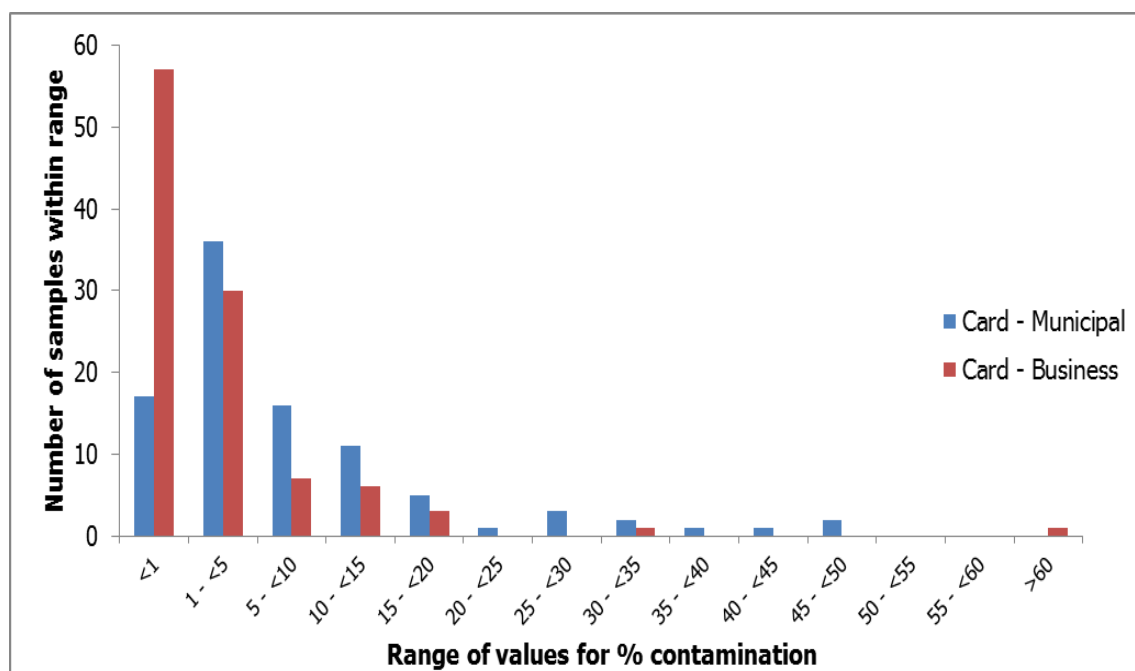
The sample size was very small (12 samples) compared to other recyclates and although typical contamination values and confidence limits around the mean have been calculated for this data, it is inappropriate to draw definite conclusions about typical contamination for this stream based on the data collated.

**Table 3.5 Sample summary statistics – paper and card**

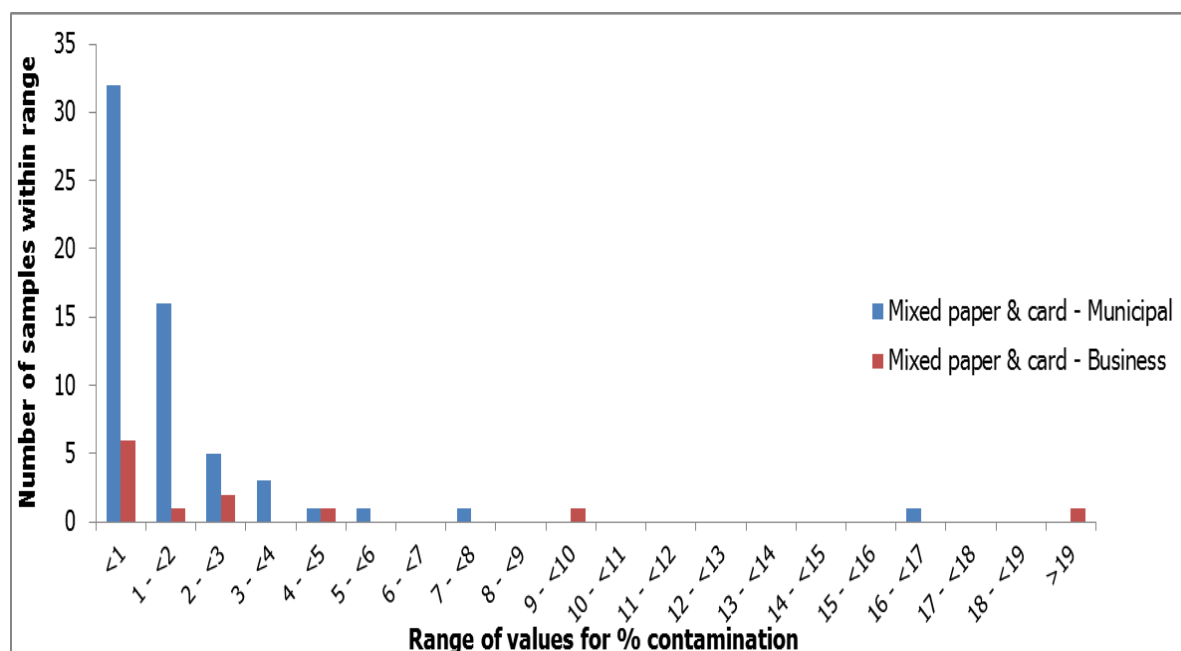
| Recyclate                       |                    | Minimum | Maximum | Arithmetic mean | Geometric mean | 25 <sup>th</sup> percentile | Median (50 <sup>th</sup> percentile) | 75 <sup>th</sup> percentile |
|---------------------------------|--------------------|---------|---------|-----------------|----------------|-----------------------------|--------------------------------------|-----------------------------|
| <b>Municipal Paper and Card</b> | Paper              | 0.1%    | 11.0%   | 1.6%            | 1.0%           | 0.5%                        | 1.1%                                 | 2.0%                        |
|                                 | Card               | 0.3%    | 47.5%   | 8.1%            | 3.9%           | 1.6%                        | 4.1%                                 | 10.8%                       |
|                                 | Mixed paper & card | 0.03%   | 16.8%   | 1.7%            | 1.0%           | 0.6%                        | 0.9%                                 | 1.8%                        |
| <b>Business Paper and Card</b>  | Paper              | 0%      | 24.4%   | 5.4%            | n/a            | 0.3%                        | 3.3%                                 | 5.9%                        |
|                                 | Card               | 0%      | 62.1%   | 3.3%            | n/a            | 0.0%                        | 0.5%                                 | 3.2%                        |
|                                 | Mixed paper & card | 0%      | 19.2%   | 3.4%            | n/a            | 0.6%                        | 1.0%                                 | 3.0%                        |

**Table 3.6 Confidence intervals (CIs) – paper and card**

| Recyclate                       |                    | Median   |          | Arithmetic mean |          | Geometric mean |          |
|---------------------------------|--------------------|----------|----------|-----------------|----------|----------------|----------|
|                                 |                    | Lower CI | Upper CI | Lower CI        | Upper CI | Lower CI       | Upper CI |
| <b>Municipal Paper and Card</b> | Paper              | 0.9%     | 1.3%     | 1.3%            | 1.9%     | 0.8%           | 1.1%     |
|                                 | Card               | 2.8%     | 5.6%     | 6.0%            | 10.2%    | 3.0%           | 5.1%     |
|                                 | Mixed paper & card | 0.7%     | 1.4%     | 1.0%            | 2.3%     | 0.7%           | 1.3%     |
| <b>Business Paper and Card</b>  | Paper              | 1.0%     | 4.0%     | 3.0%            | 7.7%     | n/a            | n/a      |
|                                 | Card               | 0.3%     | 1.6%     | 1.9%            | 4.8%     | n/a            | n/a      |
|                                 | Mixed paper & card | n/a      | n/a      | 0.0%            | 7.0%     | n/a            | n/a      |

**Figure 3.1 Variability in contamination in the samples – paper****Figure 3.2 Variability in contamination in the samples – card**

**Figure 3.3 Variability in contamination in the samples – mixed paper & card**



### 3.2.4 Typical contaminants present

Table 3.7 and Table 3.8 summarise the different types of non-target recyclable and non-target non-recyclable contaminations found within paper and card recycle from municipal and business sources. The percentage of the samples where this contaminant occurred is also shown. As set out in section 2.5.2, the nature of the contaminants was recorded following separation on site; weights of each were not measured.

Sometimes the same material is reported as both recyclable and non-recyclable, for example liquid packaging. This is because there are varying schemes in place across the country, with some local authorities having a collection scheme for liquid packaging, either separately or co-mingled, while other local authorities do not target this material at all. As set out in section 2.5.2, whether a material was classed as recyclable or not was dictated by the local scheme in place.

