A feasibility assessment of the benefits that Computerised Vehicle Routing and Scheduling (CVRS) can have in improving the efficiency of Construction, Demolition and Excavation Waste (CDEW) collection rounds
Our vision is a world without waste, where resources are used sustainably.

We work with businesses and individuals to help them reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way.

Find out more at www.wrap.org.uk
Executive summary

Key to delivering the WRAP (Waste and Resources Action Programme) objectives of reducing Construction, Demolition and Excavation Waste (CDEW) to landfill (and associated carbon emissions) is the development of efficient logistics systems from the point of collection to delivery for treatment or processing. Whilst the waste sector has developed new technologies and infrastructure over the past 10 years for recycling and recovery of waste, the logistics of commercial waste collection has remained largely unchanged. In order to promote and facilitate good practice, WRAP has funded a series of demonstration trials (and case studies) to support the development of the waste (and construction) industry towards a more efficient logistics model for waste collection.

This demonstration trial (one of a series of three delivered under the MRF114 project), assesses the financial and the CO2 benefit of Computerised Vehicle Routing and Scheduling (CVRS) technology for the design and optimisation of CDEW collection rounds. Within most Waste Management Companies (WMCs) CDEW is collected alongside other Commercial and Industrial (C&I) waste streams where site conditions allow the compactable fractions to be stored on site in wheeled containers. Compaction Refuse Collections Vehicles (RCVs) are then used to collect this material on ‘rounds’ where the vehicle makes collections (lifts) from a series of customers over the working day. This form of collection is often referred to as multi modal within the waste industry.

The design and performance of waste collection rounds is typically managed locally, with routes built up over time based on driver knowledge and in response to changing customer requirements. Variables affecting collection performance include customer locations and collection day requirements, waste volumes, tipping locations and vehicle turnaround times / congestion. Capturing these parameters, and others, as part of an ‘As Is’ model forms a useful first step towards redesigning and optimising collection rounds using CVRS technology.

Using specialist waste logistics software ‘As Is’ models of the current waste collections for three of Weir Wastes multi modal collection rounds operating in the Birmingham area were built at the start of the trial. The data and signed off statistics from the ‘As Is’ models were subsequently used to model three alternative operating scenarios. The scenarios investigated were as follows:

- Scenario one: an initial redesign where no changes to the collection method or day of collection was permitted.
- Scenario two: a redesign across the three vehicles where the day of collection could be changed for those customers receiving a single collection per week.
- Scenario three: consolidation of the collections where a customer has multiple collections per week into a single day, albeit with the collection days for those receiving single lifts fixed.

Select results from the trial are presented below for each of the scenarios modelled alongside the current (‘As Is’) situation.

<table>
<thead>
<tr>
<th></th>
<th>‘As Is’</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Mileage miles per week</td>
<td>1,360</td>
<td>1,340</td>
<td>1,149</td>
<td>1,360</td>
</tr>
<tr>
<td>Mileage saved per week</td>
<td>N/a</td>
<td>20</td>
<td>211</td>
<td>0</td>
</tr>
<tr>
<td>Estimated Savings, £ per annum</td>
<td>N/a</td>
<td>£1,287</td>
<td>£13,578</td>
<td>£0</td>
</tr>
<tr>
<td>Total CO2 savings, kg per annum</td>
<td>N/a</td>
<td>3,088</td>
<td>32,576</td>
<td>0</td>
</tr>
</tbody>
</table>

With the potential for up to 15% cost savings from reduced distance / fuel usage and a potential to increase productivity by up to 9% the case for using CVRS is favourable. WMCs are however sceptical of such technology and there is a need for investment in IT infrastructure and data to facilitate the use of CVRS. The increasing complexity of waste collection logistics is however likely to drive investment in these areas and CVRS will be well placed to realise efficiencies for the waste industry rather than just a select number of progressive WMCs.
Contents

1.0 Introduction .......................................................................................................................... 3
  1.1 Background .......................................................................................................................... 3
  1.2 Aims and objectives: scope of work ..................................................................................... 3
  1.3 This report ........................................................................................................................... 3

2.0 CDEW collection planning and routing .............................................................................. 4
  2.1 Background context: the logistics challenge ......................................................................... 4
  2.2 Existing service delivery and planning methods ................................................................. 4
    2.2.1 Skip and Roll on-Roll off (Ro-Ro) container collections .............................................. 4
    2.2.2 Multi modal (RCV) collection rounds ............................................................................ 6
    2.2.3 Operating restrictions and comparison of service delivery methods ................................ 7
  2.3 Management information ...................................................................................................... 7
    2.3.1 Skip and Ro-Ro collection rounds ..................................................................................... 7
    2.3.2 RCV collection rounds .................................................................................................... 7
    2.3.3 Collection performance data ........................................................................................... 7

3.0 The role of Computerised Vehicle Routing and Scheduling (CVRS) ................................... 8
  3.1 Overview ................................................................................................................................ 8
  3.2 Data requirements .................................................................................................................. 9
  3.3 Comparing existing and optimised collection rounds ............................................................. 9
  3.4 Outputs .................................................................................................................................. 10

4.0 Trial approach ......................................................................................................................... 10
  4.1 Trial process .......................................................................................................................... 10
  4.2 Trial subject ........................................................................................................................... 10
  4.3 Trial partners / stakeholders ................................................................................................. 11
    4.3.1 WRAP ............................................................................................................................... 11
    4.3.2 Entec UK Ltd ..................................................................................................................... 11
    4.3.3 Weir waste ......................................................................................................................... 11
    4.3.4 Webaspx ........................................................................................................................... 12
  4.4 Defining the trial ..................................................................................................................... 13
  4.5 Delivering the trial .................................................................................................................. 13
  4.6 Findings and analysis .............................................................................................................. 16
    4.6.1 Data .................................................................................................................................. 16
    4.6.2 CO₂ calculation .................................................................................................................. 16
    4.6.3 Financial calculation ............................................................................................................ 16

5.0 Trial findings and analysis ...................................................................................................... 17
  5.1 Trial results ............................................................................................................................. 17
    5.1.1 Distance ............................................................................................................................. 17
    5.1.2 Time .................................................................................................................................. 17
  5.2 Trial analysis ............................................................................................................................ 18
    5.2.1 Financial saving through reduced fuel spend ................................................................. 18
    5.2.2 Financial benefit through reduced time spent making collections ................................ 18
    5.2.3 CO₂ saving ........................................................................................................................ 19
    5.2.4 Breakeven analysis ............................................................................................................ 19
  5.3 Practical considerations ......................................................................................................... 19

