

Wiltshire County Council

Logistics Modelling

Final Report

May 2005

Entec UK Limited

Report for

Julieanna Powell-Turner
Wiltshire County Council
Environmental Services
County Hall
Trowbridge
Wiltshire BA 8JD

Wiltshire County Council

Logistics Modelling

Final Report

May 2005

Entec UK Limited

Main Contributors

Jonathan Bebb
Lindsay Reed
Damian Bell
Geoff Sampson
Alison Leavens
Julian Henley
Iain Johnston
Steve Blackburn

Issued by

.....
Steve Blackburn

Approved by

.....
Jonathan Bebb

Entec UK Limited

Windsor House
Gadbrook Business Centre
Gadbrook Road
Northwich
Cheshire
CW9 7TN
England
Tel: +44 (0) 1606 354800
Fax: +44 (0) 1606 354810

15719

h:\projects\wm-220\archived projects final reports\15719
wiltshire\wiltshire transport logistics study_final_report.doc



Certificate No. EMS 69090



Certificate No. FS 13881

In accordance with an environmentally responsible approach,
this document is printed on recycled paper produced from 100%
post-consumer waste, or on ECF (elemental chlorine free) paper

Third Party Disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Entec at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Entec excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

Contents

1.1	Context	1
1.2	Approach	1
1.3	Model Development	4
1.4	Scenario Analysis	13
1.5	Observations	22
1.6	Key Conclusions	24
Figure A.1	Facility Locator Cost Output during Model Run	2
Figure A.2	Waste Flow Schematic generated by Facility Locator	3
Figure A.3	Waste Flow Map generated by Facility Locator	4
Table A.1	Residual Household Waste Sources and Existing Waste Management Arrangements	5
Figure A.4	Household Collected Waste Postcode District Sources	6
Table A.2	HRC Sources and Existing Waste Management Arrangements	7
Figure A.5	Household Recycling Centre Sources	8
Table A.3	Reception Facility Data	10
Figure A.6	Reception Facility Locations	11
Table A.4	Logistics Unit Cost Calculation	12
Table A.5	As Is Waste Movements	14

Transport Logistics Study for Wiltshire

1.1 Context

In support of the site identification and options analysis, the impact of transport logistics on the optimum siting, sizing and configuration of residual waste treatment/disposal facilities for material arising in the county has been considered.

This analysis was conducted in 2003, using predicted 2003-04 tonnes, and a selection of the technical options from the Analysis of Options study. It facilitates comparison between using one large centralised treatment facility versus smaller facilities, at the sites identified in the preliminary sites analysis.

It has not been updated for publication at this time (Spring 2005), and therefore some elements (particularly the shortlisted sites) may now be out of date or superseded by subsequent events.

1.2 Approach

This section describes the logistics modelling tool and methodology adopted in the logistics analysis, the input data and assumptions, and scenario outputs.

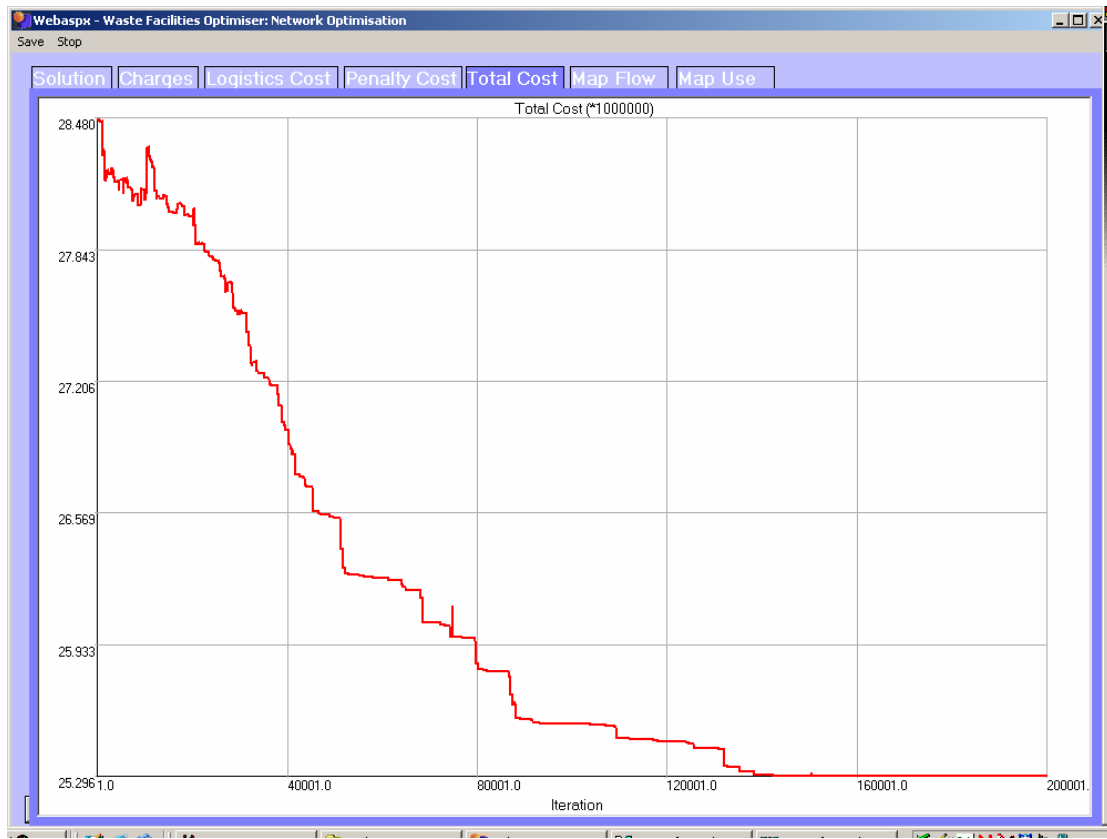
The software tool used by Entec for the analysis, Facility Locator, has been designed to support strategic planning in waste management. The software is fully map-based with all logistics calculations based on journeys along real roads, and is part of a suite of tools developed by Entec in partnership with Webaspx, an IT company providing supply chain management solutions to industry.

Facility Locator takes information about sites and material flows in any regional waste management system and allows the optimum routing of material through that system to be determined. Optimisation can be a function of cost, mileage, environmental impact or any other performance metric (or indicator) to which a numerical value can be applied. The tool is ideally suited to the strategic facility issues faced by Wiltshire and can be used to identify the optimum location and utilisation of treatment or disposal facilities, consistent with the operating constraints and material production profiles of any number of sources sites.

Running models within Facility Locator involves defining the source and treatment/disposal facility configuration to be tested under each scenario, and the number of plans (i.e. options for material to be routed through the system) to be assessed. The number of plans (model iterations) can be varied according to the complexity of the supply chain considered but typically lies in the range 50,000 - 350,000. During a model run, solutions that do not comply with the constraints imposed, e.g. an upper limit on the annual throughput of material at a facility, are penalised. Once a compliant solution is found, the tool seeks ever more efficient ways of delivering that solution.

Model progress during or over the duration of a run can be assessed via the standard reports generated. By way of an example, Figure A.1 shows how the total cost of a scenario has reduced over a model run involving 200,000 iterations.

Figure A.1 Facility Locator Cost Output during Model Run



At the end of a model run, Facility Locator produces a number of outputs in both numerical and schematic format. Information on the total charges incurred (both as gate fees and logistics costs), facility throughputs and a breakdown of material flows between sites is provided.

Figure A.2 provides an example of the schematic presentation of a solution from Facility Locator, based on the existing approach to residual waste management in Wiltshire, the As Is scenario. The same solution can also be presented in map format, as demonstrated in Figure A.3.