**Table 3.7 Percentage of samples containing recyclable and non-recyclable contaminants – municipal paper and card recycle**

| Non-target contaminant                      | % of samples |      |                    |
|---------------------------------------------|--------------|------|--------------------|
|                                             | Paper        | Card | Mixed Paper & Card |
| <b>Recyclable</b>                           |              |      |                    |
| <b>Card</b>                                 | 69%          | 0%   | 0%                 |
| <b>Paper</b>                                | 1%           | 85%  | 0%                 |
| <b>Plastics</b>                             | 34%          | 55%  | 62%                |
| <b>Metals</b>                               | 27%          | 45%  | 47%                |
| <b>Glass</b>                                | 13%          | 14%  | 32%                |
| <b>Liquid packaging</b>                     | 1%           | 20%  | 5%                 |
| <b>Other</b>                                | 15%          | 6%   | 7%                 |
| <b>Non-recyclable</b>                       |              |      |                    |
| <b>Plastics</b>                             | 59%          | 60%  | 70%                |
| <b>Food-contaminated card (pizza boxes)</b> | 3%           | 8%   | 27%                |
| <b>Liquid packaging</b>                     | 4%           | 25%  | 23%                |
| <b>Other</b>                                | 17%          | 2%   | 7%                 |

It can be observed that many samples were contaminated by recyclable and non-recyclable plastics, as well as recycle of the wrong type – paper in card or card in paper streams – which although classed as a contaminant here would not necessarily count as contamination for every reprocessor. Many samples of card and mixed paper & card contained metals and glass contaminants; this could be due to inefficiencies in material separation at the kerbside. Many samples of card also contained liquid packaging; this could be down to households wrongly assuming that it is made solely of card. Food-contaminated card (mainly pizza boxes) was a common contaminant for the mixed stream but not as much for the separate paper and card streams.

**Table 3.8 Percentage of samples containing recyclable and non-recyclable contaminants – business paper and card recycle<sup>8</sup>**

| Non-target contaminant               | % of samples |      |
|--------------------------------------|--------------|------|
|                                      | Paper        | Card |
| <b>Recyclable</b>                    |              |      |
| <b>Non-target paper</b>              | 53%          | 0%   |
| <b>Paper</b>                         | 0%           | 44%  |
| <b>Card</b>                          | 38%          | 4%*  |
| <b>Plastics</b>                      | 18%          | 31%  |
| <b>Other</b>                         | 9%           | 9%   |
| <b>Non-recyclable</b>                |              |      |
| <b>Plastics</b>                      | 44%          | 25%  |
| <b>Non-recyclable Paper</b>          | 12%          | 0%   |
| <b>Hair/beauty products</b>          | 12%          | 0%   |
| <b>Twine</b>                         | 9%           | 8%   |
| <b>Food &amp; food contamination</b> | 0%           | 8%   |
| <b>Other</b>                         | 29%          | 53%  |

\* e.g. cardboard rolls or tubes covered in plastic film

Non-recyclable plastics such as plastic film were commonly found in both the paper and card recycle streams.

### 3.3 Glass

Within the glass recycle stream, five sub-categories have been sampled – clear glass, brown glass, green glass, mixed brown & green glass, and mixed glass. Only mixed glass was collected from businesses. The data for typical contamination in glass recycle is presented in Table 3.9 with confidence intervals shown in Table 3.10 and variability in the sample data shown in Figure 3.4 and Figure 3.5.

#### 3.3.1 Clear glass

In total, 82 samples of clear glass were collected from municipal sources across 19 local authority sites. No samples were collected from business sources because glass was generally collected in mixed form. Contamination in the clear glass stream ranged from 0% to 8.2% with a typical contamination level of:

- 1.2% (median; lower CI = 1.0%, upper CI = 1.7%); and
- 1.8% (arithmetic mean; lower CI = 1.5%, upper CI = 2.2%).

#### 3.3.2 Green glass

In total, 20 samples of green glass were collected from municipal sources across five local authority sites. No samples were collected from business sources because glass was generally collected in mixed form. Contamination in the green glass stream ranged from 0.2% to 9.7% with a typical contamination level of:

<sup>8</sup> There are too few data points to provide a reliable material-specific breakdown for mixed paper & card.

- 1.9% (median; lower CI = 1.2%, upper CI = 3.4%);
- 3.0% (arithmetic mean; lower CI = 1.7%, upper CI = 4.3%); and
- 1.8% (geometric mean, lower CI = 1.1%, upper CI = 3.1%).

### 3.3.3 Brown glass

In total, 20 samples of brown glass were collected from municipal sources across five local authority sites. No samples were collected from business sources because glass was generally collected in mixed form. Contamination in the brown glass stream ranged from 0% to 22.8% with a typical contamination level of:

- 2.7% (median; lower CI = 1.3%, upper CI = 5.0%); and
- 4.2% (arithmetic mean; lower CI = 1.7%, upper CI = 6.7%).

### 3.3.4 Mixed brown & green glass

In total, 62 samples of mixed brown & green glass were collected from municipal sources across 14 local authority sites. No samples were collected from business sources because glass was generally collected in mixed form. Contamination in the mixed brown & green glass stream ranged from 0.2% to 21.8% with a typical contamination level of:

- 2.3% (median; lower CI = 1.7%, upper CI = 2.8%);
- 3.6% (arithmetic mean; lower CI = 2.6%, upper CI = 4.7%); and
- 2.2% (geometric mean, lower CI = 1.7%, upper CI = 2.9%).

### 3.3.5 Mixed glass

In total, 178 samples of mixed glass were collected (135 municipal, 43 business) across 39 sites (33 local authority, six business). Contamination in mixed glass from municipal sources ranged from 0% to 5.7% with a typical contamination level of:

- 0.4% (median; lower CI = 0.3%, upper CI = 0.6%); and
- 0.7% (arithmetic mean; lower CI = 0.5%, upper CI = 0.8%).

Contamination in mixed glass from business sources ranged from 0% to 4.5% with a typical contamination level of:

- 1.5% (median; lower CI = 1.3%, upper CI = 1.9%);
  - 1.7% (arithmetic mean; lower CI = 1.4%, upper CI = 2.1%); and
  - 1.3% (geometric mean, lower CI = 0.9%, upper CI = 1.7%).
-

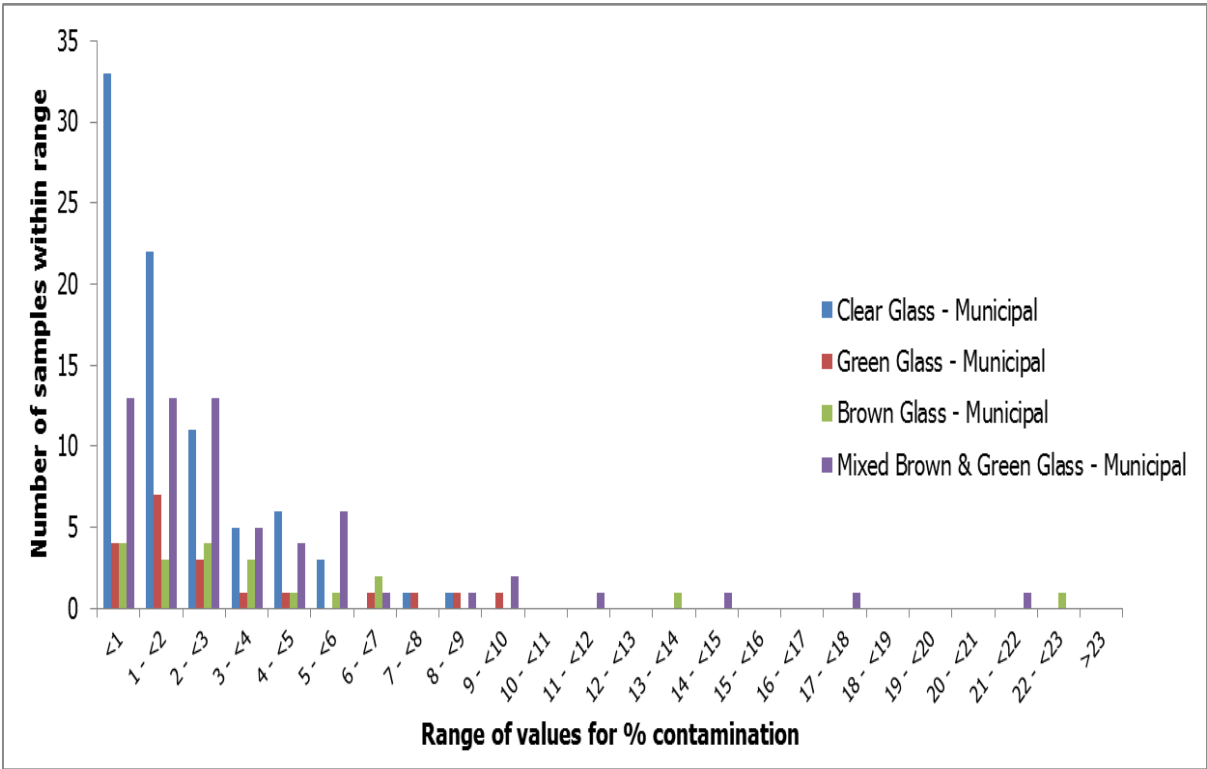
**Table 3.9 Sample summary statistics – glass recyclate**

