Material change for a better environment

Final Report

The financial costs of collecting mixed plastics packaging

Mixed plastics packaging forms a significant proportion of the household waste stream. This report explores the financial costs of collecting mixed plastics packaging for recycling using kerbside and bring site collection systems.

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WRAP helps individuals, businesses and local authorities to reduce waste and recycle more, making better use of resources and helping to tackle climate change.

Written by: Andrew Grant, Ann Balinger, Dr Adrian Gibbs

Front cover photography: [Collection of household plastic packaging.]

Executive summary

Domestic plastics packaging accounts for slightly over 11% of kerbside waste arisings by weight and increasingly there is the demand by householders for this to be diverted from landfill. In 2008 WRAP (Waste & Resources Action Programme) explored the issue to understand if it was technically and economically viable to reprocess this plastic steam including both rigid plastic and film. The findings were positive and showed that mechanically recycling collected mixed plastics packaging was achievable economically, technically and environmentally.

At the same time, local authorities were feeding back reservations about collecting mixed plastics and one of these was the potentially expensive costs of collection. With an increasing demand from householders for the recycling of mixed plastics, local authorities have been under increasing pressure to look at collecting this high volume, low weight material steam. To help local authorities make better informed decisions about collecting mixed plastics WRAP undertook an exercise to gain a greater understanding of potential incremental costs of collecting mixed plastics using established cost modelling techniques. This report explores the indicative costs of collecting mixed plastics packaging for recycling via a number of common local municipal collection systems.

Indicative costs have been generated by modelling collection costs for a single hypothetical local authority. The authority characteristics have been selected to represent an average UK waste collection authority. A selection of collection systems were modelled collecting a typical range of recyclables including plastic bottles which gave baseline models. Variant models were then calculated for the additional collection of rigid plastic packaging only and rigid plastic packaging with plastic films. The difference in modelled cost between baselines and variant options gives the indicative incremental costs for collecting these materials.

The choice of modelling input assumptions is important. Where possible input assumptions are based on operational data and have been discussed with industry stakeholders. However, there is a variable picture regarding the certainty of assumptions and in some cases uncertainty regarding key assumptions is still relatively high.

There is considerable variation between the characteristics of Waste Collection Authorities (WCAs). The applicability of the results set out in this report will depend on the similarity between the WCA concerned and the assumptions we have made for the generic local authority and certain scheme performance characteristics. It should be noted that the indicative incremental costs that we define in this report are relative to the modelled costs of the existing services (prior to collecting mixed plastics packaging). An authority with significantly different costs for the existing service is likely to incur different incremental costs than those shown.

A number of co-mingled and two stream kerbside dry recycling systems were modelled. The collection of mixed plastics packaging in co-mingled and two stream collections will generate a processing cost in the form of a gate fee from the MRF that processes the material. There is inevitable uncertainty regarding the incremental cost of processing mixed plastics packaging in MRFs and, in the case of plastic films, a high degree of uncertainty because there is so little practical evidence at present . Further work, based on the commercial scale trials and MRF financial model being published by WRAP will help give more precise guidance on processing costs.

The modelling process determined that in some cases collection vehicles may have sufficient spare volume to allow mixed plastics packaging to be collected without generating the need for additional collection resources and hence without generating an additional collection cost. In these situations the additional cost of collecting mixed plastics packaging will only be the processing cost and this has been used to generate the low end cost estimates. However, it is equally possible that current collections are restricted by volume. The modelling process has replicated the situation of volume limited existing collections to generate the high end cost estimates which includes the cost of the additional collection resources, as well as the increase in sorting costs. It is recommended that any authority considering collecting mixed plastics conducts an assessment of volume utilisation on vehicles to assess whether there is volume constraint or capacity on collection vehicles. Bulk density data to assist in making such an assessment is shown in this report.

Co-mingled collection

The indicative results show that both single and two stream co-mingled collection systems have the potential to offer an effective collection of rigid plastics packaging at an acceptable cost net of avoided disposal costs, however adding film to this collection stream is not as cost effective. A significant proportion of the overall cost of collecting mixed plastics packaging in co-mingled systems is due to the assumed increase in MRF gate fees associated with collecting these materials.

The indicative incremental costs of collecting mixed plastics packaging using co-mingled systems (excluding any savings from avoided disposal costs) are:

- rigid plastic packaging only: £1.29 to £1.69 per household (£130 to £149 per tonne); and
- additionally, with plastic film, a further £2.07 to £3.23 per household (£206 to £232 per tonne).

The indicative incremental costs of collecting mixed plastics packaging using two steam systems (excluding any savings from avoided disposal costs) are:

- rigid plastic packaging only: £0.59 to £1.13 per household (£74 to £104 per tonne); and
- additionally, with plastic film, a further £0.86 to £2.68 per household (£150 to £217 per tonne).

The costs of collecting plastic film, in both single and two stream co-mingled systems, are broadly similar and are modelling, on the whole, as more expensive options than kerbside sort or efficient bring systems. However these costs are attributable to the gate fee assumptions which we have used and there is uncertainty in these values and also a higher yield than bring systems.

Kerbside sort collection

The costs of collecting mixed plastics packaging using kerbside sort collection systems are affected by different assumption sensitivities to co-mingled and two stream systems. The costs for kerbside sort systems are driven primarily by the modelled increase in loading time. It is possible that in reality some kerbside sort collection systems are not constrained by time and additional materials could be collected without additional cost; however, this possibility has not been quantified. It is also important to note that there is uncertainty surrounding the additional loading time assumptions that have been used. Additional costs are also generated by volume constraints on some of the vehicle types modelled. Further work needs to be undertaken to determine additional loading times for the collection of mixed plastics packaging in kerbside sort systems.

The kerbside sort vehicles modelled have all, effectively, been designed for the collection of mixed plastics packaging by ensuring that sufficient volume is provided for each material in each modelled option. It is important to note that significantly higher costs could be incurred if mixed plastics packaging was collected in less optimal vehicles.

The indicative incremental costs of collecting mixed plastics packaging using kerbside sort systems (excluding any savings from avoided disposal costs) are:

- rigid plastic packaging only: £1.74 to £1.96 per household served (£239 to £268 per tonne) for collections on a fortnightly basis and £3.00 to £3.49 per household served per year (£287 to £334 per tonne) for collections on a weekly basis; and
- additionally, with plastic film, a further £0.27 to £2.20 per household served per year (£44 to £217 per tonne).

Bring collection

Through examining plastic bottle collection schemes it appears likely that bring systems will achieve significantly lower yields of mixed plastics packaging than kerbside collections. We have modelled high performing bring yields which still only account for approximately 33% of a likely kerbside collection yield. Bring systems that combine 'milk round' collection patterns (a series of local collections conducted without the need to tip between each site), with compaction vehicles, see theoretical increased economies through collecting higher yields per site due to the addition of mixed plastics packaging. If economies of scale are realised in the procurement of mixed plastics packaging bring collections, and operations are based locally, then bring systems can offer the lowest cost per tonne for collecting rigid plastic packaging.

The indicative incremental costs of collecting mixed plastics packaging using bring schemes (excluding any savings from avoided disposal costs) are:

- rigid plastic packaging only: £32.36 to £220.93 per tonne; and
- additionally, with plastic film, a further £42.42 to £150.45 per tonne.

These findings vary greatly as different bring containers and collection vehicles offer different efficiencies for collection for example Front End Loaders (FEL) have a better efficiencies than a skip loader.

We have not however, seen such modelled economies of scale being realised in the procurement of bring services which have generally been let at the same cost per lift as plastic bottles and if costs of bring continue on this basis then incremental costs are more likely to be around £250 per tonne. There tends to be a lack of competition in the procurement of such services which are typically undertaken by an incumbent service provider or bought from a specialist provider without a competitive process.

The past two years have seen the development of a number of front-of-store recycling (FOSR) systems collecting mixed plastics which are owned and operated by retailers. Examination of the yields and costs of these systems have not been considered in this project, however there is the potential that these sites may capture a proportion of the mixed plastics now and increasingly in the future that are currently entering the municipal kerbside waste stream.

The findings from the report indicate that any strategy to increase mixed plastics packaging recycling within collections should focus first on authorities using single or two stream co-mingled collection systems specifically with spare container capacity or on kerbside sort authorities re-tendering contracts and thus able to introduce new vehicle designs. Other authorities that cannot take advantage of these situations may want to consider developing bring systems possibly in collaboration with retailers' Front-of-store facilities.

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1.0 Introduction

This report details the findings of a research project that the Waste and Resources Action Programme (WRAP) commissioned to explore the financial costs of collecting mixed plastics packaging, it looks at the research methodology, the approach used to calculate costs and then the results by collection system type.

2.0 Acknowledgements

This report has been produced with the assistance and input from May Gurney, Newport Wastersavers, Resource Futures, Terberg, Veolia ES, a number of local authorities currently collecting mixed plastics packaging and ROTATE officers at WRAP. The assumptions and findings of this report do not necessarily reflect the views of these organisations.

3.0 Definition of mixed plastics packaging

It is useful to consider the full range of household plastic waste as having four components;

- plastic bottles (usually PET or HDPE);
- non-bottle rigid packaging;
- plastic film and bags (including sacks and carrier bags); and
- rigid non-packaging e.g. plastic toys

Household plastic packaging includes all the plastics packaging components of the waste stream, including plastic bottles.

The definition of mixed plastics packaging, as used in this report, includes all rigid and flexible plastic packaging items that are typically found in the household waste stream but it excludes plastic bottles and non-packaging items.

4.0 Aim of the study

The aim of this study was to further the understanding of the costs that a Waste Collection Authority (WCA) may incur if they were to add mixed plastics packaging to their domestic recycling collection scheme.

5.0 Approach to calculating the collection costs of mixed plastics packaging

Theoretically, a picture of costs can be built up by examining the actual costs that local authorities have experienced when introducing mixed plastics packaging collection schemes. However, the complexity and variability of local authority accounting practices is such that the addition of more materials to a contract will not necessarily result in a clearly stated additional cost. Furthermore, because the collection of mixed plastics packaging is a relatively new service provision, contractors are likely to price this service enhancement without adequate information. Quoted prices may therefore change once contractors have gained operational experience.

Initial research was undertaken to survey the costs incurred by local authorities which have introduced mixed plastics packaging collections. This research revealed very little regarding the costs of kerbside systems and offered patchy results relating to bring systems.

An alternative approach is to develop a theoretical model of the costs incurred by a service provider and to use this model to ascertain overall service costs to a local authority. This method allows for relatively accurate comparisons to be made between different collection options. Variability in the results of procurement processes may however prevent a local authority from obtaining these services at the modelled price. Due to the limitations of available cost data the modelling approach was taken for all collection options and where possible the modelling has been informed by cost data that was at our disposal. To undertake the modelling process for kerbside systems a proprietary model developed by Eunomia Research and Consulting was used.

The approach to ascertaining the indicative costs of collecting mixed plastics packaging has been to model a number of different collection systems for a single “generic” authority. A number of baseline collection systems were modelled that included the collection of plastic bottles and for each of these two variant options were modelled:

- **Option A – adding rigid plastics packaging only; and**
- **Option B – adding rigid plastics packaging and plastic films.**

Option A defines the indicative costs of adding rigid plastics packaging to an existing recycling system that is collecting bottles. Option B defines the additional cost of adding films to an existing system that is collecting rigid mixed plastics.The additional cost of Option B when compared the with the costs of Option A defines the indicative costs of adding films to an existing system that is collecting rigid mixed plastics.

6.0 Factors that drive the cost of kerbside collection of mixed plastics packaging

6.1 Collection costs

The costs of a recycling collection system are driven by the amount of resources required to collect a material and the resources required to sort the material into grades suitable for reprocessing. Collection resources are predominately vehicles, drivers, loaders and the support infrastructure to get these resources deployed Productivity of collection is defined by the number of households that a vehicle can collect from in a day. In practice, resources employed on recycling collections are always constrained by at least one of the following:

- **weight constraints** – the vehicle reaches the maximum permissible weight and must return to tip;
- **volume constraints** – the vehicles’ maximum containment volume is reached and must return to tip; and
- **time constraints** – the collection crew reach the end of the working day.

Time constraints are always the ultimate constraint in collection systems. Time is taken driving to collection rounds, collecting material, driving to tip the material, driving back to rounds, and sometimes returning to collection depots if they are not the final tip destination. Productive recycling collections aim to maximise the amount of time spent actually collecting material i.e. ‘productive time’. A carefully considered trade-off is necessary that strikes the right balance between loading times and the number of trips to tip. It is important to note that that time factors vary considerably between authorities and between collection methods.

6.2 Processing costs

Once materials have been collected there is a cost element associated with preparing the material for onward shipment. In the case of co-mingled collections the material is delivered to a Materials Recovery Facility (MRF) for sorting, for which a gate fee will be charged on a price per tonne basis. In the case of kerbside sort systems there will be a requirement to bulk, and in many cases bale, the collected material for onward shipment to a reprocessor. Specific gate fees and material values are explored further in later sections of this report.

6.3 Outputs from the modelling process

Key outputs from the modelling process include the incremental cost (in comparison to baseline costs) to the local authority of adding the additional plastics to the existing collection system.[1] The incremental costs are expressed both in terms of the additional cost per household served and the cost per tonne of additional material collected.

The modelling process also predicts the yields of materials collected. Incremental yields expressed as kilograms per household served per year are also expressed.

The impact in collection resources that generate additional costs are detailed in the appendices of this report.

[1] Baseline collection costs assume the kerbside collection of plastic bottles

7.0 Methodology for calculating the costs in kerbside systems

The approach to ascertaining the indicative costs of collecting mixed plastics packaging has been to model a number of different collection systems for a single “generic” authority. The generic authority used to generate indicative costs has 50,000 households, of which 48,000 receive the service. The 48,000 households are divided into housing types within the model and logistical assumptions, such as distance between each household are applied to each housing type. The characteristics of the authority have been selected to represent a mix of rural and urban rounds. Other key logistical assumptions are the average number of times per day that vehicles tip and the average time taken to return from the collection round to the depot.

Costs are built up automatically by the model using unit cost for resources such as vehicles and crews. The model calculates the numbers of containers, vehicles and crew required and multiplies these by their unit costs. Net cost/income from material sales is also included.

The model adds overheads for management and administration, depot costs, insurances, financing, corporate overheads and profit margins however excludes costs to communicate the scheme. Although capital cost requirements are listed in the model, to allow effective comparison between scenarios (which may have capital with different lifetimes) these are broken down into annual costs based on the amortised cost of capital using depreciation periods and interest rates entered by the user.

For vehicles used within kerbside sort collections, mixed plastics packaging is assumed to be added to the compartment currently used to collect plastic bottles. For vehicles used within two stream co-mingled collection systems, mixed plastics packaging is assumed to be added to the compartment currently used to collect containers.

It is important to note the limitations of a modelling approach, which can only indicate the potential costs that a real authority might expect to incur. Factors that influence collection service costs vary considerably from authority to authority, leading to a high degree of variation in actual costs incurred.

It is also important to note that in order to obtain fair and consistent results across differing collection systems in a modelling situation it is necessary to produce costs based on fractional numbers of vehicles/crews and fractional numbers of tips per day. Rounding vehicles and crews and tips to the nearest integer number would reflect the operational reality of these services but would be specific to the characteristics of an individual authority and would create extremities in the portrayal of costs for certain collection systems.

7.1 Dry recycling collection systems modelled

A variety of dry recycling systems were included within the model, taken as representative of the broad range of collection systems operating across the country. **Table 1** shows the baseline conditions modelled for the single pass collection systems.