Figure A.2 Waste Flow Schematic generated by Facility Locator

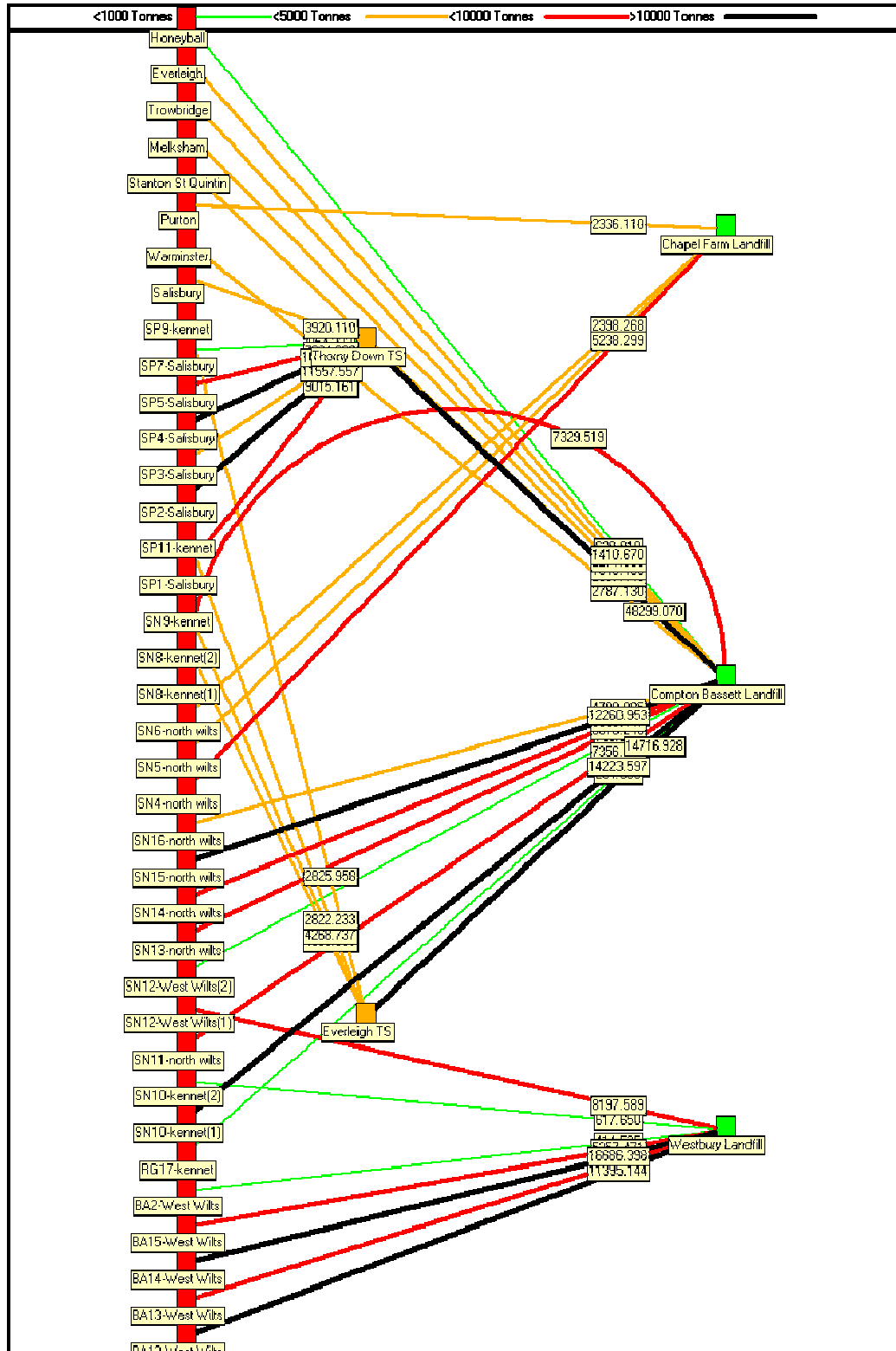
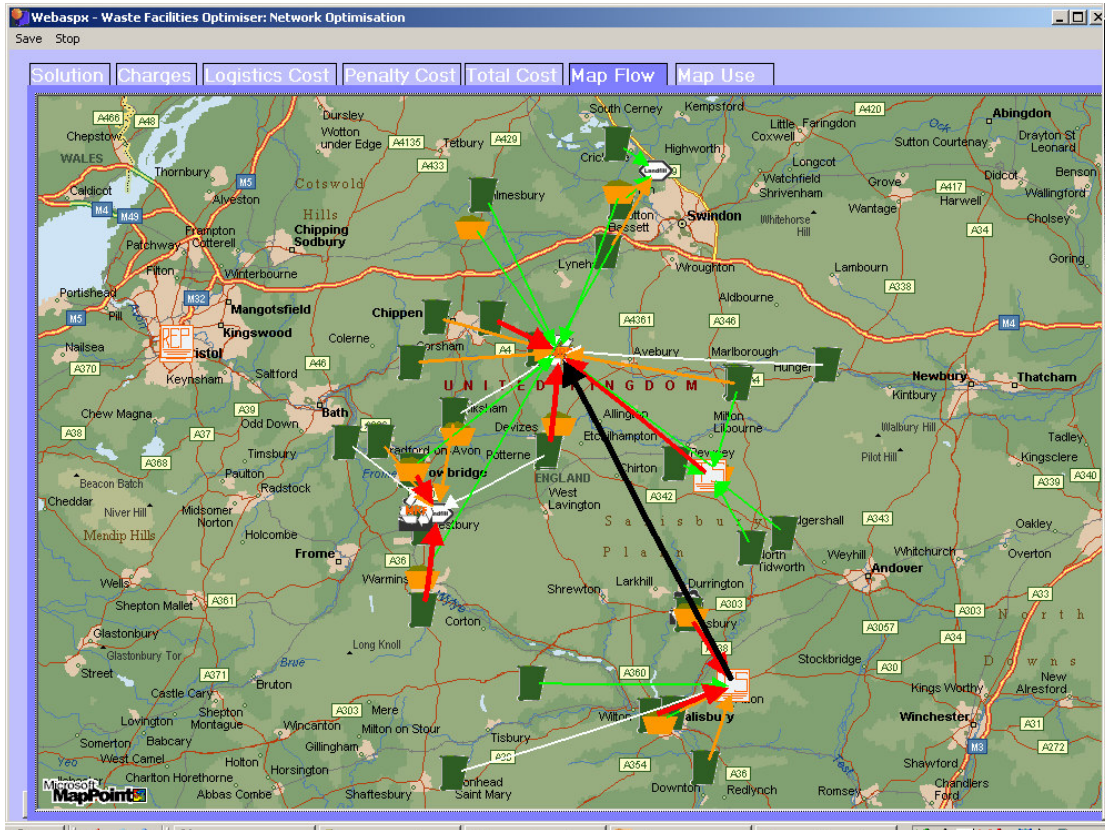


Figure A.3 Waste Flow Map generated by Facility Locator



1.3 Model Development

The following sections describe the key stages of model development within Facility Locator. The core components of the model are the material sources (the inputs), the facilities available to accept the materials and by-products, management costs throughout the supply chain and any modelling constraints imposed. Once complete, the model can be set up to evaluate a wide range of operating scenarios, details of which are provided at the end of this section.

Material Sources - Household Collected Waste

As a strategic model considering annual flows of waste and facility throughputs, an aggregated definition of the sources of collected household waste in the county was required. Using Entec’s in-house Royal Mail database, details of all residential addresses within the county have been extracted, resulting in the identification of 184,171 properties in total which compares well with published 2002 figures of 183,970 households.

A suitable level of aggregation of this base data is at postcode district level, these being of the form BA14 in the postcode BA14 8SL. Through selection of the core postcode districts containing properties within the county, 26 aggregated sources of household collected waste have been defined within the model.

