Chapter C8

Supplementary Information on Justification for Proposed Investment – Including Outcome of Cost-benefit Analysis and Carbon Accounting

This chapter sets out our approach to cost-benefit analysis, our cost-benefit assessment of our programme, and its carbon impact.

We have produced an optimised plan, in that we have:

- Assessed risks.
- Reviewed alternative options for delivering improvements and maintaining services to ensure that our programme is cost-effective.
- Taken into account synergies between different parts of the plan.
- Balanced service improvements and bills, taking into account customer research and the need for affordable bills
- Evaluated the costs and benefits of alternative service levels.
- Demonstrated that our programme would still be justified with lower values for customer willingness to pay.
- Taken into account the views of other stakeholders.

Our assessment of customer willingness to pay has been conservative, producing lower values than most other companies, and we have confirmed the acceptability of our overall price and service package by carrying out further customer research after publishing our DBP.

Our maintenance programme has been evaluated as the most cost-effective way of maintaining current service levels. Where improvements are justified they are allocated to enhanced service.

Virtually all of our enhanced service programme is assessed as being cost-beneficial. The only exception is resilience schemes for large sewage treatment works, where we do not feel that the benefit assessment, at this stage, adequately reflects the risks and costs associated with major failure.

We have included all the drinking water and environmental quality programmes, even where not cost-beneficial. We recognise that the cost-benefit approach does not fully reflect the priority placed by customers on reliable drinking water supplies and the importance of maintaining public confidence in drinking water. The sewerage quality programme is significantly reduced from the FBP, following discussions with the EA. Much of the programme is now required to meet statutory standards. We will be evaluating the costs and benefits of WFD schemes in more detail in order to respond to the River Basin Management Plan consultation.

Our programme has a broadly neutral carbon impact. Savings from increased energy efficiency and renewable electricity generation are offset by increased use, principally from higher treatment standards. The potential for further increases in treatment standards remains a concern, in terms of our objective of reducing our carbon footprint.

Chapter C8

Supplementary Information on Justification for Proposed Investment – Including Outcome of Cost-benefit Analysis and Carbon Accounting

1 Introduction

This chapter sets out:

- Our approach to cost-benefit analysis.
- Assessment of benefits.
- The optimisation approach.
- Application of cost-benefit analysis.
- Sensitivity analysis.
- Our analysis of the carbon impact of our proposals.

Details of our willingness to pay survey, which is the key component of our cost-benefit analysis, are set out in Chapter C1.

The changes since the Draft Business Plan (DBP) in this chapter are principally:

- An improved explanation of our approach to investment planning and how CBA fits into this.
- Providing additional information on the details of the application of CBA, in line with the information submitted in our October 2008 DBP annex.
- Additional sensitivity analysis.
- An appendix answering technical points on CBA issues raised in Ofwat's feedback.
- A more detailed approach to assessing embodied carbon at water and sewage treatment works.
- More explanation of how our programme for AMP5 fits in with our overall strategy on carbon reduction.

The benefit values used are unchanged from the DBP, with the following exceptions:

- A reduction in the value applied for reducing pollution incidents.
- A change in the approach for valuing sewage treatment compliance.
- A new approach to Section 101A schemes benefit valuation.
- An updated carbon conversion factor for grid electricity.

2 Our approach to cost-benefit analysis

2.1 Our overall approach to preparing our plan

We introduced a Business Planning team in 2006 and agreed processes and procedures have been used for the development of the FBP within a integrated Business Planning Framework. Adherence to this framework ensured that PR09 submissions were not 'special events' but had been developed from plans that were ly being used to manage the company. Our Strategic Direction Statement (SDS) set out our objectives for the next 25 years, based on making improvements which customers support and ensuring that we have a sustainable impact on the environment, while at the same time offering our customers the lowest possible prices. Our customer willingness to pay survey, described in Chapter C1, was carried out before the SDS was produced and enabled our strategy to be based on customer preferences. The research was carried out by Accent and RAND Europe using stated preference discrete choice experiments to establish customers' willingness to pay for improvements. It has been peer reviewed by Professor Ian Bateman, of the University of East Anglia.

Our SDS created the framework for our rolling 5-year Business Plans which have been developed into the PR09 Regulatory submissions. The 2007 Business Plan was therefore the basis of the DBP and the 2008 Business Plan updated the DBP to become the FBP. This incremental approach is directly linked to our aspiration of being the best water and waste company in the UK, delivering the highest standards, lowest charges and great people and as such delivering sustainable return to investors.

The planning framework set out above targeted the delivery of a Business Plan for 2007 that satisfied three key objectives:

- Lowest customer prices (lowest possible prices over the period).
- A single 'A' grade credit rating.
- Customer views being reflected in the plan.

The planning process established the linkage between the inputs to the Business Plan, the control framework (that sets the required output parameters) and the outputs which fed into the DBP/FBP and will continue in the development of future year's business plans. Our DBP was consistent with our SDS and set out in more detail our proposals for the next five years. We believe we put customers at the heart of our plan, by delivering improvements whilst keeping prices as low as possible. Almost all schemes in the DBP were demonstrated to be either cost-beneficial or needed to maintain service.

Alongside this a programme was created to deliver a suite of asset management tools; the Balancing Risk and Investment to Excel (BRITE) programme. The BRITE initiative was established to satisfy a business (and alongside this a wider industry) requirement for a significantly improved asset planning capability. The tools were constructed to meet the requirements of the industry Capital Maintenance Planning Common Framework (CMPCF) developed by UKWIR. BRITE uses cost-benefit analysis and our customer willingness to pay research as essential inputs in the development of the investment plan options for the defined period. These options were then reviewed during a series of iterations by business subject matter experts to arrive at the optimal investment plan for the PR09 submission.

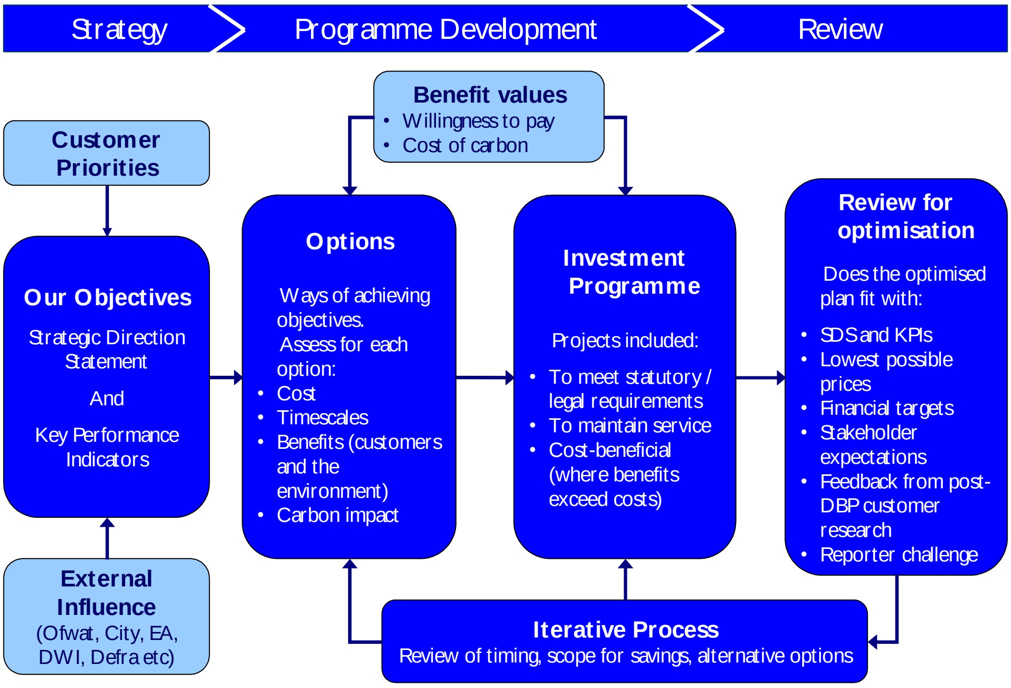
A high level of rigour and governance surrounds the data, processes and systems used in producing our programme. Quality assurance and business expert validation has been carried out at every stage of the process. In addition, we have utilised independent external expertise (Cap Gemini) to carry out model validity and sensitivity analyses which validated our approach.

Internal and external reviews ensured that the Plan was compliant with industry standards, such as the CMPCF and a 'sense check' of outputs to compare against other submissions ensured that the investment plan took account of customer and stakeholder expectations, is cost effective and is properly profiled and deliverable.

The end to end process involved all stakeholders, not only those producing the Plan but more importantly, the operational teams who would be responsible for delivering the planned schemes.

The approaches used and all outputs were also checked for alignment with wider business expectations (including corporate measures, KPIs, historic spend / performance and known problem works / processes).

The process for developing our plan is summarised in the diagram below:



We have produced an optimised plan, in that we have:

- Assessed risks using reliable data sources, with sensitivity analyses to minimise uncertainty.
- Reviewed alternative options for delivering improvements and maintaining services to ensure that our programme is cost-effective.
- Reviewed levels of risk which are acceptable, e.g. determining where single points of failure are acceptable, and reducing design standards for emergency sources.
- Taken into account synergies between different parts of the plan.
- Balanced service improvements and bills, taking into account customer research and the need for affordable bills – some schemes which are cost-beneficial have been deferred beyond AMP5 or spread over a longer period.
- Evaluated the costs and benefits of alternative service levels.
- Chosen service improvements is based on customer priorities.
- Taken into account the views of other stakeholders.

Our approach to business planning is set out in detail in Appendix 4 to this chapter “Severn Trent Water: Business Planning and the PR09 Planning Process”. In addition, Chapters B3 to B6 show how each part of the programme has been optimised.

2.2 Applying cost-benefit analysis

Our cost-benefit approach determines whether the maximum NPV is achieved, in that in some areas it chooses the optimal level of investment and some investment is included and some is excluded, on the criterion of maximising NPV. Areas where we have assessed alternative output levels using cost-benefit analysis include:

- sewer flooding.
- renewables.
- efficiency projects.
- resilience.
- water supply/demand balance – level of security of supply (where we have assessed the optimum level of hosepipe bans).
- capital maintenance – pro-active spend.

In addition to maximising cost-benefit we have considered options to ensure that we have identified the most cost-effective approach. Full description of options is within the B3 to B6 chapters. Examples include:

- Our resilience schemes, where we have considered various options to reduce the risk of an unplanned interruption, such as additional connectivity, developing new sources and operational changes.
- Drinking water quality, where we have considered blending and treatment options for nitrate removal.
- Sewage treatment to meet phosphorus consent limits, where we have evaluated biological and chemical treatment.
- Sludge disposal, where we have considered disposal to land and electricity generation options.

Almost all improvements included in our plan are either cost-beneficial, or required as part of the National Environmental Programme or to meet statutory drinking water standards. The prime basis for valuing benefits is the customer willingness to pay (WTP) survey, which established the value which customers put on improvements in the different areas of service provision. We have used this in our new investment system which balances costs and benefits to produce the best overall plan.

2.3 Developing the FBP

In developing the Final Business Plan, we have made changes in our programme to reflect:

- Further analysis of data, modelling work and consideration of options, which has enabled us to deliver outputs more cost-effectively.
- Discussions with Ofwat at our meeting after the DBP submission and written feedback received.
- Feedback from other stakeholders.
- The deteriorating economic environment
- Increased upward pressures on costs (e.g. rates and abstraction charges – see Chapter B3 for further details) and therefore the level of bills needed to maintain service, which has necessitated some changes in our programme in order to avoid imposing an excessive burden on customers, including deferral of some cost-beneficial schemes.

We carried out customer research on our DBP proposals (see Chapter C1). This showed that:

- There was strong support for our DBP proposals amongst both domestic and business customers, though slightly less strong with business customers.

- Our proposed improvements were supported even if the bill increase had been larger, i.e. if there had not been offsetting cost savings keeping the bill increase down.

The national PR09 research also showed support for our proposals.

Our approach to cost-benefit analysis approach is in line with the guidance set out in the UKWIR report "The Role and Application of Cost-Benefit Analysis". We have also followed the guidance set out by Ofwat in its PR09/08 letter on applying CBA, except where noted below.

2.4 Assessing costs and benefits

Assessment of costs relative to benefits is carried out through our BRITE (Balancing Risk and Investment To Excel) investment modelling. The Common Framework (UKWIR Capital Maintenance Planning – A Common Framework 2002) provides a basis for water companies to estimate their future capital maintenance requirements to meet two possible objectives:

- To provide steady or improving service to customers and the environment at minimum cost to the water company – the cost-effectiveness objective.
- To provide the level of service to customers and the environment which represents an economic balance between the value of the service provided and the associated costs to the water company – the cost-benefit objective.

We have adopted the cost-benefit objective and have therefore assessed the costs and benefits of maintenance schemes for proactive maintenance by comparing the costs and benefits of reducing risk of service failure. Comparisons are made with the base case of reactive maintenance only.

For reactive maintenance, we have only assessed the most cost-effective means of maintenance, as we do not consider it meaningful to assess the costs and benefits of avoiding complete service failure.

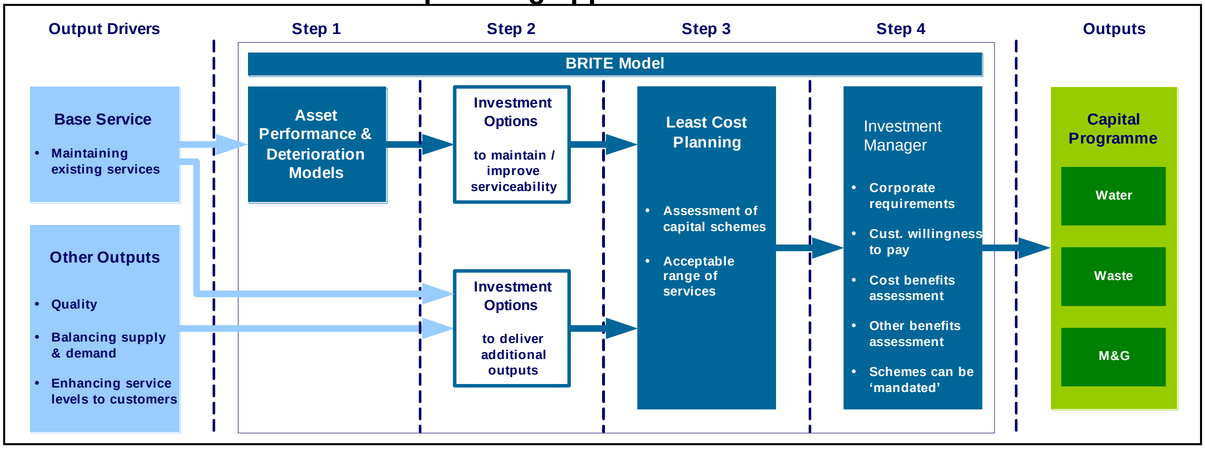
We have taken a 2-step approach. At the asset level, we identify the least-cost plan over 25 years for alternative levels of service. These are then put forward for comparison of the costs and values of the benefits to select the appropriate level of service.