| Recyclate              |                     | Minimum | Maximum | Arithmetic mean | Geometric mean | 25 <sup>th</sup> percentile | Median (50 <sup>th</sup> percentile) | 75 <sup>th</sup> percentile |
|------------------------|---------------------|---------|---------|-----------------|----------------|-----------------------------|--------------------------------------|-----------------------------|
| <b>Municipal Glass</b> | Clear               | 0%      | 8.2%    | 1.8%            | n/a            | 0.5%                        | 1.2%                                 | 2.8%                        |
|                        | Green               | 0.2%    | 9.7%    | 3.0%            | 1.8%           | 1.3%                        | 1.9%                                 | 3.5%                        |
|                        | Brown               | 0%      | 22.8%   | 4.2%            | n/a            | 1.5%                        | 2.7%                                 | 5.2%                        |
|                        | Mixed brown & green | 0.2%    | 21.8%   | 3.6%            | 2.2%           | 1.3%                        | 2.3%                                 | 4.6%                        |
|                        | Mixed               | 0%      | 5.7%    | 0.7%            | n/a            | 0.2%                        | 0.4%                                 | 0.9%                        |
| <b>Business Glass</b>  | Mixed               | 0%      | 4.5%    | 1.7%            | 1.3%           | 0.9%                        | 1.5%                                 | 2.1%                        |

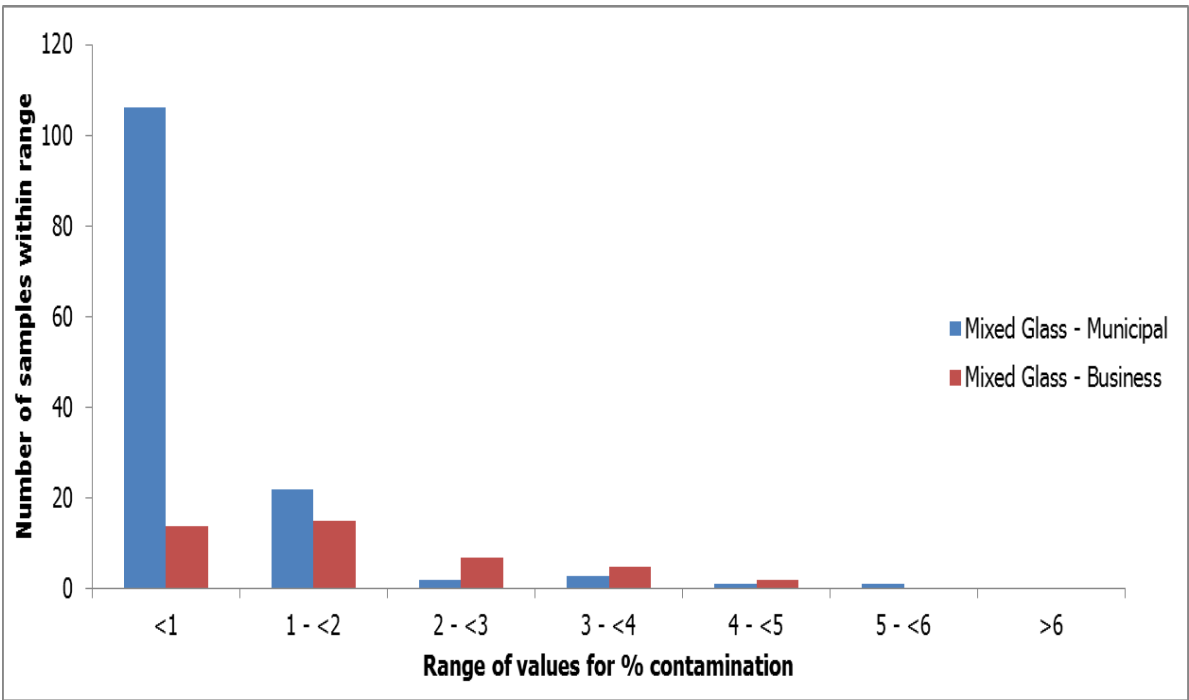
**Table 3.10 Confidence intervals – glass recyclate**

| Recyclate              |                     | Median   |          | Arithmetic mean |          | Geometric mean |          |
|------------------------|---------------------|----------|----------|-----------------|----------|----------------|----------|
|                        |                     | Lower CI | Upper CI | Lower CI        | Upper CI | Lower CI       | Upper CI |
| <b>Municipal Glass</b> | Clear               | 1.0%     | 1.7%     | 1.5%            | 2.2%     | n/a            | n/a      |
|                        | Green               | 1.2%     | 3.4%     | 1.7%            | 4.3%     | 1.1%           | 3.1%     |
|                        | Brown               | 1.3%     | 5.0%     | 1.7%            | 6.7%     | n/a            | n/a      |
|                        | Mixed brown & green | 1.7%     | 2.8%     | 2.6%            | 4.7%     | 1.7%           | 2.9%     |
|                        | Mixed               | 0.3%     | 0.6%     | 0.5%            | 0.8%     | n/a            | n/a      |
| <b>Business Glass</b>  | Mixed               | 1.3%     | 1.9%     | 1.4%            | 2.1%     | 0.9%           | 1.7%     |

**Figure 3.4 Variability in contamination in the samples – clear, brown, green and mixed brown & green glass**



**Figure 3.5 Variability in contamination in the samples – mixed glass**



### 3.3.6 Typical contaminants present

Table 3.11 and Table 3.12 summarise the different types of non-target recyclable and non-target non-recyclable contaminations in glass recyclate from both municipal and business sources. The percentage of the samples where this contaminant occurred is also shown. As set out in section 2.5.2, the nature of the contaminants was recorded following separation on site; weights of each were not measured.

**Table 3.11 Percentage of samples containing recyclable and non-recyclable contaminants – municipal glass recyclate**

| Non-target contaminant    | % of samples |             |             |             |                           |
|---------------------------|--------------|-------------|-------------|-------------|---------------------------|
|                           | Mixed Glass  | Clear Glass | Brown Glass | Green Glass | Mixed Brown & Green Glass |
| <b>Recyclable</b>         |              |             |             |             |                           |
| Mixed/blue/coloured glass | 0%           | 79%         | 85%         | 65%         | 0%                        |
| Clear Glass               | 0%           | 0%          | 50%         | 65%         | 97%                       |
| Metals                    | 73%          | 49%         | 25%         | 35%         | 50%                       |
| Plastics                  | 56%          | 26%         | 20%         | 30%         | 31%                       |
| Paper                     | 29%          | 18%         | 0%          | 5%          | 13%                       |
| Card                      | 21%          | 18%         | 5%          | 10%         | 21%                       |
| Other                     | 4%           | 7%          | 0%          | 0%          | 0%                        |
| <b>Non-recyclable</b>     |              |             |             |             |                           |
| Plastics non-bottle       | 37%          | 27%         | 15%         | 15%         | 27%                       |
| Other                     | 31%          | 27%         | 20%         | 30%         | 11%                       |

Many samples contained recyclable plastics and metals in addition to recyclate of the wrong type – clear glass in coloured glass and vice versa – which although classed as contaminants here would not necessarily count as contamination for every reprocessor. Many samples of the mixed or separate glass streams also contained bits of paper and card contaminants; this could be down to the efficiency of material separation at the kerbside. There appear to be frequent incidences of plastics contamination, much of which will be bottles, and it is possible that certain types of plastic are so similar to clear glass that the householder is having difficulty distinguishing them when setting out or the crew experience similar problems when sorting them at the kerbside.

