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The economic and environmental benefits of resource efficiency in construction

Science Report – SC050041/SR2

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- **Delivering information, advice, tools and techniques**, by making appropriate products available to our policy and operations staff.

Steve Killeen

Head of Science

Executive summary

This report provides an assessment of current resource usage within the construction sector at a national and project level. This has been achieved by analysing the overall construction products market and applying wastage allowances to this data. The wastage allowances are used for costing purposes when selecting materials/products and their associated specifications. Headline figures show that every year it is estimated that 10 million tonnes of construction product waste arises as a result of these allowances. This equates to over £1.5 billion of construction products ending up as waste as a result of waste allowances every year. This is equivalent to about 2 per cent of the overall construction sector output. If these wastage allowances were reduced by just 1 per cent, the result would be savings of £15 million and 104 million tonnes of product.

The volume estimated to arise from waste allowances has been analysed using typical recycling and landfill rates, which show that nearly two-thirds of these construction products are thought to be land filled, with a value of around £900 million. Key products which have high landfill rates include paints and finishes, floorcoverings and light fittings. Products such as ceramics, concrete and cement also have high landfill rates as well as high recycling rates. The top 10 products have been analysed in terms of wastage allowances and recycling rates and provide some suggestions on where to focus future policy and actions. This evidence can be used to both influence industry and policy and for prioritising actions on certain materials and products. It is clear that there is enormous potential for the construction sector to become more resource efficient with associated cost savings and environmental benefit. This is especially important in light of the continued growth of the construction sector and major building programmes for schools, hospitals, homes etc.

Resource efficiency has also been analysed at a project level, using typical cost plans and waste allowances and environmental performance indicators to estimate the resultant waste amount. This shows that the true cost of waste (including labour, materials and disposal) can be as much as £43/m^2. In most cases, cost savings can be made by segregating waste onsite. Insulation, plasterboard and treated timber waste has also been analysed.

In order to aid the industry in terms of site waste management and provide an element of continuous improvement, a number of simple scorecards have been developed to assess the performance at a project level. It is recommended that these scorecards are rolled out into industry and also used by the Environment Agency to provide advice and guidance.

A number of barriers have been presented in terms of better site waste management and resource efficiency with possible solutions and actions to reduce them. The recommendations clearly outline a role for each part of the construction supply chain in terms of resource efficiency. One of the most important issues is for the construction sector to work together under a common goal of resource efficiency. In order for this to happen, each part of the sector needs to understand their role in terms of the resources they use that are subsequently wasted and apply appropriate solutions. However, better data is required at a product level for this to be possible. The Environment Agency can play an important role with the sector to ensure legal compliance and promote continuous improvement in terms of site waste management and resource efficiency, in conjunction with forthcoming legislation such as the introduction of Site Waste Management Plans, which will provide more focus for the sector.

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1. Introduction

BRE (Building Research Establishment) has been contracted by the Environment Agency to provide an assessment of current resource usage on construction sites and to define the cost and benefits of site waste management activities. This assessment has produced a simple tool which can be used by the Environment Agency and others to score a site's performance in terms of waste management, and an analysis of current resource use in the construction sector. This can then provide some key headline figures and evidence as to where to focus future policy and actions.

This document represents the final report for the project covering the period of January to July 2007. This report presents the results and discusses the findings with recommendations where appropriate. The objectives of the project were as follows:

- Carry out a review of existing resource usage in the construction sector in order to identify cost savings and target areas for improvement;
- Provide evidence to maximise the environmental benefits of Site Waste Management Plans;
- Model and evaluate the economic costs and benefits of three levels of practice: compliance, good and best practice;
- Ensure findings are taken up with key stakeholders and implications for the Environment Agency are understood; this will include an analysis of potential regulatory barriers;
- Produce a final report that clearly demonstrates the economic and environmental costs and benefits of the three types of site waste management practices with solutions highlights and any further policy implications and future work.

The construction sector is hugely resource intensive; with an estimated 400 million tonnes of resources used each year it is the single biggest user in the economy, accounting for 9-10 per cent of GDP (DEFRA 2007b). In addition, the sector also produces the largest proportion of waste in England (one third) and 32 per cent of hazardous waste (DEFRA 2007a). Survey data exists for the amount of inert waste arising from construction, demolition and excavation (CD&E) activities, which is estimated at 90 million tonnes, with 30 per cent going to landfill; this is shown in more detail in Table 1.

Little data exists on the non-inert fraction of CD&E waste and in terms of tonnage it represents a smaller proportion, with WRAP (Waste & Resources Action Programme) estimating that there is 15-20 million tonnes (DEFRA 2007b). Data from the BRE shows that by volume, nearly 60 per cent of waste from all new build projects is non-aggregate waste (BRE 2006). This non-inert waste will typically be more difficult to sort and recycle and have a larger environmental impact compared to inert waste in terms of its embodied energy and final disposal.

Table 1: Summary of inert CD&E waste for England (DCLG 2005)

Classification	Million tonnes
Production of recycled aggregate	42
Production of recycled soil (excluding topsoil)	4
Unprocessed CD&E waste entering licensed landfill – for engineering use	4
Unprocessed CD&E waste entering licensed landfill – for capping use	5
Unprocessed CD&E waste entering licensed landfill – for waste disposal	18
Waste materials (mainly excavation waste) used on registered exempt sites	15
TOTAL	**90**

Managing resources and waste from construction processes and projects more efficiently is becoming increasingly important for a number of reasons, including:

Legislation: compliance with existing legislation such as Duty of Care, Hazardous Waste Regulations (Environment Agency 2007)[1] and preparation with future legislation.

Fiscal: landfill tax is increasing by £8 per tonne from April 2008 for non-inert wastes, and £0.50 per tonne for inert waste (it's currently £24 per tonne for non-inert waste and £2 per tonne for inert waste). Landfill Tax has to be paid on waste being disposed to landfill. Aggregates Levy is to increase from £1.60 per tonne to £1.95 per tonne for primary aggregates from April 2008.

Policy: increasing policy at a National and Regional level such as the English Waste Strategy, planning policy and regional strategies.

Corporate Social Responsibility: more companies are seeing the benefits of engaging with the corporate and social responsibility agenda and reporting on their activities in the public arena. Banks and financiers are increasingly rating environmental and social impacts as an important consideration.

Health and Safety: a tidier, cleaner site generally means a safer and healthier site for workers. Good site procedures go hand in hand with good waste management on-site. The Health and Safety Executive (HSE) has found that 50 per cent of construction-site accidents are related to messy and poorly organised sites (HSE 2006).

Procurement: clients have higher expectations in terms of sustainability and waste which are being reflected by procurement practices and the specification of standards such as BREEAM (BRE Environmental Assessment Method) (BRE 2007b) and the setting of waste targets.

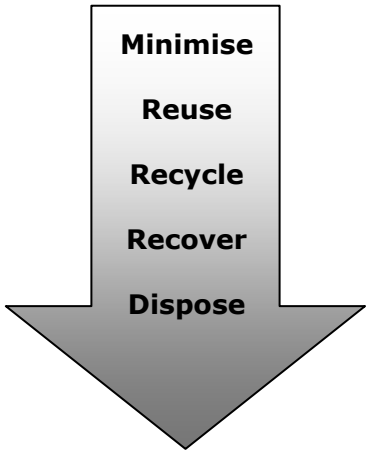
Competitiveness: many companies are benefiting from a better market position by continuously improving their sustainability credentials in response to higher client expectations.

[1] For more information on environmental legislation go to the NetRegs website; www.netregs.gov.uk

In terms of construction projects, resource efficiency and waste can be attributed to, and therefore managed appropriately at, each stage of the process i.e. design, procurement, on-site, operation, refurbishment and demolition. Ideally waste should be managed according to the waste hierarchy: reduce, reuse, recycle, recover and finally dispose, as shown by Figure 1. The Government has recently produced a Waste Strategy for England (DEFRA 2007b) and the objectives in relation to CD&E waste are:

- To provide the drivers for the construction sector to improve its economic efficiency by **creating less waste** at every stage of the supply chain, from design to demolition;
- To get the sector to treat waste as a resource, **closing the loop** by re-using and recycling more and asking contractors for greater use of recovered material;
- To **improve the economics** of the re-use and recycling sector by increasing sector demand and securing investment in the treatment of waste – this will benefit all waste streams, including construction.

Figure 1: Waste Hierarchy



A number of practical actions are summarised below in terms of managing construction waste:

Reduction: design out waste by using standard sizes, order appropriate amounts of materials and reduce wastage rates, ensure the good storage and movement of materials around site.

Reuse: reuse suitable offcuts onsite, send back excess materials, salvage materials from demolition for reuse e.g. bricks, tiles etc.

Recycle: segregate waste onsite where possible and reprocess on or offsite e.g. inert, timber, metals, plasterboard; send to a waste transfer station with a high recovery rate; procure materials with a higher recycled content.

A key mechanism for managing waste effectively are Site Waste Management Plans (SWMPs) which have been developed as a Department of Trade and Industry (DTI) (now the Department for Business, Enterprise and Regulatory Reform (BERR)) Voluntary Code of Practice (DTI 2004) and are likely to become mandatory in England from April 2008 for certain projects after a recent (Department for Environment, Food & Rural Affairs (DEFRA) consultation (DEFRA 2007a). SWMPs have been developed to help guide the project team, to ensure that waste is managed in an easily understood

manner using checklists and datasheets. This includes estimating the likely wastes that will be produced throughout a construction project and managing this waste effectively. The waste hierarchy should be followed within the SWMP and all parts of the project team should be aware of the SWMP and the importance of resource efficiency. This includes (but is not limited to) the planner, client, contractor, supplier, architect, specifier and sub-contractors (e.g. logistics gangs, foreman and operatives).

By managing waste more efficiently and effectively onsite, cost savings can be made from reduced material usage, segregation, haulage and disposal costs, management time, trades time and rework. Examples include:

- Comely Green Place, Edinburgh – saved £400,000 across 95 flats; £4,000 per flat was saved.
- Greenwich Millennium Village – 50 per cent waste reduction saving £150,000 on 300 new homes i.e. £500 saved per home (compared to anticipated cost of £1,000 per home) suggesting waste costs of around 1 to 1.5 per cent of the project value.
- Langley Park - £600 saved per housing unit (this was largely from the demolition phase which generally already has a well developed capacity to segregate, recycle and reuse waste)
- Pegasus Court - saving of £700 per housing unit, with an estimated cost saving of 50 per cent for material waste for 42 houses and 27 flats

Effective waste management can also help the performance of a site in terms of health and safety, productivity, a reduction in environmental impact and encourages the better use of resources. Additionally, strong partnerships and frameworks can be made onsite through the effective delivery of waste management through training (e.g. toolbox talks, workshops), suggestion and improvement schemes and having a champion onsite. It is therefore essential that the industry be given the appropriate tools and guidance to implement effective waste management onsite, as well as using resources more efficiently across the sector as a whole..

A number of tasks have been undertaken in order to deliver the project's objectives; these are as follows:

- Task 1: Review of existing resource usage.
- Task 2: Consultation with stakeholders.
- Task 3: Model and evaluation.
- Task 4: Analysis of barriers.
- Task 5: Interim report.
- Task 6: Workshop for Environment Agency staff.
- Task 7: Workshop for key stakeholders.
- Task 8: Final report.

The tasks are presented in turn with the associated methodology and results.

2. Review of existing resource usage

There are various data sources available within the construction and waste industries to determine the levels of resource usage; this is either at a sectoral level or a project/company level. This data has been reviewed for its applicability and availability. Many of these datasets are owned by BRE, as shown in Table 2.

Table 2: Data on existing resource usage within the construction industry

Data source	Type	Applicability	Availability
SMARTStart	Data on amount of waste arising (volumes) from different construction projects.	High – use in calculating performance indicators for waste types for project type.	BRE data – approximately 100 datasets available. This is based on companies' information.
SMARTAudit	Data on amount of waste arising (volume), type and cause, wastage rates etc.	Medium – useful if we need detailed waste analysis.	BRE data – small dataset available for selected projects.
Pre-demolition audits	Data on the amount, type and management routes for products/materials from demolition.	Medium – data is very dependant on the type of building.	BRE data – available for 20 audits.
Green Guide to Specification (1)	Wastage rates for products and components.	High – this data has been validated through industry consultation.	BRE data – currently available.
Green Guide to Specification (2)	Typical recycling and landfill routes for products and components.	High – this data has been validated through industry consultation.	BRE data – currently available.
Benchmarking data	Data being submitted by companies on waste type (European Waste Catalogue), cost and management routes.	Low – not enough data to provide accurate figures.	Ongoing – at early stages of data collection. DEFRA owned data, collected by BRE.
Survey (x2) on SWMPs	Survey data.	Medium – mainly subjective; some information on costs used for the partial Regulatory Impact Assessment on the Code for Sustainable Homes.	BRE data – restricted availability.

Data source	Type	Applicability	Availability
Case studies	Case studies showing savings in terms of segregation and waste minimisation.	Medium – can be a wide range in costs/benefits.	BRE and other data – widely available.
Market Transformation Programme	Data established for use of certain products: plasterboard, flooring, insulation, MMC, roofing and windows.	Medium – may be too market orientated.	Market Transformation Programme.
WRAP	Various reports of onsite waste management (WRAP 2007a).	Low – no specific data related to resource usage.	Available.
Communities and Local Government	Survey on the arisings of inert waste (DCLG 2005).	Low – is not linked to construction projects.	Available.
Viridis	Mass Balance of the Construction Industry (Smith *et al* 2002).	Low – is not linked to construction projects.	Available.

As a result of this review; it was agreed with the Environment Agency that the following datasets would be used:

- Construction products market data;
- BRE's Green Guide to Specification – wastage rates;
- BRE's Green Guide to Specification – recycling and landfill rates;
- Surveys on SWMPs;
- Benchmarks from BRE's SMARTStart system.

The construction products market data is a detailed dataset based on a survey of existing data sources carried out by AMA Research for BRE, covering the amounts and types of construction products sold in the UK; data relates mainly to 2004[2]. This data is based on the amount (tonnes) and/or price based; there is no suitable data for a number of products and product sectors. Table 3 shows the availability of this data for the product groups. A breakdown of products in each product group can be seen in Appendix 1.

This market data has then been combined with industry agreed wastage rates as a result of the updating of BRE's Green Guide to Specification (BRE 2007c). These wastage rates have been defined through cost books such as Laxtons (Johnson 2005) and Spons (Langdon 2006); whereby a percentage allowance for waste for each material is built in for the purpose of costing products/materials in a construction project. These costing books are frequently used by the industry to price up projects using standard costs for materials and labour. For example, hollow lightweight blocks have a 5 per cent allowance for waste, which includes wastage from cut blocks, over-ordering, breakages, theft etc. It is important to note that these waste allowances are

[2] Research carried out for BRE by AMA Research in 2007 for the BREW funded project 'Strategic Approach to Construction Waste'

assumptions which need verification in the field; they have however been consulted on with industry and where available verifiable industry data has been used.

Table 3: Availability of market data for construction product groups

Product Group	Tonnage data	Value data
Ceramic Products	✓	✓
Chemicals	×	✓
Clay	✓	✓
Concrete Products	✓	✓
Electrical Lighting Products	×	✓
Glass	×	✓
Hardware Metal Products	×	✓
Heating Products	×	✓
Insulation	✓	✓
Other Cement	✓	✓
Plastic Products	✓	✓
Plumbing, Bath and Sanitaryware Fittings	×	✓
Raw Materials	✓	✓
Rubber Products	✓	✓
Security Fire Protection Systems	×	×
Slate Products	✓	✓
Steel Products	✓	✓
Timber Products	✓	✓

The estimated waste allowances for products have also been compared with 'typical' management routes for these products/materials i.e. the percentage re-used, recycled, used in energy recovery and finally disposed of. Again these figures have been consulted on with industry as part of the updates to the BRE's Green Guide to Specification and are based on public or industry data where available.

By carrying out this exercise, findings can be made in terms of the overall market and the amounts allowed for wastage, the key product wastage allowances and their recovery routes. There are a number of assumptions that have been made with regard to the findings:

- They are based on limited market data; therefore the results only apply to products where data is available; some data is not suitable for use.
- The wastage allowances used are solely for costing purposes; they may or may not represent actual practice.
- The waste management routes for the construction products are based on either industry data or an informed judgement.
- All data presented is based on an annual basis; market data is from 2004 and wastage allowances and waste management data is from 2006.

The waste allowances for the overall market for construction products per year is shown in Figure 2 and Table 4, with concrete and ceramic products representing the largest proportion at 50 per cent (5 million tonnes) and 31 per cent (3 million tonnes). In total, 10 million tonnes of products are factored in for waste allowances.

