Appendix 5: Review of waste auditing methodologies

In this Appendix we summarise and comment on the methodologies typically employed in the compositional studies collated for this project, as follows:

- **Appendix 5.1:** UK waste auditing methodologies in the context of international practice
- **Appendix 5.2:** Review of analysis methods for kerbside wastes
- **Appendix 5.3:** Review of analysis methods for HWRC wastes.

5.1 UK waste auditing methodologies in the context of international practice

'it is always possible to do correct sampling, but it is not always at an acceptable cost'

Pierre Gy: Theory of sampling[1]

A number of different compositional analysis techniques have been applied to municipal waste streams across Europe and elsewhere in the industrialised world. These techniques have been developed since the 1970s and some have been used on a repeated basis over a couple of decades. However, there are no agreed European or international standards for conducting these studies and it is unlikely that such standards could be implemented because of the diversity of housing types, waste collection systems and research objectives in different countries. There has been little innovation in the auditing methodologies used in recent years (such as use of digital scanning and mechanical sorting technologies), with techniques much the same as those used in the 1970s and earlier. This is mainly as a consequence of simple hand-sorting being regarded as a more reliable method of sorting waste; and recognition of the difficulties associated with applying pre-sort technologies, (such as size fractioning through the use of a trommel) in making the task of sorting more difficult as smaller particles are broken off from larger pieces of material in the waste sample. For a general review of these methods see *Parfitt, Flowerdew and Pocock 1999*[2].

As with the case of compositional studies in the UK, sampling strategies have not been founded on the collection of empirical data that establish the credentials of a particular methodology. Many techniques do not attempt to estimate sampling errors or to test the stratification benefits of sampling strategies. Most methods are therefore largely a reflection of the practicalities of obtaining waste samples, how much material can be sorted by a small team in a day and to reflect local preoccupations in terms of chosen waste categories and the available budget.

As is the case in the UK, most methods have focused on kerbside collected municipal wastes. Those that have been formally referenced as 'waste analysis methods' differ from one another across a number of key parameters, which are common to the issues that face waste analyses in the UK:

- How many samples should be taken?
- How should the population to be divided into strata for sampling purposes?
- How often should samples be taken and from how many strata?
- How will seasonality be addressed?
- How should samples be obtained: at what point in the waste collection/ treatment/ disposal system: from households or refuse trucks?
- Will the sample be further sub-sampled?

1 Pitard, F.F. 1993. Pierre Gy's Sampling Theory and Sampling Practice: Heterogeneity, Sampling Correctness, and Statistical Process Control. CRC Press London.

2 Parfitt J., Flowerdew, R and Pocock, R.L.; A Review of UK Household Waste Arisings and Compositional Data; R&D Technical Report, Department of the Environment, Transport and the Regions Wastes Technical Division, 1999, pg 240.

- How should samples be sorted: what technology (if any), which categories?
- How should the data be reported, how will statistical uncertainty in estimates be defined?

The main approaches are summarised in Table 5.1 and one of the key dichotomies is whether or not samples are obtained from collection vehicle loads or from street bins/individual households. In the United States, most methodologies appear to focus on sampling from collection vehicles and then sub-sampling from the load by means of coning and quartering techniques (ASTM 2003, CIWMB 1999), whereas in Europe, auditing is generally more focused on bin-based samples. The term 'waste bin' covers a variety of different containment systems, but in the context of many European cities this would mean a capacity range of between 120 – 1100 litres, with the upper limit serving the much higher proportion of households (compared with the UK) living in apartment blocks. The housing type differences are reflected in the methodologies applied: apart from Ireland and the UK, no other country has used a sampling methodology which samples at the individual household level.

Although attempts have been made to standardise waste analysis methodologies, these have not met with much success. The most recent of these was the proposed European standard waste sampling and sorting methodology 'Solid Waste Analysis Tool', or SWA-tool, (European Commission, 2004). This project was intended to establish a universal waste analysis methodology that could be applied in all European countries with a view to improving the quality of waste audits and to make results more comparable. It involved seven participating countries and input from a number of different recognized waste analysis methodologies, such as the MODECOM method (ADEME, France and the Argus method from Germany). In total 10 different methodologies were evaluated and statistical tests were carried out on existing data sets on the factors influencing waste composition, focused on the choice of stratification variables. The objective was to confirm which choices were effective elements in sampling strategy in providing strata with more variation between than within groups. This has the benefit of increasing the accuracy of the study results for a given sample size. Following the review stage, a standardised technique was implemented, largely based on Austrian, German and UK methodologies. This was applied in selected municipalities in Austria, Germany, Italy, Spain, UK, Romania and Poland. The main output from the project was a manual describing the standardised approach to waste analysis.

The desk-based stage of the study pooled data mostly collected using the MODECOM method, with usable datasets from five countries. The evaluation of stratification criteria remains one of the few objective attempts to look at stratification benefits in any of the research literature, so is relevant to the review of techniques used in the UK. A series of bivariate (ANOVA) and multivariate tests were performed on the data (i.e. multivariate analysis of variance), although there were problems with the lack of consistency in how many elements each stratum contained and the number of samples taken per stratum. In total data from 37 waste analyses consisting of 122 waste sorting phases were analysed, from which only 35 were found to be usable. Disappointingly, the results were inconclusive in many cases, but reinforced the main stratification techniques that have been used, namely:

- residential area type (suburban, rural, etc)
- source of waste (household/ commercial)
- waste containment: bin size.

These factors were found to have stratification benefits in the majority of studies (Table 5.2). For the two stratification methods most associated with UK waste analysis, namely seasonality and socio-economic group, there were too few studies to give a clear picture of the stratification benefits. However socio-economic group and area types are likely to be inter-correlated. Surprisingly, only 12 waste analyses were available stratified by season.

Table 5.1: Basic features of waste analysis methods used in Europe and the United States

Method	Are different municipally collected waste streams separately identifiable?	Sorting of compositional fractions fully defined?	Is waste weighing methodology specically defined?	Level of sampling	Sampling units fully defined in guidance?	Sampling error estimated ?	Method of sorting components
Austria Vienna	no	yes	no	waste bin	yes	yes	manual
Austria Hauer	no	yes	no	waste bin or truck	yes	yes	manual
Germany, Brandenberg guidelines/ Argus method	yes	yes	yes	waste bin, no sub-sampling	yes	yes	manual
Italy UNI 9246	no	yes	no	truck	no	no	manual
Switzerland, Maystre and Viret 1995	yes	yes	yes	waste bin	yes	yes	manual no sub-sampling
Finland, Nordtest / NSR method	no	yes	yes	sub-sampling from trucks	no	no	combined manual and screening
France, ADEME/ Modecom	no	yes	no	sub-sampling from trucks	yes	no	combined manual and screening
Ireland EPA	yes	yes	no	household	no	no	manual
Netherlands AOO-IPA, RIVM, Cornelissen and Otte 1995	yes	yes	no	waste bin	no	no	combined manual with belt, trummel, magnets, vibrator & cyclone
USA Rugg 1997	no	yes	no	sub-sampling from trucks	no	no	manual
ASMT 2003	no	yes	yes	sub-sampling from trucks	yes	no	manual
Franklin Associated 1999	material flows analysis based on linking products with overall municipal waste	NA	NA	at a national economy level, based on production data and time lags			NA
European Commission (SWA-tool) 2004	yes	yes	yes	waste bin no sub-sampling	yes	yes	combined manual and screening