Table 1 Kerbside dry recycling single pass collection systems – baseline conditions

Short description	Collection type	Materials collected	Vehicle type (volume, capacity)	Collection frequency	Containment
B1-SS,20S,7,2*55b	Kerbside Sort	Paper, cans, plastic bottles, textiles, glass	Stillage (20m^3, 13 tonne)	Weekly	2x 55 litre boxes
B2-SS,33S,7,2*55b	Kerbside Sort	Paper, cans, plastic bottles, textiles, glass, card	Stillage (33m^3, 13 tonne)	Weekly	2x 55 litre boxes
B3-SS,33S,14,2*55b	Kerbside Sort	Paper, cans, plastic bottles, textiles, glass	Stillage (33m^3, 13 tonne)	Fortnightly	2x 55 litre boxes
B4-SS,33K,7,2*55b	Kerbside Sort	Paper, cans, plastic bottles, textiles, glass	Kerbsider (33m^3, 18 tonne)	Weekly	2x 55 litre boxes
B5-SS,33K,14,2*55b	Kerbside Sort	Paper, cans, plastic bottles, textiles, glass	Kerbsider (33m^3, 18 tonne)	Fortnightly	2x 55 litre boxes
B6-Co,22R,14,240w	Commingled	Paper, cans, plastic bottles, card	RCV (22m^3, 26 tonne)	Fortnightly	1 240 litre bin
B7-Co+g,22R,14,240w	Commingled	Paper, cans, plastic bottles, glass, card	RCV (22m^3, 26 tonne)	Fortnightly	1 240 litre bin
B8-Co,22R,7,60s	Commingled	Paper, cans, plastic bottles, card	RCV (22m^3, 26 tonne)	Weekly	1 60 kg sack
B9-Co,22R,14,2*60s	Commingled	Paper, cans, plastic bottles, card	RCV (22m^3, 26 tonne)	Fortnightly	2 60 kg sacks
B10-Co2,22SR,7,2*55b	Commingled 2 stream	Paper, cans, plastic bottles, card	Split RCV (22m^3, 26 tonne)	Weekly	2 55 litre boxes
B11-Co2,22SR,14,2*55b	Commingled 2 stream	Paper, cans, plastic bottles, card	Split RCV (22m^3, 26 tonne)	Fortnightly	2 55 litre boxes
B13-Co2,22SR,14,240w+55b	Commingled 2 stream	Paper, cans, plastic bottles, card	Split RCV (22m^3, 26 tonne)	Fortnightly	240 litre bin + 55 litre box
B15-Co2,22SR,14,2*240w	Commingled 2 stream	Paper, cans, plastic bottles, card	Split RCV (22m^3, 26 tonne)	Fortnightly	2 240 litre bins

8.0 Key assumptions used in the modelling of kerbside collection systems

This section of the report details the assumptions that have been used and are common to all the collection systems modelled. Assumptions that vary between collection systems are detailed in later sections.

8.1 The composition of mixed plastics packaging in the kerbside waste stream

The compositional analysis used within this project is based on a compilation of recent compositional datasets which were analysed by Dr. Julian Parfitt of Resource Futures[2].

This dataset included compositional data collected from 62% of districts in England, incorporating information from Waste Data Flow as well as kerbside residual compositional studies carried out for individual areas. The residual composition studies incorporated into the national dataset were carefully selected to ensure that:

- the samples taken were representative across ACORN groups, contributing to sufficient coverage of UK regions and system types to be representative of the national picture;
- the influence of seasonality had been incorporated into the composition for each area; and
- the appropriate level of categorisation had been included.

Table 2 shows the kerbside composition of the plastic waste stream across the UK, based on the national composition dataset as outlined above.

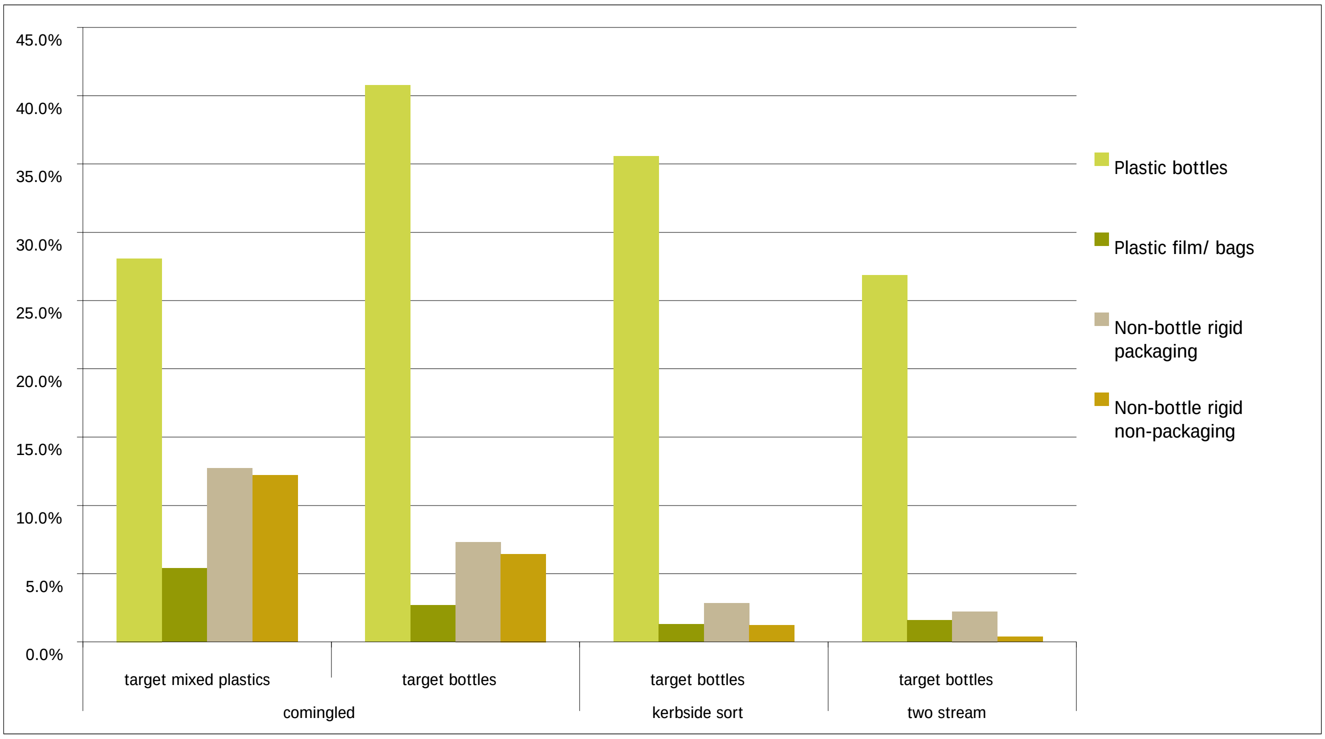
Table 2 Kerbside plastics composition

	Proportion in kerbside waste stream
Plastic bottles (usually PET or HDPE)	17%
Non-bottle rigid packaging	24%
Non-bottle rigid non-packaging	16%
Plastic film and bags (including sacks and carrier bags)	43%
Notes Plastics are assumed to comprise 11.03% of the total kerbside waste stream (comprising waste from both recycling and residual waste collection systems)	

Many local authorities collect plastic bottles for recycling and a small number also offer kerbside collections targeting other waste plastics. The capture of plastic packaging varies between the different collection systems, although in each case bottles are the predominant material collected. However, the kerbside collections that target bottles only also receive significant quantities of non-bottle plastics, particularly other rigid packaging items such as yogurt cartons (effectively contaminating the kerbside bottle collection). Figure 1 details the variation in capture rate by collection system and indicates the extent to which non-bottle plastic is captured by schemes targeting bottles only. The analysis is based on detailed compositional analysis of kerbside collections where the nature of the collection system was known and the plastic fractions set-out at the kerbside were categorised into sufficient detail during compositional analysis to permit a breakdown into the four main plastic sub-categories shown above. It should be noted that the sample sizes for some of the systems are relatively small for example data was only available for five authorities targeting mixed plastics packaging as described in this report.

[2] *Analysis conducted by Resource Futures in November 2008*

Figure 1 Variation in capture rate by collection system type



Composition of the remaining waste stream is detailed in appendices.

8.2 The bulk density of mixed plastics packaging

The bulk density of mixed plastics packaging is an important value that describes the amount of space that the material will take up when placed in containers and vehicles. Existing data on the bulk densities of mixed plastics packaging was scant at the stage of commissioning this study therefore resource was employed to take practical field measurements of the bulk density of mixed plastics packaging when contained in various containers and collection vehicles.

Two streams of mixed plastics packaging were available to us to conduct the trials and therefore were tested:

- Mixed plastics packaging (with bottles) but where non-bottle plastic packaging and films were not targeted
- Mixed plastics packaging (with bottles), where non-bottle plastic packaging and films were targeted.

These materials were loaded into a range of containers including kerbside boxes, 240 litre wheeled bins, 1100 litre euro bins and a range of collection vehicles including a 33m^3 Terberg kerbsider with MVR[3], a 22 m^3 compacting RCV, and a split back RCV (70/30).

Compacting vehicles were tested using two differing compaction settings:

- "softpack" which was intended to mimic the good practice of reducing compaction pressures on fully co-mingled materials in RCVs; and
- "hardpack" which is the standard maximum compaction ratio that the RCV could deliver.

Samples of tested materials were obtained and the composition established. The tested materials differed in composition to the mix of materials we would expect to capture in a well performing kerbside scheme that is targeting packaging plastics. Therefore, it was necessary to mathematically adjust the results obtained from the field trials to ensure a balance with the waste composition analysis. The adjusted bulk density results are shown in **Table 3** and were the values used in the modelling processes described elsewhere in this report.

[3] MVR, Material Volume Reducer, equipment fitted to Kerbsider vehicles that reduces the volume of containers when loaded through this equipment

Table 3: Bulk densities of mixed plastic components

	Bulk Densities Expressed as kg/m^3				
	Un-compacted	Kerbsider with MVR	Standard RCV "Softpack"	Split RCV (30/70) "Hardpack" using small compartment	Standard RCV "Hardpack"
Plastic Bottles	23	31	68	98	132
Packaging Rigid Plastics	26	36	80	120	149
Plastic Films	90	123	230	310	320
Non - Packaging Plastics	30	41	100	130	172

8.3 Characteristics of the hypothetical authority

The modelling approach requires the definition of baseline operating conditions for each of the collection systems under investigation. It is recognised that local characteristics e.g. socio-demographics and housing types will impart a significant influence on the cost to the authority of their collection systems. The approach taken within this project is to develop a hypothetical authority. It is recognised that the characteristics of the hypothetical authority will not match those of many local authorities. However, a central aim of this project is to provide indicative costs that may, with appropriate modification, be applied across the broad range of collection systems operating in different areas under varying local conditions.

The hypothetical authority is assumed to be a mixture of urban and rural areas, comprising a total of 50,000 households and producing total waste arisings of 850 kg per household from the kerbside, the current average for the UK. The characteristics of the other collection systems are detailed in **Table 4**. It has been assumed that 48,000 households receive the kerbside dry recycling collection service. The remaining 2,000 households were assumed to be high occupancy households with communal servicing arrangements and were not modelled for separate recycling collections.

Table 4 Hypothetical authority residual collection schemes

Parameter	**Value**
Residual waste	Fortnightly collections; containment in wheeled bins
Notes Dry recycling services are assumed to vary between the different options considered for appraisal. Detail on the dry recycling collection schemes is provided in Section 7.0 and Table 1.	

Table 5: **Logistical characteristics of hypothetical authority**

	Proportion of housing stock	**Proportion of population**	**Average distance between dwellings**	**Average speed (kph) when moving on round**	**Average time (mins) from round to tip**	**Average return to base/tip speed (kph)**
Detached	22.0%	22.0%	30	25.0	17	38
Semi-detached	43.0%	43.0%	18	18.0	17	38
Terraced	30.0%	30.0%	16	15.0	17	38
Converted house flats	1.0%	1.0%	5	13.0	17	38
Flats - purpose built blocks	4.0%	4.0%	6	14.0	17	38

8.4 Determining the current and potential capture of mixed plastics packaging

The amount of mixed plastics packaging collected in a scheme (the "yield") is a significant factor in defining the actual costs incurred. A reasonable rule of thumb in plastics collections would be the lower the yield, the lower the cost per household, but the higher the cost per tonne captured. This is due to higher yields driving the need for more collection resources hence higher costs being distributed between the same fixed number of households. However, in the case of costs per tonne, the increasing yield serves to increase the cost basis over which fixed costs can be distributed. In order to determine the marginal impact on plastic yields of adding mixed plastics packaging to a collection system, it is necessary to take into account the amount of mixed plastics packaging that is captured as contamination in existing systems.

Little data is available relating to the composition of existing plastic captured in collection systems (see 8.1.) The approach to predicting yields of materials in the baseline models and mixed plastics packaging options was to assume that the hypothetical authority had a restricted residual collection scheme such as a fortnightly collection schedule. We therefore assumed that the schemes would be relatively high performing and high capture of mixed plastics packaging (and other recyclate) would occur. Different assumptions of participation, set-out and recognition are assumed for different collection systems and differing frequencies of recycling collection.

8.5 Collection operator costs

All modelled kerbside collection options are modelled on a driver and two loader basis. The modelled annual cost of collection crews is detailed in **Table 6** and include on costs and cover.

Table 6: **Cost of collection crews**

Job	Annual cost per person
Driver	£ 24,000
Loaders	£ 21,000

We have applied 6% of service costs as an overhead fee and a further 6% on all costs as a profit margin. Supervision and depot overheads have been calculated according to a ratio related to the number of collection vehicles employed on the contract.

8.6 Avoided disposal savings

The savings an authority may incur by diverting mixed plastics packaging for recycling from residual disposal will vary from authority to authority depending on the method and cost of disposal, who is responsible for covering the cost of disposal and what financial arrangements are in place to compensate for the additional cost of recycling collections i.e. payment of recycling credits from the WDA to the WCA. The avoided disposal savings shown in this report have been calculated at £50 per tonne of material diverted for recycling.

9.0 Assumptions used to model co-mingled systems and two stream co-mingled systems

9.1 Gate fees

Co-mingled systems collect materials with less vehicles and crews than kerbside sort systems but the collected material is subject to a sorting cost at a MRF (i.e. a gate fee). Kerbside sort systems take longer to collect materials because they are sorted onto the vehicle but these systems are able to sell the collected materials for an income which helps to fund the additional collection resources.

Adding mixed plastics packaging to the input stream of MRFs will produce additional sorting costs. MRFs can process a specific volume of material over a specific period of time. Mixed plastics packaging has a much lower density than the general mix of co-mingled material, so when the proportion of mixed plastics packaging is increased the weight of material processed per hour will drop. MRF revenue is usually governed by gate fees which are charged by weight and the sale of materials which are also sold by weight. The reduction in the throughput weight of materials in a MRF as a result of adding mixed plastics packaging is therefore likely to lead to an increase in gate fee. Table 7 and 8 show the fees used for this study.

WRAP are conducting practical research into the sorting of mixed plastics packaging but until the results of this work are reported we have relied on calculating the change of gate fees from adding rigid mixed plastics packaging in co-mingled collections by calculating hourly gate fee and material revenue reductions using mass balance calculations. The process appears to be a reasonable approach for rigid plastics as they are likely to be sorted using mechanical methods relatively far down the MRF process chain.