6.0 Summary and discussion ........................................................................................................ 20
  6.1 Summary of benefits ............................................................................................................. 20
  6.2 Return on investment ............................................................................................................. 20
  6.3 Uptake considerations ............................................................................................................ 20

Acknowledgements

Many thanks to Anthony Brownsett and Tony Veal at Weir Waste and Mike Devine at Webaspx for their co-operation and assistance to complete this trial.
1.0 Introduction

1.1 Background

Key to delivering the objective of reducing Construction, Demolition and Excavation Waste (CDEW) to landfill is the development of efficient logistics systems from the point of collection to delivery for onward transfer or recovery. The combination of site-based segregation of waste materials and increasing outlets for recycling and reprocessing is changing the nature of the collection logistics requirements for these materials. New containment methods are being introduced and on site logistics specialists are now managing waste movements and removals in the same way as material deliveries are co-ordinated (driven in part by the introduction of Site Waste Management Plans (SWMPs)). On large CDE projects where regular and ongoing collections of waste materials are required for recycling or disposal, the use of mobile and flexible containment systems such as wheeled bins and re-useable sacks (multi modal methods) is increasing. This in turn is influencing the vehicles used to collect material from site and the collection method, meaning that Waste Management Companies (WMCs) and logistics contractors are able to deploy collection rounds making pick ups from multiple sites.

As the range of materials being collected increases the effective routing of collection vehicles becomes increasingly fundamental to achieving efficiency. Effective scheduling and routing means the amount of productive work (pick ups) on any given shift can be maximised and transport mileage (and associated emissions) reduced. Computer-based optimisation and job allocation packages for managing collection transport logistics are commonplace within the haulage sector. These systems have also seen increasing uptake in waste collection planning as the costs of managing wastes have increased (e.g. due to escalating landfill tax levels) and recycling has become more widespread. Computerised Vehicle Routing and Scheduling (CVRS) represents one component of a suite of software and IT applications that can support improved planning in waste collection.

1.2 Aims and objectives: scope of work

In order to evaluate the potential benefits and practical application of CVRS technologies to CDEW collection planning the following tasks were undertaken:

- engagement with WMCs to understand how collections are planned and carried out currently;
- data gathering in support of the above describing existing collection parameters (number of pick ups, vehicle mileage); and
- desk-based trial of how a CVRS system may be used to support waste collection round design, acknowledging existing practice and operating constraints.

1.3 This report

This report is one of three covering a range of CDEW collection logistics trials that explore the benefits of adopting innovative practices or technology to improve efficiency. The other trials cover the use of In-cab technology to improve communications and information transfer between vehicles and fleet managers, and use of vehicle catalyst technology to improve fuel efficiency.

The trials have been operated alongside the development of four case studies demonstrating good practice already being adopted in this area, supported by desk based research in to the subject of CDEW collection logistics.

This report provides a summary of our findings relevant to the feasibility of applying CVRS to CDEW collection. It is not intended to provide a definitive guide on how to carry out a waste collection round design project. Further information on the subject of CDEW collection logistics and relevant stakeholder interactions is provided in the main study report.

---

Following this short introduction the report covers the following elements:

- current approaches to managing job allocation and vehicle routing in CDEW collection logistics (Section 2);
- the role of CVRS, including data requirements and outputs (Section 3);
- the trial approach (Section 4);
- the findings (results and analysis) of the CVRS trial (Section 5); and
- the summary and discussion of the trial (Section 6).

2.0 CDEW collection planning and routing

2.1 Background context: the logistics challenge

Designing waste collection rounds can be a complex task due to the range of factors requiring consideration. This is particularly the case where new materials are being added to a service and requiring separate collection. Where customers are added or deleted the routes need to be dynamic; there is also the need to account for unforeseen circumstances such as vehicle breakdowns, missed bins etc. Factors such as variable collection frequencies and the expected volume of waste (including variations linked to different phases of the construction project) also need to be considered. Operating conditions are further governed by vehicle and container specifications and the locations, opening times of reception facilities and vehicle depots. Finally, the geography and available road network will have an impact on the type of operations deemed feasible in a given area. For example, some roads might be unsuitable for use (too narrow or not providing safe stopping areas) whilst others might only be useable for part of the working day, such as city centres or approaches to schools.

The complexity of the task makes it difficult, even for the most experienced waste collection managers, to produce optimal routes and schedules without the aid of some form of Computerised Vehicle Routing and Scheduling (CVRS) package. Under current arrangements a compromise situation is typically reached where the objective of delivering a truly efficient operation has to be managed in the context of historic working practices and a dynamic workload. These issues are explored more fully below.

2.2 Existing service delivery and planning methods

Based on the project team’s experience of operating and designing waste collection systems, supported by targeted engagement with a number of WMCs in support of this evaluation, the following sections summarise the existing methods by which CDEW collections are planned.

2.2.1 Skip and Roll on-Roll off (Ro-Ro) container collections

CDEW collections made by skip or Roll on-Roll off containers can be characterised as follows:

- for this service mode collections are made on the basis of a single container being picked up from each customer (and an empty container left in its place). Waste is then delivered to a reception facility once loaded on the vehicle\(^2\). There is therefore a high proportion of driving time and vehicle mileage per load collected which can limit the number of lifts achievable to an average of 6 – 10 per day;
- work is typically allocated the day prior to collections being carried out, with this task being done ‘by eye’ based on customer proximity and a target number of lifts per day. There are some regular lifts (e.g. every Friday) for larger projects within most daily schedules, these typically represent up to one third of the workload;
- collection routing is typically undertaken by the driver based on local knowledge and the list of jobs assigned for the day;
- for new jobs coming in during the day the driver may have to return to the depot / office to pick up any relevant paperwork before making the collection;

\(^2\) Some operators use trailers to support the collection of two skips on the same vehicle, albeit this is uncommon.
it is quite rare for specific collection timeslots to be requested (or offered) — this would only be agreed as an exception to the norm (e.g. where the site is unmanned and requires a key holder to be present at a certain time); and

collections are typically made over five days, with some Saturday morning collections where necessary (acknowledging increased costs due to overtime payments).