**Table 3.12 Percentage of samples containing recyclable and non-recyclable contaminants – business glass recycle**

| Non-target contaminant | % of samples |
|------------------------|--------------|
| <b>Recyclable</b>      |              |
| Cans                   | 58%          |
| Paper                  | 49%          |
| Plastic bottles        | 42%          |
| Card                   | 28%          |
| Other plastics         | 12%          |
| Other                  | 5%           |
| <b>Non-recyclable</b>  |              |
| Plastics               | 53%          |
| Ceramics               | 28%          |
| Liquid packaging       | 12%          |
| Wood                   | 7%           |
| Other*                 | 35%          |

\* e.g. textiles, straw, electric wire, tissue, razors

Many of the business samples contained recyclable plastics, cans, paper and card. Non-recyclable plastics such as plastic film were also common, along with ceramics and liquid packaging.

There appear to be frequent incidences of plastic bottles and it is possible that certain types of plastic are so similar to clear glass that the business is having difficulty distinguishing them when setting out.

### 3.4 Metals

Metals recycle typically consisted of cans and sometimes foils or foil packaging. The data for typical contamination in metals recycle is presented in Table 3.13 while confidence intervals are shown in Table 3.14. Variability of the sample data is presented in Figure 3.6.

In total, 136 samples of metals were collected (128 municipal, eight business) across 34 sites (30 local authority, four business). Contamination in metals from municipal sources ranged from 0.4% to 70.1% with a typical contamination level of:

- 6.2% (median; lower CI = 4.0%, upper CI = 8.6%);
- 9.1% (arithmetic mean; lower CI = 7.4%, upper CI = 10.8%); and
- 5.6% (geometric mean, lower CI = 4.7%, upper CI = 6.8%).

Metals recycle was the most contaminated recycle stream for all municipal recycle sampled and also the most variable.

Contamination in metals from business sources ranged from 0% to 5.3% with a typical contamination level of:

- 3.3% (median; lower CI = could not be calculated, upper CI = could not be calculated); and
- 3.1% (arithmetic mean; lower CI = 1.9%, upper CI = 4.3%).

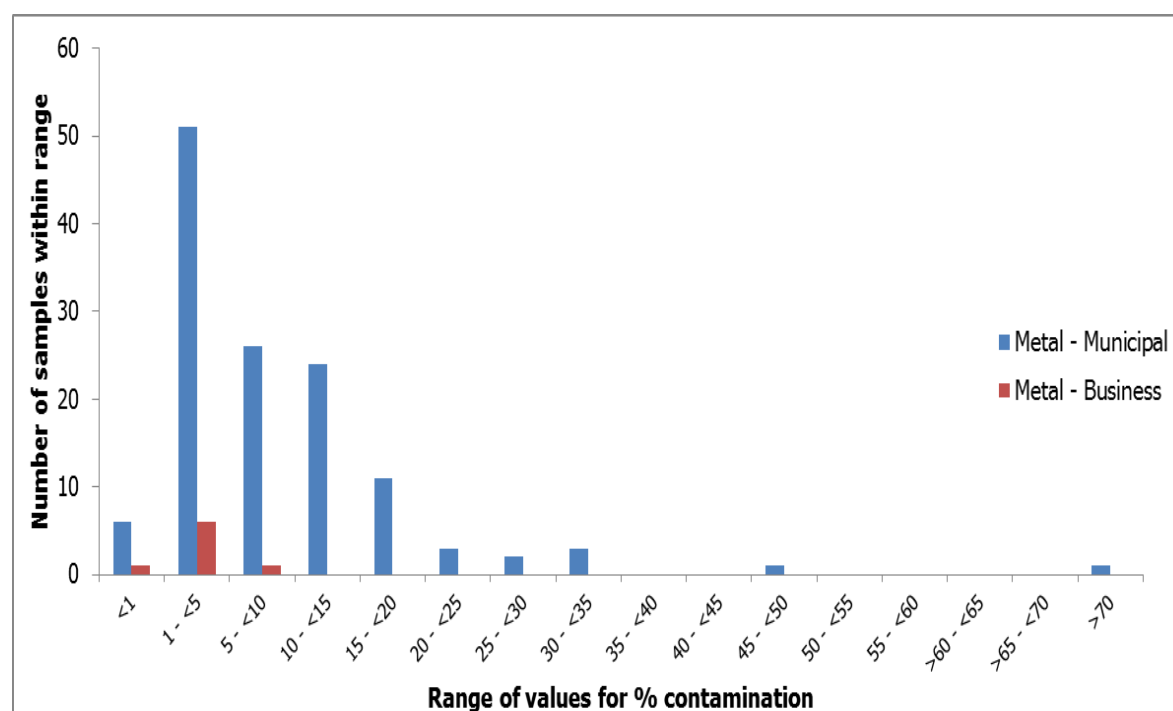
Compared to other recycles, the sample size was very small at just eight samples and although typical contamination values and confidence limits around the mean have been calculated for business metals recycle, it is inappropriate to draw conclusions about typical contamination for this stream based on the data collated.

**Table 3.13 Sample summary statistics – metals recyclate**

| Recyclate               | Minimum | Maximum | Arithmetic mean | Geometric mean | 25 <sup>th</sup> percentile | Median 50 <sup>th</sup> percentile | 75 <sup>th</sup> percentile |
|-------------------------|---------|---------|-----------------|----------------|-----------------------------|------------------------------------|-----------------------------|
| <b>Municipal metals</b> | 0.4%    | 70.1%   | 9.1%            | 5.6%           | 2.7%                        | 6.2%                               | 12.3%                       |
| <b>Business metals</b>  | 0%      | 5.3%    | 3.1%            | n/a            | 2.9%                        | 3.3%                               | 3.5%                        |

**Table 3.14 Confidence intervals – metals recyclate**

| Recyclate               | Median   |          | Arithmetic mean |          | Geometric mean |          |
|-------------------------|----------|----------|-----------------|----------|----------------|----------|
|                         | Lower CI | Upper CI | Lower CI        | Upper CI | Lower CI       | Upper CI |
| <b>Municipal metals</b> | 4.0%     | 8.6%     | 7.4%            | 10.8%    | 4.7%           | 6.8%     |
| <b>Business metals</b>  | n/a      | n/a      | 1.9%            | 4.3%     | n/a            | n/a      |

**Figure 3.6 Variability in contamination in the samples – metals recyclate**

### 3.4.1 Typical contaminants present

Table 3.15 summarises the different types of non-target recyclable and non-target non-recyclable contaminations found within the metals recyclate from municipal sources. There were too few data points to provide a reliable material-specific breakdown for metals recyclate from business sources. The percentage of the samples where this contaminant occurred is also shown. As set out in section 2.5.2, the nature of the contaminants was recorded following separation on site; weights of each were not measured.

**Table 3.15 Recyclable and non-recyclable contaminants in the samples – municipal metals recyclate**

| Non-target contaminant          | % of samples – Metals |
|---------------------------------|-----------------------|
| <b>Recyclable</b>               |                       |
| Glass                           | 77%                   |
| Plastics                        | 64%                   |
| Paper                           | 52%                   |
| Card                            | 26%                   |
| Liquid packaging                | 5%                    |
| Other                           | 16%                   |
| <b>Non-recyclable</b>           |                       |
| Plastic film, bags etc.         | 56%                   |
| Metals (various non-recyclable) | 55%                   |
| Batteries                       | 2%                    |
| Other                           | 23%                   |

Many samples contained recyclable glass, plastics and paper; this could be down to poor efficiency of material separation at the kerbside.

Non-recyclable plastics such as plastic film and plastic bags and other metals such as heavy car parts, screws, nuts and bolts were also common contaminants in the metals recyclate stream.

### 3.5 Plastics

Plastics recyclate consisted of dense packaging plastics and sometimes plastic films, depending on the collection scheme in operation. The data for typical contamination in plastics recyclate is presented in Table 3.16 while variability in the data is shown in Table 3.17. Variability in the samples is shown in Figure 3.7.

In total, 99 samples of plastics were collected (76 municipal, 23 business) across 26 sites (19 local authority, seven business). Contamination in plastics from municipal sources ranged from 0.4% to 29.9% with a typical contamination level of:

- 2.9% (median; lower CI = 2.4%, upper CI = 3.8%);
- 5.5% (arithmetic mean; lower CI = 3.9%, upper CI = 7.0%); and
- 3.3% (geometric mean, lower CI = 2.7%, upper CI = 4.2%).

Contamination in plastics from business sources ranged from 0% to 56.1% with a typical contamination level of:

- 2.5% (median; lower CI = 0.3%, upper CI = 5.3%); and
- 7.1% (arithmetic mean; lower CI = 1.6%, upper CI = 12.6%).