The economics of sorting films is very different, as the most common film separation technique in MRFs, manual labour at the pre-sort station with the assistance of over head vacuum hoods, is likely to be the only practical method in the short term. A mass balance approach is less likely to produce effective results in this case as the impact of additional labour costs is likely to be much more significant than the change in overall density of materials. At the stage of writing, little is known about the true cost of sorting films from co-mingled collections. We have used a figure of £150 per tonne of film throughput to calculate the possible impact on gate fees but it is acknowledged that more research is necessary before there can be reasonable certainty in estimates of gate fee change relating to adding plastic films. The cost results for co-mingled collections should be considered in the context of this uncertainty.

Table 7: MRF gate fees – single stream commingled collections

Materials collected	Gate fee per tonne
Paper, card, cans, plastic bottles	£21.00
Paper, card, cans, plastic bottles, glass	£28.00
Paper, card, cans, plastic bottles, rigid plastic packaging (no film)	£24.50
Paper, card, cans, plastic bottles, rigid plastic packaging (no film), glass	£30.00

Table 8: MRF gate fees – two-stream commingled collections

Materials collected	Net income/charges across all materials (per tonne)
Paper, card, cans, plastic bottles, glass	£3.07 income
Paper, card, cans, plastic bottles, glass, rigid plastic packaging (no film)	£2.79 income

The cost models calculate costs net of material income and gate fees. Where possible, material values were based on a two year average of WRAP's Materials Pricing Report database (period April 2006 to March 2008).

9.2 Set out, participation and recognition rates

Set out, participation and recognition rates determine the proportion of available material collected by each recycling system. Both set out (the presentation of containers at the kerbside) and participation (the percentage of households that are using the system at least once in a given period of time) vary between the different recycling schemes operating across the country. Many factors influence these rates - residual waste frequency (here assumed to be fortnightly) has an influence, as does the type of collection system (e.g. size of container). The type of authority is also important - the more affluent rural areas tend to achieve higher set-out and participation rates in comparison to highly urbanised regions. Recognition rates vary between different materials for users in the same collection system – the recognition rate for paper being much higher than that for plastic bottles, for example. **Table 9** and **Table 10** provide details of the scheme participation rates, set-out rates and recognition rates for individual materials that have been assumed.

In baseline models and Option A models (adding rigid only) we have assumed mixed plastics packaging is captured as contamination. The level of assumed contamination is detailed in **Table 11**

Table 9 Assumed participation, set-out and recognition in co-mingled systems

	Fortnightly bin	Weekly bin	Fortnightly sack	Weekly sack
Participation	**93%**	**93%**	**88%**	**93%**
Set out	**82%**	**82%**	**83%**	**82%**
Recognition by material				
Paper	88%	94%	77%	94%
Non-recyclable paper	30%	30%	20%	30%
Card	66%	76%	61%	72%
Plastic film	39%	40%	30%	37%
Plastic bottles	87%	91%	70%	86%
Other rigid plastic packaging	69%	71%	55%	66%
Other rigid plastic	5%	5%	5%	5%
Textiles	11%	11%	11%	11%
Glass bottles/jars	90%	94%	0%	0%
Other glass, other ferrous, aerosols, aluminium foil, other non ferrous foil, cartons, garden and kitchen waste	0%	0%	0%	0%
Ferrous cans	72%	77%	72%	66%
Aluminium cans	77%	94%	77%	94%
Misc/Fines/Hazrd/WEEE	7%	7%	9%	8%

Table 10: Assumed participation, set-out and recognition for two stream systems

	Fortnightly box	Weekly box	Fortnightly bin (fibres in box)	Weekly bin (fibres in box)
Participation	88%	93%	93%	93%
Set out	83%	82%	82%	82%
Recognition by material				
Paper	72%	94%	77%	94%
Non-recyclable paper	20%	20%	20%	20%
Card	55%	72%	61%	72%
Plastic film	20%	30%	39%	40%
Plastic bottles	62%	82%	87%	91%
Other rigid plastic packaging	45%	60%	69%	71%
Other rigid plastic	1%	1%	5%	5%
Textiles	11%	11%	11%	11%
Glass bottles/jars	72%	94%	90%	94%
Other glass, other ferrous, aerosols, aluminium foil and other non ferrous foil, cartons, garden and kitchen waste	0%	0%	0%	0%
Ferrous cans	50%	60%	72%	77%
Aluminium cans	61%	96%	77%	94%
Misc/Fines/Hazrd/WEEE	0%	0%	7%	7%

Notes: Stated containment is for the container stream (glass, cans and plastic). B15 models (see **Table 1**) have been assumed to have identical scheme performance as co-mingled bin systems

Table 11 Recognition of plastic fractions as contamination when not targeted in co-mingled and two stream systems

	Recognition	
Material	**When presented in bin or sack**	**When presented in box in 2 stream system**
Plastic film	2.7%	2.2%
Rigid plastic packaging (non-bottle)	8.2%	5.4%
Other rigid non-packaging plastic	5.5%	3.2%

9.3 Vehicles

The co-mingled collections were modelled using 22 cubic metre collection vehicles as described in **Table 1**. The bin options were modelled with vehicle 1 (see Table 12), which includes bin lifts. The sack options were modelled with a vehicle that did not have lifts and is therefore cheaper. All 2 stream collections were modelled using vehicle 3 (see Table 12) a split back RCV fitted with bin lifts.

Table 12 Vehicle capacity and costs for co-mingled collections

Number	Description	Capacity (kg)	Capacity (m^3)	GVW (laden)	Total capital cost per vehicle
1	Standard compacting RCV with bin lifts	11,000	22	26,000	£128,925
2	Standard compacting RCV excluding bin lifts	11,000	22	26,000	£118,325
3	Split Back RCV 50:50 with bin lifts	10,880	20	26,000	£163,025

9.4 Collection times specific to co-mingled and two stream systems

Loading times used in the modelling are expressed as the average time that the collection vehicle is stationary whilst a household is cleared. Loading time assumptions used are detailed in Table 13. The additional collection of mixed plastics packaging using both co-mingled and two stream collections is unlikely to cause any additional time requirement associated with clearing a household therefore in co-mingled systems the stated collection times remain the same in all options.

Table 13: Loading times for co-mingled and two stream vehicles

System	Containment	Average time per household collected from that the vehicle is stationary and being loaded (seconds) in all models
Co-mingled	Sacks	6
	Wheeled bin	9
Two stream Co-mingled	Two boxes	10
	Box and Wheeled bin	13
	Two wheeled bins	16

10.0 Indicative costs of collecting mixed plastics packaging in co-mingled collections

The significant factors driving the cost of collecting mixed plastics packaging in co-mingled systems are:

- the relationship between current capture of mixed plastics packaging and the capture when targeted;
- increases in gate fees;
- possible volume constraints; and
- possible 'spare' volume capacity in vehicles that could be utilised for mixed plastics packaging.

The baseline modelling process illustrated that there are times in co-mingled systems where the collection crew return from the final collection round of the day with spare capacity in the vehicle. In these situations, if there is sufficient spare capacity in the vehicle to contain the volume of captured mixed plastics packaging, then theoretically there is no requirement for additional vehicles and no additional collection cost. However, it is important to note that even in these situations there is likely to be an additional processing cost.

The opposite collection situation is also possible where vehicles are returning full in a baseline scenario and therefore adding mixed plastics packaging will require additional volume provision which must be provided for through more tips per day and/or more vehicles and staff being deployed. The modelling process has optimised baseline collections to achieve the highest theoretical pass rates with vehicles returning full. When mixed plastics packaging is added to these modelled systems additional volume is always required and therefore a collection cost generated.

The modelling outputs define the scenarios where baseline collections are fully volume limited and therefore collecting mixed plastics packaging will generate an additional resource need and therefore cost. These modelling outputs define the likely upper costs of co-mingled systems and are displayed in Figure 2. The lower end of the cost range in co-mingled systems is defined by the processing cost only. Cost per tonne of collection are shown in Figure 3. The results shown in Table 14 are the indicative costs per household of collecting mixed plastics packaging in co-mingled collections for the hypothetical authority. It is important to note that the indicative costs relate to the predicted yields shown in **Figure 4**, lower yields will generate lower additional recycling collection costs per household.

The additional costs of collecting mixed plastics packaging comprise of an additional collection cost, if the additional volume drives the need for further collection resources, and a processing gate fee. An example of the relative contribution of these costs to the overall costs of collection is shown in **Figure 5**.

The costs are shown as i) the cost of baseline conditions ii) the costs of additionally collecting rigid plastics and iii) the costs of additionally collecting films. The cost of films has been calculated by calculating the additional cost from Option A models (adding rigid only).

Figure 2: Indicative cost per household showing upper range for co-mingled collection of mixed plastics packaging (excluding avoided disposal savings)

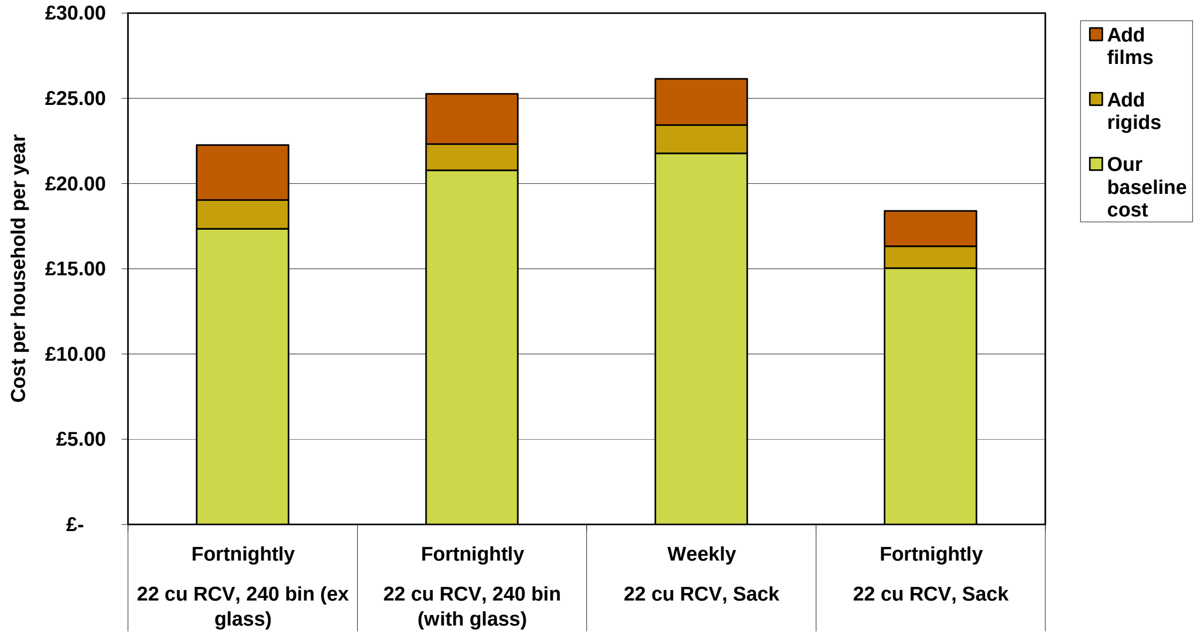


Table 14: Co-mingled indicative cost per household

		Add rigids		Add films	
System	**Frequency**	**Cost per hh per yr. (excluding avoided disposal savings)**	**Cost per hh per yr. (including avoided disposal savings)**	**Cost per hh per yr. (excluding avoided disposal savings)**	**Cost per hh per yr. (including avoided disposal savings)**
22 cu RCV, 240 bin (ex glass)	Fortnightly	£1.69	£0.95	£3.23	£2.21
22 cu RCV, 240 bin (with glass)	Fortnightly	£1.55	£0.83	£2.95	£1.96
22 cu RCV, Sack	Weekly	£1.66	£0.95	£2.72	£1.79
22 cu RCV, Sack	Fortnightly	£1.29	£0.73	£2.07	£1.36

Figure 3: Indicative cost per tonne showing upper range for co-mingled collections of mixed plastics packaging (excluding avoided disposal savings)

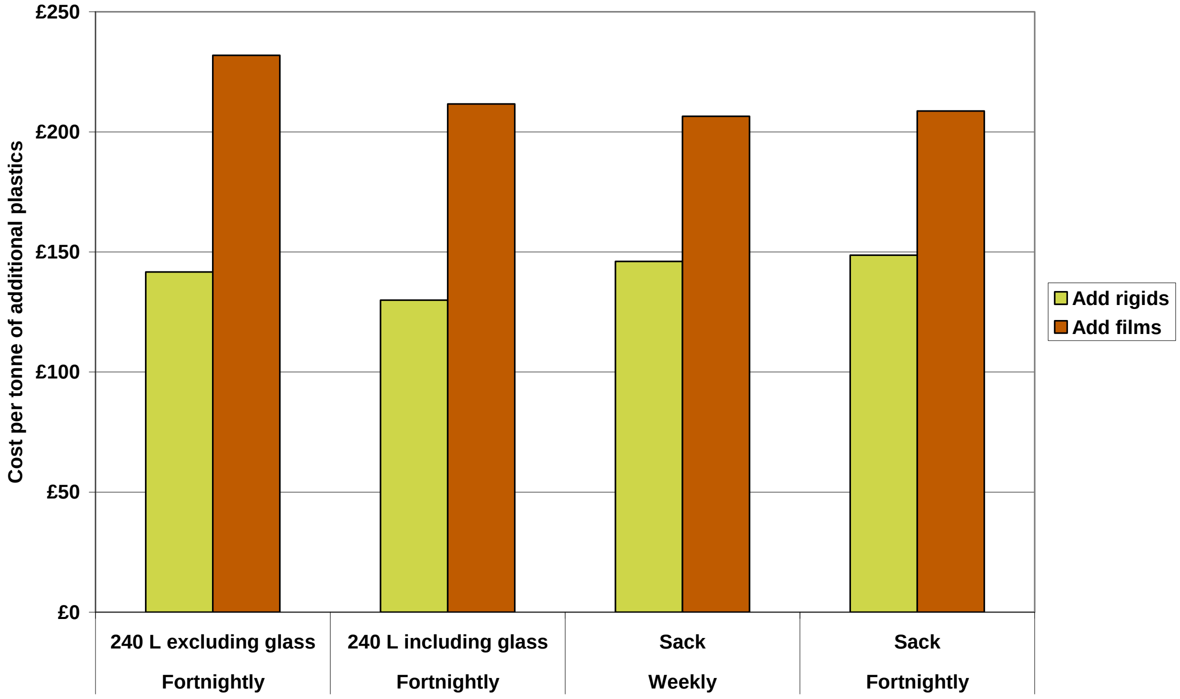


Table 15: Co-mingled indicative cost per tonne

		Cost per tonne. (excluding avoided disposal savings)	
System	**Frequency**	**Add rigids**	**Add films**
22 cu RCV, 240 bin (ex glass)	Fortnightly	£142	£232
22 cu RCV, 240 bin (with glass)	Fortnightly	£130	£212
22 cu RCV, Sack	Weekly	£146	£206
22 cu RCV, Sack	Fortnightly	£149	£209