Based on sample job sheets received from a WMC the total mileage travelled per day under this service method typically lies in the range 50 miles (where the day involves multiple loads from the same customer) to 150 miles. This clearly depends on the spread of customers, proximity to tipping points and the number of jobs in the day. A full day’s work collecting 35 yard containers may result in 30 – 60 tonnes of waste being collected. For a day’s worth of work collecting from smaller skips then the total tonnage more typically lies in the range 8 – 15 tonnes. There are, therefore, clear economies of scale to be achieved in terms of tonne miles through maximising the size of the containers collected.

Some very early starts were observed in the data provided by WMCs engaged on the project, with lifts being undertaken as early as 4 - 5am. It is clear from the sheets that some large customers generate significant workloads for WMCs; it is not uncommon for six to ten 35 yard skips to be lifted from a single site in a day on certain rounds.

The daily format of this type of collection system is shown in Figure 2.1 below.

Figure 2.1 Schematic presentation of a single modal CDEW collection system

As the diagram shows the main logistics considerations are associated with how to route each job between point of collection and drop-off and how to sequence the jobs within the day’s work.
2.2.2 Multi modal (RCV) collection rounds
For collections made via multi modal container systems, meaning multiple containers (typically 1,100 litre wheeled bins) or tipped loads can be collected on a single vehicle ‘round’, the following characteristics apply:

- these collections tend to involve a more static client base. Where wheeled containers are used to store waste on site, collection rounds are set up servicing a range of customer types, so CDEW is likely to be collected (from transient customers) alongside other (C&I) waste material from a relatively fixed client base;
- the common use of compaction vehicles for these collections with sequential pick-ups being made until the vehicle is full means an average of 120 lifts per day might be made on this type of service (covering 70 - 80 customer locations);
- new customers are typically added to rounds manually by hand - they are rarely formally routed meaning the schedules evolve over time;
- collections tend to be managed on a zonal basis, e.g. Round 1 operates in South Birmingham on a Monday, with drivers having local knowledge of the zones they cover; and
- collections may start as early as 4am, meaning double-shifting of vehicles may be possible.

The daily format of this type of collection system is shown in Figure 2.2 below.

**Figure 2.2** Schematic presentation of a multi modal CDEW collection system

Within this type of system the question of optimum routing is more complex as there are multiple combinations of collection ordering combinations that might be considered. As the WMC builds customer route density the service becomes more cost effective. Due to the temporary and geographically disperse nature of CDE projects most WMCs operate these collections combined with other C&I waste lifts using wheeled containers.
2.2.3 Operating restrictions and comparison of service delivery methods

Certain material types may not be suited to collection on compaction RCVs, due to their physical nature meaning they cannot be compacted or may damage the vehicle, or due to their size meaning they need to be stored on site in larger containers. Wood / pallets, soils and rubble, metals and some plastics (e.g. window frames) would generally be regarded as non-compactable or unsuited to a mixed waste multi modal collection, due to either their form or market value. Similarly, there are materials requiring separate management such as hazardous waste and plasterboard. These would typically be collected via skip, Ro-Ro or curtain-side vehicles.

It is therefore likely that a combination of collection types will be suitable for any given site or project during the demolition, site clearance, preparation and construction / commissioning phases.

2.3 Management information

Following contact with a number of WMCs including SITA, Premier and Weirs, sample information describing collections on existing skip and multi-modal (compaction) collection rounds was provided. This information is described below.

2.3.1 Skip and Ro-Ro collection rounds

Information received from one operator comprised job sheets completed by the driver listing the work undertaken each day. The pro-forma sheets include information summarising the day’s work (total distance covered, fuel drawn, start, finish and break times) supported by fields for each job as follows:

- driver ticket number (a unique job reference);
- customer name / address (although sheets rarely contained the address);
- bin size;
- number of lifts;
- job code (a shorthand description for the type of collection or material lifted);
- job start and finish time;
- landfill name and time on / off;
- ticket number; and
- weight.

The extent to which the pro-forma sheets are completed was seen to be variable, which places limitations on how the data can be used as part of any potential route modelling exercise.

2.3.2 RCV collection rounds

Initially, a single set of information was received from a WMC undertaking a multiple lift collection round using a compaction RCV. The daily route sheets compiled electronically listed the customer, location (as an address but no postcode) and the container / material lifted. The collections were listed in the order they are undertaken by the driver.

From the job sheets received it is evident that only a small proportion of customers serviced on these rounds are typically producing CDEW. It is difficult therefore to draw meaningful comparisons between the different models of collection and relate the findings of any analysis directly to the CDEW element (in isolation from other C&I waste collections made on the same rounds). What it also means, therefore, is that the findings from this trial can be extrapolated to C&I waste collections in general.

2.3.3 Collection performance data

Skips and Ro-Ro containers are normally collected on an individual basis. The exceptions of double stacking and use of a trailer unit represent a minority of the overall collections. When the skip or Ro-Ro is delivered to the reception facility the weight is recorded via a weighbridge. This provides accurate data on the weight of the waste held within the container. This data can be compiled by the weighbridge IT system and feeds into the main scheduling and accounting IT systems used by the WMCs. Reports for clients can be produced and in some cases customers can have instant access to the data via web portals.

---

2 These are all parameters which could equally be captured through the use of In-cab technology (see http://www.wrap.org.uk/construction/how_do_i_reduce_waste/waste_recovery/waste_collection.html).
For multi modal collections the entire weight of the vehicle is recorded when tipped. Given that these rounds collect upwards of 120 containers from 70 to 80 customers in a day the time taken to weigh individual containers could be considerable. Some on board technology from suppliers such as Avery Berkel and Vishay can weigh individual containers but weighing technology is not widely found on most multi modal vehicles. The current method of weight calculation for such collections is to use assumed standard densities for the waste types being disposed of. Typically a 1,100 litre container will weigh between 50 and 80kg based upon this method of calculation.

Global Positioning Systems (GPS) are not commonly used across the waste companies selected for the case studies and trials. The start and finish times are recorded on daily worksheets, clock cards and within the vehicle tachographs. The multiple sources and the paper driven nature of the recording media create a complex and time consuming system to monitor vehicle and driver operations. This also means that tip turnaround times are often not studied unless anecdotal information is passed from the driver to the depot manager. The driver’s hours are normally managed via the tachographs alone. Improvements in IT and linked technologies such as GPS via in-cab technologies could improve the information available to managers to be more effective in the monitoring of vehicle and driver utilisation.