TRANSPORT LOGISTICS STUDY FOR WILTSHIRE - FINAL REPORT

The annual tonnage of waste produced by each defined source was allocated pro-rata based on current quantities of waste generated in each district and the number of households in each of the postcode districts for each collection authority region.

Details of the household collected waste sources defined in the model and the existing waste management arrangements for each district in the county are presented in Table A.1.

Table A.1 Residual Household Waste Sources and Existing Waste Management Arrangements

District	Households (2002 figures)	Household Collected Waste (2003/4 tonnes)	Landfill Destination	Model Defined Sources	Model Allocation (predicted 2003/4 tonnes)
N. Wilts	52,120	38860.26 9740.88	Compton Bassett Chapel Farm	SN11-north wilts	7357
				SN13-north wilts	5678
				SN14-north wilts	8986
				SN15-north wilts	12261
				SN16-north wilts	4709
				SN4-north wilts	5238
				SN5-north wilts	1973
Kennet	32,000	21809.52 14715.06 617.65	Compton Bassett Everleigh Xfer Westbury	SN6-north wilts	2398
				RG17-kennet	255
				SN10-kennet(1)	14224
				SN10-kennet(2)	618
				SN8-kennet(1)	7330
				SN8-kennet(2)	4800
				SN9-kennet	4269
Salisbury	48,600	44378.96	Thorny Down Xfer	SP11-kennet	2822
				SP9-kennet	2826
				SP1-Salisbury	9015
				SP2-Salisbury	11558
				SP3-Salisbury	4669
				SP4-Salisbury	10819
				SP5-Salisbury	7364
W. Wilts	51,250	753.26 48867.66	Compton Bassett Westbury	SP7-Salisbury	954
				BA12-West Wilts	11395
				BA13-West Wilts	6917
				BA14-West Wilts	16686
				BA15-West Wilts	5257
				BA2-West Wilts	415
				SN12-West Wilts(1)	8198
SN12-West Wilts(2)	753				
Total	183,970	179,743			179,743

Note: A number of the sources have been split in two to facilitate allocation to multiple destinations as part of the As Is model

Taking the centre of mass of the properties in each of the postcode district sources, i.e. location weighted by household density, it is possible to represent each aggregated source as a distinct location; it is from these locations that journey distances to reception facilities are calculated within the model.

The distribution of the household collected waste sources defined in the model is presented in Figure A.4.

Figure A.4 Household Collected Waste Postcode District Sources



- District**
- Kennet
 - North Wilts
 - Salisbury
 - West Wilts

Material Sources - Household Recycling Centres (HRCs)

HRCs have been defined as discrete sources in the model; there was no need to aggregate these as was the case with the household collected waste sources. Details of the sites and the disposal points for the residual waste arising at each based on existing arrangements is presented in Table A.2. The locations of the sites are presented in Figure A.5.

Table A.2 HRC Sources and Existing Waste Management Arrangements

Site	District	Postcode	Total Arisings (2003/4 tonnes)	Residual Waste Arisings (predicted 2003/4 tonnes)	Landfill Destination
Salisbury	Salisbury	SP2 7NP	12279.34	3920.11	Compton Bassett
Warminster	West Wilts	BA12 8PE	8678.14	2787.13	Compton Bassett
Purton	North Wilts	SN5 4HG	7193.20	2336.11	Chapel Farm
Stanton St Quintin	North Wilts	SN14 6BD	8461.13	2387.44	Compton Bassett
Melksham	West Wilts	SN12 6QT	6404.93	1846.48	Compton Bassett
Trowbridge	West Wilts	BA14 8RQ	8697.42	2271.56	Compton Bassett
Amesbury	Salisbury	(SP4 7RX) Mills Way, Boscombe Down Ind Est	Opens Mar 2004		Compton Bassett
Devizes	Kennet	(SN10 2EU) Hopton Road Ind Est	Opens Mar 2004		Compton Bassett
Everleigh	Kennet	SN9 6LZ	4286.46	1410.67	Compton Bassett
Honeyball	N Wilts	SN11 8RB	2008.13	620.81	Compton Bassett
Total				17580.31	

Beyond the As Is scenario, two additional HRCs become operational (Amesbury and Devizes). In assigning residual waste arisings to these facilities the assumption has been made that the new sites result in the diversion of a proportion of the material arising at other sites in their proximity. On this basis, the site at Devizes attracts waste previously delivered to Melksham and Everleigh, the Amesbury site attracts waste previously delivered to Salisbury.

The impact of known housing development and its associated impact on localised waste growth may be incorporated within the model should this be required at a later stage.

Material Sources - Trade Waste

Trade waste is collected separately in West Wilts but is co-collected in Salisbury, North Wilts and Kennet. The contribution of trade waste to the total residual waste arising at the sources defined in the model (see above) has been taken into account in the waste flow models..

Material Sources - Recycling Residues

Where considered in the overall scenario configurations, recycling facility residues are included in the residual waste tonnages. These are assumed to be 5% of the input for both the MRF and composting facilities described in the waste flow models.

Waste Transfer and Reception Facilities

A number of waste processing and disposal facility types can be defined within the model, each with different functionality regarding material outputs and costs.

A summary of the core facilities considered in the Wiltshire analysis, including costs applied in the model, is presented below and in Table A.3.

Transfer Stations simply bulk-up material and transfer it on; they have no effect on the input tonnage of material. A unit handling cost is applied at the transfer station. The two transfer facilities included in the model, and retained for the future scenario analysis, are Thorny Down and Everleigh.

Landfill Sites are end-receptors for material; no output materials are generated. Three sites are considered in the model scenario analysis, these being at the existing sites at Chapel Farm, Compton Bassett and Westbury. In addition to the gate fee applied at each site, as set out in Table 7.3, landfill tax is applied to all incoming wastes at the following rates:

- 2003/4 (As Is scenario) £13/tonne
- 2004/5 £15/tonne
- 2009/10 £30/tonne
- 2029/30 £35/tonne

Energy from Waste (EfW) facilities are configured as end receptors of material in the model and as such do not produce any material outputs requiring onward transport and re-use/disposal within the model. In reality, EfW plants are waste processors that lead to the production of residues in the form of bottom ash and air pollution control (APC) residues. An initial estimate of the relative proportions that these make up of the incoming feedstock is: bottom ash – 30%, APC residues – 5%. It may be possible to recycle the bottom ash (as a construction material). APC residues will have to go to a licensed hazardous waste landfill (possibly in Gloucestershire,

possibly further afield as the impacts of the end to the co-disposal of hazardous and non-hazardous wastes take effect, (e.g. to the proposed underground storage facility at Winsford, Cheshire). Should it be a requirement that all elements of the EfW option supply chain be included in the analysis, the downstream residue outlet options can be built into the model at a later stage.

In this analysis, EfW is considered to be viable at the Ratfyn site (Amesbury) and West Wilts Trading Estate (Westbury), as identified in the preliminary sites assessment.

Mechanical Biological Treatment (MBT) facilities act (in logistics terms) to separate the incoming waste into 4 products, the overall weight of which may be less than the material coming in. The products are recycled material, recovered material, residues and RDF (Refuse Derived Fuel).

The model has been configured to generate MBT products in the ratios (as a percentage of the input tonnage) and with downstream management requirements as defined below:

- Recycled material post-MBT constitutes 7% of the input material. The assumption in the model is that this material is sent to a reprocessor in Bristol where it is accepted free of charge;
- Recovered material makes up 8% of the input material. This is also assumed to be sent to a reprocessor in Bristol where it is accepted free of charge;
- RDF makes up 39% of the site input tonnage. Under the scenarios considered, this material either goes to third party EfW in Slough (Slough Heat and Power is the nearest current market outlet, and has been used to model a generic market 80 miles distant), or to landfill. The material incurs the standard gate fees charged at these facilities.
- MBT residues represent 20% of input tonnage and are disposed of via landfill.
- Twenty six percent of throughput tonnage is assumed to be lost through evaporation.