Figure 4: Modelled capture of mixed plastics packaging in co-mingled systems

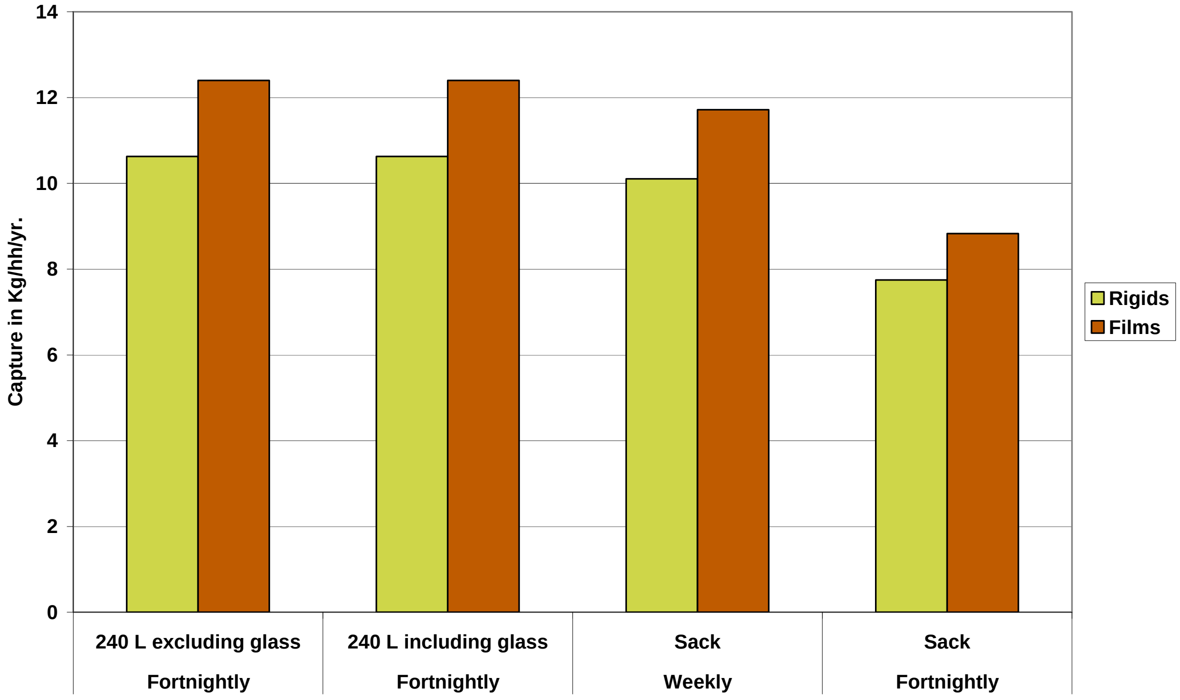


Figure 5: Example cost components: fortnightly co-mingled, 240 litre wheeled bin system

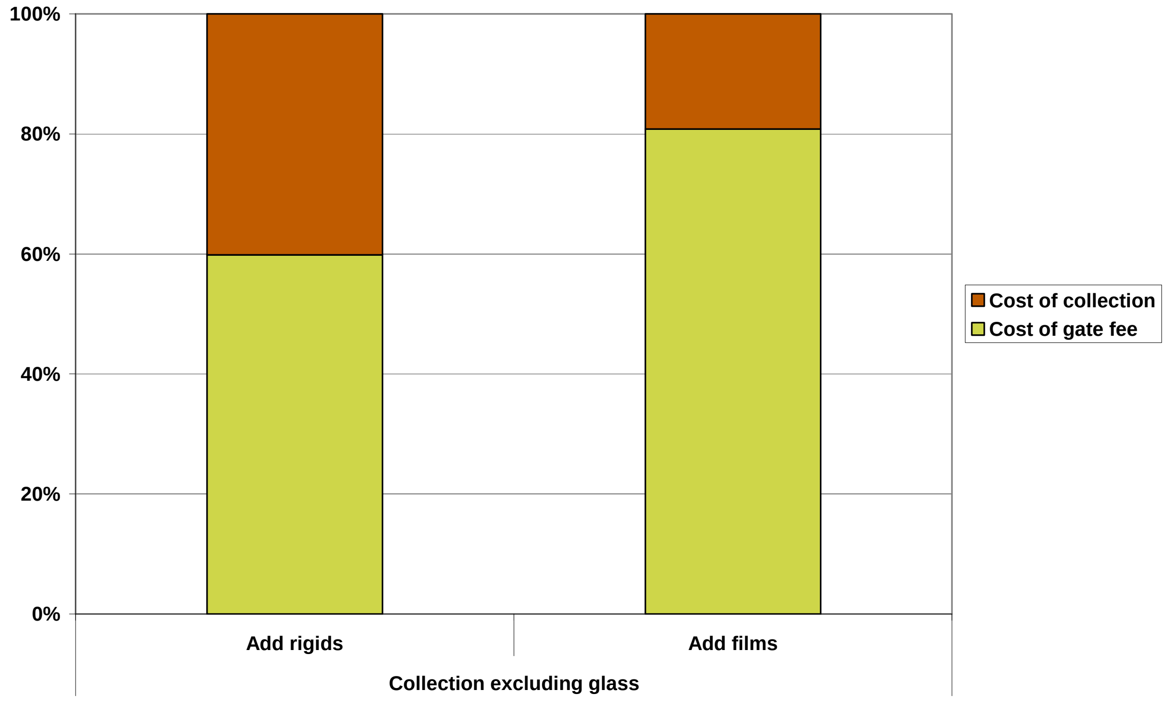


Figure 5 shows the percentage of the increase in fees that representational of the gate fee and the additional collection costs.

11.0 Indicative costs of collecting mixed plastics packaging in two-stream collections

The two-stream collection system modelled differs from fully co-mingled collections in that fibre products (paper and cardboard) are kept separate from the containers such as plastics, glass and cans. There are therefore two streams; fibres and containers. The householder is given separate containers for each stream and RCVs with two compacting compartments collect both streams at the same time. We modelled two-stream collections with different household containments as described in **Table 16** .

Table 16: Two-stream containment options

	Fibre containment	Containers containment
Variant 1	55 litre box	55 litre box
Variant 2	55 litre box	240 litre wheeled bin
Variant 3	240 litre wheeled bin	240 litre wheeled bin

The significant factors driving the cost of collecting mixed plastics packaging in two-stream co-mingled systems are:

- the relationship between current capture of mixed plastics packaging and the capture when targeted;
- possible volume constraints; and
- possible 'spare' volume capacity in vehicles that could be utilised for mixed plastics packaging.

Vehicles in two-stream collections must return to tip when one compartment becomes full, which inevitably leads to some under utilisation of the other compartment. A vehicle therefore may return with spare capacity on the container compartment because the fibre compartment is full or may return on the last tip of the day with spare capacity in both compartments. In both situations, if there is sufficient spare volume to collect mixed plastics packaging then it is possible that it could be collected with out any additional vehicles or crews and therefore only a processing cost would apply. However, as with co-mingled collections, the modelling process has optimised baseline collections to achieve the highest theoretical pass rates. When mixed plastics packaging is added to these modelled systems additional volume is always required and therefore a collection cost generated.

Increasing volume constraints in two-stream collections (due to one chamber filling before the other) result in increased redundant capacity relative to single-stream co-mingled collection and therefore pass rates diminish more rapidly when mixed plastics packaging is added. Two-stream systems also rely on a MRF to sort the containers. However, the addition of mixed plastics packaging to these facilities is likely to have a smaller cost impact per tonne than a single stream MRF due to the fact that additional mixed plastics packaging would be displacing higher volume lower value items than would be the case in a single stream MRF. The results shown in **Figure 6** are the indicative costs per household of collecting mixed plastics packaging in two-stream co-mingled collections for the hypothetical authority, based on the material yields assumed.

The costs are shown as the cost of baseline conditions, the costs of additionally collecting rigid plastics and the costs of additionally collecting films. The cost of films has been calculated by calculating the additional cost from Option A models (adding rigid only).

Figure 6: Two-stream co-mingled Indicative cost per household showing upper range for two-stream co-mingled collections of mixed plastics packaging (excluding avoided disposal savings)

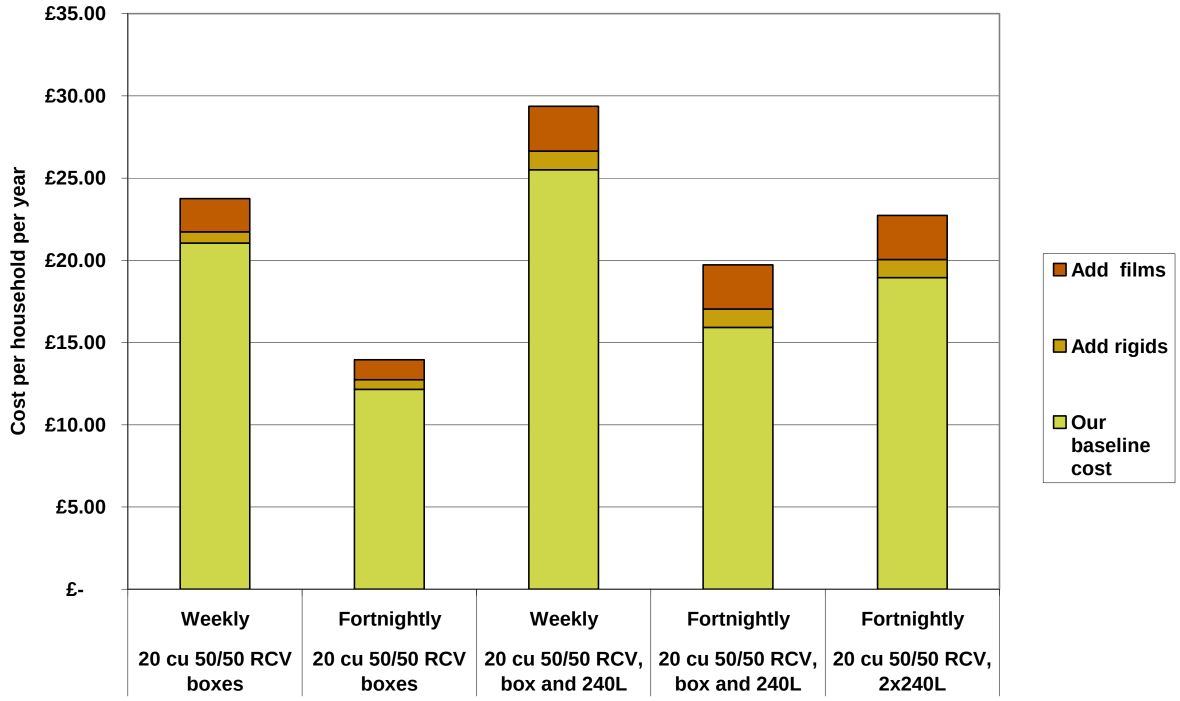


Table 17: Two-stream co-mingled indicative cost per household

		Add rigids		Add films	
System	**Frequency**	**Cost per hh per yr. (excluding avoided disposal savings)**	**Cost per hh per yr. (including avoided disposal savings)**	**Cost per hh per yr. (excluding avoided disposal savings)**	**Cost per hh per yr. (including avoided disposal savings)**
20 cu 50/50 RCV boxes	Weekly	£0.68	£0.12	£2.03	£1.29
20 cu 50/50 RCV boxes	Fortnightly	£0.59	£0.19	£1.21	£0.76
20 cu 50/50 RCV, box and 240L	Weekly	£1.13	£0.44	£2.72	£1.74
20 cu 50/50 RCV, box and 240L	Fortnightly	£1.11	£0.43	£2.69	£1.72
20 cu 50/50 RCV, 2x240L	Fortnightly	£1.10	£0.53	£2.68	£1.77

Figure 7: Indicative cost per tonne showing upper range for two stream co-mingled collections of mixed plastics packaging (excluding avoided disposal savings)

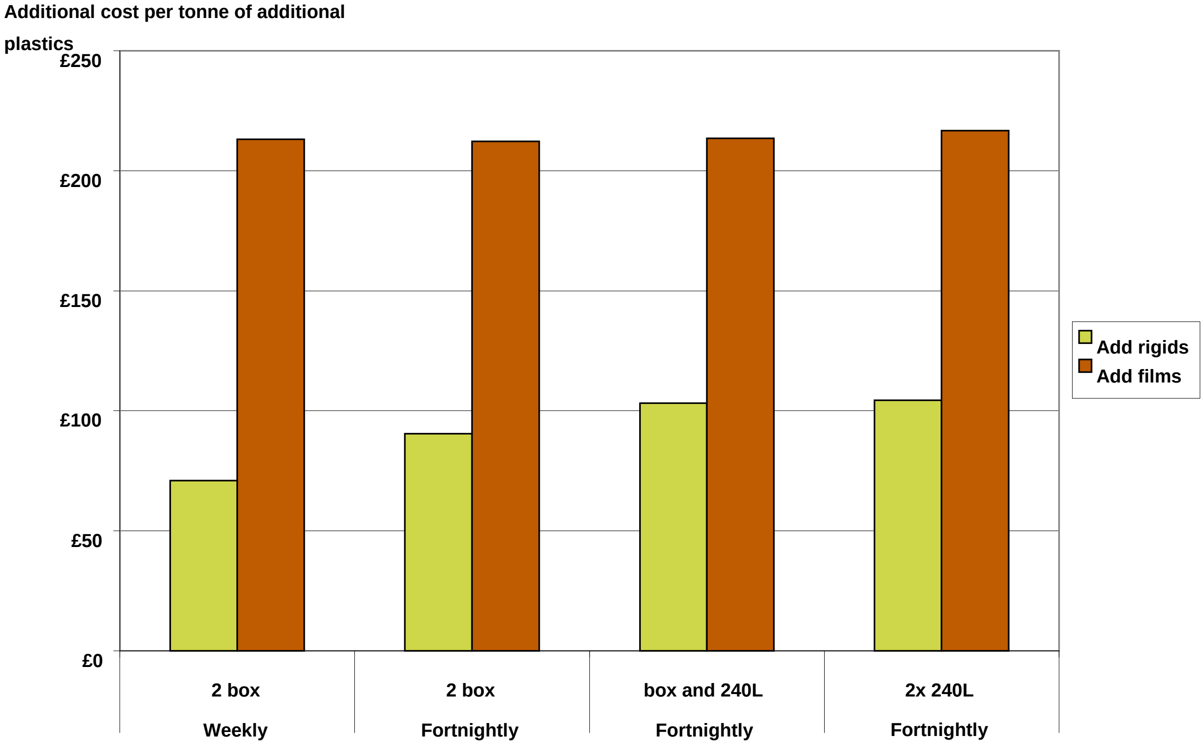
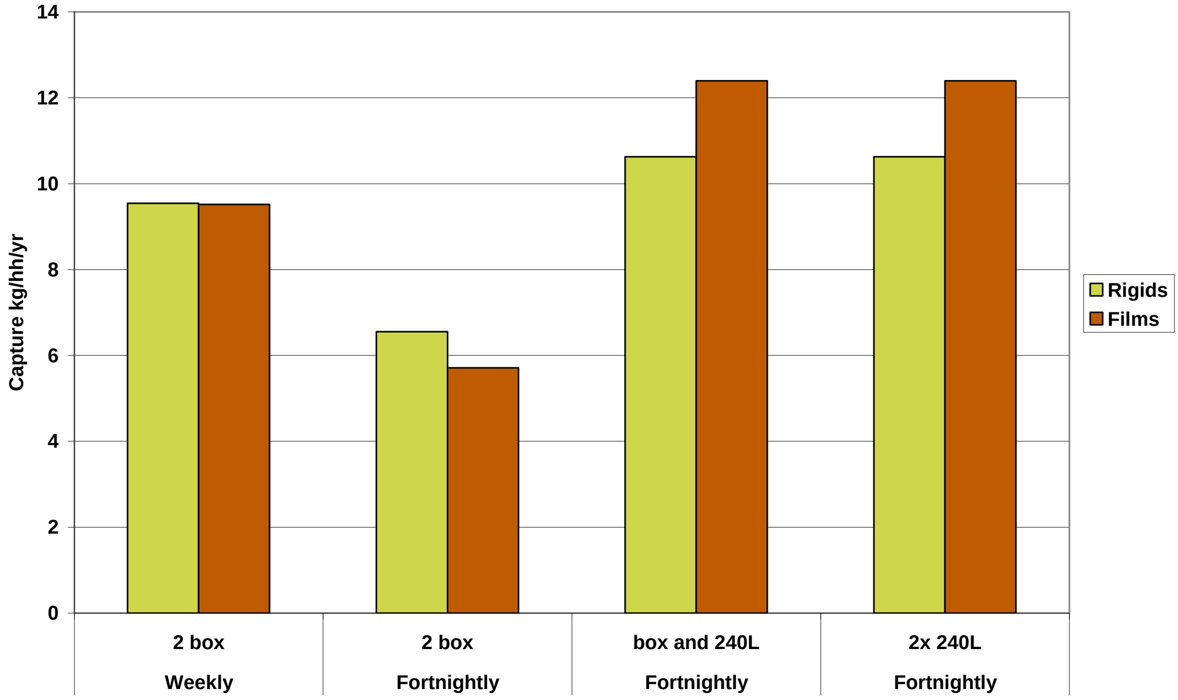


Table 18: Two stream co-mingled indicative costs per tonne

		Cost per tonne. (excluding avoided disposal savings)	
System	**Frequency**	**Add rigids**	**Add films**
20 cu 50/50 RCV boxes	Weekly	£71	£213
20 cu 50/50 RCV boxes	Fortnightly	£90	£212
20 cu 50/50 RCV, box and 240L	Fortnightly	£103	£214
20 cu 50/50 RCV, 2x240L	Fortnightly	£104	£217

Figure 8: Modelled capture of mixed plastics packaging in two-stream co-mingled systems



12.0 Discussion of co-mingled and two stream results

A range of results have been displayed to illustrate the likely costs of collecting mixed plastics packaging. To ascertain the actual costs that are likely to be incurred by an authority it would be necessary to understand the volume restrictions that exist. Although there is uncertainty regarding the exact costs of collecting mixed plastics packaging once the costs associated with processing mixed plastics packaging are removed it can be seen that the additional costs of collecting mixed plastics packaging, particularly rigid and getting the material to a MRF are likely to offer an acceptable cost in both co-mingled and two stream systems.