A number of schemes are also included under maintenance which involve investment to reduce operating costs. These are assessed in terms of whether the NPV of the savings exceeds the costs, and their carbon impact.

For expenditure other than maintenance, options for delivering improvements are developed by our Strategy Teams and the most cost-effective approach established. This is then assessed to determine whether it is cost-beneficial. Non-cost-beneficial schemes are excluded from the programme unless required to meet statutory standards, or they are needed to maintain service and we have judged that it would not be in customers' interests to allow a service deterioration.

The figure below shows the BRITE approach for investment planning. All investment projects are evaluated through this process.

BRITE end-to-end investment planning approach



The process is made up of four stages:

Step 1 - Asset performance & deterioration models

This involves statistical analysis to develop forward-looking service-risk models with the following components:

- Likelihood of an asset failure (e.g. expected number of mains bursts, number of equipment failures / works failures).
- Likelihood of a service consequence following an asset failure (expected number of service incidents e.g. interruption >6h).

Step 2 – Investment options

We identify investment and operating cost options and their impact on asset performance, the environment, customer service and operating costs. These investment options come from either the asset performance and deterioration models or other sources.

Step 3 – Least-cost planning model

In each asset operating area, we assess the change in risk to service for all options and choose the least cost options for delivering a range of service levels.

Step 4 – Investment Manager

Outputs from the least-cost planning model are input into the our Investment Manager, which assesses costs and benefits. Willingness to pay and other values are used to assess each project. Projects are selected where the benefits exceed the cost, or if they are required, e.g. to meet statutory obligations. We consider the net present value of costs and benefits over a 25 year planning period.

The investment plan is then subject to review where the deliverability, impact on bills, serviceability and long-term aspirations of the company are considered. This includes review by the PR09 Steering Group, which is the senior governance group for the PR09 programme chaired by the Director of Regulation.

2.5 Period for evaluation

We have carried out our evaluation over a 26-year period (2009/10 to 2034/35); less than the 40-year period proposed by Ofwat. However, we have annualised capital expenditure, which ensures that residual values beyond the 26-year period are taken into account. This is generally a more accurate approach than using a 40-year period without residual values.

Determination of the most cost-effective way to deliver alternative service levels was carried out using annualised expenditure in the asset modelling and in the Investment Manager. This represents an improvement from the DBP, where the Investment Manager used 25-year expenditure without annualising expenditure or residual values, and residual values were calculated post-optimisation.

2.6 Discount rate

We have applied 5% (our post-tax cost of capital) to produce annualised costs (in order to ensure that costs include the cost of finance) and the Treasury social discount rate (3.5%) to produce annualised benefits in the optimisation. We have then produced NPVs from the annualised costs and benefits. The annualised costs approach is almost identical in NPV terms to the approach using bill impacts proposed by Ofwat, as demonstrated in Appendix 1.

2.7 Inclusion of non-cost-beneficial schemes

All enhanced service schemes are included on the basis of being cost-beneficial, with the exception of schemes at sewage treatment works to reduce risk of failure following loss of power supply, where we do not consider that the cost-benefit analysis fully reflects the significance of works failure. In other expenditure categories, schemes which have not been assessed or are not cost-beneficial have been included in the following cases:

- Although we have evaluated the costs and benefits of maintaining current service levels, we would need strong evidence before allowing service to deteriorate. Therefore some maintenance schemes where benefits are less than costs have been included.
- We have not assessed the benefits of maintaining service where expenditure involves a reactive response to asset failure. It is clear that where an asset is required to provide a service, and it has failed, it must be replaced. We have evaluated proactive interventions to reduce risk of service failure.
- The Health and Safety programme is based on policy decisions, rather than a cost-benefit analysis – Ofwat stated at the PR09 workshop at Aston University that we were not required to apply CBA to health and safety proposals.
- We have not assessed the costs and benefits of some legal obligations, including investment to enable new customers to be served and the costs of meter options.
- Schemes required by government or quality regulators have been included even if they are not cost-beneficial.
- Management & General expenditure has been assessed as to whether it is the most cost-effective approach, e.g. our new headquarters building has been assessed against the alternative of refurbishing the existing building, rather than against whether it is needed at all.

2.8 Level of aggregation

We have assessed costs and benefits at project level. This avoids the possibility that some non-cost-beneficial schemes are included within an overall beneficial programme, which could occur if the assessment were made at a higher level. In some cases, a project inevitably involves some aggregation. Examples include:

- Sewer flooding, where we know that there will be future problems arising but do not know their precise details. Based on past experience, expected future problems have been grouped into a collection of projects of similar severity / frequency, so that the cost-benefit analysis can distinguish whether are any lower priority projects are likely to be non-cost-beneficial.
- Separation of joint supplies, where we have estimated the number of properties with joint supplies which will not meet the standard, but do not know the cost of individual problems, or the likely distribution of costs. The cost-benefit position can be assessed in individual cases when costs are known. However, the benefits significantly exceed costs so the number of cases which would not be cost-beneficial will be low.

In relation to enhanced service projects, where CBA is particularly critical, 87% of water expenditure and 61% of sewerage expenditure has been assessed at the project level rather than in blocks. Much of the sewerage block expenditure relates to sewer flooding, where the division into groups of differing priority removes the potential problems arising from aggregation.

3 Assessment of benefits

3.1 Benefit assessment – willingness to pay

The prime basis for our cost-benefit analysis is our willingness to pay survey. In general, revealed preference analysis, whereby valuations are derived from observed consumer decisions, is not possible for water industry services. Therefore values have to be derived from stated preference, which we have done through our customer research.

The details of the service measures included in the willingness to pay survey and the methodology are set out in Chapter C1. The application of the results of this in cost-benefit analysis is discussed in this chapter. The sixteen measures included in the survey are shown below. These were developed through internal discussions, consultation with Ofwat, DWI, EA and CCWater, and customer focus groups.

Service measures in willingness to pay survey

1	Hosepipe ban frequency	9	Low pressure
2	Internal sewer flooding	10	Discoloured water
3	External sewer flooding	11	Odour and flies
4	Leakage	12	Taste and smell
5	Interruptions	13	Energy conservation
6	Change to river ecology due to pollution	14	Hardness
7	Customer contact	15	Low flow rivers
8	Metering	16	Supply pipe adoption

The survey involved three stages:

- Choice experiments, in which the service measures were divided into groups of four and customers were asked to choose between options involving different levels of service for the four service attributes and different bill levels.

- An experiment with all sixteen service attributes and cost included simultaneously. In each group of four attributes the service attributes were set at their maximum or minimum level, and customers were asked to choose between two options. This was to address the concern that the WTP from multiple experiments using a subset of attributes in each may lead to an overstatement of the total willingness to pay for all of the improvements.
- An experiment where customers were asked "would you be prepared to pay £x for the maximum level of service?".

The results from the second experiment were used to scale down the results from the first experiment, reducing values by 12% to 45% for households. For businesses, the range was a reduction of 18% to an increase of 18%. The third experiment produced lower results than the second experiment, with an average WTP for the maximum service level of £13 in the third experiment compared with £42 in the second experiment.

In line with the recommendation of RAND, who carried out the analysis, we have not used the results from the third experiment. This experiment focuses on price and tends to understate valuation of services. It may also cause some "protest votes" from people who think water companies should finance improvements, rather than reflecting real choices. Our peer reviewer, Professor Ian Bateman, commented that the second experiment, which we have used, could understate WTP. This is because the inclusion of 16 service measures could lead to cognitive overload and focus on the simplest measure, price. Therefore we consider that we have been conservative in the WTP values used in cost-benefit analysis. This is confirmed by comparisons with valuations used by other companies. Our service valuations are generally well below median values (the only exception of which we are aware is discoloured water but this is not driving any enhancement expenditure).

The Ofwat feedback on our DBP raised some questions on our WTP analysis. We have included the response from RAND as an appendix to this chapter. In summary, the issues raised by Ofwat were:

- Did the order in which questions were asked affect the results?
- Would alternative model formulations have had better statistical properties?
- Was the exclusion of a small number of outlier responses from business customers justified?

RAND's response, which we support, was that:

- Adjustments made to the results excluded any bias from ordering of the questions. As noted above, results from the first experiment were scaled by results from a second experiment in which all service measures were considered together. There was no clear tendency for scaling of later questions to be higher or lower than for earlier questions.
- A number of alternative formulations were considered and that chosen was assessed to be the most satisfactory both theoretically and in terms of statistical properties.
- Exclusion of outliers is appropriate where responses appear to be irrational.

Their response is included in full in Appendix 2.

3.2 Results from the survey

The table below sets out the results from the WTP survey. The explanation of how aggregate WTP has been derived is set out in Chapter C1.

Results of willingness to pay survey

	Change in service level		Per customer		Total WTP – All customers £'000	Per unit of improvement			
	From	To	All Business	All residential		Units	From	To	Annual WTP (£'000)
Customer contact – phone call success rate in getting through	90%	95%	£2.36	£0.31	1,407	1% improvement	90	95	281.39
	90%	98%	£3.75	£0.49	2,246	1% improvement	95	98	279.79
Internal flooding – number of incidents p.a.	740	1,000	-£3.93	-£1.27	-5,264	1 flooding incident	740	1,000	-20.25
	740	450	£4.42	£1.41	5,859		740	450	20.20
	740	150	£7.51	£2.06	8,796		450	150	9.79
External flooding – number of incidents p.a.	3,500	4,000	-£3.93	-£0.52	-2,663	1 flooding incident	3,500	4,000	-5.33
	3,500	2,500	£1.94	£1.03	4,002		3,500	2,500	4.00
	3,500	1,600	£3.69	£1.96	7,597		2,500	1,600	3.99
Metering - % of customers metered	33%	50%	£3.75	£0.17	830	1,000 meters	1,006	1,524	1.60
	33%	66%	£7.20	£0.33	1,598	1,000 meters	1,524	2,012	1.57
Leakage – litres per property per day	160	140	£11.99	£1.19	5,995	1 Ml/d	519	454	92.37
	160	110	£19.86	£2.97	12,979	1 Ml/d	454	357	71.75
Interruptions – number per year	11,500	7,500	£7.26	£1.76	6,785	1 interruption	11,500	7,500	1.70
	11,500	3,500	£14.53	£3.51	13,570	1 interruption	7,500	3,500	1.70
Low pressure – number of customers at risk	10,000	15,000	-£8.17	-£1.38	-5,807	1 customer	10,000	15,000	-1.16
	10,000	5,000	£8.17	£1.38	5,807	1 customer	10,000	5,000	1.16
	10,000	2,000	£8.17	£2.21	8,336	1 customer	5,000	2,000	0.84
Hosepipe ban frequency (1 in 10/33/100 years)	1 in 33	1 in 100	£2.66	£1.11	3,914	Per 100 years	33	100	3,914
	1 in 10	1 in 33	£0.91	£0.38	1,336	Per 100 years	33	10	-1,336
Discoloured water – no of complaints p.a.	3,000	5,000	-£10.47	-£2.60	-9,999	1 complaint	3,000	5,000	5.00
	3,000	1,500	£7.81	£1.95	7,484	1 complaint	3,000	1,500	4.99
	3,000	1,000	£10.41	£2.59	9,961	1 complaint	1,500	1,000	4.95
Taste - % of customers dissatisfied	10	7	£3.15	£1.83	6,188	1,000 dissatisfied	10	7	63.57
	10	5	£5.21	£1.83	6,594	1,000 dissatisfied	7	5	6.25
Hardness - % of customers dissatisfied	12	9	£5.51	£1.10	4,448	1,000 dissatisfied	12	9	45.69
	12	8	£7.32	£1.46	5,909	1,000 dissatisfied	9	8	45.02
Treatment works odour – no of complaints	4500	2000	£7.99	£1.99	8,657	1 complaint	4,500	2,000	3.46
	4500	1000	£11.14	£2.79	12,097	1 complaint	2,000	1,000	3.44
River Ecology - % of rivers affected by discharges	43%	30%	£12.95	£2.31	10,842	1% good status	43	30	833.97
	43%	20%	£22.88	£4.09	19,157	1% good status	30	20	831.51
Low Flow Rivers - % of rivers affected	16%	10%	£14.77	£1.35	7,028	1% good status	16	10	1,171.32
	16%	5%	£14.77	£2.46	10,417	1% good status	10	5	677.77
Energy Generated – equivalent to no. of households' use	40,000	70,000	£6.60	£1.06	5,111	1 household's use	40,000	70,000	0.17
	40,000	100,000	£13.14	£2.13	10,239	1 household's use	70,000	100,000	0.17
Supply Pipe Adoption	Customer	Company	£19.86	£4.90	18,843	All adopted			18,843

The WTP results were used directly in our CBA with the exception of:

- Renewable energy, where the Defra social cost of carbon was used. Values are set out in Section 7.
- Leakage, where an economic level of leakage has been assessed, based on the value of water saved, costs of leakage control, congestion costs of leakage control work, and the environmental impact of abstraction. Leakage is identified both in our own customer research and national research as a high priority. We need to establish whether customers consider it is worthwhile paying more to reduce leakage than to use other means of balancing supply and demand. Professor Bateman, in peer reviewing our analysis, suggested that we should pursue further research on customer valuation of leakage reduction before using the results. We have, therefore, assessed leakage applying the same value as for other supply / demand projects, in terms of a benefit per Ml/d saved (see Section 5.3).
- Sewage treatment compliance, where costs of avoiding failure were used rather than impact on the river of failure.

