The Optimisation of Household Waste Recycling Centres for Increased Recycling – A Case Study in Sussex, UK

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Abstract

Sixteen percent of household waste in the UK is handled at Household Waste Recycling Centres (HWRC). These facilities will play an important role if the UK is to achieve the national target of recycling 25% of household waste by 2005, as most sites now provide containers for recyclables as well as a mixed waste pile. However, few published studies have been conducted regarding the activities of HWRC site users and the composition of waste that is delivered, especially to the mixed waste pile. This paper presents the results of a site survey in Sussex, UK and discusses the role of HWRC in handling household waste.

During the week of sampling 969 site users were monitored. The target group was those depositing only on the mixed waste pile. Two main categories of waste

dominated. The first, identified as garden waste, was deposited by 37% of the target group and represents approximately 20% of arisings by observed volume. The second was miscellaneous waste bagged, present in 34% of loads and equating to approximately 21% of arisings by observed volume. Despite the availability of containers for segregating recyclable and compostable materials, 29% of users deposited these onto the mixed waste pile. The site was clearly not able to operate at its optimum. The reasons for this and potential solutions are presented.

Key words: Recycling Targets, Household Waste Recycling Centres, Waste Analysis, Recycling Activity, GIS.

1. Introduction

In 2001/02, 13% of the municipal waste generated in the UK was recycled or composted, 9% was sent to energy from waste plants with the remaining 77% delivered to landfill or land raise sites (DEFRA, 2003). However, waste management in the UK is rapidly changing as national and European legislation, combined with diminishing landfill capacity, dictates a move towards a more integrated, sustainable system for managing waste. Important components of this system are recycling and composting. In Waste Strategy 2000, the national waste strategy for England and Wales, the UK Government introduced, for the first time, a series of statutory recycling targets for individual local authorities (DETR, 2000). These targets were set based upon the recycling performance of individual local authorities from 1998/99 and followed this broad criteria; authorities with a recycling or composting rate of

under 5% were set a target of 10%, those achieving between 5% and 15% had to double this rate, the remaining authorities had to recycle or compost at least one third of household waste by 2003/04. For example Dorset County Council, which recorded the highest recycling rate of 31% in the country in 1998/99 had to recycle 33% by 2003/4 whereas Sunderland City Council which recycled 1% in 1998/99 had to recycle 10% by 2003/04 (DETR, 2000). The aim was to attain a national household waste recycling rate of 25% by 2005. As a consequence, local authorities throughout the UK are currently implementing and modifying recycling and composting strategies to meet their respective targets.

The UK definition of household waste was laid down in the Environmental Protection Act 1990, supplemented by the Controlled Waste Regulations 1992. The definition includes material that is collected through household collection, materials delivered to household waste recycling centres (HWRC), materials recycled from households and bulky and clinical waste collected from households using special collections (DETR, 2000). In 2000/01 England generated some 25.6 million tonnes of household waste (DEFRA, 2003). Household waste consists of a diverse range of materials including garden waste (20% of the total), paper and board (18%), putrescible waste such as kitchen (17%), glass (7%), miscellaneous non-combustible waste (5%), dense plastics (4%) and textiles (3%) (Strategy Unit, 2002).

The management of household waste operates on a two-tier system. The Waste Collection Authority (hereafter referred to as WCA) which is usually a borough or district council conducts waste collection. WCAs are required to dispose of the collected waste but they do not have the responsibility for providing disposal

facilities: this is the duty of the Waste Disposal Authority (hereafter referred to as the WDA). WDAs plan, implement and manage waste disposal facilities, such as landfill sites and energy from waste plants, and accept waste directly from the WCAs. WDAs are normally county councils that control waste disposal for districts and boroughs in a respective county. Unitary authorities (UA), such as city councils, are the exception as they have the dual role of waste collection and disposal.

As mentioned previously authorities in the UK have been set statutory recycling rate targets. However, the criterion for calculating the recycling rate varies depending on the authority managing the waste; WCA, WDA and UA have rates based on their individual responsibilities (See Table 1).

Insert Table 1.

Waste generated from households can take several management routes. Since the Public Health Act of 1936, local authorities have had the statutory duty of collecting household waste free of charge (DoE, 1975). Thus, 65% of household waste is collected directly from households (DEFRA, 2003). However, not all household waste is suitable for inclusion in this form of collection. For example, mattresses, white goods or large quantities of garden waste, may be prohibited from direct collections as their bulky nature presents logistic difficulties. Therefore, since the 1967 Civic Amenities Act authorities have been required to provide waste facilities known as Civic Amenity sites for the public to deposit these wastes (DoE, 1975). These are centralised facilities where residents can also deliver material in excess of household collection; some authorities place a limit on the quantity of material they

will accept in household collections. These facilities are paid for through local taxation and unlike other countries residents do not have to pay each time they deposit materials (DEFRA, 2002a).

Though these facilities were originally designed to accept waste, the role of Civic Amenity sites is evolving as the demand for recycling increases. Sites are now being promoted as facilities at which to recycle materials. This is reflected in the change of name from Civic Amenity sites, a name synonymous with waste disposal, to Household Waste Recycling Centres (hereafter referred to as HWRC). This paper investigates the role that HWRC can play in assisting authorities in achieving their statutory recycling targets.

2. Household Waste Recycling Centres

Approximately 16% of household waste in England is handled at HWRC (DEFRA 2003) and effective management of such facilities can assist authorities in improving recycling rates. According to annual waste statistics for England compiled by DEFRA, the total amount of waste collected for recycling from HWRC and recycling centres (bring banks) has been increasing. About 2.2 million tonnes of recyclable material were collected from HWRC and bring banks in 2001/02, which is an 11% increase over the 2 million tonnes collected in 1999/00 (DEFRA, 2003). More specifically, of the total household waste materials collected for recycling and composting in 2001/02, 85% of glass, 86% of compost, and 97% of scrap metal were collected at HWRC (DEFRA, 2002b). Through effective planning and management up to 65% of waste flowing into these sites can be recycled (Letsrecycle.com 2003).