The modelled yields of mixed plastics packaging are still relatively uncertain. A rule of thumb relating to the capture of rigid plastic packaging that has been noted by a number of collection authorities operating mixed plastic collections and MRF operators handling the material is to expect a similar yield of rigids as currently gained for plastic bottles. The modelled yields reflect these observations. However, it is notable that the compositional data available shows that a number of collection systems that are specifying mixed plastics packaging rigids are obtaining lower captures (see **Figure 1**, Variation in capture rate by collection type). Relatively little is known regarding the potential capture of plastic films when targeted. The modelled capture of films has been based on a reasonable judgement from a number of contributing parties.

There is further uncertainty regarding the current capture of mixed plastics packaging as contamination in schemes that do not specify mixed plastics packaging. The assumptions detailed in **Table 11** (Recognition of plastic fractions as contamination when not targeted in co-mingled and two steam systems)are based on the findings from the compositional work shown in **Figure 1**. However, again it is important to note that the levels of mixed plastics packaging captured as contamination are likely to vary considerably from authority to authority. This sensitivity is important because in situations where a collection authority is capturing substantially more mixed plastics packaging as existing contamination then the incremental costs of targeting the collection of the material and possibly the incremental additional cost of gate fees will be lower than those modelled in this report.

The cost differences between each specific modelled system vary marginally between each other and are primarily driven by the modelled yield for each system. Yields are likely to vary between collection authorities relating to many factors in addition to the specific systems type and communication strategies. Furthermore, there is uncertainty regarding the modelled yield differences between the different systems.

The results demonstrate the significance of gate fees in determining the overall costs that would be incurred through collecting these materials in co-mingled and two stream systems. In the case of two stream systems the sorting of rigid mixed plastics packaging is relatively straightforward and unlikely to generate gate fee impacts that are significantly different to those modelled. Processing rigid plastics in fully co-mingled MRFs is a more complex issue. The modelling approach has used a simplistic mass balance approach to calculating the change in gate fees. It is possible that the collection of mixed plastics packaging could introduce additional food waste due to food trays being un-cleansed. The introduction of additional food waste would potentially impact on the quality of fibre products from the MRF and result in a lower income and this potential impact has not been allowed for. Furthermore, specifying the collection of rigid plastic packaging may result in additional capture of plastic films as a contaminant (if not actively collected) and which would also impact on gate fees, we have not allowed for this possibility in the modelled costs for rigids.

The costs of collecting plastic films in both co-mingled and two stream systems are almost entirely associated with the cost of processing the materials at the MRF. At the stage of writing this report very few MRFs are accepting plastic films and little is known about the potential capture of this material. From a technical perspective sorting films from co-mingled materials is significantly more difficult than sorting rigids. The primary methods of sorting fibre products from containers in MRFs relies on the two dimensional properties of paper and card differentiating these items from the containers that have three dimensional properties. Plastic films exhibit two dimensional properties therefore commonly used sorting systems in MRF such as ballistic screens/star screens will tend to sort films into the fibre fraction. We believe that the common method of sorting films in existing facilities is manual, assisted by vacuum hoods in the pre-sort cabin. The £150 sorting fee has been selected as a plausible charge for this type of manual separation system but it is important to note that there is a high degree of uncertainty associated with this value.

MRFs are varied in their designs and capacities and therefore it is likely that actual gate fees associated with collecting mixed plastics packaging will vary. MRFs accepting mixed plastics packaging will have varied approaches to managing the different volumes associated with specifying this material. Some facilities will be designed to accept mixed plastics packaging whilst others may need to retro-fit additional capacity in order for the sorting of mixed plastics packaging to be economically feasible. Some facilities will manage plastic volumes by blending material with low plastic volumes with material with higher plastic volumes. These differing strategies coupled with the end value of mixed plastics packaging and the longevity of the deal with the WCA will all potentially impact on the actual gate fee incurred by an authority collecting mixed plastics packaging.

For individual authorities to understand the cost implications of collecting mixed plastics packaging using co-mingled or two stream systems we would recommend that the following points are considered:

- an understanding should be gained of whether additional collection resource will be required;
- the cost associated with gate fee changes should be clarified and the stability of this price considered in context with the length of the contractual arrangements with the MRF reprocessor; and
- strategies should be adopted to minimise unwanted contamination, particularly due to food wastes and unspecified plastics.

13.0 Conclusions drawn on the costs of collecting mixed plastics packaging using co-mingled and two stream collections

A range of possible costs exist for collecting mixed plastics packaging through co-mingled and two stream systems. The cost of collecting the material and delivering it to a MRF could be as little as zero if there is existing capacity in the collection operation. However, even if the additional specification of mixed plastics packaging does drive the need for additional collection resources, the modelled costs for this eventuality are still low.

It has been shown that the gate fee component of the collection costs is an important aspect of collecting all mixed plastics packaging in co-mingled systems and plastic films in two stream systems. There is uncertainty regarding the potential gate fees that would be incurred for all mixed plastics packaging but this is particularly true regarding the collection of films.

Primarily due to the low incremental gate fee impact of collecting mixed plastics packaging in two stream collections it is likely that this system offers the lowest cost per tonne collection costs for rigid plastics (bar possibly some bring systems).

The cost of collecting mixed plastics packaging using co-mingled systems is predominately due to the incremental cost of gate fees and is likely to range between 60% and 100% of the total cost. If gate fee assumptions are correct then it is likely that co-mingled and two stream systems offer the two least expensive kerbside collection methods for rigid plastics.

The cost of collecting plastic films is relatively high in both systems which is almost entirely associated with the gate fee component of collecting this material. If the gate fee assumptions we have used are correct then both these systems appear to be the more expensive systems for collecting films.

14.0 Assumptions used to model kerbside sort systems

14.1 Material values

An important economic component of kerbside sort systems is the income that these schemes derive from the sale of collected material. The time period over which this report has been written has seen depressed material values which followed a period during the summer of 2008 where exceedingly high material values could be obtained. We have attempted to model conservative long term material values. To achieve this we have used historic data, where possible based on the historic data contained within WRAP's Materials Pricing Report (MPR) and based on a two year period from April 2006 to March 2008. **Table 19** shows the assumptions within our model with regard to the commodity prices for source separated recyclables. Prices shown here may be higher than those being achieved under the market conditions of early 2009 following the sharp decline in commodity values that occurred towards the latter part of 2008.

Table 19: Commodity prices for source separated recyclables

Material	Price per tonne
Paper	£55
Card	£20
Plastic film	£0
Plastic bottles	£100
Other rigid plastic packaging	£40
Textiles	£120
Colour-mixed glass bottles/jars	£21
Mixed cans	£130

14.2 Set out, participation, recognition rates and contamination rates

As reported in section 9.2, set-out, participation and recognition rates determine the proportion of available materials collected. The values assumed and used for the kerbside sort systems in the modelling process are shown in **Table 20**. Although the compositional data detailed in section 8.1 is a small sample size it serves to illustrate that some kerbside sort systems are capturing mixed plastics packaging as contamination. In lieu of more accurate data we have modelled capture of mixed plastics packaging as contamination in all kerbside sort systems on the basis of the compositional data and as set out in **Table 21**.

Table 20: **Set-out, participation and recognition in kerb sort systems**

	Fortnightly box	Weekly box
Participation	88%	93%
Set out	83%	82%
Recognition by material		
Paper	72%	94%
Non-recyclable paper	20%	20%
Card	55%	72%
Plastic film	20%	30%
Plastic bottles	62%	82%
Other dense plastic packaging	45%	60%
Other dense plastic	1%	1%
Textiles	11%	11%
Glass bottles/jars	72%	94%
Other glass, other ferrous, aerosols, cartons, aluminium foil other non ferrous foil, kitchen waste and misc/Fines/Hazrd/WEEE	0%	0%
Ferrous cans	50%	60%
Garden	0%	0%
Aluminium cans	61%	96%

Table 21: Mixed plastics packaging capture as contamination in kerbside sort systems

Material	Recognition
Plastic film	1.6%
Rigid plastic packaging (non-bottle)	2.6%
Other non-packaging rigid plastic	1.0%

14.3 Vehicles used in kerbside sort modelling

Three kerbside sort vehicles were modelled and are described in **Table 22**.

Table 22 Vehicle capacity and costs

Number	Description	Capacity (kg)	Capacity (m^3)	GVW (laden)	Total capital cost per vehicle
4	33 m^3 Kerbsider	8,500	31.5	18,000	£111,000
5	20m^3 Stillage	5,000	20	12,000	£46,000
6	33m^3 Stillage	4,500	33	12,000	£63,000

All the modelled vehicles are based on actual vehicles employed on collection contracts. However, slightly different approaches were taken for each vehicle regarding defining the individual compartment volumes. With vehicles 4 and 5 (the kerbsider and 20m^3 stillage) we assumed that compartments were optimally designed for the material mix in the baseline scenario and then re-designed to be optimal for each of the mixed plastic collection options. To provide 30m^3 of containment volume on stillage vehicles it is generally necessary to use two tiers of containment, with the upper tier used for light, high volume materials. Due to this arrangement on this vehicle it is not possible to optimise all compartments for use in the baseline situations because the upper tier of containment cannot be used for higher density materials. This vehicle remained with the same containment configuration in each option. Due to the slightly differing captures of materials in fortnightly collections the optimal compartment configurations are different to those modelled for weekly collections.

Table 23 Vehicle compartments

		Compartment volume provision					
		1 Paper	2 Plastics	3 Glass	4 Cans	5 Textiles	6 Card
Kerbsider	Weekly Baseline	13.78	8.87	4.52	4.24		
	Weekly option 1	11.80	12.07	3.87	3.63		
	Weekly option 2	10.88	13.57	3.56	3.35		
	Fortnightly Baseline	13.85	8.85	4.50	4.30		
	Fortnightly option1	11.94	11.98	3.88	3.71		
	Fortnightly option2	11.15	13.27	3.62	3.46		
20 m^3 stillage	Weekly Baseline	6.10	8.24	2.44	2.96	0.14	
	Weekly option 1	4.84	10.64	1.94	2.35	0.11	
	Weekly option 2	4.53	11.21	1.82	2.20	0.10	
33m^3 stillage	All options	6.74	13.00	2.54	3.01	0.18	7.52

Notes:
Compartment 2 on kerbsider has an additional 1.5 cubic metres of containment used by incorporating an MVR.
Compartment 6 on the 33m^3 incorporates compaction.

14.4 Collection times modelled for kerbside sort collections

It was assumed that the pick up time per household will increase in the kerbside sort schemes when rigid plastic packaging and film are added to the collection system. A smaller increment is assumed to occur in those schemes collecting rigid plastic without the plastic film. **Table 24** shows our assumptions for pick up times by vehicle type for each of the modelled scenarios.

Table 24: Loading times for kerbside sort vehicles

		Average time per household collected from that the vehicle is stationary and being loaded (seconds)		
		20m^3 stillage	**33 m^3 stillage**	**33 m^3 Kerbsider**
Weekly	**Baseline weekly**	20.0	20.0	16
	Baseline + rigids	23.5	23.5	19.5
	Baseline + rigids + films	25.0	25.0	21
Fortnightly	**Baseline weekly**	Not modelled	26.6	24
	Baseline + rigids		31.3	28.5
	Baseline + rigids + films		33.3	30.5

15.0 Indicative costs of collecting mixed plastics packaging in kerbside sort collections

Kerbside sort collections have all been based on the assumption that householders are given two 55 litre boxes for containment. Three different collection vehicles have been modelled:

- a 20 m^3 13 tonne stillage vehicle;
- a 30 m^3 13 tonne stillage vehicle; and
- a 33 m^3 Kerbsider fitted with a Material Volume Reducer on the plastic compartment.

The significant factors driving the cost of mixed plastics packaging in kerbside sort are:

- additional loading times; and
- volume constraints.

Due to the need to re-optimise compartment volumes when specifying the collection of mixed plastics packaging it is unlikely that there will be adequate spare capacity to accommodate the addition of mixed plastics packaging in most kerbside sort vehicles. As a result we have not been able to model a range of costs for each of the kerbside sort systems. The 33 m^3 stillage vehicle options are an exception to the assumption that there is no spare volume in baseline collection as these vehicles are designed to collect high volume materials such as plastics by utilising a second tier of containment. In the baseline models it is not possible to utilise this second tier of containment for the other denser materials and therefore this vehicle has considerable spare capacity for high volume materials. In fact this vehicle is never volume limited on plastics in our modelling and therefore all costs associated with this vehicle are associated with additional loading times generating a need for additional resources.

The modelled costs for kerbside sort systems are shown in **Figure 9** and in a tabular form in **Table 25.**

The costs are shown as the cost of baseline conditions, the costs of additionally collecting rigid plastics and the costs of additionally collecting films. The cost of films has been calculated by calculating the additional cost from Option A (adding rigid) models.

