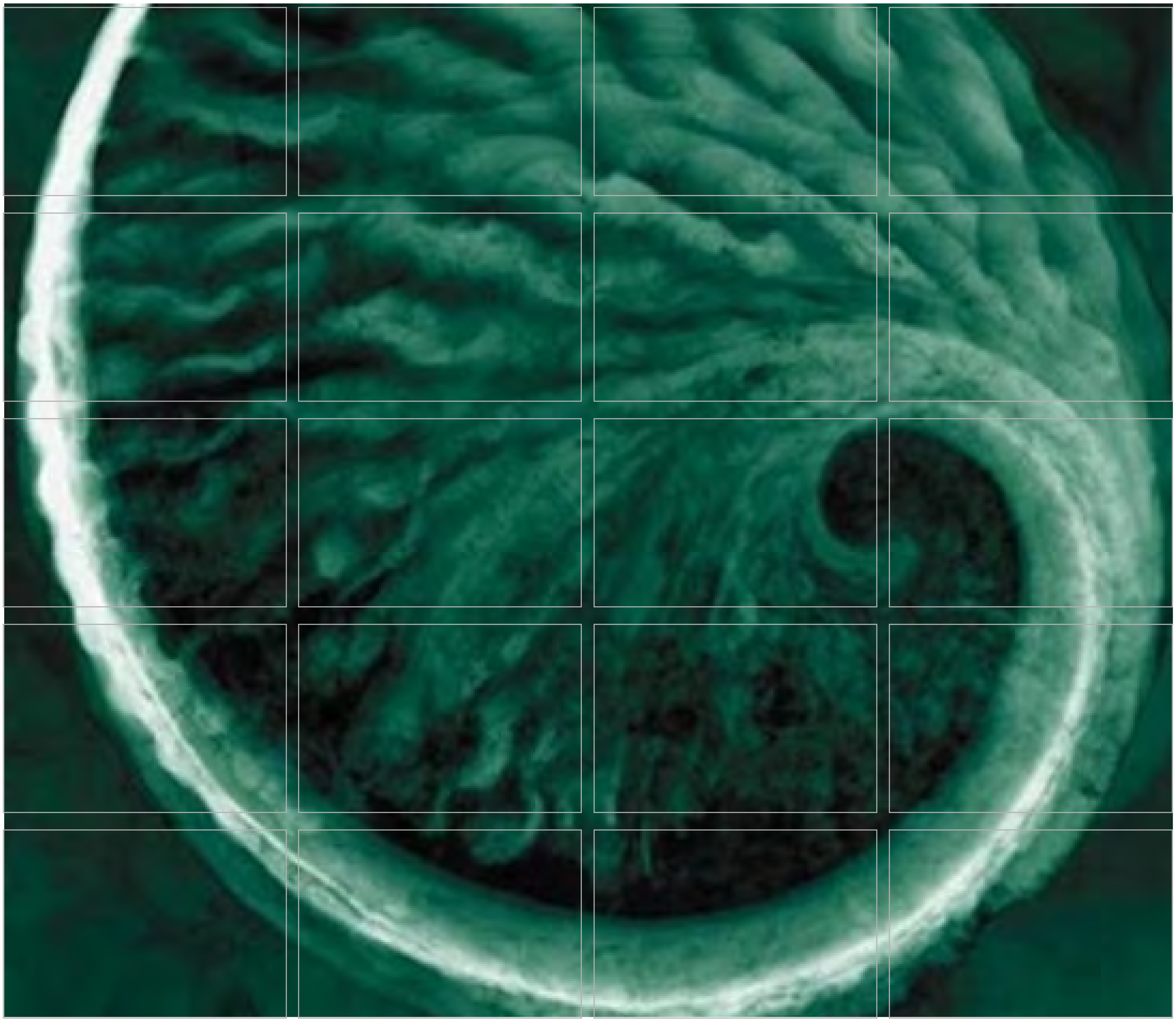
Annex D

Residual Waste Options Appraisal

The Joint Municipal Waste Management Strategy
for Herefordshire and Worcestershire 2004 - 2034

First review August 2011



Annex D Residual Options Appraisal July 2009

Updated with Appendix C January 2010

Environmental Report

January 2010

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Annex D Residual Options Appraisal July 2009

Updated with Appendix C January 2010

Environmental Report

January 2010

Prepared by Natalie Maletras

For and on behalf of
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Approved by: Paul Fletcher ______________

Signed: ________________________________

Position: Partner ________________________

Date: 15th January 2010___________________

EXECUTIVE SUMMARY

INTRODUCTION

The Joint Municipal Waste Management Strategy (JMWMS) is currently being reviewed by the waste disposal authorities of Worcestershire and Herefordshire, in partnership with their constituent waste collection authorities (the Partnership).

The JMWMS aims to promote waste minimisation but, inevitably, some residual municipal solid waste (MSW) will continue to be generated and will need to be managed. Residual waste managed by the Partnership is mostly disposed to landfill at present but this cannot continue due to changing legislation, the rising cost of landfill and a lack of capacity. Furthermore, the Partnership wishes to address the challenges of climate change and believes that, wherever possible, waste should be viewed as a resource.

A long list of possible options for treating the residual waste was developed for the Partnership to review. After consideration, the following final short list of options to be appraised was agreed:

- Option A – a single Energy from Waste (EfW) facility
- Option B – a single EfW facility with combined heat and power (CHP)
- Option C – two Mechanical Biological Treatment (MBT) facilities, located on two separate sites, one with on-site combustion.
- Option D – two MBT facilities each with off site combustion
- Option E – a single autoclave
- Option F – two autoclaves, located on separate sites
- Option G – EfW located out of county

The options listed above were assessed against a range of environmental, social and economic criteria. A workshop was held with both Officers and Members of the Partnership to agree the criteria and to ensure that any specific concerns that an authority had were identified.

The required capacity for the residual waste treatment facility(ies) is assumed to be 250,000 tonnes per annum. This is based on an assumed growth rate; predicted recycling and composting performance; and sending 10% of untreatable residual waste directly to landfill.

Assessment of the different options against the environmental criteria was undertaken using the Environment Agency's life cycle assessment tool - Waste and Resources Assessment Tool for the Environment (WRATE). The assessments against the remaining criteria were undertaken using both quantitative and qualitative appraisal methods.

The results of the appraisal are summarised below.

ENVIRONMENTAL CRITERIA

Criteria	Results Summary
Resource Depletion	Resource depletion potential estimates the amount of extraction of scarce minerals and fossil fuels. Option D was found to be the best performing option in terms of resource depletion because of the offsetting of fossil fuel used in the cement kiln. Option B performs well due to the conversion of waste into electricity and heat energy.
Freshwater Ecotoxicity	Freshwater aquatic ecotoxicity potential is a measure of the detrimental effects to aquatic organisms from exposure to toxic substances such as heavy metals. The results suggest that the recycling performance of the facilities is closely coupled with a favourable ecotoxicity score and options C-F score very well for this reason.
Greenhouse Gas Emissions	Global warming potential assesses the amount of carbon dioxide and other gases emitted into the atmosphere that cause global warming. Due to the increased efficiency of the plant in option B, it is by far the best option and although options E and F perform well in terms of reduced greenhouse gas emissions due to increased recycling, this is counter-balanced by the impacts associated with the actual treatment technology.
Air Acidification	Acidification potential relates to the release of acidic gases, such as sulphur dioxide, which can form 'acid rain' and damage ecosystems. Increased recycling in options E and F is again significant and these are the best performing options against this criterion. Option G is the worst performing due to the high impact of the treatment technology for this option.
Eutrophication	Eutrophication potential reflects the amount of nitrate and phosphate released. High concentrations of these compounds in water can encourage excessive algal growth, thereby damaging ecosystems through reduced oxygen supply within the water. Again, recycling strongly influences the result and options E and F are the best performing options in this assessment. The greater amounts of materials landfilled in options C and D results in lower scores against this criterion.

SOCIAL CRITERIA

Criteria	Results Summary
Health	Human toxicity potential is a measure of the impacts on human health and the results indicate that the majority of options have a beneficial impact, which can be accredited to increased recycling and the offsetting of burning fossil fuels. Options E and F perform best because they recycle the most. The creation of energy from waste in option B is also highly beneficial.
Transport	This accounts for the associated risks/impacts of transporting waste and assumes that the waste is moved by road. The greater the distance travelled, the worse the score, as more distance increases the risk of accidents, congestion and has a greater impact on local communities. Owing to the low levels of onward transport from the facilities, options A and B score well while option F performs the worst.

FINANCIAL AND RISK CRITERIA

Criteria	
Costs	The financial cost associated with each waste management option has been considered. Capital (CAPEX) and operational (OPEX) costs, landfill tax and the costs of landfill and hazardous landfill were all included in this assessment. CAPEX typically includes civil engineering works, all external works and all process plant costs while OPEX includes labour, maintenance, consumables, insurances and overheads. Option C has the largest total cost, closely followed by option D.
Reliability of Delivery	Newer types of waste treatment technology that are largely untested in the UK may face problems with both implementation and funding. Facilities that have not been shown to work at large scale in the UK are therefore given lower scores. Options E and F were the only options not to achieve the top score.
Planning Risk	The options involving the use of two sites are considered to incur the greatest risk as they require two Planning Permissions. Hence options C and D are considered to be the worst options in terms of planning risk. There are already planning approvals in place for two autoclave facilities within the authorities and so options E and F are assumed to have a low planning risk. A sensitivity analysis has been carried out to reflect the fact that the planning permissions for the autoclave facilities have since lapsed.
Compliance with Policy	This criterion assesses how closely each of the options matches national waste policy in terms of how the waste is managed. Government policy seeks to drive the management of waste up the waste hierarchy and the JMWMS aims to maximise value from the residual waste and use it wherever possible as a resource. Taking this into account, option B performed the best, followed closely by options E and F, due to the management of waste at or near the top of the waste hierarchy. In contrast, option C was found to be the worst because it involves a large amount of waste being sent for disposal.
Flexibility	The options were assessed for their flexibility in terms of ability to accept waste with differing compositions. This is important because waste composition can change in the short term, for example due to seasonal variations, and in the longer term due to potential changes to packaging material etc. Options A, B and G are the better performing options and can accept a relatively large range of waste compositions. Options C and D, on the other hand, require stricter controls over the mix of materials for their input. In terms of flexibility to varying quantities of input, option C performed well because additional capacity can be added in a modular fashion. Options D, E & F perform less well than C because they would typically require a minimum supply contract for the RDF and autoclave fibre. The worst performer against this criterion was option G.
End Product Liability	The options with the least liability associated with their end products, and therefore the best performing, are options A and B. Due to the relatively high risk associated with finding a market for the autoclave fibre, options E and F have the highest liability.

OVERALL RESULTS AND CONCLUSIONS

The appraisal has assessed each of the options against fourteen criteria. A ranking has been devised based on the performance against all of these criteria. The ranked order of options is shown in *Table 3.1.*
Option B scores the best overall; however the criteria were not weighted, so no criteria are assumed to be more important than any others. Members of the Partnership highlighted cost, reliability and resource depletion as the most important criteria. With the exception of cost, option B scored well against these key criteria. If the potential income from the heat generated by option B is also taken into consideration, this option will also have a lower overall cost than assumed by this assessment.

Option E was ranked second overall and scored well against many of the environmental criteria, however it did not score well against the resource depletion or reliability criteria and was scored as average against cost.

Option D performed very well in terms of resource depletion and reliability, but poorly in terms of cost. The overall ranking for option D was sixth, reflecting lower performance against compliance with policy, cost and some of the environmental criteria.

Option A also performed well against two of the key criteria - cost and reliability. It also finished third against resource depletion, the other key criterion, and finished third in the overall scoring. This was due to a lower performance against some of the environmental criteria.

Option G is the worst performing option. The reliance on an out of county facility means the option performed badly in relation to flexibility in terms of quantity of throughputs and also against the transportation criterion. This option also performs poorly against the environmental criteria. This is partly as a result of assessment assuming this option is similar to the Coventry EfW, rather than a new, more efficient, EfW technology. To assess the impact of this assumption, a sensitivity analysis was undertaken. This further analysis did change slightly the results of option G (moving it from 7th to 6th place). However, it didn't result in any significant changes to the top performing options.