In light of the European Landfill Directive, which aims to reduce the quantity of biodegradable waste deposited to landfill (European Union, 1999) and the Waste Electronic and Electrical Equipment (WEEE) Directive, which sets out the protocol for the management of electrical equipment (European Union, 2002), HWRC are set to play an increasingly important role in legislative compliance.

Despite the importance of HWRC in the management of household waste, few UK studies have been published on the operation of these facilities. Detailed investigations were carried out in the late 1980s to early 1990s by the Recycling Evaluation Consortium. This research included cost appraisal of HWRC provision (Pocock *et al*., 1991) and public awareness and activities of site users (Coggins *et al*., 1990). The Recycling Evaluation Consortium also adopted a common classification of Civic Amenity waste in 1987 and used a sort-and-weigh analysis to provide the average weight of material deposited by a sample of site users, which could then be used to estimate the site arisings. The data could be converted to volumetric assessments or 'sack equivalents' for estimating bulky items in the absence of quality weighbridge data. Bagged household waste, timber, cardboard and metals were all found to be abundant in the waste stream with garden waste the dominant component - up to 60% of the waste stream by weight (Poll *et al*., 1990).

Additional research has also suggested that HWRC offer an important route for handling garden waste. Benfield (1997) found that 53% of site users deposited garden waste, and further studies indicate the proportion of garden waste entering these facilities is susceptible to seasonal variation. In April garden waste may present 33%

of material being delivered to facilities compared with 20% in November (Network Recycling, 2000).

Other research has reinforced the importance of HWRC as facilities to recycle material. Speirs and Tucker (2001) demonstrated that numbers of recyclers making special trips to recycle were generally higher at HWRC than supermarket recycling centres (bring banks). Studies have also been conducted on the level of abuse at HWRC by commercial users. Commercial waste is prohibited from entry into HWRC, but traditionally such restrictions have been exposed as inadequate. Recent research suggests that levels of commercial waste entering HWRC varies from 4% to 9% (Network Recycling, 2002).

Improved knowledge of the HWRC waste stream could help improve the management and operation of these facilities and in turn increase recycling rates. Thus a HWRC operating in the county of East Sussex, in the south-east of England was monitored in depth and the results of this investigation are presented and discussed below.

3. East Sussex

The county of East Sussex covers approximately 1,725 sq km of which 63% is designated an Area of Outstanding Natural Beauty (AONB). It is made up of five districts and also has historical links with the neighbouring city of Brighton & Hove (see Fig. 1). East Sussex and Brighton & Hove City have a combined population of 740,000 (National Statistics, 2003).

Insert Figure 1.

In East Sussex and Brighton & Hove City, each of the 14 HWRC in operation (including two mobile sites) offer recycling facilities for a range of materials. The range at each of the facilities varies, but the trend is to develop larger sites in the future with the capacity to capture more of the waste stream as segregated recyclables. One of the large and busy sites was thus chosen for this study, in the town of Eastbourne. In 1999/2000 the site accepted 12,806 tonnes of material, the fourth highest out of the fourteen HWRC. Out of the total waste materials entering the site only 2,125 tonnes was being recycled, equating to a 20% recycling rate, and ranking it 10th out of the 14 sites in operation (see Table 2). The site was clearly not performing well, despite its size and thus relative importance to the county. For this reason, and because the authorities were interested in working in partnership, this HWRC site was chosen for this study.

Insert Table 2.

The HWRC site was located in a residential area with a high population density of 20.3 people per hectare compared with 2.9 for East Sussex as a whole and 3.5 for England and Wales (National Statistics, 2003). As such, the site had a large number of users because of the high population density - estimated at 3,000 for the week of monitoring. Opening hours were Monday to Friday between 09:00-16:00 and 08:00-12:00 on Saturday and Sunday.

Site users entering the site had access to self-service containers for various segregated recyclable wastes and also a mixed waste pile, which was continually shovelled up, loaded into roll-on-roll-off containers and delivered to landfill. The recycling facilities provided for a diverse range of sorted materials including paper, cans, glass, telephone books, textiles, metals and engine oil. Containers were also provided for hazardous materials such as chemicals, asbestos and batteries. A separate roll-on-roll-off container was available for cardboard recycling, and four skips were available specifically for segregated garden waste.

This work did not consider the site users who were making use of the segregated containers for recycling. The target group of users studied in this work were those who deposited waste in the mixed waste pile and none other. They are referred to throughout as the 'monitored users'.

General household items with potential value were either delivered directly to an area cordoned-off by the site operatives, or were manually removed from the mixed waste pile by site operators. Such items included metals, white goods (e.g. refrigerators, cookers, and washing machines), bicycles and furniture.

4. Study Aim

The research had four main aims focussed on the target group (site users who used only the mixed waste pile).

i. The first aim was to understand the activity of the target group and the form in which they delivered waste. It was desirable to determine whether they deposited

homogenous material, such as garden waste that could be recycled, or if they delivered mixed loads that would require more effort to separate.

ii. The second aim was to determine the place of origin and distance travelled by the target group to make use of the facilities on offer. This would allow an understanding of patterns of use between alternative sites.

iii. The third aim was to gain detailed composition information on the waste being deposited and the proportion of materials that could be diverted from the mixed waste pile to the recycling facilities at the same site. It was also of interest to assess how frequently specific types of waste materials were deposited, to assist planning future supplementary recycling facilities or sites.

iv. The final aim was to identify problems with the site operation that were preventing the HWRC from working to its optimum and to suggest ways in which these could be overcome.