Figure 9: Kerbside sort indicative cost per household (excluding avoided disposal savings)

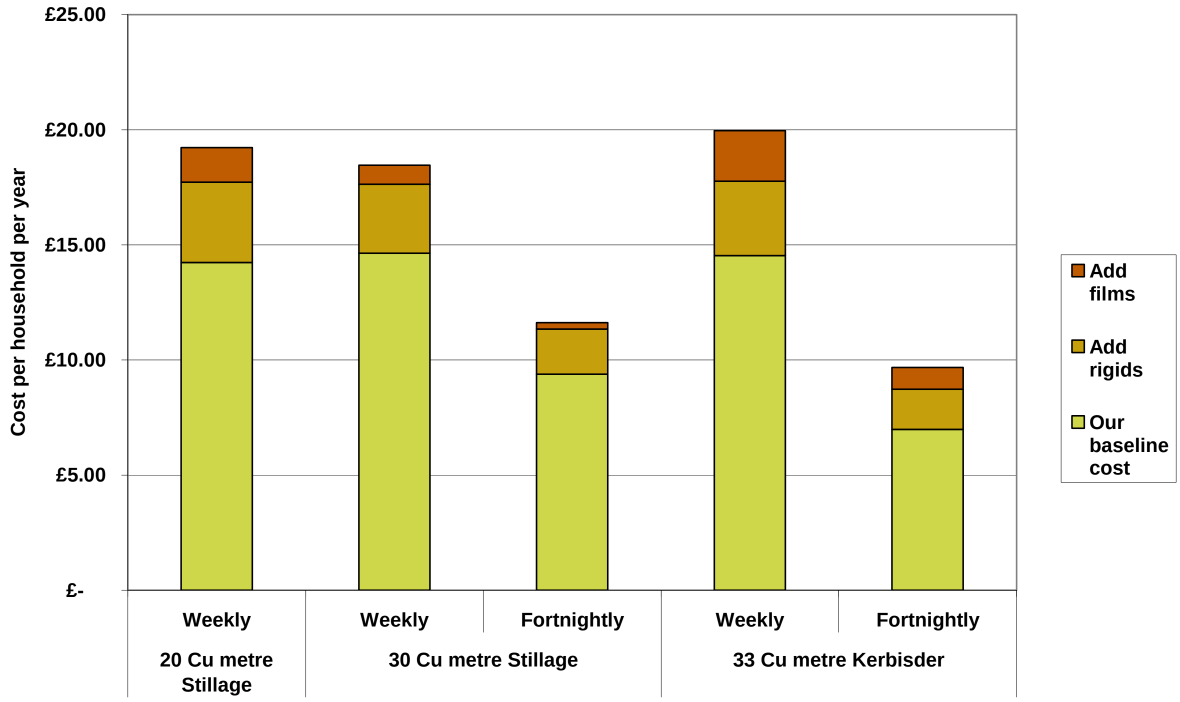


Table 25: Kerbside sort indicative cost per household

		Add rigids		Add films	
System	**Frequency**	**Cost per hh per yr. (excluding avoided disposal savings)**	**Cost per hh per yr. (including avoided disposal savings)**	**Cost per hh per yr. (excluding avoided disposal savings)**	**Cost per hh per yr. (including avoided disposal savings)**
20 m^3 stillage	Weekly	£3.49	£2.52	£1.50	£0.83
30 m^3 stillage	Weekly	£3.00	£2.14	£0.83	£0.24
	Fortnightly	£1.96	£1.38	£0.27	-£0.06
33 m^3 Kerbsider	Weekly	£3.23	£2.33	£2.20	£1.42
	Fortnightly	£1.74	£1.16	£0.94	£0.50

Figure 10: Kerbside sort indicative cost per tonne (excluding avoided disposal savings)

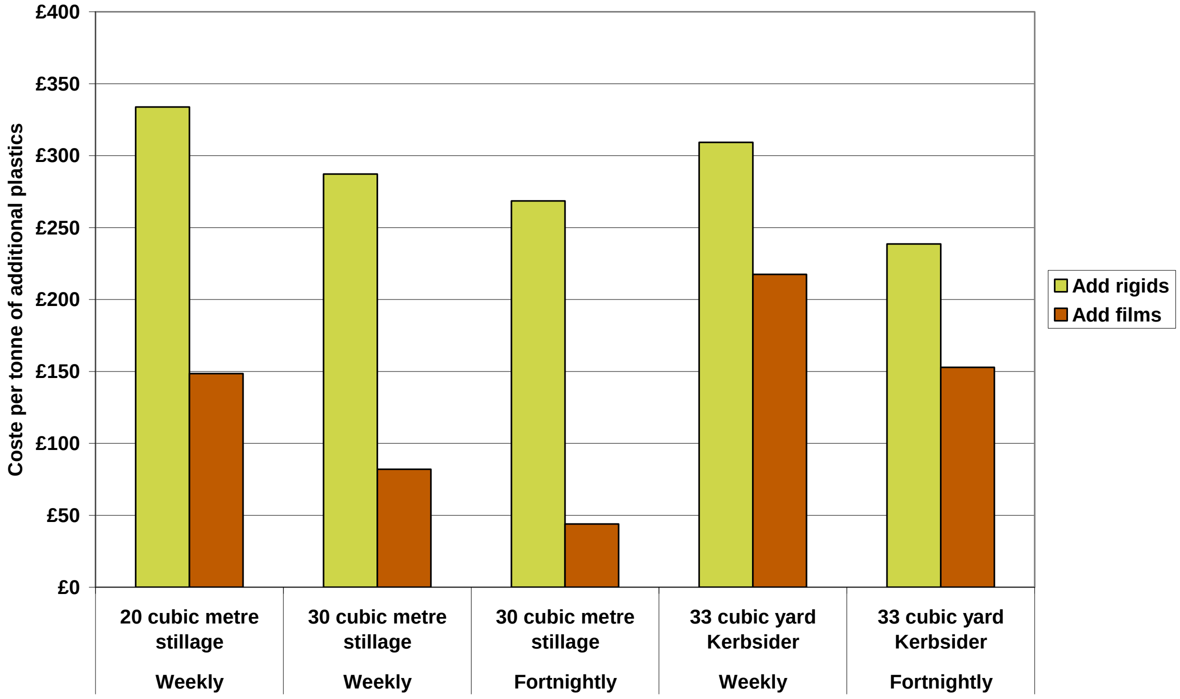
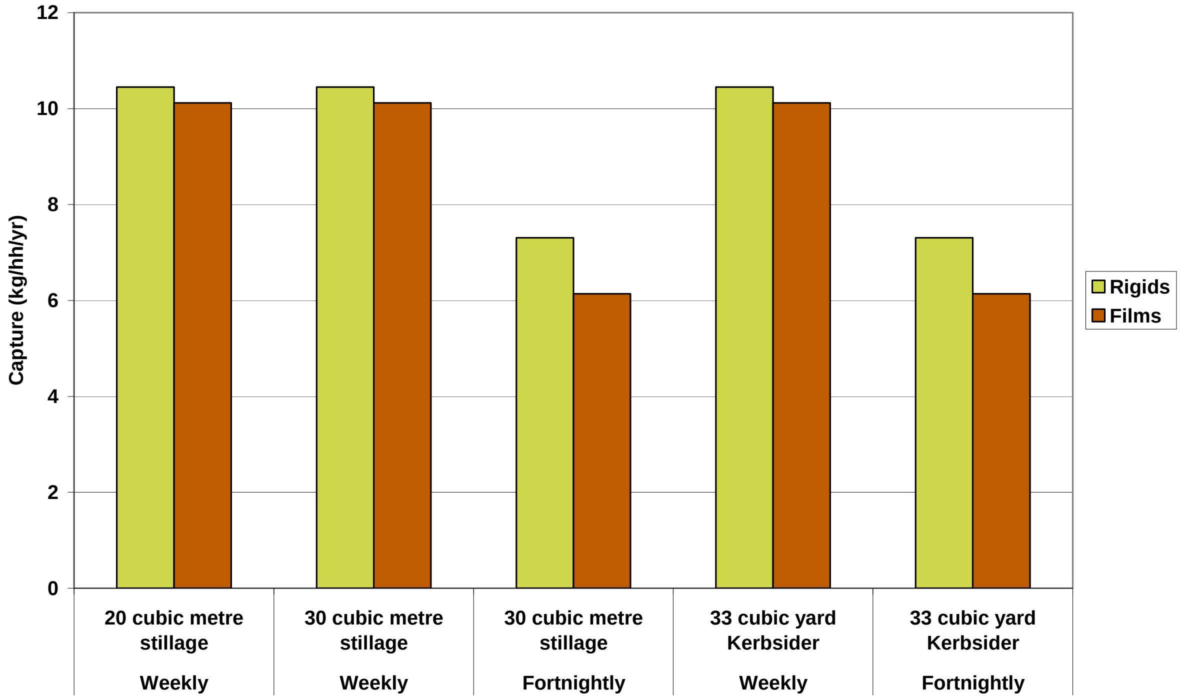


Table 26: Kerbside sort indicative cost per tonne

		Add rigids	Add films
System	**Frequency**	**Cost per hh per yr. (excluding avoided disposal savings)**	**Cost per hh per yr. (excluding avoided disposal savings)**
20 m^3 stillage	Weekly	£334	£149
30 m^3 stillage	Weekly	£287	£82
	Fortnightly	£268	£44
33 m^3 Kerbsider	Weekly	£309	£217
	Fortnightly	£239	£153

Figure 11: Modelled capture for kerbside sort collections



16.0 Containment restrictions

Provision of 110 litres of box containment was, in general, an adequate amount of volume for all scenarios except in the situation of fortnightly collections. The impact of modelled yields in fortnightly collections on box utilisation is shown in **Table 27**. The calculations are based on the uncompacted bulk density of materials being palced in the box and therefore assumes that all items are neatly stacked in the container and that some items will be squashed. The table shows that whilst average users have spare capacity heavier users will be constrained in capacity and therefore some level of additional containment may be required.

Table 27: Example of containment capacity in fortnightly box schemes

	Containment spare capacity (litres)		
Option	**Average (across all households)**	**For the top 5% of users**	**For the top 1% of users**
Option A – collect rigids	36.84	2.46	-31.92
Option B –collect rigids and films	33.68	-2.20	-38.07

17.0 Discussion of kerbside sort results

It is important to note that we have selected three vehicles that are optimally configured for collecting mixed plastic packaging and are of a modern design that allows loaders to load material without having to climb onto the vehicle. Other kerbside sort vehicles with insufficient volumes and longer loading times would produce significantly different cost results than those modelled. Compared to co-mingled systems, due to the compartment restrictions in kerbside sort vehicles and the low densities of un-compacted plastics it is much less likely that there will be spare capacity on kerbside sort vehicles that can be utilised for collecting additional mixed plastics packaging.

The collection results for rigid plastic packaging are relatively consistent between the different vehicle options. The main variation between cost (on a household basis) is related to the different modelled yields between fortnightly and weekly collections. When examined as a cost per tonne, measureing the cost of collecting rigids is similar between all vehicle types with rigids slightly more expensive to collect in the smaller 20 m^3 vehicle.

The collection costs for films are highly variable between vehicle options. The cost of collecting films on the 33 m^3 is virtually all associated with additional collection time and only a minor volume restriction in the weekly option. The collection of films on the 20 m^3 stillage vehicle and the Kerbsider are displacing other dry recyclates and therefore effectively volume constraints are driving additional resource requirements. In the case of films, the Kerbsider is not benefiting from any significant volume reduction from the MVR and therefore, with the higher operating costs of this vehicle the additional collection costs are slightly higher.

The cost of kerbside sort systems are, in general, relatively sensitive to the assumptions made relating to material incomes. However, in the case of modelling the collection of mixed plastics packaging, material incomes are making a relatively small contribution to the overall cost of collecting the material. For example, the ex works material income stream for the weekly options is approximately 12% of the incremental costs of collecting these items. A significant difference in material values from those modelled could significantly affect the overall costs of the system.

An important component of collecting materials in kerbside sort systems is the provision of bulking facilities for separated materials and the ability to adequately reduce the volume of materials if it requires onward transportation for anything but a local journey. The modelling process has assumed that the collection of dry recyclate in baseline options includes plastic bottles and therefore some element of baling is likely in these options. An allowance of approximately £40,000 per annum of costs (weekly option) has been generated for the bulking and handling all dry recyclate and then a further £4.50 per tonne has been added for each incremental tonne of mixed plastics packaging.

The marginal costs of collecting mixed plastics packaging on kerbside sort vehicles are highly sensitive to the loading time assumptions that are used. Small deviations from the increased times shown can lead to significantly higher or lower marginal costs than those modelled. It is therefore important that the design of kerbside sort systems collecting mixed plastics packaging incorporate suitable household containment, clear communications with householders and vehicles that can be loaded efficiently.

The costs of collecting mixed plastics packaging will vary according to the yields achieved. As noted for co-mingled and two stream systems our understanding regarding potential yields is relatively poor. However, in the case of kerbside sort systems then the understanding is lower because there are so few systems currently delivering this service. The one kerbside sort system that we have detailed compositional data for is achieving much lower captures of rigids and even lower captures of films than we have modelled.

Although our understanding of existing contamination by mixed plastics packaging in existing kerbside sort schemes is relatively poor it is likely that in most cases actual capture will be in a similar order to those modelled and therefore this aspect is not considered a significant sensitivity in kerbside sort systems.

For individual authorities to understand the cost implications of collecting kerbside sort collections we would recommend that the following points are considered:

- clarify the practicalities of specifying new vehicles that are optimised for collecting mixed plastics packaging;
- consider containment options and increased household communication in order additional loading time is minimised;

- gain a more detailed understanding of additional loading times that may be incurred and material yields by trialling collections before committing to a full roll-out of services; and
- understand whether bulking operations and onward transport to reprocessors is feasible at a reasonable cost.

18.0 Conclusions drawn on the costs of collecting mixed plastics packaging using kerbside sort collections

The costs of collecting rigid mixed plastics packaging using kerbside sort systems appear to be relatively high when compared with other collection systems. Plastic films appear to be cost effectively collected in kerbside sort systems, however costs for rigid mixed plastics packaging and plastic films should be considered together as films should only be collected in conjunction with other rigid plastics.

The modelled costs are partly driven by volume constraints on vehicles. However the more significant factor driving costs in kerbside sort systems where well designed vehicles are employed is the incremental rise in loading times. The level of uncertainty attributable to the loading time assumptions used in this report is relatively high and therefore there is a level of uncertainty attributable to these modelled costs. There is therefore a need to conduct practical trials of collecting these materials using kerbside sort methods in order that accurate time impacts can be ascertained.

19.0 Modelling the Indicative Costs of Bring Site Collection of Mixed plastics packaging

19.1 Background

Many local authorities currently obtain plastic bottle collection services using bring systems in a number of ways, and a few collect other mixed plastics packaging. In situations that are contracted out bring site services are most often contracted as part of the authority's kerbside collection contract. This may then be delivered by the kerbside collection contractor or may be sub-contracted to a specialist operator. In both these cases the cost of delivering the bring collection element of the contract, and in particular the cost of collecting plastic mixed plastics packaging is often not transparent to the authority. In some situations authorities procure plastic bring site collection services separately to the kerbside collection contracts and in these cases the cost of collecting plastics should be relatively transparent to the authority.

The economics of the collection service will differ depending on the potential utilisation of the resources employed in the mixed plastics packaging bring collection system. Most waste collection authorities will have relatively small amounts of material being collected through bring site systems which may result in a requirement for collection resources that amount to little more than a day per week. In these situations, for the bring system to be economic it is important that the collection vehicles and crews can be utilised elsewhere when not on bring system collections. This can limit the selection of bring resources to common vehicles that are easily deployed on other jobs but might not necessarily be the best suited to bring operations.

Furthermore, an operation collecting mixed plastics packaging will need a tipping location where plastics can be bulked and preferably baled. In situations where smaller amounts of plastics are collected it is more difficult to provide bulking and baling facilities in a cost effective manner. Utilisation of resource issues has lead in recent times to a growth in contracts being issued to regional, specialist material contractors who can employ and utilise specialist collection vehicles and utilise bulking and baling operations over a number of collection contracts.