3.0 The role of Computerised Vehicle Routing and Scheduling (CVRS)

3.1 Overview

Computerised Vehicle Routing and Scheduling (CVRS) has been applied for many years by organisations involved in moving materials by road between multiple collection and delivery locations. The technology uses information describing the road network and operating constraints of the system (such as details of pick-ups and deliveries, travel speeds, working hours) in order to model an optimised collection / distribution plan. The output from CVRS applications typically takes the form of combined collection and delivery (route) lists supported by mapped data.

CVRS has increasingly been applied to municipal solid waste (MSW) collection planning in the UK (and abroad) as systems have moved away from being based on the collection of a single material stream (historically residual waste) delivered to long running reception facilities, e.g. landfill sites. As the costs of waste collection and disposal have increased, due to rising fuel costs, landfill tax etc, and legislative targets have required materials to be diverted from disposal for recycling, multi-compartment vehicles are increasingly used to collect segregated material streams through a minimal number of customer ‘passes’. Collections made in this way are more sensitive to variations in material yields, bulk densities and vehicle capacities and as such the ability to test a number of ‘what-if?’ scenarios through the use of computer-based models offers various benefits. As part of any upfront service planning CVRS can help to assess the capacity of the collection resources (vehicles and crew) available; it can be used to determine what changes in parameters will cause the collection rounds to break, i.e. run late, and also to produce the most efficient routing between points in the network. Being computer-based multiple calculations can be undertaken within a short space of time meaning far more options can be considered over a given timeframe than is possible through manual methods (which typically involves marking up hard copy maps).

For MSW collection systems, the decision to employ CVRS is often triggered by the need to make a major service change (e.g. involving the collection of a new material or changing the collection frequency) or because there is a need to deliver service efficiencies. Domestic waste collection has the benefit of the customer base remaining relatively constant, meaning that once a set of collection rounds has been designed they require only minor adjustments in order to keep them balanced. There is a direct correlation between cost and environmental performance in that a logistically efficient collection operation that minimises mileage (and time) allows more fee earning work to be done within the working day.

A number of computer applications exist that might be suitable for modelling waste collections, comprising a mix of packages derived from the haulage sector and those specifically designed for modelling this type of operation.

The application of CVRS in MSW collection round design has delivered benefits to local authorities and their contractors seeking to design new collection systems or improve the performance of existing services. It is not always possible to quote direct savings as a result of service re-engineering projects involving CVRS due to changes in service design often made as part of the process. However, a number of projects have identified direct cost savings, typically in the range 2 - 10 percent (more where neighbouring operational systems are
merged). This is either through the ability to deliver the same amount of work with fewer resources or the ability to defer investment in new vehicles as the service grows.

The combination of CVRS with changes in service delivery method offer further opportunities to deliver efficiencies. On domestic waste collection services the option of amending contract hours (e.g. by moving crews to a 3 or 4 day working shift but with the service still operated over 5 or 6 days in the week) has received considerable interest. In this way capital equipment (vehicles) are worked harder over the week reducing the overall costs of the service. More typically within C&I waste collections, of which CDEW forms a part, operators may double-shift vehicles in order to improve productivity.

3.2 Data requirements

The process of redesigning waste collection rounds starts with the collection of detailed operational data along with Key Performance Indicators (KPI) on the existing rounds. The following data will be needed as a minimum:

- details of the customer base and their service requirements in terms of container type, materials targeted, collection frequency and any specific service rules (e.g. collection windows) to be met. As the software incorporates a geographical routing function it is important that address information allowing each customer to be geo-coded on a map is available and that it has been checked as being correct. For commercial customers errors are commonly introduced due to billing addresses being provided (such as that of a Head Office) rather than that from which the collection is actually made;
- weight and volume of waste. Building on the customer data described above it is necessary to define the carrying capacity of the vehicle which will be a function of the legal payload, the bulk density of the material collected and any compaction applied to that material inside the vehicle. For single load (skip) collections a trigger identifying the need to collect that load may be sufficient;
- number and capacity of vehicles, incorporating effective payload capacities;
- loading and unloading times and vehicle speeds whilst making journeys to and from loading activities; and
- details of service infrastructure, comprising depots (locations, ‘O’ license restrictions and operating hours) and reception points (locations, material acceptance rules, operating hours and vehicle turnaround times).

Data quality and any associated investment in generating it will depend on the intended use of the modelling outputs. A study requiring a tactical evaluation of the level of resource required to service a set of customers requires a lesser investment in data than one from which an operational collection plan is to be produced. Even with validated input data the outputs need to be sense-checked as it is impractical to capture every piece of local knowledge that influences collection performance on the ground.

As WMCs invest in data capture technology such as GPS, chipped bins and remote data transfer then the building blocks for a round design project will be more readily available.

3.3 Comparing existing and optimised collection rounds

As part of a project involving CVRS it may be appropriate to develop a baseline (or ‘As Is’) model of the existing collections. This may be done for some or all of the existing rounds and is used to derive productivity and yield information for the new designs. The process of building a model of the existing collection arrangements can help to identify service rules that influence performance, e.g. vehicle access restrictions, areas of congestion. It will also give a quantified performance level against which the new waste collection rounds can be compared. Building a full ‘As Is’ model is only likely to be relevant where there is a stable set of customers and regular collection round structures, so that a robust set of comparable performance statistics can be developed. This is often not the case on C&I / CDEW collections as the job list is subject to change on a weekly (and sometimes daily) basis.

4 Within the main study report for MRF114 the use of fill sensors in skips and other containers is described representing a move towards an IT-based approach to planning collection requirements. This level of automation does not readily exist within the UK waste management industry and collections are normally triggered through a pre-agreed collection frequency or a call made from the customer to the WMC requesting that the skip be emptied. See http://www.wrap.org.uk/construction/how_do_i_reduce_waste/waste_recovery/waste_collection.html
Modelling existing rounds is possible with most applications but requires considerable effort from the user to specify them as ordered lists of the locations visited, or through the development of a theoretical sequence using the software. Locations may be specified either as postcodes, Ordnance Survey grid references or lat / long co-ordinates depending on the software used.

Models may allow optimisation according to various criteria such as time taken, distance travelled or some cost function. Optimising rounds according to time taken is a reasonable choice as time is strongly correlated with distance travelled and with cost.