CONTENTS

1 RESIDUAL OPTIONS APPRAISAL

1.1 INTRODUCTION

The waste disposal authorities of Worcestershire and Herefordshire, in partnership with their constituent waste collection authorities (the Partnership), are currently reviewing their Joint Municipal Waste Management Strategy (JMWMS).

A key principle of the JMWMS is to focus on waste minimisation and to promote the management of waste up the waste hierarchy. However, despite these efforts, there will continue to be an element of residual municipal solid waste (MSW) requiring management.

Currently the majority of residual waste managed by the Partnership is disposed to landfill. There are three primary reasons why this can not continue:

- **Legislation** - The Waste and Emissions Trading Act (2003) introduced the Landfill Allowance and Trading Scheme (LATS), under which challenging targets for the diversion of biodegradable municipal waste from landfill have been introduced for each waste disposal authority (WDA) in England. In the event of a WDA failing to meet its targets directly, they may purchase allowances from the other WDAs, if available, or borrow against future capacity.

- **Finance** – Landfill has historically been a relatively cheap option for WDAs however this situation has changed dramatically over recent years. Landfill tax is increasing to £48 per tonne from 2010. This, on top of gate fees increasing due to high demand plus the unknown costs of LATS allowances, means that the long term cost of landfill is no longer viable for many authorities and alternative treatment technologies are becoming price competitive.

- **Lack of Capacity** – The amount of landfill void space, suitable for residual MSW, is reducing across England. In simple terms, we are running out of holes to fill up. This is particularly the case in Worcestershire and Herefordshire, with local void space expected to run out by Summer 2023 (1).

Beyond the three reasons above, there is another key driver to divert waste away from landfill being highlighted by the JMWMS. This is to **address the challenges of climate change and viewing waste as a resource.**

In response to this challenge, a series of options for the introduction of residual waste treatment capacity for Worcestershire and Herefordshire have

(1) Based on 3.5 m3 current void remaining and an infill rate of 19,000 tonnes per month (October 2008)

been developed. These options are not intended to be prescriptive, and are not directly related to any site specific proposal. The purpose of this report therefore is not to identify '*the best option*' but to provide information on the advantages and disadvantages of various treatments to help guide and inform future strategic decisions regarding the treatment of residual MSW.

Having identified strategic options, methods were developed to appraise them objectively against a number of environmental, social and economic criteria. The purpose of this rigorous approach to options appraisal is to assist the Partnership with the strategic decision making process by identifying the potential environmental, social and economic benefits of each option.

1.2 DEVELOPING THE CRITERIA

A technical options appraisal requires that the performance of alternative options be assessed against key objectives, reflected through a range of criteria, in order to identify the option (or options) that perform best overall.

The criteria were not only used to indicate the environment and social impacts of the options, but also to demonstrate how they perform in relation to deliverability and cost.

As a basis for criteria selection, the draft Key Principles of the JMWMS and the Strategic Environmental Appraisal Objectives produced during development of the SEA of the JMWMS were reviewed. Some of the latter concerned more site specific issues, and thus were not appropriate for a strategic level assessment.

A workshop was held with both Officers and Members of the Partnership on 22 September 2008. This provided the opportunity to identify appropriate assessment criteria for Worcestershire and Herefordshire and ensured any authority specific concerns were identified.

The agreed criteria to be used for the assessment of the different options are as shown in *Table 1.1.*

Table 1.1 Criteria

Criteria Type	Criteria
Environmental Criteria	
	Resource Depletion
	Air Acidification
	Greenhouse Gas Emissions
	Freshwater aquatic ecotoxicity
	Eutrophication
Financial and Risk Criteria	
	Financial Costs
	Reliability of Delivery
	Planning Risk
	Compliance with Policy
	Flexibility
	End Product Liability
Social Criteria	
	Transport
	Health

It is essential that the chosen criteria help both to differentiate between the options and are able to be assessed in a robust manor. It is for these reasons that the issue of public acceptability has not been identified as a separate criterion. Any proposal for new infrastructure will be expected to generate an element of public opposition. This is particularly the case with waste management development. This is obviously a key concern to local authority Members and could cause delay in deliverability.

However, there is no evidence to demonstrate that the public are more or less accepting of any particular waste management technology. Opposition for new infrastructure is more often on the grounds of development of a certain site or related to local amenity issues (for example increased traffic) associated with the proposal rather than a focus on a particular technology type. For this reason it would not be possible for to differentiate between the options in this assessment.

A robust planning framework, and appropriate community engagement programmes, can help address misplaced perceptions and assist deliverability.

1.3 DEVELOPING THE OPTIONS

A facilitated workshop was held with the Partnership officers on 24 September 2008 to develop the list of residual waste options to be appraised and considered in the JMWMS.

1.3.1 *Developing a Long List*

A long list of generic technology types was initially identified. These are listed below:

- Mass burn incineration;

- Energy from Waste (EfW);
- Mechanical Biological Treatment (MBT) with Anaerobic Digestion (AD);
- MBT producing Refuse Derived Fuel (RDF);
- Gasification and pyrolysis (Advanced Thermal Treatment (ATT));
- Plasma Arc; and
- Autoclave.

1.3.2 Developing a Short List

The JMWMS aims to view waste as a resource and generate the most out of the residual waste it produces. For that reason mass burn incineration (combustion of waste without the generation of energy or heat) was not considered an option worth taking forward to the assessment.

Advanced Thermal Treatment (ATT) of untreated residual MSW has not been proven on a large scale in either the UK or Europe. It is essential that any option identified by the Partnership works and can be delivered. Therefore, it was considered to review the performance of ATT only in conjunction with a pre treatment technology (MBT) rather than in isolation. Plasma Arc technology was also felt to be in early development thus not suitable for further consideration at this stage.

In addition, the workshop considered the number and scale of facilities required. It is estimated the total residual treatment capacity required by the Partnership is ~ 250,000 tonnes per annum (tpa) (1).

Options were considered for provision of: one, two, or three or more facilities. The proposal for three or more facilities was dismissed as it was not considered appropriate for the capacity required in terms economies of scale and the risks associated with site availability and deliverability.

Currently the Partnership export ~ 30,000tpa of residual waste to the energy from waste facilities in the West Midlands. There are a number of operating and planned waste treatment facilities in the areas surrounding Worcestershire and Herefordshire. It was therefore deemed necessary to assess an option that utilises waste treatment capacity outside the Partnership area.

In consideration of all the issues identified above, the following final list of options to be appraised was agreed.

- Option A - 1 site EfW
- Option B - 1 site EfW with CHP
- Option C - 2 site MBT with on site combustion

(1)This figure is based on information provided in Annex A - Waste Growth Paper and Annex B - Recycling & Composting Assessment of the JMWMS

- Option D - 2 site MBT with off site combustion
- Option E - 1 site autoclave
- Option F - 2 site autoclave
- Option G - Out of county EfW

2 THE APPRAISAL

2.1 KEY ASSUMPTIONS

The waste minimisation and recycling & composting appraisals undertaken by the Partnership (Annex B & C of the JMWMS) as part of the review of the JMWMS provided the backdrop for this assessment.

Although a Key Principle of the JMWMS is to maximise diversion of waste from landfill, there will always be an element of residual waste not suitable for treatment and thus requiring landfill. For the purpose of this appraisal, it is assumed 10% of the residual waste will be untreatable.

The overall assumed residual treatment capacity required for the life of the JMWMS is 250,000 tonnes per annum. This based on the assumed growth rate; recycling and composting performance; and sending 10% of untreatable residual waste directly to landfill.

This assessment considers performance of a range of waste management options based on tonnage forecast to be produced in the year 2020. For the assessment of the environmental criteria, using WRATE, it is necessary to identify a specific year to assess. 2020 was identified to ensure full LATS obligations were acknowledged.

2.1.1 Residual Waste Composition

The composition of the residual waste is shown in *Table 2.1*.

Table 2.1 Residual Waste Composition as Forecast in 2020

Material	**%**
Paper and Card	16.28%
Plastic Film	7.30%
Dense Plastic	6.27%
Textiles	3.27%
Absorbent Hygiene Products	4.31%
Wood	0.56%
Combustibles	0.65%
Non Combustibles	6.62%
Glass	3.87%
Organic	46.86%
Ferrous	1.82%
Non Ferrous	0.66%
Fines	0.70%
WEEE	0.57%
Special Household Hazardous Material	0.25%
Total	100.00%

*Data calculated from recycling and composting model outputs provided by Worcestershire County Council (U131.02.02.02.01 081001 - Waste Analysis NI192 43.13percent.xls)

2.2 *ENVIRONMENTAL CRITERIA*

Assessment against the environmental criteria was undertaken using the Waste and Resources Assessment Tool for the Environment (WRATE). WRATE is a model, developed by the Environment Agency and promoted by Defra. Although WRATE is a useful tool to compare and assess waste treatment options, and every effort is made by the Environment Agency to update and verify data included within it, it is a model and therefore the results should be read with appropriate consideration.

Appendix A presents an explanation of WRATE and the assumptions used within the WRATE modelling.

2.2.1 *Resource Depletion*

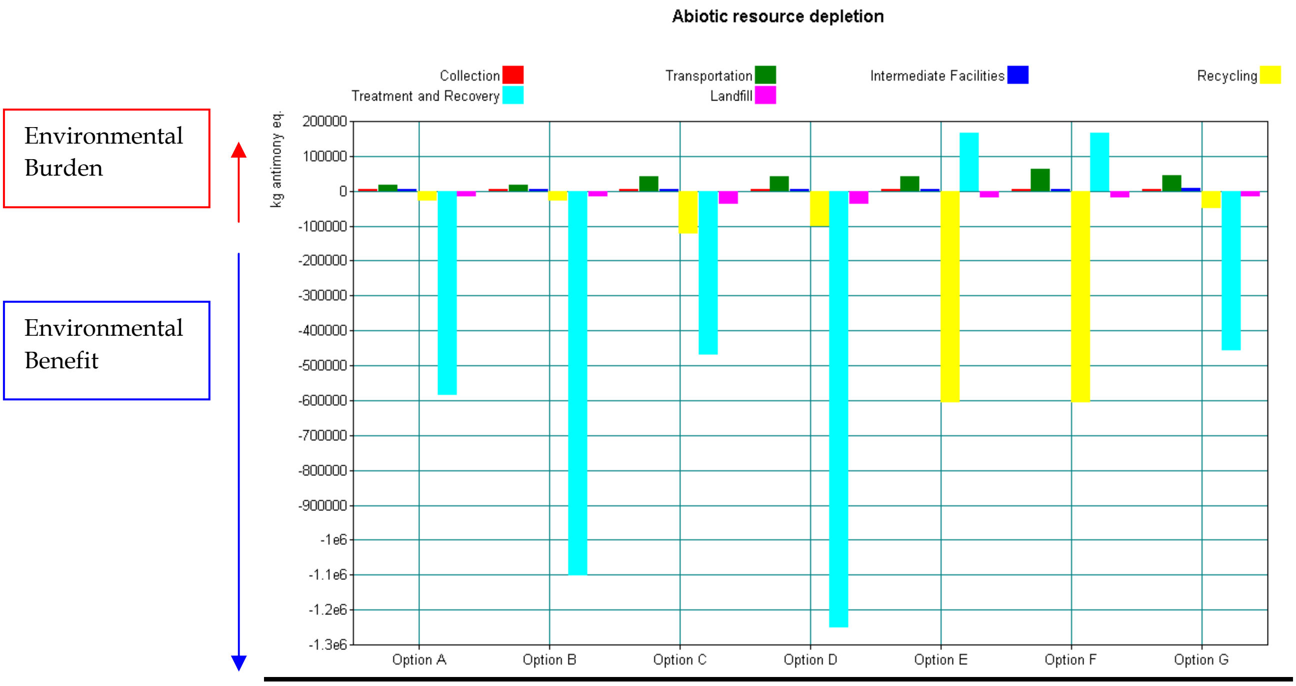
Resource depletion potential estimates the extraction of scarce minerals and fossil fuels. An abiotic depletion factor is determined for the extraction of each mineral and fossil fuel based on the remaining global finite resource reserves and their rates of extraction. The measurement used is kilograms of antimony equivalents. The results of this assessment are presented in *Table 2.2* and *Figure 2.1.*

Table 2.2 Resource Depletion Results

	Unit	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Abiotic resource depletion	kg antimony eq.	-601,000	-1,120,000	-578,000	-1,336,000	-405,000	-384,000	-462,000
Rank		3	2	4	1	6	7	5

NB: negative numbers represent an environmental benefit. The larger the negative number, the larger the environmental benefit.