Table 5.2: Assessment of stratification criteria used in waste analysis methods across Europe (SWA-Tool, European Commission 2004)

Strata	Example descriptions	Comments	% of waste analysis studies with stratification benefit	Waste categories associated with strata
area type defined by residential structure	suburban, multiple occupancy and high rise		60%	
bin size	120 litre, 240, 1100 litre bin sizes (ARGUS data)		75%	paper, card, plastics
waste collection system	areas with and without bio-bins	insufficient data	no clear results	
socio-economic group	more affluent v less affluent areas (Vienna), social class A,B,C (Dublin)	stratification benefit in 2 cases, but only 4 studies available	some benefit, limited data	glass, metals and plastics fines more difference between strata
source of waste	household or commercial	limited data	benefits found, but limited data	paper, card, healthcare products, composites, fines, textiles
season	many of the single season studies in spring or autumn	insufficient data	no clear results	garden waste

The SWA-tool used the German approach defined a volume (45 cubic metres) as the minimum for a waste analysis campaign for samples derived from bin sampling, sub-divided into strata. With commercial waste samples, the guidance recommends increasing the sample to 80 cubic metres. The ADEME / MODECOM method, where the unit of sampling is the collection vehicle, set a minimum of 5 refuse trucks per waste analysis survey, from which less than 2 tonnes of waste is sorted, with 10 random samples selected from each vehicle.

The number of categories used by different European studies are usually arranged into primary, secondary and occasionally tertiary category lists. The SWA-tool study settled on 12 primary categories, and ADEME used 13 categories. One distinction between many of these classifications and those used in the UK is their tendency to have ‘organic’ or ‘biowaste’ as a primary category rather than ‘garden waste’, ‘food waste’ and ‘other organic’. Apart from this distinction, the primary categories are mostly similar to the primary list developed in this review, (minus the special categories used in this study to deal with HWRC materials): paper, plastics, glass, metals, wood, textiles, hazardous waste, miscellaneous combustibles, miscellaneous non-combustibles and fines.

The SWA-tool also attempted to set the number of samples required in a compositional analysis to achieve a pre-determined level of statistical significance. This determined by the formula:

$$n^* = \left[\frac{s * t}{e' * \bar{x}} \right]^2$$

where:

(s) is the coefficient of variation for the proportion of the waste component in question, obtained from previous studies
(t) is a t-test value for a chosen level of statistical significance and the degree of freedom (obtained from previous studies)
(e') is the chosen significance level (e.g. 0.01)

($\bar{x}$) is the mean value of the proportion of the waste category in question.

This equation has fundamental implications for the design of waste analysis, not given full recognition in the wider literature, nor in the SWA-tool’s attempt at a standard approach to European waste analysis. For waste categories that are a small proportion of the waste, with a high coefficient of variation, the number of samples required will be very large. It is therefore not possible to set pre-determined levels of statistical significance for compositional analyses as it is not possible to achieve this level of statistical significance for all categories (at both primary and secondary levels).

Even though there are high recycling rates in many European countries, there is little consideration of how compositional analysis of residual waste can be best integrated with operational data (residual and source-separated) and combined to produce estimates for a locality, region or country. This may be partly due to the lack of any equivalent system to WasteDataFlow that reports waste arisings at a local level in other European countries, from which local authority operational statistics can be compiled and grossed-up to produce national or regional estimates of composition.

5.2 Review of analysis methods for kerbside wastes

Following on from discussion of the international context, most UK kerbside studies have involved the sampling bins at the kerbside rather than from collection vehicles at a facility. However historically, this has not been the case with the National Household Waste Analysis Programme in the early 1990s sampling from RCV’s, followed by sub-sampling and the use of a trommel.

Some form of area type stratification and coverage of seasonality were two of the factors used in the selection process, described in Appendix 3, to choose which kerbside studies to collate and analyse further. Across the collated studies the basic features of the physical acquisition of waste samples and sorting procedures did not vary significantly between contractors (unlike the analysis of HWRC sampling described in Appendix 5.3). All of the 120 collated studies were based on waste as set-out at the kerbside, rather than sampled from collection vehicles. They do differ, however, in several aspects that are reviewed in more detail here:

- level of sampling
- the use of stratification within overall study design
- categorisation: mainly at the secondary rather than primary level.

5.2.1 Level of sampling

The main approach taken in the UK is to stratify the sample and then identify street blocks that have characteristics that relate to a chosen stratum of the population of households to be sampled. Waste set out for collection is then sampled in order to fulfil a target quota of households belonging to a particular stratum of the population that has been determined for the district. Samples are labelled on the round as they are picked-up and sorted in bulk at a depot or other suitable facility. Less than 5% of all kerbside studies (selected and non-selected) sorted material and analysed material at the household level. The vast majority of kerbside sampling was therefore based on bulk samples as a more cost-effective means of characterising composition without the difficulty of recording weights against individual (anonymous) household records. The difference in approach represents a difference in research objectives, with studies focused on the household level far more interested in predictive modelling and a direct link between household characteristics and waste, such as would be the case for modelling householder responses to a recycling trial or a home composting programme.

5.2.2 Stratification of samples

Four different stratification methods were used to choose samples within kerbside waste analysis studies:

1. ACORN: a geodemographic package based on Census 2001
2. Mosaic: a geodemographic package based on Census 2001
3. Council Tax banding
4. Urban / Rural.

ACORN, like Mosaic and the ONS classification, is a general-purpose geo-demographic classification devised to help businesses target potential clients. It is based on factor analysis of a set of variables thought to be relevant to this targeting. Waste generation is likely to be linked to some of these variables, but others will be totally irrelevant. It can also be difficult to work out exactly what the categories represent; the somewhat simplistic category labels sometimes misrepresenting the majority of the population because a minority group is well represented. Mosaic suffers from the same problems.

The use of Council Tax bands has the advantage of transparency – it is clear how the sampling is organised. However, it probably does not reflect all the factors affecting waste generation, nor can it be used easily for comparisons between authorities (due to the lack of equivalence of banding between areas and regions of the country). Likewise the use of urban / rural measures is conceptually clear but only refers to one of several factors that may affect household waste.

In theory it is more effective to use the relevant original variables as they are presented by Census or Neighbourhood Statistics, rather than the less relevant (or irrelevant) factors used in general-purpose geo-demographic classifications. These variables can form the basis of a sampling strategy. This was the approach taken by the 2003 Welsh Assembly Government study (Burnley *et al.* 2007). Essentially this consisted of randomly selecting many sets of neighbourhoods to evaluate, and choosing the set which will best allow the effect of individual variables to be picked out by maximising their standard deviations and minimising inter-correlations between variables. Such a strategy should make it easier to determine which variables are most related to waste. However, the use of such a stratification technique within a sampling strategy could only be taken forward if a unified programme was planned as the basis for generating national estimates of kerbside waste composition.

The benefit that ACORN has is that it is understood and used by local authorities; however the stratification benefits have not been formally quantified and the 'level' at which ACORN is used needs further consideration. Most of the studies reviewed here use ACORN at its highest level (termed 'ACORN Category', it contains 5 categories: 1.'wealthy achievers', 2.'urban prosperity', 3. 'comfortably off', 4. 'moderate means' and 5. 'hard pressed'). However, when sub-divided into at the 'group' level it might prove more effective in creating different strata in some districts ('wealthy achievers' contain three groups: 'wealthy executives', 'affluent greys' and 'flourishing families': each of these might be associated with differences in waste arisings and composition).