5. Methodology

Surveyors were positioned by the mixed waste pile where monitored individual users delivering waste. Only those site users solely depositing material on the waste pile were included in the survey. A record was made of the manufacturer and model of each target group user's vehicle as well as the postcode for where the waste originated from.

Observational analysis was used to estimate the quantity and composition of waste being deposited. This required an assessment to be made of the volume of material present in the vehicle. This method is typically used where sort-and-weigh analysis is not a practical option, such as at waste disposal facilities. Previous studies where observational analysis has been used include the New Zealand Waste Analysis Protocol (Worley Consultants Limited, 1992) and waste flows into landfill (Harder & Freeman, 1997; Siders, 1999; Environment Protection Agency of South Australia, 2000).

When the site user began unloading the waste from their vehicle, visual estimates were made by the surveyor of the relative proportions of boot capacity attributed to each material category, and recorded as percentages. In instances where vehicles delivered waste in excess of their boot capacity (i.e. the boot was propped open, waste was delivered in a trailer, on a back seat or on a roof rack) the estimates were adjusted accordingly. Comparisons of recordings made by different surveyors assessing the same load showed values agreed within 10%.

The data was collated in a database along with information from manufacturers on vehicle boot capacities. It was then possible to calculate how full each vehicle was and also to convert percentages into volume for quantities of individual materials present using the following formulae:

$$v = (c / 100)* p$$

$$m = (v / 100)* op$$

Where *v* is the volume of waste present in each load, *c* is the capacity of the vehicle, *p* is the observed percentage of how full the vehicle is, *m* is the volume of material present and *op* is the observed percentage of material present in the load. The data was also analysed using Geographical Information Systems (GIS) to show spatial patterns in site use, by requesting post code information from the users.

During the sampling period, surveyors kept a diary of activity at the site noting key observations such as times and potential causes of congestion. These observations were collated and strategies were developed to resolve these problems.

6. Results

The site was monitored between September 20th and 24th 1999. Nine hundred and sixty-nine vehicles were surveyed at the mixed waste pile, delivering an estimated 560 m^3 of non-compacted mixed household waste.

6.1 Site user activity at the waste pile

Fifty percent of monitored users deposited only one category of waste with 3% depositing three or more types. Moreover, 29% of monitored users deposited loads that only contained materials which could have been recycled or composted using the existing facilities on site (see Table 3).

Insert Table 3.

Eighty-five percent of monitored users were able to provide postcodes from where the waste originated. Of these users, 95% delivered waste from within the borders of Eastbourne district (see Fig. 2) with the remaining 5% of monitored users travelling from outside the district to use the facility. Moreover, 3% of monitored site users delivered material to the site despite the waste originating from within a 5 km radius of an alternative HWRC (see Fig. 3).

Insert Figure 2.

Insert Figure 3.

6.2 Materials delivered

The frequency and homogeneity of loads delivered is presented in Table 4 and the composition of materials is presented in Table 5.

Insert Table 4

6.2.1 Garden waste

Garden waste was the most abundant material deposited onto the mixed waste pile, representing 30% of the observed volume. Over 80% of this material was foliar, which included leaves, grass cuttings and general prunings. The remaining 18% was predominantly woody material such as branches and trunks. Garden waste was frequently delivered to the site, with 40% of visitors dropping off this material, whilst 23% of total loads entering the site contained homogenous loads of garden waste.

Insert Table 5

6.2.2 Bagged waste

Twenty-one percent of the waste by observed volume was classified as bagged. This is waste typically delivered either in black refuse sacks or closed boxes and was deposited by 34% of monitored users with 13% of them depositing no other type of waste. Inspection of some of these bags suggests that they contained materials generated from house clearances such as books and miscellaneous household objects. The lack of homogeneity of the contents from bag to bag makes it difficult to estimate overall contributions of the bagged waste to the composition of the mixed waste pile.

6.2.3 Timber

Eight percent of the total observed arisings by volume were timber or timber-based products. Forty-eight percent was classified as treated timber while 31% was untreated. Panel board including medium density fibreboard (MDF) and chipboard made up the remaining 21%.

6.2.4 Cardboard

Cardboard was present in 15% of loads delivered by monitored users, and was 5% of total waste by observed volume. Only three users deposited homogeneous loads.

6.2.5 Furniture

Typically, any reusable furniture delivered to the site was taken directly to the site operatives. However, some furniture was still placed on the waste pile - 9% of overall observed arisings. Surveyors estimated 41% of this material was potentially reusable.

6.2.6 Refurbishment waste

Materials associated with building maintenance and construction (excluding timber and segregated hardcore) were classified as refurbishment waste. Five percent of the arisings, by observed volume, was from this category. The majority of material was bagged up in thick transparent plastic sacks and therefore its detailed composition was hard to assess. Nine percent of monitored users delivered mixed refurbishment waste.

6.2.7 Metals

Metal has significant value on the secondary market and as such the site operatives collected most of the metal deposited. However, metal still made up 2% of the waste pile by observed volume and was present in 7% of the loads delivered.

6.2.8 Other materials

Hardcore inert materials represented 2% of arisings, by observed volume, and were delivered by 5% of monitored users. Dense plastics comprised 2% of arisings by observed volume and were present in 7% of loads. Carpet and mattresses both made up 3% of arisings and were delivered by 7% and 1% of monitored users respectively.

7. Discussion

7.1 User activity

Fifty percent of monitored users deposited just one category of material, which was similar to the findings reported by Coggins *et al*., (1990), albeit using a different methodology. Twenty-nine percent solely deposited materials onto the mixed waste pile that could have been recycled or composted using the existing facilities.