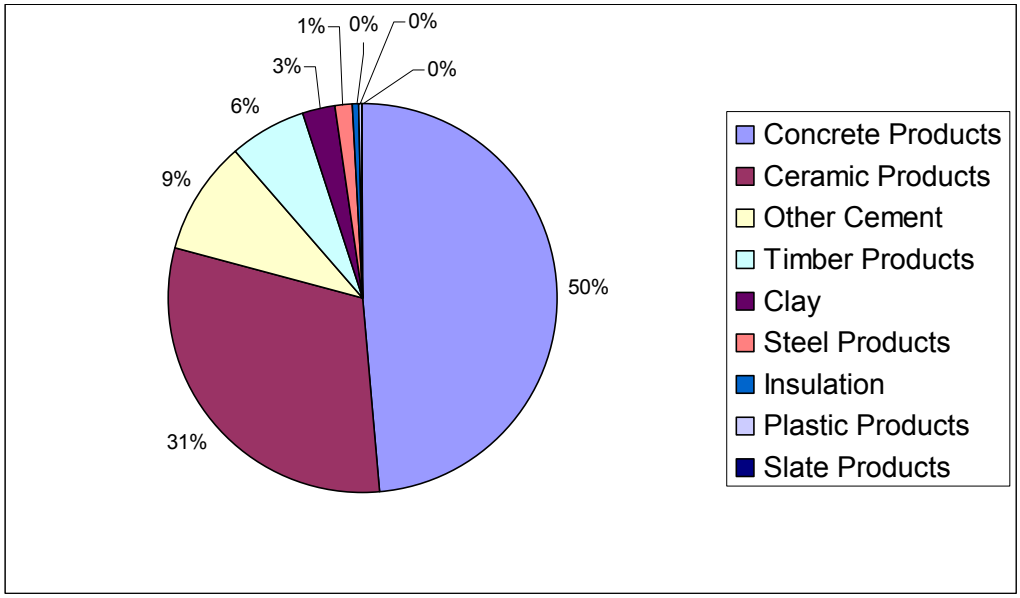
Table 4: Overall wastage allowances for construction products by amount and value

Group	Waste amount (K Tonnes)	Waste value (£ m)
Ceramic Products	3,188	32
Chemicals	Data gap	117
Clay	288	32
Concrete Products	5,066	261
Electrical Lighting Products	Data gap	164
Glass	Data gap	248
Hardware Metal Products	Data gap	27
Heating Products	Data gap	46
Insulation	45	48
Other Cement	989	91
Plastic Products	28	68
Plumbing, Bath and Sanitaryware Fittings	Data gap	27
Raw Materials	Not suitable data	218
Rubber Products	Not suitable data	192
Security Fire Protection Systems	Data gap	Data gap
Slate Products	8	Not suitable data
Steel Products	156	Not suitable data
Timber Products	651	Not suitable data
TOTAL	**10,419**	**1,571**

Data gap - raw market data is not available for the construction data

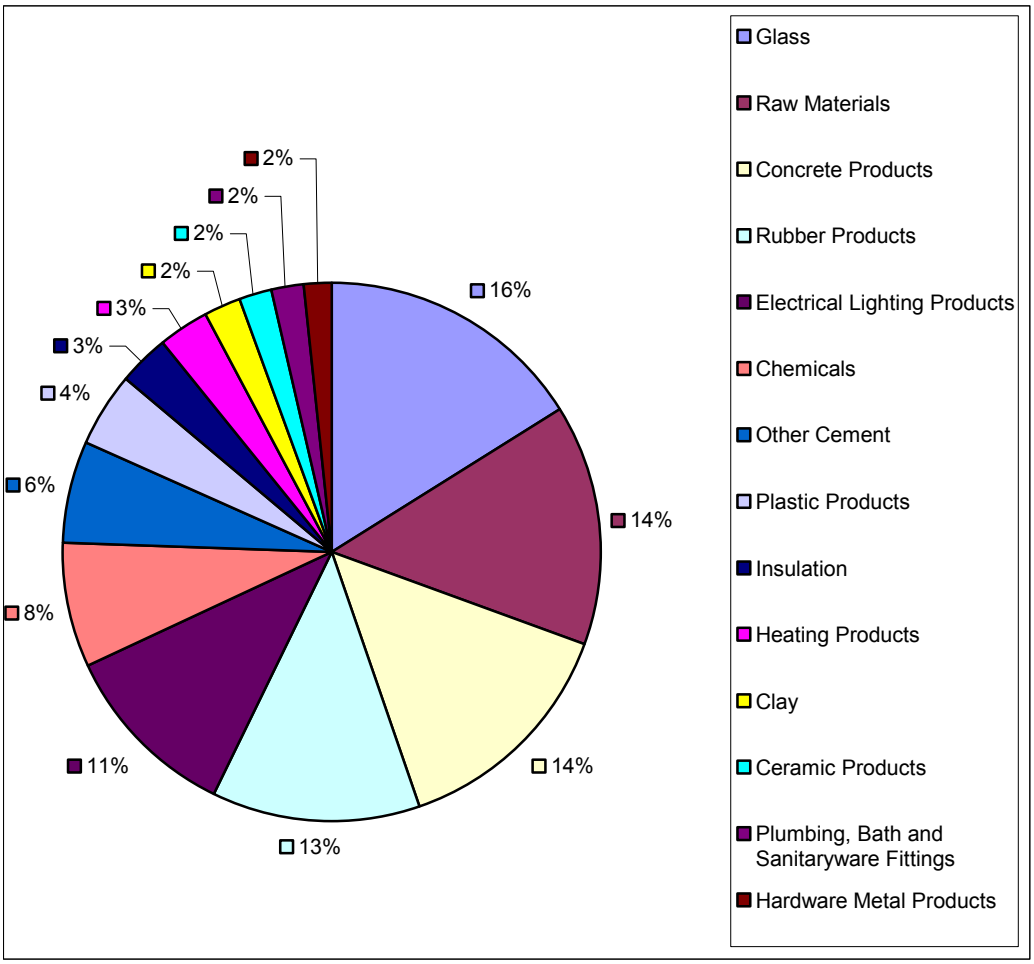
Not suitable data – data cannot be used to define wastage allowances or waste management routes

Figure 2: Proportion of wastage allowances for construction products by amount



More data is available for the amount of products factored in for waste allowances by value (as shown by Figure 3 and Table 4) as there is more value-based market data available. Glass is the highest at 16 per cent, followed by raw materials (primary and secondary aggregates) and concrete products at 14 per cent each; closely followed by rubber products and electrical lighting products. Over £1.5 billion is costed in for 'wasted' products i.e. waste allowances. Suitable data is not available for security fire protection systems, slate products, steel products and timber products.

Figure 3: Overall wastage allowances for construction products by value



The waste allowances have been compared to the amount that is recycled and landfilled by tonnage and value, as shown by Tables 5 and 6. Over 6 million tonnes of wastage allowance products (61 per cent) are estimated to be land filled, with the remaining 3.9 million tonnes being recycled. Concrete and ceramic products, at 42 per cent and 36 per cent, show the highest proportion of land filled waste, as shown by Figure 4. Concrete, however, has an estimated recycling rate of 50 per cent - the highest proportion recycled by far. Ceramics has recycling rate of 30 per cent. Products with the lowest recycling rates include other cement products (e.g. plasterboard, mortars) and plastic products (e.g. plastic profiles, decking and fencing), both at 10 per cent.

Table 5: Estimated recycling and landfill rates by amount for product groups

Product Group	Recycled (K tonnes)	Landfill (K Tonnes)	Total (k tonnes)	% Recycling rate per product	%Recycling rate (overall)
Ceramic Products	956.25	2231.25	3187.5	30	9.4
Chemicals	n/a	n/a	n/a	n/a	n/a
Clay	86.28	201.32	287.6	30	0.9
Concrete Products	2,533.36	2,533	5066.36	50	25.0
Electrical Lighting Products	n/a	n/a	n/a	n/a	n/a
Glass	n/a	n/a	n/a	n/a	n/a
Hardware Metal Products	n/a	n/a	n/a	n/a	n/a
Heating Products	n/a	n/a	n/a	n/a	n/a
Insulation	9.89	40.57	50.46	20	0.1
Other Cement	98.78	890.22	989	10	1.0
Plastic Products	2.52	23	25.52	10	0.0
Plumbing, Bath and Sanitaryware Fittings	n/a	n/a	n/a	n/a	n/a
Raw Materials	n/a	n/a	n/a	n/a	n/a
Rubber Products	n/a	n/a	n/a	n/a	n/a
Security Fire Protection Systems	n/a	n/a	n/a	n/a	n/a
Slate Products	3.91	3.91	7.82	50	0.0
Steel Products	132.6	23.4	156	85	1.3
Timber Products	202.56	258.83	461.39	44	2.0
Total	**3927.37**	**6,206**	**10132.87**		

Figure 4: Proportion of product groups that are estimated to be land filled

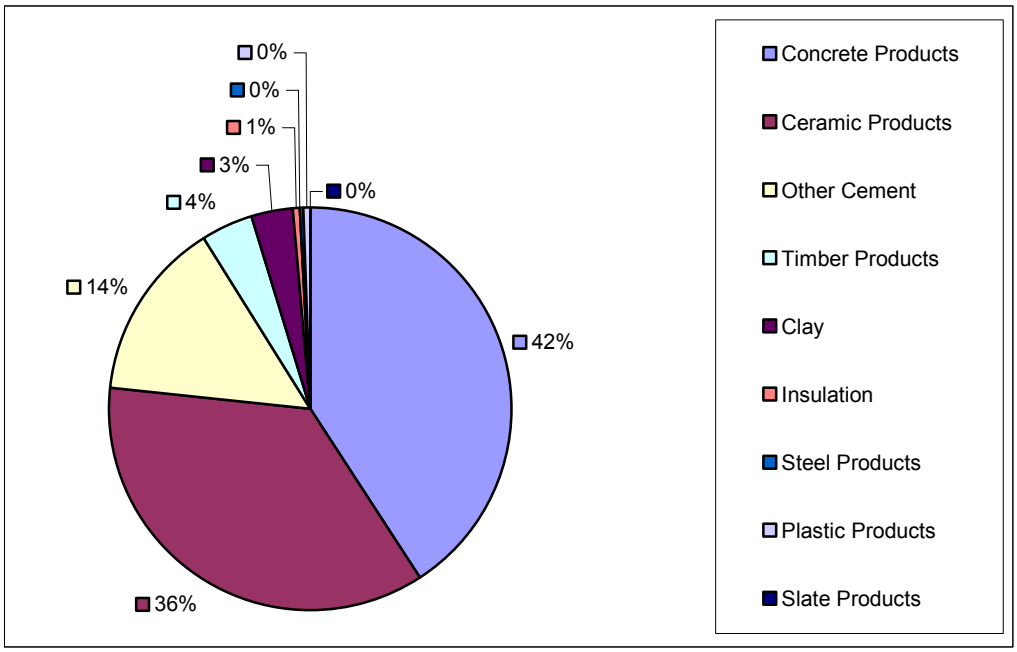


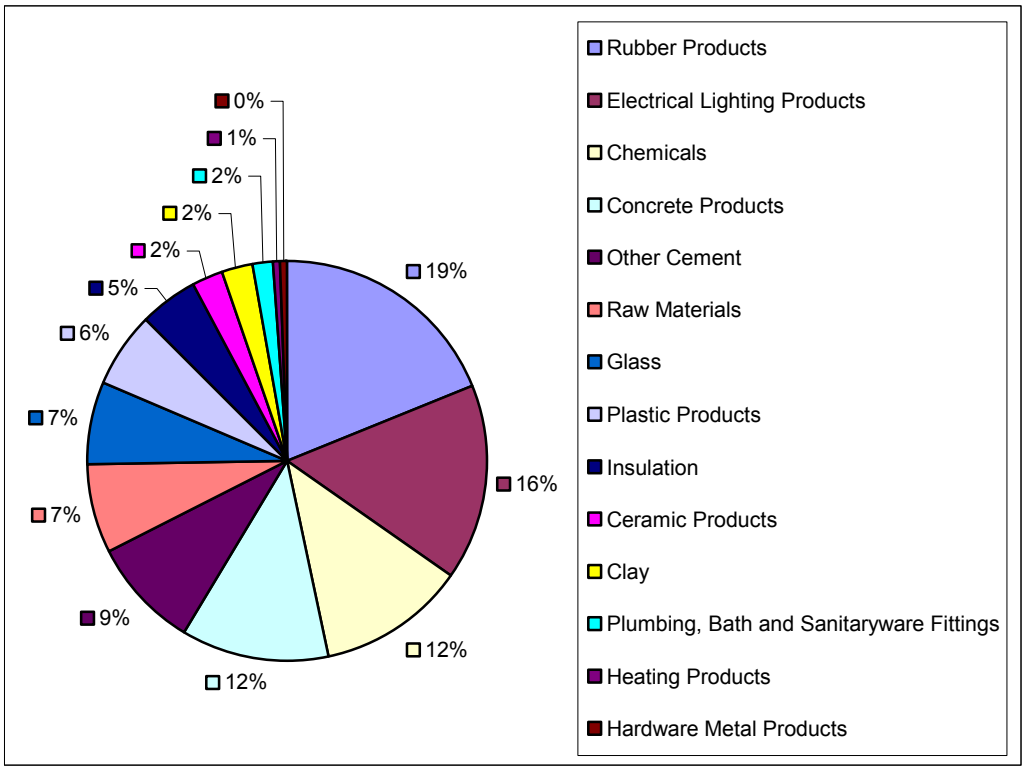
Table 6 and Figure 5 show the estimated recycling and landfill rates by value for the 'wasted' product groups. The total amount of products from wastage allowances that is land filled is equivalent to £904 million; 59 per cent of the total value of waste

allowances; the remainder (£624 million) is recycled. Rubber products (e.g. roof tiles, floor coverings), electrical lighting products, chemicals (e.g. paints and finishes) and concrete products represent the highest values in terms of land filled products. Products being recycled the most (again, going by value of product) are glass and raw materials. Product groups with a high recycling rate per product include hardware metal products, heating products and plumbing, bath and sanitary fittings.

Table 6: Estimated recycling and landfill rates by value for product groups

Product group	Recycled/ recovered (£m)	Landfill (£m)	Total (£m)	% Recycling rate per product	%Recycling rate (overall)
Ceramic Products	9.59	22.37	31.96	30	0.6
Chemicals	5.84	110.87	116.71	5	0.4
Clay	9.55	22.28	31.83	30	0.6
Concrete Products	108	108	216	50	7.1
Electrical Lighting Products	21	144	165	13	1.4
Glass	185.74	61.91	247.65	75	12.2
Hardware Metal Products	23.25	4.1	27.35	85	1.5
Heating Products	39.49	6.97	46.46	85	2.6
Insulation	5	43	48	10	0.3
Other Cement	10.12	81.23	91.35	11	0.7
Plastic Products	12.23	55.72	67.95	18	0.8
Plumbing, Bath and Sanitaryware Fittings	22.03	5.42	27.45	80	1.4
Raw Materials	152.88	65.52	218.4	70	10.0
Rubber Products	19.01	172.49	191.5	10	1.2
Security Fire Protection Systems	n/a	n/a	n/a	n/a	n/a
Slate Products	n/a	n/a	n/a	n/a	n/a
Steel Products	n/a	n/a	n/a	n/a	n/a
Timber Products	n/a	n/a	n/a	n/a	n/a
TOTAL	**623.73**	**903.88**	**1527.61**		

Figure 5: Value of construction products estimated to be landfilled



Actual products have been analysed to determine the top 10 products wasted by wastage allowance for value and amount. Table 7 shows the waste allowances for products by amount, with ceramic tiles and flagstones the largest, followed by ready mixed concrete and other precast products. The top 10 products represent 96% of the overall amount, suggesting that attention should be focused on these particular products.

Table 7: Top 10 products from wastage allowances by amount

Wastage allowance by product	Amount (K tonnes)	% of total
Ceramic Tiles and Flagstones (Glazed and Unglazed)	3,188	31
Ready Mixed Concrete	2,346	23
Other Precast Concrete Products	2,132	20
Cement	665	6
Concrete Blocks	589	6
Non Refractory Clay Building Blocks	271	3
Wood Flooring	241.8	2
Wood chips, sawdust, shavings, peelings etc	168.6	2
Mortars - Factory Made	167	2
Plasterboard	156	1
Total	**9,924.4**	**96**
Overall waste amount	**10,418**	

Table 8 shows the top 10 waste allowances for products by value; with primary aggregates being the highest, followed by commercial glazing, precast concrete products, paints and finishes, floor coverings and glass – replacement doors and windows. When comparing the datasets, precast concrete products is the only product group in both datasets, i.e. value and amount. These top 10 products represent 63 per cent of the total amount by value.

Table 8: Top 10 products from wastage allowances by value

Waste allowance by product	Value (£m)	% of total
Primary Aggregates	167.2	11
Commercial Glazing	113	7
Other Precast Concrete Products	112	7
Paints, finishes	110	7
Floorcoverings	105.1	7
Glass: Replacement Doors & Windows	102	7
Ready Mixed Concrete	74	5
Light fittings (Luminaires)	74	5
Cables - mostly copper with plastic based sheathing.	64	4
Pipes and Ducting	51.95	3
Total	**973.25**	**63**
Overall waste value	**1,526**	

In terms of the top 10 products that are estimated to be landfilled, this is shown by volume in Table 9, with ceramic tiles and flagstones the highest, followed by ready mixed concrete and other precast concrete products. The top 10 represent 97 per cent of the overall amount thought to be landfilled.

Table 9: Top 10 products estimated to be landfilled by amount

Product	Land filled by amount (K Tonnes)	% of total
Ceramic Tiles and Flags (Glazed and Unglazed)	2231.25	36
Ready Mixed Concrete	1172.96	19
Other Precast Concrete Products	1066.13	17
Cement	598.50	10
Concrete Blocks	294.28	5
Non Refractory Clay Building Blocks	189.49	3
Mortars - Factory Made	149.91	2
Plasterboard	140.22	2
Wood Flooring	111.23	2
Timber by products: Wood chips, sawdust, shavings, peelings etc	77.56	1
Total	**6031.53**	**97**
Total amount landfilled	**6206.00**	

Table 10 shows the top 10 products estimated to be landfilled by value, with paints and finishes being the highest, followed by floor coverings and light fittings. These top 10 products account for 64 per cent of the total value estimated to be landfilled. When comparing the landfill lists by value and tonnage, common products are precast concrete products.

When comparing the top 10 products by wastage allowance and landfill rates focusing on amount rather than value, there are many products in common. Ceramic tiles and flagstones appear in both categories, as does ready mixed concrete, other precast products, cement, concrete blocks, non-refractory clay building blocks, mortars (factory made), plasterboard and wood flooring.. Comparing by value, there is also some commonality, with 8 of the 10 products appearing on both lists.

Table 10: Top 10 products estimated to be landfilled by value

Product	Land filled by £m	% by total
Paints, Finishes	104.50	12
Floorcoverings Market	94.59	10
Light fittings (Luminaires)	65.08	7
Cables - mostly copper with plastic based sheathing.	56.10	6
Other Precast Concrete Products	55.95	6
Primary Aggregates	50.16	6
Pipes and Ducting	42.60	5
Insulation	39.35	4
Cement	37.98	4
Ready Mixed Concrete	37.24	4
Total	**583.55**	**64**
Total value landfilled	**903.88**	

Table 11 shows the top 10 products that are estimated to be recycled by amount, with ready-mixed concrete being the highest, followed by precast products and ceramic tiles and flagstones. These top 10 products represent 98 per cent of the total amount of products estimated to be recycled.

In terms of the top 10 products estimated to be recycled by value, the highest is primary aggregates, followed by commercial glazing, replacement windows and doors and secondary materials as shown by Table 12. These top 10 products represent 62 per cent of the overall value of products being recycled. When comparing the top 10 lists for recycling by amount and value, the only common product group is ceramic tiles and flagstones.

There is commonality between those products that are in the top 10 for wastage allowances and recycling by amount, with 7 product types being in both these two lists. In terms of value there is much less commonality, with only primary aggregates, commercial glazing and glass (replacement doors and windows) in both lists.

Table 11: Top 10 products estimated to be recycled by amount

Product	Recycled by amount (K tonnes)	% by total
Ready Mixed Concrete	1172.96	30
Other Precast Products	1066.13	27
Ceramic Tiles and Flagstones (Glazed and Unglazed)	956.25	24
Concrete Blocks	294.28	7
Wood Flooring	87.05	2
Non Refractory Clay Building Blocks	81.21	2
Prefabricated Structural Comps	63.70	2
Wood chips, sawdust, shavings, peelings etc	60.70	2
Heavy sections and beams >80mm	52.32	1
Board and Sheet Timber Products	35.68	1
Total	**3870.28**	**98**
Total recycled by amount	**3927.37**	

Table 12: Top 10 products estimated to be recycled by value

Product	Recycled by value (£m)	% by total
Primary Aggregates	117.04	19
Commercial Glazing	84.79	14
Glass: Replacement Doors & Windows	76.58	12
Secondary aggregates	31.08	5
Housebuilding Doors &Windows	24.38	4
Door/window fittings	12.13	2
Pumps	11.73	2
Ceramic Tiles and Flagstones (Glazed and Unglazed)	9.59	2
Air conditioning units	9.32	1
Boilers	8.19	1
Total	**384.83**	**62**
Total amount recycled by value	**623.73**	

3. Consultation with stakeholders

A key requirement during this project was to gain buy-in from key stakeholders including policymakers and the industry. Three groups of stakeholders were identified:

- Industry contacts representing each part of the supply chain;
- Policymakers/key stakeholders e.g. DEFRA, DTI, Envirowise, WRAP;
- A larger group of contacts representing the construction industry.

In terms of consultation, a questionnaire was prepared covering issues related to site waste management which was then completed through telephone interviews with industry contacts; 20 contacts were telephoned and 15 responses were obtained. In addition, the questionnaire was emailed to a larger group of contacts (50) with responses obtained from 5 organisations. The poor response may be due to the fact that email is not the necessarily the best mechanism for engagement. Policymakers and key stakeholders were contacted on an informal basis. The questionnaire was carried out in April 2007 and a copy can be found in Appendix 2. The results are summarised below and are considered in further detail in the analysis of barriers and discussion sections of this report.