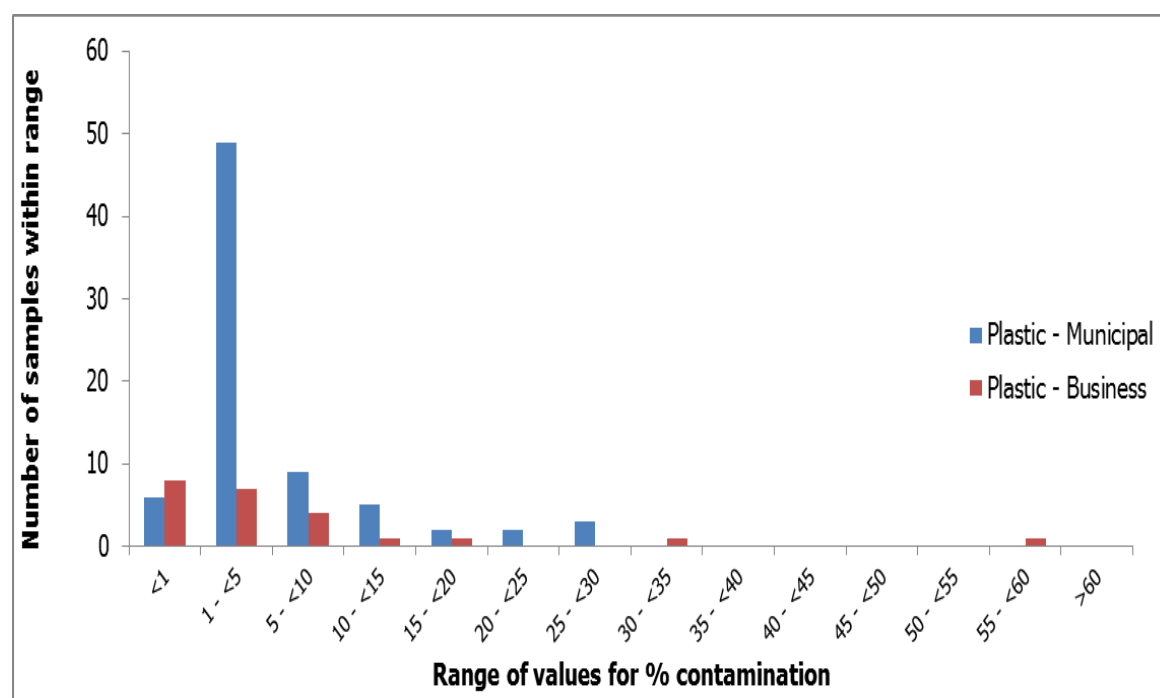
The sample size was very small at just 23 samples and although typical contamination values and confidence limits have been calculated for this data, it is inappropriate to draw definite conclusions about typical contamination for this stream based on the data collated.

**Table 3.16 Sample summary statistics – plastics recycle**

| Recyclate                 | Minimum | Maximum | Arithmetic mean | Geometric mean | 25 <sup>th</sup> percentile | Median 50 <sup>th</sup> percentile | 75 <sup>th</sup> percentile |
|---------------------------|---------|---------|-----------------|----------------|-----------------------------|------------------------------------|-----------------------------|
| <b>Municipal Plastics</b> | 0.4%    | 29.9%   | 5.5%            | 3.3%           | 2.0%                        | 2.9%                               | 5.4%                        |
| <b>Business Plastics</b>  | 0.0%    | 56.1%   | 7.1%            | n/a            | 0.4%                        | 2.5%                               | 6.4%                        |

**Table 3.17 Confidence intervals – plastics recycle**

| Recyclate                 | Median   |          | Arithmetic mean |          | Geometric mean |          |
|---------------------------|----------|----------|-----------------|----------|----------------|----------|
|                           | Lower CI | Upper CI | Lower CI        | Upper CI | Lower CI       | Upper CI |
| <b>Municipal Plastics</b> | 2.4%     | 3.8%     | 3.9%            | 7.0%     | 2.7%           | 4.2%     |
| <b>Business Plastics</b>  | 0.3%     | 5.3%     | 1.6%            | 12.6%    | n/a            | n/a      |

**Figure 3.7 Variability in contamination in the samples – plastics recycle**

### 3.5.1 Typical contaminants present

Table 3.18 and Table 3.19 summarise the different types of non-target recyclable and non-target non-recyclable contaminations found within the plastics recycle from municipal and business sources. The percentage of the samples where this contaminant occurred is also shown. As set out in section 2.5.2, the nature of the contaminants was recorded following separation on site; weights of each were not measured.

**Table 3.18 Recyclable and non-recyclable contaminants in the samples – municipal plastics recycle**

| Non-target contaminant | % of samples –<br>Plastics |
|------------------------|----------------------------|
| <b>Recyclable</b>      |                            |
| Glass                  | 50%                        |
| Metals                 | 72%                        |
| Paper                  | 49%                        |
| Card                   | 39%                        |
| Liquid packaging       | 13%                        |
| Other                  | 13%                        |
| <b>Non-recyclable</b>  |                            |
| Plastics               | 75%                        |
| Metals                 | 9%                         |
| Glass                  | 5%                         |
| Liquid packaging       | 14%                        |
| Other                  | 26%                        |

Many samples contain glass and metals in addition to the wrong type of plastics, with plastic film and bags commonly the culprits; some of this could be down to the efficiency of material separation at the kerbside. The incidence of paper and card contamination is somewhat puzzling as these materials are typically considered to be easily distinguishable from plastics.

**Table 3.19 Recyclable and non-recyclable contaminants in the samples – business plastics recycle**

| Non-target contaminant | % of samples -<br>Plastics |
|------------------------|----------------------------|
| <b>Recyclable</b>      |                            |
| Paper                  | 30%                        |
| Card                   | 30%                        |
| Cans                   | 26%                        |
| Non-target plastics    | 17%                        |
| Glass                  | 9%                         |
| Other*                 | 48%                        |
| <b>Non-recyclable</b>  |                            |
| Plastics               | 26%                        |
| Paper                  | 17%                        |
| Other                  | 78%                        |

\* Mainly textiles and liquid packaging

Many samples contained paper, card and metal cans in addition to the wrong type of plastics; some of this could be down to the efficiency of material separation at the kerbside.

The proportion of samples, both municipal and business, with non-recyclable plastics present is a clear indication that recycling messages on plastics need improvement. What is accepted will differ from scheme to scheme and not all plastics bearing the recyclable logo will be accepted. Some local authorities and private companies collect a wide range of plastics including plastic film, PET and HDPE, while others only collect plastic film and HDPE. Yet more only collect dense plastic packaging described as PET and HDPE. Considering the many different types of plastic packaging materials available and the difficulty the general public experience with classifying items (e.g. yoghurt pots, salad packs, punnets, egg boxes), it is to be expected that there will be a high degree of confusion but effective communications can minimise this.

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## 4 Conclusions

This section summarises the substantive results of the project in terms of levels of contamination in source-separated recyclate. It also draws together methodological lessons in terms of what worked, what did not work and what should be done differently if the study were to be repeated.

### 4.1 Levels of contamination in source-separated recyclate

Contamination levels in source-separated *municipal* recyclate were generally low, as set out in Table 3.1 on p.27. The metals recyclate stream was the most heavily contaminated (median = 6.2% contamination by weight), followed by card (median = 4.1%), plastics (median = 2.9%) and brown glass (median = 2.7%).

Contamination levels in source-separated *business* recyclate were also generally low (Table 3.2 on p.27), although caution should be exercised in using these figures due to the low sample size obtained. As with municipal recyclate, the metals stream was the most heavily contaminated (median = 3.3% contamination by weight) although paper and plastics were also high (medians = 3.3% and 2.5% respectively).

It should be borne in mind when interpreting the results that certain types of contamination are more problematic for reprocessors than others.

### 4.2 Constraints and caveats

When using the data it is important to bear in mind the confidence intervals which are reported in Table 3.3 and Table 3.4 on p.28. Confidence intervals reflect sampling error; so the smaller the sample obtained, the more the sampling error and the wider the confidence intervals. The confidence intervals are calculated at a 95% probability level; in simple terms this means that if you repeated the study 20 times, 19 times out of 20 the level of contamination would likely fall within this range. It is important to remember that any individual measure of recyclate may fall outside these bounds; the range of sampled values (minimum and maximum) is shown in Table 3.1 for municipal recyclate and Table 3.2 for business recyclate, both on p.27.

The intention was to produce a consolidated estimate of contamination for municipal and business recyclate. Due to the small sample size for business, the study could not calculate robust estimates for business recyclate and so a consolidated estimate for recyclate from all sources could not be produced. The only business recyclate for which figures are robust enough to use is card.