3.3 Benefit assessment – additional analysis

We have supplemented our survey of willingness to pay by additional analysis, in order to:

- Cover those issues not incorporated within our willingness to pay survey.
- Provide more detailed assessment based on characteristics of individual projects than could be derived from a customer survey.

Not all issues could be incorporated within the WTP survey because:

- The number of aspects of service included in the survey had to be limited in order to give a manageable number for putting questions to customers.
- Some issues could not readily be expressed in a way which would be meaningful to customers in the survey.

For the FBP we have made amendments to the values for pollution and sewage treatment compliance.

Drinking water compliance

Drinking water compliance was not included in our Willingness to Pay survey because it was considered that it was difficult to put a meaningful question on relatively rare compliance failures. However, safe drinking water always emerges as a very high priority in our customer surveys so it is important to put a value on improvements.

Two sources of information have been examined:

- An assessment of the benefits of improving private water supplies in Scotland, as set out in The Private Water Supplies (Scotland) Regulations 2006 and the November 2001 consultation on Private Water Supply Regulation.
- An assessment of the benefits of changing the lead standard to 10 µg/l, assessed in the WRc report on Cost Benefit Analysis of Reducing Lead in Drinking Water.

The value of health benefits of improving private water supplies in Scotland was assessed as £61.5m. It was estimated that around 150,000 people used private water supplies, which gives a benefit per person of £407. The consultation stated that the risk of contracting disease from private water supplies as being between 22 to 50 times more likely than from the public mains. We have used this figure to scale down the benefits of improving public water supplies, and used a figure towards the bottom of the range.

We have taken this value as being the value of improvement to 100% compliance from 99.98% (2006 performance). The calculation is set out below:

Scotland benefit per person	£407	
Scaled-down value	£9.50	Range £18.50 to £8.10
Water population	7,408	
Total benefit	£70.4m	
Annual benefit (total benefit was based on a 15-year assessment)	£5.95m	For 0.02% improvement in compliance
Annual benefit	£2.97m	For 0.01% improvement
Number of zones	208	
Average zone population	35,615	
Annual number of samples	109,845	
	0.001%	% failure rate for one sample (1/109,845)
Value of compliance failure – total	£297,000	= £2.97m for 0.01% improvement / 0.001%
Value of compliance failure	8.40	per person (297,000 / 35,615)

As a cross-check against this, for achieving the lead standard, the total health benefits of achieving the final lead standard have been estimated at between £724m and £2,741m, and the non-health benefits at between £124m and £360m (1997 prices). Severn Trent's share of the total benefits would be £153m to £510m (apportioned by population and at 2007/08 prices). This was for the benefit of around 300,000 customers (740,000 population) with lead communication / supply pipes, i.e. a benefit of around £200 to £700 per person affected (or £17 to £44 per year). The £8.40p per person attributed to removing occasional water quality failures does not appear disproportionate relative to this estimate.

In addition, relative to other willingness to pay estimates, and bearing in mind the high priority put on water quality by customers, this may be a low estimate.

Water quality has also emerged as a high priority in the further customer research we have been carrying out following submission of the DBP.

Pollution incidents

We do not have a willingness to pay value for pollution incidents. However, the Thames Tideway study gives willingness to pay of £1.50 per year for reducing fish kills by one per year. This is a relatively serious incident and can be taken as a value for Category 1 and 2 incidents. United Utilities' willingness to pay survey showed similar values of £1.41 for reducing Category 1 and 2 pollution incidents.

We used these figures in the DBP but stated that we would review the valuation of pollution incidents. In the Annex submitted in October we used a lower value following review of the transferability of the United Utilities (UU) results. In assessing suitability of WTP values for transfer, we considered WTP relative to levels of bills and incomes in the companies for which we had WTP values (United Utilities and Thames).

- In the case of Thames, higher income levels might be expected to yield slightly higher WTP than would apply in the Severn Trent area.
- For the United Utilities area, bills are higher and incomes lower, which might be expected to produce a lower value than would apply to Severn Trent.

UU results are almost all significantly higher than the values from our own WTP analysis. We have therefore scaled down the value used to reflect the generally lower results from our survey. On average, UU WTP values were 5.5 times our values, so we have divided the results by 5.5.

Using a figure of £1.41 per incident, then reducing Category 1 and 2 incidents has a value:

Category 1 and 2 incidents £1.41 x 3,467 / 5.5 = £0.88m per incident per year.

We do not have a value for Category 3 incidents but the EA definition of incident categories indicates that the value should be very much less. We have used a value of 5% of the Category 1 and 2 incident value. This would mean that eliminating all Category 3 incidents would have a similar value to eliminating all Category 1 and 2 incidents. The resulting value for Category 3 incidents is £44,000 per incident per year. Further details of the calculation are given in Appendix 3.

Sewage treatment compliance

The DBP used a value from the WTP survey, which gives a value for length of river not achieving good status. This was questioned in the Ofwat feedback, which suggested that this value could be overstated. We have replaced it with the costs of taking action to avoid failure, because actual failures are rare – we can normally take operational measures to avoid failure. This has been set at £0.76 per population equivalent for a maintenance failure, which can be resolved in a few weeks, and £180.40 per population equivalent for longer term failures – capacity failures which can only be resolved by a scheme to increase works capacity. The figures are based on actual costs for tankering to another works. This has resulted in a significantly lower value for benefits of maintenance schemes. We are, therefore, evaluating the least-cost way of maintaining current compliance. Evaluation for the DBP using WTP values did not indicate that we should be changing service levels.

Section 101A schemes

These schemes involve connecting properties to the sewerage system which have not previously been connected. There is no suitable information from the WTP survey to assess benefits.

We are required to evaluate the costs of a range of solutions, both public and private. In the case that the cost of the public solution is less than that of the private option, we are required to implement the public solution, for which we bear the costs. After connection the properties then served have to pay sewerage charges.

Benefits are assessed in the following categories:

- Public health risk
- Pollution of controlled waters
- Adverse effects on Sites of Special Scientific Interest
- Amenity (Odours, external ponding)

- Industrial Effluents contributing to problem

The benefits under these categories and their basis are shown in the tables below:

Summary of the benefits valuations

Benefit	Value per property per year	One-off value	Comments on Basis
Public health risk	£200	0	Cost to employer of one day of lost work per year per household due to gastric illness
Pollution of controlled waters	£308	£121	Saving 4 hours of EA investigation time per incident per year @£77 per hour, ref. EA Pollution Incident Cost Recovery, plus saving on an application to discharge low volumes of sewage
Adverse effects on SSSIs	£100	0	
Amenity	£500	£30,000	Annual - 10 trips from home per year at a cost of £50 each to avoid odour and non-availability of garden. The one-off value is the estimated effect on the house price of having unsatisfactory sewerage facilities, assumed 10% of a house price of £300k
Industrial effluents	£2,500	0	Cost of a typical “Tier 2” discharge licence under the “Environmental Permitting” scheme

Congestion costs

Atkins carried out for us an analysis of congestion costs, included in “Social and Environmental Costs and Benefits of Leakage Reduction” (2006). Congestion costs for leak repairs were derived by estimating vehicle and pedestrian delays and valuing these using standard values of time. The results were as follows (shown at 2006 prices below, but updated to 2007/08 prices in our analysis):

1. Delays to road users

Social costs of traffic delays range from £0.65 for a customer supply pipe repair in the Oswestry and Ellesmere Water Resource Zones (WRZs) to £237.39 for a mains repair in the Birmingham WRZ. The costs vary between WRZs as a result of the different likelihood of jobs being conducted in rural or urban roads and the different proportion of roads of categories A, B or minor. In addition, the traffic flow rate varies between WRZs therefore the number of vehicles delayed by each job is different.

2. Delays to pedestrians

Social costs of delays to pedestrians vary from £0.06 for a mains repair job in the Oswestry and Ellesmere WRZ to £5.13 for a mains repair in the Birmingham WRZ. The costs vary between WRZs according to how urban the areas is (jobs are only considered to cause delays to pedestrians in urban areas).

3. Carbon emissions from 'find and fix' vehicle movements

The average mileage per repair job was converted to the social/environmental cost of carbon emissions. This was based on the average rate of emissions of 'find and fix' vehicles as well as the social cost of carbon emissions published by the Government Economics Service (GES, 2002).

Mileage data could not be disaggregated for the different types of leakage repair job therefore a combined cost was calculated for each WRZ. The lowest cost is £2.20 for a job in the Forest & Stroud WRZ and the highest cost is £3.74 for a job in the East Midlands WRZ.

The overall average social/environmental cost per repair job is £63.76. This value is weighted according to the proportion of repair jobs of each type and the proportion of repair jobs currently conducted in each WRZ.

Environmental benefits of leakage reduction

A reduction in the level of leakage would allow STW to reduce the output of its water treatment works and therefore reduce abstraction of raw water. This may result in social and environmental benefits as there may be an improvement in the flow and/or water quality of the source environment.

The social and environmental benefits of a reduction in abstraction in each of Severn Trent Water's WRZs were estimated using the Environment Agency's Benefits Assessment Guidance (BAG). Each value is expressed in terms of the benefit of reducing leakage by one cubic metre according to the corresponding reduction in abstraction of raw water.

There was not found to be any significant social and environmental benefit of reducing leakage in the Forest & Stroud and Oswestry & Ellesmere WRZs, in relation to any changes in the environmental or recreational value of the source rivers. This is as a result of the small reduction in leakage that is possible in comparison to the high river flows of the chosen source rivers. The social/environmental benefit of reducing abstraction in the remaining WRZs is up to 2.3 p/m^3 leakage reduction.

3.4 Private costs of failure

If our service does not meet required standards, then we incur costs in investigating and dealing with the failure. We have included these costs in assessing the costs of changes in service levels. The costs included are shown in the table below. We have not included transfer payments such as Guaranteed Standard Scheme payments as this would be double-counting – impact on customers is already assessed through willingness to pay.

With the exception of the costs of avoiding sewage treatment compliance failure, these costs are not significant in terms of determining the scale of changes in service.

Area of service	Costs included	Cost
Complaints	Cost of dealing with operational complaints	£7.41 per complaint
	Cost of dealing with customer service complaints e.g. billing	£7.48 per complaint

Area of service	Costs included	Cost
Water quality	Provision of additional equipment (e.g. a temporary measure to fix the problem in the short term such as the pumping out of a tank and jet washing) Man hours for additional checks of water quality Additional sampling of water.	£190 per failure
Interruptions to supply	Call handling Investigation into an interruption Provision and refilling of water bowsers Provision of bottled water	£4 per customer 12 to 24 hours £4.30 per customer > 24 hours
Low pressure	Pressure below 15m threshold at property boundary: Investigation costs Call handling	£4.36 per property
Sludge quality	Application of additional treatment	£5.68 per tds
	Tankering	£63 per tds
Sewage treatment compliance failure	Tankering to avoid compliance failure Failure costs: Man hours for additional sampling Use of one-off equipment. Responses to the Environmental Agency Attending meetings with the Environment Agency.	Tankering to avoid failure: £ 0.76 per population equivalent for a short-term failure £180.40 per population equivalent for longer term failures due to capacity shortfall
Sewer flooding	Investigation into the flood Clean up of the flood Call handling costs Ex gratia payments: Hotel costs for temporarily re-housing family. Householders' insurance excess.	£260.43 per property flooded internally £258 per area flooded externally
Sewage treatment works odour	Public meetings Additional man hours Meetings with Environmental Health Officers	£7.41 per complaint £6,000 for community action £26,000 for EHO involvement
Pollution incidents	Investigation into the pollution Clean up of the pollution, e.g. removal of dead fish / plants, removal of sewage debris Call handling costs Ex gratia payments made to households EA liaison	£549 per incident

4 The optimisation process

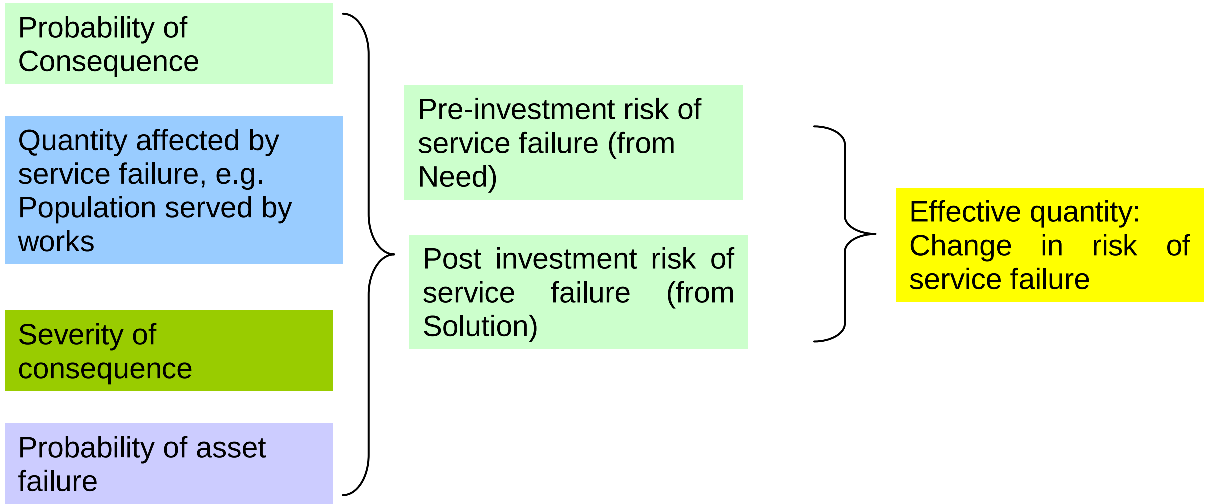
Assessment of costs relative to benefits is carried out in our BRITE (Balancing Risk and Investment To Excel) investment modelling. Within this, the Investment Manager applies cost-benefit analysis and determines the investment plan by maximising the difference between annual benefit and annual cost. As described above, benefits are mainly derived from WTP values, which established the value which customers put on improvements in different areas of service provision. In addition to the values derived from the WTP survey, literature valuations were obtained for social values (such as congestion and amenity costs), and values for breaches of standards on drinking water quality, costs of avoiding breaches of sewage treatment consent, and pollution incidents. The Defra values have been used for the cost of carbon.