A variety of different approaches to the use of ACORN stratification are apparent in the larger county-level waste analyses:

- ACORN stratification is applied to each district separately and may or may not be weighted to the ACORN profile for each district
- ACORN stratification is applied across a county as a whole, but without each category represented in each district.

It is usually the case that districts within a county differ significantly in a number of factors that are not represented in ACORN. The most important of these are likely to include differences in waste collection systems (alternate week collections for refuse or not; differences in HWRC provision and recycling infra-structure). In this respect, the use of ACORN to estimate composition for districts that have not been sampled is a dubious practice and likely to produce inaccurate projections at the county level.

5.2.3 Kerbside component categorisation at secondary level

This study has analysed compositional datasets at a primary category level (see Appendix 4.1). However dealing with waste components at a primary category level somewhat obscures the problems arising from different categorisation systems used across kerbside studies at a *secondary category level.* The types of problems and ambiguities arising from varying descriptions of secondary categories is illustrated in Figure 5.1, which demonstrates the categorisation of food waste across 14 kerbside residual studies. Each of the studies has described or defined food waste subcategories differently. Some of the differences are trivial, whilst others are highly significant, and there are also some "grey areas" wherein some subjective judgement is required.

Figure 5.1: Food waste subcategories in 14 kerbside residual studies

Year	Contractor	Area	FW "home compostable"	FW "non-home compostable"	Other putrescibles
2001	SWAP	Westminster	Kitchen compostable	Kitchen non-compostable	
2003	NR	South Oxfordshire	Home compostable kitchen waste	Other kitchen waste (meat, bones etc)	
2003-04	AEAT	North London WA	Kitchen waste		Other putrescibles
2003-04	SWAP	Shropshire County Council	Meat, cooked food + other kitchen waste		
2004-05	RF	Cambs & Peterb	Kitchen home compostable	Kitchen other organics	Cooking oils
2005	MEL	Tees Valley	Raw fruit and vegetable matter	Cooked, prepared food inc meat and fish	Unidentified
2005-06	nk	Edinburgh (?)	Organic Kitchen (catering) Waste Only		
2006	MEL	Dorset	Compostable putrescibles	Cooked or prepared food inc. meat and fish	Unidentified putrescibles
2007	RF	East Riding	Home compostable food waste	All non home compostable food waste	Oils and liquids eg milk
2007	RF	South Oxfordshire	Kitchen home compostable	Kitchen other organics	Liquid foodstuffs
2007	RF	Western Riverside	Kitchen home compostable	Kitchen other organics	
2007	RPS	Northern Ireland review	Home Compostable Kitchen Waste	Non-Home Comp Kitchen Waste	Other Organic
2008	MEL	Bromley	Raw Fruit & veg	Cooked/prepared food	All other putrescible
2008	RF	Hull	Kitchen home compostable	Kitchen other organics	Cooking oils

A further complication arising at the secondary category level is that, for an individual dataset, it is often the case that the actual meaning of a category description can only be understood in the context of other categories.

Quite apart from this, across all the collated kerbside datasets there is a huge proliferation of waste component descriptions at the secondary category level. Very often there are only trivial differences between secondary categories, even down to using slightly different spelling or phrasing. However in other cases there are potentially substantial differences between the different categories.

The issues arising at a secondary category level are further illustrated in Table 5.1, wherein paper & card across 40 of the collated kerbside residual datasets have been collectively analysed, to produce a list of all secondary categories used across the studies. In total there are 92 secondary categories relating to paper and card across these 40 studies. The complexity of the related data is illustrated in Figure 5.2, which shows how compositional audit data is arrayed across these 92 subcategories.

Table 5.1: Paper and card subcategories used in 40 kerbside residual datasets

All Non-recyclable paper & card	Newspapers
All Non-recyclable paper & card (inc window envelopes)	Newspapers and magazines, brochures and catalogues
All Non-recyclable paper & card inc Brown Envelopes	Newspapers and magazines, brochures and catalogues & Soft Cover Books
All Non-recyclable paper AND card	Newspapers and magazines, brochures and catalogues, soft books
All other recyclable paper	Newspapers and magazines, directories and catalogues
All Thin card	Newspapers, Magazines and Junk Mail
All Thin card inc packaging	Newsprint grade paper
All Thin card inc packaging & Cards	Non corrugated packaging
All Thin card inc packaging & Hard Back Books	Non-recyclable but compostable paper
All Thin card inc packaging inc Egg Boxes & Toilet Rolls	Non-recyclable liquid cartons
All thin card packaging	Non-recyclable non-compostable paper
Board packaging	Non-recyclable paper
Books	Non-recyclable paper e.g. tissue
Books and blue or white directories	Office Type Paper, leaflets, flyers, junk mail and plain envelopes.
Brochures, junk mail & other recyclable paper	Other card
Card and Cardboard	Other card - non-packaging
Card packaging	Other card packaging
Cardboard	Other non-recyclable paper & card
Cardboard (corrugated)	Other non-recycled paper
Cardboard boxes/containers	Other packaging card
Cardboard heavy	Other paper and card
Cardboard packaging - boxboard	Other recyclable paper
Cardboard packaging - corrugated	Other recyclable paper (inc envelopes)
Catalogues	Other recyclable paper inc envelopes, junk mail and white directories
Catalogues and other directories	Other recyclable paper inc plain envelopes, junk mail and white directories
Composite packaging - predominantly paper & card	Other recyclable paper- white envelopes, junk mail and white directories
Corrugated and all thick card	Other recycled paper
Corrugated cardboard	Other WHITE recyclable paper inc envelopes, junk mail and white directories
Corrugated cardboard, Egg Boxes & Toilet Tubes	Packaging card
Corrugated packaging	Packaging Card inc Egg Boxes
Egg Boxes & Toilet Tubes	Paper
Envelopes	Paper and light card
Envelopes with windows and other non-recyclable paper	Paper packaging
Flat and corrugated	Potentially reusable hard/paper back books
Flat card	Recyclable household paper
Flat card/card packaging	Recyclable paper
Glued spine (catalogues / directories)	Recyclable paper hi grade
Gluespined books & magazines etc	Recyclable paper lo grade
Hardback Books	Shredded paper
High grade paper	Telephone directories inc yellow pages
Household paper	Tetra Pak containers
Liquid cartons	Tissue & Kitchen Roll
Liquid cartons (tetrapak)	Tissues
Low grade paper	Tissues and hand towels and other non recyclable paper
Magazines	Whole cardboard boxes bigger than kerbside box
Newspapers & magazines	Yellow pages

Figure 5.2: Array of compositional data against comprehensive secondary category list for 40 kerbside residual datasets