Similarly, an estimate of contamination for each of the five recyclate categories in the Waste (Scotland) Regulations 2012 could not be generated. This is because many authorities and businesses collect sub-categories of material and some co-mingle across categories (e.g. paper & card; metal cans & plastics). It is unclear how the data could be reliably weighted across the sub-categories to calculate the national picture for Scotland, for each of the main recyclate categories.

### 4.3 Methodology

In general terms, the methodology adopted for the study worked well. This section draws out the lessons that have been learned so that they can be borne in mind should the study ever be repeated.

#### 4.3.1 Sampling framework

For municipal recyclate, the study made use of WRAP's database of collection schemes, which is updated annually by contacting local authorities and requesting they provide amendments if required. The database used related to 2012, so was already 9 months out of date by the start of the work programme. Although only a relatively short space of time, many authorities were found to have

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changed their schemes which meant they became out of scope for the study. Any future study should ensure sufficient time and resource is allowed to contact authorities to double-check their eligibility.

For business recyclate, a suitable list of businesses could not be found and one had to be constructed from scratch. In retrospect this should have been done much earlier in the process to allow time for the businesses to be contacted. In addition, the list was collated using web searches on trade body websites. Many of the businesses identified were subsequently found not to collect the appropriate waste stream. Any future study should allow sufficient time and resource to identify the best source of relevant information on material streams collected by businesses so that the sampling population is more targeted.

The local authorities and businesses were assigned a random number and were supposed to be contacted in number order to avoid any bias occurring. While it was desirable to contact local authorities and businesses in the numbered order and await a response before moving to the next one, in practice this was impossible mainly due to the challenges experienced with recruitment, contacting personnel and getting responses back promptly. Continuing entirely on that course would have resulted in a study lasting a year or more. A decision was taken at the start of recruitment to contact sites in batches each time and ensure letters were sent out and an initial follow-up call was made before contacting the next batch on the list. Each batch of contacts was assigned a task lead to keep track of progress and ensure sites were scheduled-in promptly. This helped speed up the pace of recruitment although it meant that the random element of the survey was put at risk. Given that all authorities and businesses on both the municipal and business recyclate source lists were contacted anyway, we are confident that this approach did not significantly influence or bias the overall objectives and design of the sampling framework. Any future study should continue to adopt a random allocation approach but be realistic about the need to contact batches.

#### 4.3.2 *Recruitment*

Recruitment of local authorities and businesses took much longer than anticipated. Running the study over the summer holiday period did not help with this. Any future study should consider carefully the time of year for recruiting and allow additional time and resource.

At the start of the project, relevant stakeholders were engaged including regulators, local government bodies, waste management operators and industry stakeholders across the whole UK. While we achieved a very good and responsive body of stakeholders, a missed opportunity was the lack of representation of the full spectrum of reproprocessors (particularly for metals, glass and plastics). Consequently, when the businesses were contacted to participate, many had either not heard of the study or were not convinced of the benefits. It would have been beneficial to engage with representatives of each industry either within the stakeholder group or through a separate panel to facilitate the wider buy-in of the industry to the study. We believe this oversight contributed to the underachievement of the target for the business recyclate sampling survey and any future study should ensure they are on board much sooner.

The local authorities surveyed covered a good spread of the characteristics required to obtain a representative sample of the local authorities which separately collect municipal recyclate. The only exception was representation of compulsory recycling where a target of two authorities was set. At the time of the study, only one London borough was still operating a compulsory recycling scheme and they were in the process of switching to a co-mingled scheme and hence declined to participate. Setting targets for coverage of different characteristics, rather than including those characteristics within a stratified sampling framework, was a strategy that worked well.

#### 4.3.3 *On-site sampling*

For municipal recyclate, 10 recyclate streams were sampled including paper/card (paper, card and mixed paper & card), glass (clear, green, brown, mixed brown & green, and mixed glass), metals and plastics. A total of 860 samples of municipal recyclate were collected across 59 sites. An additional 147 samples were collected during the two pilot surveys but the data has been excluded from the

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analysis. Regarding the target individual sample weight of 100 kg, achieved samples ranged from 12 kg to 190 kg, with an average of 99 kg. Where the 100 kg target was not achieved, this was typically because the vehicle had collected less than this so the material was not available for sampling.

For business recycle, six recycle streams were sampled including paper/card (paper, card and mixed paper & card), mixed glass, metals and plastics. A total of 225 samples of business recycle were collected across 18 sites. This includes samples for the pilot survey. Regarding the target individual sample weight of 100 kg, sample weights ranged from 14 kg to 762 kg, with an average of 108 kg. Where the 100 kg target was not achieved, this was typically because the bale contained less than this so the material was not available for sampling.

The on site sampling progressed well with few if any complaints. Some sites found the disruptions and vehicle stoppages while samples were collected to be a little challenging. Issues with vehicle arrival times also arose, which meant that often the targeted route was not eventually collected due to a need to balance access by RPS to bays for sampling with limited disruption of daily site operations. Two lessons quickly identified by RPS were the need for flexibility in work times and the need to arrive on site on the day at a time close enough to the arrival of vehicles so that their teams were fresh and ready to work. There was also a need to plan ahead for the routes and vehicles which they wanted to sample, particularly for municipal recycle. This meant that the team leader could negotiate with the site manager to hold back the vehicles if need be for a less busy time to enable sampling. Our observation on the site visits attended was that this process particularly could sometimes have been managed better. Future studies should have a plan in place for selecting the target routes/samples and this should be shared and agreed between the client-side project manager and the contractor ahead of time and then consistently implemented.

Some potentially suitable local authority sites had to be discounted due to issues with use of vehicles, particularly forklift or loading shovels for tipping and mixing. A major challenge with obtaining samples for the analysis was that, in many cases, there was only one shovel or forklift on site and this was dedicated to the vehicles, meaning that the samples had to be collected by hand. This was more time-consuming. Initially, RPS had assumed that it might be possible to hire-in suitable mechanical equipment where needed, but this proved to be impossible due to commonly voiced concerns about the health and safety implications of allowing untrained personnel onto the sites. Any future work study needs to take into account the practicalities of sampling for the design of the sampling programme.

#### *4.3.4 On site compositional analysis*

Finding space on sites for sampling and access to suitable and/or covered facilities was a constant challenge for the compositional analysis. By adopting a flexible approach, including purchasing inflatable tents for use where necessary, the number of sites that could not be visited due to a lack of suitable sorting areas was limited significantly. Flexibility with the work plan is a key lesson for any future work programmes.

One of the challenges with the compositional analysis was ensuring that no additional materials (target or non-target) were introduced into the study sample during the analysis. This was managed by collecting each sample in a suitable container (builders' bags for paper, card and plastics; boxes for metals and glass), clearly labelling it, sorting each sample individually and clearing all material away prior to sorting a new sample. The floors were also lined with plastic sheeting each time and this was cleared and emptied after each sample was sorted. The sorting space was also segregated into areas designated for each material to be sorted. This helped to minimise cross-contamination of recycle. All these are good practices which should be adopted for future studies.

There were some health and safety considerations, particularly with manual handling of glass and especially broken glass. In general, these concerns were managed by the sampling personnel wearing appropriate gloves and eye protection when handling glass. There were no reported health and safety incidences and this showed a good and well managed process.

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A key requirement by WRAP was that a site-specific health and safety assessment should be undertaken by RPS for each site visited. This requirement was also demanded by the sites themselves, with most also carrying out a site induction for the sampling personnel. This is good practice that should be embedded in future studies.

The project manager conducted a series of site visits during the course of the surveys, including attending the municipal recycle pilots. This was useful in gaining an appreciation of the challenges faced by the survey team and their general working practices. It was also useful to see a range of different site layouts and how the survey team adapted to each of these restrictions. Stakeholders were also offered the opportunity to undertake some site visits if interested. Future studies should ensure this practice continues.

#### *4.3.5 Data collation and analysis*

One of the assumptions at the start of the work programme was that it would be relatively easy to assess the typical level of affluence/deprivation of a collection round, by asking the local authority, site or driver; this was so the possible link between levels of affluence and contamination of recycle could be investigated. This was found not to be the case. Instead the Index of Multiple Deprivation (IMD) for areas corresponding as closely as possible to the collection round was used. This was only available for England and was time-consuming. Any future study should a) allow sufficient time and resource for this and b) not expect that local authorities, sites or drivers can give information of this nature.

One requirement was that the data be processed and uploaded within one week following completion of the survey. For a number of reasons relating to data availability, this was not possible. Future studies should engage with the contractors from the beginning to discuss and agree what is realistic and practicable, so project plans for delivery can better fit to more realistic timescales.