Private costs representing the cost of service failure to Severn Trent Water are also included in the benefit calculation (but not if they only represent a transfer payment rather than a real cost).

Each service measure is assessed using a number of components (e.g. the probability of asset failure, the probability of consequence, a quantity measure and a severity measure). These components are used to calculate a change in the risk of service failure from an investment (see the diagram below).

Calculation of the change in risk of service failure

For each Need and Solution:



The change in risk of service failure is multiplied by the WTP and private costs for each unit of service improvement, and totalled to give the total benefit of the proposed solution. Social and environmental benefits are also included at this point. The average benefit is calculated by taking the NPV of the total benefit over the planning horizon (25 years) and calculating an annual benefit with the same NPV. Solutions are selected by the optimiser if they are cost-beneficial, i.e. if the benefit value exceeds the costs.

In addition to selecting cost-beneficial schemes, schemes are included which are statutory obligations or necessary to maintain service.

The Investment Manager chooses an optimal programme in that:

- It selects schemes which are cost-beneficial.
- It chooses between alternative service levels in a number of areas, e.g. sewer flooding.
- It chooses between reactive and proactive maintenance to maintain service.
- It determines optimal timing for investment.

This is, however, only a part of the optimisation process, described in Section 2.1, which includes analysis of options before inclusion in Investment and a review of the whole programme against our objectives and those of other stakeholders.

The list of measures which are used to calculate benefits are set out in the table below.

Aspect of service	Measures	WTP Value
Water service		
Discoloured water	Number of complaints	£4,981 per complaint
Water hardness	Number of customers perceiving water is too hard	£1.47m per 1% customers dissatisfied
Taste and odour	Number of customer complaints	£9,447 per complaint
DWI standards	Failures per year Population affected by failure Severity of failure	£8.40 per person affected
Unplanned interruptions	Population affected Frequency Duration	£1,696 per interruption Scaled up for long interruptions (4x) Scaled down for short interruptions x 0.125 for <3 hours x 0.375 for 3-6 hours
Low pressure	Number of properties affected Severity of problem	£1,161 per property
Low flow rivers	Length of river affected	£1.17m per 1% of rivers designated as low flow
Resource schemes / leakage	Ml/d contribution to meeting headroom gap	£0.1336m p.a. per Ml/d (see Section 5.3)
Supply pipe adoption	% of supply pipes adopted	£188,000 per 1% of supply pipes adopted
Metering	Number of customers metered	£48,000 per 1% of customers metered
Pollution	Frequency Severity	Per incident: £880,000 Category 1 and 2, £44,000 category 3
Customer contact		
Calls abandoned	Number	£281,000 per 1% of calls not abandoned
Carbon impacts		
Change in CO_2 per annum from activities	Tonnes CO_2	Defra values (see section 7)
Congestion	Type of road affected Type of disruption caused by the project Type of area affected	See section 3.3

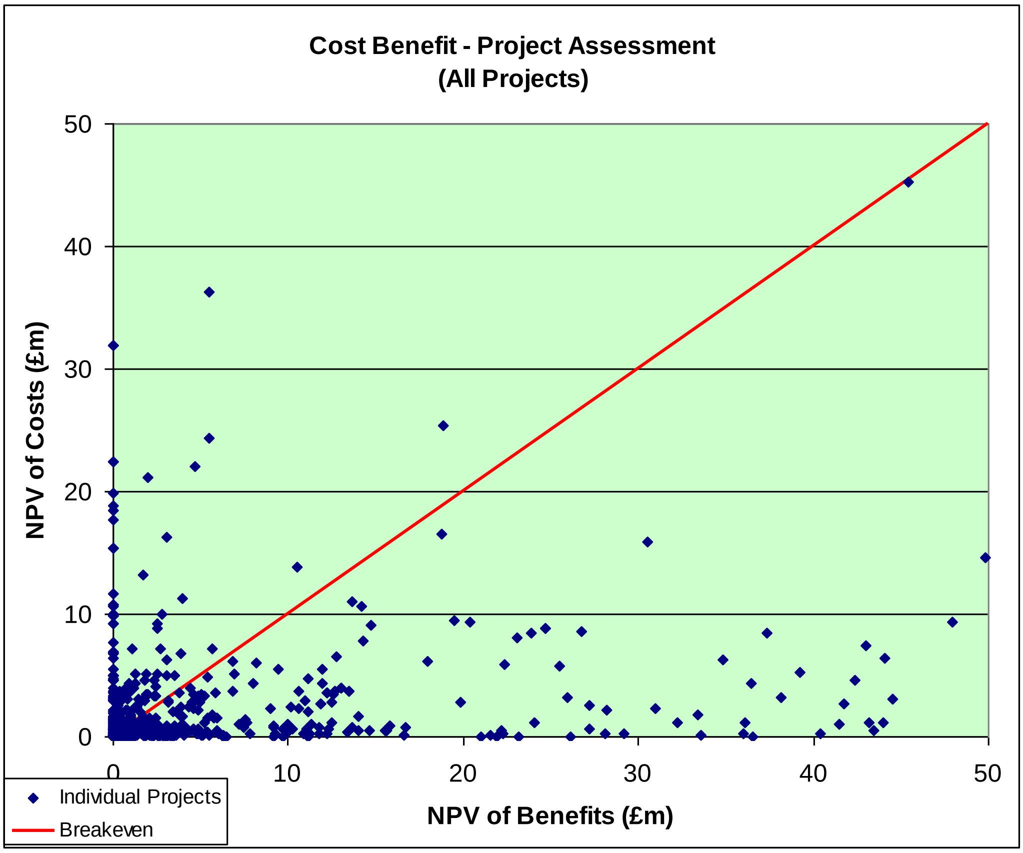
Aspect of service	Measures	WTP Value
Sewerage service		
Breach of consent	Frequency Population served Severity of breach	Determined by private costs of avoiding failure
Flooding	Frequency Prioritisation score – depends on location, frequency and severity Number of areas / gardens / properties / highways / open spaces affected Restricted toilet use	£23.80 per P point (see Chapter C1)
River ecology	Length of river affected	£833,000 per 1% of river affected
Odour and flies	Number of complaints Severity of complaints	£3,451 per complaint

6 Summary

The table and graph below shows by Ofwat expenditure category the extent to which the programme is cost-beneficial. Almost all enhanced service and sewer flooding schemes are cost-beneficial. In other areas, schemes which are not assessed as cost-beneficial are included in order to meet statutory standards or to maintain service.

Capital expenditure programme (excluding efficiency savings) (£m)

	Cost-beneficial	Not cost-beneficial	Not assessed / maintaining service
Water			
Maintenance	304.9	289.0	259.4
Quality	56.5	44.0	29.5
Supply / demand	48.8	74.9	54.1
Enhanced service	174.3	0.0	0.0
	584.6	408.0	343.0
Sewerage			
Maintenance	160.6	196.3	589.9
Quality	98.3	160.9	16.6
Supply / demand	109.6	28.6	50.4
Enhanced service	167.7	0.9	0.1
	536.1	386.7	656.9
Total			
Maintenance	465.5	485.3	849.3
Quality	154.8	205.0	46.1
Supply / demand	158.4	103.5	104.5
Enhanced service	342.0	0.9	0.1
	1,120.7	794.6	1,000.0



Bill impacts

Tables C8.1 and C8.2 show the bill impacts of our proposed programme. Enhancement calculations are the bill impact of the opex and capex associated with those programmes. "Maintaining current service" is the balancing item, so that the total bill impacts add to the change in bills for each service from 2009/10 to 2014/15. The Part A summary table breaks this down further between changes in opex, capital maintenance and taxation.

7 Uncertainties and sensitivity analysis

The key components of the cost-benefit assessment are:

- The cost of carbon.
- Customer willingness to pay.

The reporting requirements suggest that optimism bias should be considered but we do not believe that there is any evidence of such a bias, and no such adjustment is made in setting price limits.

Cost of carbon

In view of uncertainties about the future impact of climate change, and the need to reduce CO2 emissions, the social cost of carbon is highly uncertain. We have tested a cost of carbon 50% higher than the Defra value. This only made three projects no longer cost-beneficial, with a £6m impact on the capital programme.

Customer willingness to pay

We have tested willingness to pay sensitivities using a range based on the values obtained by other companies for WTP for service improvements. For example:

- We have tested a significantly lower value for discoloration because our WTP is relatively high compared with other results. A typical value is about a quarter of our level.
- For internal sewer flooding, our value is relatively low so we have tested a significantly higher figure. A typical figure is around 3.5 times our value.
- For interruptions to supply, a typical figure is about 2.5 times our value (in a comparison with seven other companies, the range of willingness to pay per 1,000 reduction in interruptions was from 41p to £3.50, with an average of £1.20 – our figure was 50p).

The ranges used are shown in the table below. They reflect the range of results, excluding outliers, from the information we have on other companies' results:

Service Measure	Value (£)	Units	Sensitivity range	
			Low	High
Discoloured water	4,981	per complaint	1,245	4,981
Water hardness	1,471,816	% dissatisfied		
Water Taste and Odour	9,447	per complaint	4,724	14,171
Water failing DWI standards	8.40	per PE affected	4.20	12.60
Unplanned interruptions	1,696	per property interrupted (> 6 hours)	1,272	3,392
Low pressure	1,161	Number properties experiencing low pressure	871	2,323
Risk of breach of consent	17	per PE affected	8	25
Flooding (other causes) external	3,998	per flooding incident (all areas)	2,999	11,995
Flooding (other causes) internal	20,224	per flooding incident (properties)	15,168	60,672
Flooding (hydraulic) external	3,998	per flooding incident (all areas)	2,999	11,995
Flooding (hydraulic) internal	20,224	per flooding incident (properties)	15,168	60,672
River ecology	832,739	% river affected	416,369	1,249,108
Odour and flies	3,451	complaints	2,589	10,354
Risk of pollution	884,000	per Cat 1 and 2 incident	442,000	1,326,000

The differences in capital expenditure in AMP5 are shown in the table below. The changes in WTP have a relatively small impact on the programme, even though WTP values determine about 15% of the total programme (principally enhanced services and sewer flooding). Only one water enhancement scheme (£0.5m) which is dependent on CBA for inclusion is removed with lower WTP values. There are also some capital maintenance schemes removed.

The effect is greater on the sewerage programme, with 15 sewer flooding schemes and three pollution control schemes removed. In view of the relatively small change in the total programme (around 3%), we do not consider uncertainty about WTP values to necessitate any changes in our proposals.

Sensitivity analysis – impact on the capital programme of changes in WTP values

	Low WTP		High WTP	
	£m	%	£m	%
Water	-31	-2.4%	+1	+0.1%
Sewerage	-48	-4.5%	+87	+8.1%
Total	-79	-3.3%	+88	+3.7%

8 Carbon accounting

Our Strategic Direction Statement (SDS) Key Strategic Intention 4 (KSI 4) is *Minimising our carbon footprint*. In KSI 4 we state '*We believe we can deliver a leading position in sustainable operations thereby minimising our carbon footprint, provided it does not compromise standards or increase bills beyond levels which customers are willing to pay'*.

Our approach in the FBP has therefore been an economic one which includes a shadow price for carbon. This is consistent with the approach required from Ofwat. We believe that this approach strikes the right balance between our intention to seek to minimise our carbon footprint and our other commitments to customers.

This chapter summarises the context of our SDS, explains our approach and outcomes of calculating embodied and operational carbon, how we have costed carbon, and how we are delivering our KSI of minimising our carbon footprint.

8.1 Our approach

8.1.1 Strategic Direction Statement Key Strategic Intention 4

We have been calculating and publicly reporting on operational GHG emissions for some years. In 2008 UKWIR published the final workbook for calculating operational greenhouse gas emissions[1] and the carbon accounting guidelines for embodied carbon[2]. The June Return 2008 (JR08) required STW to report on operational GHG emissions using the UKWIR methodology. We have aligned our operational GHG footprinting and forecasting to the UKWIR methodology.

Our strategy to reduce our carbon footprint is based on being more efficient and increasing our renewable energy generation (for more detail see SDS pp6 and 27). We are seeking to meet government carbon reduction targets, even though there is no statutory duty upon us to do so, as they are a benchmark of our progress in emission reduction. At present the government targets are all for reductions in operational carbon or renewable energy generation not for embodied carbon.

Severn Trent has a renewable energy generation target of 30% by 2013 with a current sector leading performance of 17% (the UK Government target is 20% by 2020 with the current level being at 5%). This shows the importance of renewable energy to delivering our KSI 4. We follow the relevant DEFRA and UKWIR methodologies for calculating our GHG emissions and we account for the emissions savings from our renewable energy generation when comparing our performance against government targets, even though we sell the ROCs. Our approach is transparent as we present both the total and net emission levels. At the end of this chapter is a review of the impact of the AMP5 plan on our intention to reduce emissions and meet government targets.

Our SDS was published in 2007. Since then the UK Government has passed the Climate Change Act 2008 which sets tougher reduction targets for the UK than previously seen and also introduces the Carbon Reduction Commitment (CRC), the emissions cap and trade scheme that ST Plc (UK) will have to enter. See section B3 of the FBP for the financial implications of the CRC.

8.1.2 Our approach in the Final Business Plan (FBP)

[1] *Carbon accounting in the UK Water Industry: methodology for estimating operational emissions, report no 08/CL/01/5*

[2] *Carbon Accounting in the UK Water Industry: guidelines for dealing with embodied whole life carbon accounting report no 08/CL01/6*

For the FBP we have estimated the additional operational and embodied carbon resulting from the proposed programme of investment:

- Embodied carbon has been calculated using the UKWIR embodied whole-life cost methodology.
- Operational carbon has been calculated on a project-specific basis using the UKWIR operational emissions methodology.

The embodied carbon and operational emissions resulting from the proposed projects to be constructed during AMP5 have been estimated using the processes described below (sections 7.2 and 7.3).