Figure 2.1 Resource Depletion Results Chart



The table and chart above show that option D is the best performing option against the resource depletion criterion. This is due to the use of the RDF from the MBT facility as a fuel at a cement kiln. WRATE scores this favourably as it offsets the use of fossil fuels in the kiln. Option B performs well due to the conversion of waste into electricity and heat energy. Options E and F perform very well for the level of recycling that is carried out, however the impact associated with the treatment due to the heating of the waste, means that they do not perform as well as options A-D.

2.2.2 *Freshwater Ecotoxicology*

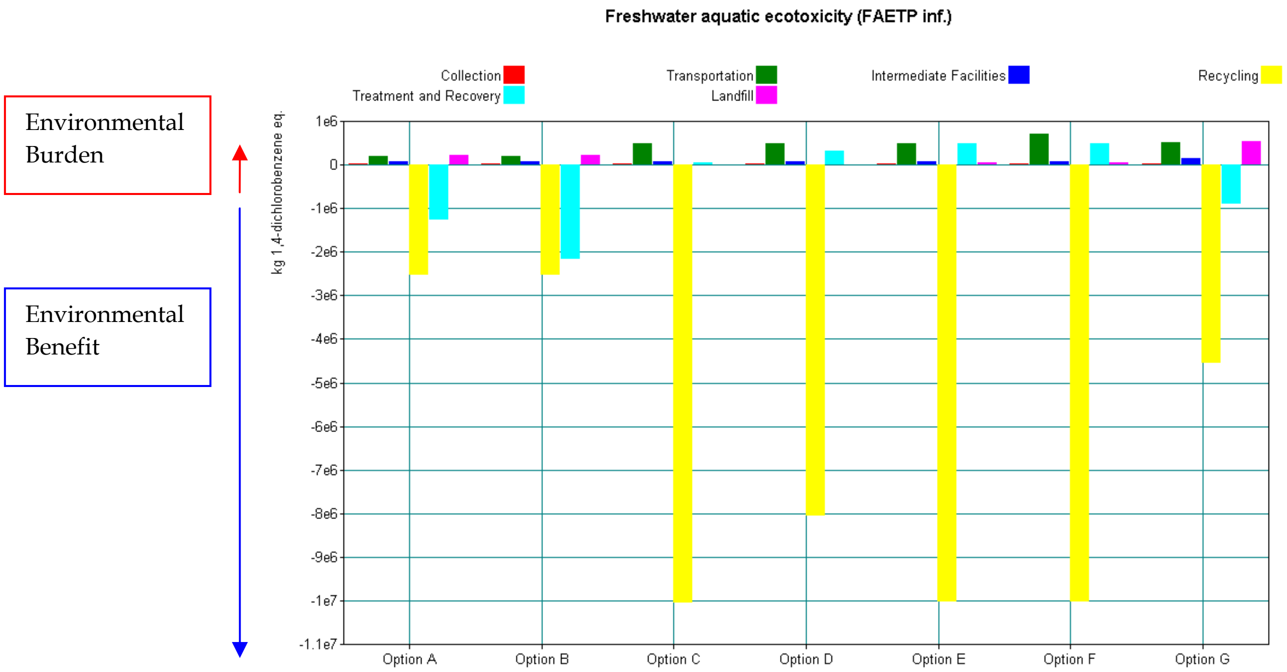
Freshwater aquatic ecotoxicity potential is a measure of the adverse effects to aquatic organisms that result from being exposed to toxic substances. It is well known that fish can 'bioaccumulate' concentrations of mercury and other toxins. Mobile heavy metals are extremely toxic to aquatic life, so activities that reduce releases of heavy metals will be favourable in this assessment.

Table 2.3 Ecotoxicity Results

	Unit	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Freshwater aquatic ecotoxicity	kg 1,4-dichlorobenzene eq.	- 3,260,000	- 4,158,000	-9,396,000	-7,114,000	- 8,877,000	- 8,639,000	- 4,203,000
Rank		7	6	1	4	2	3	5

NB: negative numbers represent an environmental benefit. The larger the negative number, the larger the environmental benefit.

Figure 2.2 Ecotoxicity Results Chart



The results for ecotoxicity are closely linked to the recycling performance of the facilities. This is due to the avoided burdens of primary production of virgin materials as these are replaced by recovered materials. Non-ferrous metals have a particularly large effect due to the high levels of energy used to extract the virgin materials. Options C-F score very well due to the increased level of recycling in these options. Option D does not score as highly as there is no output of bottom ash to be recycled from the cement kiln.

2.2.3 Greenhouse Gas Emissions

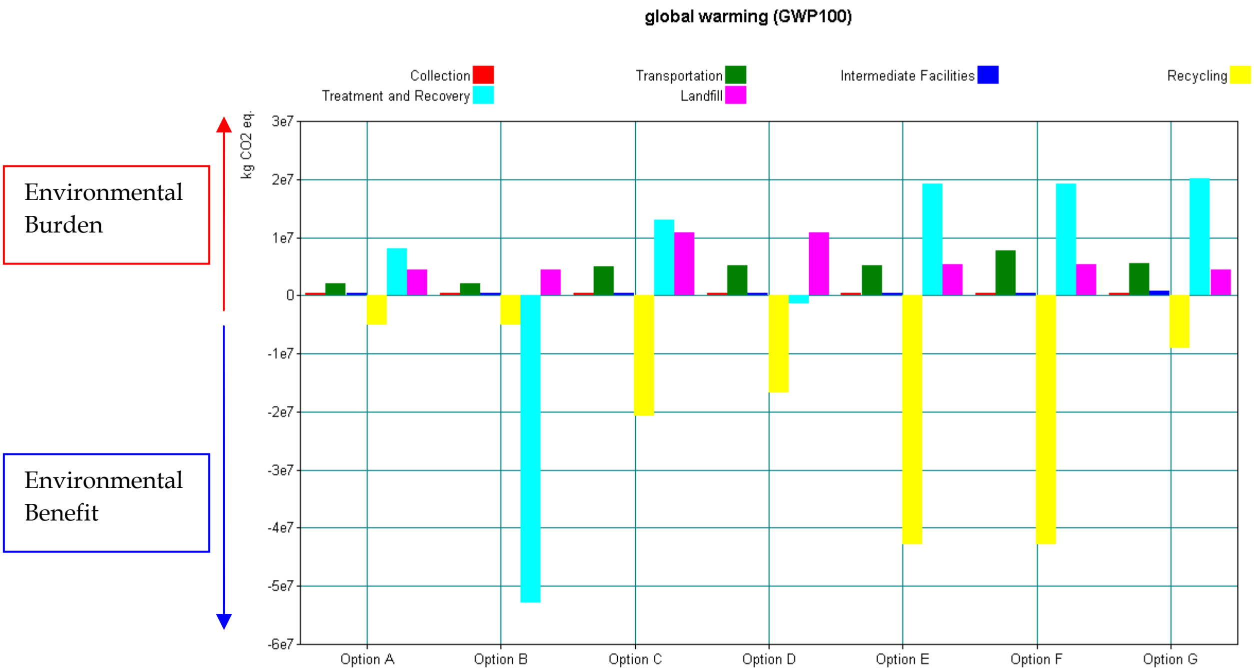
Global warming potential is an assessment of the amount of carbon dioxide and other gases emitted into the atmosphere that cause global warming. Apart from CO_2, the other major greenhouse gas is methane, which is 23-times more potent than CO_2. The measurement used in this assessment is CO_2 equivalents.

Table 2.4 Global Warming Results

	Unit	Option A	Option B	Option C	Option D	Option E	Option F	Option G
global warming potential (GWP100)	kg CO2 eq.	10,555,000	-50,573,000	8,851,000	-1,150,000	-12,265,000	- 9,809,000	22,486,000
Rank		6	1	5	4	2	3	7

NB: negative numbers represent an environmental benefit. The larger the negative number, the larger the environmental benefit.

Figure 2.3 *Global Warming Results Chart*



Option B is by far the best option in terms of global warming potential due to the increased efficiency of the plant which produces heat energy as well as electricity. Options E and F also perform well in terms of reduced greenhouse gas emissions. The increased level of recycling under these options is the driving force for this result; however this is tempered by the impacts associated with the treatment technology itself.

2.2.4 *Air Acidification*

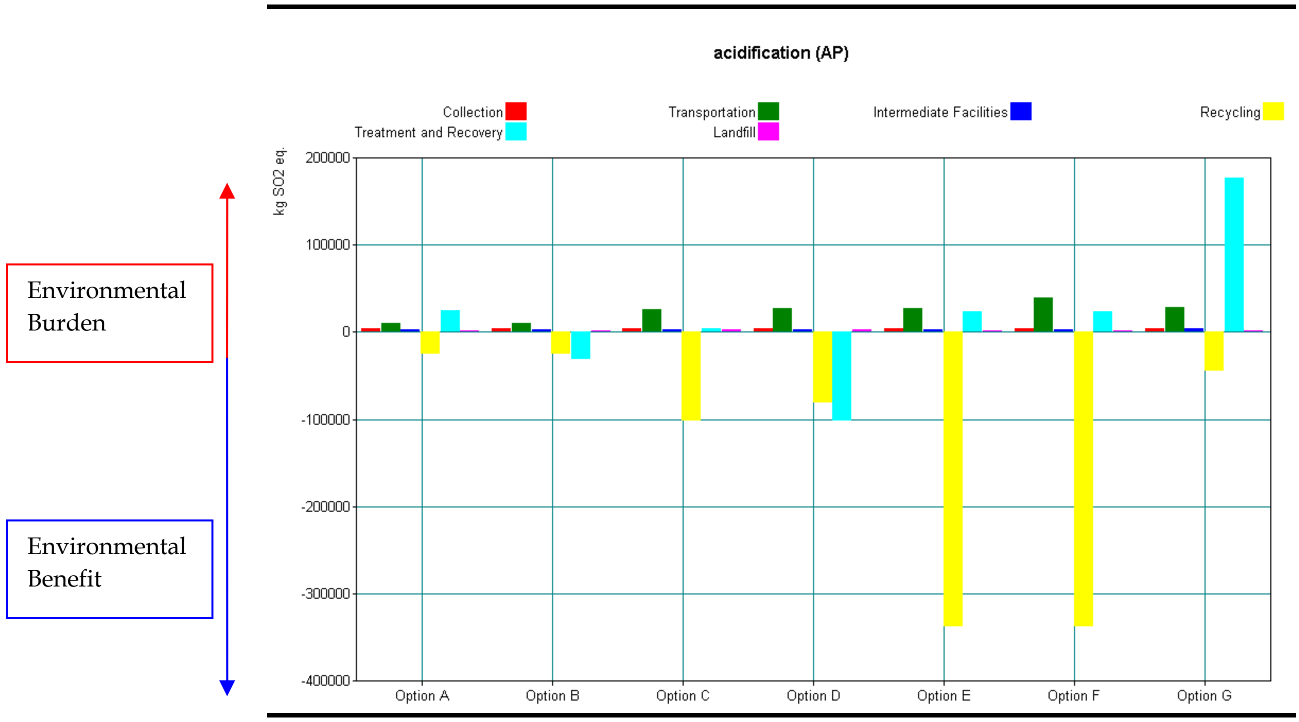
Acidification potential relates to the release of acidic gases such as sulphur dioxide. These have the potential to react with water in the atmosphere to form 'acid rain', causing ecosystem impairment. Kilograms of sulphur dioxide equivalents is used as the unit of measurement in this assessment.