Eighty-five percent of monitored users were able to supply postcodes. Analysis shows that the majority of them lived within close proximity of the site with 5% travelling from further away. Additional analysis shows that 97% of users were within a five-minute drive from the site (assuming normal driving conditions), 3% between 5 and 10 minutes, 0.5% from 10 to 15 minutes and 0.2% more than 15 minutes away. It was surprising that some users visited the site as the waste they delivered was generated in close proximity to an alternative HWRC. Three percent of users deposited material that originated from within a 5 km zone of another HWRC (see Fig. 3). An explanation for this may be that these users were visiting the Eastbourne area anyhow and therefore made use of the facility.

7.2 Materials deposited

7.2.1 Garden waste

Garden waste was the main material category that was delivered to the site. When combining the foliar and woody categories 37% of monitored users delivered loads containing garden waste, this is less than the 54% cited in other research (Coggins *et al*., 1991). Moreover, 22% of monitored users deposited loads of homogeneous garden waste material. The combined categories represented 30% of total arisings by observed volume. This supports previous research indicating garden waste to be the most abundant material in the HWRC waste stream (Poll *et al.,* 1990; Network Recycling, 2000).

Garden waste is traditionally taken to a HWRC because of restrictions placed on the quantity of material collected by the local authority; in some areas garden waste is prohibited from being placed out with household refuse intended for collection. Residents have the option of composting the material at home, burning it (with any bye-law restrictions) or delivering it to a HWRC.

7.2.2 Bagged waste

Bagged waste represented 21% by observed volume of the waste stream. Although the adopted methodology meant that the contents of these bags was unknown, it is likely that some bags contained household waste from missed refuse collections. Indeed, from May to September 1999 the national average for missed waste collections was 194 per 100,000 households (Audit Commission, 2001). Furthermore, studies have shown that 28% of people use HWRC to dispose of excess household waste (Coggins *et al*., 1991). House clearances and commercial waste in the guise of household waste are other possible reasons for the presence of bagged waste.

Research by Network Recycling suggests that between 4% to 9% of site users deliver non-household waste such as commercial or trade wastes. As this waste does not adhere to the definition of household waste it is prohibited from entry into HWRC (Network Recycling, 2002). Many authorities have implemented procedures to reduce the quantity of trade waste entering HWRC such as van and truck bans, vehicle height restrictions and monitoring of site users.

7.2.3 Timber

Timber and wood waste represented 9% of the sampled waste stream by volume. Sources of timber were likely to have been from building work, replacement of household units, fencing and other gardening activities. Treated timber formed the largest portion of this material type representing 48% of total sampled timber arisings. This included timber that had been painted, tanalised and creosoted. Such timbers are used in garden maintenance and refurbishment and therefore are susceptible to seasonal variation.

Thirty-one percent of the timber waste stream sampled was untreated in nature, whilst the remaining 21% was comprised of composite material such as medium density fibreboard (MDF) and chipboard. Both of the latter materials were often observed to be coated as is usually the case for boards used in the manufacture of kitchen units and furniture.

The surveyed site did not provide facilities for segregating timber. Whilst a proportion of the timber deposited had value on the secondary materials market it did not possess

enough value for the operatives to remove it from the general waste. Other material was observed to be of sufficient quality to be used by local artists or passed onto existing voluntary and charitable organisations for re-use. Untreated waste timber is also suitable for energy recovery applications and these results demonstrate that the provision of a separate collection point for timber would result in a significant quantity of material being recovered from this site.

7.2.4 Furniture

As furniture consists of a mix of materials, it was placed into its own category. Moreover, it was of interest to equate the quantities of furniture that could be diverted through reuse. It was estimated furniture represented some 9% of the waste stream.

Due to its bulkiness, furniture is not included in normal household waste collections. Residents have the option of paying to have the unwanted items collected by a private company, by the council in separate bulky waste collections, donating items to charity and neighbours or depositing items at HWRC. It should be noted that the presence of furniture in the waste stream would have been higher but the operatives removed some of the re-usable items from the waste pile. Even then, out of the remaining furniture the auditors recorded that 41% was potentially reusable. One option for management could therefore be to allocate an area of the site in which members of the public could deposit serviceable furniture. The items could be resold or passed to existing appropriate charitable organisations. Overall, this would appear to represent a sustainable source of furniture since reusable items were recorded in 4% of total vehicles entering the site.

7.2.5 Dry recyclables

Despite the presence of appropriate recycling facilities, 6% of waste by sampled volume entering the mixed waste pile was paper and card, while 8% was textiles. It therefore appeared that improvements could be made to the overall site layout to increase the quantities of recyclable material being diverted. However, the site was already operating under several constraints, which were having an impact upon its performance. The surveyors kept a diary of observations and from this data various barriers to increasing the recycling rate at the site were identified. These are discussed in the following section along with recommendations on how these problems could be resolved.

7.3 Site operation

7.3.1 Problems

The key observation was the congestion at the facility. The site was located in a densely populated residential area and being in close vicinity to so many residents it had a high visitor throughput. It was estimated that on average 1.5 site users deposited waste each minute during the working week, which increased to 3 users per minute at weekends. According to anecdotal evidence from the site operatives these figures could be higher at peak times of the year in early to mid-summer.

The high vehicle throughput led to congestion problems that were exacerbated by impatient site users. Figure 4 illustrates a commonly observed phenomenon. Although the problem appears simple, the observed knock-on effects are significant. Figure 4.1 shows schematically how the site was designed to operate. Cars at the mixed waste pile deposit materials and other site users should wait their turn. However, Figure 4.2 shows a typical scenario in which users are not prepared to wait and the impact that this has on site operation. Although vehicle A has pulled out, allowing vehicle E to pull in, this site user has already started to unload waste from their place in the queue and is not now prepared to move. Moreover, E is blocking vehicles C and D which have finished depositing material. In the meantime user G, delivering solely garden waste, has become impatient and instead of waiting in turn to gain access to the separate garden waste recycling facilities has deposited compostable material onto the mixed waste pile.