19.2 Approach to ascertaining the costs of collecting mixed plastics packaging in bring systems

Due to a lack of data regarding the costs that local authorities have incurred, indicative bring system costs for mixed plastics collections have been established through a modelling exercise. In order to allow comparability between bring and kerbside systems key assumptions have been established based on the same single hypothetical authority that has been used for modelling kerbside costs. The authority has 50,000 households, some urban and rural rounds and collects refuse from the kerbside on a fortnightly basis from 48,000 of those households. In the case of modelling bring systems it has been assumed that the hypothetical authority does not collect any plastics, including bottles, through kerbside collections.

The approach to modelling has been to select five methods of collecting mixed plastics packaging from bring sites and model their application within the hypothetical authority. We have assumed that the operational base for providing this service is based locally. Regional, specialist collection services will have slightly different costs than those modelled as they will have longer drive times and miles to reach collection sites, potentially longer operational days, but may employ more efficient specialist techniques, vehicles and infrastructure.

19.3 Systems modelled

A wide range of bring systems are currently employed for the collection of plastic bottles. The following five bring systems were selected to be modelled:

1. 18 tonne skip loader and 14 cubic metre skip based bank;
2. 32 tonne front end loading (FEL) compacting RCV and 7 cubic metre FEL containers;
3. 26 tonne bulk tipper bodied lorry fitted with lorry loading crane and 3 cubic metre module banks;
4. 26 tonne compacting RCV and 1200 litre wheeled bins; and
5. 18 tonne RCV and static banks.

19.4 Potential bring site yields

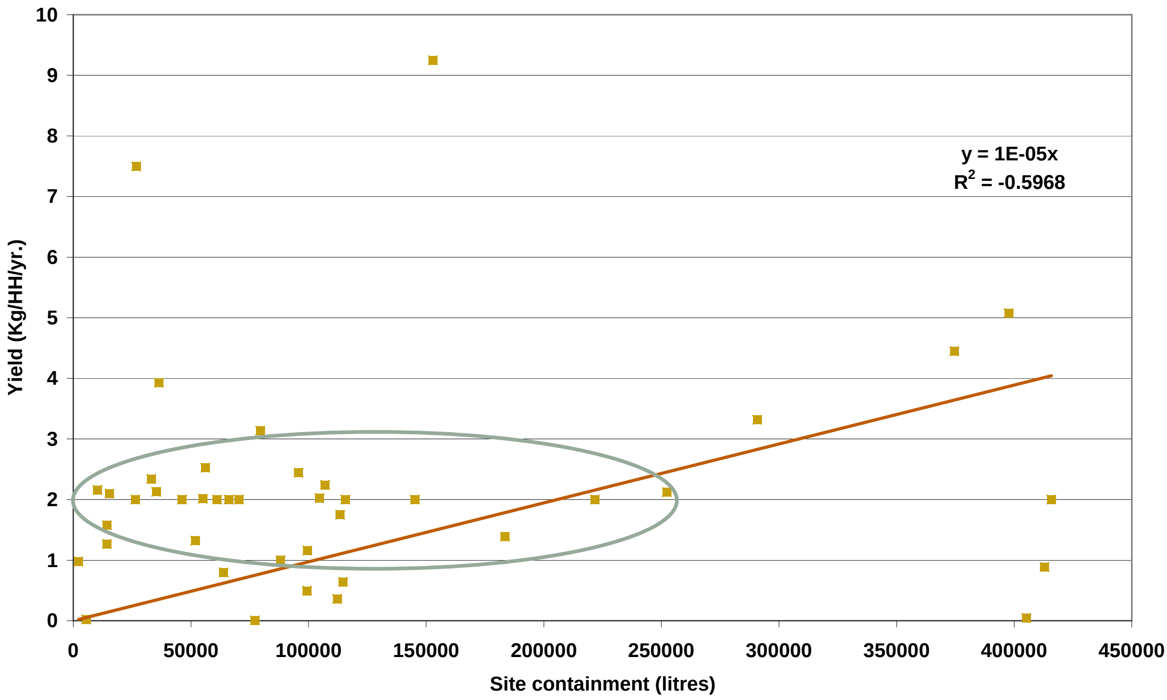
The potential yield of material (capture) is an input assumption to the modelling approach. Available data on the yields of mixed plastics packaging from existing bring systems targeting this material did not lead to a conclusive indication of likely yields. An examination of plastic bottle yields using data gathered by the WRAP funded Valpak Consultancy and Recoup survey[4] indicated that bring plastic bottle yields were generally between 1 and 3 kg/hh/yr. It is important to note that the data and a number of case studies indicate a number of bring systems that are capturing substantially higher yields of plastic bottles (4-9 kg/hh/yr). Little is known about why these systems are performing better **Figure 12**. However, it is of note that a number of the bring systems recorded in the Recoup survey have particularly small numbers of bring sites/containment and therefore logic would dictate that we would expect relatively low yields. The approach to setting yields in the modelling process has to be assume that the modelled authority is serious about capturing material and providing a good coverage of bring systems. The base assumptions are shown in **Table 28**.

The survey work that was carried out showed an extremely wide range of yields achieved in schemes collecting both household plastic packaging (plastic bottles and mixed plastics packaging) and only plastic bottles using bring systems. It has also been assumed that a wide range of factors is likely to affect the yield of household plastic packaging in bring systems such as;

- local socio-economics;
- number of bring sites provided;
- footfall at bring sites for other purposes such as shopping;
- collection of plastics in kerbside schemes;
- promotion of service; and
- importation of material from neighbouring authorities.

Available data on the yields of mixed plastics packaging from existing bring systems capturing this material was poor and did not lead to a conclusion being drawn. An examination of plastic bottle yields using the Recoup survey data is displayed in **Error! Reference source not found.**. A number of attempts were made to analyse the available data to find patterns which would explain the yields obtained.

Figure 12: Yield of plastic bottles in bring schemes based on data from Recoup survey



[4] *Published as the 2008 Annual Local Authorities Plastics Collection Survey, WRAP, Valpak Consultancy and Recoup*

The approach to setting yields in the modelling process has to be assume that the modelled authority is serious about capturing material and providing a good coverage of bring systems as well as a good supporting promotions campaign. The base assumptions are shown in **Table 28**. The approach has been to assume the following factors should apply to the baseline (plastic bottle schemes);

- current schemes are reporting yields that include some mixed plastics packaging as contamination; and
- a scheme with good coverage should obtain approximately 3.5kg/hh/yr.

Table 28: Modelled yields in bring systems

Composition	Assumed yields of baseline and modelled scenarios (Kg/Hh/yr).		
	Baseline scheme targeting plastic bottles	**Mixed plastics packaging scheme targeting rigid plastic packaging**	**Mixed plastics packaging scheme targeting rigid plastic packaging and films**
Plastic bottles	2.53	3.49	3.49
Other plastic packaging rigids	0.47	3.49	3.49
Plastic films	0.23	0.27	3.49
Non - packaging plastics	0.07	0.33	0.33
Other contamination	0.17	0.47	0.47
Total amount collected	**3.47**	**8.05**	**11.28**

Yields of the two mixed plastics packaging scenarios have been derived by assuming the following:

- plastic bottle yields will increase due to increased popularity of scheme and promotion;
- capture of other rigid plastics packaging and films will relate to plastic bottles in a similar manner to the assumptions derived in the kerbside modelling which examined participation rates and recognition rates and resulted in a relationship of 33.3% Plastic Bottles; 33.3% Other Rigid Plastic Packaging and 33.3.% Films; and
- contamination will be marginally higher in bring schemes than in kerbside schemes.

The yield assumptions used in the modelling process have been translated into estimated recognition rates in **Table 29**.

Table 29: Modelled yields for bring scheme targeting mixed plastics packaging converted to estimated Recognition Rates

Available household kerbside arisings	As % kerbside arisings	Available arisings (kg/Hh/Yr.)	Recognition rate of mixed plastics packaging in modelling (rigids and films targeted)
Total arisings	100%	850	N/A
All plastics	11%	94	12%
Plastic bottles	2%	16	22%
Plastic packaging rigids	3%	23	16%
Plastic films	5%	40	9%
Non - packaging plastics	2%	15	2%

19.5 Virtual Sites

The collection of materials through bring site systems are limited in a practical sense by the availability of land to place collection banks on. To obtain reasonable yields it is important to achieve a good level of coverage which means a reasonable number of sites must be found. The usage and therefore yield of individual sites is highly variable with some popular sites such as supermarkets achieving significantly higher yields than smaller sites.

From a point of view of organising collection schedules, an operator would prefer to organise the capacity on each site so that it matches the yield of material in order that they can operate a set weekly or fortnightly collection schedule. Practically, this is not always possible because the land available for bring systems is limited and therefore the number of containers that can be placed on the site is also limited. The restricted availability of land can lead to increased frequency of collections.

Capacity of sites and collection frequency schedules are both factors that will affect the costs of bring site collections, therefore we have incorporated a set of 21 virtual sites within the modelling process. The modelling process calculates individual site yields. The model then attempts to provide sufficient containment capacity to allow a once weekly collection plus a margin of 10% volume to allow for variability. However, in providing extra containment the model checks the availability of land and will stop adding additional containment when the maximum land availability for each site is reached.

Table 30: Description of virtual sites used in the bring model

Site	Site description	Max land take for plastic containment m^2	Usage weighting	Usage weighting as %
1	Large Supermarket	35.2	3.5	12%
2	Large Supermarket	35.2	3.5	12%
3	Large Supermarket	35.2	3	11%
4	Medium Supermarket	22	3	11%
5	Medium Supermarket	22	2.5	9%
6	Medium Supermarket	22	2.5	9%
7	Busy Community	8.8	1	4%
8	Busy Community	8.8	1	4%
9	Busy Community	8.8	1	4%
10	Busy Community	8.8	1	4%
11	Medium Community	7.9	0.75	3%
12	Medium Community	7.9	0.75	3%
13	Medium Community	7.9	0.75	3%
14	Medium Community	7.9	0.75	3%
15	Medium Community	7.9	0.75	3%
16	Light Community	4.4	0.3	1%
17	Light Community	4.4	0.3	1%
18	Light Community	4.4	0.3	1%
19	Light Community	4.4	0.3	1%
20	HWRC	13	0.75	3%
21	HWRC	13	0.75	3%

The modelling process uses the data provided in **Table 30** to calculate individual site yields. The model then attempts to provide sufficient containment capacity to allow a once weekly collection plus a safety margin of 10% volume to allow for variability. However, in providing extra containment the model checks the availability of land and stops adding additional containment when the maximum land availability for each site is reached.

19.6 Timings of operations

Collection resource requirements are very important assumptions which the model is highly sensitive too and are displayed in **Table 31**.

Table 31: Timings of collection operations

	Collection system and time in minutes				
	Skip	FEL	Crane	1200L/RCV	RCV Bank
Average time to start of round	20	20	20	20	20
Average time to empty a bank	20	7	6	1.5	10
Average time between sites	15	15	15	15	15

Average time to start of round is the drive time from depot to the first collection site. Average time to empty a bank is self explanatory apart from in the skip scenarios where it acts as a proxy for the time taken to unload the empty skip, load the full and any necessary shunting time.

19.7 Material values and gate fees

These have been assumed to be the same as used in the kerbside model (see section 14.1). We have assumed that all materials are dealt with as source separated mixed plastics packaging and therefore MRF gate fees do not apply.

19.8 Collection resources

The capital resources used in the modelling process are defined in the following tables

Table 32: Vehicle assumptions

	Vehicle specification and Gross Vehicle Weight				
	26 tonne compacting RCV	**32 tonne compacting FEL**	**Skip loader**	**26 tonne bulk tipper (crane)**	**Specialist 18 tonne RCV**
Volume (Cubic Metres)	20	20	N/A	20	20
Purchase Price (£)	£120,000	£165,000	£50,000	£120,000	£140,000
Write of Period (years)	7	7	7	7	7
Fuel Consumption (miles per gallon)	6	6	12	8	8

Table 33: Container assumptions

Container specification	1200 Litre wheeled bin	Front End Loader Skip	Skip	Modules for Crane Operation	Banks for RCV
Width (metres)	1.3	1.8	2.2	1.5	2.2
Depth (metres)	1.5	2.2	3.6	1.5	2
Height (metres)	1.5	1.7	1.8	1.5	1.5
Volume (Cubic metres)	1.2	6.7	14.3	3.4	7
Land take (m^2) for a single unit	1.9	4.0	7.9	2.3	4.4
Unit cost	£180	£1,800Too much	£1,400Too much	£800Too much	£800
Life of containers (years)	7	7	7	7	7

We have assumed that all collection vehicles are operated by a single driver working a 40 hour contract but delivering 35 effective hours of driving and collecting. Base salary is converted to a total annual cost which includes pension, employers NI, agency sickness and holiday cover. This calculation is shown in **Table 34**.

Table 34: Driver costs

	Salary	Working hours	Salary including NI and Pension	Holiday and Sick Cover
Driver	£23,130	40	£26,830.80	£3,996.08

19.9 Overheads and Contractor profit

As in the kerbside modelling we have applied a 6% off contract charges as an overhead fee and a further 6% on all costs as a profit margin. Supervision and depot overheads have been charged at £10,000 per annum per vehicle employed on the contract.

20.0 The incremental costs of collecting mixed plastics packaging in bring site systems

Based on the parameters discussed above, the modelling process produced the results detailed in this section. The significant factors driving the cost of collecting mixed plastics packaging in bring systems are:

- the yield of plastics;
- the provision of sufficient containment volume so that individual site collections yield large quantities of material; and
- the loading times associated with the specific system.

With the additional yields that occur when mixed plastics packaging are targeted, collection methods that are based on a "milk round" round structure and utilise compaction become increasingly more efficient.

It is important to note that the costs shown in this paper only detail the proportion of capital costs that are associated with the collection. In certain instances, and particularly in the case of specialist bring site vehicles, this method of costing may not be applicable and a bring contract price may include the entire capital costs of the collection vehicle even though it is only used for one or two days per week. In these instances a higher cost would be incurred than those shown in this paper.