ID	RF-001a	RF-002a	RF-003a	RF-004a	RF-006a	RF-008	RF-009a	RF-011a	RF-012a	RF-013a	RF-015-1	RF-016a-1	RF-017a-1	RF-018	RF-019	RF-022a	RF-024a	RF-025a	RF-026a	RF-028a	RF-031	RF-033	RF-034a	RF-035	AEA-115a	MEL-116a	AEA-117-1	ENT-118a-7	MEL-119a-5	ENT-147-1	WW-158	WW-148	MEL-172b	MEL-174	MEL-193-1	MEL-195-6	MEL-198	MEL-202	MEL-173-12	MEL-196
Study	Adur05	Arun07	BANES06-07	Barnet07	Beds08	Bournemout	Brighton06-0	Bristol05	Bucks06-07	Camden07	Amber Valley	Exeter	Chester-le-S	EastRiding07	EastSussex0	Greenwich05	Hereford07	Hull08	Islington05	Lancs05-07	Leics06a	Lichfield04-0	NSomerset0	Oxfordshire0	Milton Keyne	Merton	Barnet	South Norfol	Stockton-on-	Corby	Teignbridge	Rochford	Bracknell	Bradford	Caradon	Wansbeck	Hounslow	Coventry	Tunbridge W	Derby City
IMD	20.5	16.6	11.5	21.2	12.3	23.0	25.6	27.8	9.0	28.6	18.1	20.3	20.4	14.2	18.8	33.9	17.6	38.3	39.0	22.3	10.8	12.1	15.0	10.9	15.3	14.6	21.2	10.8	23.8	26.2	17.3	9.2	8.8	32.0	18.8	29.9	23.2	27.9	11.5	26.6
MSW stream	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid	KS resid
startyr	2005	2007	2006	2007	2008	2005	2006	2005	2006	2007	2005	2005	2006	2007	2004	2005	2007	2008	2005	2005	2006	2004	2007	2006	2005	2004	2003	2005	2005	2006	2007	2006	2007	2007	2007	2007	2007	2008	2007	2007
No. phases	1	1	4	3	2	2	4	4	2	2	3	3	4	2	2	2	4	4	1	6	1	2	1	2	2	2	4	2	1	1	3	1	1	1	2	2	2	1	1	1
Ph1	Oct-05	Sep-07	May-06	Feb-07	May-08	Jul-05	Apr-06	Mar-05	Nov-06	Feb-07	Sep-05	Sep-05	Oct-06	Aug-07	Nov-04		Feb-07	Mar-08	Aug-05	Mar-06	Mar-06	Dec-04	Oct-07	Dec-06	Jun-05	Oct-04	Oct-03	Nov-05	Oct-05	Oct-06	Jun-07	May-06	Mar-07	Nov-07	Jun-07	Apr-07	Sep-07	Feb-08	Oct-07	Aug-07
Ph2			Aug-06	Apr-07	Sep-08	Jan-06	Jul-06	Jun-05	Jun-07	Jun-07	Nov-05	Nov-05	Feb-07	Nov-07	May-05		Mar-07			Jul-06		Dec-05		Feb-08	Jan-06	May-05	Jan-04	Mar-06			Jul-07				Dec-07	Nov-07	Feb-08			
Ph3			Nov-06	Jul-07			Oct-06	Sep-05			Feb-06	Feb-06	May-07				Jul-07			Mar-07							Apr-04				Oct-07									
Ph4			Mar-07				Feb-07	Dec-05					Aug-07				Nov-07			Jul-07							Jul-04													
Phase	all	all	all	all	all	all	all	1	1	all	1	all	all	1	all	1	all	1	all	6	all	1	all	all	all	1	all	2	all	all	3	all	all	all	2	2	2	all	all	all
Acorn	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	all	All Mosaic	all	all	na	"Beat 1"	na	all	1	all	all	5, non-recycl	1	1	1	5	2	all	1	1
All Non-recyclable paper & card																																	2.19%						4.50%	
All Non-recyclable paper & card (inc window envelopes)																																								5.21%
All Non-recyclable paper & card inc Brown Envelopes																																			6.19%					
All Non-recyclable paper AND card																																					4.89%			
All other recyclable paper																																						2.65%		
All Thin card																																				0.16%				
All Thin card inc packaging																																	1.50%		1.84%					
All Thin card inc packaging & Cards																																							1.85%	
All Thin card inc packaging & Hard Back Books																																					2.09%			
All Thin card inc packaging inc Egg Boxes & Toilet Rolls																																								2.65%
All thin card packaging																																						3.06%		
Board packaging																												0.33%		1.84%										
Books																													0.03%											
Books and blue or white directories													0.29%																											
Brochures, junk mail & other recyclable paper																																4.51%								
Card and Cardboard																																6.34%								
Card packaging																												1.66%		4.60%										
Cardboard	4.67%		5.22%										6.79%			3.75%	1.42%																							
Cardboard (corrugated)										1.54%																														
Cardboard boxes/containers																											6.90%													
Cardboard heavy																																		4.30%						
Cardboard packaging - boxboard																									3.34%															
Cardboard packaging - corrugated																									1.39%															
Catalogues						0.00%	0.41%	0.82%			1.65%	0.20%			0.43%				0.35%		0.76%	0.22%									0.61%									
Catalogues and other directories		0.15%							0.17%	0.25%								0.24%		1.25%			0.05%	0.75%																
Composite packaging - predominantly paper & card																																						0.23%		
Corrugated and all thick card																																						17.92%		
Corrugated cardboard		0.37%				1.76%	0.89%	1.84%	1.35%		1.85%	0.52%		1.34%	1.52%			2.73%	2.22%	1.02%	0.79%	1.55%	1.33%	1.23%		0.86%			3.23%		1.13%		1.87%			0.53%	2.25%		0.91%	0.48%
Corrugated cardboard, Egg Boxes & Toilet Tubes																																			1.08%					
Corrugated packaging					2.17%																																			
Egg Boxes & Toilet Tubes																																	0.23%				0.40%		0.26%	
Envelopes																															1.21%									
Envelopes with windows and other non-recyclable paper																																				1.68%				
Flat and corrugated				8.14%																																				
Flat card		1.41%				3.41%	2.32%	2.72%	3.40%		1.90%	1.84%		4.50%	3.57%			4.50%	2.23%	2.19%	2.64%	2.22%	4.29%								2.00%									
Flat card/card packaging																								2.72%																
Glued spine (catalogues / directories)																										0.43%														
Gluespined books & magazines etc																																						0.92%		
Hardback Books																																						0.00%		
High grade paper			2.25%														1.42%																							
Household paper		2.02%				5.83%	3.84%	5.48%	4.95%		5.52%	3.72%			5.08%				7.63%	1.87%	7.03%	4.78%	6.23%								2.81%									
Liquid cartons																									0.41%			0.65%		1.18%		0.81%						0.38%		
Liquid cartons (tetrapak)					0.36%																																			
Low grade paper			9.29%														5.41%																							
Magazines					1.95%					1.48%										1.74%					2.78%			1.05%		2.63%										
Newspapers & magazines		2.45%							4.06%							12.04%		6.47%					4.24%	4.20%		6.90%	4.18%		6.41%			7.36%						7.61%		
Newspapers					4.33%					2.46%															4.66%			0.80%		2.83%										
Newspapers and magazines, brochures and catalogues																																	5.16%		1.78%					3.58%
Newspapers and magazines, brochures and catalogues & Soft Cover Books																																							2.76%	
Newspapers and magazines, brochures and catalogues, soft books																																					2.63%			
Newspapers and magazines, directories and catalogues																																				2.18%				
Newspapers, Magazines and Junk Mail													8.71%																											
Newsprint grade paper						4.50%	3.95%	5.17%			2.20%	2.84%			2.67%				3.61%	1.25%	3.23%	4.60%									3.76%									
Non corrugated packaging					1.61%																																			
Non-recyclable but compostable paper		4.07%				2.03%	2.86%	1.93%	3.22%		1.71%	3.21%		1.96%	2.35%			1.97%	2.51%	4.21%	3.45%	3.76%	2.57%								2.90%									
Non-recyclable liquid cartons																													1.14%											
Non-recyclable non-compostable paper		0.85%				0.14%	0.53%	0.03%	0.76%		0.49%	0.87%		0.40%	1.73%			0.70%	0.46%	2.36%	0.91%	1.46%	0.59%								0.90%									
Non-recyclable paper					2.35%					4.35%			3.84%											4.00%	4.43%	3.34%				4.21%										
Non-recyclable paper e.g. tissue																													6.26%											
Office Type Paper, leaflets, flyers, junk mail and plain envelopes.																																				1.19%				
Other card					0.29%					0.10%															0.22%	0.11%		0.70%	0.89%	0.07%										
Other card - non-packaging																																						0.13%		
Other card packaging																													3.53%											
Other non-recyclable paper & card																																						0.82%		
Other non-recycled paper																												6.02%												
Other packaging card										2.62%																														
Other paper and card																											6.84%													
Other recyclable paper					1.96%								2.03%												2.67%	5.18%			1.48%	1.84%										
Other recyclable paper (inc envelopes)										5.09%																														
Other recyclable paper inc envelopes, junk mail and white directories																																	2.10%				4.24%			
Other recyclable paper inc plain envelopes, junk mail and white directories																																								2.35%
Other recyclable paper- white envelopes, junk mail and white directories																																			1.95%					
Other recycled paper																												1.59%												
Other WHITE recyclable paper inc envelopes, junk mail and white directories																																							2.62%	
Packaging card																										3.56%														
Packaging Card inc Egg Boxes																																				1.40%				
Paper	11.98%																																							
Paper and light card																																		11.36%						
Paper packaging					0.04%																				0.49%			0.18%		0.39%								0.61%		
Potentially reusable hard/paper back books																															0.75%									
Recyclable household paper																		2.26%						3.34%																
Recyclable paper				11.91%																							2.95%													
Recyclable paper hi grade														1.13%																										
Recyclable paper lo grade														4.24%																										
Shredded paper					0.42%																							0.30%							0.44%		0.13%	0.23%	0.65%	0.04%
Telephone directories inc yellow pages																																0.14%								
Tetra Pak containers				0.78%									0.28%	0.34%										0.41%									0.51%		0.54%	0.14%	0.58%		0.60%	0.37%
Tissue & Kitchen Roll																																				1.37%				
Tissues																																						2.36%		
Tissues and hand towels and other non recyclable paper																																3.12%								
Whole cardboard boxes bigger than kerbside box																										0.00%														
Yellow pages		0.00%		0.16%		0.00%	0.18%	0.11%	0.02%		0.00%	0.16%	0.66%		0.52%			0.61%	0.10%	0.07%	0.04%	0.16%	0.00%					0.00%			0.73%		0.00%		0.00%		0.00%		0.00%	0.00%