Table 2.5 *Acidification Results*

	Unit	Option A	Option B	Option C	Option D	Option E	Option F	Option G
acidification (AP)	kg SO2 eq.	17,000	- 38,000	- 63,000	-148,000	- 279,000	- 266,000	170,000
Rank		6	5	4	3	1	2	7

NB: negative numbers represent an environmental benefit. The larger the negative number, the larger the environmental benefit.

Figure 2.4 *Acidification Results Chart*



Options E and F are the best performing options in this assessment; the increased recycling having a significant impact once more in this criterion, again due to the avoided burden of extracting raw materials and the use of recovered materials instead. Option G is the worst performing option with a high impact relating to the treatment technology specific to that option (Coventry EfW).

2.2.5 *Eutrophication*

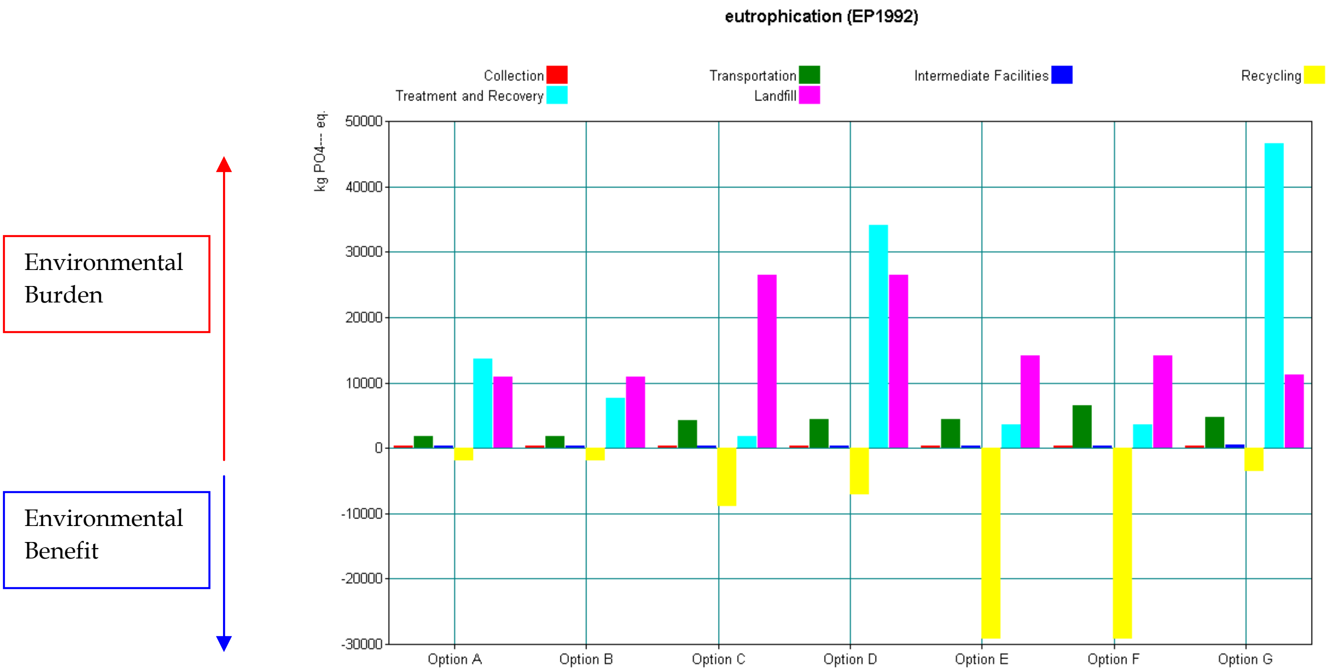
Eutrophication potential is a reflection of the amount of nitrate and phosphate released. Nitrates and phosphates are essential for life but increased concentrations in water can encourage excessive growth of algae, reducing the oxygen within the water and causing damage to ecosystems.

Table 2.6 *Eutrophication Results*

	Unit	Option A	Option B	Option C	Option D	Option E	Option F	Option G
eutrophication (EP1992)	kg PO4--- eq.	25,000	19,000	24,000	58,000	- 6,000	- 4,000	60,000
Rank		5	3	4	6	1	2	7

NB: negative numbers represent an environmental benefit. The larger the negative number, the larger the environmental benefit.

Figure 2.5 Eutrophication Results Chart



Options E and F are again the best performing options in this assessment; the increased recycling appearing to be the deciding factor once more. The higher level of landfill has a significant negative impact on options C and D.

2.3 SOCIAL CRITERIA

2.3.1 Health

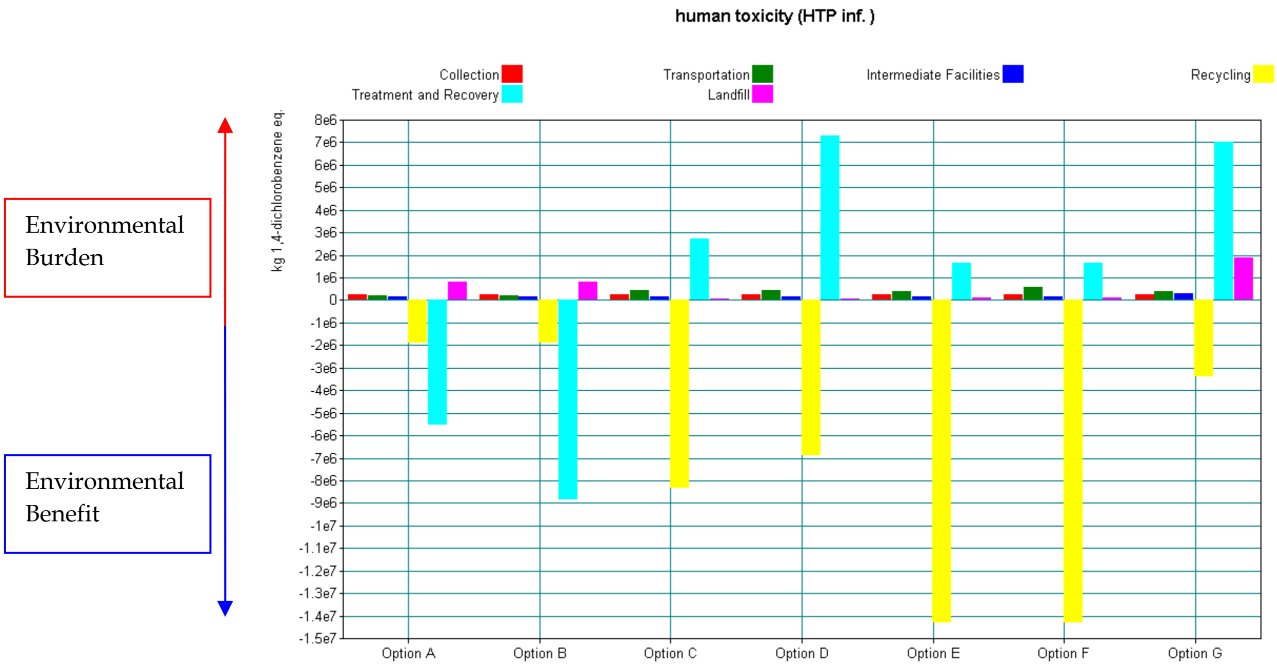
Human toxicity potential is a measure of the impacts on human health. Characterisation factors, expressed as Human Toxicity Potentials (HTP), describe fate, exposure and effects of toxic substances for an infinite time horizon. WRATE is also used to compare the different options against this criterion.

Table 2.7 Health Results

	Unit	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Human toxicity potential	kg 1,4-dichlorobenzene eq.	- 6,002,000	- 9,315,000	-4,687,000	1,358,000	-11,753,000	-11,543,000	6,487,000
Rank		4	3	5	6	1	2	7

NB: negative numbers represent an environmental benefit. The larger the negative number, the larger the environmental benefit.

Figure 2.6 *Health Results Chart*



The health criterion is often an emotive issue and is one that requires clear interpretation. The method used in this assessment is only a (partial) indicator. The results show that the majority of options have a beneficial impact on human health. This is due to the avoided health impacts associated with increased recycling and the offsetting of burning fossil fuels. Option E and F are the best performing as they are the options that recycle the most. Option B also has a highly beneficial effect due to the offsetting of burning fossil fuels by creating energy from waste instead. The results from this assessment are indicative and are based on an impact assessment method from *CML (1999) Problem oriented approach HTP inf. (Huigbregts, 1999 & 2000).* Any technologies that were to be procured by the Partnership would need to adhere to strict EA emission standards and as such the impacts highlighted in this assessment are within those standards.

2.3.2 *Transport*

This criterion takes into account the associated risks/impacts of transporting waste. All of the options assessed assume that waste is moved by road because the alternatives of rail and water transport are not considered feasible in the medium term. The comparison is therefore measured in annual kilometres travelled by the vehicles used in each scenario, this is provided by WRATE. WRATE takes the amount of waste being moved per year, divides it by the payload of the vehicle and then multiplies this by double the assumed 'one-way' distance. This gives the number of kilometres needed to be covered annually to move the waste under each option. The higher the number of kilometres travelled, the worse the score, as more kilometres means greater risk of accidents, increased congestion and a greater impact on local communities.

The specific location of the new facility/facilities is currently unknown and therefore, for the purpose of this assessment, indicative locations have been used. Once specific site/s are indentified, a more detailed, site specific, transport appraisal will be undertaken. *Appendix A* gives details of the assumptions behind the transport distances used in WRATE and thus this assessment. *Table 2.8* presents the results of the transport assessment.

Table 2.8 ***Transport Results (Total Annual Kms)***

	Upfront	Transfer	Onward	Total	Rank
Option A	631,532	896,297	447,573	**1,975,401**	**1**
Option B	631,532	896,297	447,573	**1,975,401**	**1**
Option C	953,687	1,186,134	2,874,519	**5,014,340**	**3**
Option D	953,687	1,186,134	3,139,231	**5,279,052**	**4**
Option E	631,532	896,297	4,155,863	**5,683,691**	**5**
Option F	953,687	1,186,134	6,056,223	**8,196,044**	**7**
Option G	1,161,047	4,215,895	748,085	**6,125,027**	**6**

Options A and B score well in this assessment and this is due to the low levels of onward transport from the facilities in comparison to the other options. Option F leads to much higher levels of transport overall because the recyclate separated from the process needs to be transported for onward reprocessing. This, coupled with the fact that there are two facilities assumed in this option, one of which is quite far from the assumed destination for the fibre recycling facility (where much of the output from the Autoclave goes), gives a high level of transport attributed to this option. Options C, D and E are all very similar, and considerably less than option F. A new transfer station is assumed to be built at site A (used in the one site options) to bulk waste from the districts prior to delivery to the EfW for option G.

2.4 *FINANCIAL AND RISK CRITERIA*

2.4.1 *Costs*

The financial cost associated with any waste management option is obviously a key consideration for the Partnership. The authorities have a responsibility to deliver value for money services to their residents and to make the most of the council tax funds available to them.

The costs in this assessment are not necessarily indicative of actual costs currently being incurred for ongoing contracts but do provide representative costs for comparison of the technologies being considered here for new contracts.

CAPEX and OPEX have been established from a review of publically available sources (e.g. Defra Waste Strategy 2007 and New Technology Demonstrator programmes, Local Authority PFI and Procurement documents and published reports), and by obtaining information directly from operators of existing facilities.

Capital and operating cost data in the public domain for each technology varies significantly, and is dependant on the specific plant configuration, design and local circumstances. We have used a variety of sources and example costs where available for each option, and produced costs based on an average of these sources. Where cost sources are not current (financial year 2008) an uplift has been applied to reflect inflation.

The approach taken has used the standard Discounted Cash Flow (DCF) techniques as set out in HM Treasury Green Book and costs are presented as Net Present Value. Capital costs are based on either facilities of a > 200,000 tonne per year capacity, or two > 100,000 tonne per year capacity as indicated in *Table 2.9*.