For operational carbon we have used the latest conversion factors:

- Electricity 0.537 kgCO_2e/kWh (as published by Defra in June 2008)
- Gas 0.206 kgCO_2e/kWh
- Tanker movements 1.178 kg CO_2e/km

As described in Section 8, our embodied carbon estimates are based on work carried out for us by MWH in 2008, before the publication of the latest Defra figures. It has therefore used the previous conversion factor of 0.523. This could not readily be updated because we had generic carbon curves for various project types, which included electricity and other carbon impacts. The difference is, however, not material in the context of the level of uncertainty in estimating embodied carbon.

Evaluating carbon impacts will be a normal part of our capital programme development in future. We are developing models for high-level assessment at feasibility stage, and more detailed estimation as a project develops. We are working with our supply chain on approaches to estimation.

8.2 Embodied carbon

Embodied carbon has been calculated using a bottom-up methodology, calculating carbon from generic curves provided to us by MWH, who carried out the work for the UKWIR project on embodied carbon. These curves have been constructed for a group of asset types which enable a reasonable cross-section of the programme to be estimated (10% by value). These estimates have then been extrapolated based on asset type to cover the whole AMP5 programme. The analysis was carried out using data from a draft version of the UKWIR project. There were subsequently minor changes but MWH have confirmed that these are not significant, in the context of the general level of uncertainty in carbon estimation.

The AMP5 programme was reviewed to determine the most commonly constructed asset types in the upcoming investment period. Based on this MWH was then contracted to produce curves to estimate both embodied and operational carbon resulting from the following 12 asset types.

i) Nitrate reduction
ii) Chemical dosing
iii) Activated sludge
iv) Biofilter
v) Sludge dryer
vi) Centrifuge
vii) Sewerage infrastructure
viii) Water infrastructure

ix) Media filters
x) RBC and Reedbed
xi) Sewerage pumping stations
xii) Water pumping stations

The generic curves are based on current best practice and guidance in the industry and have been tailored to represent our design specifications. These curves have been used to carry out some detailed carbon calculations across the different sub-services. Slightly varying methodologies have been used for the different strands depending on the type of information available for those proposed investments. For example, the projects required to deliver sewage treatment quality obligations already have substantial information available so detailed carbon forecasts can be made per project. However, because there is not the same level of certainty around infrastructure schemes and pumping station investments for AMP5, an historical analysis has been carried out on these assets.

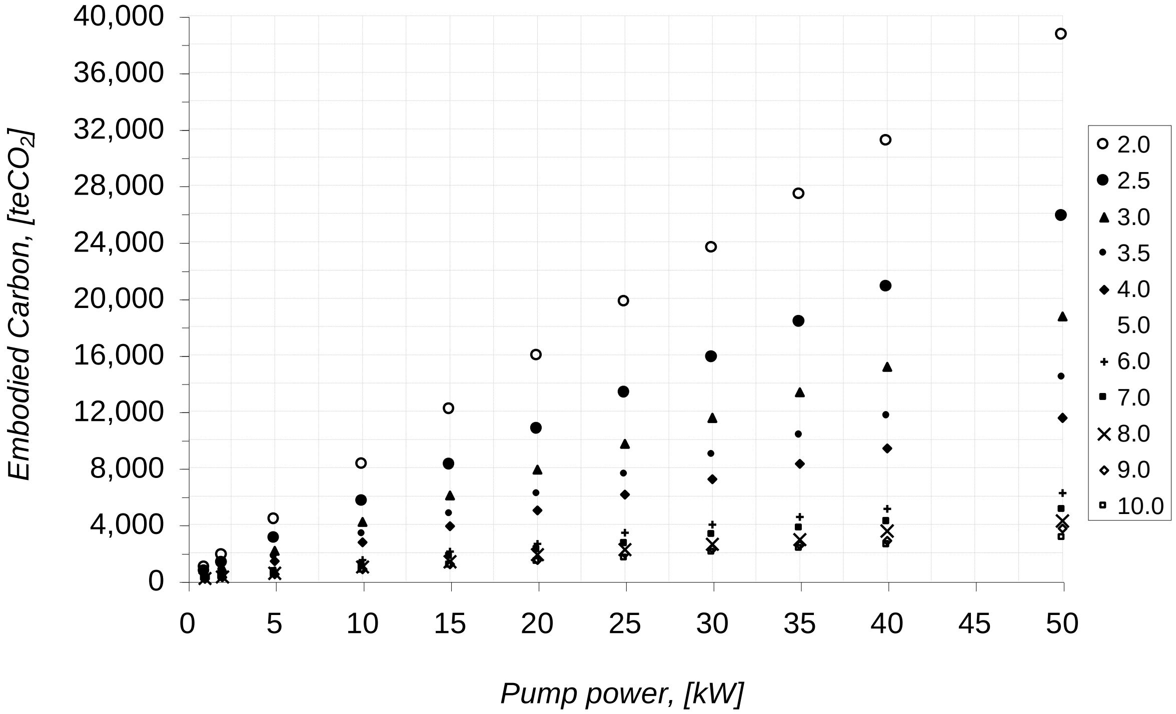
The carbon curves and analysis of historic projects have allowed the development of a detailed embodied carbon prediction for more then 10% of the AMP5 programme (by value). It is estimated that the £412m pounds of investment highlighted below will result in approximately 283,000 tCO_2e of embodied carbon over the course of the five year investment period.

The following paragraph, graph and table is an extract from the report written for us by MWH showing the detail regarding the curves (in this case for Sewerage Pumping Stations):

Sewerage Pumping Station

Power is the preferred driver for Severn Trent Water but requires some explanation. Power is the product of pumped flow and head. The physical size of the pump / motor, and hence the embodied carbon, is a function of flow and pump station depth. For a selected power on the x-axis and a selected head from the 2 m – 10 m range the flow can be calculated. As the head increases the flow decreases and the size decreases and thus the embodied carbon can be seen to decrease.

Carbon Accounting - Sewerage - Pumping Station



Inclusions / Exclusions

	Included	Excluded
Embodied Carbon	Concrete blinding, base and benching	Step irons
	Pre-cast concrete rings and roof slab	Pump
	Pipework: incoming and outgoing	-

Estimates of embodied carbon in our investment programme

We have assessed the projects by asset type to determine a bottom-up average value for each investment strand for:

- Embodied carbon per million pounds of civil expenditure.
- Embodied carbon per million pounds of M&E expenditure.
- Or, where appropriate, embodied carbon per million pounds of total expenditure.

The results are set out below:

Tonnes of CO_2e/£m conversion factors for different types of investment

Investment Type	Tonnes of CO_2/£m			Source
	Building and Civil	Mechanical and Electrical	Total	
RBC and S101a	285	124	-	Average of 13 RBC and reedbad schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon). M&E vs. civil splits according to MWH table on Page 7.
ASP	1,043	252	-	Average of 30 ASP schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon). M&E vs. civil splits according to MWH table on Page 7.
Biofilter	597	237	-	Average of 3 filter schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon). M&E vs. civil splits according to MWH table on Page 7.

Investment Type	Tonnes of CO_2/£m Building and Civil	Mechanical and Electrical	Total	Source
Sewage treatment works weighted average	912	246	-	Weighted average of RBC (2%), ASP (72%) and Filter (26%).
Water treatment works average	912	246		Assumed to be same overall as WTW due to similar asset types.
SPS	1766	484	-	Average of 16 Sewage Pumping Station. schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon).
WPS	2448	121	-	Average of 10 Water Pumping Station. schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon).
Dosing water	411	1144	-	Average of 34 water treatment dosing schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon).
Dosing waste	101	279	-	Programme level calculation for 35 dosing rigs. Individual cost for a scheme multiplied by 35 to get overall Programme cost, carbon calculated using MWH curves.
Sewerage Infra	-	-	456	Average of 23 Sewerage infra. schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon).
Water Infra	-	-	465	Average of 19 Water infra. schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon).
Nitrates	-	-	62	Average of 5 Nitrate schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon).
GAC	-	-	220	Average of 2 GAC schemes fully costed (Project Estimator tool for financial, MWH curves for embedded carbon).
Sludge Dryers	-	-	719	One fully costed (Project Estimator tool for financial, MWH curves for embedded carbon) scheme (£11.4m) was used to calculate this figure.

Investment Type	Tonnes of CO_2/£m			Source
	Building and Civil	Mechanical and Electrical	Total	
Centrifuges	-	-	610	One fully costed (Project Estimator tool for financial, MWH curves for embedded carbon) scheme (£2.6m) was used to calculate this figure.
Buildings	-	-	1000	See text below.
Vehicles	-	-	250	See text below.

Embodied carbon in buildings

The embodied carbon in buildings would be expected to be similar to embodied carbon for buildings and civils. The average embodied carbon for buildings and civils for the AMP5 programme, using the MWH carbon factors, is 1,102 tonnes per £1m capex (660,056 / £598.8m).

Estimates of embodied carbon in buildings generally show a figure of around 1,000 tonnes per £1m capex. For example, the calculation on the right (Source www.building.co.uk) gives a figure of 1,023 (346.5 / 338.8 x 1000).

We have used a figure of 1,000 which is broadly consistent with the figures we are using for buildings and civils and with external estimates for embodied carbon in buildings.

Building assessment: distribution centre				
	£/m2 gifa	%	Kg embodied carbon/m2 gifa	%
Substructure	59	17.4	146.5	42.3
Frame, upper floors and stairs	60.7	17.9	68.4	19.7
Roof	48.5	14.3	41.6	12
External walls, windows and doors	14.7	4.3	13.3	3.8
Internal walls and doors	0.8	0.2	2.3	0.7
Internal finishes	4.4	1.3	5.6	1.6
Building services installation, including dock levellers	31.8	9.4	30.2	8.7
External works and services	81.4	24	38.6	11.1
Preliminaries	37.5	11.1		
Total construction cost/m2 gifa	338.8	100		
Total embodied carbon emissions/m2			346.5	100
Exclusions: site preparation, site abnormals, distribution centre and administration area fit-out, operating equipment, professional fees				

Embodied carbon in transport

We have based this on estimates of embodied carbon in cars. In the New Scientist (17/11/2007) article: "Why bother going green?", the embedded carbon in cars was cited as between 3 and 5 tonnes per car. The average price of a new car is around £15,000 pre-tax (Source EurotaxGlass's). This gives a range of 200 to 333 tonnes per £1m spent.

We have used a figure of 250 tonnes/£m, which is consistent with the above estimate and with our figures for M&E embodied carbon, which are mainly in the range 121 to 484 tonnes per £1m.

Changes between DBP and FBP

In the DBP, embedded carbon values at a generic level were used for STWs and WTWs. For the FBP, every scheme has been assessed and the M&E and B&C categorised by process types above. For example, an activated sludge plant, with civil costs of £5m and M&E costs of £1m would therefore attract an embedded carbon of (5 x 1043) + (1 x 252) = 5467t CO_2/year of embedded carbon. In this way the carbon has been built up scheme by scheme. This has given us greater granularity than at DBP and we can now have confidence that the embodied carbon picture is a robust one. For the majority of schemes, it was possible to exactly match the investment amount with the process type. Where this was not possible, an expert team chose the conversion factor most appropriate (by considering asset types).

The following table gives the split, with respect to embodied carbon between civil and mechanical contributions. This is directly from the report written by MWH for us.

Strand	Driver		Embodied Carbon		
	Type	Value	[teCO_2]	% Civil	% M&E
ASP	PE	2,500	422	90%	10%
		20,000	2,546	90%	10%
		50,000	7,269	90%	10%
		100,000	16,367	90%	10%
Biofilter	PE	2,500	655	95%	5%
		20,000	4,723	95%	5%
		50,000	11,681	95%	5%
		100,000	23,396	95%	5%
SPS	kW	2[3]	437	90%	10%
		20[3]	3,595	90%	10%
		50[3]	8,108	90%	10%
WPS	Flow (Ml d^{-1})	5[4]	137	85%	15%
		25[5]	147	85%	15%
		75[6]	226	85%	15%
RBC	PE	500[7]	130	70%	30%
Chem dosing	Flow (l h^{-1})	5	193	25%	75%
		25	193	25%	75%
		100	193	25%	75%

[3] Assuming 5.0 m deep wet well.
[4] Actually 4.3
[5] Actually 25.9
[6] Actually 69.1
[7] Actually 505

Results

Water service – Embodied Carbon Summary

	GHG emissions to build in AMP5
	Kt CO2e
A - Water service	645.558
B - Base service	430.398
Maintaining current service in terms of key serviceability indicators	425.076
Renewable energy	0.000
Efficiency Initiatives	5.322
C - Enhanced service levels	84.917
Resilience: WTW and Strategic Grid	60.913
Resilience: Borehole Resilience	8.001
Resilience: Single Points of Failure	3.797
Resilience: Flooding Risk Mitigation	5.065
Resilience: Power Risk Mitigation	3.134
Common Supply Pipe Separation	4.007
D - Supply / demand balance	73.984
Maintaining current level of security of supply for expected demand	31.963
Leakage	21.781
Additional Resources	0.000
STW Consumption Reduction	0.635
Metering Strategy	9.201
Low Pressure (DG2)	4.182
Undersized Reservoirs	6.222
Competition	0.000
E - Quality enhancements	56.260
Isolated Communities	17.360
Defra: SEMD	29.906
DWI: Nitrates Removal	1.906
DWI: Lead	4.816
DWI: Other	2.014
EA: Low Flow Rivers	0.000
EA: Habitats Directive	0.259
Catchment Management	0.000

Sewerage service – Embodied Carbon Summary

	GHG emissions to build in AMP5
	Kt CO2e
A - Sewerage service	784.218
B – Base service	444.927
Maintaining current service in terms of key serviceability indicators	437.463
Renewable energy	2.826
Efficiency Initiatives	4.638
C - Enhanced service levels	75.541
Nuisance (Flies and Odour)	2.601
Resilience	4.249
Sewer Flooding (ESL)	62.371
Pollution Strategy	4.536
Dual Manhole Separation	1.783
D - Supply / demand balance	98.864
Maintaining current level of security of supply for expected demand	60.774
Foul/Storm Sewer Separation	4.716
Sewer Flooding (SDB)	33.374
SUDS Adoption	0.000
Competition	0.000
E - Quality enhancements	164.886
First Time Sewerage (S101a)	6.946
Dry Weather Flow Compliance	7.234
Other Sewage Treatment	8.087
Fisheries Directive	11.587
UWWTD P Removal	83.088
WFD - BOD and Ammonia	20.372
Quality Programme Sludge	22.559
Other	5.014

8.3 Operational Carbon emissions

Operational GHG emissions have been calculated on a project specific basis in accordance with the Defra guidelines and the UKWIR workbook Version 2.0 June 2008, with the exception that the electricity factor has been changed from 0.523 kgCO2e/kWh to 0.537 kgCO2e/kWh in accordance with latest Ofwat Guidelines.