In this analysis, MBT is considered to be viable at the Compton Bassett site, Ratfyn site (Amesbury) and West Wilts Trading Estate (Westbury), as identified in the preliminary sites assessment.

Summary reception locations

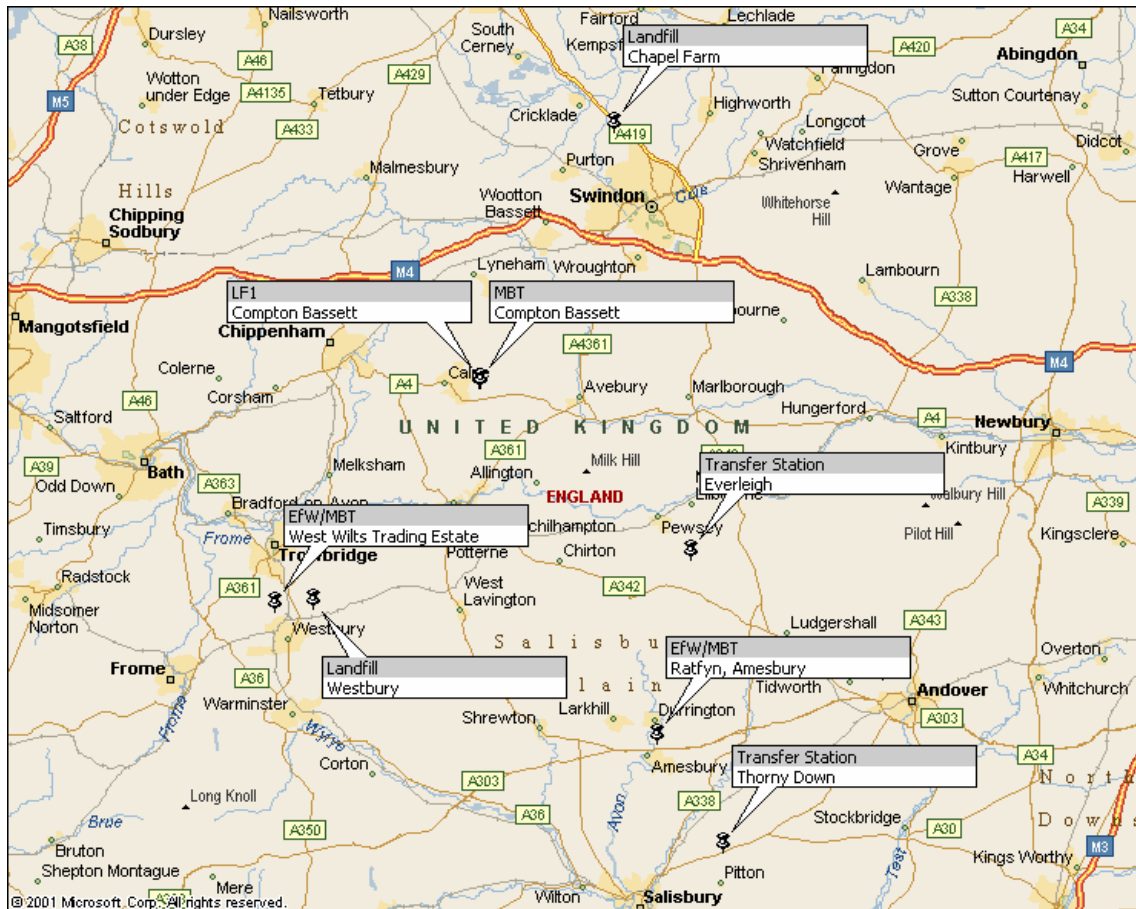
The locations of existing and potential development sites for the waste reception facilities included in the model are presented in Table A.3 and Figure A.6.

Table A.3 Reception Facility Data

Facility Type	Name	Location	Existing / Future	Gate Fee (£/tonne)
Transfer Station	Thorny Down	SP5 1BL	Existing	9
	Everleigh	SN9 6LZ	Existing	9
Landfill	Compton Bassett	SN11 8RB	Existing	25
	Westbury	BA13 4LX	Existing	25

	Chapel Farm	SN26 8DD	Existing	25
EFW	Ratfyn	Amesbury	Future	55
	Westbury	West Wilts Trading estate	Future	55
MBT	Ratfyn	Amesbury	Future	45
	Compton Bassett	SN11 8RB	Future	45
	Westbury	West Wilts Trading Estate	Future	45

Figure A.6 Reception Facility Locations



Waste Transport

An important element of Facility Locator is that cost calculations throughout the waste supply chain are based on real journeys on real roads, i.e. it is not just the gate fees charged and reprocessing costs/revenues that drive the optimum solution.

Journey mileages are derived from the front-end mapping software used within Facility Locator which calculates the quickest route between points, sticking to A roads and motorways if there are any. No roads have been excluded from use in the analysis but they can be if required. For example, the logistics impact of forcing waste movements along freight routes in Wiltshire could be considered.

The allocation of material arising at the defined sources to the processing and disposal facilities available under each scenario includes transport costs for material delivered directly by RCVs (Refuse Collection Vehicles) and also via transfer stations. The calculation used to determine the unit cost (£/tonne/mile travelled) for the two journey types included in the logistics model is presented in Table A.4.

The logistics cost output reported for each scenario is based on one-way journey distances, i.e. from the point of arising to the point of delivery. The total mileage reported for each modelled scenario is based on return journey distances, i.e. from the point of arising to the point of delivery and the vehicle return journey whilst empty.

The calculation has been built up based on two types of bulk transfer of material, these being movements from HRCs and from transfer stations. For simplicity, these have been combined in the current Wiltshire logistics model. These could be included as separate journey types and costs should a more detailed analysis be required at a later stage.

Table A.4 Logistics Unit Cost Calculation

Parameter (units)	Journey Type			Notes
	RCV	Bulk Transfer	HRC Bulk	
Input Data				
Driving Speed (mph)	20	30	35	The average speed whilst making transit journeys to/from the reception facility has been used
Driver Cost (£/hr)	10	10	10	
Crew Cost (£/hr)	9	9	9	Assumes wheeled bin collections on the household rounds
Crew Number	2	0	0	
Fuel Economy (mpg)	3	5.2	6	
Average Load (Te)	9	20	7	
Vehicle Cost (£)	110000	125000	85000	
Depreciation Period (years)	7	5	7	
Maintenance Cost (£/year)	10000	30000	11000	
Working Days	260	260	260	
Fuel Cost (£/l)	0.68	0.68	0.68	
Standard day (hrs)	2	5	8	Based on hours spent undertaking transit journey activities
Calculation				
Fuel Costs/hr	20.4	17.65	17.85	
Vehicle Cost/hr	49.45	42.31	11.13	
Labour Costs/hr	28	10	10	

Total Cost (£/hr)	97.85	69.96	38.98
Total Cost (£/tonne/mile)	0.54	0.12	0.16
Model Total Cost (£/tonne/mile)	0.54	0.14	Average bulked logistics cost used in model

All materials generated as an output from a process, e.g. MBT residues, are transported as 20 tonne bulk material loads, with resulting journey costs calculated on the basis of the lower unit logistics cost.

Model Unit Costs

Unit costs of management at each stage in the transport and treatment/disposal supply chain have been built into the model at the levels described previously. On this basis, total scenario costs take account of both variations in the gate fees at different types of facility and also the cost-benefit of dealing with waste close to its point of arising as a result of reduced transport costs. The only cost parameter altered over the core modelling horizon (2004/5 – 2029/30) relates to the level of landfill tax applied to each tonne of material disposed of by landfill.