Parking problems were also observed to be further exacerbated by individuals that deposited recyclables at the bring banks while their vehicles were parked in front of the mixed waste pile. Similarly, trailers and vans that were unloading caused problems by taking up extra parking spaces as well as taking a longer time to empty.

The congestion problems identified are not unique to this site. Since the 1967 Civic Amenities Act, society and consumer attitudes have changed considerably, but HWRC site capacity and operation has, in many circumstances, remained the same. Car use in the UK, for example, has increased since 1960 from 30% of households having regular use of a car to over 70% by 1996 (DETR, 1998). HWRC have therefore become more accessible to the car-driving public and this has meant that

traffic throughputs have increased. Allied with this and adding further pressure to HWRC, is that the UK is now generating more waste. Whilst in 1974-75 some 1 million tonnes of material were handled through HWRC (DoE, 1976) by 2000-01 this had increased to 4.3 million tonnes (DEFRA, 2002b). Sites originally developed 30 or more years ago are not designed to handle the demands of modern society, greater varieties of material and the new requirements to segregate.

Insert Figure 4.

7.3.2 Recommendations

From the data collected from this site from 969 users, there are several suggestions that can be made to improve site operation and probably lead to higher rates of recovery. Although some of these seem rather simple, it is clear from other brief surveys this research group has carried out at other sites, and from requests for information to this research group from other local authorities, that the priorities for actions to improve such sites are not obvious, and factually based ones are needed. The following are thus offered:

- Site staff should direct parking activity and make sure users are not depositing recyclable or compostable material on the mixed waste pile.
- Clearly marked bays should be put in place with separate parking provision for the unloading of trailers and vans. This would allow people driving cars to have a ‘fast track’ in and out of the site.

- A traffic filtering system to recycling banks and garden waste recycling facilities should be implemented preventing those site users wishing to recycle from being caught up in the scramble to deposit mixed waste.
- Effective sign posting should be used, guiding users to appropriate recycling banks and unloading bays. At the time of monitoring, the site was poorly signed; a new site user would have been unaware that garden waste recycling facilities at the far end actually existed.
- Recycling and composting facilities should be moved to a more prominent part of the site.

However, the opportunities for implementing these improvements in site operation are often constrained by the current site layout, and without serious investment the impact of changes would be minimal. Moreover, although improved layout would increase the throughput of vehicles the facility would remain under pressure as the same number of users would still be depositing material at the site.

A further option is to reduce the number of site users by installing alternative facilities. Take for example garden waste. Of the monitored users depositing material on the mixed waste pile, 22% solely delivered garden waste (this does not take into account those users that utilised the garden waste recycling facilities, as these were not included in the monitoring). If alternative garden waste facilities were provided some 22% of site users, based upon the sample monitored, could be diverted from the site, thus helping to significantly alleviate congestion problems.

Postcode data provided by monitored users that were solely delivering garden waste was analysed using GIS (see Fig. 5). The aim was to identify clusters of housing from where homogeneous loads of garden waste were generated. Results show that there were five principle clusters of housing, denoted by the darker areas (excluding the cluster from around the existing site). Satellite sites or mobile facilities, two of which were already in use in other parts of East Sussex, could be established in these areas to solely handle garden waste thereby reducing some of the burden on the existing site. Ideally, these new facilities would be located at or nearby local composting facilities thereby reducing transportation costs for the local authority.

Insert Figure 5.

8. Further work

Further proposed work will investigate waste composition using sort-and-weigh analysis. This will provide more accurate and detailed information on the composition of waste. Data will be collected on the composition of bagged and refurbishment waste, of which little is known (see sections 6.2.2 and 6.2.6).

The site that was monitored was achieving a low recycling rate. It would be interesting to conduct detailed waste analysis at a site where a more established system for diverting recyclable and compostable materials was in place. Analysis would indicate the prominence of particular recyclable material types remaining in the waste stream and also possibly identify alternative materials, not commonly recycled at HWRC, which would be desirable for diversion after some development.

9. Conclusions

HWRC play an important role in the UK to help meet statutory recycling targets. However, few published studies have been conducted regarding the activities of their site users and the composition of waste that is delivered. To gain a better understanding of these issues research was conducted at a HWRC in East Sussex.

The results suggest that two main categories of material were deposited by site users onto the waste pile. The first, garden waste was delivered by 37% of site users and presents 20% of arisings by observed volume. Bagged waste was present in 34% of loads and equates to approximately 21% of total materials by volume.

At the time of analysis the site was not performing to its optimum; it was attaining a recycling rate of only 20%. Large quantities of garden waste and dry recyclables continued to be placed on the mixed waste pile. A contributing reason for this is the congestion at the site. Some HWRC are based upon site layouts and operation from 20 to 30 years ago when the demands were very different and cars less commonly used. The situation is exasperated by irresponsible site users. Changes to site layout and operation could improve the facility's performance but not reduce the number of site users.

Analysis of loads has shown that 22% of users deposited homogeneous loads of garden waste, coming from five cluster areas nearby. An alternative strategy to

improve services could thus be to set up satellite or mobile sites in the five areas, thus reducing the number of users at the existing multi-material site.