For the DBP, operational emissions were derived from MHW operation carbon curves and calculations undertaken by Entec for sludge emissions. For the FBP, the approach taken has been to take the split schemes into three groups;

- Group 1: Those schemes that can be categorised as impacting significantly on carbon emissions only by virtue of additional electricity or vehicle movements
- Group 2: Those (more complex) schemes that impact GHG significantly in areas not limited to electricity and transportation. All Quality sludge, all Growth sludge, SAS rheology and Acid Phase Digestion were assessed in this way. In total, only 5 completed assessments were created for schemes that made it through the optimisation process into the FBP.
- Group 3: Those schemes involving separate (SEAMS) modelling outside of the Corporate Optimiser and work relating to M&G.

We used this methodology because we felt that we had more specific information at site level regarding predicted electricity used and tanker movements than at DBP.

The approach used has made it straightforward to apportion carbon emissions in accordance with Ofwat guidelines (including the inclusion of transport in 'Emissions from other GHGs').

8.3.1 Group 1 Schemes

These are typically schemes where a new process needs to be employed to meet an obligation or where a significant increase in growth results in more power and sludge tankering. Augmentation codes within the Investment Manager have been populated with the additional kWh per year of energy required and the additional km per year of tanker movements. The Investment Manager then uses these values and multiplies by the conversion factors (in line with UKWIR guidance) to arrive at an "Operational Carbon" emission in tCO_2e per annum. We believe that this is an appropriate way of calculating GHG emissions for simple schemes because the majority of non-power and transport related GHG emissions are associated with sludge – and this is dealt with separately.

Hydro generation schemes were included in this group, simply having a negative effect on kWh required. Following Iteration 6 of Investment Manager, these schemes were not cost beneficial and did not make it into the FBP.

8.3.2 Group 2 Schemes

Wherever power generation from biogas or sludge treatment is involved in schemes, the approach identified for Group 1 schemes was considered inadequate. This is because there are significant amounts of GHG emissions associated with the by-products of biogas production and from sludge to land operations.

For each of these schemes, a full UKWIR spreadsheet (Version 2.0, June 2008) was completed to allow for:

- electricity used;
- electricity generated (including the impact of ROCs);

- effects of biogas produced;
- GHG from sludge to land operations;
- transportation impacts.

This was subsequently amended to account for the change in electricity factor discussed previously.

Sludge

The amount of additional sludge created for the AMP5 Programme has been calculated based upon population increase, level of treatment and other relevant factors. A model generates optimal disposal routes and computes the distances between Sludge Treatment Facilities (STF) to disposal areas.

Rather than complete a detailed UKWIR spreadsheet for any individual Quality or Growth scheme that creates a small amount of additional sludge (which impacts GHG in all the ways listed above), we have collected all sludge's together (split by driver) and completed an overall UKWIR Spreadsheet for the total additional sludge.

Volumes of sludge are batched and assigned to a particular Sludge Treatment Facility, and the emissions associated with tankering were computed using the emission factor in the UKWIR (1.178kg CO_{2e} per km), using a figure of 44.2 km (per round trip) to represent the average distance travelled from the STF to the point of disposal (to land). A figure of 61km per round trip was used for the average round trip of a STW to a STF.

Where the total new sludge exceeds the existing capacity, a new scheme has been proposed within the Business Plan for a new STF.

The net overall impact of this additional sludge is not re-apportioned to individual schemes but rather kept at Strand level. The effect is represented in the correct strand in the overall graphs presented on Page 16 onwards.

Enhanced digestion

A group of schemes were put through Investment Manager that seek to increase the yield of biogas from the digestion process. These are chiefly those relating to the weakening of Surplus Activated Sludge cells (SAS Rheology schemes) and to Acid Phase Digestion (APD). In both of these cases, a full UKWIR spreadsheet was used to assess the impact upon GHG emissions because the schemes seek to reduce the mass of sludge to land per year (by converting more solid material into biogas) whilst generating more renewable energy. It was assumed that no ROCs would be sold for these schemes and this was consistent with the OPEX values put into Investment Manager.

For Group 2 schemes (along with Group 3 schemes) GHG emissions were input directly into Investment Manager as tCO_2e per annum for use in CBA.

8.3.3 Group 3 Schemes

Some schemes have been assessed in detail outside of the Corporate Optimiser, these include:

- M&G: Work on the Severn Trent Centre and the impact of site closures on GHG emissions;
- Impact of changes in leakage and water use.

The impact of Severn Trent Centre and site closures on GHG emissions

The new Severn Trent Centre (STC) in Coventry has a GHG emissions target of 50Kg CO_2e m^2 which is the BREAM Excellent Standard (2006). For the STC this will mean a target of 750 tCO_2e per year.

The move to STC will take place in autumn 2010 and we plan to close seven other office buildings. We have therefore calculated the projected net change in CO_2e emissions.

The tCO_2e emissions from these seven buildings has been calculated using the 2007/08 electricity and gas consumptions for each building and by converting to tCO2e/m^2 using the current UKWIR workbook GHG conversion factors and the building floor areas. We have focused on electricity and gas consumption for the existing buildings as we have accurate records and we believe that these are the two key sources of emissions from these offices.

The net reduction in tCO2e is therefore calculated as *Total current emissions – STC target emissions.* Which we calculate to be 4118 – 750 = 3368 tCO_2e per year

As the final specification for STC is still being determined we have not accounted for any emission savings that would be derived from any on site energy generation nor have we accounted for any other GHG emissions that may arise.

There may be other property developments or refurbishments during the AMP5 period and we currently expect these to have CO_2e emission targets similar to that used for STC. However, this property programme is still in development and so in the FBP we have not included any change in CO_2e emission calculations for other properties.

8.3.4 Leakage and Water use

In common with other water companies in the UK, we have a mandatory requirement to calculate our economic level of leakage (ELL). This is currently undertaken in accordance with the best practice approach contained within the 2002 Tripartite Report. The report recognised that costs and benefits included within the ELL calculation should not be limited to those borne directly by the water company. It therefore introduced the concept of social and environmental costs and benefits as a result of external impacts. By including both direct and external costs and benefits it is possible to set leakage targets that are at the optimum level for customers, society and the environment.

The Tripartite Report was used by water companies for the 2004 periodic review of prices (PR04). However, the absence of detailed guidance on appropriate valuation methods made it difficult to fully assess and compare the effects of external costs and benefits. With ever increasing political and social pressures on the water industry to continue to reduce leakage, Ofwat recognised the need to improve on the assessment of external impacts for PR09. As such, in 2007 Ofwat commissioned RPS Water (RPSW) to provide Best Practice Guidance[8] (Guidance) on the Inclusion of Externalities in the ELL calculation. The Guidance and accompanying Main Report have been published on the Ofwat website for consultation. The Guidance provides a practical methodology for:

- Calculating environmental and social costs and benefits
- Calculating carbon emissions for differing leakage levels and activities
- Integrating the environmental, social and carbon costs in the ELL calculation.

[8] Providing Best Practice Guidance on the Inclusion of Externalities in the ELL Calculation, Ref PROC/01/0075, Guidance, V08. 1 October 2008

We commissioned RPS in April 2007 to undertake an assessment of externalities for inclusion in our SELL analysis. The scope of work was based on an assessment of leakage externalities in accordance with the Ofwat Guidance. The Guidance identifies a range of externalities associated with leakage-related and leakage management activities.

Leakage-related externalities are the environmental and carbon related externalities arising from the effects of leakage reduction. These are generally associated with resultant changes in levels of abstraction, treatment and distribution as a result of changes in leakage levels. For each zone it was determined that the carbon related externalities are dominated by energy consumption.

Leakage Management externalities are the social disruption and carbon related externalities arising directly from the implementation of leakage management activities. These will tend to increase as the level of activity increases. Carbon leakage management externalities were found to be dominated by asset renewal activities. Asset renewal was itself dominated by emissions from worksites and is a reflection of the volumes of renewal activity. Leak repairs were also found to be dominated by emissions from worksite repairs.

The values for operational carbon per ML have been used to assess both the reduction in emissions associated with a reduction in leakage per area and also from the predicted reduction in water use across the AMP period.

The tCO_2/Ml figure for Oswestry was challenged at Audit. The figure has not been re-assessed as the overall contribution of Oswestry to the carbon data is <0.5%. This is within the margin of error for our carbon calculations.

An issue emerged subsequent to completion of the tables and through audit challenge involving the Water Service supply/demand balance lines (Block D, lines 23 and 26 of Table C8.3). The overall numbers are correct (and there is no impact on overall carbon impact). However, the table below describes the correct split between the different elements.

		Increase (or decrease) in annual greenhouse gas (GHG) emissions to operate in 2014 -15 relative to 2009-10.	
		As submitted in Table C8.3	**Corrected Table**
		Kt CO2e/year	**Kt CO2e/year**
21	**D - Supply / demand balance**	-8.117	-8.117
22	Maintaining current level of security of supply for expected demand (W)	0.243	0.243
23	Leakage	-8.289	-4.463
24	Additional Resources	0.000	0.000
25	STW Consumption Reduction	-2.025	-2.025
26	Metering Strategy	1.913	-1.913
27	Low Pressure (DG2)	0.041	0.041
28	Undersized Reservoirs	0.000	0.000
29	Competition	0.000	0.000

Water service – Operational Carbon Emissions Summary

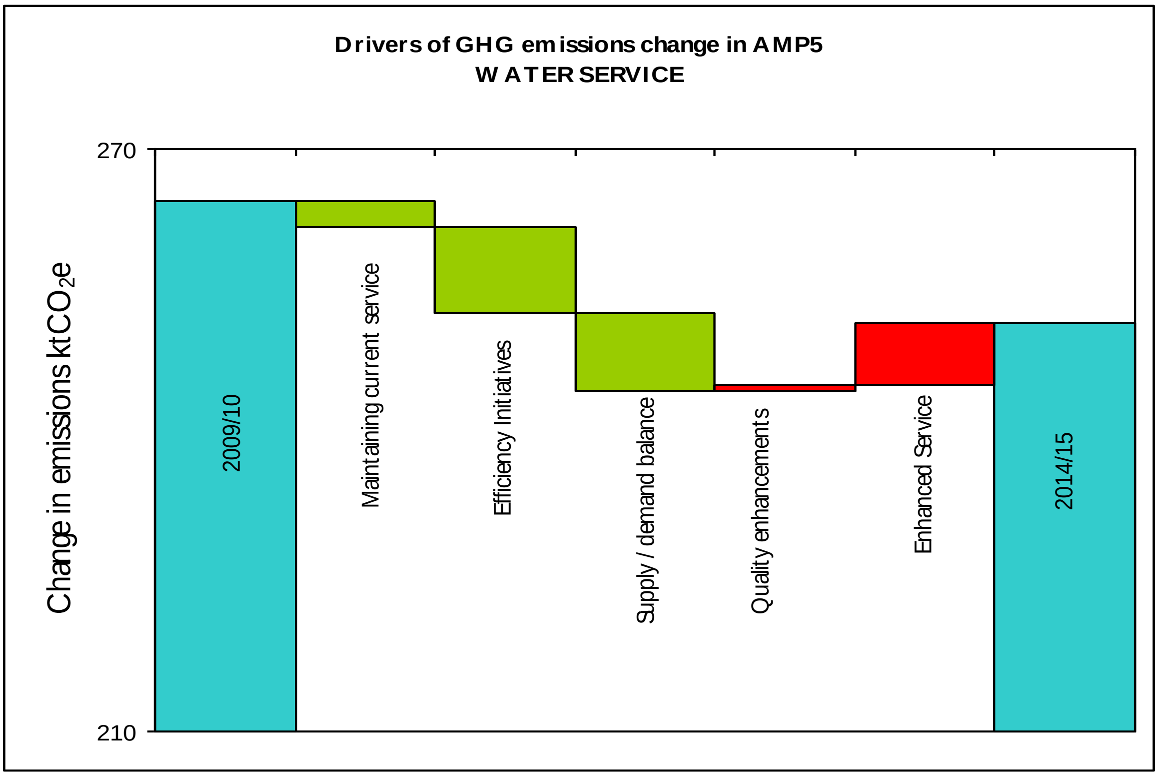
Kt CO2e/year	Total change in annual greenhouse gas (GHG) emissions to operate in 2014/15 relative to 2009/10	Change in annual carbon emissions to operate in 2014/15 relative to 2009/10	Change in annual other GHG emissions to operate in 2014 -15 relative to 2009-10	Operational Carbon Group
A - Water service	-12.652	-12.652	0.000	
B – Base service	-11.427	-11.427	0.000	
Maintaining current service in terms of key serviceability indicators	-2.756	-2.756	0.000	1
Renewable energy	0.000	0.000	0.000	
Efficiency Initiatives	-8.671	-8.671	0.000	1
C - Enhanced service levels	6.299	6.299	0.000	
Resilience: WTW and Strategic Grid	6.298	6.298	0.000	1
Resilience: Borehole Resilience	0.001	0.001	0.000	1
Resilience: Single Points of Failure	0.000	0.000	0.000	
Resilience: Flooding Risk Mitigation	0.000	0.000	0.000	
Resilience: Power Risk Mitigation	0.000	0.000	0.000	
Common Supply Pipe Separation	0.000	0.000	0.000	
D - Supply / demand balance[1]	-8.117	-8.117	0.000	
Maintaining current level of security of supply for expected demand	0.243	0.243	0.000	1
Leakage	-8.289	-8.289	0.000	3
Additional Resources	0.000	0.000	0.000	
STW Consumption Reduction	-2.025	-2.025	0.000	3
Metering Strategy	1.913	1.913	0.000	3
Low Pressure (DG2)	0.041	0.041	0.000	1
Undersized Reservoirs	0.000	0.000	0.000	
Competition	0.000	0.000	0.000	
E - Quality enhancements	0.593	0.593	0.000	
Isolated Communities	0.000	0.000	0.000	
Defra: SEMD	0.000	0.000	0.000	
DWI: Nitrates Removal	0.291	0.291	0.000	1
DWI: Lead	0.161	0.161	0.000	1
DWI: Other	0.141	0.141	0.000	1
EA: Low Flow Rivers	0.000	0.000	0.000	
EA: Habitats Directive	0.000	0.000	0.000	
Catchment Management	0.000	0.000	0.000	