The information required was specified and agreed with the contractor in the early stages. A sample spreadsheet of the data was then provided prior to data population and submission of each site's data. Agreeing the format and requirements upfront ensured that the contractor was aware of our expectations in terms of information required and that this was provided in a suitable and consistent format. Prompt feedback to the contractor at each stage was also important to ensure that nothing was missed. This practice is to be encouraged in any future study.

A real benefit to the project was the establishment of a secure website where the data could be uploaded. This was very useful as it ensured inboxes were not constantly clogged up with large files. Also folders could be created to show when new data was uploaded, making tracking of information provided very easy. For future studies with large amounts of data handling, this practice should be strongly encouraged.

A lot more statistical analysis was required than was originally anticipated. A lesson learned from this project is that the data analysis involves a large statistical component, hence appropriate time and resource should be allocated to this.

#### *4.3.6 External peer review*

Having a peer reviewer engaged at the very start of the process proved a useful way to get immediate feedback on the project and make amendments as the project progressed, rather than wait until the end to get the report peer-reviewed, by which time it would have been too late to adapt.

The experience in waste management and particularly sampling that the peer reviewer brought also enabled improvements to be made to the sampling and evaluation programmes and this was very useful. Engaging the right peer reviewer for any such project is therefore essential.

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## 4.4 Recommendations

### 4.4.1 *Tackling contamination*

Although contamination is generally low in source-separated recycle streams, there are still improvements that can be made. Metals streams are the most heavily contaminated, so work could be done with collection crews to ensure contamination is removed more effectively.

In particular, plastics appear to be a significant contaminant in many recycle streams. People find it difficult to determine which plastics are recyclable due to the range of plastic polymers and differences between schemes. Further efforts should be made to educate waste producers – both householders and businesses – as to what is accepted in each stream.

### 4.4.2 *Addressing shortcomings in the study*

The most significant shortcoming in the study was the failure to secure enough samples of business recycle, resulting in unreliable data on business recycle contamination. Because the data collected indicate that business recycle is less contaminated than municipal recycle, it would be possible to use only the municipal data to set benchmarks or acceptable ranges for contamination from combined schemes across all sources, municipal and business. Ideally, though, a way would be found of boosting the sample size for business recycle to make the data more reliable. Commissioning a further programme of sampling would be an option, ensuring more time for recruitment and engagement of key influencers such as trade associations and major reprocessors. Statisticians should advise on whether it is possible to combine new data with the existing data, or whether a whole new programme would be required.

Taking into account the evidence from this study that local authorities are moving away from source-separated collections, the study should be repeated, if possible, in a few years' time when the Scottish regulations have had time to take effect. Any repeat of the study should repeat best practice including:

- a clear strategy for sampling at each site;
- a focus on health and safety, including the requirement for site-specific risk assessments;
- the involvement of a peer reviewer throughout the whole process; and
- involvement of a wide range of stakeholders with regular meetings.

It should also take account of the methodological lessons set out above, including:

- allowing more time for the study, particularly to ensure the data on which sampling frameworks are based is as robust and complete as possible;
- avoiding recruiting over the summer holiday period;
- taking more time to ensure all the key industry bodies are involved and willing to contribute;
- finding ways to solve some of the on site challenges, including limited access to mechanical loading equipment; and
- allowing plenty of time for high quality data analysis.

In repeating this study, it will be important to give consideration to capturing and reporting weights of each contaminant separately. This will help differentiate contaminants that are problematic to reprocessors from those that are less problematic.

Zero Waste Scotland will publish a separate report or briefing paper, based on the data collected for this study, on the factors that influence contamination. This is expected to be in summer 2014.

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## Appendix A: Examples of contaminants in source-separated recycle material (as described by the reprocessor)

**Table A0.1 Contaminants in source-separated recycle**

| Primary material | Examples of items counted as contaminants (non-target or non-recyclable)            | Examples of integral contaminant items that will not be counted                                                                                                                                                                    | Examples of non-integral items that will <u>not be counted</u> as contamination (i.e. they would typically be accepted by the reprocessor) (not to be sorted) |
|------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Paper            | Cardboard, plastic bottles, plastic wrappers                                        | Staples, plastic windows on envelopes, binders, string (unless loose)                                                                                                                                                              | Wet or soggy paper. This will be sorted by the waste contractor with additional notes made, such as paper-wet                                                 |
| Card             | Magazines, sandwich boxes (assume these would be preferred under paper), catalogues | Paper labels, staples, glue, binding                                                                                                                                                                                               | Cigarette packets, laminates (e.g. Pringles tubes)                                                                                                            |
| Glass            | Green or brown glass in a clear glass collection stream, plastic bottles            | Straws in bottles, metal lids on jars and bottles, liquid bottle contents (i.e. original contents), other bottle contents (e.g. cigarette ends), paper labels, foil on necks, corks/plastic stoppers, lemon/lime wedges in bottles |                                                                                                                                                               |
| Metals           | Aluminium foil where not specifically collected, aluminium food trays/ containers   | Paper labels, plastic wraps, plastic six-pack rings/yokes                                                                                                                                                                          |                                                                                                                                                               |
| Plastics         | Plastic film in dense plastic stream, plastic food trays in HDPE stream             | Plastic film wraps, paper wraps/labels, bottle contents                                                                                                                                                                            |                                                                                                                                                               |

*\*The non-contaminants listed here are anticipated to be inherent within the recycle material and will not be sorted into the non-target or non-recycle category unless these are collected among the residuals stream, i.e. no additional effort would be made, for example, to extract the straw or lime wedges inside a glass bottle. However, the waste analysis contractor would be asked to record observations such as "a large proportion of the target recycle glass stream contained lemon/lime wedges and plastic straws; it is possible that these may be a collection from a bar/pub/club or similar business establishment".*

## **Appendix B: Summary of the peer reviewer's comments**

**Name of document author (individual and organisation):**

Dr Barbara Leach and Nnenna Isiadinso

**Name of peer reviewer (individual and organisation):**

Dr Robin Curry; SRI Consulting

**Name of document/s reviewed:**

Contamination in source-separated municipal and business recycle in the UK 2013. Final Project Report. March 2014

|   | <b>A. Identification of issue to be clarified.</b><br><br><i>Please identify the location in the report/database and the nature of the issue</i> | <b>B. Thoughts or concerns of peer reviewer.</b><br><br><i>What would you like to receive more clarity on?</i>                                                                             | <b>C. Response from report author</b><br><br><i>How have you addressed the peer reviewers thoughts or concerns?</i>                                                    | <b>D. Response from peer reviewer</b><br><br><i>Has the report author adequately addressed your thoughts and concerns?</i> |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| 1 | Executive summary.<br>Methods.                                                                                                                   | Is it correct to use the term 'three measures of the average' to describe:<br><br>Mean (geometric);<br>Mean (arithmetic); and<br>Median.<br><br>Suggest 'Three measures of contamination'? | Comment accepted – report changed throughout including in the Executive Summary, in paragraph 1 on page 5, the final paragraph on page 24, and paragraph 1 on page 25. | Yes                                                                                                                        |

|   |                                                             |                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                      |     |
|---|-------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 2 | Executive summary.<br>Factors that influence contamination. | I would replace this with the para of text from 1.2?<br><br>' In addition it was decided that the study should also attempt to analyse the relationship between some key variables and the level of contamination measured in order to draw some tentative conclusions about the kinds of factor that might lead to more and less contamination in source separated recycle'. | Agreed – it is an oversight that this is still included. It now says:<br><br>"The data collected as part of the project lends itself to an analysis of the factors that influence contamination. This analysis will be published separately by Zero Waste Scotland." | Yes |
| 3 | Introduction.                                               | The report provides an excellent description of the justification for the research project:<br><br>'No recent and robust information on levels of contamination in source separated recycle could be identified'.                                                                                                                                                             | No action required                                                                                                                                                                                                                                                   | Yes |
| 4 | 1.4 This report.                                            | Typos in final para:<br><br>(chapter 3 starting on page 28)<br><br>Finally the conclusions and recommendations are presented in chapter 4 on page 49.                                                                                                                                                                                                                         | There were problems in automatic cross-referencing in the version sent to the peer reviewer – this has been corrected in the final version                                                                                                                           | Yes |
| 5 | 2 Methodology.                                              | Typos in final para of Section 2 intro:<br><br>'Chapter 4 on page 49'                                                                                                                                                                                                                                                                                                         | There were problems in automatic cross-referencing in the version sent to the peer reviewer – this has been corrected in the final version                                                                                                                           | Yes |
| 6 | 2.1 Key definitions.                                        | 'Statistical significance/level <b>or</b> certainty'<br><br>1. Should this be 'level of certainty'?<br>2. Suggest removal of 'tentatively'?                                                                                                                                                                                                                                   | Yes – it should be 'level of certainty' – this has been corrected<br><br>'Tentatively' has been removed                                                                                                                                                              | Yes |