1.4 Scenario Analysis

A number of defined residual waste management scenarios have been evaluated within the logistics model consistent with those developed as part of the county-wide options appraisal.

The first scenario developed represents the ‘As Is’ situation for residual waste management in the County (i.e. collection from households and HRCs with transfer or direct delivery to landfill), the foundation year being 2003-04. Beyond this future combinations of treatment options and locations are tested, details of which are provided below. For each future-looking scenario option, waste quantities and facility configurations have been tested at three benchmark years: 2004/5, 2009/10, and 2029/30.

Scenario Performance

In addition to facility outputs indicating total waste throughput at each facility, for each of the scenarios tested an evaluation of overall performance is presented via a set of common summary statistics, comprising:

- Total charges, representing all gate fees and revenues incurred at facilities;
- Logistics charges, representing all transport costs (direct delivery and bulked);
- Total scenario costs (sum of the above); and
- Total scenario mileage.

All figures are reported on an annual basis for each modelled year. The results from each scenario are described reporting the following sections.

As Is Scenario

Under this scenario, the model has been configured such that material flows are constrained to match existing arrangements across the county in 2003/4 (as introduced in Table A.1 and A.2). The constrained destinations of the waste arising in the As Is model are presented in Table A.5 below.

Table A.5 As Is Waste Movements

Model Source	Tonnage	Destination
SN11-north wilts	7357	Compton Bassett Landfill
SN13-north wilts	5678	Compton Bassett Landfill
SN14-north wilts	8986	Compton Bassett Landfill
SN15-north wilts	12261	Compton Bassett Landfill
SN16-north wilts	4709	Compton Bassett Landfill
SN4-north wilts	5238	Chapel Farm Landfill
SN5-north wilts	1973	Chapel Farm Landfill
SN6-north wilts	2398	Chapel Farm Landfill
RG17-kennet	255	Compton Bassett Landfill
SN10-kennet(1)	14224	Compton Bassett Landfill
SN10-kennet(2)	618	Westbury Landfill
SN8-kennet(1)	7330	Compton Bassett Landfill
SN8-kennet(2)	4800	Compton Bassett Landfill via Everleigh TS
SN9-kennet	4269	Compton Bassett Landfill via Everleigh TS
SP11-kennet	2822	Compton Bassett Landfill via Everleigh TS
SP9-kennet	2826	Compton Bassett Landfill via Everleigh TS
SP1-Salisbury	9015	Compton Bassett Landfill via Thorny Down TS
SP2-Salisbury	11558	Compton Bassett Landfill via Thorny Down TS
SP3-Salisbury	4669	Compton Bassett Landfill via Thorny Down TS
SP4-Salisbury	10819	Compton Bassett Landfill via Thorny Down TS
SP5-Salisbury	7364	Compton Bassett Landfill via Thorny Down TS
SP7-Salisbury	954	Compton Bassett Landfill via Thorny Down TS
BA12-West Wilts	11395	Westbury Landfill
BA13-West Wilts	6917	Westbury Landfill
BA14-West Wilts	16686	Westbury Landfill
BA15-West Wilts	5257	Westbury Landfill
BA2-West Wilts	415	Westbury Landfill
SN12-West Wilts(1)	8198	Westbury Landfill
SN12-West Wilts(2)	753	Compton Bassett Landfill
Salisbury	3920	Compton Bassett Landfill
Warminster	2787	Compton Bassett Landfill
Purton	2336	Chapel Farm Landfill
Stanton St Quintin	2387	Compton Bassett Landfill
Melksham	1846	Compton Bassett Landfill
Trowbridge	2272	Compton Bassett Landfill
Amesbury	0	N/A
Devizes	0	N/A
Everleigh	1411	Compton Bassett Landfill
Honeyball	621	Compton Bassett Landfill
Total	197324	

Summary statistics:

2003/4: Tonnes into system 197,324. Tonnes via transfer stations 63,016 (48,299 through Thorny Down, 14,717 through Everleigh). Tonnes to Compton Bassett landfill 135,893. Tonnes to Westbury landfill 49,485. Tonnes to Chapel Farm landfill 11,946. Charges £8,262,763. Logistics costs £1,184,467. Total costs £9,447,229. Total miles 650,465.

Whilst running unconstrained, i.e. where the software is free to determine movements from source to receptor (as is the case with all subsequent scenarios), the model has been configured such that an artificial penalty is applied to annual waste flows between sites less than 2,000 tonnes in total. This is designed to minimise solutions where the model may allocate waste from a source to multiple end locations in a bid to find the least-cost solution. The model has thus been configured to more closely match reality, where collection rounds and HRC bulk movements are generally operated such that waste collected from a defined location is always delivered to the same reception facility.

Baseline Option

The Baseline option maintains the As Is management of residual waste via existing landfill sites in the county (but does not force waste from the sources to go to a particular disposal point). Throughput constraints at the available sites have been imposed in line with current site capacity and contract expectations as follows:

- Westbury landfill can accept up to 50,000 tonnes per annum until 2004/5, after which time it will become unavailable; and
- Minimal capacity will be available at Chapel Farm beyond 2004/5, with an upper limit of 25,000 tonnes per annum applied at this site within the model.

Summary statistics:

2004/5: Tonnes into system 179,135. Tonnes via transfer stations 13,106 (100% through Thorny Down). Tonnes to Compton Bassett landfill 113,784. Tonnes to Westbury landfill 50,000. Tonnes to Chapel Farm landfill 15,352. Charges £7,283,361. Logistics costs £1,403,669. Total costs £8,687,031. Total miles 698,900.

2009/10: Tonnes into system 208,135. Tonnes via transfer stations 20,659 (100% through Thorny Down). Tonnes to Compton Bassett landfill 190,202. Tonnes to Chapel Farm landfill 17,933. Charges £11,633,355. Logistics costs £1,787,799. Total costs £13,421,154. Total miles 843,263.

2029/30: Tonnes into system 307,167. Tonnes via transfer stations 30,678 (100% through Thorny Down). Tonnes to Compton Bassett landfill 284,918. Tonnes to Chapel Farm landfill 22,249. Charges £18,706,123. Logistics costs £2,662,909. Total costs £21,369,031. Total miles 1,225,734.

Option 1

In option 1 a minimum tonnage is diverted from landfill to EfW at each of the modelled years, consistent with the waste diversion requirements described in Section 4.5 and 5.

The earliest modelled year at which EfW is considered viable within the county is 2009/10. The EfW minimum tonnages applied at the target years are: 2009/10 (93,661 tonnes), 2029/30 (261,092 tonnes).

No upper limit on throughput at the EfW sites considered has been applied. The same restrictions on future landfill capacity at Westbury and Chapel Farm as described in the Baseline option apply.

For each year where EfW is considered, three site configurations have been tested:

- a) EfW at Ratfyn only
- b) EfW at Westbury only
- c) EfW at both sites

For configuration c), no minimum tonnage throughput at either of the EfW facilities has been applied. Alternatively, a maximum throughput at the competing landfill sites (Compton Bassett and Chapel Farm) was applied within the model equal to the total waste entering the system minus the quantity required to be diverted to EfW. Given the fixed upper capacity limit applied at Chapel Farm throughout the future years (25,000 tonnes), Compton Bassett was assigned a maximum throughput equal to the balance.