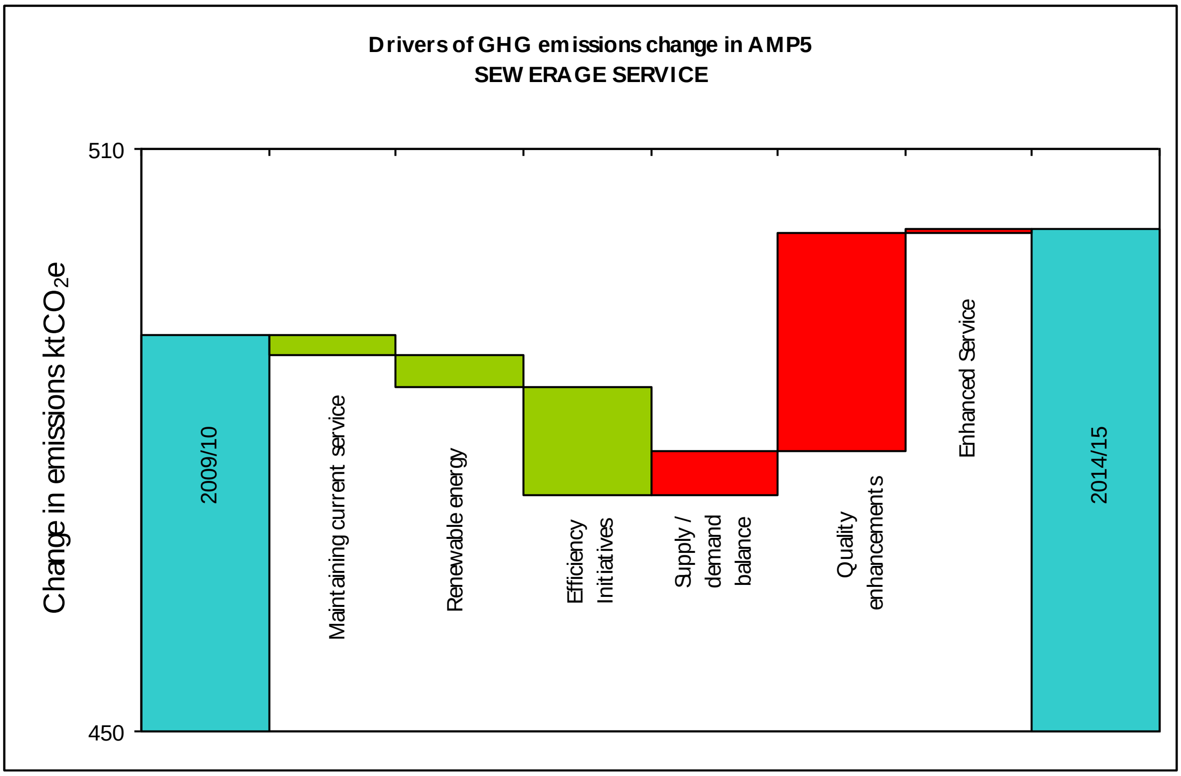
Sewerage service – Operational Carbon Emissions Summary

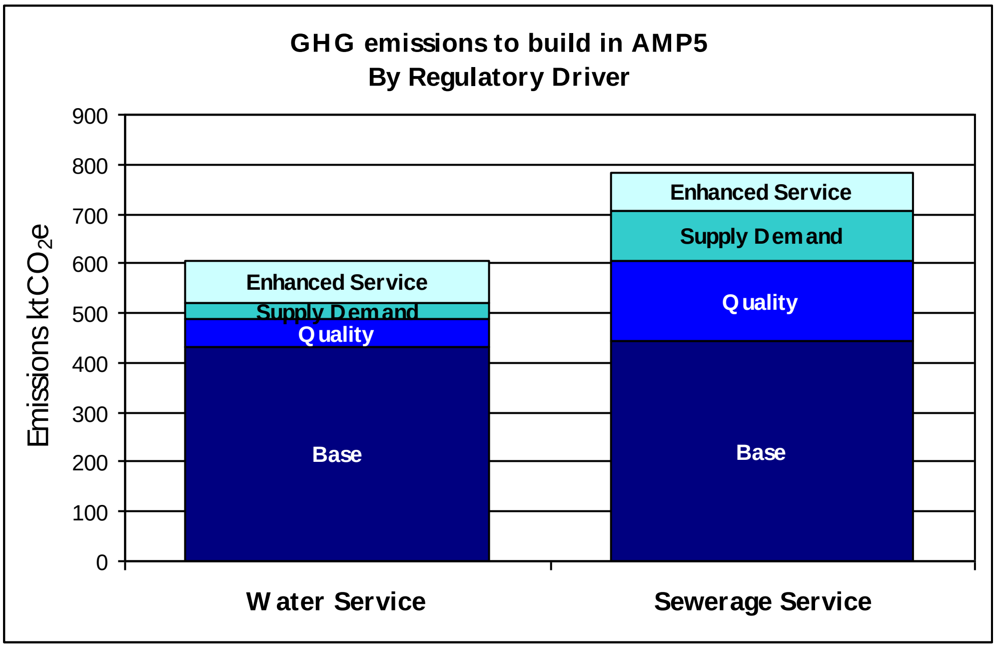
Kt CO2e/year	Total change in annual greenhouse gas (GHG) emissions to operate in 2014/15 relative to 2009/10	Change in annual carbon emissions to operate in 2014/15 relative to 2009/10	Change in annual other GHG emissions to operate in 2014 -15 relative to 2009-10	Operational Carbon Group
A - Sewerage service	10.892	-2.144	13.036	
B - Base service	-16.505	-14.056	-2.449	
Maintaining current service in terms of key serviceability indicators	-2.010	-1.330	-0.680	1
Renewable energy[1]	-3.318	-1.854	-1.464	2
Efficiency Initiatives	-11.177	-10.872	-0.305	1
C - Enhanced service levels	0.405	-0.043	0.448	
Nuisance (Flies and Odour)	0.072	0.072	0.000	1
Resilience	-0.019	-0.467	0.448	1
Sewer Flooding (ESL)	0.353	0.353	0.000	1
Pollution Strategy	0.000	0.000	0.000	
Dual Manhole Separation	0.000	0.000	0.000	
D - Supply / demand balance	4.803	2.706	2.097	
Maintaining current level of security of supply for expected demand	3.538	1.440	2.097	1
Foul/Storm Sewer Separation	0.000	0.000	0.000	
Sewer Flooding (SDB)	1.266	1.266	0.000	1
SUDS Adoption	0.000	0.000	0.000	
Competition	0.000	0.000	0.000	
E - Quality enhancements	22.189	9.249	12.940	
First Time Sewerage (S101a)	0.719	0.719	0.000	1
Dry Weather Flow Compliance	0.273	0.232	0.040	1
Other Sewage Treatment	0.133	0.095	0.038	1
Fisheries Directive	0.816	0.808	0.008	1
UWWTD P Removal	7.658	6.765	0.893	1
WFD - BOD and Ammonia	1.163	1.089	0.074	1
Quality Programmes Sludge	11.427	-0.460	11.887	2
Other	0.000	0.000	0.000	

[1] Due to an error in Netheridge Acid Phase Digestion, the overall ‘Renewable energy’ benefit is overstated by 0.044ktCO2e/year in the table above (the above table understates ‘carbon emissions’ by 0.003 ktCO2e/year and overstates the ’other GHG benefits’ by 0.047 ktCO2e/year). The scheme is still cost beneficial.

Summary of key drivers of GHG emission change in AMP5







8.4 Net additional operational and embodied GHG emissions from the programme

8.4.1 Summary

The table below shows an estimate of the net additional emissions per unit volume of treatment for water and waste. Embodied carbon emissions associated with M&G have been divided equally between the two sub-services.

Net additional emissions per volume treated

Sub-Service	Embodied carbon tCO_2e AMP5 total	Change in operational carbon tCO_2e/year	Change in other GHG Operational tCO_2e/year	Capex (£m)	Embodied carbon tCO_2e / £m capex
Draft Business Plan					
Water	697	-12	0	£1,454m	0.48
Waste	1,021	+50	+16	£1,738m	0.59
TOTAL	**1,718**	**+38**	**+16**	£3,192m	0.54
Final Business Plan					
Water	646	-13	0	£1,238m	0.52
Waste	784	-2	+13	£1,473m	0.53
TOTAL	**1,430**	**-15**	**+13**	£2,711m	0.53

8.4.2 Uncertainty

There is considerable uncertainty in the estimation of embodied carbon. MWH commented that "confidence grades for the data given in the final UKWIR report are generally rated C3-C5 (OFWAT confidence grading matrix), which reflects relatively low confidence and accuracy. There is a great deal of room for future updating of the emissions in the UKWIR report. This low confidence reflects the relative infancy of the science of carbon accounting. So, change is inevitable as experience and confidence increases". We agree with this view, with the overall estimate likely to be C5.

In relation to operational carbon, our estimates of energy use are more reliable than our embodied carbon estimates. We have evidence available on the effect of new processes on energy. There is inevitably uncertainty in forecasts but this is likely to be generally in the range +/- 10% - giving an assessment of B3. As noted in the UKWIR report on operational emissions, there is much more uncertainty in estimating non-CO2 emissions in relation to sludge processes - the overall level of uncertainty suggests a grade of C5.

8.5 Cost of carbon

The whole life carbon cost can be calculated from the quantity of carbon emissions multiplied by the shadow price of carbon for the year in which the emissions occur. Embodied carbon from construction is only counted once at the price in the year of construction. Operational carbon is counted for the first and all subsequent years of operation. Although expressed in pounds sterling, the carbon cost is not to be incorporated into the financial analysis but rather in cost-benefit analysis for investment planning.

The shadow price of carbon (SPC) for 2008 is £26 $(tCO_2e)^{-1}$ as specified by Defra and increases by 2% per year to account for increasing damage costs. It is not necessary to include an additional inflationary increase. Therefore, the present and future SPC for use in calculating whole life carbon cost is shown in the table below.

Defra shadow price of carbon

Year	*£ $(tCO_2e)^{-1}$*	*Year*	*£ $(tCO_2e)^{-1}$*	*Year*	*£ $(tCO_2e)^{-1}$*	*Year*	*£ $(tCO_2e)^{-1}$*
2008	26.0	2015	29.8	2022	34.3	2029	39.3
2009	26.5	2016	30.4	2023	34.9	2030	40.1
2010	27.0	2017	31.0	2024	35.6	2031	40.9
2011	27.5	2018	31.6	2025	36.4	2032	41.8
2012	28.1	2019	32.3	2026	37.1	2033	42.6
2013	28.7	2020	32.9	2027	37.8	2034	43.4
2014	29.2	2021	33.6	2028	38.6	2035	44.3

The figures presented are considered central estimates. For comparison, the lower and upper bound current SPC, as recommended in the UKWIR guidelines for whole life carbon accounting, are £16.3 $(tCO_2e)^{-1}$ – £71.4 $(tCO_2e)^{-1}$ respectively.

The shadow price of carbon has been used in the whole life cost assessment for every project. This calculation has been carried out following the Corporate Optimisation for embodied carbon but we have checked that this did not lead to any project becoming not cost-beneficial.

For operational carbon, we have applied a single figure for cost of carbon (£33.67) which has the same NPV over a 25-year period as the above annual figures. For embodied carbon, we applied an average figure for the period for AMP5 capex (£28.70) and a higher figure based on the above table for replacement in the period.

8.6 Impact of our AMP5 programme on SDS KSI 4

8.6.1 Our approach

Our approach in the FBP has been an economic one which includes a shadow price for carbon. This is consistent with the approach required from Ofwat. We believe that this approach strikes the right balance between our intention to seek to minimise our carbon footprint and our other commitments to customers. Using our operational GHG forecasting model we have examined the impact of the AMP5 programme on our intention to meet government targets both within the period of AMP5 and beyond and also the impact of the CRC (see B3 of FBP).

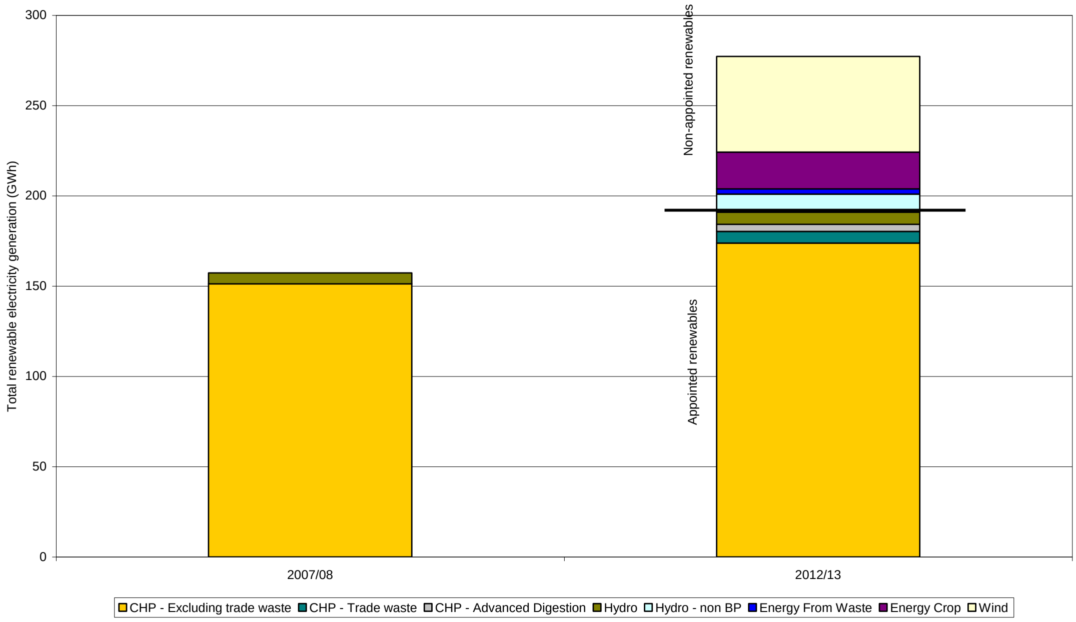
There is no statutory reduction target placed upon STW but there are three relevant government targets for operational GHG emission reduction (all against 1990 levels) against which we can measure performance and demonstrate STW contribution to reductions in UK GHG emissions to UK reductions. These targets are:

1. CO_2 20% reduction by 2010 UK National target
2. GHG 12.5% reduction by 2012 Kyoto target on UK
3. GHG 26% reduction by 2020 UK Climate Change Act 2008

In addition to reduction targets the UK Government has a target of 20% renewable energy by 2020. Severn Trent has a target of generating the equivalent of 30% of its electrical energy need from renewable energy by 2012/13. STW currently generates 17% and the proposed investment in AMP5 will take this to approximately 21% or some 191 GWh.