Respondents found the cost of better site waste management difficult to estimate, with the cost of implementation onsite proving particularly hard to assess. Estimates were that the cost of site waste management was less than 1 per cent of project cost, though it was suggested that it may be more complex for a housing project than a civil engineering project (we spoke to a mix of contractors working on housing, non-domestic and civil construction projects).

Some respondents gave specific costs, though not always the associated project value. One suggestion was that their SWMP had cost £2,000 on a £700,000 project (less than 0.3 per cent of contract value). A £0.5 million project had costs of £500 to write and 1 day or £350pcm (say a 9 month project) to implement (which gives a cost of around 0.7 per cent of project value). On larger projects the cost as a proportion of project value drops rapidly, for example costs of £7,000 were reported on a £330 million hospital (0.002 per cent), and set up costs of £20,000 on a £4.2 billion project with 2 full time staff for the duration of the project (say £50,000 per person for 6 years) equates to just 0.01 per cent.. While some respondents quoted implementation costs, many said that these were absorbed into the project and so could not be evaluated.

Several respondents reported that it was becoming easier to implement better site waste management as they became more experienced. There is a trend for the cost of waste management as a proportion of the project budget to decrease as project size increases..

Benefits identified from using SWMPs included cost reduction by recovering more waste, earlier identification of waste types and amounts, increased awareness, company differentiation and better control of waste.

A workshop was also held with the Environment Agency on the 13th April 2007, with 5 attendees. The purpose of this was to present the progress of the project so far and discuss what should be included, what the likely outputs should be and what needed to be included in the final report. Feedback from the Environment Agency on the project outputs included evidence to influence policy, key stakeholders and the Environment Agency's own construction activities, production of a toolkit for industry and aid to public procurement through planning and advice. Key findings should include the top

5/10 wasted materials in terms of environmental impact and cost, and recommendations should be made on how to influence the various parts of the supply chain such as the client, quantity surveyor, regulators, policymakers, contractors, waste management companies etc.

It was recommended that the final report and associated model should, where appropriate, include legal compliance, the effect of the Landfill Tax escalator, and be suitable for various projects including: civil/infrastructure, demolition/refurbishment and a smaller projects. Cost of waste management offsite should also be presented.

A further workshop was undertaken for key stakeholders in order to present the project and obtain relevant feedback, discuss implications for industry and policymakers and the next steps to be taken. The workshop was held at BRE on the 23rd April 2007 with 20 delegates attending, mostly representing industry. Four areas were covered and delegates were asked if they agreed with our approach and to indicate how useful they felt each feature was, and what else they thought could be included. These areas were:

- Standard, good and best practice definitions;
- The scorecard;
- Evaluation of cost at a project level;
- Barriers.

Feedback has been incorporated within the project's output where appropriate. Delegates were largely positive about the project outputs. The feedback can be seen in Appendix 3.

4. Model and evaluation

In terms of developing a model and evaluating the cost and environmental impact of different levels of site waste management, a number of approaches have been developed. This has included defining the level of standard, good and best practices and their associated costs. These definitions are based on the definitions that have recently been used for the WRAP series of Advanced SWMP workshops (WRAP 2007a).

These definitions have been aligned to reflect differences between demolition, refurbishment and new build projects and also show costs applicable at each stage. The 'generic' definitions are shown on Table 13.

Table 13: Definitions for standard, good and best practice and associated costs

SWMP level	Standard	Good	Best
Legal compliance			
	Duty of care documentation	Duty of care documentation	Duty of care documentation
	SWMP	SWMP	SWMP
Waste minimisation / avoidance			
	None	None or little	Considered at design stage
			Contractual agreements
			Internal incentives
Reuse			
	Inert	Inert	Inert
	Soils	Soils	Soils
		Concrete (either on-site or off-site)	Concrete (either on-site or off-site)
			Wood based wastes (off-site)
			Metal wastes (off-site)
			Others?
Recycling			
	Metal wastes	Metal wastes	Metal wastes
		Wood based wastes	Wood based wastes
		Key waste products (e.g. plasterboard) via recycle factors / firms	Key waste products (e.g. plasterboard) via recycle factors / firms
			Others?
Site segregation			
	Hazardous	Hazardous	Hazardous
	Non-hazardous (mixed)	Metal	Metal
		Wood based	Wood based
		Packaging	Packaging
		Gypsum	Gypsum
		Inert	Inert
			Others?
Costs			

SWMP level	Standard	Good	Best
	Skip removal and tip cost (inc Landfill Tax): mixed wastes, hazardous waste, any segregation of materials	Skip removal and tip cost (inc Landfill Tax): mixed wastes, hazardous waste, any segregation of materials	Skip removal and tip cost (inc Landfill Tax): mixed wastes, hazardous waste, any segregation of materials
	Generic cost of materials within the skip	Generic cost of materials within the skip	Generic cost of materials within the skip
	Generic cost of labour to fill the skip	Generic cost of labour to fill the skip	Generic cost of labour to fill the skip
	Reuse of inerts / civils on-site versus off-site – savings in primary aggregates (inc Aggregate Levy and disposal costs)	Reuse of inerts / civils on-site versus off-site – savings in primary aggregates (inc Aggregate Levy and disposal costs)	Reuse of inerts / civils on-site versus off-site – savings in primary aggregates (inc Aggregate Levy and disposal costs)
	May include exemptions / licensing	May include exemptions / licensing	May include exemptions / licensing
	Implementation of SWMP (labour)	Implementation of SWMP (labour)	Implementation of SWMP (labour)
		Consider cost of segregation (i.e. number of skips) versus number required if mixed waste	Consider cost of segregation (i.e. number of skips) versus number required if mixed waste
		Cost of implementation of higher level SWMP (e.g. labour cost)	Cost of implementation of higher level SWMP (e.g. labour cost)
		Cost of takeback schemes e.g. plasterboard	Cost of takeback schemes e.g. plasterboard
			Modern Methods of Construction / standardisation
			Just in time / consolidation centres
			Waste champion
			Waste minimisation

These definitions have then been used to form the basis of a scorecard, which benchmarks performance for onsite waste management. These scorecards were

consulted on with industry and different versions have been developed for new build, refurbishment and demolition projects. They do not cover cost or environmental impact. The scorecards show progress for onsite waste management, giving the user a score for each category and then overall. The scorecard shows where the user has scope to improve their score in each category and overall, encouraging continuous improvement. A simple scoring system is used to differentiate between standard, good and best practice, with standard receiving 1 point, good receiving 2 points and best receiving 3 points. Weightings are applied to a number of categories whereby more importance is given to these issues from a waste management perspective i.e. waste avoidance, reuse on- and off-site, site set up and segregation and recycling The user can change the weighting if required (and the related score) to suit their own circumstances, or the weightings can be removed entirely. Each category can score a maximum of 100 per cent, with the categories differing slightly for new build, refurbishment and demolition projects, as different waste management issues need to be considered. The categories include:

- Site Waste Management Plan;
- Pre-refurbishment/pre-demolition (where appropriate);
- Duty of Care;
- Waste avoidance;
- Reuse on/off-site;
- Recycling materials;
- Site set up and segregation;
- Subcontracting;
- Monitoring;
- Training.

It is envisaged that the scorecard can have a number of uses including:

- Inputting into a Site Waste Management Plan;
- Environmental auditing/compliance with procedures at a site level;
- Providing a tool for the project team to set levels of performance and aid in continuous improvement;
- For use in responding to pre-qualification questionnaires and tender requirements;
- For clients to set expected waste management levels onsite;
- For the Environment Agency and other key stakeholders to regulate and provide information on how to improve site waste management activities.

The scorecards can be used throughout the supply chain, i.e. client, contractor, subcontractor, waste management company, the Environment Agency and other key stakeholders e.g. WRAP and Envirowise. However, as the owner of the Intellectual Property Rights (IPR), the Environment Agency has the ultimate decision on how these scorecards might be applied.

Figures 6, 7 and 8 are screenshots of the scorecards for new build, refurbishment and demolition projects. The scorecards are supplied with this report as excel files. There is also a separate user guide (as a word document) for the scorecards.

Figure 6: Screenshot of the new build project scorecard

Site waste management scorecard						Newbuild
Practice level	Required					Achieved
Legal	Duty of care documentation showing compliance with legal requirements					☑
Practice level	Standard	Achieved	Good	Achieved	Best	Achieved
SWMP	SWMP completed at appropriate level	☑				
Duty of Care	Waste transfer note tickets with EWC codes	☑	Check waste transfer station licence	☐	Use of e-commerce for waste transfer notes	☐
	Consignment notes for hazardous waste	☑	Check waste carrier's licence	☐	Audit of waste facilities	☐
			Pre-contract dialogue with waste contractor	☐		
			Use standard form of contract developed for waste subcontractors	☑		
			Payment only after receipt of waste transfer note confirming delivery to waste recovery or disposal facility	☑		
Waste avoidance	Identify waste arisings in SWMP	☑	Opportunities to recycle or reuse identified before start on site	☑	Waste avoidance considered at design stage, eg modular dimensioning	☑
			Special ordering eg pre-cut plasterboard	☐	Maximum use of off site manufacturing	☑
					Regular site visits by company waste champion	☑
Reuse on/off site	Inert materials	☑	Soils, concrete	☐	Compound set aside for storing materials for reuse	☐
Recycling materials	Metals and other high value materials	☑	Wood based, packaging, gypsum based materials	☑	Take back schemes for unused materials and packaging	☑
Site set up and segregation	Layout of skip compound considered before start on site	☐	Segregated containers at workface	☐	Use of compactors	☑
	Separate clearly defined skips for each waste	☑	Dedicated staff to monitor waste segregation in secure waste compound	☑	Just in time deliveries, minimum on site storage	☑
Sub contracting	Tender clause with trade contractors on waste management strategy	☑	Pre-contract dialogue with trade contractors to reduce packaging	☑	Framework agreement with waste contractor	☑
					Set and monitor KPI for framework contract	☑
Monitoring	Skip costs monitored	☑	Data on volume of waste monitored and collated for all sites	☑	Use of auditing tool such as SMARTWaste	☐
			Targets based on industry KPIs	☐	Targets based on company KPIs	☐
					Performance of all sites reviewed and continuous improvement regime adopted	☐
Training	One person designated as site waste manager	☐	Individual areas of site assigned to individuals	☑	Champion identified for company wide waste management	☐
			On site training for all site based individuals in site waste management	☑	Company wide training scheme in site waste management	☐
					On site training for all site trade contactors in site waste management	☐
					Internal incentives for feedback	☐

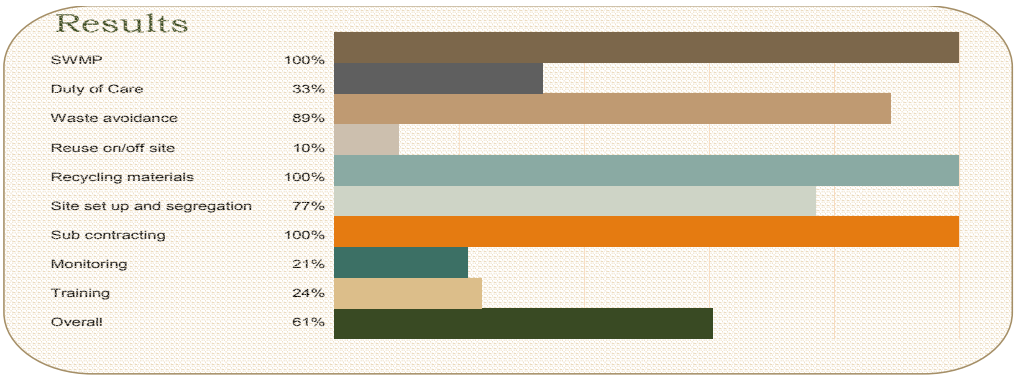


Figure 7: Screenshot of the refurbishment project scorecard

Site waste management scorecard						Refurbishment
Practice level	Required					Achieved
Legal	Duty of care documentation showing compliance with legal requirements					☑
Practice level	Standard	Achieved	Good	Achieved	Best	Achieved
SWMP	SWMP completed at appropriate level	☑				
Prerefurbishment	Asbestos survey(if appropriate)	☑	M+E assessment	☑	Prerefurbishment audit	☐
			Identification of waste arisings	☑		
Training	One person designated as site waste manager	☐	Individual areas of site assigned to individuals	☐	Champion identified for company wide waste management	☑
			On site training for all site based individuals in site waste management	☑	Company wide training scheme in site waste management	☐
					On site training for all site trade contactors in site waste management	☐
					Internal incentives for feedback	☑
					On site training for all individuals in site waste management	☑
Waste avoidance	Identify waste arisings in SWMP	☐	Opportunities to recycle or reuse identified before start on site	☐	Waste avoidance considered at design stage, e.g. modular dimensioning	☑
			Special ordering e.g. pre-cut plasterboard	☐	Maximum use of off site manufacturing/systems	☐
					Regular site visits by company waste champion	☑
Reuse on/off site	Inert (if appropriate)	☑	Salvage materials/products for reuse	☑	Work with local community to find outlets for refurbishment waste	☑
					Compound set aside for storing materials for reuse	☑
					Bricks,blocks, insulation, plasterboard and other offcuts surplus materials	☑
Recycling materials	Metals and other high value materials	☑	wood based, packaging, gypsum based materials	☑	Take back schemes for unused materials and packaging	☑
					Soft strip materials inc others	☑
Site set up and segregation	Layout of skip compound considered before start on site	☐	Dedicated staff to monitor waste segregation in secure waste compound	☐	Appropriate segregation for strip-out waste	☐
	Separate clearly defined skips for each waste	☐	Segregated containers at workface	☐	Use of compactors/balers	☑
					Just in time deliveries, minimum on site storage	☐
Monitoring	Skip/container costs	☑	Volume/tonnage generic targets for project including monitoring	☑	Targets based on prerefurbishment audit	☑
			Volume/tonnage generic targets for company including monitoring	☑	Use of auditing tools such as SMARTWaste	☑
					Separate targets for fit out waste and installation waste	☑
					Performance of all sites reviewed and continuous improvement regime adopted	☑
Duty of care	Waste transfer ticket with EWC codes	☑	Checking waste carrier's licence	☑	Use of e-commerce for waste transfer notes	☐
	Consignment notes for hazardous waste	☐	Payment only after receipt of waste transfer note confirming delivery to waste recovery or disposal facility	☐	Audit of waste facilities	☑
			Checking waste transfer licence	☑		
Sub contracting	Tender clause with trade contractors on waste management strategy	☑	Pre-contract dialogue with waste contractor	☑	Framework agreement with waste contractor	☐
			Pre-contract dialogue with trade contractors to reduce/recycle waste	☑	Set and monitor KPI for framework contract	☐
			Use standard form of contract developed for waste subcontractors	☑		

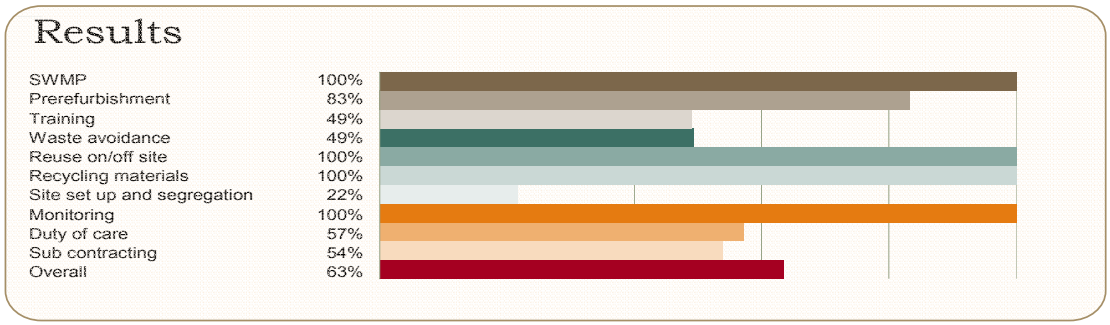
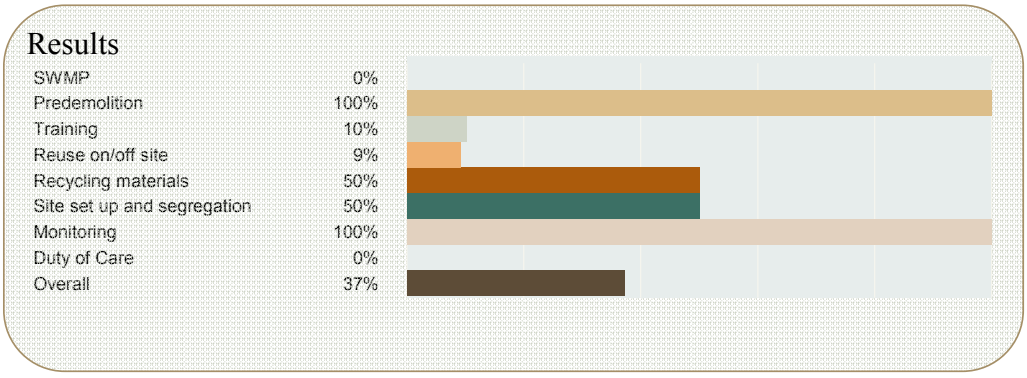


Figure 8: Screenshot of the demolition project scorecard

Site waste management scorecard						Demolition
Practice level	Required					Achieved
Legal	Duty of care documentation showing compliance with legal requirements					☑
Practice level	Standard	Achieved	Good	Achieved	Best	Achieved
SWMP	SWMP completed at appropriate level	☐				
Predemolition	Asbestos survey(if appropriate)	☑	Identification of waste arisings	☑	Predemolition audit	☑
	Contaminated land survey(if appropriate)	☑				
	M+E decommissioning plan(if appropriate)	☑				
Training	One person designated as site waste manager	☑	Individual areas of site assigned to individuals	☑	Champion identified for company wide waste management	☐
			On site training for all site based individual in site waste management	☐	Company wide training scheme in site waste management	☐
					On site training for all site trade contactors in site waste management	☐
					Internal incentives for feedback	☐
Reuse on/off site	Inert	☑	Inert/soils/concrete to agreed standards - RA	☐	Segregate to RCA standards	☐
					Salvage, reclamation M&E	☐
					Compound set aside for storing materials aside	☐
Recycling materials	Metals/inert/concrete/ceramics	☑	Timber	☑	Soft strip materials inc plasterboard	☐
Site set up and segregation	Separate clearly defined skips for each waste	☐	Segregated containers at workface	☑	Appropriate segregation for strip-out waste	☐
	Layout of skip compound considered before start on site	☐	Dedicated staff to monitor waste segregation in secure waste compound	☑		
Duty of Care	Waste transfer ticket with EWC codes	☐	Checking of waste carrier's licence	☐	Use of e-commerce for waste transfer notes	☐
	Consignment notes for hazardous waste	☐	Payment only after receipt of waste transfer note confirming delivery to waste recovery or disposal facility	☐	Audit of waste facilities	☐
			Checking of waste facilities license	☐		
Monitoring	Skip/container costs	☑	Volume / tonnage generic targets for project	☑	Targets based on predem audit or local area targets for each material	☑



In order to define and evaluate costs at a site level, three projects were selected: a house, office and a bridge. The cost plans for each project have been compared to wastage allowances within BRE's Green Guide to Specification to show the cost factored in for wastage of the products. The cost of labour has been removed. These cost plans have then been analysed in terms of the cost of the waste allowances (using the Green Guide to Specification information). Results are shown by value as the units in terms of amount vary widely. It should be noted that the costs for the waste allowances only apply for materials/products going into the project and are estimates; it does not include any costs for the removal of the material as waste. Therefore, the cost of waste leaving the site has also been estimated using benchmarks from BRE's SMARTWaste system, to illustrate the amount of waste likely to be produced by the type of development, presented as volume against floor area ($100m^2$) and project value (£100,000) [3]. Table 14 shows these benchmarks.