CAPEX generally includes:
- civils
- external works
- all process plant

OPEX generally includes:
- labour
- maintenance
- consumables
- insurances
- overheads

Table 2.9 ***Capex and Opex Costs – over 25 year period***

Option	Technology	Capex £million	Opex £million
A	EFW (200K TPA)	74	101
B	EFW + CHP (200K TPA)	118	113
C	MBT – gasification (100K TPA)*2	65	244
D	MBT – cement kiln (100KTPA)*2	62	229
E	Autoclave (200K TPA)	56	143
F	Autoclave (100K TPA)*2	56	143
G	WTS	4	11
G	EFW Gate Fee Only	0	216

The costs in *Table 2.9* only include CAPEX and OPEX and do not account for transportation, disposal of residuals and income from recycling.

2.4.1.1 Gate Fees and Landfill Tax

Prices shown in *Table 2.10* are based on current gate fees. In real terms, these costs are likely to increase.

Landfill tax is assumed to be £48 / tonne which is the maximum figure already announced by Defra and thus most relevant for the assessment year.

Table 2.10 Gate Fees and Landfill Tax

	Current (£ per tonne)
Landfill Gate Fee	£21.00
Hazardous Landfill Gate Fee	£150.00
Energy from Waste Gate Fee	£71.00 (1)
Landfill Tax	£48.00 (2)

2.4.1.2 Overall Option Comparative Costs

Each option will have an overall cost to the Partnership. The following table does not provide an accurate projection of the actual charges to the Partnership, but allows over the project lifetime (25 years) the different options to be compared. The costs in *Table 2.2* include the costs associated with the disposal of residues from the facilities for each option. There are no additional costs for option G as it is assumed that all costs are incorporated into the gate fee for this facility. The Capital cost and operating costs of a Waste Transfer Station with a capacity of 110K tpa is included in option G. Transportation costs and potential income from heat, energy and recyclate are not included in these figures.

(1) WRAP Gate Fees Report 2008
(2) Current Defra figure for 2010/11

Table 2.11 ***Option Costs (£million)***

Option	CAPEX	OPEX	Landfill Costs	Haz Landfill Costs	Landfill Tax	Total	Rank
A	74	101	0	13	4	192	1
B	118	113	0	13	4	248	5
C	65	244	12	0	28	349	7
D	62	229	12	0	28	331	6
E	56	143	7	0	17	223	2
F	56	143	7	0	17	223	2
G	4	227	0	0	0	231	4

2.4.2 *Reliability of Delivery*

To get financial backing for a waste management facility, there needs to be security for the lender that the technology proposed can work on the scale proposed in the bid. It is therefore important to consider to what extent each of the options is 'proven'.

2.4.2.1 *Method and Assumptions Used*

There is a danger that a 'new' technology being presented to the market place in the UK may face problems with implementation and funding. However, such technologies should not be disregarded. Whilst it is difficult to consider unknown risks, it is still prudent to account for them.

In addition, it is often harder to secure financial backing for facilities that have not been proven in the UK; that have not been shown to work at large scale; or which have only been used on feedstock with different characteristics from the intended waste stream.

Table 2.12 shows the different scores band on how 'proven' any particular technology is.

Table 2.12 ***Points Attributed to Proven Technologies***

Development Sate	Score
Proven on a large scale in the UK	4
Proven on a large scale in Europe	3
Proven on a small scale in the UK	2
Proven on a small scale in Europe	1

*A large scale plant is a plant greater than pilot or experimental scale

2.4.2.2 *Results*

Due to the initial shortlisting of the options, all of the options assessed are of a reasonably proven nature. Only two options did not score the top score of 4 for being proven on a large scale in the UK, and these are options E and F. Autoclaving of residual MSW is not as yet proven on a large scale in the UK or Europe, and thus only scores a 2 for being proven on a small scale in the UK.

There is a merchant facility in Rotherham working with a capacity of 100,000tpa operated by Sterecycle who have plans for four more in the UK, however, currently this would be classed as relatively small scale operations. *Table 2.13* shows the scores assigned to each option for this assessment.

Table 2.13 *Option Scores*

Option	Proven Technologies Score	Rank
A	4	1
B	4	1
C	4	1
D	4	1
E	2	6
F	2	6
G	4	1

Worcestershire and Herefordshire Councils currently have a PFI contract with Mercia Waste Management for the disposal of residual waste. The original PFI framework was set to deliver energy from waste capacity for the authorities. However, with the appropriate contract variations, it would be feasible to delivery any of the technologies listed through the existing contract. It should be noted that any contract variations would be expected to incur additional cost.

2.4.3 *Planning Risk*

One of the greatest risks to any waste facility project is planning. The development of this assessment has compared the options in terms of number of sites required for each option. As previously stated, the public acceptability of the options will be considered outside this appraisal. Options therefore fall into three categories; one site options (A, B and E), two site options (C, D and F) and the export option (G).

The two site options are considered to incur the greatest risk. To ensure the JMWMS is successfully delivered, the authorities would need both sites to be successful through the planning process. For this reason the one site options are considered to have less planning risk associated with them.

Option G, the export option, assumes the designated facility is already established and thus the delivery of this option does not rely on obtaining additional planning permissions. This option however does incur an additional risk in relation to availability of spare capacity out of county.

Planning permissions have been granted for two autoclave facilities, one at Madley in Herefordshire and the other at Hartlebury in Worcestershire. Therefore, options E & F are assumed to have lower planning risk associated with them. However, these permissions are due to expire during 2009. If development doesn't begin before the expiration of the permissions then the facilities would be subject to obtaining new planning permissions, and their risk would therefore increase. A sensitivity analysis has been carried out to assess the impact of these planning permissions expiring, and the subsequent change in planning risk. This can be found in *Appendix B*.

A ranking of the options is provided in *Table 2.14*.

Table 2.14 ***Planning Risk Rankings***

Option	Description	Planning Risk Ranking
A	One site EfW	4
B	One site CHP	4
C	Two site MBT (on site burning)	6
D	Two site MBT (off site burning)	6
E	One site Autoclave	1
F	Two site Autoclave	1
G	Out of County EfW	1

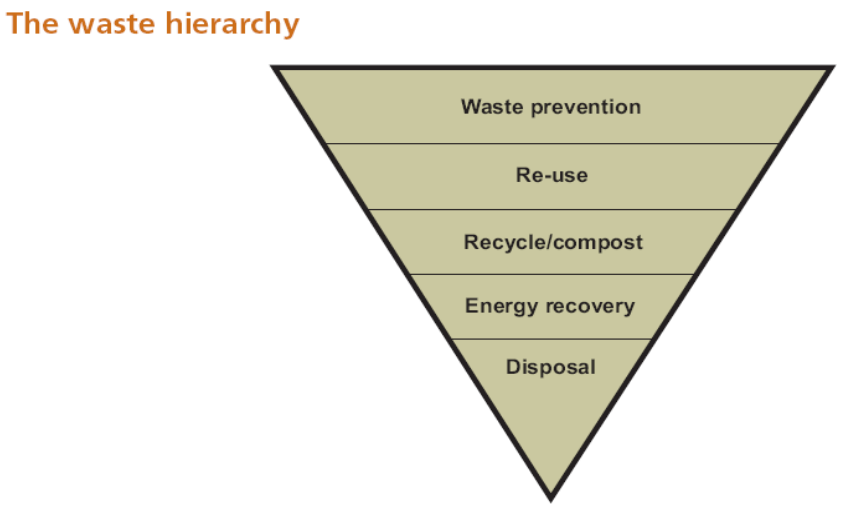
2.4.4 *Compliance with Policy*

This criterion assesses the ability of each of the options to manage waste in accordance with national waste policy.

Government policy seeks to drive the management of waste up the waste hierarchy. The waste hierarchy represents a prioritisation of waste management options in which waste reduction is deemed to be the most preferable, followed by re-use, recycling, composting, recovery and finally disposal. Where waste is produced, it should be viewed as a resource to be put to good use and disposal should be viewed as the last option for dealing with it. The waste hierarchy is the overarching policy for both European and national legislation.

The waste hierarchy is shown schematically in *Box 2.1*.

Box 2.1 ***The Waste Hierarchy***



Waste Strategy for England 2007. Defra. May 2007.

The hierarchy encourages the removal of the need for treatment or disposal through waste recycling and composting, and recovery. This hierarchy has been used to determine the performance of each option.
The Keys Principles of the JMWMS include the wish to maximise value from the residual waste and use it wherever possible as a resource. To this end ERM has devised a method that allows the benefit of gaining value from waste to be quantified.

2.4.4.1 *Method and Assumptions Used*

ERM compared the options based on the tonnages of material handled by each of the following management methods:

- the amount of waste landfilled;
- the amount of mass lost during treatment;
- the amount of waste used to generate electricity;
- the amount of waste used to generate heat; and
- the amount of waste recycled.

The score for each option was based on the relative tonnages for each management method, and multiplied by a weighting factor to represent the preference for each of these in the waste hierarchy. These weightings are presented in *Table 2.15*.

Table 2.15 Compliance with Policy Weightings Factors

Management method	Weighting Factor
Recycling / Composting	1
CHP generation/ recovery	2
Electricity generation / recovery	3
Diversion from Landfill (no generation)	4
Landfill	5

The weighting factor for landfill is greater than that for the other waste management methods located higher in the waste hierarchy. The greater the tonnage of waste landfilled, the higher, and therefore 'worse' the score. Recovery, recycling and composting receive a lower, and therefore 'better' weighting for the tonnage of material managed by that method. For each option, the amount of waste (tonnage) that is managed by each of the four methods is multiplied by the method weighting and these individual scores are then summed to give an overall score for the option. The options are then ranked according to these overall scores.

All of the incinerator bottom ash (IBA) associated with EfW is assumed to be diverted from landfill and recovered on site for recycling as a construction material. However, it is assumed that hazardous fly ash resulting from the process needs to be landfilled. The waste hierarchy score associated with landfill is therefore applied to this material. Any waste that is 'lost' during the process and a not direct output from the facility is assumed to be recovered and classed as either electricity or CHP recovery, or recovery with no generation of electricity or heat.

The lowest scoring option employed treatment facilities that manage waste at the top of the waste hierarchy, and has therefore been awarded the highest overall rank (1). The option that scored least well (highest score) relies on managing waste lower down the waste hierarchy and was allocated the lowest rank (7). All other options were ranked according to their position within this range.

2.4.4.2 *Results*

Table 2.16 shows the scores for each option. The four categories (recycling/composting, CHP, electricity generation and landfill) are listed for each option, with the tonnage that is sent to each of these destinations. The tonnages are then multiplied by the score weighting (1-5) to give the overall score for each option against this criterion.

Table 2.16 Waste Hierarchy Scores

Scenario	Waste Hierarchy	Weight (tonnes)	Weighting	Total (score)	Rank
A	Recycling/Composting	43,218	1	723,644	5
	CHP Generation		2		
	Electricity Generation	174,735	3		
	Recovery (no Generation)		4		
	Landfill	31,244	5		
B	Recycling/Composting	43,218	1	548,910	1
	CHP Generation	174,735	2		
	Electricity Generation		3		
	Recovery (no Generation)		4		
	Landfill	31,244	5		
C	Recycling/Composting	12,447	1	925,696	7
	CHP Generation		2		
	Electricity Generation	99,714	3		
	Recovery (no Generation)	71,074	4		
	Landfill	65,963	5		
D	Recycling/Composting	42,052	1	866,487	6
	CHP Generation		2		
	Electricity Generation	70,109	3		
	Recovery (no Generation)	71,074	4		
	Landfill	65,963	5		
E	Recycling/Composting	161,413	1	560,303	2
	CHP Generation		2		
	Electricity Generation		3		
	Recovery (no Generation)	40,034	4		
	Landfill	47,751	5		
F	Recycling/Composting	161,413	1	560,303	2
	CHP Generation		2		
	Electricity Generation		3		
	Recovery (no Generation)	40,034	4		
	Landfill	47,751	5		
G	Recycling/Composting	76,882	1	672,464	4
	CHP Generation		2		
	Electricity Generation	132,997	3		
	Recovery (no Generation)		4		
	Landfill	39,318	5		

This criterion identifies option B as the best performing option. This is largely due to the generation of heat in that option. Options E and F score highly and come in joint second due to the high level of recycling attributed to this technology.