|    |                                                                 |                                                                                                                                                     |                                                                                               |     |
|----|-----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----|
| 7  | 2.2.1 Local authority sampling – municipal and business recycle | Para 4:<br>The 160 local authorities were randomly <b>assigned</b> to an ordered list?                                                              | Agree – it should say 'randomly assigned' – 'assigned' has been added                         | Yes |
| 8  | 2.3 Recruiting the sites                                        | A two-phase recruitment <b>programme</b> was conducted?                                                                                             | Agreed and amended                                                                            | Yes |
| 9  | 2.3.1 Local authority recruitment                               | 'In many cases this was due to cans and plastics being collected comingled <b>and cardboard being mixed with green waste</b> '.<br>Is this correct? | Yes this is correct – some local authorities allow cardboard to be collected with green waste | Yes |
| 10 | 2.3.1 Local authority recruitment                               | Para beginning 'Later in the study the prerequisite..<br>Del 'Later in the study', begin sentence 'The prerequisite'....                            | Agreed and amended by the proof reader                                                        | Yes |

|    |                                                       |                                                                                                                                                                                                                                                                       |                                                                                                                                                                    |     |
|----|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 11 | 2.4 Compositional analysis                            | <p>Final para.</p> <p>'and an approximation of the level of deprivation along the route'.</p> <p>Revise wording to 'an approximation of the socio-economic make-up of the collection route'?</p>                                                                      | Agreed and amended                                                                                                                                                 | Yes |
| 12 | 2.4.2 Source separated business recycle               | <p>'Samples were collected from sites in three out of the four UK nations'.</p> <p>Should we say what these were?</p>                                                                                                                                                 | Agreed (England, Northern Ireland and Scotland) and we have also added that this was due to businesses not being willing to take part in the fourth nation (Wales) | Yes |
| 13 | 2.5.2 Contextual factors                              | <p>'indicative level of deprivation of households on the collection route based on level of affluence (lower, lower-middle, middle, middle-upper, upper and mixed incomes)'</p> <p>Change to social-economic category (this is the terminology used in Table 2.7)</p> | Agreed and amended                                                                                                                                                 | Yes |
| 14 | 2.5.2 Contextual factors                              | A detailed summary of this information is presented for each recycle in chapter 3.                                                                                                                                                                                    | There were problems in automatic cross-referencing in the version sent to the peer reviewer – this has been corrected in the final version                         | Yes |
| 15 | 2.5.3 Measures of typical contamination               | Detailed findings are presented in chapter 3                                                                                                                                                                                                                          | There were problems in automatic cross-referencing in the version sent to the peer reviewer – this has been corrected in the final version                         | Yes |
| 16 | 3 Levels of contamination in source separated recycle | <p>Para 2.</p> <p>I think this form of words is as good as it gets in terms of presenting the research results to policy makers and regulators.</p>                                                                                                                   | No action required                                                                                                                                                 | Yes |

|    |            |                                                                                                                  |                                                                                                     |     |
|----|------------|------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----|
| 17 | 3.3 Glass  | Possibly state in Para 1 that only mixed glass samples were collected from business sources?                     | Agreed – the following sentence was added:<br><br>“Only mixed glass was collected from businesses.” | Yes |
| 18 | 3.4 Metals | ‘Contamination in <b>mixed glass</b> from business sources’<br><br>Contamination in metals from business sources | Agreed and amended by the proof reader                                                              | Yes |

|    |               |                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |     |
|----|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 19 | 4 Conclusions | <p>General comment</p> <p>Switches to first person under Recruitment:</p> <p>` At the start of the project, <b>we</b> sought to engage with all the relevant stakeholders'</p> <p>Sections on Recruitment, on-site sampling and data collation and analysis all probably overlong, and written in different style to the rest of the report.</p> | <p>Use of first person has been removed.<br/>The paragraph mentioned now says:</p> <p>"At the start of the project, relevant stakeholders were engaged including regulators ..."</p> <p>4.3.5 now says " this was so the possible link between levels of affluence and contamination of recycle could be investigated."</p> <p>And</p> <p>"This was found not to be the case. Instead the Index of Multiple Deprivation (IMD) for areas corresponding as closely as possible to the collection round was used."</p> <p>4.3.6 now says:</p> <p>"Having a peer reviewer engaged at the very start of the process proved a useful way to get immediate feedback on the project and make amendments as the project progressed, rather than wait until the end to get the report peer-reviewed, by which time it would have been too late to adapt."</p> <p>Appendix A now says</p> <p>"... it is possible that these may be a collection from a bar/pub/club or similar business establishment."</p> <p>We have also cut some text out of some paragraphs to reduce the length.</p> | Yes |
|----|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|

|    |                        |                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                 |     |
|----|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 20 | 4.3.3 On-site sampling | <p>Para 3.</p> <p>` Future studies should have a plan in place for selecting the target routes/ samples and this should be shared with and agreed with the <b>project manager</b> ahead of time then consistently implemented`.</p> <p>Should this be site manager?</p>                                                                                                                | <p>No, we meant that the contractor should share this information with the Zero Waste Scotland project manager. We have rephrased to make this clearer:</p> <p>"...should be shared and agreed between the client-side project manager and the contractor ahead of time and then consistently implemented."</p> | Yes |
| 21 | 4.4 Recommendations    | <p>I think it's important to refer to the ongoing research in 'Factors that influence contamination' here?</p> <p>This will/should provide insights that can provide an evidence base for policies or interventions that could further reduce contamination i.e. identifying where contamination is caused by householders, and where it is more likely to be sorting crew errors?</p> | <p>Agreed and the following paragraph has been added:</p> <p>"Zero Waste Scotland will publish a separate report or briefing paper, based on the data collected for this study, on the factors that influence contamination. This is expected to be in summer 2014."</p>                                        | Yes |

|    |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |     |
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| 22 | 4.4 Recommendations | <p>Since the study was clearly a 'success' with respect to assessing the levels of municipal contamination, but less so with respect to business, should the recommendations reflect this?</p> <p>I think it is worthwhile specifically addressing this para from Chapter 3:</p> <p>'The levels of contamination in both municipal and business recycle are presented for each material sampled. Although we present the data for business recycle, the small sample size means that caution should be exercised when using the figures as it is likely that the results are an unreliable representation of the situation in the UK. <b>The same does not apply to municipal recycle, the results of which can be relied upon as being representative of the situation in the UK in 2013</b>'.</p> <p>This goes back to the starting point of the study, which was:</p> <p><b>Background.</b></p> <p>'To address the lack of robust data on the quality of source-separated dry recycle'.</p> <p><b>So we now have robust data on municipal, but not business.</b></p> <p>Is it appropriate for the report to suggest options for improving the business data - for example, carrying out further work dedicated to business recycle (or investigating the options for doing this?); or</p> <p>What the options might be for use and/or target setting for business recycle contamination.</p> | <p>Agreed. The recommendations section has been restructured and the following paragraph added::</p> <p>"The most significant shortcoming in the study was the failure to secure enough samples of business recycle, resulting in unreliable data on business recycle contamination. Because the data collected indicate that business recycle is less contaminated than municipal recycle, it would possible to use only the municipal data to set benchmarks or acceptable ranges for contamination from comingled schemes across all sources, municipal and business. Ideally, though, a way would be found of boosting the sample size for business recycle to make the data more reliable. Commissioning a further programme of sampling would be an option, ensuring more time for recruitment and engagement of key influencers such as trade associations and major reproducers. Statisticians should advise on whether it is possible to combine new data with the existing data, or whether a whole new programme would be required."</p> | Yes |
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**Overall comments from peer reviewer (to be completed at the end of the peer review process):****1. What was the purpose of the peer review?**

To peer review the final project report for the Zero Waste Scotland study 'Contamination in source separated municipal and business recyclate in the UK 2013'.

**2. What method did you use to complete the peer review?**

The WRAP Peer Review template.

**3. Are you confident that the peer reviewed document is fit for purpose?**

The report is well written and structured and provides a transparent and robust description of the methods, results and conclusions. The report does an excellent job of presenting the results of a complex project in a way that should facilitate its use by policy makers and/or regulators, particularly in its use of carefully worded language to describe the limitations of the research outputs and the use of different measures of contamination. The final report has fully addressed all of the thoughts and/or concerns set out in my peer review dated 19.03.2014.

Dr Robin Curry  
Peer reviewer  
21.03.2014