Summary statistics:

2004/5:	As Baseline 2004/5
2009/10a):	Tonnes into system 208,135. Tonnes via transfer stations 0. Tonnes to Ratfyn EfW 94,151. Tonnes to Compton Bassett landfill 95,527. Tonnes to Chapel Farm landfill 18,455. Charges £11,447,425. Logistics costs £1,482,206. Total costs £12,929,631. Total miles 658,950.
2009/10b):	Tonnes into system 208,135. Tonnes via transfer stations 7,691 (100% through Thorny Down). Tonnes to Westbury EfW 108,693. Tonnes to Compton Bassett landfill 80,986. Tonnes to Chapel Farm landfill 18,455. Charges £11,516,647. Logistics costs £1,423,714. Total costs £12,940,362. Total miles 650,930.
2009/10c):	Tonnes into system 208135. Tonnes via transfer stations 0. Tonnes to Ratfyn EfW 61,518. Tonnes to Westbury EfW 59,805. Tonnes to Compton Bassett landfill 68,356. Tonnes to Chapel Farm landfill 18,455. Charges £11,447,425. Logistics costs £942,422. Total costs £12,389,847. Total miles 422,066.
2029/30a):	Tonnes into system 307,167. Tonnes via transfer stations 4,644, (100% through Everleigh). Tonnes to Ratfyn EfW 261,098. Tonnes to Compton Bassett landfill 23,940. Tonnes to Chapel Farm landfill 22,129. Charges £17,166,331. Logistics costs £3,095,169. Total costs £20,261.500. Total miles 1,423,587.

2029/30b): Tonnes into system 307,167. Tonnes via transfer stations 0. Tonnes to Westbury EfW 261,113. Tonnes to Compton Bassett landfill 22,275. Tonnes to Chapel Farm landfill 23,779. Charges £17,124,457. Logistics costs £2,689,093. Total costs £19,813,550. Total miles 1,184,083.

2029/30c): Tonnes into system 307,167. Tonnes via transfer stations 4,539 (100% through Thorny Down). Tonnes to Ratfyn EfW 104,368. Tonnes to Westbury EfW 159,880. Tonnes to Compton Bassett landfill 21,058. Tonnes to Chapel Farm landfill 21,861. Charges £17,149,629. Logistics costs £1,878,525. Total costs £19,028,154. Total miles 860,362.

Option 2

Within option 2, all residual waste arising is diverted to Mechanical Biological Treatment at each of the modelled years where it is considered viable, i.e. at 2009/10 and beyond.

Both MBT residues and RDF are sent for onward disposal via landfill. Recovered and recycled material outputs are sent to reprocessors in Bristol.

The same restrictions on future landfill capacity at Westbury and Chapel Farm as described in the Baseline option apply.

For each year where MBT is considered, three site configurations have been tested:

- a) MBT at Ratfyn only
- b) MBT at Westbury only
- c) MBT at Compton Bassett only
- d) MBT at all sites

For configuration d), no minimum tonnage throughput at the MBT facilities has been applied. Alternatively, the landfill sites have been configured in the model such that they may only accept material that has been through the MBT process (i.e. they cannot accept raw residual waste).

Summary statistics:

2004/5: As Baseline 2004/5

2009/10a): Tonnes into system 208,135. Tonnes via transfer stations 4,697 (100% via Thorny Down). Tonnes to Ratfyn MBT 208,135. Tonnes to Compton Bassett landfill 120,800. Tonnes to Chapel Farm landfill 2,000. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Charges £13,727,148. Logistics costs £2,502,174. Total costs £16,229,321. Total miles 1,357,867.

2009/10b): Tonnes into system 208,135. Tonnes via transfer stations 4,697 (100% through Thorny Down). Tonnes to Westbury MBT 208,135. Tonnes to Compton Bassett landfill 120,799. Tonnes to Chapel Farm landfill 2,001. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Charges £13,727,148. Logistics costs £2,087,680. Total costs £15,814,827. Total miles 1,051,084.

- 2009/10c): Tonnes into system 208,135. Tonnes via transfer stations 4,697 (100% through Thorny Down). Tonnes to Compton MBT 208,135. Tonnes to Compton Bassett landfill 120,799. Tonnes to Chapel Farm landfill 2,001. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Charges £13,727,148. Logistics costs £1,764,982. Total costs £15,492,129. Total miles 846,911.
- 2009/10d): Tonnes into system 208,135. Tonnes via transfer stations (11,218 through Thorny Down, 17,146 through Everleigh). Tonnes to Ratfyn MBT 57,654. Tonnes to Westbury MBT 73,531. Tonnes to Compton Bassett MBT 76,950. Tonnes to Compton Bassett landfill 116,793. Tonnes to Chapel Farm landfill 6,007. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Charges £13,940,144. Logistics costs £1,596,605. Total costs £15,536,749. Total miles 894,418.
- 2029/30a): Tonnes into system 307,167. Tonnes via transfer stations 8,080 (3,440 through Thorny Down, 4,640 through Everleigh). Tonnes to Ratfyn MBT 307,167. Tonnes to Compton Bassett landfill 178,853. Tonnes to Chapel Farm landfill 2,375. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Charges £21,175,094. Logistics costs £3,658,246. Total costs £24,833,340. Total miles 1,994,420.
- 2029/30b): Tonnes into system 307,167. Tonnes via transfer stations 8,080 (3,440 through Thorny Down, 4,640 through Everleigh). Tonnes to Westbury MBT 307,167. Tonnes to Compton Bassett landfill 178,853. Tonnes to Chapel Farm landfill 2,375. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Charges £21,175,094. Logistics costs £3,026,756. Total costs £24,201,850. Total miles 1,524,650.
- 2029/30c): Tonnes into system 307,167. Tonnes via transfer stations 8,080 (3,440 through Thorny Down, 4,640 through Everleigh). Tonnes to Compton Bassett MBT 307,167. Tonnes to Compton Bassett landfill 178,853. Tonnes to Chapel Farm landfill 2,375. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Charges £21,175,094. Logistics costs £2,538,119. Total costs £23,713,213. Total miles 1,222,915.
- 2029/30d): Tonnes into system 307,167. Tonnes via transfer stations 15,262 080 (4,640 through Thorny Down, 10,622 through Everleigh). Tonnes to Ratfyn MBT 88,966. Tonnes to Westbury MBT 104,559.). Tonnes to Compton Bassett MBT 113,642. Tonnes to Compton Bassett landfill 174,705. Tonnes to Chapel Farm landfill 6,524. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Charges £21,239,731. Logistics costs £1,873,011. Total costs £23,112,742. Total miles 1,084,248.

Option 3

This option is identical to option 2, but with the RDF output from the MBT sent to third party EfW (modelled as 160 mile round trip to Slough Heat and Power as the nearest current market outlet).

Summary statistics:

2004/5:	As Baseline 2004/5
2009/10a):	Tonnes into system 208,135. Tonnes via transfer stations 17,197 (5,295 through Thorny Down, 11,902 tonnes through Everleigh). Tonnes to Ratfyn MBT 208,135. Tonnes to Compton Bassett landfill 39,625. Tonnes to Chapel Farm landfill 2,002. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Tonnes to Slough EfW 74,929. Charges £13,839,647. Logistics costs £3,105,669. Total costs £16,945,317. Total miles 1,796,816.
2009/10b):	Tonnes into system 208,135. Tonnes via transfer stations 17,197 (5,295 through Thorny Down, 11,902 tonnes through Everleigh). Tonnes to Westbury MBT 208,135. Tonnes to Compton Bassett landfill 39,625. Tonnes to Chapel Farm landfill 2,002. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Tonnes to Slough EfW 74,929. Charges £13,839,647. Logistics costs £3,071,000. Total costs £16,910,648. Total miles 1,756,828.
2009/10c):	Tonnes into system 208,135. Tonnes via transfer stations 17,197 (5,295 through Thorny Down, 11,902 tonnes through Everleigh). Tonnes to Compton Bassett MBT 208,135. Tonnes to Compton Bassett landfill 39,625. Tonnes to Chapel Farm landfill 2,002. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Tonnes to Slough EfW 74,929. Charges £13,839,647. Logistics costs £2,690,987. Total costs £16,530,634. Total miles 1,470,531.
2009/10d):	Tonnes into system 208,135. Tonnes via transfer stations 38,634 (19,545 through Thorny Down, 19,089 tonnes through Everleigh). Tonnes to Ratfyn MBT 63,272. Tonnes to Westbury MBT 53,587. Tonnes to Compton Bassett MBT 91,276. Tonnes to Compton Bassett landfill 35,626. Tonnes to Chapel Farm landfill 6,001. Tonnes to Bristol recycled 14,569. Tonnes to Bristol recovered 16,651. Tonnes to Slough EfW 74,929. Charges £14,032,588. Logistics costs £2,510,661. Total costs £16,543,249. Total miles 1,484,663.
2029/30a):	Tonnes into system 307,167. Tonnes via transfer stations 4,629 (100% through Thorny Down). Tonnes to Ratfyn MBT 307,167. Tonnes to Compton Bassett landfill 59,433. Tonnes to Chapel Farm landfill 2,000. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Tonnes to Slough EfW 110,580. Charges £20,545,058. Logistics costs £4,418,787. Total costs £24,963,845. Total miles 2,527,450.
2029/30b):	Tonnes into system 307,167. Tonnes via transfer stations 4,629 (100% through Thorny Down). Tonnes to Westbury MBT 307,167. Tonnes to Compton Bassett landfill 59,433. Tonnes to Chapel Farm landfill 2,000. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Tonnes to Slough EfW 110,580. Charges £20,545,058. Logistics costs £4,194,398. Total costs £24,739,455. Total miles 2,401,784.

2029/30c): Tonnes into system 307,167. Tonnes via transfer stations 4,629 (100% through Thorny Down). Tonnes to Compton Bassett MBT 307,167. Tonnes to Compton Bassett landfill 59,433. Tonnes to Chapel Farm landfill 2,000. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Tonnes to Slough EfW 110,580. Charges £20,545,058. Logistics costs £3,773,225. Total costs £24,318,282. Total miles 2,005,805.

2029/30d): Tonnes into system 307,167. Tonnes via transfer stations 36,167 (17,055 through Thorny Down, 19,112 through Everleigh). Tonnes to Ratfyn MBT 95,627. Tonnes to Westbury MBT 77,364. Tonnes to Compton Bassett MBT 134,175. Tonnes to Compton Bassett landfill 55,432. Tonnes to Chapel Farm landfill 6,002. Tonnes to Bristol recycled 21,502. Tonnes to Bristol recovered 24,573. Tonnes to Slough EfW 110,580. Charges £20,828,900. Logistics costs £3,406,187. Total costs £24,235,088. Total miles 2,032,003.

Option 6

Option 6 is the same as option 1, (i.e. landfill diversion via EfW, with a minimum tonnage), but with a lower residual waste tonnage entering the system at each modelled year.

Summary statistics:

2004/5: Tonnes into system 178,150. Tonnes via transfer stations 20,160 (100% through Thorny Down). Tonnes to Compton Bassett landfill 110,676. Tonnes to Westbury landfill 49,998. Tonnes to Chapel Farm landfill 17,476. Charges £7,307,440. Logistics costs £1,355,073. Total costs £8,662,513. Total miles 630,454.

2009/10a): Tonnes into system 184,049. Tonnes via transfer stations 7,489 (100% through Thorny Down). Tonnes to Ratfyn EfW 76,190. Tonnes to Compton Bassett landfill 89,632. Tonnes to Chapel Farm landfill 18,227. Charges £10,190,092. Logistics costs £1,295,261. Total costs £11,485,353. Total miles 591,659.

2009/10b): Tonnes into system 184,049. Tonnes via transfer stations 6,851 (100% through Thorny Down). Tonnes to Westbury EfW 96,124. Tonnes to Compton Bassett landfill 71,698. Tonnes to Chapel Farm landfill 16,266. Charges £10,184,351. Logistics costs £1,259,610. Total costs £11,443,961. Total miles 574,693.

2009/10c): Tonnes into system 184,049. Tonnes via transfer stations 24,480 (22,051 through Thorny Down, 2,430 through Everleigh). Tonnes to Ratfyn EfW 68,877. Tonnes to Westbury EfW 44,577. Tonnes to Compton Bassett landfill 49,497. Tonnes to Chapel Farm landfill 21,099. Charges £10,343,016. Logistics costs £1,091,230. Total costs £11,434,246. Total miles 522,135.

2029/30a): Tonnes into system 255,039. Tonnes via transfer stations 5,059 (100% through Everleigh). Tonnes to Ratfyn EfW 191,308. Tonnes to Compton Bassett landfill 46,241. Tonnes to Chapel Farm landfill 17,491. Charges £14,391,332. Logistics costs £2,429,985. Total costs £16,821,317. Total miles 1,119,791.

2029/30b): Tonnes into system 255,039. Tonnes via transfer stations 11,519 (100% through Everleigh). Tonnes to Westbury EfW 196,536. Tonnes to Compton Bassett landfill 35,732. Tonnes to Chapel Farm landfill 22,771. Charges £14,423,335. Logistics costs £2,127,362. Total costs £16,550,698. Total miles 954,661.

2029/30c): Tonnes into system 255,039. Tonnes via transfer stations 0. Tonnes to Ratfyn EfW 87,825. Tonnes to Westbury EfW 115,256. Tonnes to Compton Bassett landfill 29,510. Tonnes to Chapel Farm landfill 22,448. Charges £14,286,938. Logistics costs £1,320,675. Total costs £15,607,612. Total miles 605,413.

Option 8

Option 8 is the same as option 6, with reduced levels of residual waste entering the system, but with EfW treating all waste arising at the years where it is considered viable, i.e. 2008/9 and beyond.

Summary statistics:

2004/5: As Option 6 2004/5

2009/10a): Tonnes into system 184,049. Tonnes via transfer stations 0. Tonnes to Ratfyn EfW 184,049. Tonnes to Compton Bassett landfill 0. Tonnes to Chapel Farm landfill 0. Charges £10,122,695. Logistics costs £2,164,596. Total costs £12,287,291. Total miles 980,954.

2009/10b): Tonnes into system 184,049. Tonnes via transfer stations 0. Tonnes to Westbury EfW 184,049. Tonnes to Compton Bassett landfill 0. Tonnes to Chapel Farm landfill 0. Charges £10,219,441. Logistics costs £1,771,901. Total costs £11,991,342. Total miles 790,942.

2009/10c): Tonnes into system 184,049. Tonnes via transfer stations 0. Tonnes to Ratfyn EfW 65,935. Tonnes to Westbury EfW 118,114. Tonnes to Compton Bassett landfill 0. Tonnes to Chapel Farm landfill 0. Charges £10,122,695. Logistics costs £1,275,841. Total costs £11,398,536. Total miles 568,591.

2029/30a): Tonnes into system 255,039. Tonnes via transfer stations 0. Tonnes to Ratfyn EfW 255,039. Tonnes to Compton Bassett landfill 0. Tonnes to Chapel Farm landfill 0. Charges £14,027,145. Logistics costs £3,004,119. Total costs £17,031,264. Total miles 1,367,271.

2029/30b): Tonnes into system 255,039. Tonnes via transfer stations 13,245 (9,342 through Thorny Down, 3,903 through Everleigh). Tonnes to Westbury EfW 255,039. Tonnes to Compton Bassett landfill 0. Tonnes to Chapel Farm landfill 0. Charges £14,146,350. Logistics costs £2,474,439. Total costs £16,620,789. Total miles 1,110,462.

2029/30c): Tonnes into system 255,039. Tonnes via transfer stations 0. Tonnes to Ratfyn EfW 91,067. Tonnes to Westbury EfW 163,972. Tonnes to Compton Bassett landfill 0. Tonnes to Chapel Farm landfill 0. Charges £14,027,145. Logistics costs £1,771,827. Total costs £15,798,972. Total miles 793,216.