Many of the subcategories used in these studies can be pooled into larger subcategories, as illustrated in Table 5.2.

Table 5.2: Membership of subcategories in simplified category list; paper & card

Newspapers	Newspapers	1	5
	Newsprint grade paper	1	11
Magazines	Magazines	2	6
Catalogues and directories	Catalogues	3	10
	Catalogues and other directories	3	7
	Glued spine (catalogues / directories)	3	1
	Telephone directories inc yellow pages	3	1
	Yellow pages	3	23
Other recyclable paper	All other recyclable paper	4	1
	Household paper	4	14
	Office Type Paper, leaflets, flyers, junk mail and plain envelopes.	4	1
	Other recyclable paper	4	6
	Other recyclable paper (inc envelopes)	4	1
	Other recycled paper	4	1
	Recyclable household paper	4	2
	Envelopes	4	1
	Brochures, junk mail & other recyclable paper	4	1
Non-recyclable paper	Envelopes with windows and other non-recyclable paper	5	1
	Non-recyclable non-compostable paper	5	16
	Non-recyclable paper	5	7
	Non-recyclable paper e.g. tissue	5	1
	Other non-recycled paper	5	1
	Tissue & Kitchen Roll	5	1
	Tissues	5	1
	Tissues and hand towels and other non recyclable paper	5	1
	Non-recyclable but compostable paper	5	16
Non recyclable card inc liquid cartons	Liquid cartons	6	5
	Liquid cartons (tetrapak)	6	1
	Non-recyclable liquid cartons	6	1
	Tetra Pak containers	6	10
Corrugated cardboard	Cardboard (corrugated)	7	1
	Cardboard packaging - corrugated	7	1
	Corrugated and all thick card	7	1
	Corrugated cardboard	7	24
	Corrugated packaging	7	1
	Whole cardboard boxes bigger than kerbside box	7	1
Other card packaging	All Thin card	8	1
	Cardboard packaging - boxboard	8	1
	Egg Boxes & Toilet Tubes	8	3
	Flat card/card packaging	8	1
	Non corrugated packaging	8	1
	Other card packaging	8	1
	Other packaging card	8	1
	Flat card	8	16
	All thin card packaging	8	1
Other Card	Other card - non-packaging	9	1
	Other card	9	7
Books	**Books**	**10**	**1**
	Hardback Books	**10**	**1**
	Potentially reusable hard/paper back books	**10**	**1**

From the total listing of 92, 75% of paper/card categories occurring across the 40 studies could be matched to one of the ten subcategory groups in the table above. Of the remainder, some were simply combinations of existing categories that needed to be split (e.g. 'newspaper and magazines'). A minority consisted of categories that were not easy to place (e.g. 'high grade' and 'low grade' paper).

For further comments relating to categorisation of municipal waste components, refer to Appendix 7.2.2.

5.3 Review of analysis methods for HWRC wastes

Three reports detailing recent analysis campaigns undertaken by different organisations were reviewed. These are referred to as “Study A” (contractor Resource Futures), “Study B” (contractor WastesWork) and “Study C” (contractor MEL). These studies do not definitively characterise all aspects of the methodologies employed by these respective contractors for HWRC auditing that they carry out; and the comments provided here relate only to the methodologies exhibited in these individual studies. However these studies are broadly representative of the most common approaches currently employed in relation to auditing HWRC wastes in the UK.

5.3.1 Stated Campaign Aims and Objectives

The design of a sampling campaign is influenced both by the clients’ remit and by the contractor’s standard approach to waste analysis. A standard approach by a contractor facilitates planning, implementation and reporting of campaigns and the generation of consistent data sets over time that permit a more rigorous assessment of the confidence levels they can place in the outcome of a given campaign. However, the client’s requirements (and resource / time constraints) may require standard methods to be amended and compromises made. The level of change required may make a contract more suited to one analysis contractor rather than another because their standard approach is more compatible (and cost effective). Thus comments made on the three examples need to be put in context of the specific remit. Although some observations on suitability of the three methods adopted for use for a national assessment of waste are made, it should not be assumed that the contractors approach would remain unaltered in response to a changed remit.

The aims of the three studies are summarised below:

Study A: The client’s aims are not explicitly stated in the report but the highlighted findings are confined to assessment of the category composition and biodegradable fraction of the residual waste and potential to enhance recycling at the sites assessed. The waste auditing protocol used permits the proportion of black-bag “dustbin-type” waste to be assessed. No attempt was made to identify source location of householder delivering the waste.