BRE's SMARTWaste system[4] provides a number of tools for the industry to collect waste data at both a project and company level. It is currently being used on over 600 projects.

The cost of segregation and waste removal is then presented for the waste generated. Results are presented for a single unit and extrapolated for a development. It has not been possible to compare the costs from the waste allowance against the costs for waste removal, as the datasets are different.

Table 14: Benchmarks generated from BRE's SMARTWaste system

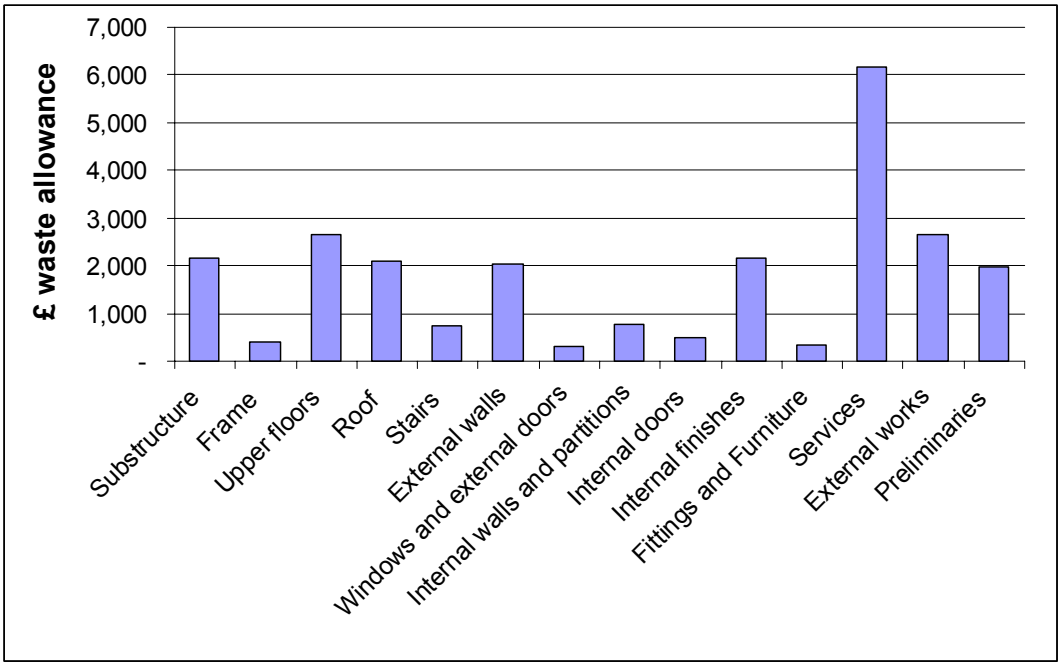
Project Type	EPI $M^3/100m^2$	KPI M^3/£100,000
Civil Engineering	42.79	24.61
Commercial Offices	19.33	11.75
Commercial Retail	15.94	10.80
Education	13.59	9.68
Healthcare	12.50	7.46
Industrial Buildings	14.36	7.46
Leisure	8.09	12.10
Public Buildings	48.47	18.63
Residential	15.14	11.47
All projects	**18.58**	**11.89**

Offices

A cost plan for a typical office with a floor area of $932m^2$ has been used, based on a steel frame with reinforced concrete columns and concrete slab and beam floors. The total cost of the office is £960,000 (materials and labour). Of this, £25,000 has been costed in for waste allowances for products (based on typical wastage rates); i.e. 2.6 per cent of the overall cost. This equates to a wastage allowance of £27.03/m^2 gross floor area, or £2,703.00/$100m^2$ gross floor area. Services (i.e. heating, sanitary, lighting etc) provide the largest opportunity for savings, with over £6,000 allowed for waste – a quarter of the overall wastage costs. This is followed by external works and upper floors (at 10 per cent apiece – approximately £2,600 each). The substructure, external walls, internal finishes and preliminaries account for 8 per cent each (approximately £2,000 each). This is shown in Figure 9.

[3] For further information see: www.smartwaste.co.uk/benchmarking.jsp
[4] For more information on SMARTWaste, please go to www.smartwaste.co.uk

Figure 9: Cost of waste allowance for an office



Obviously the waste allowance in terms of cost is dependant upon the amount of products/materials required and their cost. Services have a high waste allowance cost as they account for over a quarter of overall costs. However, if the factored costs of waste are compared against the overall costs for services then the waste allowance only accounts for 2.5 per cent. When looking at the wastage as a percentage of the overall cost, figures vary from 0.26 per cent (windows and external doors) to 4.86 per cent (substructure). This is illustrated in more detail in Table 15.

Table 15: Wastage allowance costs by elements for the office

Element	Cost (£)	% cost per overall cost	Waste cost (£)	% wastage cost per overall wastage cost	% wastage cost per element cost	% wastage cost per overall cost
Substructure	44296	5	2155	9	5	0.22
Frame	21125	2	415	2	2	0.04
Upper floors	77793	8	2645	11	3	0.28
Roof	59901	6	2102	8	4	0.22
Stairs	26585	3	731	3	3	0.08
External walls	68310	7	2040	8	3	0.21
Windows and external doors	118719	12	312	1	0	0.03
Internal walls and partitions	25216	3	767	3	3	0.08
Internal doors	26240	3	494	2	2	0.05
Internal finishes	79872	8	2507	9	3	0.22
Fittings and Furniture	14500	2	326	1	2	0.03
Services	247103	26	6175	25	3	0.64
External works	88268	9	2564	11	3	0.28
Preliminaries	65300	7	1959	8	3	0.20
Totals	**963228**		**25192**			**2.60**

Focusing on services (which account for 25 per cent of overall wastage costs), electrical installations account for 75 per cent of the wastage costs (5.25 per cent of overall costs), followed by lift and conveyor installations at 7 per cent and water installations at 5 per cent. Appendix 4 shows a more detailed breakdown for the other elements.

Percentage wastage rates range from zero to 10 per cent. The highest percentage wastage rates (based on the Green Guide to Specification) are at 10 per cent for items such as paving stones, flags, blockboard shelves, mdf boards and Formica beauty board. Items with no wastage rates factored in include gas boilers, radiators, service equipment and external doors. Any excavation waste is assumed to be spread onsite.

The same exercise has been carried out for 5 offices, with the waste allowances factored into the cost plan increasing. No percentage discount has been made for building 5 offices, however in practice a discount from bulking etc would be expected. For 5 offices, the total floor area would be 4660 m^2 with an overall cost of nearly £5 million (materials and labour). The waste allowance costs within the cost plan are £125,000.

In order to analyse the costs of the waste being generated from the project, the Environmental Performance Indicators have been used (see Table 14). These waste figures are then analysed in terms of the costs for segregated and missed waste including labour costs. No allowance has been given for compaction, or the use of different containers, which may have an impact on the overall costs. In addition, the costs have only been looked at for the removal of waste from site, no costs for reprocessing have been analysed due to the large number of different wastes being generated. A cost of £150 per skip has been used for an 8 cubic yard skip (which includes Landfill Tax), and a 20% discount has been given for waste that is likely to be segregated while metal is considered free. Labour for filling the skips is assumed at £30/m^3 of waste.

Table 16 shows the costs for segregating all waste and sending waste off in mixed skips from the office building. It shows that for 1 office building the costs of segregation are slightly less than for mixed waste (assuming a separate skip is used for each waste type). The total cost of segregating using 8 cu yard skips is £12,020.67 or £12.90/m^2 compared to £12,200.67 for mixed waste or £13.09/m^2. There is also an added value of segregating onsite through achieving greater recovery offsite.

Table 16: Costs of segregating waste onsite for 1 office

	EPI (m3/100m2)	GIFA (m2)	Vol of Material (m3)	Bulking factor (Exc. Matl 20%,conc, masonry 60% - WRAP, other 50%	Gross bulked up vol m3	No of Skips if segregated (8cu yd = 6.12m3)	Skip cost (inc landfill tax) @ £150/8yd	Discount for segregation (%)	Discounted skip price	Labour in filling skips @ £30/m3	
						6.12	£150.00			£30.00	
Canteen/office/ad-hoc	0.8300	932.00	7.74	1.50	11.60	2	£300.00	20	£240.00	£348.10	
Ceramics/bricks	0.0009	932.00	0.01	1.50	0.01	1	£150.00	20	£120.00	£0.37	
Concrete	0.5294	932.00	4.93	1.50	7.40	2	£300.00	20	£240.00	£222.02	
Electrical equipment	0.1646	932.00	1.53	1.50	2.30	1	£150.00	20	£120.00	£69.05	
Furniture	0.0286	932.00	0.27	1.50	0.40	1	£150.00	20	£120.00	£11.98	
Hazardous	0.0168	932.00	0.16	1.60	0.25	1	£150.00	20	£120.00	£7.51	
Inert	9.8311	932.00	91.63	1.50	137.44	23	£3,450.00	20	£2,760.00	£4,123.15	
Insulation	0.4521	932.00	4.21	1.60	6.74	2	£300.00	20	£240.00	£202.27	
Liquids and Oils	0.0004	932.00	0.00	1.50	0.01	1	£150.00	0	£150.00	£0.19	
Metals	1.0258	932.00	9.56	1.50	14.34	3	£450.00	100	£0.00	£430.20	
Packaging	0.8929	932.00	8.32	1.50	12.48	3	£450.00	0	£450.00	£374.47	
Plaster/cement	0.7071	932.00	6.59	1.50	9.89	2	£300.00	20	£240.00	£296.58	
Plastics	0.1077	932.00	1.00	1.50	1.51	1	£150.00	20	£120.00	£45.19	
Timber	1.2389	932.00	11.55	1.50	17.32	3	£450.00	0	£450.00	£519.59	
				Segregated skips		46	£6,900.00		£5,370.00	£6,650.67	**£12,020.67**
									Cost/m2 gfa		**£12.90**
		-	Gross bulked volume	Unsegregated skips	221.69	37	£5,550.00		**£5,550.00**	£6,650.67	**£12,200.67**
									Cost/m2 gfa		**£13.09**

For 5 offices, as shown by Table 17, the savings for segregation increase by £1.00/m^2, equivalent to a cost saving of approximately £4,600. This shows that significant savings can be made by segregating waste if enough waste is present.

Table 17: Costs of segregating waste onsite for 5 offices

EPI for offices	EPI (m3/100m2)	GIFA (m2)	Vol of Material (m3)	factor (Exc. Matl 20%,conc, masonry 60% - WRAP,	Gross bulked up vol m3	No of Skips if segregated (8cu yd = 6.12m3)	Skip cost (inc landfill tax) @ £150/8yd	Discount for segregation (%)	Discounted skip price	Labour in filling skips @ £30/m3	
										£30.00	
Canteen/office/ad-hoc	0.8300	4,660.00	38.68	1.50	58.02	9	£1,516.76	20	£1,213.41	£1,740.48	
Ceramics/bricks	0.0009	4,660.00	0.04	1.50	0.06	0	£1.62	20	£1.30	£1.86	
Concrete	0.5294	4,660.00	24.67	1.50	37.00	6	£967.43	20	£773.94	£1,110.12	
Electrical equipment	0.1646	4,660.00	7.67	1.50	11.51	2	£300.89	20	£240.71	£345.27	
Furniture	0.0286	4,660.00	1.33	1.50	2.00	0	£52.19	20	£41.75	£59.88	
Hazardous	0.0168	4,660.00	0.78	1.60	1.25	0	£32.71	20	£26.17	£37.54	
Inert	9.8311	4,660.00	458.13	1.50	687.19	112	£17,965.79	20	£14,372.63	£20,615.75	
Insulation	0.4521	4,660.00	21.07	1.60	33.71	6	£881.34	20	£705.07	£1,011.33	
Liquids and Oils	0.0004	4,660.00	0.02	1.50	0.03	0	£0.81	0	£0.81	£0.93	
Metals	1.0258	4,660.00	47.80	1.50	71.70	12	£1,874.53	100	£0.00	£2,151.02	
Packaging	0.8929	4,660.00	41.61	1.50	62.41	10	£1,631.69	0	£1,631.69	£1,872.37	
Plaster/cement	0.7071	4,660.00	32.95	1.50	49.43	8	£1,292.27	20	£1,033.82	£1,482.88	
Plastics	0.1077	4,660.00	5.02	1.50	7.53	1	£196.90	20	£157.52	£225.95	
Timber	1.2389	4,660.00	57.73	1.50	86.60	14	£2,264.01	0	£2,264.01	£2,597.96	
				Segregated skips		181	£28,978.94		£22,462.82	£33,283.33	**£55,746.15**
									Cost/m2 gfa		**£11.96**
		-	Gross bulked volume	Unsegregated skips	1108.44	181.12	£27,167.75		£27,167.75	£33,253.33	**£60,421.08**
									Cost/m2 gfa		**£12.97**

Summary for offices

Table 18 shows the total cost for waste for 1 office project and 5 offices in terms of waste allowance and waste management costs.

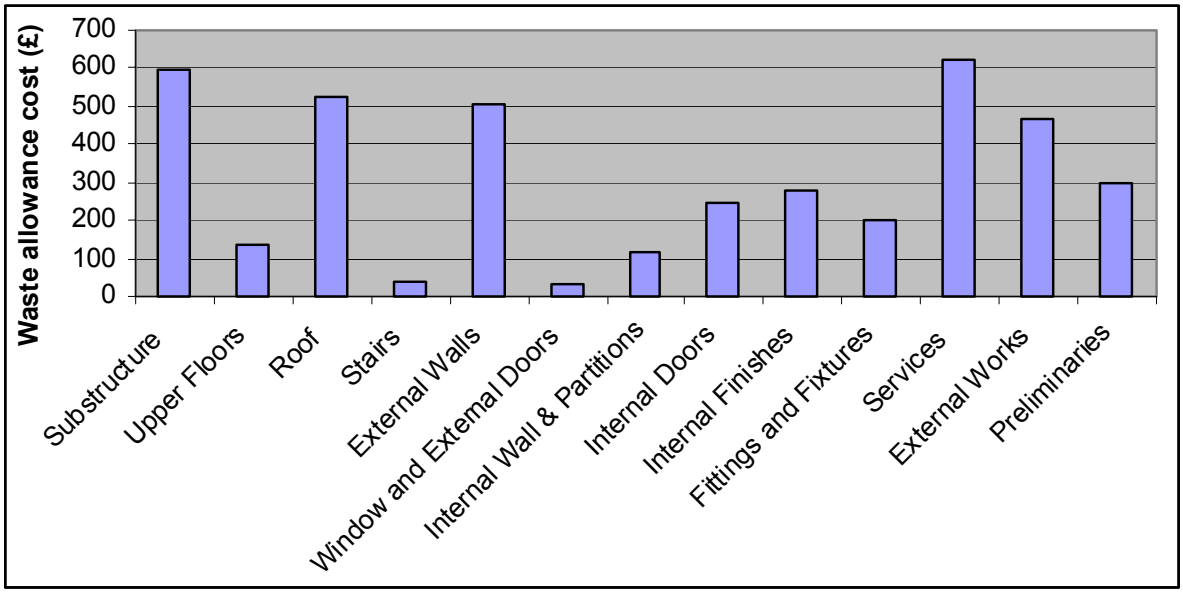
Table 18: Summary costs for offices

	Cost per m^2	Overall cost
1 office		
Allowance in cost plan for waste	£27.03	£25,191.96
Cost of segregated waste	£12.90	£12,022.80
Cost of mixed waste	£13.09	£12,199.88
Total (with segregated waste)	**£39.93**	**£37,214.76**
Total (with mixed waste)	**£40.12**	**£37,391.84**
5 offices		
Allowance in cost plan for waste	£27.03	£125,960
Cost of segregated waste	£11.96	£55,733.60
Cost of mixed waste	£12.97	£60,440.20
Total (with segregated waste)	**£38.99**	**£181,693.40**
Total (with mixed waste)	**£40.00**	**£186,400.00**

Houses

A cost plan for a typical house has been used, with a floor area of 142m^2 and based on brick and block construction. The total cost of the house is £153,360 (materials and labour). Of this, £4,069 has been costed in for waste allowances for products (based on typical wastage allowances); i.e. 2.7 per cent of the overall cost. This equates to a wastage allowance of £28.66/m^2 of gross floor area. It is quite evenly split in terms of areas that show the greatest opportunities for savings, with services representing 15 per cent of wastage costs (£624), substructure 14 per cent (£598), roofs 13 per cent (£525), external walls at 12 per cent (£504) and external works 12 per cent (£470). This is shown by Figure 10.

Figure 10: Cost of waste allowance for a house



When looking at the wastage allowance cost as a percentage of the overall cost, the highest is the superstructure, as shown by Table 19. Appendix 4 shows a more detailed breakdown for all elements.

Percentage wastage rates range from zero to 25 per cent. The highest percentage wastage rate (based on the Green Guide to Specification) is at 25 per cent for worktops, 15 per cent for plywood finish and followed by 10 per cent for softwood board and skirting. Products with no wastage rate include windows/doors and kitchen appliances. Any excavation waste is assumed to be spread onsite.

The same exercise has been carried out for 30 houses, and as expected the waste allowances factored into the cost plan increase. No percentage discount has been made for building 30 houses, however in practice a discount from bulking etc would be expected. For 30 offices, the total floor area would be 4260m^2 with an overall cost of over £4.6 million (materials and labour). The waste allowances within the plan are nearly £125,000.

Table 19: Wastage allowance costs by elements for the house

Element	Cost £	% cost per overall cost	Waste cost (£)	% wastage cost per overall wastage cost	% wastage cost per element cost	% wastage cost per overall cost
Substructure	12,681.77	8	597.89	23	5	0.4
Superstructure	68,768.09	45	1,600.49	63	2	1.0
Internal finishes	10,545.69	7	277.07	11	3	0.2
Fitting and furniture	4,645.38	3	199.44	8	4	0.1
Services	21,045.08	14	623.77	24	3	0.4
External works	25,673.80	17	469.80	22	2	0.4
Preliminaries	10,000.00	7	300.00	12	3	0.2
Total	**153,359.81**		**4,068.46**			**2.7**

Table 20 shows the costs for segregating waste and sending waste off in mixed skips from the house. It shows that for 1 house, the costs of segregation are higher than mixed waste (assuming a separate skip is used for each waste type). The total cost of segregating using 8 cubic yard skips is £2,974.31 or £20.95/m^2, compared to £1,984.31 for mixed waste or £13.97 per m^2. This does not take into account any added value as a result of segregating the waste onsite.