Great care should be taken when trying to compare the output from a model with existing rounds to ensure that the comparison is fair. The new rounds need to be checked by someone with good local knowledge of the road network and of the waste collection requirements of the operator to ensure that the solution is feasible and does not violate any traffic restrictions.

3.4 Outputs

As mentioned previously the primary outputs from CVRS applications include:

- exportable data listing the customer locations and collection service rules (which may include details of the container at each, weight of waste collected, access restrictions);
- ordered collection lists, by customer, address or street (depending on the quality and level of definition of the base data);
- maps or mappable data identifying the customer locations and/or the collection routes; and
- user-configurable performance reports including round lengths, weights collected.

4.0 Trial approach

This section of the report details the process used to identify the subject for the trial, the running of the trial and ultimately the findings detailed within this report.

4.1 Trial process

The trial process consisted of six discrete tasks. These tasks were:

- the identification of the trial subject;
- the identification of the trial partners / stakeholders;
- defining the trial, including agreement of the trial aims, parameters and timescales;
- delivery of the trial;
- gathering results and analysis; and
- reporting.

4.2 Trial subject

The trial subject has been developed from the initial desk based research undertaken as part of this project. Through the engagement of WMCs and other stakeholders valid logistics related trial subjects were identified. The CVRS trial has been selected due to the potential logistics benefits for multi modal vehicle operations.

The aim of the trial has been to assess the financial and the CO2 benefit of the CVRS technology over and above the manual methods of routing RCVs using A-Z maps etc that are currently employed. The main focus of this trial therefore is to assess the efficiencies that can be identified through the use of CVRS, especially in the assessment of multiple design parameters.
4.3 Trial partners / stakeholders

The trial stakeholders include the sponsor (WRAP), the trial manager (Entec), the technology provider (Webaspx) and the waste management company (Weir Waste). The figure below shows the interaction flow between the stakeholders. The trial partners were Webaspx and Weir Waste who committed to undertake the trial under the guidance of Entec.

**Figure 4.1 Stakeholder interactions**

4.3.1 WRAP
WRAP works with businesses and individuals to help them reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way. WRAP provided financial support for the trial.

4.3.2 Entec UK Ltd
Entec is a multidisciplinary engineering and environmental consultancy offering both a breadth and depth of service to provide commercial and technically robust business solutions. Entec has provided consultancy services to WRAP across multiple waste disciplines including best practice guidance and case studies. Entec managed the day to day running of the trial as the project manager.

4.3.3 Weir waste
Weir Waste Services Ltd is a leading independently owned waste management company operating in the West Midlands, Warwickshire and Worcestershire. Weir Waste is a signatory to the Construction Commitment: Halving Waste to Landfill.

Weir Waste Services Ltd operates a transfer station with advanced separation processes and a fleet of waste collection vehicles based in Birmingham. The company processes 300,000 tonnes of material per annum through the transfer station with a turnover of approximately £7.8 million. The majority of the waste delivered in to the transfer station is collected directly by Weir Waste's own vehicles.

Weir Waste provided the data and contributed in kind to the checking and validation of the CVRS models. Weir Waste operates a transfer station and one operational depot located on the same site as the transfer station. Weir Waste has a separate administration and vehicle maintenance centre located near to the transfer station and depot. The location of these facilities is shown in Figure 4.2.

Weir Waste seeks to internalise waste deposits to maximise the financial benefits of the waste collection and uses the transfer station for mixed loads of waste. Weir Waste use third party sites also but this is usually for large volumes of single material wastes where there is limited benefit to them bringing the material into the transfer station for sorting. Spare containers are located at the transfer station.

4.3.4 Webaspx

Webaspx are leaders in the field of waste and recycling collection round design, working with public and private sector clients to develop optimised solutions and supporting software. Webaspx have completed waste collection optimisation projects with over 100 local authority and private contractors, many working with Entec. The optimised designs have been implemented with many authorities such as Ashfield District Council and Walsall Metropolitan Borough Council.

Webaspx's role on the project was to take the As-Is rounds data collected by Entec and Weir Waste and to produce a new set of optimised rounds using Webaspx's CVRS technology.

The software used for the CVRS data gathering / cleansing and new round design has been undertaken using WMDesign.

**WMDesign** takes geographical location information together with load information and seeks to optimise the creation of a number of rounds. In this study ‘As Is’ rounds are ordered within WMDesign as this level of information did not exist within the base data though it is possible to use WMDesign to fit GPS tracking data from ‘As Is’ rounds.

**WMDesign** allows the coverage and performance of a set of rounds to be amended and tested under different operating conditions (incorporating changes to weights collected, collection rates, speed of travel etc). The tool also facilitates the manual refinement and balancing of rounds through the ability to move properties between crews and days.

WMDesign allows a number of outputs to be produced including round sizes (bins per day); working hours; vehicle mileages; expected number of tips per day; and spare capacity on the vehicles. Round Maps and round sheets as well as a range of other outputs can be produced. Round summary maps including routing information can be generated on high quality background maps from WMDesign if this information is available.
4.4 Defining the trial

The focus of the trial was to ascertain if the CVRS technology can identify any benefits over the current method of manual route optimisation commonly used within the waste industry. This has been measured in financial terms as well as environmental (CO₂) linked to the mileage travelled and productivity levels.

The trial required the CVRS technology to be tested upon real rounds being operated by Weir Waste. The ad hoc nature of single modal collections does not lend itself to the modelling and subsequent optimisation of waste collection rounds, as the work is dynamic and rarely repeated. It is likely that job scheduling packages will offer greater benefits to the single modal collections especially when combined with In-cab technology⁶. In-cab technology refers to the suite of handheld and vehicle mounted hardware and software that can facilitate the efficient transfer of data from an office to the vehicles, such as PDAs. The multi modal collections are somewhat more fixed than the single modal collections. The multi modal collection clients do change but these tend to be small changes to individual days of work on a weekly or monthly basis, rather than the daily changes experienced with the single modal collections.

It was decided therefore to undertake the CVRS trial upon three multi modal vehicles only, with the modelling focused on the following logistics performance parameters:

- mileage travelled (before and after the collection round redesign); and
- the time required to complete the waste collection rounds.