Study B: Stated aims were to identify materials not recycled by householders and to identify new streams to be recycled at the HWRC sites in order to improve recycling and contribute to achieving LATS requirements. Samples were taken only of waste destined for the residual skip. The waste audit protocol and category definitions used enable calculation of biodegradable fraction and the proportion of black-bag “dustbin-type” waste to be assessed. Although not stated as a requirement, the protocol permitted identification of source locations of householders delivering the waste.

Study C: Baseline compositional data is presented on all waste entering HWRC sites for use in developing contract performance levels (target diversions etc.) A long list of information to become available from the analysis campaign is given including identifying source of householders delivering the waste, biodegradable waste content, recyclable content and proportion of black bag “dustbin-type” waste. No attempt was made to identify what skips the householder would have used in practice (i.e. information that would identify lost recyclables to the residue and the amount of biodegradable waste entering landfill).

In the context of a national assessment, data from Studies A and B focus directly on the category composition and BMW destined to landfill and neither provides a composition of waste entering HWRC sites. For Study C, the reverse holds true.

From the perspective of generating national waste data, both the information for the input waste and the material disposed to landfill would be important but perhaps the latter more so as it directly relates to LATS calculations and UK responsibilities under the EU landfill directive. However, a focus on residual composition does not preclude an assessment of all arisings entering a site, nor does an input analysis preclude calculating a residual flow. If only the residue has been sampled, operators will have (or can obtain easily) the weight data for all other segregated “recyclable” flows and given the generally low contamination levels of segregated materials, compositional data could either be assumed or data may be available from monitoring / measurements made by the end user. However the level of category detail from such sources is unlikely to match that obtained from sampling and analysis and a comprehensive assessment would require samples of other segregated streams to be analysed to the same level of detail. Conversely analysis data on the input to a HWRC could be used to “calculate” the residual waste sent to landfill, again by using weight data for segregated and residual waste and assuming or measuring the composition of the segregated flows. As a general rule, analysis of the output flows (residuals and segregated recyclables) to calculate the input is a more reliable / cost effective procedure than measuring the input and calculating the composition of one of the outputs (the residuals in this case). This is simply due to the lower weight flows of the outputs and the tendency of managed waste (the outputs) to exhibit lower variability than the input in terms of composition.

This latter point is most easily visualised by considering garden waste. Compositional variability entering HWRC sites over the year will be high due to seasonal factors; hence sampling frequency (over the year) and size of sample need to reflect this. However, when garden waste is segregated for recycling, the garden waste content in the residual skip will be low (i.e. Study B averaged < 2% garden waste in all four seasons) and exhibit lower variance. Essentially the segregation management on site ensures the output streams are more homogenous and input variability is captured primarily by a change in the output weight distributions monitored constantly, and accurately, by the weighbridge; (i.e. the number of garden waste skips filled per week reduces during winter). Thus, for a given confidence level, lower sample weights / less frequent samples can be taken for analysis.

5.3.2 Sample Capture method

Sample capture method covers issues of selecting the sampling time / location in terms of the handling and management of the waste stream of interest, the total number of samples analysed, the number of increments taken to make up each sample and the method of selecting increments. This needs to be undertaken in a manner that ensures the sample is representative of the “lot” (i.e. the total population / mass under investigation) and conforms to the requirements for applying statistical analysis tools. Random sampling should be adopted as this conforms with the requirement that all particles have an equal chance of reporting in the sample. If a stratified approach to sampling is taken (e.g. sample population is split according to selected factors such as male/female or socio-demographic lines) samples taken within these strata should be selected randomly. The main practical point of adopting random sampling is to avoid bias and ensure sample results will converge on the true mean, i.e. an accurate result is obtained. In material sampling, the precision and confidence level in the analysis is dependent on the natural variability exhibited by the material sampled and analysts have to adopt sample sizes and number of increments that are either known to be sufficient for required precisions or permit the precision to be calculated from the data set obtained.

Again the aims of a campaign determine decisions in this area but it should be recognised that there can be practical obstacles and/or conflicting requirements between objectives that militate against adopting best sampling practice. For example, best practice requires that increment extraction is performed on a random basis. In the context of protocols adopted in these studies, if 50 householders are required for the sample and typical numbers over the day are 500, one should avoid sampling every 10^{th} visitor; but instead randomly generate 50 numbers from 0 to 500 and sample visitors according to these numbers. In practice the likely bias introduced by selecting every 10^{th} visitor or at regular time intervals as opposed to the visitors corresponding to the random numbers is miniscule (there is no reason to postulate any factor relevant to visitor waste composition recurring at this level of periodicity). On the other hand, a site may have a few very busy periods when practical resources prevent both the every 10th or the random nth visitor contributing to the sample and householders in these busy periods contribute much less sample relative to visitors in quieter periods. This could conceivably lead to bias (for example if high visitor flow numbers coincided with high garden waste disposal).

In relation to the issue of the precision or confidence level placed on the data, one needs to be clear about what is under discussion, namely the individual sample analyses, the aggregated site analyses, the data at authority level, yearly data etc. Also for a given sample size, variance will vary between the differing categories identified, depending the nature of that category (particle size/weight) and the proportion of the material found. There is no problem in designing sampling campaigns which permit variances to be calculated from the data set produced but this will require replicates (at the right level for the purpose) and invariably adds to costs. If however the variability found for a particular waste type at a given sample size has been established by previous campaigns, it is common practice to assume that the same sample sizes taken for similar wastes will provide the similar level of precision. Efforts can then concentrate on increasing the breadth of the study for the same resources.

Study A: From the report, it appears that a residual skip on the sample day in question was selected for analysis. At each site, samples were taken at the weekend and on a weekday to capture any differences in the type of visitor / nature of waste disposed of (weekends are usually much busier and those in full time employment may have constraints on using sites during the week). Neither the analysis contractor nor HWRC staff had any reason to approach users. All sites in the county were assessed. To accommodate seasonal variability, samples were taken in December and June.

Studies B and C: At both these sites, the contractor / HWRC staff approached users to gather postcode information and agreement for their waste to be sampled. In the case of Study B, householders approaching the residual waste skip were intercepted but were also expected to continue using the site as normal, i.e. place recyclables in recyclable skips as well as depositing the residual waste with the analysis contractor. For Study C, the user was asked to provide all their waste for the analysis. In Study B, samples were taken in winter, spring, summer and autumn to assess seasonal variability and 7 of the 14 sites in the county were assessed. In Study C all sites were assessed but only on one occasion during the summer period.

If the increments (individual householder waste) contributing to the samples in Studies B and C were collected over the full day, although not fully randomised the sample analysed would be considered representative of the HWRC waste input during the days on which samples were taken. From the reports it is not clear that this actually happened. For Study B the time interval between the 40 householder increments was reported to be ~5 minutes which suggests a 4 hour sampling period; and strictly the waste sampled represents that 4 hour period only, which could indicate samples taken only during the morning. The sample for Study A is for a residual skip load on that particular day and, again, unless only one skip is produced on that day, it does not represent waste inputs over the whole day for that particular site. The survey report for Study A does not give any information on how the specific skips analysed were selected other than it was waste for that particular day. It is likely that this will be the first skip filled on the day in question, to give the analysis team the most time to sort. Although there is no evidence to suggest morning waste differs in a systematic way from afternoon waste, neither strategy is ideal, though one can easily appreciate the practical reasons for adoption. For Study C the sampling period is stated to be "over the day", and assuming this means the full day, represents the day's input.