Table 20: Costs of segregating waste onsite for 1 house

	EPI (m3/100m2)	GIFA (m2)	Vol of Material (m3)	Bulking factor (Exc. Matl 20%,conc, masonry 60% - WRAP, other 50%	Gross bulked up vol m3	No of Skips if segregated (8cu yd = 6.12m3)	Skip cost (inc landfill tax) @ £150/8yd	Discount for segregation (%)	Discounted skip price	Labour in filling skips @ £30/m3	
						6.12	£150.00			£30.00	
Canteen/office/ad-hoc	3.9770	142.00	5.65	1.50	8.47	2	£300.00	20	£240.00	£254.13	
Ceramics/bricks	0.2941	142.00	0.42	1.50	0.63	1	£150.00	20	£120.00	£18.79	
Concrete	0.4483	142.00	0.64	1.50	0.95	1	£150.00	20	£120.00	£28.65	
Electrical equipment	0.1253	142.00	0.18	1.50	0.27	1	£150.00	20	£120.00	£8.01	
Furniture	0.0488	142.00	0.07	1.50	0.10	1	£150.00	20	£120.00	£3.12	
Hazardous	0.0178	142.00	0.03	1.60	0.04	1	£150.00	20	£120.00	£1.21	
Inert	0.5435	142.00	0.77	1.50	1.16	1	£150.00	20	£120.00	£34.73	
Insulation	1.0765	142.00	1.53	1.60	2.45	1	£150.00	20	£120.00	£73.37	
Liquids and Oils	0.0023	142.00	0.00	1.50	0.00	1	£150.00	0	£150.00	£0.15	
Metals	0.9307	142.00	1.32	1.50	1.98	1	£150.00	100	£0.00	£59.47	
Packaging	2.7192	142.00	3.86	1.50	5.79	1	£150.00	0	£150.00	£173.76	
Plaster/cement	3.6772	142.00	5.22	1.50	7.83	2	£300.00	20	£240.00	£234.97	
Plastics	0.7373	142.00	1.05	1.50	1.57	1	£150.00	20	£120.00	£47.11	
Timber	2.2977	142.00	3.26	1.50	4.89	1	£150.00	0	£150.00	£146.82	
				Segregated skips		16	£2,400.00		£1,890.00	£1,084.31	**£2,974.31**
									Cost/m2 gfa		**£20.95**
		-	Gross bulked volume	Unsegregated skips	36.14	6	£900.00		**£900.00**	£1,084.31	**£1,984.31**
									Cost/m2 gfa		**£13.97**

For 30 houses, the picture is slightly different as Table 21 shows. The cost for segregating waste is less than for sending waste offsite mixed. The cost saving is about £7,000 or £1.62/m^2. This shows that savings can be made by segregating waste if enough waste is present.

Table 21: Costs of segregating waste onsite for 30 houses

	EPI (m3/100m2)	GIFA (m2)	Vol of Material (m3)	Bulking factor (Exc. Matl 20%,conc, masonry 60% - WRAP, other 50%	Gross bulked up vol m3	No of Skips if segregated (8cu yd = 6.12m3)	Skip cost (inc landfill tax) @ £150/8yd	Discount for segregation (%)	Discounted skip price	Labour in filling skips @ £30/m3	
						6.12	£150.00			£30.00	
Canteen/office/ad-hoc	3.9770	4,260.00	169.42	1.50	254.13	42	£6,300.00	20	£5,040.00	£7,623.92	
Ceramics/bricks	0.2941	4,260.00	12.53	1.60	20.04	4	£600.00	20	£480.00	£601.33	
Concrete	0.4483	4,260.00	19.10	1.50	28.65	5	£750.00	20	£600.00	£859.38	
Electrical equipment	0.1253	4,260.00	5.34	1.60	8.54	2	£300.00	20	£240.00	£256.29	
Furniture	0.0488	4,260.00	2.08	1.50	3.12	1	£150.00	20	£120.00	£93.56	
Hazardous	0.0178	4,260.00	0.76	1.50	1.14	1	£150.00	20	£120.00	£34.16	
Inert	0.5435	4,260.00	23.15	1.50	34.73	6	£900.00	20	£720.00	£1,041.92	
Insulation	1.0765	4,260.00	45.86	1.50	68.79	12	£1,800.00	20	£1,440.00	£2,063.61	
Liquids and Oils	0.0023	4,260.00	0.10	1.50	0.15	1	£150.00	0	£150.00	£4.49	
Metals	0.9307	4,260.00	39.65	1.50	59.47	10	£1,500.00	0	£1,500.00	£1,784.22	
Packaging	2.7192	4,260.00	115.84	1.50	173.76	29	£4,350.00	100	£0.00	£5,212.77	
Plaster/cement	3.6772	4,260.00	156.65	1.50	234.97	39	£5,850.00	20	£4,680.00	£7,049.19	
Plastics	0.7373	4,260.00	31.41	1.50	47.11	8	£1,200.00	20	£960.00	£1,413.38	
Timber	2.2977	4,260.00	97.88	1.50	146.82	24	£3,600.00	0	£3,600.00	£4,404.70	
				Segregated skips		184	£27,600.00		£19,650.00	£32,442.90	**£52,092.90**
									Cost/m2 gfa		**£12.23**
		-	Gross bulked volume	Unsegregated skips	1081.43	177	£26,550.00		**£26,550.00**	£32,442.90	**£58,992.90**
									Cost/m2 gfa		**£13.85**

Summary for houses

Table 22 shows the total cost for waste for 1 house and 30 houses in terms of waste allowance and waste management costs.

Table 22: Summary costs for houses

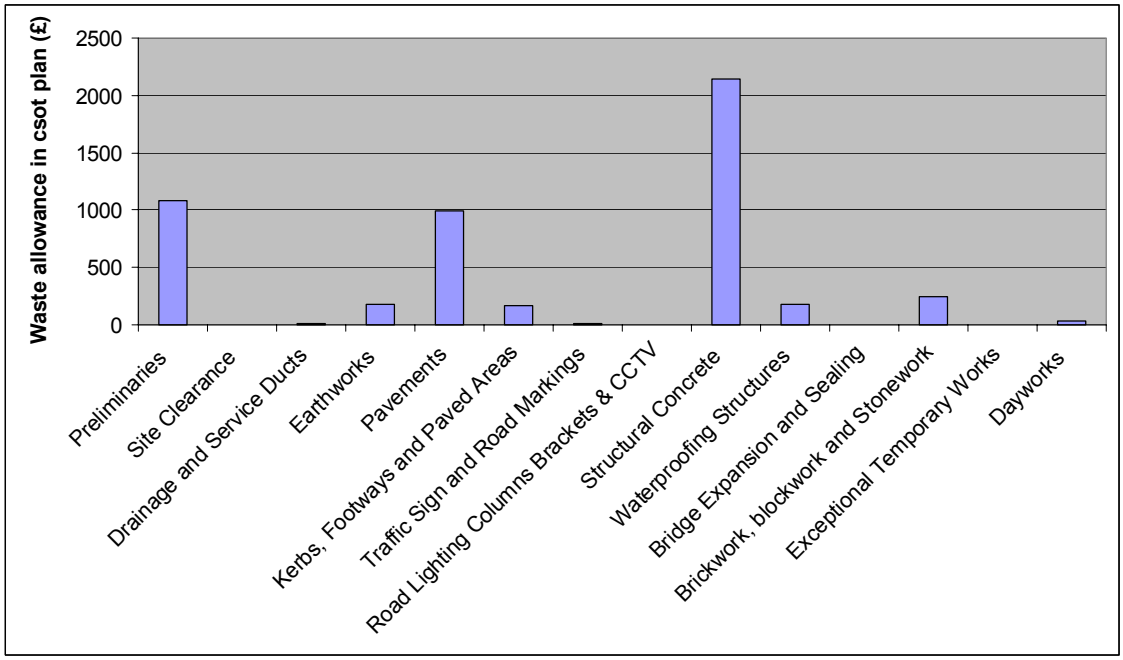
	Cost per m^2	Overall cost
1 house		
Allowance in cost plan for waste	£28.66	£4,069.72
Cost of segregated waste	£20.95	£2,974.90
Cost of mixed waste	£13.97	£1,983.74
Total (with segregated waste)	**£49.61**	**£7,044.62**
Total (with mixed waste)	**£42.63**	**£6,053.46**

30 houses		
Allowance in cost plan for waste	£28.66	£122,091.60
Cost of segregated waste	£12.23	£52,099.80
Cost of mixed waste	£13.85	£59,001.00
Total (with segregated waste)	**£40.89**	**£174,191.40**
Total (with mixed waste)	**£42.51**	**£181,092.60**

Bridge

A similar exercise has been carried out for a concrete bridge, using a typical cost plan for a bridge with a total area of 539m^2. The total cost is £179,501, with the material cost of this at 30 per cent (£53,020). The remainder is labour and other expenses. The waste allowance in the cost plan totals £5,060, which is approximately 5 per cent or equivalent to £9.38/m^2. The greatest opportunities for savings are for structural concrete, accounting for 42 per cent of the waste cost, followed by preliminaries at 21 per cent and pavements at 19 per cent. This is illustrated by Figure 11.

Figure 11: Cost of waste allowance for a bridge



As with offices and houses, the cost of the waste allowance is dependant upon the amount of products/materials required and their cost. Structural concrete accounts for nearly 40 per cent of the total costs. If the factored costs of waste are compared against the overall material cost for structural concrete, then the waste costs account for approximately 3 per cent. This is shown in more detail in Table 23.

Percentage wastage allowances range from 2.5 per cent for granite kerb, to formwork at 13 per cent. No wastage rate has been applied to excavation material as this is assumed to be spread onsite.

Table 23: Wastage allowance costs by elements for the bridge

Element	Cost (£)	% cost per overall cost	Waste cost (£)	% wastage cost per overall wastage cost	% wastage cost per element cost	% wastage cost per overall cost
Preliminaries	35,991.94	20.39	1,079.76	21	3	0.6
Site Clearance	12,537.52	7.10	0.00	0	0	0.0
Drainage and Service Ducts	182.54	0.10	7.27	0	4	0.0
Earthworks	16,909.95	9.58	183.98	4	1	0.1
Pavements	17,913.93	10.15	998.71	20	6	0.6
Kerbs, Footways and Paved Areas	5,028.92	2.85	168.81	3	3	0.1
Traffic Sign and Road Markings	336.11	0.19	12.64	0	4	0.0
Road Lighting Columns Brackets & CCTV	59.51	0.03	0.00	0	0	0.0
Structural Concrete	68,051.41	38.56	2,147.71	42	3	1.2
Waterproofing Structures	3,202.08	1.81	180.60	4	6	0.1
Bridge Expansion and Sealing	107.29	0.06	3.39	0	3	0.0
Brickwork, blockwork and Stonework	9,658.24	5.47	248.73	5	3	0.1
Exceptional Temporary Works	2,447.45	1.39	0.00	0	0	0.0
Dayworks	4,075.00	2.31	28.75	1	1	0.0
Total	**176,501.89**		**5,060.35**			**2.8**

As with the office and housing projects, benchmarks have been used for civil engineering, generated from the SMARTStart system in order to determine the cost of wastage generated by segregated and non-segregated waste. This is illustrated in Table 24. The results show that it is currently cheaper to segregate the waste, with an overall cost of £12,045.17 (£22.35/m^2), rather than an overall cost for mixed waste at £12,496.17(£23.18/m^2). The bridge project has not been bulked up as the office and house figures were as it can be considered a typical project.

Table 24: Cost of segregating waste onsite for a bridge

	EPI (m3/100m2)	GIFA (m2)	Vol of Material (m3)	Bulking factor (Exc. Matl 20%, conc, masonry 60% - WRAP, other 50%	Gross bulked up vol m3	No of Skips if segregated (8cu yd = 6.12m3)	Skip cost (inc landfill tax) @ £150/8yd	Discount for segregation (%)	Discounted skip price	Labour in filling skips @ £30/m3	
						6.12	£150.00			£30.00	
Canteen/office/ad-hoc	0.9584	539.00	5.17	1.50	7.75	2	£300.00	20	£240.00	£232.46	
Ceramics/bricks	0.0037	539.00	0.02	1.50	0.03	1	£150.00	20	£120.00	£0.90	
Concrete	1.2407	539.00	6.69	1.50	10.03	2	£300.00	20	£240.00	£300.93	
Electrical equipment	0.0357	539.00	0.19	1.50	0.29	1	£150.00	20	£120.00	£8.66	
Furniture	0.0202	539.00	0.11	1.50	0.16	1	£150.00	20	£120.00	£4.90	
Hazardous	0.0521	539.00	0.28	1.60	0.45	1	£150.00	20	£120.00	£13.48	
Inert	18.4630	539.00	99.52	1.50	149.27	25	£3,750.00	20	£3,000.00	£4,478.20	
Insulation	1.3512	539.00	7.28	1.60	11.65	2	£300.00	20	£240.00	£349.58	
Liquids and Oils	0.0000	539.00	-	1.50	0.00	0	£0.00	0	£0.00	£0.00	
Metals	1.2317	539.00	6.64	1.50	9.96	2	£300.00	100	£0.00	£298.75	
Packaging	0.9444	539.00	5.09	1.50	7.64	2	£300.00	0	£300.00	£229.06	
Plaster/cement	2.5887	539.00	13.95	1.50	20.93	4	£600.00	20	£480.00	£627.89	
Plastics	0.3276	539.00	1.77	1.50	2.65	1	£150.00	20	£120.00	£79.46	
Timber	0.7046	539.00	3.80	1.50	5.70	1	£150.00	0	£150.00	£170.90	
				Segregated skips		45	£6,750.00		£5,250.00	£6,795.17	**£12,045.17**
									Cost/m2 gfa		**£22.35**
		-	Gross bulked volume	Unsegregated skips	226.51	38	£5,700.00		**£5,700.00**	£6,795.17	**£12,495.17**
									Cost/m2 gfa		**£23.18**

Summary for bridges

Table 25 shows the total cost for waste for the bridge project in terms of the waste allowance and the cost of waste management.

Table 25: Summary of waste costs for a bridge

	Cost per m^2	Overall cost
1 bridge		
Allowance in cost plan for waste	£9.38	£5,055.82
Cost of segregated waste	£22.35	£12,046.65
Cost of mixed waste	£23.18	£12.494.02
Total (with segregated waste)	**£31.73**	**£17,102.47**
Total (with mixed waste)	**£32.56**	**£17,549.84**

There are differences between each type of project because the composition and amount of waste will vary.

Analysis at a product level

In order to develop a picture of the costs once waste is removed from site, three products have been analysed in terms of the options and associated costs for their recovery/disposal. The products are plasterboard, treated timber and insulation, all of which are common products on construction sites.

Insulation waste

Insulation waste has been considered for the typical detached house. Data derived from BRE's SMARTWaste suggests that on average, $1m^3$ of insulation waste will be produced for every $100m^2$ of floor area in the housing development. Using the housing project described before, which has an overall floor area of $142m^2$, this will result in $1.42m^3$ of insulation waste. If this insulation is assumed to be a 75mm polyurethane board product, it would equate to approximately 6.5 wasted boards, priced at approximately £24. The cost of this wasted material would therefore be £156 per house. For 30 houses the cost would increase to £4,680.

When placed in a skip, it is common for material to occupy a greater volume, due to the presence of void spaces. If void spaces are assumed to represent an extra 50 per cent in addition to the material volume, the bulk volume of the insulation waste would become $2.13m^3$. This would fill approximately a third of an 8 cubic yard skip, commonly priced at £150. Thus the space occupied in the skip is equivalent to approximately £50. Finally, it is estimated that the labour cost to place materials in a skip is around £30 per m^3. At $2.13m^3$, the labour cost for placing insulation waste in a skip is approximately £64. Therefore, the overall cost of removing insulation waste per house is £270. If this is multiplied up for a development of 30 houses, the cost of insulation waste would be £8,100. This is shown in Table 26. Typically, the density of polyurethane insulation board is $40kg/m^3$. The mass of insulation wasted per house would be 56kg per house, amounting to 1.68 tonnes on a development of 30 houses.

Table 26: Summary of costs for insulation waste

Insulation waste costs	Per House (£)	Per 30 Houses (£)
Cost of wasted product	156	4,680
Cost of mixed skip (including labour)	270	8,100
Total	**426**	**12,780**

Although several waste contractors are now prepared to accept segregated plastic waste, it would still appear that polymer-based insulation waste cannot be mixed with other segregated plastics. Insulation is apparently classed as a 'difficult' waste and would usually be subject to relatively high disposal/ skip costs as a result. (i.e. no discounts on skip costs would be likely for segregating insulation waste).

If sufficient quantities arose to justify it, which is not thought likely on new build projects, it may be possible for individual contractors to make arrangements directly with manufacturers or other companies that are able to reprocess certain types of insulation materials to deal with any waste. For example, it should be possible to reprocess rockwool material if returned to the manufacturer; polystyrene products could be treated and secondary outlets found for the resulting material. An issue restricting the latter may be the availability of appropriate equipment. Such machinery is not widespread at present, although it may become more common as further end uses are identified for the resulting reprocessed material and companies become inclined to purchase the necessary equipment to deal with the volumes of waste being created. Recycling insulation materials in this way may result in savings on the cost of landfilling the waste, however transport and processing costs would need to be balanced out.

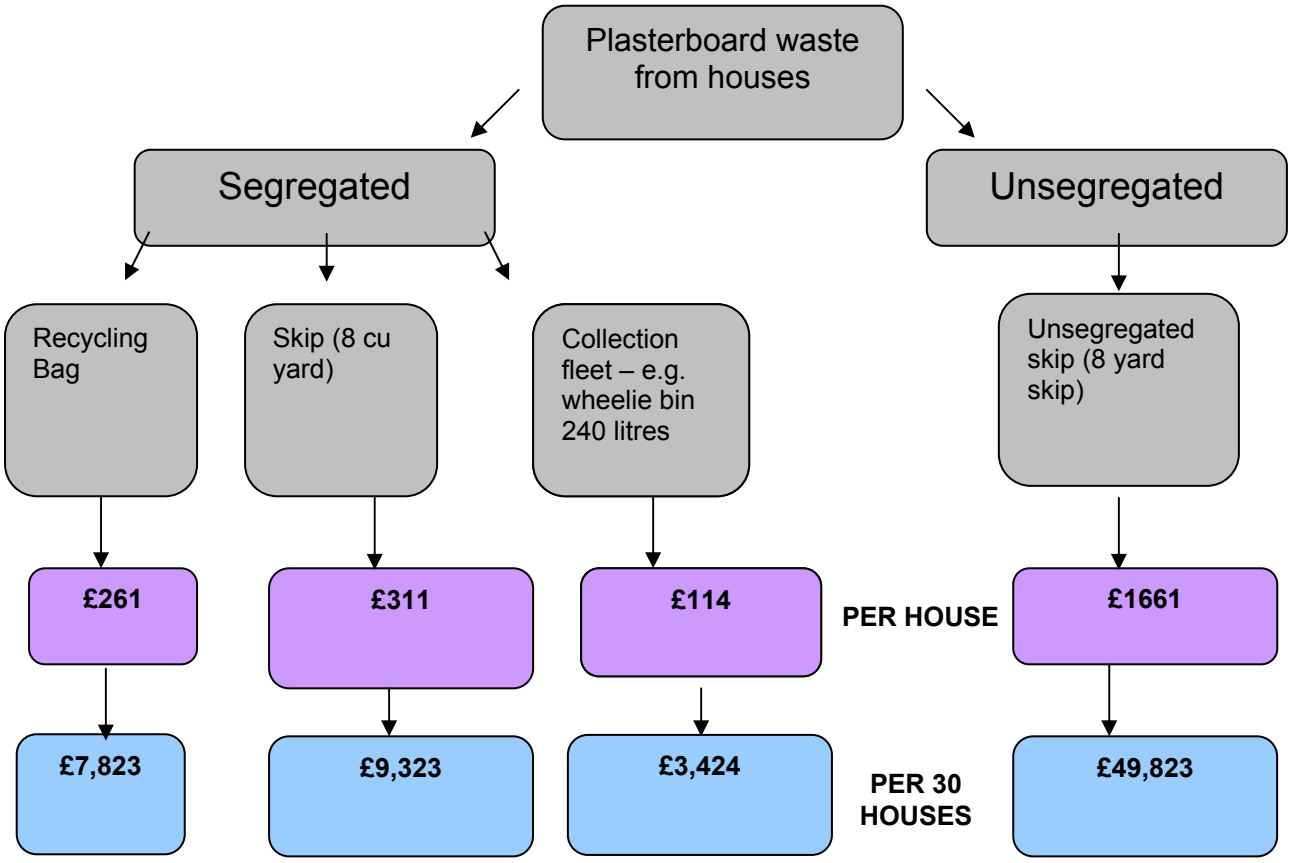
Plasterboard waste

Using the housing development as an example, the average volume of plasterboard waste arising for each house is 5.54m^3, using the Environmental Performance Indictors (EPI) derived from BRE's SMARTWaste system. Plasterboard waste has a variety of different disposal options, and costs vary between different methods. Recycling bags cost approximately £25 per bag, which would total £260.76 per house. For 30 houses this would therefore cost £7,822.80. A segregated 8 cubic yard skip can cost £200 per skip, which would lead to a total cost of £310.76 per house and £9,322.80 for 30 houses. In contrast, a collection fleet of 240 litre wheelie bins would cost £114.13 per house or £3,423.90 for 30 houses. An unsegregated skip would cost £1,660.76 per house and the total cost for 30 houses would be £49,822.80, taking into consideration that an unsegregated skip can only legally contain 10 per cent plasterboard (however it could be mixed at a waste transfer station). Landfill Tax by 2011 would increase this cost by a further £14,606, totalling £64,428.80 for 30 houses for plasterboard waste in unsegregated skips. These calculations take into consideration 50 per cent void space and labour costs. This is summarised in Table 27 and Figure 11.