Figure 13: Modelled cost per tonne of collecting mixed plastics packaging using bring systems

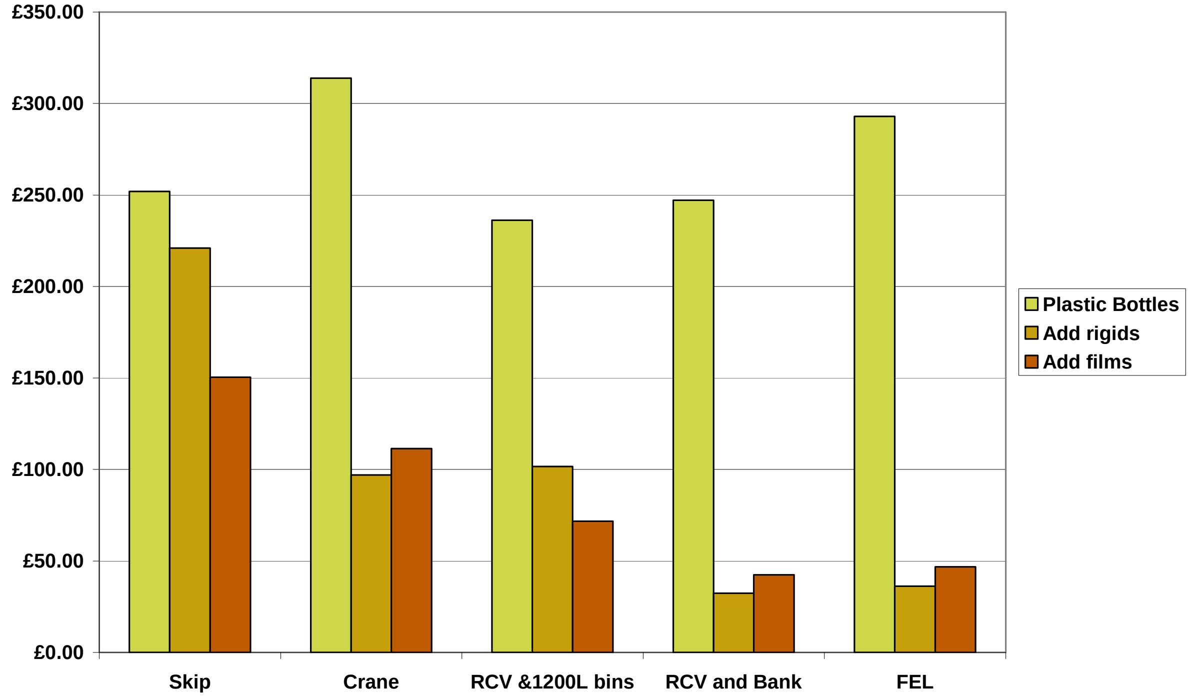


Table 35: Modelled cost per tonne of collecting mixed plastics packaging using bring systems

		Cost per tonne	
	Plastic bottle collections	**Additional cost of rigid plastic packaging**	**Additional cost of films**
Skip	£251.98	£220.93	£150.45
Crane	£313.89	£96.97	£111.44
RCV &1200L bins	£236.23	£101.71	£71.75
RCV and Bank	£247.19	£32.36	£42.42
FEL	£293.02	£36.27	£46.86

21.0 Front-of-store retailer (FOSR) bring schemes

Over the past two years there has been a growth in the number of bring recycling sites that retailers own and operate for the collection of plastic bottles and mixed plastics. The economics of these retailer operated schemes considerably differ to those operated by local authorities.

FOSR bring schemes tend to collect a range of dry recyclates using equipment that is technically sophisticated and in some cases employs material recognition technology. Transport economics will also be potentially different from other bring collection facilities for some of these FOSR schemes. In some cases the volumes of plastics are reduced considerably for storage and onward transportation. It is also possible that some materials may be reverse hauled back to central distribution depots before being bulked for onward transportation to reprocessors. It was not within the scope of this project to detail the potential yields and costs associated with collecting mixed plastics using FOSR methods.

Retailers have started to increase the number of front-of-store facilities and collaborate with local authorities that cannot take advantage of some of the operational recommendations from this report, where traditional bring sites could be incorporated.

22.0 Discussion on bring results

There are efficiency gains to capturing higher yields of material which is demonstrated by the cost per tonne generally decreasing as yields increase. This is due to a number of factors including:

- increased bulk density of mixed plastics packaging when compared with plastic bottles leading to higher yields per lift;
- for all systems except skip systems marginally increased numbers of containers on each site meaning that more lifts of material can be achieved for the same amount of time spent driving to and from depots, sites and tips in the same time frame, though unlikely in practice; and
- better utilisation of the container capital as there is a higher yield per container per year.

Although collection costs per tonne decrease with increasing yields it is important to note that the cost per household served (arguably a better indicator of local authority costs) **rises** with increased yield, though the cost curve slowly drops off demonstrating increased efficiency.

It is important to note that not all modelled collection systems act in a similar manner to increasing yields. Skip systems do not exhibit all of the efficiency gains that 'milk round' systems employ and therefore costs per tonne do not significantly decrease with increasing yields.

We have modelled systems with a high volume of containment (when compared with surveyed authorities) and all the systems manage well within increase yields of material. For instance, the FEL system collecting mixed plastics packaging including films has capacity that is sufficient to avoid the necessity for weekend collections up until yields of 21 kg/hh/yr. Beyond 21 Kg/hh/yr, one site proves to have insufficient capacity without weekend collections and then beyond 27 Kg/hh/yr seven sites become problematic. The 1200 litre wheeled bin system exhibits particular problems in providing sufficient capacity. This is due to the low volume provision that can be achieved using a given land area with this type of containment. Yields above 7 kg/hh/yr begin to cause weekend capacity problems with the range of sites that we have specified in the modelling. Yields of 11.28 kg/hh/yr (mixed plastic including films), the standard yield that we have modelled across all schemes, causes weekend capacity problems on seven sites unless they are emptied during the weekend.

The modelled costs should be read in context with some specific system characteristics. There were some virtual sites modelled where the site was of insufficient size to place a skip, therefore yields in this system are 95% of those obtained in other systems. The 1200 litre wheeled bin system provides the least volume containment per square meter of land taken. This lack of volume meant that sites required frequent emptying and would probably overfill at weekends unless a weekend collection schedule was utilised. No site cleansing costs associated with litter or fly-tipping have been applied to any of the bring systems.

Analysis of known bring site costs for collecting mixed plastics packaging show that those currently incurred by authorities are highly variable but in general costs are higher than those modelled. The most common form of bring charging appears to be the addition of mixed plastics packaging at the same cost per lift for as for plastic bottles.

22.1 Bring results conclusions

The costs of collecting mixed plastics packaging differ considerably between collection systems and are sensitive to a number of factors such as yields and collection timings. Given the potential problems with the accuracy of some input parameters and the fact that individual authorities are likely to vary considerably from the characteristics of the hypothetical authority the following conclusions should be treated with an element of caution.

It is important to note that these cost assumption are based on a yield that is approximately 1/3 of the modelled yield for kerbside systems We have modelled brings site mixed plastics packaging yields of 3.5kg/hh/yr for rigid plastic packaging and 3.5kg/hh/yr. for plastic films. These modelled yields are high compared with existing bring schemes which may be run alongside a kerbside collection system targeting the same materials, may have weekly residual collections or may have low coverage of bring sites. However, these relatively high modelled bring yields compare with kerbside modelled rigid plastic yields that are in the order of 10 to 12kg/hh.yr.

The results of the bring modelling show that efficient plastic bottle collection systems, such as the FEL system, can convert to collecting both specifications of mixed plastics packaging at a marginal incremental collection cost. An examination of actual bring site costs incurred by local authorities are highly variable. For instance one authority stated that they received a bring site service at the same cost as the recycling credit that they received (so presumably at around d £50 per tonne). Other authorities have converted to household plastic packaging at a cost of approximately £300 per tonne when averaged across plastic bottles and rigid plastic packaging. The variability of costs incurred by authorities reflects the varied nature of bring services employed on contracts, the variability of local authority logistics and probably reflects the variability in competition from contractors to provide these services.

If the theoretical efficiencies that have been shown in this modelling process for milk round collections utilising compacting vehicles are translated to contract prices then bring systems offer collection costs that when expressed as a cost per tonne are:

- comparable to the upper range of costs modelled for two steam systems; and
- cheaper than all other kerbside collection methods.

We are aware of some mixed plastics packaging bring contracts that are let at a similar cost per lift basis as plastic bottles and ranging as a cost per tonne of between £250 and £300 for the collection of plastic bottles and mixed plastic rigids. If contracts are let on the basis then the cost per tonne are:

- comparable to the costs modelled for kerbside sort systems; and
- more expensive than other kerbside collections.

Skip systems are commonly employed for collecting plastic bottles, presumably because skip loaders are commonly available in local authority collection circumstances and relatively easily utilised on other work. However, skip systems produce the most expensive incremental costs of adding mixed plastics packaging.

Although 1200 litre bin systems perform moderately well in terms of incremental costs the lack of volume capacity in these systems will mean that sites must be emptied frequently and would probably require a weekend empty.

An additional cost relating to bring sites that has not been considered in this report is the cost of cleansing sites. Reports from a number of authorities collecting mixed plastics packaging have noted increased cleansing costs that may be associated with fly tipping of mixed plastics packaging. It is thought that fly tipping of mixed plastics packaging tends to be associated with one of two factors:

- containers overfilling; and
- restricted apertures to containers resulting in items being left by containers.

Some authorities operating wheeled bin collections have reported some success in minimising fly tipping by leaving lids unlocked so items can be tipped directly into the bin. However this approach is likely to lead to higher contamination.

Appendix 1 Data Assumptions

23.0 Kerbside composition used in all kerbside models

The composition used in the modelling has been produced by Dr. Julian Parfitt and it is considered to be the most accurate review of the United Kingdoms kerbside arisings. The composition is based on the average total kerbside arisings of 850kg per household per year.

Table 36: Kerbside composition used

Paper	*15.9%*
Non-recyclable paper	*4.0%*
Card	*5.1%*
Cartons	*0.4%*
Plastic film	*4.5%*
Plastic bottles	*1.9%*
Other dense plastic packaging	*2.3%*
Other dense plastic	*1.8%*
Textiles	*2.9%*
Glass bottles/jars	*6.1%*
Other glass	*0.4%*
Ferrous cans	*1.4%*
Other ferrous	*1.5%*
Aerosols (ferrous & non ferrous)	*0.0%*
Garden	*14.5%*
Kitchen waste	*24.8%*
Aluminium cans	*0.3%*
Aluminium foil	*0.1%*
Other non ferrous	*0.0%*
Misc/Fines/Hazrd/WEEE	*12.3%*

24.0 Recycling containers

Bins and boxes are assumed to have been purchased upfront by the authority (not financed over a number of years), with the cost split across the lifetime of the container. We also assume an annual replacement rate (where households request lost or broken bins) leading to additional cost. **Table 37** outlines our assumptions with regard to recycling collection containers.

Table 37 Recycling collection containers

	Capacity	Lifespan (years)	Cost per unit	Replacement rate
Box	55 litre	5low	£2.75high	4.0%
Box + lid	55 litre	5low	£3.75	4.0%
Bin	240 litre	10	£17.00	2.5%
Sack	60 kg	n/a	£0.05	n/a
Notes Users on box schemes receive two boxes, one of which is assumed to have a lid 52 sacks required per year				

Appendix 2: Results

25.0 Modelled Resource Requirements

This section details the modelled resource requirements for each option. The resources shown relate to scenarios where the baseline options are modelled as full and thefore drive the highest incremental costs

25.1 Co-mingled modelled resource requirements

	B7-Co,22R,14,240w	O7a-Co,22R,14,240w	O7b-Co,22R,14,240w	B9-Co+g,22R,14,240w	O9a-Co+g,22R,14,240w	O9b-Co+g,22R,14,240w	B10-Co,22R,7,60s	O10a-Co,22R,7,60s	O10b-Co,22R,7,60s	B11-Co,22R,14,2*60s	O11a-Co,22R,14,2*60s	O11b-Co,22R,14,2*60s
Coverage (households)	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000
Total households	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Average participation	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	88.1%	88.1%	88.1%
Average set-out	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	82.8%	82.8%	82.8%
Number of vehicles required	3.5	3.7	3.9	3.7	3.9	4.0	4.9	5.0	5.1	2.8	3.0	3.0
Pass rate (all houses/veh/day)	1,368	1,295	1,235	1,300	1,232	1,208	1,977	1,902	1,875	1,690	1,608	1,578
Pick-ups / veh / day	1,121	1,060	1,012	1,064	1,009	989	1,619	1,558	1,535	1,400	1,332	1,307
Number returns to base (average)	2.1	2.3	2.5	2.3	2.4	2.5	1.6	1.7	1.8	2.2	2.4	2.5
Ave collection time/hh (secs)	11.2	11.2	11.2	11.2	11.2	11.2	8.7	8.7	8.7	8.8	8.8	8.8
Miles driven per vehicle per annum	15,509	16,337	17,157	16,353	16,989	17,282	14,807	15,419	15,704	17,132	17,881	18,157

25.2 Two stream modelled resource requirements

	B12-Co,20SR,7,2*55b	O12a-Co,20SR,7,2*55b	O12b-Co,20SR,7,2*55b	B13-Co,20SR,14,2*55b	O13a-Co,20SR,14,2*55b	O13b-Co,20SR,14,2*55b	B14-Co,20SR,7,240w+55b	O14a-Co,20SR,7,240w+55b	O14b-Co,20SR,7,240w+55b	B15-Co,20SR,14,240w+55b	O15a-Co,20SR,14,240w+55b	O15b-Co,20SR,14,240w+55b	B17-Co,20SR,14,2*240w	O17a-Co,20SR,14,2*240w	O17b-Co,20SR,14,2*240w
Coverage (households)	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000
Total households	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Average participation	93.1%	93.1%	93.1%	88.1%	88.1%	88.1%	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%
Average set-out	81.9%	81.9%	81.9%	82.8%	82.8%	82.8%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%
Number of vehicles required	6.1	6.3	6.4	3.3	3.5	3.5	7.2	7.5	7.6	4.1	4.4	4.5	4.6	4.9	5.0
Pass rate (all houses/veh/day)	1,561	1,525	1,500	1,445	1,386	1,362	1,337	1,285	1,264	1,168	1,091	1,061	1,041	979	954
Pick-ups / veh / day	1,279	1,249	1,229	1,197	1,148	1,128	1,095	1,052	1,035	957	894	869	853	802	782
Number returns to base (average)	1.0	1.3	1.3	1.4	1.7	1.7	1.0	1.2	1.3	1.6	1.9	2.0	1.5	1.7	1.8
Ave collection time/hh (secs)	12.0	12.0	12.0	12.1	12.1	12.1	14.5	14.5	14.5	14.5	14.5	14.5	16.9	16.9	16.9
Miles driven per vehicle per annum	10,533	11,642	11,935	12,130	13,325	13,621	9,594	10,493	10,906	12,515	13,761	14,301	11,146	12,333	12,839

25.3 Kerbside sort modelled resource requirements

	B1-SS,20S,7,2*55b	O1a-SS,20S,7,2*55b	O1b-SS,20S,7,2*55b	B2-SS,33S,7,2*55b	O2a-SS,33S,7,2*55b	O2b-SS,33S,7,2*55b	B3-SS,33S,14,2*55b	O3a-SS,33S,14,2*55b	O3b-SS,33S,14,2*55b	B4-SS,33K,7,55b	O4a-SS,33K,7,2*55b	O4b-SS,33K,7,2*55b	B5-SS,30K,14,55b	O5a-SS,30K,14,2*55b	O5b-SS,30K,14,2*55b
Coverage (households)	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000
Total households	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Average participation	93.1%	93.1%	93.1%	93.1%	93.1%	93.1%	88.1%	88.1%	88.1%	93.1%	93.1%	93.1%	88.1%	88.1%	88.1%
Average set-out	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	82.8%	82.8%	82.8%	81.9%	81.9%	81.9%	82.8%	82.8%	82.8%
Number of vehicles required	10.7	12.5	13.1	10.5	12.0	12.3	6.9	7.9	8.0	8.5	9.8	10.5	5.9	6.8	7.3
Pass rate (all houses/veh/day)	899	770	731	917	802	778	694	607	600	1,133	977	918	815	702	662
Pick-ups / veh / day	736	631	599	751	657	637	574	503	497	928	800	751	675	582	548
Number returns to base (average)	1.3	1.4	1.4	1.3	1.3	1.2	1.4	1.4	1.4	1.0	1.0	1.0	1.0	1.0	1.1
Ave collection time/hh (secs)	20.2	23.1	24.3	20.2	23.1	24.3	25.9	29.7	29.7	16.9	19.8	21.0	23.6	27.5	29.2
Miles driven per vehicle per annum	9,833	9,951	9,931	9,677	9,307	8,696	9,757	9,263	9,614	8,936	8,486	8,401	8,177	7,813	7,736

Waste & Resources
Action Programme

The Old Academy
21 Horse Fair
Banbury, Oxon
OX16 0AH

Tel: 01295 819 900
Fax: 01295 819 911
E-mail: info@wrap.org.uk

Helpline freephone
0808 100 2040

www.wrap.org.uk/mixedplastics

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