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Fig. 1. Location of East Sussex and Brighton & Hove City

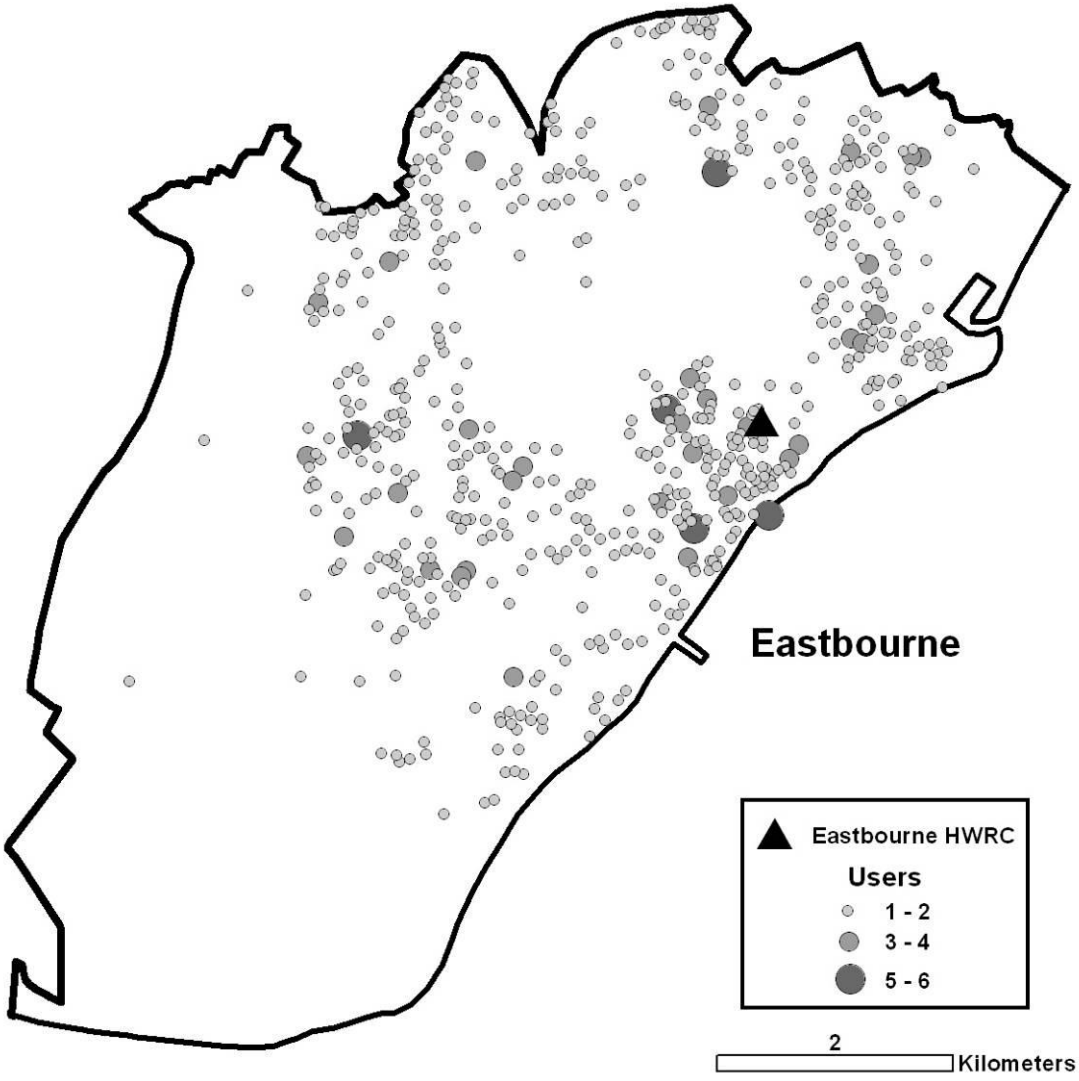

Fig. 2. Location of site users depositing material on the waste pile from within Eastbourne district

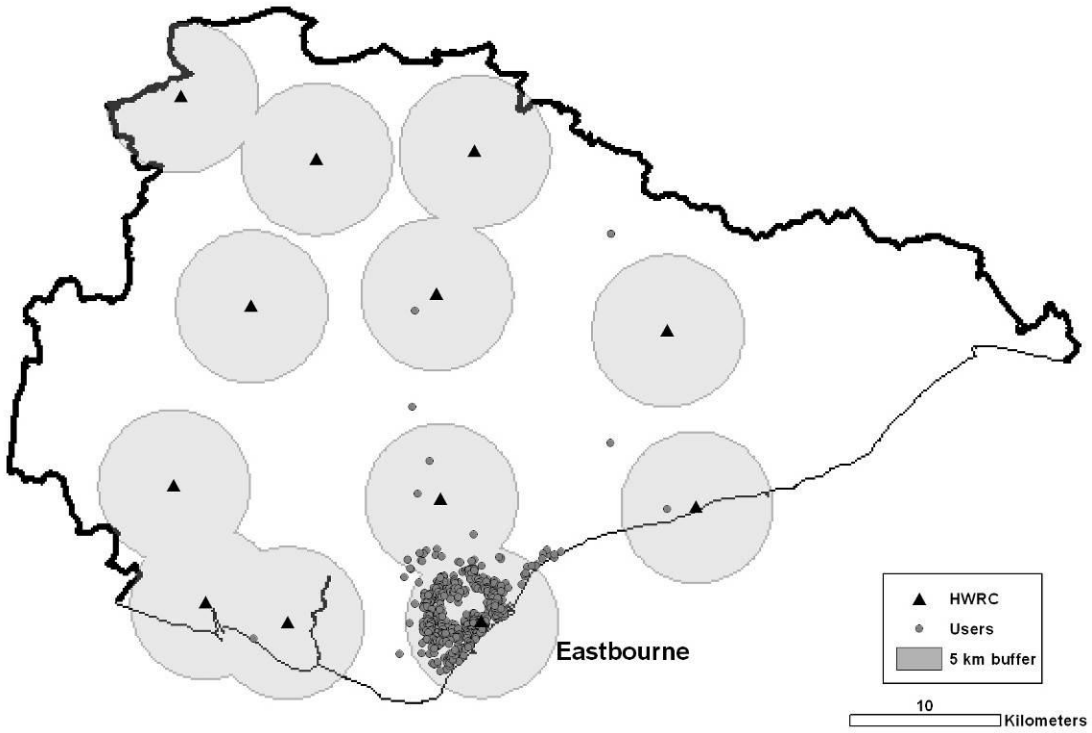

Fig. 3. Location of site users depositing material on the waste pile from within East Sussex and their proximity to other HWRC in the county