Table 27: Summary of costs for plasterboard waste from housing development

Waste Management Method for houses	Per House (£)	Per 30 Houses (£)
Recycling Bags	260.76	7,822.80
Skip – segregated (8 Yard Skip)	310.76	9,322.80
Collection fleet – Wheelie bin (240 litres) -Including waste management contractor disposal costs.	114.13	3,423.90
Skip – not segregated (10% maximum)	1660.76	49,822.80

Figure 12: Costs of plasterboard waste from houses

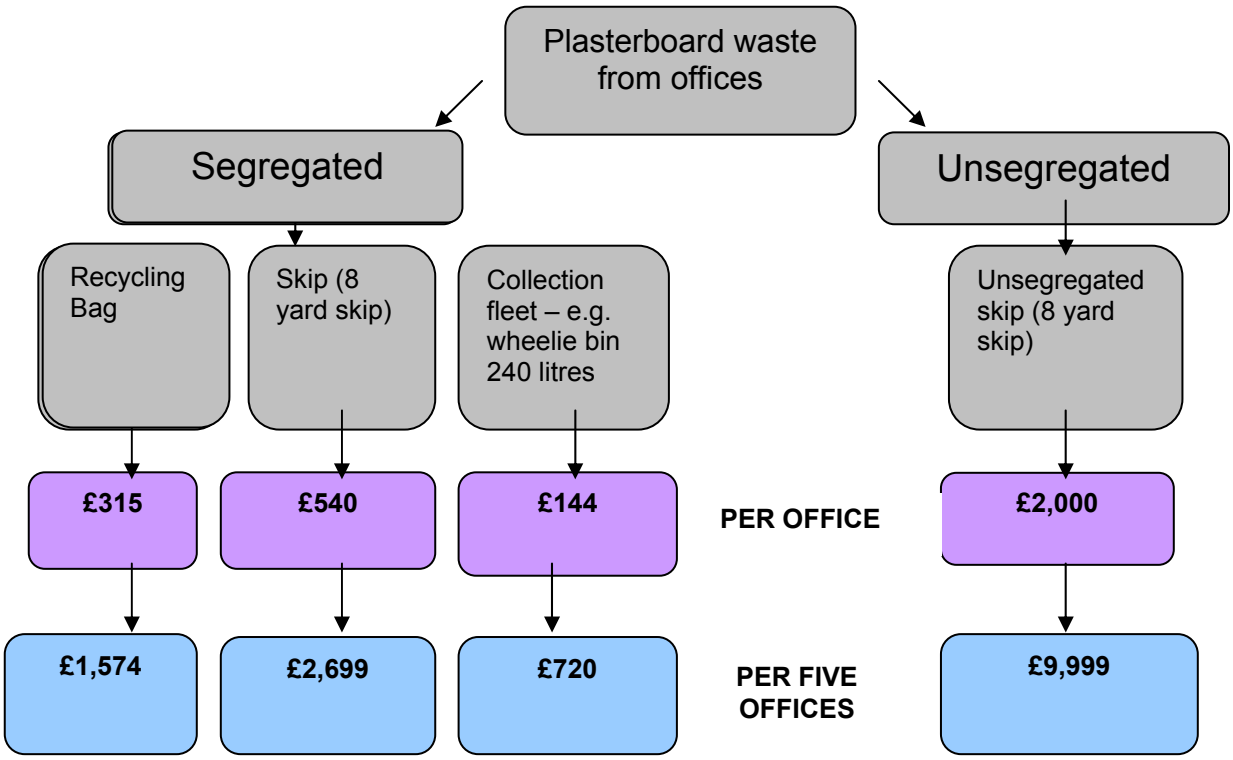


For the office development described earlier, EPIs from BRE's SMARTWaste system suggest that on average the volume of plasterboard waste found in each office is 6.99m^3. If recycling bags are used this would cost £314.80 per office and £1,574 for five offices. Using a segregated 8 yard skip the cost per office is £539.80 and for five offices £2,699. A collection fleet of 240 litre wheelie bins would cost £144.01 per office and £720.05 for five offices. An unsegregated skip would cost £1,999.80 per office and the total cost for 5 offices would be £9,999.00, taking into consideration that an unsegregated skip must legally only contain 10 per cent plasterboard (although it could be mixed at a waste transfer station). Landfill Tax in place by 2011 would increase this cost by a further £3,114.56, totalling £13,113.56 for plasterboard waste in unsegregated skips for five offices. These calculations take into consideration 50 per cent void space and labour costs. This is summarised in Table 28 and Figure 12.

Table 28: Summary of costs for plasterboard waste for an office development

Waste Management Method for offices	Per office (£)	Per 5 offices (£)
Recycling Bags	314.80	1,574.00
Skip – segregated (8 Yard Skip)	539.80	2,699.00
Collection fleet – Wheelie bin (240 litres) -Including waste management contractor disposal costs.	144.01	720.05
Skip – not segregated (10% maximum)	1,999.80	9,999.00

Figure 13: Costs of plasterboard waste from an office development



Treated timber

For the housing development, the volume of treated timber waste for each house is an average 0.97m^3, based on EPIs from BRE's SMARTWaste system. If the treated wood is segregated into an 8 cubic yard skip, with a cost of £200 including Landfill Tax, the total cost would be £219.43 per house, including labour costs. For 30 houses the cost would rise to £1,582.77. By 2011 with the increase in Landfill Tax prices this cost would rise to £1,702.12. Alternatively, if this waste was taken to an Energy from Waste (EfW) facility the cost would be £220.55 per house and £2,178.78 for 30 houses. These calculations take into consideration 50 per cent void space and labour costs. This is shown in Table 29.

Table 29: Summary of costs for treated timber waste for housing development:

Waste Management method for Houses	Per House (£)	Per 30 Houses (£)
Segregated - 8 cu yard skip (disposed of)	219.43	1,582.77
EfW	220.55	2,178.79

For the office development, on average the volume of treated timber waste for each office would be 3.47m^3. If it is segregated into an 8 yard skip, with a cost of £200 including Landfill Tax; the total cost would be £269.34 per office, including labour costs. For 5 offices the cost would rise to £946.70. By 2011 with the increase in Landfill Tax this cost would rise to £1,024.26. Alternatively, if this waste was taken to an EfW facility the cost would be £323.18 per office and £1,293.44 for 5 offices. These calculations take into consideration 50 per cent void space and labour costs. This is shown in Table 30.

Table 30: Summary of costs for treated timber waste for an office development

Waste Management method for Offices	Per Office (£)	Per 5 Offices (£)
Segregated - 8 cu yard skip (disposed of)	269.34	1,024.26
EfW	323.18	1,293.55

5. Analysis of barriers

Barriers to better site waste management were obtained from the industry thorough the industry consultation (Task 2) and the workshop for key stakeholders (Task 7). Respondents were presented with a number of barriers based on current knowledge, and asked if they agreed with them and what other barriers they faced. In addition, other barriers have been included which have been presented from other projects and surveys, such as the series of SWMPs workshops run by both Envirowise and WRAP last year.

Table 31 shows the barriers associated with better site waste management and resource efficiency, along with possible actions and those who could be responsible for reducing/removing such barriers.

Table 31: Common barriers for better site waste management and resource efficiency

Barrier	Action	By whom
Circle of blame: • Contractor - site waste management is not undertaken because the client does not ask for it, not a legal requirement; • Clients – it is a site issue, don't know how much it will cost me, not aware of benefits to me; • Designers – it will all be changed by the contractor so why bother.	• Better communication between different job functions, joint responsibility and ownership for waste, integrated teams; • Greater understanding of why waste is caused and the apportionment of cost of waste throughout the supply chain.	• Entire construction supply chain.
Sub contractors abuse the SWMP.	• Workforce bonus schemes need to be changed to focus on quality of work, not quantity installed per day (which can encourage waste); review procurement and contracts used.	• Clients, contractors.
Sub contractors produce different waste streams at different times.	• Specific waste targets need to be set for each trade in terms of waste material and rework costs.	• Contractors, subcontractors.

Barrier	Action	By whom
Plasterboard is the largest component of waste.	This high waste cost can be reduced by: • Making sure it is precut at the factory, in height and width; • Setting up the bonus system to recognise quality, and penalise poor work; • Protect vulnerable corners with waste cuttings of plasterboard; • Order specific requirements, not to the nearest 20 boards.	• Designers, specifiers, manufacturers. • Clients, contractors. • Contractors, subcontractors. • Specifers, buyers.
Too much packaging on products; it is hard to deal with on a construction site.	• Work with supply chain to encourage reuse of packaging and minimisation where appropriate; • Develop voluntary agreements on packaging.	• Manufacturers, contractors, advisory bodies; • Government, manufacturers, Environment Agency.
If the Take Make Waste chain is to become a Take Make Use and Re-use chain there have to be stronger penalties for creating and disposing of waste in landfill. Until then re-use and recycling will not happen.	• Legalisation and enforcement of SWMPs; • Develop other policy/targets for CD&E waste.	• Government, Environment Agency, local authorities.

Barrier	Action	By whom
It is difficult to minimise waste before it gets to the site.	• Design stage – design for minimum waste; • Dimensional co-ordination: ➢ brick, block; ➢ ceiling tiles, diffusers, fittings flash gaps; ➢ storey heights; • Offsite manufacture; • Can you influence the designer; • Steel versus concrete frame.	• Designers, clients, contractors.
Materials and services come in random sizes.	Consider offsite fabrication: • Services (pipe and wiring looms, ductwork); • Staircases; • Balustrading; • Door sets; • Pods (toilets, bathrooms, kitchens); • Cladding; • Cassettes (floor, roof); • Pre-cut (timber joists).	• Contractors, specifiers, manufacturers.
Health and safety – requirements of some materials/storage limit waste recovery.	• More research required in terms of the impact of heath and safety on waste management.	• Government, Environment Agency, Advisory Bodies, Health and Safety Executive.
Definition of waste - using waste as a resource; waste exemptions can be costly (~£550) for a small amount of waste and take time to obtain.	• Review waste exemptions and their appropriateness in relation to scale; • Promote waste protocols; • Voluntary agreements with the reprocessing industry.	• Environment Agency, Government.

Barrier	Action	By whom
Lack of appropriate data at both a project and sector level.	• Collection of data through SWMPs; • Setting of targets/policies with clear monitoring and data collection methods.	• Government, Environment Agency, industry, advisory bodies.
Time – we are here to build not manage waste, and we are already very busy.	• Benefits of better waste management need to be clearly defined.	• Government, advisory bodies.
High wastage allowances are built into costing and ordering systems.	• Greater understanding of what the wastage allowances are by project and by product, and the associated costs; • Specify appropriate maximum wastage targets that do not impinge on construction activities.	• Quantity surveyors, buyers, manufacturers; • Contractors.
Culture – we have always done it this way, so why change?	• Develop consistent and linked training packages, from onsite induction to various professions, including school and life long learning.	• CITB, construction advisory bodies.
Space – some sites, especially those in city centres, have limited space with no room for segregation.	• Development of systems for use on small sites e.g. milk round collections, smaller containers; • Work with waste management companies that have good recovery rates.	• Waste management industry; • Contractors, waste management industry.

Barrier	Action	By whom
Perception of cost - better site waste management is going to cost me more.	• Greater understanding of the true costs of waste (e.g. labour, material cost); • Clarification of cost of waste by waste management industry; • Raise awareness of added benefits of better waste management e.g. health and safety, increased productivity.	• Contractors, advisory bodies; • Waste management industry; • Contractors, advisory bodies, Environment Agency.
Who actually owns the waste? If there is no joint ownership then it is hard to buy in from other parts of the supply chain to manage the waste more effectively.	• Transparent mechanisms for the ownership of waste and its cost through better procurement systems; • Integrated supply chain partnerships.	• Supply chain (lead by clients and contractors).
Lack of respect for other trades and their workmanship, causing rework (at a cost) and waste.	• Better communication and co-ordination between trades onsite, • Full buy-in to SWMPs, • An understanding of why rework occurs, • Contractual tie-in.	• Trade associations, contractors, subcontractors.
Lack of awareness of the savings and environmental benefits of better site waste management.	• Raise awareness and provide targeted information on cost savings and environmental benefits i.e. what can I actually do for my particular project – specific guidance by trade and project type.	• Government, construction advisory bodies.

Barrier	Action	By whom
There is still a lack of waste markets for certain materials e.g. insulation, composite materials.	• Specify products/materials that are easier to recover; • Manufacturers to be encouraged to make products which are recoverable; • Provide incentives for more waste infrastructure on and offsite; explore use enhanced capital allowances.	• Designers/contractors; • Government, WRAP, manufacturers; • Government.
Smaller contractors – what's in it for me?	• Greater understanding needed of the difficulties facing smaller contractors and development of bespoke solutions that are quick and easy e.g. take back at builders merchants, milk round collections; • More pressure from the supply chain.	• Trade associations/bodies, advisory bodies. • Contractors.
Refurbishment waste is difficult with lots of different materials of little or no value.	• Promote small scale, local, segregated waste collection and reuse/recycling services tailored to meet the needs of refurbishment contractors; • Possibly link with social enterprise; • Require resource efficiency (within SWMPs) as part of social housing refurbishment.	• Government, Environment Agency, waste industry; • Social enterprise sector; • Government, local authorities, housing associations.
Lump sum/fixed price contracts for waste management do not encourage waste minimisation.	• Specify the use of 'pay as you throw' contracts which provide incentives for waste minimisation.	• Waste management industry, contractors, waste brokers, logistics teams.

Barrier	Action	By whom
Little awareness of Duty of Care or enforcement of it.	• Promote compliance; • Set up schemes showing compliance e.g. certification of resource management sites; • Provision of trade recycling facilities at Household Waste Recycling Centres for smaller contractors.	• Environment Agency, Government; • Environment Agency, Government, waste management industry; • Government, local authorities.
Demolition – lack of time to fully realise value from salvaging/reclaiming materials.	• Require pre-demolition audits (within SWMPs); • Educate the client in terms of benefits of reuse and associated cost savings.	• Clients; • Advisory bodies.

For most of the barriers outlined above to be reduced it is essential that the construction sector works together under the common goal of resource efficiency. For this to happen effectively, a key issue is for each part of the supply chain to understand its role, both in terms of the cause of waste and in providing solutions with a shared pain/gain element. As part of this it is important to understand the root cause of waste and use this to determine what waste is avoidable and unavoidable, in order to provide a focus for action.

6. Discussion

Analysing annual construction products market data against wastage allowances has shown that there is huge potential for the industry to become more resource efficient. At a national level, reducing these wastage allowances by just 1-2 per cent would result in savings of approximately £15-31 million of construction products (based on an estimated £1.5 billion annual wastage allowance). In terms of tonnage, a 1-2 per cent reduction would be equivalent to 104,000 to 208,000 tonnes of material (based on an estimated 10.5 million tonne annual wastage allowance). However, some of the national level datasets are incomplete in terms of being able to define how much product is sold into the construction sector, especially in terms of tonnage. A key recommendation is the requirement to have an efficient system in place to record this data in a more consistent manner. It is likely that the numbers presented here would increase if any more data was included.

The wastage allowances used within the analysis are based on cost books and as such are estimates used for costing; they may or may not be representative of actual practice. A key requirement is therefore to obtain accurate wastage rates for different types of products. This would involve understanding how much waste arises from using a certain product, how much of the product was originally used and importantly the cause of the waste. This would have to be done on a project-by-project basis. Once these factors are known, then the wastage allowances can be reduced appropriately. However, it must be noted that for the majority of products/materials there will always be a requirement for wastage allowances to ensure that there is enough material to build with whilst allowing for natural wastage etc. The key is to understand how much the wastage allowance could be reduced by, without affecting the construction process. Certainly for some products, the wastage allowances would appear quite high.

Using different metrics (i.e. amount and value) can have a big impact on the results produced, a factor which should be considered when setting policy, particularly by Government and the Environment Agency. For instance, ceramic products have the second highest wastage allowances at 3 million tonnes with the equivalent value of £32 million; this contrasts to clay products, which have the same value but the waste amount is significantly lower at 288 million tonnes. Using these metrics in an appropriate manner is important – industry may be more focused on cost, whereas the Government and Environment Agency may be more focused on the amount of waste arising.

In terms of the amounts and types of products that are estimated to be recycled and land filled, concrete and ceramic products have the far highest recycling rates by quantity, but also the highest amounts destined for landfill. This shows that there is still much to do with these types of products and materials. Both these product groups have high estimated wastage allowances, which will affect the amount being recycled/land filled.

In terms of value, glass and raw materials have the highest value in terms of recycled products, with rubber and chemicals responsible for the highest value to be land filled. Chemicals are also likely to be hazardous at the end of their life. There seems to be little correlation between value and amount in terms of recycling and landfill.

These recycling and landfill rates are estimates, and another key recommendation is to obtain better data as to the actual fate of these products. It is also important to collect this data at the product level (as well as a material level) so resource efficiency can be implemented at the product level.

The top ten ‘wasted’ products by value are quite varied. They include inert materials such as primary aggregates, ready mixed concrete and precast concrete products.

However, there are also products which are likely to have a greater environmental impact at the end of their life, such as floor coverings, light fittings, cables, pipes and ducting.

There seems to be little in common between the amount and cost of the products that are wasted, though this could be because of the lack of data regarding quantities of product. By amount, materials that are inert at end of life are commonly present, but other materials such as plasterboard and wood flooring are also present.