2.4.5 Flexibility

2.4.5.1 Flexibility to Composition Variations

The options were assessed for their flexibility in terms of ability to accept waste with differing compositions arising from seasonal variations, potential changes to packaging material etc.

2.4.5.2 Method and Assumptions Used

This criterion was assessed qualitatively by ERM, using professional judgement based on our knowledge of the different technologies and experience of previous technical options appraisals. The methods employed in all these appraisals have been used previously in studies that have been approved by Defra.

2.4.5.3 Results

Options A, B, and G are the better performing options. EfW can accept material of a wide ranging calorific value. Autoclave also has the ability to accept a wide ranging feedstock. However, the output of the Autoclave will dictate what needs to be processed to provide a quality product to the end user. MBT options (C and D) require stricter controls over the material mixture of the input.

Table 2.17 Flexibility of Technology to Accept Variations in Composition

Option	Rank	Commentary
A	1	• Relatively large range of Calorific Value (CV) is acceptable - large bunker enables flexibility to mix loads
B	1	• Relatively large range of CV is acceptable - large bunker enables flexibility to mix loads
C	6	• The contract for the RDF would require a relatively consistent composition and strict quality protocol
D	6	• The contract for the RDF would require a relatively consistent composition and strict quality protocol
E	4	• Can run on a wide range of composition effectively • Contract for outputs will determine what scope of input is acceptable
F	4	• Can run on a wide range of composition effectively • Contract for outputs will determine what scope of input is acceptable
G	1	• Relatively large range of Calorific Value (CV) is acceptable - large bunker enables flexibility to mix loads

2.4.5.4 Flexibility to Accept Variations on Tonnage Throughputs

The purpose of this criterion is to asses the flexibility of the option in terms of varying tonnage changes. This may be through seasonal variations or more significant changes through unexpected waste growth / decline etc over time.

2.4.5.5 Results

Options C performs well due to the potential to add additional capacity in a modular fashion. It is also unlikely to have a supply contract for output material. This means that without disrupting the performance of the original facility, providing planning and finances allow, extra capacity can be added to deal with more waste, should the need arise over time. Option D, E & F perform less well than C because one would expect there to be a minimum supply contract for RDF & Fibre.

Table 2.18 Effectiveness to be able to Manage Changes in Tonnage Throughputs

Option	Rank	Commentary
A	2	• All can operate at slightly lower capacity but costs will increase • Possibility of burn through* if considerably less • Can't add additional small modules easily although another line could be added to increase throughput
B	2	• All can operate at slightly lower capacity but costs will increase • Possibility of burn through* if considerably less • Can't add additional small modules easily although another line could be added to increase throughput
C	1	• All can operate at slightly lower capacity but costs will increase • Potential to add modules of additional capacity if land is available • Gasifier will require consistent amount as with EFW – possibility of lower efficiency if amount reduced
D	6	• All can operate at slightly lower capacity but costs will increase • Potentially will have a minimum contract to supply RDF • Potential to add modules of additional capacity if land is available
E	4	• All can operate at slightly lower capacity but costs will increase • Potentially will have a minimum contract to supply fibre • Potential to add modules of additional capacity if land is available. This is easier than with other technologies due to small nature of each module
F	4	• All can operate at slightly lower capacity but costs will increase • Potentially will have a minimum contract to supply fibre • Potential to add modules of additional capacity if land is available. This is easier than with other technologies due to small nature of each module
G	7	• Potentially will have a minimum & maximum contract to supply waste • If site can not accept enough waste, further merchant capacity must be found. Worst case scenario waste may end up in landfill

* Burn through is when the entire backlog (waste awaiting processing) is processed, such that waste throughput is less than the design minimum thereby reducing efficiency

2.4.6 *End Product Liability*

This criterion considers the risks associated with finding a market for the end products arising from the technologies. Some waste management technologies have greater risks associated with the management of end products because the markets for these materials are unproven or under-developed. The method used to assess the likely risks associated with the markets for end products is outlined below.

2.4.6.1 *Method and Assumptions Used*

ERM compared the options based upon the tonnages of each material end product arising from the technologies involved in each option.

The end product(s) from each technology have been assigned a coefficient based on the risks associated with finding a market for them. These risks have been based on ERM's knowledge and experience of the secondary materials market.

Table 2.19 presents the coefficient that has been awarded to end product markets. A high value (0.10) indicates a higher risk of finding a market willing to accept an end product. A low value (0.01) indicates that markets for end products are stable and well established. These coefficients have been applied to the end product tonnages to provide a score to determine the performance of each option.

Table 2.19 End Product Liability Coefficient

End Product & Destination	Risk of not Finding a Market	End Product Liability Coefficient
RDF for off-site combustion	HIGH	0.07
Market for Autoclave fibre	HIGH	0.06
Hazardous material to landfill	MED	0.05
Markets for IBA	MED	0.04
Markets for dry recyclables	MED	0.03
Non-hazardous material to landfill	LOW	0.02
On-site gasification	LOW	0.01

A high liability coefficient has been attached to RDF produced by treatment technologies for combustion off-site because there is, as yet, no guarantee that this material will be accepted at a reasonable gate fee.

The ban on co-disposal of hazardous waste with non-hazardous waste in the UK has severely reduced the number of landfill sites licensed to accept hazardous waste. However, there is a landfill site capable of accepting hazardous material in operation approximately 60 km from the proposed sites. The disposal of hazardous waste to landfill has been ranked as medium risk, as any problems at this landfill would require significant extra transport to the next nearest hazardous landfill site.

It is assumed that the EfW and EfW+ CHP options (options A&B) would only be developed on sites with suitable and secure outlets for the heat and/or electricity produced and therefore these outputs have not been included in this assessment.

2.4.6.2 Results

Table 2.20 Option Scores

	All Recyclates	IBA	Autoclave fibre recycling	Hazardous Residues	Non-Haz Residues	RDF for Off-Site Burning	RDF/fluff for On-Site Burning	Total*	Score	Rank
A	61	1,648	-	316	498	-	-	2,523	2.6	1
B	61	1,648	-	316	498	-	-	2,523	2.6	1
C	373	-	-	-	1,319	6,980	-	8,673	6.5	5
D	373	1,184	-	-	1,319	-	997	3,874	3.5	3
E	1,237	-	7,210	-	955	-	-	9,402	7.0	6
F	1,237	-	7,210	-	955	-	-	9,402	7.0	6
G	111	2,927	-	720	498	-	-	4,257	3.7	4

*Totals may not sum due to rounding

The options with the least liability associated with their end products, and therefore the best performing are option A and B. The EfW/CHP options perform well due to the limited number of outputs which are usually of low risk. The options with the highest liability related to them are options E and F. This is due to the relatively high risk associated with finding a market for the autoclave fibre. Option C also has a high element of risk associated with it due to the potential risks in finding a market for the RDF. Whilst this may not be the case in the areas surrounding Worcestershire and Herefordshire, in general this usually presents a significant risk.

The appraisal has assessed each of the options against fourteen criteria. A ranking has been devised based on the performance in all of these criteria. The ranked order of options is shown in *Table 3.1*. Option B scores the best overall; however, the criteria were not weighted, so no criteria are assumed to be more important than any others. Option B scores the best against global warming, transport, reliability, compliance with policy, flexibility and end product liability. The workshop held with the Partnership members prior to the completion of the appraisal included a session assessing the most important criteria to the Partnership. Whilst all the criteria assessed were seen as important, cost, reliability and resource depletion were seen as key criteria. The top scores against these key criteria were as follows:

- Cost – Option A, followed by Options E and F;
- Reliability – Options A, B, C, D and G were all equally reliable; and
- Resource depletion – Option D followed by Option B.

Option B scored well against these key criteria with the exception of cost, where it was ranked fifth. However there is potential income from the heat generated that has not currently been taken into consideration.

Option E was ranked second overall and scored well against many of the environmental criteria, however it did not score well against resource depletion or reliability and was scored as average against cost.

Option D performed very well against resource depletion and reliability, but poorly against cost. The overall ranking for option D was sixth, reflecting lower performance against compliance with policy, cost and some of the environmental criteria.

Option A also performed well against two of the key criteria - cost and reliability. It also finished third against resource depletion, the other key criteria, and finished third in the overall scoring. This was due to a lower performance against some of the environmental criteria.

Option G is the worst performing option overall. This is partly as a result of assumptions made on facility type (see sensitivity analysis below). However, the reliance on an out of county facility causes the option to perform badly in relation to flexibility of tonnage throughputs and transportation.

Table 3.1 *Total Scores and Ranks*

	Resource Depletion	Global Warming	Ecotoxicology	Acidification	Eutrophication	Health	Transport	Cost	Reliability	Planning Risk	Compliance with Policy	Flexibility - composition	Flexibility - tonnage	End Product Liability	Average	Rank
Option A	3	6	7	6	5	4	1	1	1	4	5	1	2	1	**3.36**	**3**
Option B	2	1	6	5	3	3	1	5	1	4	1	1	2	1	**2.57**	**1**
Option C	4	5	1	4	4	5	3	7	1	6	7	6	1	5	**4.21**	**5**
Option D	1	4	4	3	6	6	4	6	1	6	6	6	6	3	**4.43**	**6**
Option E	6	2	2	1	1	1	5	2	6	1	2	4	4	6	**3.07**	**2**
Option F	7	3	3	2	2	2	7	2	6	1	2	4	4	6	**3.64**	**4**
Option G	5	7	5	7	7	7	6	4	1	1	4	1	7	4	**4.71**	**7**

KEY:

Option A	1 x EFW
Option B	1 x EFW + CHP
Option C	2 x MBT – gasification
Option D	2 x MBT – cement kiln
Option E	1 x Autoclave
Option F	2 x Autoclave
Option G	EFW out of county

Best Performing	
Worst Performing	

4 SENSITIVITY ANALYSIS

4.1 OPTION G – CHANGE IN EFW REFERENCE PLANT

In assessing the options there were a number of assumptions that had to be made. One of these assumptions was the example facility that each option was based on. Worcestershire and Herefordshire currently send a proportion of their waste to EfW facilities in the West Midlands, including the Coventry EfW. Option G was therefore based on sending waste to this EfW. The results are therefore based on the performance of this particular plant. In reality there may be another, more recently built, EfW that could be utilised by the Partnership in the future. To assess this possibility the same plant that was used as the basis for option A was used in a sensitivity analysis (option G2). This allows the impacts of transporting the waste to Coventry to be easily identified as the treatment technology is now the same in options A and G2.

The results presented below for option G and G2 are for those criteria that have been affected by the change: environmental criteria, health, transport, compliance with policy and end product liability.

Table 4.1 Option G and G2 Results

	Compliance with policy	End product Liability	Transport	Health	Resource Depletion	Global Warming	Freshwater Ecotoxicity	Acidification	Eutrophication
Option G	672,464	4,257	6,125,027	6,487,000	-462,000	22,486,000	-4,203,000	170,000	60,000
Option G2 - sensitivity	723,644	2,523	5,923,948	-5,658,000	- 570,000	14,279,000	- 2,900,000	36,000	28,000

*Lower numbers are a better result for all criteria in this table

Option G2 is a better performing option than Option G when compared against the majority of the criteria that change. Option G2 performs marginally better overall with a total score of 4.50, compared to 4.71 for Option G. This only slightly alters the ranking for G2 which moves up from 7 to 6, so it still remains one of the worst performing options, replacing Option D in 6th position.

Option G2 performs well in the planning, reliability of deliver and end product liability criteria. However, when compared to option A (EfW in county) the option still performs less well in the majority of the environmental criteria. This is due to the additional transport required to transport the waste to the facility.