The protocols adopted for Studies B and C permit user locations to be noted along with the precise number of users contributing to the total sample. This information could be valuable in terms of planning facilities / promoting services etc but could easily be attained in a separate exercise. It also permits, if desired, individual users' wastes to be weighed and separately sorted.

It is not clear from the reports whether only individual user weights or full compositions were obtained but both yield information of statistical interest (e.g. assessing sample sizes for given confidence levels). Individual household composition data could lead to predictive modelling in combination with census data linked to postcodes in the longer term but, equally, general catchment data may permit modelling on a broader basis using the overall composition and weight data for a site. Gathering individual user composition data on a routine basis has major cost implications and on this point alone is not likely to be a candidate for a recommended method for contributing data for use at national level. For Study A, the waste sampled could not be related to individual users and analysis data is for the total waste collected in the residual waste skip analysed.

For Study B, a drawback of approaching users is the potential to change their disposal behaviour (likely to be more rigorous in using all the recycling options available) which would affect the nature of the residual waste sample. The report indicates that users “approaching” the residual skip were selected and, as many will be making more than “one trip” to and from a vehicle to complete their deposit, this method could potentially lead to missing some of the waste. In this context, the remit to gather user information does not sit happily with the need to avoid a sampling method that could affect the sample. This is not a problem for Study C as the users were selected before depositing any waste and both the recyclable and residual wastes from the selected householder were taken for analysis.

For both Studies A and B, seasonal samples were obtained (summer and winter for Study A, four seasons for Study B). As noted earlier, residual skips are less likely to exhibit the major seasonal variability experienced for HWRC inputs due to garden waste, as all sites segregated this material for recycling. However there are other residual categories which could be expected to exhibit seasonal variability, such as refurbishment waste associated with decorating / renovating rooms/kitchens; and small building jobs which most people try to avoid during the winter period. The data from Study B indicate that the composition of the residues was affected by the season, but not to a level that affected the main categories of each sort and with only minor changes in the ranking of these categories. This suggests that whilst a sample campaign that is repeated at differing times of the year is to be preferred to a one-off sample, it may not be as important for the assessment of HWRC residual waste on sites where effective recycling and segregation occurs. However it is also clear that no studies have been conducted to demonstrate that a four season approach is sufficient to provide the average waste for a site / authority. It is clearly “common sense” that campaigns are conducted in a manner that attempts to capture seasonality, as this is important for management of the site; but if an unbiased average over the year is wanted, random sampling of skips over the whole year, i.e. to give all waste an equal chance of reporting in the sample, is what is required. Alternatively if seasonal stratification is required, random samples need to be taken within each of the 4 “three month” seasons.

It is only from such studies that the potential bias of routine seasonal analyses that studiously avoid “problem times” like Christmas or bank holidays could be investigated. It is perhaps surprising that Study C was conducted as a one-off assessment over the summer of 2007 given this was for input waste when the garden component could be expected to be high compared to other seasons. Although cost may have been a reason for not replicating sampling at other times of the year, time constraints associated with the stated aim to inform impending contract discussions may have been a factor. Although not carried out for Study C, taking samples over time is entirely independent of the general approach to sample capture used by the analysis contractor.

None of the sampling campaigns appears to be designed as an ongoing exercise; For collecting national data, identifying trends over longer time periods (i.e. over several years) will be an important consideration and, once established, the potential to streamline some of the approaches exhibited in one-off campaigns present themselves. For example, MEL base reported confidence levels in their approach on availability of past datasets that have established variability exhibited by categories in waste, information that isn’t directly available from the design of the specific campaign carried out for Study C. SEPA have analysed the extensive datasets in the Welsh waste survey to base their proposals for size of sample needed for 90% confidence; and are also consulting on sampling protocols over extended time periods, i.e. suggesting four seasons of analysis in the first year, no analyses in the second year, two seasons in the third year, etc.

5.3.3 Sorting and weighing

Study A: The total collected was sorted in three stages; stage one involved all loose course items being sorted and weighed off, the cut-off size selected was material above ~160mm or, as stated in the report, the size of a house-brick. In the second stage, loose waste below 160 mm was sub-sampled to extract ~150kg for sorting, and the remainder weighed but not sorted. In stage 3 all bagged waste which was typical of dustbin waste (i.e. a mix of food, packaging etc) was extracted separately, a sub sample of between 300 and 500 kg extracted for sorting and weighing, and the non-sorted bags were weighed. The effect of the sub sampling is to reduce analysis time and cost with minimal impact on the accuracy of the overall analysis. Smaller items weigh less and hence present a large number of particles for a given weight, which means that a significantly smaller weight can be taken sorting compared to the course size items for a given confidence level. Although the protocol of course / fine assessment should not impact on the overall waste analysis, the application of the cut-size is a subjective visual assessment and hence comparing course or fine compositions across samples will be subject to additional uncertainty.

Study B: The report indicated that the waste for each householder was weighed before putting into a skip and the waste of all 40 householders was sorted for the analysis. Bagged waste that was of the same nature as dustbin waste was dealt with separately. No sub-sampling was carried out and all the loose waste was sorted.

Study C: The protocol appears to be very similar to Study B, with all visitor waste being weighed in. Sorting appears to be visitor by visitor, with initially the main 13 categories followed by subcategory sorts. What is not clear is whether category weigh-off occurs at primary or subcategory level for each visitor, or whether weigh–offs have been carried out for the full day's sort. The former would provide some 40 odd separate compositional analyses rather the one for the skip load. If this was done, there is no reporting or statistical information that indicates such data is held by the contractor. This would be very useful information to assess individual household variance but would be an expensive approach compared to protocols adopted for Study A.

5.3.4 Waste categorisation and category aggregation methods

Waste categorisation has become more detailed and precise as waste management systems become more technical, recovered materials have to meet end-user specifications and legislation requires more precise data.

Originally, classification at primary level was all based on material content, i.e. paper, metal, plastics etc. The subcategory level would more closely specify the material, sometimes by "product" type, e.g. plastic bottles as a sub-category of plastic. Generally the subcategory breakdown was aimed at identifying more precisely the material quality / grade from an end-user perspective. The only non-materials specific category was "fines", usually relating to material too small to sort effectively and of no practical interest for recycling.

As concerns about household hazardous waste have developed, non-material categories have been introduced into the primary list by most analysis contractors. This has inevitably led to potential confusion; i.e. a metal paint tin could be classified under hazardous or ferrous metal depending on whether empty or not, gloss or emulsion etc. Producer responsibility legislation has also led to interest in data on packaging / non packaging, ELV and the WEEE content of waste.

For packaging / non-packaging analysis, practitioners did not attempt to add to the primary list but developed packaging subcategories under the main materials types as many of the existing recycling orientated subcategories were already consistent with packaging definitions; (this has occurred in Europe as well as in UK practice). For WEEE, practitioners have added a WEEE category to the primary category list. In the Resource Futures category list for Study A, a primary category has been allocated for ELV waste. Both these latter categories clash with a materials based system and also systems that include a hazardous waste category at the primary level. With no national guidance or standards, these latter developments are adding to the problems of compatibility between approaches of different contractors, more diversity between approaches for different waste flows within municipal waste, greater opportunities to misallocate during sorting and increased problems when looking at trends over time.