Looking at products that are landfilled by value, there are a number of products whose impact may be greater at end of life, such as paints and finishes, insulation and light fittings. The top products that are landfilled by amount are similar to the ones that are wasted by amount – this similarity is probably due to the lack of data. Products with higher recycling rates include concrete, timber and steel, which is likely to be due to the increased attention that has been paid to these products in recent years.

Table 32 shows a matrix of the top 10 products to illustrate any commonality between those products which have high wastage rates (by amount/value), estimated to be landfilled (by amount/value) and estimated to be recycled (by amount/value). It shows that for most products there is little correlation between value and amount, except for other precast concrete products and ready mixed concrete, which are in the majority of the top 10 lists. Certain products, such as ceramic tiles, wood chips etc and wood flooring, appear in the top 10 lists for the most being land filled (by amount) and recycled. Those products that have high landfill rates (either by amount or value) but lower recycling rates include cement, factory made mortars, light fittings, paints and finishes, pipes and ducting and plasterboard. This suggests that more attention should be paid to some of these products, especially those which are considered to have a higher environmental impact at the end of their life.

It should be noted that these wastage allowances do not include any specific information on packaging materials. The cost of the packaging per product would be part of the overall cost of that product and therefore would be included in the value of the wastage allowances. However, the amount and type of packaging would not be included in the datasets used, so this is an 'extra' waste that needs to be considered.

Resource usage at a project level shows that there is both a cost for materials going into a project as well as materials going out (in terms of waste). Savings can be made through better site waste management, especially when working on larger projects whereby segregation, including labour costs, shows economic savings. This is working on the assumption that all materials are segregated. This is important in terms of increasing recovery of materials and complying with legislation such as the Landfill Regulations.

It has not been possible to compare the wastage allowance data with that of waste arisings. Therefore, a further recommendation is that product waste management data should be collected at the project level, thus showing the resource efficiency for a product within a certain project. Consultation with stakeholders has shown that the actual cost of waste and the cost of implementing SWMPs is relatively unknown and is often absorbed into project costs. It is therefore important that these costs are clarified, in order to reduce them and associate cost savings with them. Indeed, this report is the first attempt at costing waste allowances at both a national and project level. The office development data shows that the overall cost of waste is around £185,000, clearly a significant amount. The same is also true for houses and the bridge development.

For offices, services are responsible for the largest proportion of overall wastage cost, though they also have the highest purchasing cost. For houses, the largest savings can be made for the superstructure, and for the bridge it is the structural concrete. This demonstrates that when looking at reducing these wastage allowances it has to be

done at a project level, as projects vary widely in terms of the types and amounts of materials used.

It is clear that reducing wastage allowances has a positive effect in terms of reducing the cost of materials brought onto a project and reducing the amount of waste created and its associated costs, i.e. there is clearly a double saving to be made. A reduction in wastage rates for common materials will also have a good positive effect. Analysis on plasterboard shows that it is cheaper to collect waste plasterboard for recycling using a Wheelie bin collection fleet than using skips to dispose of it in landfill.

Table 32: Analysis of the top 10 products

Top 10 Product	Wastage allowance by amount	Wastage allowance by value	Estimated to be landfilled by amount	Estimated to be landfilled by value	Estimated to be recycled by amount	Estimated to be recycled by value
Air conditioning units						
Board and timber sheet products						
Boilers						
Cables – mostly copper with plastic based sheathing						
Cement						
Ceramic Tiles and Flagstones (Glazed and Unglazed)						
Commercial Glazing						
Concrete blocks						
Door/window fittings						
Floor coverings						
Glass: replacement doors and windows						
Heavy sections and beams >80mm (steel)						
Housebuilding: doors and windows						
Insulation						
Light fittings (Luminaries)						
Mortars - factory made						
Non refractory clay building blocks						
Other precast concrete products						
Paints, finishes						
Pipes and Ducting						
Plasterboard						
Prefabricated structural components (steel)						
Primary Aggregates						
Pumps						
Ready mixed concrete						
Secondary aggregates						
Wood chips, sawdust, shavings, peelings etc						
Wood flooring						

7. Conclusions

This report provides key evidence in terms of the resource usage in the construction industry at a national, project and product specific level. This evidence can be used to both influence industry and policy and for prioritising actions on certain materials and products. Construction products market data has been analysed in terms of typical wastage allowances for these products once they are specified for use on construction projects, and on the resulting waste management options for these wastes. Key headline figures at a national level for resource usage are as follows:

- Every year it is estimated that 10 million tonnes of construction product waste arises as a result of waste allowances;
- Nearly two-thirds (61 per cent) of the volume of these construction products are estimated to be land filled;
- Over £1.5 billion of construction products are estimated to end up as waste as a result of waste allowances every year;
- Nearly 60 per cent of these construction products are estimated to be landfilled (by value), equivalent to over £900 million;
- Products with the highest recycling rates are hardware metals and heating systems;
- The top 10 products estimated to arise from waste allowances represent 95 per cent of all products (by amount) and include ceramics, concrete, cement and blocks;
- The top 10 products estimated to arise from waste allowances represent nearly two-thirds by value, and include items such as primary aggregates, glazing, precast concrete, paints and finishes and floor coverings;
- By value, paints and finishes, floor coverings and light fittings have the highest landfill rates;
- By amount, ceramics, concrete and cement have the highest landfill rates, but also the highest recycling rates;
- By value, primary and secondary aggregates and glazing have the highest recycling rates;
- There is a lack of suitable data on the construction products market for items such as security fire protection systems, plumbing, bath and sanitaryware fittings, rubber and slate.

Three distinct projects (house, office and a bridge) have been analysed in terms of their waste allowances for materials going in to the project, and the cost of waste coming out of the project i.e. waste disposal. Key headlines from this exercise include:

- A waste allowance of nearly £27/m^2 has been costed in for a typical office development, equivalent to 2.6 per cent of the overall cost;
- Services provide the largest opportunities for savings based on waste allowance costs for a typical office development;
- It is cheaper to send waste off as segregated rather than mixed for an office development (including labour costs);
- The overall cost of waste is estimated to be around £40/m^2 for an office development (4 per cent of overall cost) including labour, materials and disposal;
- Nearly £30/m^2 has been factored in for wastage allowance for a typical house, which is 2.7 per cent of overall cost
- For 30 houses, the estimated waste allowance is estimated to be £125,000;

- Most savings can be made for the superstructure, especially for the roof and external walls;
- It is economical to segregate waste for 30 houses, with cost savings of £7,000 equivalent to £1.62/m^2;
- For a bridge, structural concrete represents the best opportunity for savings, with wastage allowances at 5 per cent of total cost;
- Segregating waste from a typical bridge development leads to cost savings of £0.83/m^2.

To provide information on costs once waste leaves a site (and the associated benefits of recovery), treated timber, insulation and plasterboard waste have been reviewed. Key headlines figures for these products are as follows:

- It is estimated that £156 of insulation is 'wasted' per house and a further £270 is required for the removal of it, equating to over £12,000 for 30 houses;
- For both offices and houses it is much cheaper to use a collection fleet of wheelie bins for plasterboard waste;
- For treated timber it is currently cheaper to land fill than send to an Energy from Waste recovery facility.

By looking at all the above figures it is obvious that there is great potential for the construction sector to become more resource efficient. This is especially true considering the continued growth in output, with Government policies increasing the number of new houses, schools, prisons and hospitals etc. A significant difference can be made in terms of cost savings and environmental impact simply by reducing wastage allowances by 1-2 per cent for selected materials. This is true at both the project and sector level.

Many barriers have been presented with possible solutions and actions to reduce them. The recommendations clearly outline a role for each part of the construction supply chain in terms of resource efficiency. Of critical importance is that the sector works together under a common goal, helped along by Government and the Environment Agency. The Environment Agency can support this effort by providing appropriate support and guidance, both in a regulatory and advisory role. The development of the scorecards for new build, refurbishment and demolition projects is a key tool which the Environment Agency can use to engage with the industry to ensure legal compliance and promote continuous improvement in terms of site waste management. This should be considered particularly important in terms of the likely legislation of SWMPs in England by April 2008, and the role the Environment Agency can play in terms of supporting the industry and realising the associated environmental benefits.

8. Recommendations

Recommendations have been made in terms of the different roles of the key stakeholders and are outlined below. In addition, there are also a specific number of recommendations for the scorecard and how it could be rolled out for use in the industry.

Client/procurement process

It is important to address how a client can affect site waste management and push practices from standard to good/best. Commissioning clients can play a key role in encouraging improved waste management on the construction site. The appropriate choice of procurement route can deliver lower costs, higher levels of service and greater cooperation with the supply chain. Setting targets for waste minimisation sends the right signals to the tenderers about the client's commitment to the matter.

The procurement process encompasses the whole lifecycle of the project – from identification of the need, through the design, tendering and appointment processes, contract management, and on to the end of the contract. In order to encourage improved waste management and the greater use of recycled materials onsite, the procurement route adopted should tackle two key cultural habits:

- Lowest capital cost as the dominant value comparator;
- Lack of and/or late involvement of specialist contractors and suppliers in the design and planning process.

The most effective procurement process allows the client, designers, contractors and suppliers to work together as an integrated team, partnering with the joint aim of managing waste onsite. Clients with long experience of traditional procurement may find partnering a challenge, e.g. where they remain sceptical of the motives of the supply side. Contractors, on the other hand, are wary of giving too much away and taking on new risk in such situations. It helps if the lead comes from clients that want to demonstrate best practice, encourage innovation, and gain the support of the supply side. The choice of procurement route sends a clear signal about how a client wants to be seen by the industry and other stakeholders. Clients wishing to encourage waste minimisation and improved waste management should:

- Select procurement routes that include long-term relationships and continuous improvement targets, including improved onsite waste management;
- As part of procurement good practice:
    - Ensure that the clients' corporate objectives to encourage site waste management are incorporated into buying decisions;
    - Ensure that adequate internal expertise and knowledge of procurement routes are deployed;
    - Ensure that relevant management information on the implementation of procurement is collected across the organisation, including achieved levels of waste minimisation;
    - Establish training levels for staff and contractors on how to encourage better management of waste materials and how to manage the procurement process;
    - Provide corporate oversight and a mandate for the reduction of waste materials in construction projects;

- Consider early involvement of the supply chain in order to improve predictability, time and quality, reduce whole-life costs, and increase the opportunities for innovation – including reducing waste on sites.

Pretender/prequalification stage

Before issuing full tender documentation, it is cost-efficient to identify those potential contractors that will support the client's objectives and help to develop them further. This is achieved through a prequalification exercise in which prospective tenderers are asked to demonstrate credentials against criteria that are not readily quantifiable. Only those who meet certain criteria, for example their environmental policy and experience in the use of recycled materials, should be asked to submit a full tender. At this stage it could be specified that a SWMP should be used on the site, with the associated setting of relevant targets.

Prequalification is based on financial assessment, technical capacity and history of past performance. Suppliers should demonstrate that they have the technical and financial capacity to undertake the work, and that they have appropriate management systems, such as quality assurance, occupational health, safety and rehabilitation, environmental management and industrial relations.

It should be made clear that the client may choose to visit to verify claims. Clients wishing to encourage waste minimisation and improved waste management should:

- Invite prequalification tenders in order to evaluate tenderers' capability and approach to support the client's environmental objectives, including the prospective tenderer's approach to waste minimisation such as the use of SWMPs and a scorecard (see below);
- Ensure that environmental objectives, including the requirement to manage waste materials, have an adequate weighting (when scoring responses) to be seen by tenderers as a worthwhile "swing" factor;
- Ensure that the evaluation scoring process is communicated to the tenderers.

Tender documentation

The definition of client requirements in the tender specification is the key intervention point in the procurement process where policy objectives such as sustainability can be given force. At the tender evaluation stage, the client can create the incentive for more sustainable solutions to be offered, by making tenderers aware that greater credit will be awarded for them. Clients wishing to encourage waste minimisation and improved waste management should:

- Set outcome-based requirements for construction waste management and recycling in the tender specification. These requirements may include:
    - Quantitative minimum requirements and improvement targets for site generated waste to landfill (or recycling);
    - A requirement to agree targets for such parameters and demonstrate their achievement;
    - Minimum requirements for specific elements of work (such as percentage site generated recycled content in sub-base from demolition).

Where the client proposes to agree targets with the contractor once the contract has been established, the following should be put in place:

- The client and the contractor should set up a forum, which meets at least quarterly throughout the contract term to develop material use, agree specifications and record/compare sustainability data;
- The contractor will be required to provide baseline data, agree targets and demonstrate an improvement in waste minimisation and recycled materials/products year-on-year throughout any framework contract period.

At the tender evaluation stage, award credit to those tenders that most effectively contribute to the client's requirements and objectives, including those on waste minimisation and recycling. The way that tenders are to be evaluated should be made clear to potential contractors. Various criteria may be considered in identifying the most economically advantageous tender, including:

- Price;
- Time allowed for completion;
- Running or whole-life (maintenance) costs;
- Technical merit;
- Sustainability, including approach to the use of recycled materials and waste management.

Clients should also provide key support in terms of the construction phase of a project. This could include (and is not limited to):

- Monitoring performance against targets;
- Encouraging innovation;
- Rewarding good performance;
- Engaging with the Site Waste Management Plan and the project team with regards to waste.

Main contractors and subcontractors (including quantity surveyors)

Contractors and subcontractors are critical in terms of site waste management and improving resource efficiency. It is essential for contractors to have an understanding of the following:

- Type of waste being generated;
- Amount of waste being generated;
- Cost of the waste – quantity surveyors can play an important role here;
- Current waste management routes.

Once the baseline is known for the above information, appropriate targets should be set such as:

- Waste prevention targets (applicable to waste from new build/installation) - this can be based on limiting wastage allowances (e.g. % reduction), maximum material purchase, or a benchmark figure related to waste generation (with a % reduction related to this). Common metrics (key performance indicators) for waste generation are:

    - M^3 of waste / 100 m^2 of floor area
    - M^3 of waste / £100,000 project value

    Waste prevention is preferable as this is where the biggest impact will be for a company in terms of lessening environmental impact and reducing cost.

- Waste recovery targets, such as percentage diverted from landfill, percentage reused, percentage recycled etc;

- Other targets include 'zero net waste,' zero waste and waste neutral

Any targets set should also involve the supply chain and a full understanding in terms of subcontractors and the wastage they generate is required. SWMPs are an effective tool in developing this information and should include within them:

- Collection of data and subsequent review of data;
- Increasing awareness through training/toolbox talks;
- Looking at onsite procedures e.g. material storage, logistics;
- Working with waste management companies, including provision of waste equipment onsite;
- Working with the supply chain on areas such as over ordering, packaging etc;
- Feeding back recommendations (based on cost and environmental impact) to the project team;
- Integrating recommendations with company polices and procedures.

Obviously a certain amount of waste will also be produced from construction activities. It is therefore important that the waste is managed as effectively as possible. Important issues are to ensure that the waste is being reused/recycled with the least environmental impact and to ensure legislation is complied with. Areas that need to be considered are:

- Legal requirements of waste;
- Recovery options for waste;
- Waste management companies;
- Links with community/charity sectors;
- Development of new markets.

Again, knowing the amount and type of waste being generated has an important impact on what can be realistically achieved for the recovery of the materials/products. In terms of actual onsite management, contractors need to consider good storage, logistics – encouraging just in time deliveries, the use of consolidation centres and workmanship.

Contractors should also be encouraged to apply for environmental awards for good practice. Waste management often forms part of these and helps to raise standards, save money and provides excellent PR and market differentiation. They are also a useful tool to engage with stakeholders and the company board. Clients and other bodies, such as the Environment Agency, can encourage these awards or event set up their own award schemes.

Designers

Designers play a vital role in resource efficiency, with particular need for attention on the following areas:

- Designing the building/layout to reduce the overall amount of material resource usage e.g. consider floor areas, reduction in number of materials, avoid complex designs and encourage 'straight' lines etc. This will eliminate waste being produced. Obviously buildings and systems are not usually designed with the sole purpose to eliminate waste but avoidance of waste can be achieved within an overall design/sustainability framework.

- Designing out waste within the new build/fit out processes by using products/materials that aid waste reduction e.g. standard sizes, prefabrication, dry trades etc. This will minimise the amount of waste arising from installing these products/materials.
- Designing products/systems/buildings that are adaptable for further uses or can be disassembled. This would require working closely with manufacturers at the product design stage e.g. use of equipment which can be 'debranded', leasing systems.

It is important that designers are kept within a feedback loop in terms of the amount of waste generated onsite and the cause of this waste. The SWMP presents a good opportunity for this. If a designer knows how much waste was generated from a particular specification, this can then be targeted in future projects.

Manufacturers

Manufacturers play an important role in terms of delivering resource efficiency. Firstly, there need to be incentives to manufacture products which are durable and have a lower environmental impact overall, and in terms of resource efficiency use less resources and use recovered materials where environmentally beneficial. Manufacturers should also be encouraged to look at their product within a whole lifecycle approach, particularly considering products being designed and manufactured today have limited options in terms of recovery. A project being led by BRE, known as BE AWARE, is working with the whole supply chain to look at a number of specific products and address resource efficiency throughout the lifecycle of that product (BRE 2007a).

Secondly, manufacturers should be encouraged to take back surplus materials/products (which could be a result of over ordering and wastage allowances), ensuring that the products go back into the construction cycle. In terms of packaging, more manufacturers are being encouraged by Government and their clients to ensure that packaging used is appropriate for the product's needs and that packaging can be returned for reuse and recovery. As packaging waste can account for up to 50 per cent by volume on certain construction sites (BRE 2007a), it is still an area where action is required.

Manufacturers also need to be engaged with in the first instance in terms of lead in times to ensure products are designed specifically for use in order to reduce the amount of offcuts. Installation is another area where waste can occur, and it is therefore important that operatives have adequate training and knowledge on how to install products properly.

Voluntary agreements are a good example of manufacturers working together to minimise the amount of waste going to landfill. The Ashdown Agreement is a voluntary initiative between the Gypsum Products Manufacturers Association, the three plasterboard manufacturers (Knauf, Lafarge and British Gypsum and Government), outlining key actions and targets to reduce plasterboard waste (WRAP 2007b). DEFRA is also working on a number of product roadmaps, including plasterboard and window systems, in the context of lifecycle thinking.

Waste management companies

The waste management industry is responsible for managing waste effectively and providing suitable equipment both on and offsite for the construction sector. The construction sector and the waste management industry need to work in partnership in terms of developing solutions for waste with increased recovery rates. This involves

providing the waste management industry with the economic stability of being able to invest in new infrastructure through longer term contracts. The waste management industry needs to provide data back to the construction sector, especially in terms of SWMPs, and ensure the services it provides are legitimate. Smaller contractors need to be offered services which suit their needs and sites with space restrictions obviously need innovative solutions in terms of waste handling and storage. A key recommendation is for the waste sector (with the help of advisory bodies and the Environment Agency) to develop a certification scheme to promote the compliance and quality of the services it offers to the construction sector.

Regulators

The Environment Agency has an important role to play in terms of enforcing environmental legislation and also providing guidance and advice to reduce environmental impact. This dual role can be difficult. The Environment Agency needs to ensure that it is consistent in its application of environmental legislation (this is especially important in relation to waste licensing) and provides good in-house guidance and training to its staff. The Environment Agency should also be encouraged to move towards a more resource efficient approach for its enforcement activities to encourage greater reuse and recovery. For instance, requiring all builders to have a waste carriers licence for removal of waste (albeit waste that may be reused) may have an impact on the reuse/recovery rates for certain wastes. However, this has to be balanced with the threat of and environmental damage caused by environmental crime and flytipping.