The introduction of option G2 does not affect the ranking of the top performing options against the three key criteria indentified in *Section 3* and provided below for confirmation.

The top scoring options against these key criteria were as follows:

- Cost – Option A, followed by Options E and F;
- Reliability – Options A, B, C, D and G were all equally reliable; and
- Resource depletion – Option D followed by Option B.

Table 4.2 Total Scores and Ranks – Sensitivity Analysis

	Resource Depletion	Global Warming	Ecotoxicology	Acidification	Eutrophication	Health	Transport	Cost	Reliability	Planning Risk	Compliance with Policy	Flexibility - composition	Flexibility - tonnage	End Product Liability	Average	Rank
Option A	3	6	6	6	5	4	1	1	1	4	4	1	2	1	**3.21**	**3**
Option B	2	1	5	5	3	3	1	5	1	4	1	1	2	1	**2.50**	**1**
Option C	4	5	1	4	4	6	3	7	1	6	7	6	1	5	**4.29**	**5**
Option D	1	4	4	3	7	7	4	6	1	6	6	6	7	4	**4.71**	**7**
Option E	6	2	2	1	1	1	5	2	6	1	2	4	4	6	**3.07**	**2**
Option F	7	3	3	2	2	2	7	2	6	1	2	4	4	6	**3.64**	**4**
Option G2	5	7	7	7	6	5	6	4	1	1	4	3	6	1	**4.50**	**6**

KEY:

Option A	1 x EFW
Option B	1 x EFW + CHP
Option C	2 x MBT – gasification
Option D	2 x MBT – cement kiln
Option E	1 x Autoclave
Option F	2 x Autoclave
Option G	EFW out of county

Best Performing

Worst Performing

Appendix A

WRATE Assumptions

A1 INTRODUCTION TO WRATE

A1.1.1 How WRATE works

WRATE is a Life Cycle Assessment (LCA) software tool for comparing different management systems treating Municipal Solid Waste (MSW). There are other LCA tools; however, none offer the same scope of waste technologies that are provided by WRATE or have the level of sophistication of technical development.

WRATE is designed for waste managers. It produces information on the environmental aspects of integrated waste management systems in a form that is accessible to financial and political decision-makers and stakeholders. WRATE calculates potential impacts stemming from all stages in the management and processing of municipal waste. These impacts include waste collection, transport, treatment and disposal activities, taking account of the associated infrastructure, together with the avoided burdens associated with materials recycling and energy recovery.

The software follows the "Gate to Grave" modelling approach. The system boundary is initiated when materials are discarded into a waste management system (the Gate), and the waste is followed to its point of recycling, recovery or final disposal (the Grave).

WRATE includes site process data collected by the Environment Agency's Waste Technologies Data Centre (WTDC) for 40 waste treatment processes. The tool forecasts the environmental costs and benefits of processes and waste management systems in terms of resources used, transport and the operational impacts of materials, and energy treated downstream from WTDC processes. In addition, users are able to develop and evaluate new, user-defined processes on the basis of proposed designs or existing operations.

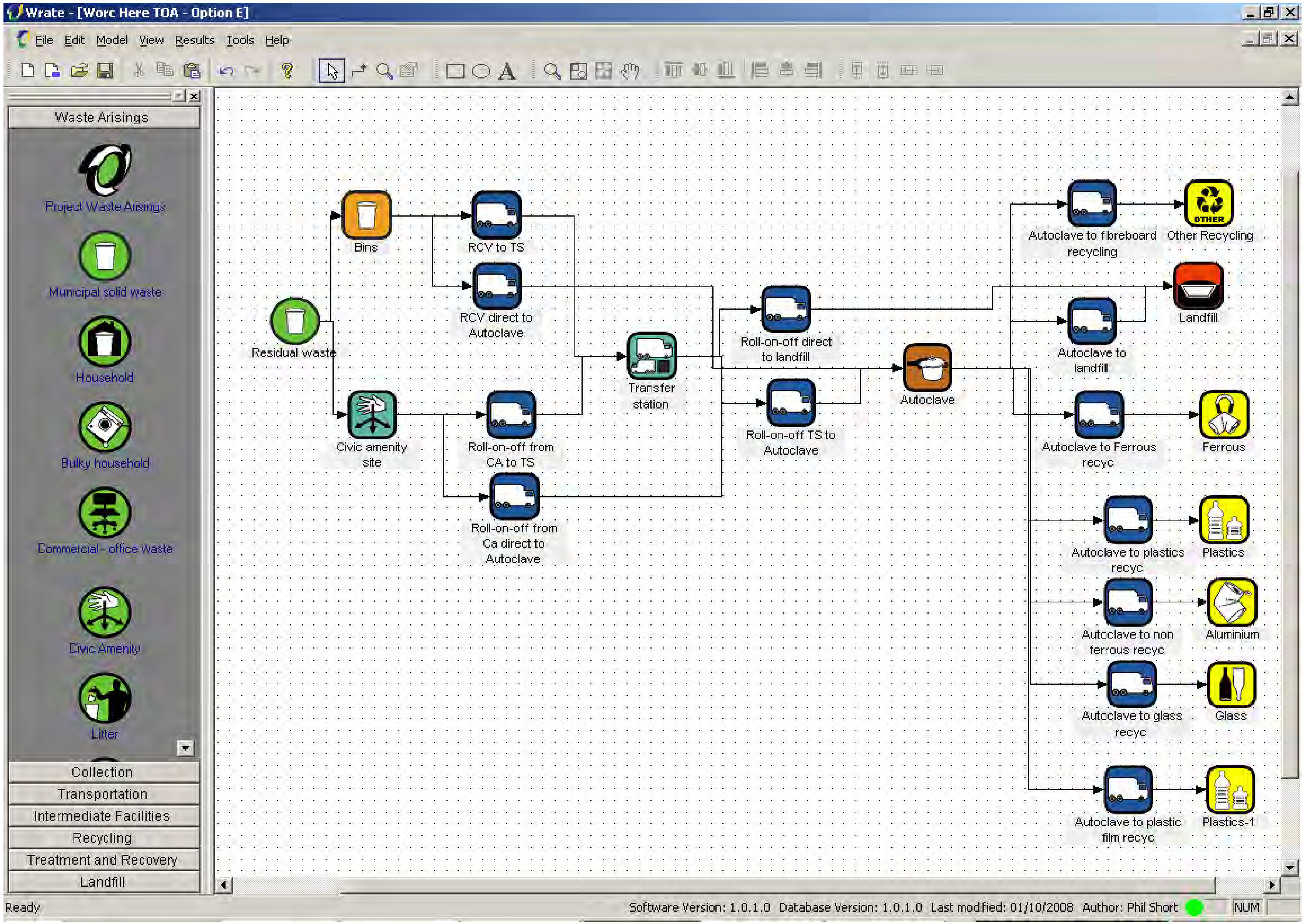
The WRATE methodology is composed of three main parts: the waste inputs, the calculation engine, and the results display and interpretation.

A1.1.2 Waste Inputs

Waste composition is defined by users, by waste streams (including household waste, street sweeping) and by waste fraction (including paper, plastic, textile, glass) and subfractions (for paper, newsprint, office paper among others). Each fraction and subfraction has a pre-defined chemical composition.

The system, or 'Scenario' is then defined, process by process, in a Graphical User Interface (GUI) by the user; for example: collection container, vehicle, collection round distance, intermediate transport and final recovery or disposal.

Figure 1.1 WRATE's Graphical User Interface



A1.1.3 Calculation Engine

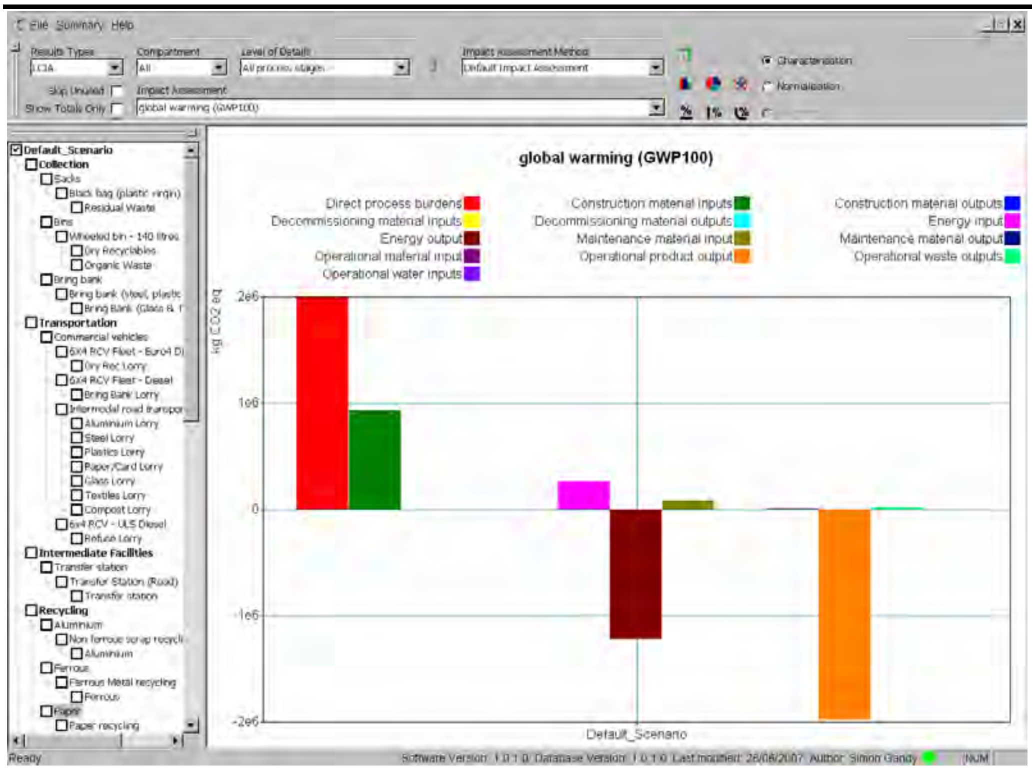
The basis for calculations is that each process in the waste management system places a burden on the environment. Each burden is described in the generic process structure per unit of waste processed.

A process can range from a simple process, such as a bin, to a more complex process, such as a thermal treatment plant. All the outputs are calculated through allocation algorithms that link all the inputs to the outputs of a process. These can be dependent on the waste composition input (fractional or elemental composition), the total quantity of the waste or the properties of the treatment plant. The software does this by drawing on a series of databases, including the ecoinvent v1.2 database that is used to estimate the life cycle costs for the materials and energy that are used or recovered by processes.

A1.1.4 Results

Results can be provided at the process Scenario levels. A Life Cycle Inventory of all the environmental inputs and outputs caused by the modelled waste management system is calculated. To this several Life Cycle Impact Assessment methods can be applied (e.g. Global warming potential, acidification potential etc). Scenarios can then be compared and a number of results formats are produced, suitable for communicating to non-technical audiences.

Figure 1.2 Sample Results Screen Plot



A2 WRATE ASSUMPTIONS

A2.1 SITE ASSUMPTIONS

The seven options that have been assessed have used a combination of one and two site options. All options with one site are assumed to go to Site A, which is close to Worcester City on the M5 corridor. The two site option includes two sites that are assumed to be located at Hartlebury and Madley.

A2.2 WASTE COLLECTION ASSUMPTIONS

All waste has been assumed to go via two routes:

- Kerbside 240L wheeled bins, and
- Civic Amenity sites (large – with compaction)

Waste is then transported from these points either to a transfer station, or direct to one of the proposed facilities.

A2.3 TRANSPORT ASSUMPTIONS

A2.3.1 Waste Collection

All waste from CA sites (or Household Waste Sites, HWS) is assumed to go direct to the proposed facilities. This is as per current practice in which waste is compacted on each site, and therefore has no need to go via transfer stations for bulking.

Waste from kerbside collections goes either via transfer stations to the proposed facilities, or direct to the proposed facilities. The table below provides a basic view of the flows of waste from each local authority.