4.5 Delivering the trial

Within most WMCs, CDEW collected by multi modal vehicles (compactable wastes) is collected alongside C&I waste. However, Weirs have sufficient volume and density of clients to have a dedicated construction waste collection vehicle. It was agreed to capture data from this dedicated vehicle and two typical C&I multi modal vehicles to be able to demonstrate how efficiencies can be gained even within a small fleet of multi modal vehicles. These vehicles operate in the Coventry / Warwick and the Birmingham areas. The CDEW vehicle is predominantly Birmingham / Walsall based. The construction waste vehicle operates on a five day week and tends to collect from fewer sites but with more containers per site, whilst the C&I waste vehicles collect 6 days per week. The vehicles work in defined areas or zones that have been determined by the operational staff.

The areas of work for the trial vehicles are shown in Figure 4.3.

---

⁶ In-cab technology has been trialled as one of the series of three trials commissioned by WRAP through the MRF114 study. See [http://www.wrap.org.uk/construction/how_do_i_reduce_waste/waste_recovery/waste_collection.html](http://www.wrap.org.uk/construction/how_do_i_reduce_waste/waste_recovery/waste_collection.html)
Figure 4.3 Trial vehicle weekly areas of work

Key:
- Round 2 (C&I round) is in Green.
- Round 3 (C&I round) is in Red.
- Round 7 (dedicated construction round) is in Blue.

The trial tested three 26 tonne (multi modal) vehicles collecting wheeled containers. This vehicle type is shown in Figure 4.4.
The trial commenced with a data collection phase in October 2009. Current round data was supplied with post code locations and collection sequencing that was subsequently used to map the individual days of work using the RoundManager™ tool. The mapped rounds were cleansed on site with Weirs so that the locations of the clients represented the genuine locations of the sites serviced on each round. Supporting data used to complete the baseline (or ‘As Is’) model included:

- daily vehicle weights;
- individual vehicle payloads;
- access and time restrictions for collections;
- start and finish times for the rounds;
- bin sizes and numbers;
- depot and reception location (the same site for this trial);
- driver breaks (legally required);
- reception facility turnaround time; and
- average travel speeds (per round from Tachographs).

The ‘As Is’ model was agreed remotely with Weirs to be representative of the current waste collection operation for the three vehicles. This was achieved through the use of maps and data spreadsheets reviewed by operational managers and supervisors at Weir Waste.

The data supplied in the spreadsheets included the:

- duration of the working day in hours;
- distance travelled in miles;
- bin numbers collected;
- number of loads tipped;
tipping time;
- picking time;
- pick rate (number of bins collected per hour, excluding the travel time to the round (and return), and tipping time);
- total weight collected;
- yield per bin; and
- spare capacity on the vehicle.

The data generated from the ‘As Is’ model such as pick rates were used to generate an optimised design for three operating scenarios. The scenarios investigated were as follows:

- Scenario one: The optimisation and rebalancing of the weeks work across all three vehicles within the parameters set out for the ‘As Is’, e.g. maximum day length remains the same and sites must receive the same day and number of collections as in the ‘As Is’. This represents the scenario having least impact on customers as no day changes are required.
- Scenario two: The optimisation of the weeks work across all three vehicles using the same parameters for the ‘As Is’ model except those sites receiving a single collection per week may receive a change to the day of collection.
- Scenario three: The optimisation of the rounds if all of the multiple day collections were to have a single day of collection with multiple containers collected equivalent to the weekly volume collected in the ‘As Is’ model. This represents a change in service design reflecting the situation where the WMC may seek to influence the collection frequency by placing more containers on site (subject to storage space on site) and making fewer visits to make collections.

The scenarios were developed through discussions with WMCs highlighting areas of their operations where they felt they were potentially inefficient. Key to all of the scenarios is the search for financial and environmental efficiency savings.

The redesigned collection rounds (days of work) from the three scenarios were reviewed and assessed at a meeting with Weirs Waste who confirmed the rounds to be deliverable. It was not feasible to implement these rounds within the timescales of the trial.

4.6 Findings and analysis

4.6.1 Data
The data gathered from the scenarios has been used to calculate potential CO₂ and financial saving benefits.

4.6.2 CO₂ calculation
The CO₂ emission calculation has been undertaken using the 2009 Guidelines to Defra / DECC’s Green House Gas (GHG) Conversion Factors for Company Reporting. The calculation has been undertaken using the Annex 7 data for freight transport and uses the conversion factor for litres of diesel into total Kg of CO₂ of 2.6391.

4.6.3 Financial calculation
Fuel savings have been calculated using a standard pump price for Diesel of £1.10 per litre (correct 31st January 2010).

This report uses a litre to gallon conversion factor of 4.5 litres per gallon. Other financial calculations are based upon data provided from Weirs Waste and are identified in further sections of this report.
5.0 Trial findings and analysis

5.1 Trial results

This section of the report summarises key results from the trial and includes commentary from meetings and interviews with staff at Weir Waste.

The summary statistics for the three trial vehicles for the ‘As Is’ and the redesign scenarios are identified in Table 5.1 below. The time data below is expressed as a decimal hour. For example 5 hours and 30 minutes would be expressed as 5.50 hours.

Table 5.1 ‘As Is’ model and scenario data summary

<table>
<thead>
<tr>
<th></th>
<th>‘As Is’</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total miles per week</td>
<td>1,360</td>
<td>1,340</td>
<td>1,149</td>
<td>1,360</td>
</tr>
<tr>
<td>Total hours per week</td>
<td>150.75</td>
<td>144.00</td>
<td>137.00</td>
<td>145.00</td>
</tr>
<tr>
<td>Average miles per day</td>
<td>80.0</td>
<td>78.8</td>
<td>67.5</td>
<td>80.5</td>
</tr>
<tr>
<td>Average hours per day</td>
<td>8.86</td>
<td>8.47</td>
<td>8.05</td>
<td>8.50</td>
</tr>
</tbody>
</table>

5.1.1 Distance

Table 5.1 above shows that the CVRS optimisation software has been able to deliver a small improvement over the manual routing completed by the operational staff at Weir Waste in scenario one. All of the modelling parameters (e.g. days of collection) remained the same in scenario one, but the vehicle allocation for each job and sequencing could change. The CVRS technology has been able to reduce the weekly distance travelled by 20 miles per week. This is a 1.5% reduction from the ‘As Is’ mileage. This efficiency is through the better routing and vehicle allocation. With a larger fleet the potential for savings may proportionally increase due to the additional scope to improve the property allocation to vehicles and the routing of the vehicle.