1.5 Observations

As Is and Baseline

In the short term, maintenance of the As Is approach to residual waste management is seen to decrease in cost, as a result of increased diversion via recycling.

In future years (2009/10 – 2029/30), reliance on Compton Bassett landfill increases as waste quantities rise and alternative capacity at Westbury and Chapel Farm reduces. Total costs and mileages increase consistent with the increase in waste and rising landfill tax charges over the modelled period.

Option 1

Option 1 considers landfill diversion via EfW at Ratfyn and Westbury, modelled years being 2009/10 and 2029/30. When EfW is considered at one site only:

- Facilities are required to handle in excess of 260,000 tonnes of waste in 2029/30; and
- Under the modelled conditions, Westbury would appear to be marginally preferable, attracting 15,000 tonnes more waste than Ratfyn in 2009/10, at a comparable total scenario cost. By 2029/30, the variation in waste throughput at the two sites reduces, although the logistics costs are approximately £400,000 less in the Westbury scenario, also resulting in approximately 240,000 less road miles.

When EfW is considered at both sites concurrently:

- Overall costs are slightly lower than EfW at one site, this being achieved primarily through reduced logistics costs. Total scenario mileage in 2009/10 with EfW at both sites is approximately one-third lower than EfW at either Ratfyn or Westbury (this relationship also holds true in 2029/30);
- Ratfyn is seen to attract more waste than Westbury as part of the optimum solution in 2009/10. This trend reverses in 2029/30 when Westbury attracts more than Ratfyn (159,880 tonnes versus 104,368).

When compared with the baseline scenario, which is based on landfill primarily via Compton Bassett, total scenario costs under option 1 (EfW) are cheaper at all modelled years. By 2029/30, when landfill tax levels have reached £35/tonne, the total cost benefit through adoption of EfW is in excess of £1million per annum.

Option 2

Within this option, all residual waste goes through MBT, with the subsequent residues and RDF being sent to landfill; recovered and recycled material is sent to Bristol. As such, the strategy results in a considerable amount of waste being landfilled. Compton Bassett landfill, as the primary available site, accepts approximately 120,000 tonnes in 2009/10 and just under 180,000 tonnes in 2029/30.

Gate fees, logistics costs, total costs and total scenario mileages are all significantly higher than equivalent option 1 scenarios.

When MBT is considered at one site only:

- Facilities are required to handle in excess of 307,000 tonnes of waste in 2029/30; and
- Under the modelled conditions, MBT at Compton Bassett represents the least cost solution, resulting in significantly lower logistics charges and mileage (due to its proximity to the downstream landfill site).

When MBT is considered at all sites concurrently:

- Overall costs are lower than MBT at one site, the difference being significant when compared with MBT at Ratfyn (£692,572 in 2009/10, £1,720,598 in 2029/30). Total scenario mileage in 2009/10 with MBT at all sites is slightly higher than the equivalent with MBT solely at Compton Bassett; by 2029/30 the total mileage with MBT at all sites is less than the equivalent with MBT solely at Compton Bassett.
- The distribution of waste amongst the three sites is fairly even, with Compton Bassett attracting marginally more waste than the other two sites in 2009/10 and 2029/30. Again, this is likely to be due to the locally available landfill capacity where approximately 60% of the output material ends up in this option.

Option 3

Within option 3, all residual waste goes through MBT, with subsequent residues sent to landfill and RDF sent to EfW at Slough (modelled as 160 mile round trip to Slough Heat and Power as the nearest market outlet); recovered and recycled material is sent to Bristol.

As with option 2, when considered at individual sites, MBT at Compton Bassett represents the lowest cost scenario, primarily as a result of the lower total mileage.

Reliance on downstream landfill for the MBT outputs is reduced in option 3, although there is a resulting need for significant EfW capacity for the RDF produced, representing over 110,000 tonnes per annum in 2029/30.

As in option 2, where MBT is considered at all sites, Compton Bassett attracts the most material (134,000 tonnes in 2029/30). Ratfyn comes second, attracting 95,000 tonnes in 2029/20, with Westbury attracting 77,000 tonnes.

Option 6

Option 6 is based on the same management strategy as option 1, i.e. diversion of a minimum tonnage of residual waste to EfW, but with reduced arisings.

The findings are consistent with those of option 1, with reduced overall costs and mileages linked to the lower levels of waste. As with option 1, EfW at Ratfyn is seen to attract slightly more waste than EfW at Westbury when both facilities are online in the 2009/10 modelled scenario. By 2029/30, the balance reverses, with Westbury seen to attract more waste as part of the least-cost scenario (115,256 tonnes at Westbury versus 87,825 at Ratfyn).

Option 8

Within option 8, waste arisings are the same as option 6, but with all waste sent to EfW. Diversion of all waste to EfW is seen to add approximately £1million to total costs in early years (i.e. 2009/10). The cost differential reduces significantly by 2029/30, as the impact of increased landfill taxes take effect, option 8 scenarios being typically just £100,000 per annum more expensive.

Scenario mileage with both facilities online is considerably less than the equivalent options with a single facility. Under both the 2009/10 and 2029/30 configurations, total mileage is almost double where 100% of waste goes via Ratfyn, compared with split allocation between Ratfyn and Westbury operating concurrently.

General

Given the default unit costs applied within the model, the transfer of collected household waste via direct delivery is not significantly more expensive than delivery via transfer stations. In reality, RCV transit journeys over a given distance would be avoided due to the detrimental impact on round performance in terms of the ability of the collection authorities to complete their rounds.

Where multiple facility options are considered, i.e. EfW or MBT at more than one site, overall scenario costs are less than the single site equivalent scenarios due to reduced mileages and associated logistics costs. With respect to this observation, it is important to note that no consideration has been given to any economies of scale linked to plant size in the model; the unit per tonne cost of management through the gate is assumed constant irrespective of the facility size. In reality, there will be some differential as a result of the increased capital (and infrastructure) costs associated with developing multiple sites. These cost factors may be built in to the model at a later stage if required.

1.6 Key Conclusions

The key conclusions arising from the analysis are:

MBT-based options

1. On the basis of optimum logistics costs and road miles travelled, it is preferable to construct two or three smaller sites rather than one large facility
2. Compton Bassett represents the optimum site, due to downstream reliance on landfill for the residues fraction (and the RDF fraction if an EfW outlet does not exist).
3. The waste is generally evenly distributed amongst the three sites in the long term and therefore it may be advisable to site the first plants at Compton Bassett and Ratfyn and bring Westbury online as necessary.
4. If distributing the waste evenly between the sites then each will be required to have a capacity of 100,000 tonnes per annum
5. In Option 3 where it is assumed that the RDF will be sent to Slough (as the nearest current market outlet), Compton is again more preferable, perhaps due to the proximity of the M4 to West London. In this case it is again preferable to divide the waste

between sites rather than operate a single plant. The logistics model divides the waste follows: Compton 130ktpa, Ratfyn 100ktpa, Westbury 80ktpa.

EfW-based options

1. Again, on the basis of optimum logistics costs and road miles travelled, it is preferable to construct two smaller sites rather than one large facility. The model has not however taken into account any outputs from the EfW e.g. bottom ash, the inclusion of which may alter results.
2. Where two smaller facilities are adopted, Ratfyn attracts more waste in the short term and Westbury becomes more favourable in later years.
3. Option 1 and 6 are similar although Option 6 is cheaper in terms of logistics costs and mileage travelled.
4. Option 8 is most expensive as all residual waste is treated through an EfW plant and therefore associated logistics costs are increased. In Option 8 it is favourable to evenly distribute the waste between the two sites and approximately 125ktpa capacity is required at each site.