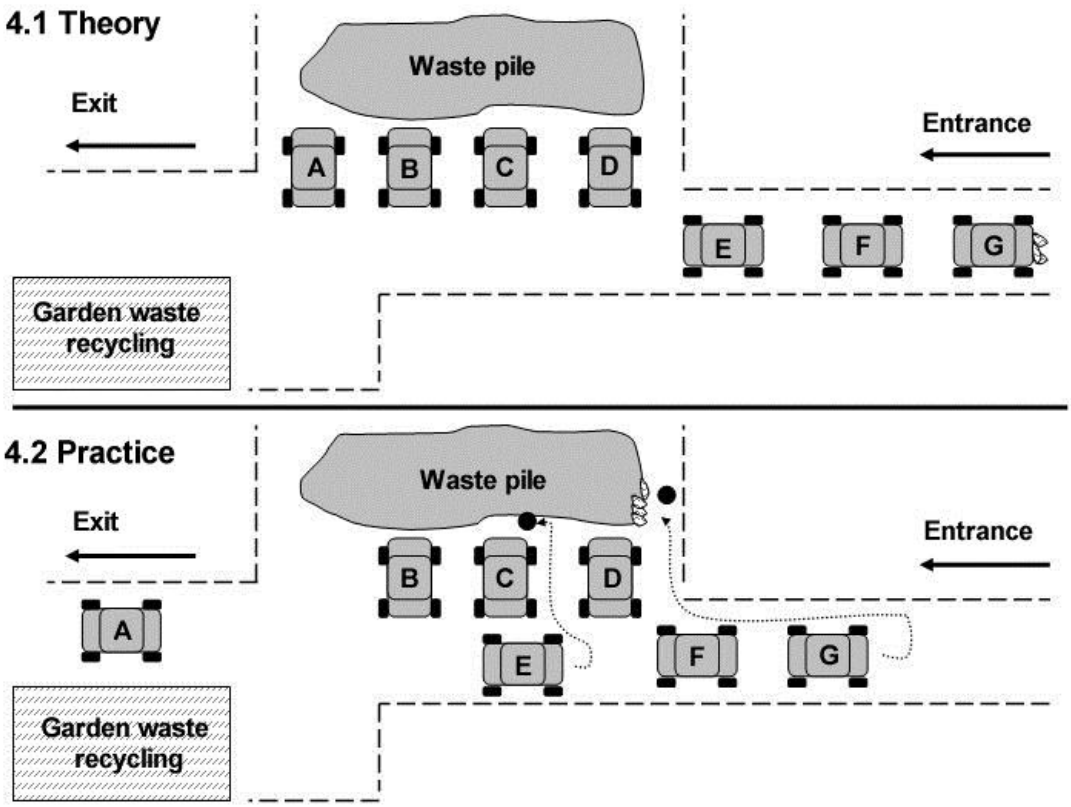

Fig. 4. Example of the problem caused by congestion at the site

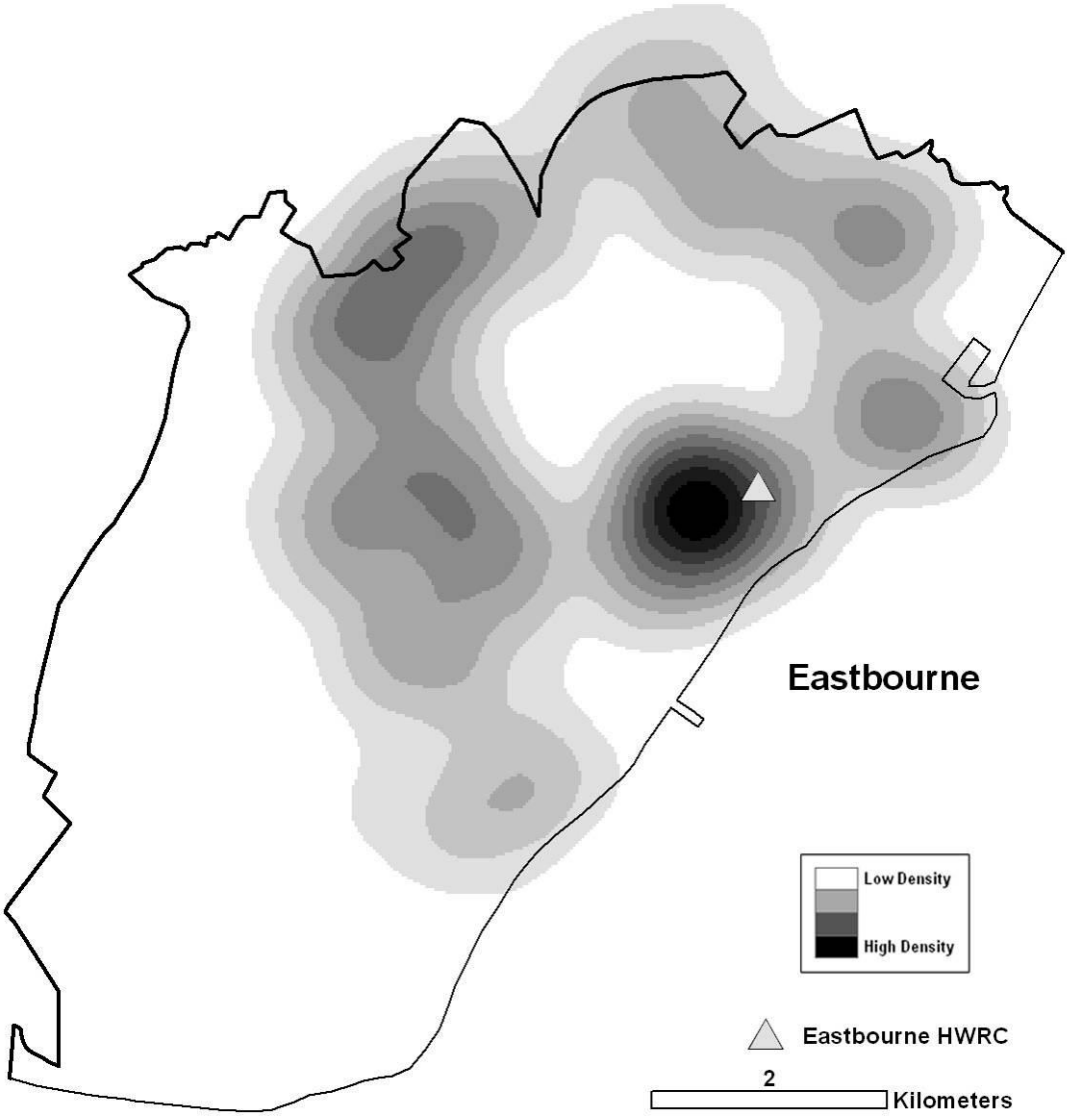

Fig. 5. Map showing density of site users that delivered homogeneous loads of garden waste to the Eastbourne HWRC

Table 1
Calculation of recycling rates for different waste management authorities (DETR, 2001)

Authority	Formulae for recycling rate	Where
Waste Collection Authorities	X/Y x 100	X = Tonnage of household waste collected by the WCA which is sent for recycling (including private/voluntary collections of household waste for recycling) Y = Total tonnage of household waste collected by the WCA (including private/voluntary collections of household waste for recycling)
Waste Disposal Authorities	X/Y x 100	X = Tonnage of household waste collected by the WDA which is sent for recycling plus tonnage of household waste which is sent for recycling by the constituent WCAs (including private/voluntary collections of household waste for recycling) Y = Total tonnage of household waste collected at Civic Amenity sites by the WDA plus total tonnage of household waste collected by constituent WCAs (including private/voluntary collections of household waste for recycling)
Unitary Authorities	X/Y x 100	X = Tonnage of household waste collected by the authority which is sent for recycling (including private/voluntary collections of household waste for recycling) Y = Total tonnage of household waste collected by the authority (including private/voluntary collections of household waste for recycling)

Table 2
Waste inputs to HWRC in East Sussex and Brighton & Hove City 1999/2000 (East Sussex County Council, 2001)

Site location	Site input (tonnes)	Site input rank	Waste to landfill (tonnes)	Recycled (tonnes)	Recycling rate (%)	Recycling rate rank
Hove	21,114	1st	18,092	3,022	17	11th
Pebsham	18,561	2nd	17,364	1,197	7	14th
Brighton	16,488	3rd	13,164	3,324	25	7th
Eastbourne	12,806	4th	10,681	2,125	20	10th