Scenario two shows a greater reduction in the distance travelled. Scenario two varies from scenario one in that the day of collection was permitted to change for those customers requiring one collection (lift) per week. Putting the results in context there are 445 single lifts undertaken across the three vehicles, from a total of 1,661; the single collections thus represent 27% of the overall collections undertaken. The reduction in mileage in scenario two is 211 miles per week. This is a 15% reduction over the ‘As Is’ distance travelled. The movement of the days of collection for the single weekly waste collections should be a simple task. Most sites would not object to a day change.

Within scenario three we have taken all of the locations that receive a multiple weekly collection and placed them onto a single day, with the total weekly volume to be collected at that visit. The multiple collections represent 73% of the total lifts undertaken, but only from 358 (45%) of the 803 locations serviced. The majority of the multiple collection sites require between two and three lifts per week. The redesign for this scenario has not delivered any significant benefit over the ‘As Is’ position. Without reviewing the results on a site-by-site basis it is unclear why there has been little saving potential through this method of working. A contributory factor is likely to be the large volumes of waste needing to be collected on single sites at a time, filling the vehicle capacity up quickly. Furthermore, as each vehicle spends most of the working week making collections for reasonably well defined areas there is no logistics penalty associated with re-visiting sites more than once. Had Weirs’ operation been smaller, e.g. involving just a single vehicle making collections in distinctly different areas each day, then we would expect the results to be different. This finding reflects the benefits for WMCs of achieving high numbers of collections within operating regions, enabling them to achieve high route density on vehicles and providing flexibility to respond to customer’s needs in terms of making repeat visits during the working week.

5.1.2 Time

Scenario one shows an overall time saving of 6.75 hours. This is a 4.5% time saving based upon the ‘As Is’ model.

---

7 Comment from Weirs Waste operational staff / manager
Scenario two indicates a higher time saving than in scenario one with 13.75 hours saved. This is a 9% saving in time from the ‘As Is’ model. Within this scenario an average of 0.80 hours (48 minutes) is saved on average for each day of work.

Scenario three requires 5.75 hours less time to complete the work than the ‘As Is’ model. This is a 4% reduction in the time required compared with the ‘As Is’ model.

With the exception of Round 3 Monday to Friday which tips twice per day all of the other vehicles tip once per day. The minimum weight capacity remaining on any vehicle is 3 tonnes. It can therefore be concluded that the time saving created within the above scenarios could be converted into productive (fee earning) time and would not be restricted by the vehicles’ carrying capacity to collect additional waste.

5.2 Trial analysis

This section analyses the results of the CVRS trial.

5.2.1 Financial saving through reduced fuel spend

The headline mileage statistics and associated fuel savings across the three trial vehicles are presented in Table 5.2 below. The fuel-related savings have been calculated based upon an average fuel consumption figure of 4 mpg, 4.5 litres to a gallon, £1.10 per litre for diesel and a 52 week year.

<table>
<thead>
<tr>
<th></th>
<th>‘As Is’</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total miles per week</td>
<td>1,360</td>
<td>1,340</td>
<td>1,149</td>
<td>1,360</td>
</tr>
<tr>
<td>Mileage saved per week</td>
<td>N/a</td>
<td>20</td>
<td>211</td>
<td>0</td>
</tr>
<tr>
<td>Estimated fuel savings, £ per annum</td>
<td>N/a</td>
<td>£1,287</td>
<td>£13,578</td>
<td>£0</td>
</tr>
</tbody>
</table>

Weirs have a multi modal fleet of eight vehicles. If the savings identified in scenario one were extrapolated directly to the eight multi modal vehicles the annual savings would be £3,432 per annum. This figure has been calculated by the trial savings above being divided by the number of trial vehicles (3) and then multiplied by the Weirs Waste multi modal fleet (8).

If the same extrapolation were undertaken for scenario two then the annual saving would be £36,208 per annum. This is a significant saving and is equivalent to saving seven weeks worth of fuel per annum for the multi modal vehicles. The single days of collection are often selected randomly by the client at the point of sale and as such could, in most cases, be changed without significant disruption.

5.2.2 Financial benefit through reduced time spent making collections

For scenario two, which delivers the greatest potential level of efficiency saving, the average time saved per day is 48 minutes. The average number of containers collected by the vehicles is 285 bins per hour, expressed as an equivalent of a 240 litre container to normalise the variety of containers used within CDEW and C&I waste collections. For example a 1,100 litre container is equivalent to 4.58 x 240 litre bins. In theory, therefore, an additional 228 x 240 litre bin equivalents (50 x 1,100 litre containers) could be collected in the 48 minutes saved per day (on average), subject to the following caveats:

- some of the sites included in this study have over 50 containers collected per day, thus collecting 50 containers does not necessarily mean visiting 50 locations; and
- it may not be possible to collect this number of additional containers if any deviation from the existing routing is required. Additional travel time to new sites will reduce the ability of the vehicle to collect the maximum additional containers.

Considering the results of scenario three, the volume of multiple weekly collections is 73% of all of the collections undertaken. Despite the theoretical potential for efficiencies no savings have been identified through this change of working practice. The number of sites visited and the volume collected may be constraining the potential for savings to be achieved. It is important to note that for the single weekly collections we did not allow a change of collection day within this scenario, which constrained the solution. If the trial were re-run it is recommended that this constraint be relaxed so the full benefit of changing collection days and consolidating lifts can be tested.
5.2.3 CO₂ saving

The CO₂ savings for each of the scenarios when compared to the ‘As Is’ results can be seen in Table 5.3.

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total CO₂ savings, kg per annum</td>
<td>3,088</td>
<td>32,576</td>
</tr>
</tbody>
</table>

The CO₂ emissions are a function of the fuel consumed. The CO₂ savings are directly linked to the distance travelled and the fuel consumption (miles per gallon, mpg).

The greatest CO₂ savings are to be found from scenario two with 32.5 tonnes of CO₂ being saved per annum. This is equivalent to a 15.5% saving in CO₂ emissions for the multi modal vehicles. Scenario one achieves negligible CO₂ savings whilst scenario three achieves none.

5.2.4 Breakeven analysis

The costs and approaches to using CVRS varies. The two main approaches currently employed are:

- the use of external consultants to gather the data and undertake the modelling; and
- the purchase of software for the optimisation of the rounds to be completed internally.