Table 2.1 Waste Flow - 1 Site Options

Authority		**Destination**
Worcester City		site A
Bromsgrove DC	Transfer	site A
Malvern Hills DC	Transfer 10%	site A 90%
Redditch BC	Transfer	site A
Wychavon DC		site A
Wyre Forest DC		site A
Hereford Council	Transfer	site A

Depending on whether the option has one or two proposed sites, there are differences in the waste flows.

Table 2.2 *Waste Flow - 2 Site Options*

Authority		Destination
Worcester City		site 1
Bromsgrove DC	Transfer	site 1
Malvern Hills DC	Transfer 10%	site 2 90%
Redditch BC	Transfer	site 2
Wychavon DC		site 1 (50%) site 2 (50%)
Wyre Forest DC		site 1
Hereford Council	Transfer	site 2

A2.4 DISTANCES

Each authority is assumed to produce waste at a single central point. These points were provided by Worcestershire County Council and constitute the centre of population in each district. The distances from each of these central points to the designated destination, or to the transfer station (if relevant), were averaged for that journey for the purpose of modelling in WRATE. This was weighted using the proportion of residual waste produced by each authority. For example, an average of the three weighted journeys from Worcester City, Wychavon and Wyre Forest to Site A were used in the one site options for the journey from waste collection to Site A.

A2.5 ONWARD TRANSPORT

Facilities currently used by the Partnership were used to estimate the onward transport of treatment residues/recyclates. These are presented below:

Non haz landfill – Hill and Moor Landfill, WR10 2PW
Haz landfill – Wingmoor Farm, Gloucestershire
Cement kiln – assumed to be 100km away
Glass recycling - T Berryman & Son Ltd, West Yorkshire, WF9 3NR
Ferrous recycling – European Metal Recycling, Smethwick, B66 2PG
Non ferrous recycling – Alutrade, Oldbury, B69 4NH
Fibreboard manufacture - Hollands Recycling Ltd – Wednesbury, WS10 8LN
Plastic recycling – Recoup Services (Broker), Peterborough, PE2 7UH

A2.6 FACILITY ASSUMPTIONS

In WRATE there are examples of different types of facility that are used as a proxy in the modelling. For this assessment the following facilities were used as representations of technologies in the various options.

- EfW – Chineham EfW;
- CHP – user defined CHP plant, (based on Chineham with added heat recovery);
- MBT – MBT (Bio-drying of MSW for RDF production) Ecodeco process
- Autoclave – Esstech process; and

- Out of County EfW – Coventry

A2.6.1 Comment on data quality

- The autoclave and gasifier models in WRATE are based on design data, rather than operational data;
- The heat recovery included in the CHP option (B) is an estimate based on data from an existing plant.
- Option G is based on the EfW at Coventry, as this is the assumed destination of waste under this option. However it could be the case that another facility would be used, and therefore, impacts relating to the process could be different, as could the impacts relating to transport.
- Health impact limitations:

  - Emissions (or saved avoided emissions) relating to each of the options assessed occur in a multitude of physical places across the life cycle, and there is not account of whether these are diffuse rather than point emissions.
  - It is worth noting that there have been many subsequent methods developed since the CML method, all have limited validity, since there are just too many uncertainties.
  - The practice guidance for WRATE suggests a formal Health Impact Assessment would be the only way to ever really compare options for Human health, outside a WRATE assessment.

Appendix B to Annex D

Planning Assumptions Sensitivity Analysis

B1.1.1 Planning Risk – Sensitivity

In *Section 2.4.3* of the Residual Options Appraisal report, the planning risk associated with each of the options was assessed. A key assumption in this appraisal was that planning permissions had been granted for two autoclave facilities: one at Madley in Herefordshire and the other at Hartlebury in Worcestershire. Therefore, options E & F were assumed to have low planning risk associated with their delivery.

However, these permissions have now expired and subsequently the planning risk associated with these options has increased. This section assesses the impact this change in assumption has on the overall options appraisal.

One of the greatest risks to any waste facility project is planning. The development of this assessment has compared the options in terms of number of sites required for each option. As previously stated, the public acceptability of the options will be considered outside this appraisal. Options therefore fall into three categories; one site options (A, B and E), two site options (C, D and F) and the export option (G).

The two site options are considered to incur the greatest risk. To ensure the JMWMS is successfully delivered, the authorities would need both sites to be successfully delivered through the planning process. Option F (two site Autoclave) fits within this category and is therefore assumed to have a planning risk ranking of 5. The one site options, including option E (one site autoclave), are considered to have less planning risk associated with them and have therefore been given a planning risk ranking of 2.

A ranking of the options is provided in *Table* 1.

Table 1 Planning Risk Rankings - Sensitivity

Option	Description	Planning Risk Ranking
A	One site EfW	2
B	One site CHP	2
C	Two site MBT (on site burning)	5
D	Two site MBT (off site burning)	5
E	One site Autoclave	2
F	Two site Autoclave	5
G	Out of County EfW	1

The impact these changes in planning risk have to the overall results is shown in the table below. The ranking of the options has not changed so Option B remains overall the best performing option. Some of the total scores have altered slightly as a result, but these are not significant enough to change the conclusions in the main report.

Table 2 Total Scores and Ranks – Planning Sensitivity

	Resource Depletion	Global Warming	Ecotoxicity	Acidification	Eutrophication	Health	Transport	Cost	Reliability	Planning Risk	Compliance with Policy	Flexibility - composition	Flexibility - tonnage	End Product Liability	Average	Rank
Option A	3	6	7	6	5	4	1	1	1	2	5	1	2	1	**3.21**	**3**
Option B	2	1	6	5	3	3	1	5	1	2	1	1	2	1	**2.43**	**1**
Option C	4	5	1	4	4	5	3	7	1	5	7	6	1	5	**4.14**	**5**
Option D	1	4	4	3	6	6	4	6	1	5	6	6	6	3	**4.36**	**6**
Option E	6	2	2	1	1	1	5	2	6	2	2	4	4	6	**3.14**	**2**
Option F	7	3	3	2	2	2	7	2	6	5	2	4	4	6	**3.93**	**4**
Option G	5	7	5	7	7	7	6	4	1	1	4	1	7	4	**4.71**	**7**

KEY:

Option A	1 x EFW
Option B	1 x EFW + CHP
Option C	2 x MBT – gasification
Option D	2 x MBT – cement kiln
Option E	1 x Autoclave
Option F	2 x Autoclave
Option G	EFW out of county

Best Performing	(light green)
	(yellow)
	(peach)
	(pink)
	(magenta)
	(orange)
Worst Performing	(red)

Appendix C to Annex D

Site Location Sensitivity Analysis

C1 APPENDIX C TO ANNEX D

C1.1 LOCATION OF FACILITY IN ONE SITE OPTIONS – SENSITIVITY ANALYSIS

C1.1.1 Introduction

The Residual Options Appraisal undertaken in February 2009 (and published July 2009) aimed to provide a strategic level appraisal of alternative residual treatment options to inform the development of the *Joint Municipal Waste Management Strategy for Herefordshire & Worcestershire.* At the time this appraisal was undertaken, the specific location of any new facility/ facilities was unknown. Therefore, assumptions were made based on indicative locations to ensure the environmental and amenity issues associated with transport were not overlooked. Appendix A2 to the Residual Options Appraisal details the assumptions made.

Following the publication of the Residual Options Appraisal, an application for a scoping opinion on a specific residual treatment facility was submitted to Worcestershire County Council, by their waste disposal contractor Mercia Waste Management. This application provided details of a potential site location for a single residual treatment facility which aims to deal with municipal residual waste arising in Worcestershire and Herefordshire. The proposed site for the facility is on the Hartlebury Trading Estate, close to the A449 in Wychavon.

C1.1.2 Purpose of Sensitivity

The purpose of this sensitivity analysis is to understand how changing the assumed location of Site A impacts the results of the Residual Options Appraisal.

Table C1.1 Changes to Site Location Assumptions

Original Assumption	Site A = a site close to Worcestershire City on the M5 corridor
Sensitivity Assumption	Site A = the site proposed on Hartlebury Trading Estate, close to the A449 in Wychavon
NB	All other transport, site and technical assumptions remain the same

This assumption changes impacts upon the single site options only. The options considered in the Residual Options Appraisal where the site location has been changed include:

- Option A – 1 site EfW
- Option B – 1 site EfW with CHP
- Option E – 1 site autoclave

C1.1.3 Results of the Sensitivity Analysis

The results presented in *Table C1.2* below are for those criteria that have been affected by the site location assumption change. These are primarily the environmental criteria which change as a result of the changing transport distances. The criteria subject to change include: Resource Depletion, Global Warming, Freshwater Ecotoxicity, Acidification, Eutrophication, Health and Transport. *Table C1.3* presents the total scores and ranks.

Table C1.2 Sensitivity Results

Option	Resource Depletion	Global Warming	Freshwater Ecotoxicity	Acidification	Eutrophication	Health	Transport
Unit	kg antimony eq.	kg CO2 eq.	kg 1,4-dichloro-benzene eq.	kg SO2 eq.	kg PO4-- - eq.	kg 1,4-dichloro-benzene eq.	km
A – Original	-601,000	10,555,000	-3,260,000	17,000	25,000	-6,002,000	1,975,401
A1 -Sensitivity	-600,000	10,698,000	-3,245,000	18,000	25,000	-5,986,000	2,098,232
B - Original	-1,120,000	-50,573,000	-4,158,000	-38,000	19,000	-9,315,000	1,975,401
B1 - Sensitivity	-1,118,000	-50,429,000	-4,143,000	-37,000	19,000	-9,299,000	2,098,232
E - Original	-405,000	-12,265,000	-8,877,000	-279,000	-6,000	-11,753,000	5,683,691
E1 - Sensitivity	-403,000	-12,121,000	-8,862,000	-278,000	-6,000	-11,737,000	5,806,522

* Lower numbers are a better result for all criteria in this table

As can be seen from *Table C1.2*, changing the assumed location of Site A has had a very small effect on the criteria assessed in this study.

In all cases, where a change in impact is discernible, the impact has increased slightly. The percentage change is however very small. *Table C1.3* shows the rankings of each of the options considered and demonstrates that although the location of Site A has changed, this has had no impact on the overall results of the Residual Options Appraisal. Therefore, the conclusions drawn in the original Residual Options Appraisal remain valid.

Table C1.3 *Total Scores and Ranks - Site Location Sensitivity Analysis*

	Resource Depletion	Global Warming	Ecotoxicology	Acidification	Eutrophication	Health	Transport	Cost	Reliability	Planning Risk	Compliance with Policy	Flexibility - composition	Flexibility - tonnage	End Product Liability	Average	Rank
Option A	3	6	7	6	5	4	1	1	1	4	5	1	2	1	**3.36**	**3**
Option A1 Sensitivity	3	6	7	6	5	4	1	1*	1*	4*	5*	1*	2*	1*	**3.36**	**3**
Option B	2	1	6	5	3	3	1	5	1	4	1	1	2	1	**2.57**	**1**
Option B1 Sensitivity	2	1	6	5	3	3	1	5*	1*	4*	1*	1*	2*	1*	**2.57**	**1**
Option C	4	5	1	4	4	5	3	7	1	6	7	6	1	5	**4.21**	**5**
Option D	1	4	4	3	6	6	4	6	1	6	6	6	6	3	**4.43**	**6**
Option E	6	2	2	1	1	1	5	2	6	1	2	4	4	6	**3.07**	**2**
Option E1 Sensitivity	6	2	2	1	1	1	5	2*	6*	1*	2*	4*	4*	6*	**3.07**	**2**
Option F	7	3	3	2	2	2	7	2	6	1	2	4	4	6	**3.64**	**4**
Option G	5	7	5	7	7	7	6	4	1	1	4	1	7	4	**4.71**	**7**

* - these criteria were not reassessed as part of the sensitivity study.

KEY:

Option A	1 x EFW
Option B	1 x EFW + CHP
Option C	2 x MBT – gasification
Option D	2 x MBT – cement kiln
Option E	1 x Autoclave
Option F	2 x Autoclave
Option G	EFW out of county

Best Performing

Worst Performing