Seaford	6,757	5th	5,236	1,521	29	3rd
Newhaven	6,175	6th	4,979	1,196	24	8th
Hailsham	4,530	7th	4,028	502	12	13th
Mountfield	3,329	8th	2,748	581	21	9th
Lewes	2,964	9th	2,324	641	28	4th
Wadhurst	2,942	10th	2,312	629	27	5th
Heathfield	2,594	11th	1,774	820	46	1st
Crowborough	2,335	12th	2,050	284	14	12th
Forest Row	2,164	13th	1,722	442	26	6th
Uckfield	868	14th	627	241	38	2nd
Totals	103,625	-	87,100	16,525	19	-

Table 3
Number of different material categories delivered by site users

Number of material categories delivered (i.e. paper, bagged waste, garden waste, etc)	Number of sampled site users	% of sampled site users
1	488	50.4
2	270	27.9
3	136	14.0
4	44	4.5
5	19	2.0
6	11	1.1
7	1	0.1
Total	969	100
Recyclable and compostable categories only	Total site users	% of total site users
1	233	24.0
2	45	4.6
3	6	0.6
4	1	0.1
Total	285	29.4

Table 4
The frequency of deposit and homogeneity of materials deposited at the waste pile

Material	No.	% of total loads	No. of homogenous	% of total site loads
Garden waste (foliar)	342	35.3	172	17.8
Bagged waste	330	34.1	129	13.3
Cardboard	147	15.2	3	0.3
Treated timber	92	9.5	12	1.2
Refurbishment waste	87	9.0	27	2.8
Metals	68	7.0	-	-
Garden waste (woody)	66	6.8	38	3.9
Plastic dense	65	6.7	2	0.2
Carpet	63	6.5	11	1.1
Furniture (disposable)	51	5.3	14	1.4
Timber untreated	48	5.0	6	0.6
Hardcore	44	4.5	20	2.1
Furniture (reusable)	34	3.5	12	1.2
Electrical goods	34	3.5	4	0.4
Paper	30	3.1	-	-
Mattresses	29	3.0	10	1.0
MDF	29	3.0	9	0.9
Textiles	26	2.7	2	0.2

Table 5
Observed volumes of waste deposited over sampling period

Total sampled	Volume (m^3)	%
Garden waste (foliar)	138.0	24.5
Bagged waste	119.0	21.1
Cardboard	29.5	5.2
Garden waste (woody)	31.1	5.5
Furniture (disposable)	30.2	5.4
Refurbishment waste	29.8	5.3
Timber treated	23.0	4.1
Furniture (reusable)	21.1	3.7
Carpet	15.9	2.8
Mattresses	16.6	2.9
Timber untreated	14.9	2.6
Hardcore inert	11.8	2.1
Metals	10.5	1.9
MDF	9.8	1.7
Plastic dense	8.2	1.5
Other	54.6	9.7
Totals	563.9	100.0