The cost of the use of consultants is likely to be in the range of:

- £5,000 - £10,000 to develop a baseline (‘As Is’) model for a medium sized waste company upto 12 vehicles;
- and
- each subsequent scenario dependant upon complexity is likely to be in the range of £2,000 - £6,000.

The cost of suitable software is in the region of £10,000 to £30,000 per year for the licence and operation of the software. The costs will be largely dependent upon the size of the fleet and the quality of the available data.

Based on the identified best level of saving identified in Table 5.1 (considering fuel alone) the payback period is indicatively expected to be within one and two years depending on the CVRS procurement route, the data available and number of scenarios analysed. Should it be possible to take on additional fee-earning work due to the identified reduction in daily working time on scenario 2, the cost-benefit of undertaking such an exercise improves further still.

5.3 Practical considerations

Through engagement with some of the larger national WMCs such as SITA and the medium sized WMCs such as Weir Waste, the current quality and availability of suitable data for use with CVRS is variable. The data reviewed by Entec on the MRF114 study identified that in many cases just client names are provided, with no street or postcode details available. One of the larger companies indicated that to supply the data electronically was difficult and that the system remains paperwork driven. The data required for a CVRS exercise were often found to be incomplete or not readily accessible. Examples of data gaps in this trial included 41 missing postcodes (used to geo locate the sites) and 28 locations with missing bin sizes and missing bin quantities. In the context of the number of collections modelled this was considered to be a reasonable level of data quality.

There are bespoke waste IT solutions on the market that provide part or full solutions to the issues of data quality and availability such as the Isys GateHouse and Skipman software, where data to support a CVRS exercise can be readily downloaded and accessed. The use of IT systems to improve the quality and accessibility of suitable data will be critical to CVRS systems being adopted more widely by the waste industry. It is through such a system that the data for this trial was provided. There is also a cultural barrier to be overcome. Some of the collection paperwork is not always completed by drivers (from the range of data we observed) and this is not
always enforced by internal procedures and / or the capability / will of the drivers and the management staff. Improved data management and IT systems are thus crucial to realising the efficiencies that CVRS can deliver.

6.0 Summary and discussion

6.1 Summary of benefits

The vehicle routing (at Weir Waste) is managed using local knowledge and a zonal approach where vehicles operate in a defined area. Weir Waste undertakes the manual redesign process twice per year to ensure that the routing remains efficient. This exercise normally takes between two and three days of management time to complete. Not all WMCs review their waste collection rounds at this frequency. The zonal approach of the round design at Weirs has limited the potential for savings due to the short distance of shared borders and small geographic overlap of the rounds and zones. When considering the findings of the scenario one redesign, where collection days were not permitted to change, the potential 1.5% reduction in mileage suggests that the existing rounds are reasonably efficient.

Scenario two identified the greatest financial and time savings of all three scenarios by allowing the single days of collection to change. The annual potential saving in fuel for scenario two is £36,208 (for the Weir Waste fleet) which is a 15.5% reduction in these costs. Scenario two also requires 13.75 hours less per week to complete the work across the three vehicles assessed. The ease of moving the days of collections for sites that receive a single day of collection per week is not considered to be a significant barrier to the implementation of the scenario two findings. The high level of short term effort required to make the initial day changes will be rewarded by the potential for savings.

The projected reduction in time to complete the work on scenario two has also added capacity to the rounds to collect from more customers. This has the potential to avoid investment in new vehicles should the opportunity arise to take on more business and / or reduce overtime requirements. In the short term, tyre wear and maintenance costs could be reduced due to the decrease in the distance travelled in scenario two. Longer term it would be an aim to fill this capacity, enabling the vehicles to become more productive and profitable.

The scenario two findings highlight the importance of generating route density within a given area and selecting the day of collection appropriately for sites receiving a single weekly collection. Typically the day of collection for such sites is based upon the availability of a vehicle in the area on set days and customer preference. In terms of realising the benefits this solution offers, the WMC may seek to manage a change in collection days through a financial incentive such as the offer of a free waste collection. The efficiencies could also be achieved on an ongoing basis through the sales personnel. This could be achieved by restricting the day of collection for new sites requiring just one waste collection per week in a given geographical area (or postcode). The sensitivity of the day of collection for single weekly collections is a critical factor for WMCs to understand if the maximum logistical savings for CDE (and C&I) waste collections are to be achieved.

6.2 Return on investment

The costs of CVRS studies and software packages vary. Typical costs for building a baseline data model ('As Is') and an optimised model for up to 12 vehicles is likely to be in the range of £5,000 - £10,000 for the baseline model with an additional £2,000 to £6,000 per scenario. The potential fuel savings from scenario two (based on a permitted change of collection days) of £36,208 per annum indicates that the benefit of CVRS is greater than the cost of the software and licensing. The trial findings suggest that a return on investment can be made within one to two years, depending on the degree of service change the WMC is prepared to accept and implement on the ground.

It is the opinion of the modellers that a higher proportional saving can be achieved with a larger fleet than the three tested. The potential savings that can be identified by the CVRS will also be a function of the current efficiency of the collection rounds. To assess the full range of savings that could be achieved it would be necessary to undertake more testing to delimit the lower and upper ends of the potential savings range for various scenarios.

6.3 Uptake considerations
The implementation of CVRS systems is considered key to delivering logistical efficiencies to the waste sector. The historical approach to routing decisions being determined by the drivers, and operator scepticism of computerised systems within many WMCs will need to be overcome. Where CVRS adds value is its ability to assess multiple options in a detached way. This has been identified within the trial where a simple change to the day of collection identified potential financial savings on fuel of up to 15%. The routing and scheduling of waste collection vehicles needs to be considered as part of regular service reviews undertaken by WMCs to ensure they are operating efficiently. These service reviews may also consider different vehicle types that may increase the flexibility, and service options available to the WMC to respond to changing markets.

The logistics of waste collections for the private sector is likely to become increasingly complex as the market changes. New developments include WMCs such as Biffa and SITA (Birmingham) offering co-mingled collections of recyclable materials for small companies. Policy indicators are placing future emphasis on C&I waste recycling which will encourage these types of service development and/or increased segregation of materials on site for separate collection. With increasing logistics complexity the role of CVRS will become progressively more important to the day-to-day operations of WMCs.