All three contractors show strong awareness of the wide range of potential uses of waste compositional data in their approach to category selection and definition at the most detailed sub-category level for HWRC flows. However there are significant differences at the primary level of categorisation.

At the primary categorisation level, WastesWork and MEL adopt the same 13 material / waste type classification and include “black bag” as category denoting waste which was similar to normal dustbin refuse; though if single categories of waste were bagged, i.e. wallpaper, these wastes were included under the main material classification heading. The 13 classifications used are the same as would be adopted by these and most other contractors (including Resource Futures) for collected domestic refuse.

Resource Futures’ classification is 16 categories at the primary level plus the black bag domestic waste category. However, their primary classification system is much more targeted to the type of products and activities that lead to typical HWRC waste and deviates more strongly from a materials based approach. For example, Study A separately classifies automotive waste, furniture, refurbishment, wood and batteries. Some of these primary categories (i.e. refurbishment) have no equivalent at any level in the other contractors’ category definitions. Components contributing to these categories would be either classified as main categories (i.e. plastic film) or subcategories (such as furniture as a subcategory of miscellaneous combustibles) and may be distributed over more than one of the primary categories used. Thus if only level one / primary category information had been collected, the data set from Resource Futures could not be “converted” to the categories used by the other contractors or vice versa. In terms of providing an insight to the generation of HWRC type waste and factors that might, in future, link to some predictive modelling or consumer purchasing behaviour, the Resource Futures classification is probably more useful. However, if undertaken only at the primary level, it will generate data that cannot be mapped across to collected refuse data to produce aggregate information for all domestic / municipal waste streams, clearly a disadvantage from a “national waste” data perspective. However, at subcategory level, this problem largely disappears as definition differences are less pronounced or relate to components which do not appear in significant quantities.

Irrespective of resolving the different approaches at the primary level categorisation, if a national standard were to be adopted, a common classification system at the most detailed breakdown would also be required and some anomalies were evident even if the impact on the overall composition (at aggregated category levels) would be marginal. MEL has some 67 subcategories, 79 were used by WastesWork and Resource Futures adopted 65.

An example of a difference of low practical significance is wallpaper; wallpaper is reported as a separate subcategory by MEL and reported as “wallpaper and other non recyclable paper” by WastesWork; and in both cases these appear in subcategories in the paper and card primary category. The Resource Futures system classifies wallpaper as a subcategory in the renovation category, with the non-recyclable paper a subcategory of paper and card. However by transfer of data it is possible to present all three analyses as non-recyclable paper under the paper and card category if desired. Another example illustrating lack of full compatibility between analyses is the glass category. All three studies report container glass in a glass category but WastesWork identifies light bulbs as a subcategory along with “other glass”, the MEL list uses “other glass” for all non-packaging glass, and Resource Futures has subcategories for fluorescent tubes and “other glass”. However this is not the full picture regarding this category as MEL report fluorescent tubes under the WEEE category and there is no specific mention of fluorescent tubes in the WasteWork list. This raises ambiguities as to whether the light bulb category would include fluorescents or were these materials would be reported in the “Other WEEE” category or “Other Hazardous” category. As HWRC samples rarely reported more than ~2% glass in total, these allocation/definition differences for HWRC residuals / inputs are unlikely to be of major practical significance but such anomalies will need to be resolved for any national standard.

In general the subcategory list used by WastesWork is the most detailed, followed by MEL and Resource Futures. Although all subcategory listings would be considered “fit for purpose”, the selections used in the MEL and WastesWork studies are more easily mapped across to each other and to analysis data for other municipal waste fractions (e.g. black bin waste). Resource Futures’ category selection is considered a more tailored suite for looking at HWRC arisings specifically. Resolving the anomalies and retaining the benefits exhibited by the different approaches is considered feasible; but from a national perspective of providing broad municipal / household waste compositions the MEL and WastesWork category definitions provide more immediate utility.

5.3.5 Statistical analysis

As one-off studies, the contractors are careful to avoid claims of specific confidence limits for the individual analyses obtained for particular sites at a particular time, as such studies require replicate sampling to permit direct application of statistical tests on the actual data generated. MEL indicate that their historic data set includes such study designs to enable them to give indicative confidence levels for each analysis result using the minimum sample size and increment number for their sampling and analysis protocol. This statement has the caveat that normal distribution for the material category applies and is stated as +/- 10% at 95% confidence. It has been assumed that this information is based in HWRC wastes rather than dustbin wastes (but this is not stated explicitly in the report for Study C). If this is not the case If not, then this is likely to refer to household collected wastes and is not directly relevant to HWRC wastes. It is also not clear whether this refers to all or the main categories at the top (13 category) level or for all subcategories; but given the caveat, it is considered this only holds for the top level categories and possibly not all of them. Although the other contractors do not address this issue specifically, sample sizes and increments are very similar and confidence levels will also be similar, probably better given Resource Futures and WastesWork were sampling residual waste where the inherent variability over time is likely to be lower than the input to HWRC sites sampled by MEL.

The contractors did not report any statistical analysis of the data sets gathered. This would have been possible and informative regarding the variability of the waste inputs over a variety of sites, time periods, weekday versus weekends, and so forth. This would have illustrated differences between the confidence level stated by MEL (which - it is assumed - refers to how representative the sample was of the waste arriving on site that particular sampling period) and variability of HWRC waste over location, time, etc.

5.3.6 Data presentation

It is interesting to note that the level of data reported in the main body of the text for all reports focussed on the top level category compositions and the presence of bagged dustbin type waste, which is sufficient to inform the clients on issues regarding biodegradable content and general site management. The detailed subcategory data was used only to present information on the content of recyclable material in the samples, part of the remit for all three studies. The full subcategory analyses were presented in appendices in the case of Studies B and C; Resource Futures did not present these data in the report for Study A, though it is understood that this data was provided to the client in a separate Excel file.

With regard to reporting recyclable waste content, classification decisions are somewhat more arbitrary and can include a view being taken on how materials are presented (i.e. within bagged dustbin waste or loose) and the size of the item. This is ultimately a subjective decision, with the analysis contractor differentiating between what is theoretically recyclable but in practice, if present in a mixed flow at this stage, cannot be realistically salvaged by on-site management. Clearly comparing between studies on this aspect is more difficult, but all three studies detail their particular procedures.

5.3.7 Additional information presented

It can be helpful to report weather (rainfall, storms, floods, high winds) data during sample collection and for the previous week or so, as moisture contents, and possibly arisings of certain components, could vary significantly for some of main HWRC inputs, i.e. garden waste, soils, wastes associated with property damage, etc. None of the studies did so, though weather was noted in terms of affecting sampling and analysis due to lack of visitors or lack of cover for the sorts.

Perhaps more seriously for utility as data inputs to compiling national compositions, reports do not include information on the weight flows at the sites during the sample periods or annually. Such data would have been available to the clients and hence not an output required from the analysis contractor, but this gap in data reporting illustrates if national data is to make best use of locally funded analysis campaigns, the broader view of what information is needed requires identifying and communicating to the practitioners. The WasteDataFlow system captures weight data on an annual basis but classification, definition and degree of detail needs to be reviewed alongside of available waste composition data to develop optimum strategies.

Consideration should be given to recommending standard reporting of what might be useful additional information (i.e. site weight data, weather, most recent bank holiday, refuse collection strike, or any particular facility provisions that affect usage).