Site Waste Management Plans provide the Environment Agency with a good opportunity to advise the industry (especially smaller contractors) in terms of how it can manage its waste effectively and continuously improve. The scorecards are a useful tool for this.

The Environment Agency is in a good position (with Government) to help enable the various elements of the supply chain to work together under a common resource efficiency goal and should assist the sector in providing clear and authoritative guidance. This could also include presenting its own good practices as a major construction client in terms of site waste management. The Environment Agency should be looking to work in partnership with key organisations in the construction sector, such as trade bodies and advisory bodies, to ensure greater awareness. The Environment Agency probably has more contact with the waste management industry than any other body or organisation and as such can provide a key role in facilitating the relationship between this sector and the construction sector.

Policymakers

The construction sector requires clear guidance in terms of policy development in resource efficiency. The recent Waste Strategy (DEFRA 2007b) and the Draft Sustainable Construction Strategy (DTI 2007) go some way to express Government's policies, targets and actions for the construction industry. The policymakers now must work in partnership with the industry, understand the issues the sector faces and meet the challenges together. A key requirement is to obtain better data at a project and sector level in order to provide evidence to set polices. Government should also set a leading example in terms of its own construction activities by, for example, specifying the use of Site Waste Management Plans and setting appropriate targets and disseminating good practice widely.

Scorecard

The scorecards developed as part of this project should be made available to industry via the Environment Agency. They could be downloadable from the NetRegs website with the associated user guidance and linked to the current guidance the Environment Agency has produced on SWMPs. To ensure good take up, they need to be freely available, be easy to access and remain quick and simple to undertake. The Environment Agency could also work with a number of trade associations to roll out these scorecards and tailor make them (if required) to their members; this would ensure a greater take up.

It is also recommended that the tool is used by Environment Agency staff and they are therefore trained in its use, especially those responsible for providing guidance and advice to the construction industry and those that may be responsible for enforcing SWMPs.

As a client, the Environment Agency could introduce these scorecards for its framework contractors and one-off projects and ensure that a continuous improvement methodology is set in place for waste management. This could provide a good example to other construction clients and encourage other clients to follow suit.

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Appendix 1

Breakdown of product groups

Product Groups	Products
Ceramics	Ceramic tiles and flags (glazed and unglazed)
Chemicals	Paints and finishes Additives, admixtures Coatings Bituminous finishes
Clay	Non refractory clay building blocks Non refractory roof tiles Non refractory clay building products Non refractory clay pipes Reclaimed bricks
Concrete	Concrete blocks: • Dense • Lightweight • Aerated • Concrete bricks Other precast products: • Tiles and flagstones • Roof tiles • Block paving • Paving and walling • Prefabricated structural components • Kerbs, culverts, lintels, channels • Pipes of cement, concrete or artificial stone Ready mixed concrete
Electrical and lighting	Lighting controls Light fittings Electrical accessories Cables Switchgear and control equipment
Glazed systems	Glazing
Hardware metal	Door/window fittings Building fittings and fasteners Cabinet makers fittings Copper construction products
Heating	Radiators Boilers Pumps Heat pumps Air conditioning units Fans and extractors

Product Groups	Products
Insulation	Insulation: • Glass wool • Rock (mineral) wool • Foam/polymer based • Cellulose based Membranes: • Membranes including damp proof coursing • Bitumen based and waterproof felts
Other cement	Cement Mortars – factory made Plasterboard Suspended ceiling tiles
Plastic	PVC in profiles Plastics pipes and ducting Damp proof course/membrane Decking and fencing
Plumbing, bath and sanitary fittings	Baths Sanitaryware Showers Taps and fittings (brassware) Copper pipe Plumbing fittings
Raw materials	Primary aggregates Recycled/secondary aggregates Growing media Materials used in bulk fills
Rubber	Roof tiles Floor coverings Carpet underlay Cement manufacture
Security fire protection systems	Alarm systems Security control systems Building management systems
Slate	Roofing – natural slate Architectural cladding Powder and granules
Steel	Heavy sections and beams >80mm Reinforcing bar Other hot rolled bar Wire rod Metallic coated sheet and strip
Timber	Timber by-products Manufactured joinery products Prefabricated structures – shed, conservatories, greenhouses Timber decking Roof trusses Wood flooring Board and sheet products Reclaimed wood

Appendix 2

Questionnaire

Background

The main objective of this work is to identify both the economic and environmental costs and benefits of more efficient practices on construction sites. This will be undertaken by including a review of current patterns of resource usage, a workshop to gain buy-in and access to data, a formulation of a model to evaluate the economic and environmental cost and benefits, analysis of any potential regulatory barriers and dissemination through a workshop to Environment Agency staff and a final report.

The study will identify and quantify the potential amount of materials savings (both in volume/tonnages and costs) that could be realised through good and best practice, as opposed to the baseline of legal compliance. The cost of implementation of good and best practice will also be analysed.

The tasks of the project are as follows:

- Carry out a review of existing resource usage in the construction sector in order to identify cost savings and target areas for improvement;
- Provide evidence to maximise the environmental benefits of Site Waste Management Plans;
- Model and evaluate the economic costs and benefits of three levels of practice: compliance, good and best practice.

This questionnaire/interview is seeking views on:

- Definition of compliance, good and best practice;
- Wastage rates on construction sites;
- Costs and benefits of waste management;
- Gain examples of evidence;
- Obtain buy in from delegates and future usage/sharing of information.

Waste arisings

One of the key objectives will be to identify waste arisings, including quantities, types, causes and when they occur in the construction programme along with costs.

Site waste

1. Site-generated waste might be categorised under a number of headings or streams such as:

- Temporary works (e.g. formwork, hoarding);
- Cutting to fit (e.g. plasterboard, blocks, joists);
- Over ordering (e.g. ‘ready mix’ concrete, bricks, plasterboard) ;
- Packaging (e.g. protection);
- Nugatory (e.g. reworking);
- Uncontrolled (e.g. water, paper);
- Late changes (e.g. design).

Do you agree with this list and can you think of more?

Barriers to waste recycling

2. What are the barriers to undertaking recycling site waste: Do you agree with the following statements?

- Manufacturers stress that the material must be free from all other debris;
- Board must be broken into small sizes to maximise efficiency;
- The waste lorry will take up more time in the loading bay, and we operate strict booking times for City of London sites - it will take ½ hour to load the waste;
- How long will it take to build up the load of waste?
- How much space will this take on our congested site?
- Will the weight of the waste impose too much load on the structure – city site?
- Handling of Waste regulations is too complex;
- Price for collection of plastic is per tonne. Construction sites do not produce enough plastic to make recycling collection (transport costs and time spent loading onto a lorry) viable;
- Plastic recycling plants are in the north of England, therefore high transport costs;
- Where would cardboard be stored onsite? Would it be a fire risk?

Have you any others?

Costs

How do you estimate the following?

- Quantities at SWMP stage (contract award);
- Cost of landfill (waste factor/contractor costs) versus onsite segregation (additional skips, labour, sub contractor costs, management, storage facilities).

Does the capital cost, size of project and type trigger a higher level of SWMP (currently the trigger threshold is expected to be £250,000)
Do you expect good and best practice to be a cost to the project, of neutral cost, or a cost saving?

Action points

If the huge amount of waste is to be avoided actions need to be promoted. Do you think the following action points are appropriate and can you add some others to the list?

- Circle of blame:
    - Contractor - site waste management is not undertaken because the client does not ask for it, not a legal requirement;
    - Clients – its a site issue, don't know how much it will cost me, not aware of benefits to me;
    - Designers – it will all be changed by the contractor so why bother?
- Workforce bonus schemes need to be changed to focus on quality work, not quantity installed per day, which encourages waste-making;
- Specific waste targets need to be set for each trade, in terms of waste material and rework costs;
- Plasterboard is the largest component of waste. This high waste cost can be reduced by:
    - Making sure it is precut at the factory, in height and width;
    - Setting up the bonus system to recognise quality, and penalise poor

quality work;
    - Protect vulnerable corners with waste cuttings of plasterboard;
    - Order specific requirements, not to the nearest 20 boards.
- Too much packaging is thrown away because it is cheap to produce. Other industries investigate alternative methods of re-usable packaging:
    - Waste disposal companies that do the final tipping at landfill sites pay by weight. Why then do clients pay by volume? Much site waste is lightweight – paying by volume costs the client money. Perhaps paying for waste disposal by weight;
    - If the Take Make Waste chain is to become a Take Make Use and Re-use chain there have to be stronger penalties for creating and disposing of waste in landfill. Until then, re-use and recycling will not happen;
    - Perhaps legislation to control packaging waste should be extended to the UK construction industry.
- Offsite fabrication:
    - Services (pipe and wiring looms, ductwork);
    - Staircases;
    - Balustrading;
    - Door sets;
    - Pods (toilets, bathrooms, kitchens);
    - Cladding;
    - Cassettes (floor, roof);
    - Pre-cut (timber joists).
- Design stage – design for minimum waste:
    - Dimensional co-ordination:
        - Brick, block;
        - Ceiling tiles, diffusers, fittings flash gaps;
        - Storey heights.
    - Offsite manufacture;
    - Can you influence the designer;
    - Steel versus concrete frame;

SWMP

This scheme is due to be introduced in 2008. Have you undertaken, or do you already undertake, a SWMP? Is there a trigger for undertaking a SWMP e.g. capital cost?

Do you agree with following statements?

- There is potential for SWMPs to provide companies and local authorities with significant benefits. A BREW survey found that C&D companies that utilise a SWMP find them a benefit, mainly financially, and not overly onerous;
- Few local authorities have implemented a requirement for SWMP in the planning process at present, with more looking to adopt them;
- There was a significant portion of local authorities that did not rate the introduction of SWMP highly;
- It was highlighted that should the benefits of SWMPs, especially waste reduction, be identified to local authorities then more would potentially be interested in its uptake.

Benefits

Do you agree with the following benefits of undertaking good and best practice SWMPs?

- Saves money;
- Improves productivity;
- Improves quality;
- Saves time ;
- Encourages ‘right first time’ and zero defects approach;
- Tidy and safe site;
- Reduced risk of:
    - Fire;
    - Contamination;
    - Injuries.
- Demonstrate improvement against Environmental Key Performance Indicators;
- Reduces environmental impact;
- Encourages early dialogue with supply chain;
- Supports company environmental policy;
- Differentiation;
- Marketing.

Appendix 3

Feedback from the Industry Workshop 23/4/07

DEFINITIONS

Do you agree with the definitions?

- Moving Target for best practice – updating?
- Poor compliance – can only improve on compliance/enforcement;
- Play around with words (poor and best standard);
- Gypsum minimum compliance?
- Good /comprehensive;
- Standard. Good. Best. Similar to H+S;
- Everyone has same understanding, need to use the same definitions;
- Waste hierarchy to classify;
- Is standard the minimum requirement?
- Hazardous waste – has to be legal requirement; segregation of hazardous waste should match scorecard, is it a legal requirement;
- Plasterboard - standard in the site segregation – otherwise agree with standard;
- Do not call it Site Management;
- Terminology matching BREEAM – Standard, G, VG, Excellent, 5 waste streams;
- Onsite vs. offsite segregation;
- Difference between good and best practice for segregation is others category - are there any more?
- Is reuse onsite or offsite? It's not clear;
- SWMP shouldn't be as standard, not everyone is doing currently;
- Columns - should those in standard be repeated?
- Doesn't match scorecard.

What else needs to be included?

- Take back (in segregation);
- Packing obligation compliance;
- Specifications for recycled content – standard/good/best – based on WRAP;
- Tools to use – SMARTStart, EPIs and KPIs;
- Prefabrication ;
- Hazardous waste producers licence;
- What about offsite construction – no waste onsite.

SCORECARD

- Fit into EMS;
- Need to be quick – 5/10 minutes to complete for subcontractors;
- More points for "Standard" (7= too low);
- Weighting so 33% standard, 66% good, 100% best;
- Definition/scorecard – link with waste hierarchy;
- Change point allocation system;
- Flashing red light when not meeting required standards;

- Pass/Fail options only for standard/compliance;
- Applicable to all contractors;
- Colour score overall versus points;
- Should be linked with Construction (Design and Management);
- Cost of management also;
- Labour cost;
- Would be better on A3;
- Why is standard required? It looks bad!
- Don't have as cumulative – more different to read;
- Good pre-contract - not contractually;
- Good - waste minimisation – KPI that have specified themselves;
- Best – segregated, WEEE should be removed;
- Advised most Mechanical and Electrical installations not covered;
- Check with Environment Agency;
- Exceeded not right word!
- Have are EPIs calculated? Has range been looked at? Have data been verified?
- Sample size?
- All New Build projects?
- Any refurbishment, any demolition onsite?
- Bigger differential between good and best;
- Caution over weightings;
- How is refurbishment considered? How is Demolition considered?
- Office/retail - hard to compare projects.

Usefulness/finalisation

- Internal use would be helpful and are likely to be put in pre-qualifiers?
- Scorecard – A3 not cumulative;
- More incentive;
- Would be good checklist to help within continuing SWMP.

Cost Model

- Detailed quantities not recorded/known;
- Overly detailed - information not available;
- £ - good for estimators/managers;
- Tonnages are needed for contractors;
- Waste figures more readily available;
- Every company has its own wastage figures;
- Suitable for Quantity Surveying;
- Use to provide information on specific products;
- WRAP/BREEAM/Waste combined;
- Top 5 Good Focus;
- Skip destination;
- Break even points for skips – Segregated vs non Segregated;
- On materials basis and wastage rates;
- Review skip costs;
- Review KPIs;
- Needs correct data;

Usefulness/finalisation

- Complex;
- Time consuming;
- Use as educational aid –inform project team;
- WRAP – common activities/linkage?
- Keep cost model and scorecard separate at moment, but flow together;
- Scorecard initial impact followed by cost model;
- 2 different levels;
- Discount onsite taken into consideration;
- CSCS cards – good but problem with language, but could link it;
- Consider markets for these tools?
- Which bits can we do at the moment, and then use appropriate one?

DATA

- Most Housebuilders should have the information;
- 100 developers;
- Contractors feedback wastage data regularly;
- Volunteered to comment on wastage rates;
- Use case studies to verify? Not possible as it's the prediction (estimates);
- Not actual arising onsite;
- Site Managers' knowledge.

Appendix 4

Breakdown of office waste cost per element

Description	Cost Total (£)	Waste cost per element(£)	Waste cost as % of total element waste cost
1.0 SUBSTRUCTURE			
1.1 Substructure (271 m2)	44,295.58	2,154.48	100
TOTAL	**44,295.58**	**2,154.48**	
2.0 SUPERSTRUCTURE			
2.1 Frame (932m2)	21,125.07	414.72	4
2.2 Upper Floors (614 m2)	77,792.54	2,644.95	27
2.3 Roof (403 m2 on plan)	59,901.45	2,101.73	21
2.4 Stairs ()	26,585.38	731.10	7
2.5 External Walls (614 m2)	68,310.26	2,040.03	21
2.6 Windows and External Doors (214 m2)	118,719.18	311.50	3
2.6.2 External doors (24 m2)	9,514.56	311.50	3
2.7 Internal Wall & Partitions (481 m2)	25,215.75	766.75	8
2.8 Internal doors (84 m2)	26,239.94	493.87	5
TOTAL	**433,404.13**	**9,816.15**	
3.0 INTERNAL FINISHES			
3.1 Wall finishes (1086 m2)	21,185.51	817.13	33
3.2 Floor finishes (779m2)	30,284.37	974.53	39
3.3 Ceiling finishes (809 m2)	28,401.66	715.55	29
TOTAL	**79,871.54**	**2,507.21**	
4.0 FITTING & FURNITURE			
4.1 Fittings	14,499.71	325.80	100
TOTAL	**14,499.71**	**325.80**	
5.0 SERVICES			
5.1 Sanitary Appliances	12,343.84	214.24	3
5.2 Services equipment	2,000.00	0.00	0
5.3 Disposal Installations	4,626.48	161.93	3
5.4 Water Installations	7,277.53	291.10	5
5.5 Heat Source	76,927.35	0.00	0
5.6 Space Heating	2,558.52	0.00	0
5.7 Ventilating system	5,666.94	0.00	0
5.8 Electrical Installations	88,124.33	4,626.53	75
5.9 Gas Installations	2,002.32	0.00	0
5.10 Lift & Conveyor Installations	23,759.66	415.79	7
5.11 Protective Installations	5,876.82	102.84	2
5.12 Communication Installations	7,870.75	137.74	2
5.13 Special Installations	1,300.00	22.75	0
5.14 Builders work	6,768.19	201.89	3
TOTAL	**247,102.73**	**6,174.81**	
6.0 EXTERNAL WORKS			
6.1 Site work	2,447.56	0*	0
6.1.1 Site Preparation	3,360.78	0*	0
6.1.2 Surface Treatments	47,815.93	2,119.04	83
6.1.3 Site Enclosure & Divisions	4,106.52	61.16	2
6.2 Drainage	13,753.24	357.28	14
6.3 External Services	16,784.20	26.27	1
TOTAL	**88,268.23**	**2,563.75**	
Preliminaries	**65,300.00**	**1,959.00**	100

* Assumed spread onsite

Breakdown of house waste cost per element

Description	Cost Total	Waste cost per element (£)	Waste cost as % of total element waste cost
1.0 SUBSTRUCTURE			
1.1 Substructure (86 m2)	12,681.77	597.89	100
TOTAL	**12,681.77**	**597.89**	
2.0 SUPERSTRUCTURE			
2.2 Upper Floors (55 m2)	2,398.77	136.95	9
2.3 Roof (110 m2 on plan)	15,928.62	524.58	33
2.4 Stairs (1nr)	1,423.02	41.73	3
2.5 External Walls (76 m2)	15,569.99	503.87	31
2.6 Windows and External Doors (35 m2)	17,790.92	33.36	2
2.7 Internal Wall & Partitions (153 m2)	6,250.82	113.58	7
2.8 Internal doors (40 m2)	9,405.95	246.42	15
TOTAL	**68,768.09**	**1,600.49**	
3.0 INTERNAL FINISHES			
3.1 Wall finishes (264 m2)	4,840.08	61.81	22
3.2 Floor finishes	3,824.88	172.05	62
3.3 Ceiling finishes (115 m2)	1,880.73	43.21	16
TOTAL	**10,545.69**	**277.07**	
4.0 FITTING & FURNITURE			
4.1 Fittings	4,645.38	199.44	100
TOTAL	**4,645.38**	**199.44**	
5.0 SERVICES			
5.1 Sanitary appliances	2,505.19	44.86	7
5.2 Services equipment	1,737.78	0	0
5.3 Disposal Installations	1,467.24	60.8	10
5.4 Water Installations	2,469.12	123.46	20
5.5 Heat Source	915.54	0	0
5.6 Space Heating	4,387.50	0	0
5.7 Ventilating system	398.07	0	0
5.8 Electrical Installations	5,262.03	394.65	63
5.9 Gas Installations	587.09	0	0
5.10 Builders work	1,315.52	0	0
TOTAL	**21,045.08**	**623.77**	
6.0 EXTERNAL WORKS			
6.1 Site work	16,151.19	249.20	53
6.2 Drainage	4,804.41	88.00	19
6.3 External Services	4,718.20	132.60	28
TOTAL	**25,673.80**	**469.8**	
Preliminaries	10,000.00	300	100

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The Environment Agency. Out there, making your environment a better place.

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