The graph below shows our strategy for achieving the 30% target. This is based on those schemes within this plan (CHP, and some hydro), and those Ofwat required[9] to be excluded (non business plan hydro, energy from waste, energy crop and wind) (see chapter B2). As noted above (section 8.3.1) hydro generation forms part of our strategy for achieving the 30% but 2.5GWh pa (see *Hydro non BP*, graph below) were removed on the basis of not being cost effective. This means that the FBP does not save an additional 1.3 ktCO_2e pa.

ST renewable energy strategy for meeting 30% by 2012/13 target

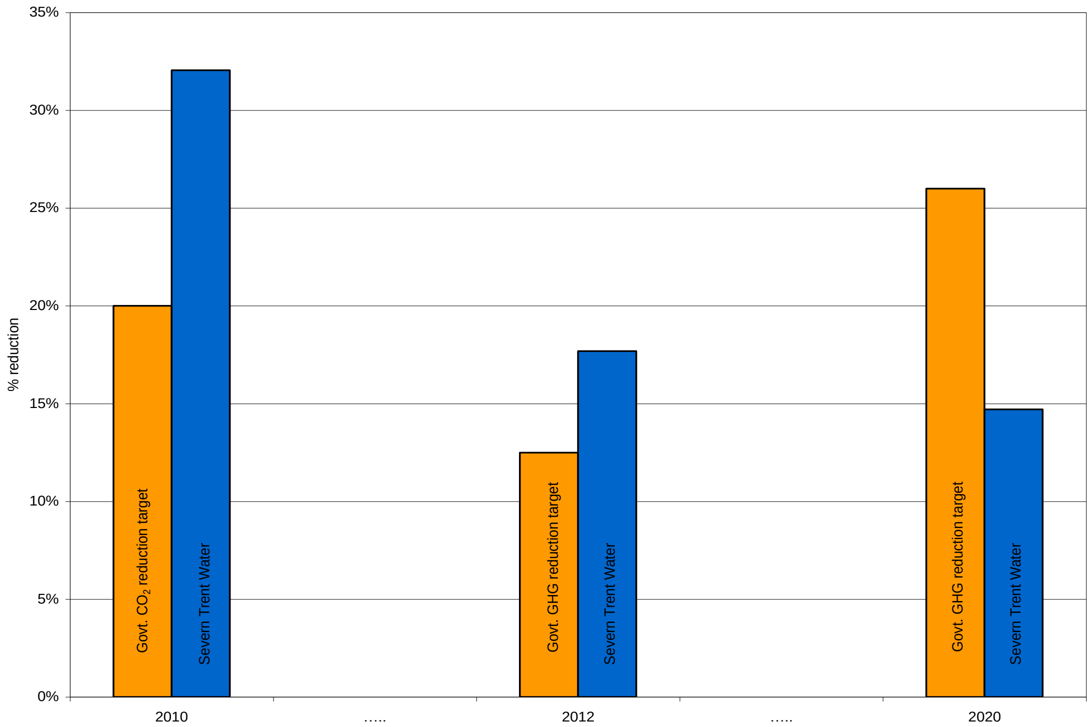


[9] Letter from Ofwat To all Regulatory Directors of all
water and sewerage companies and water only companies 26 June 2008 *PR09 Treatment of renewable energy*

To assess our progress in reducing emissions and against government targets we have structured our GHG emissions forecasting tool to match the UKWIR operational greenhouse gas emissions workbook. We have established an STW 1990 baseline, tracked AMP4 emissions and forecast the impact of our AMP5 investment.

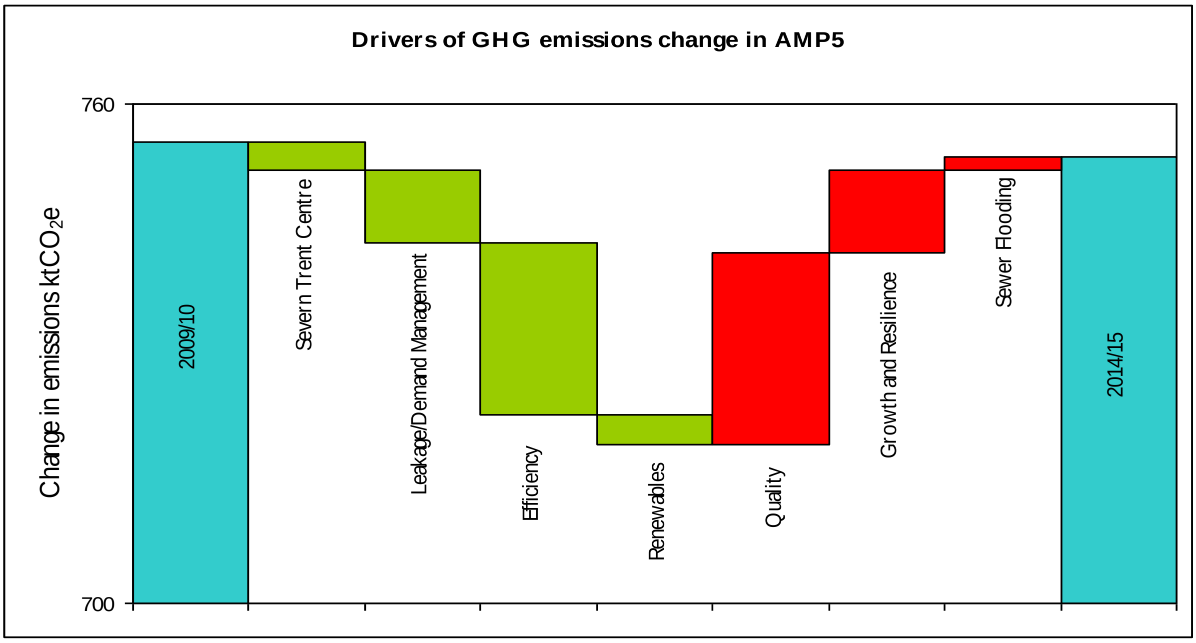
The graph below shows the forecast percentage reduction in total net emissions against the three government reduction targets for the appointed business within the FBP. Although the first reduction target is in that period of transition between AMP4 and AMP5 it is relevant as it shows the impact of our recent and current emission reduction activities and sets the starting position as we go into AMP5. The graph below clearly shows that we expect to beat the 2010 and 2012 term targets for emission reductions but that the Climate Change Act 2008 target of 26% reduction by 2020 will not be matched.

STW appointed business forecasts of percentage reductions (over 1990 base) against UK Government emission reduction targets



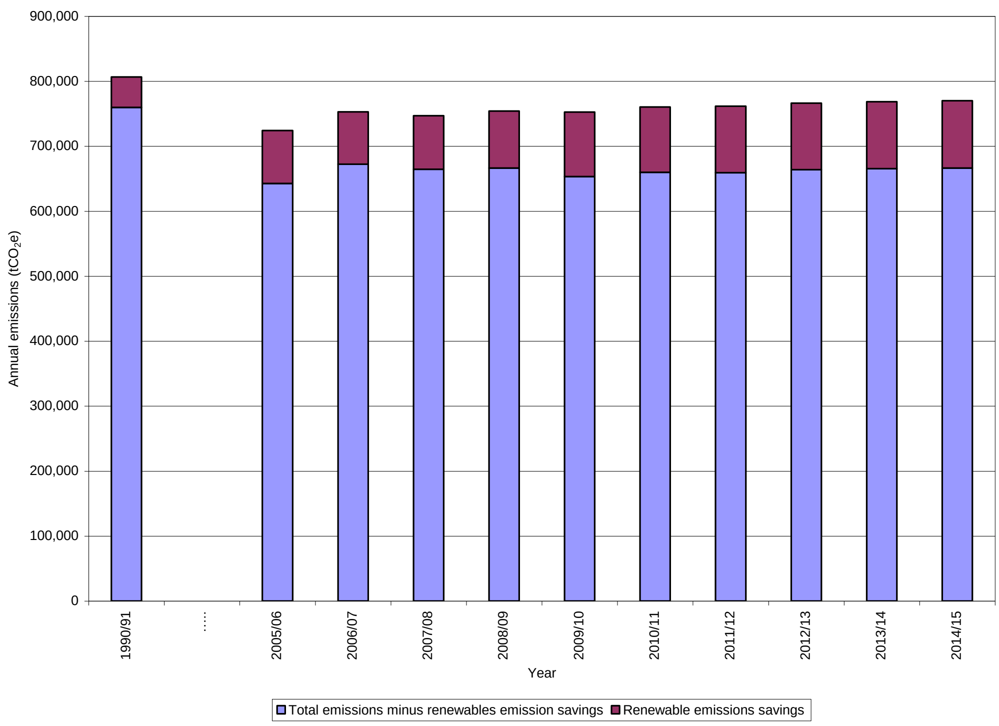
The graph below summarises how the AMP5 programme leads to reductions in emissions but also the significant negative effect that the quality and other programmes has on our efforts to reduce emissions (see table in section 7 and graphs above for details). The net effect on emissions of the business plan proposals is a 1.8ktCO_2e decrease.

Key drivers of GHG emission change in AMP5



The graph below shows the year on year net and total emission forecasts from the investment programme to the end of AMP5. Our net GHG reduction by 2012/13 will be 18%, as shown in the graph below, with increased renewable generation making a significant contribution to this reduction. By the end of the AMP5 period the net value of the renewables is a net saving of 104 ktCO_2e pa by 2015. From this we forecast that our net GHG reduction by 2012 will be 18%, see the graph above. By 2014/15 there is a slight overall increase in GHG emissions due to allowance for the natural gradual decline in equipment efficiency leading to a slight increase in energy consumption.

Annual STW AMP4 and forecast AMP5 emissions against 1990 base year



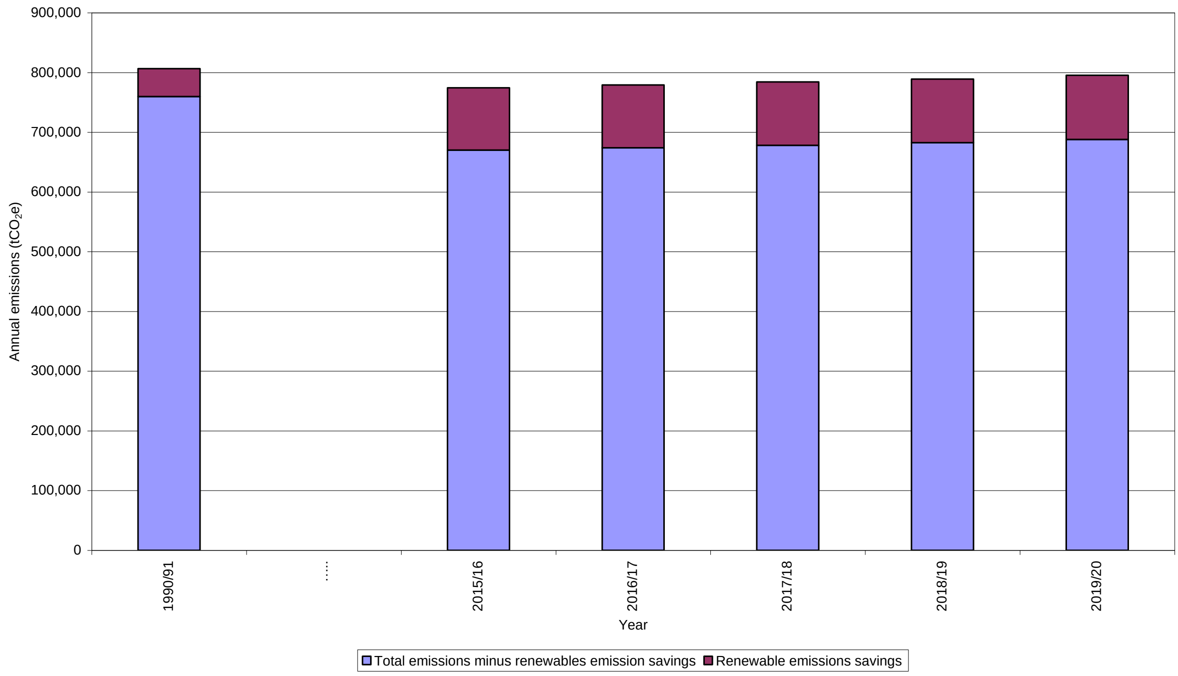
8.6.2 Forecasting emissions beyond AMP5

Our investment in reducing emissions in AMP5 is important if we are to continue to work to minimise our carbon footprint into the future and contribute to UK reduction targets.

The graph below shows our current forecast of a growth in emissions post AMP5 under a business as usual scenario of increased growth and increasing quality standards. This shows that emissions will again begin to increase and that we would not match the government 2020 emissions reduction target under these conditions. We believe this is a conservative forecast as future quality requirements from the Water Framework Directive are as yet not quantified and that there could be a bigger increase in emissions due to the requirements of quality standards.

There is a tension between the government desire to see reductions in GHG and the requirements placed upon us to increase quality. We will continue to work with our regulators to seek to resolve these tensions between government environmental targets.

Forecast of annual STW emissions post AMP5 against 1990 base year

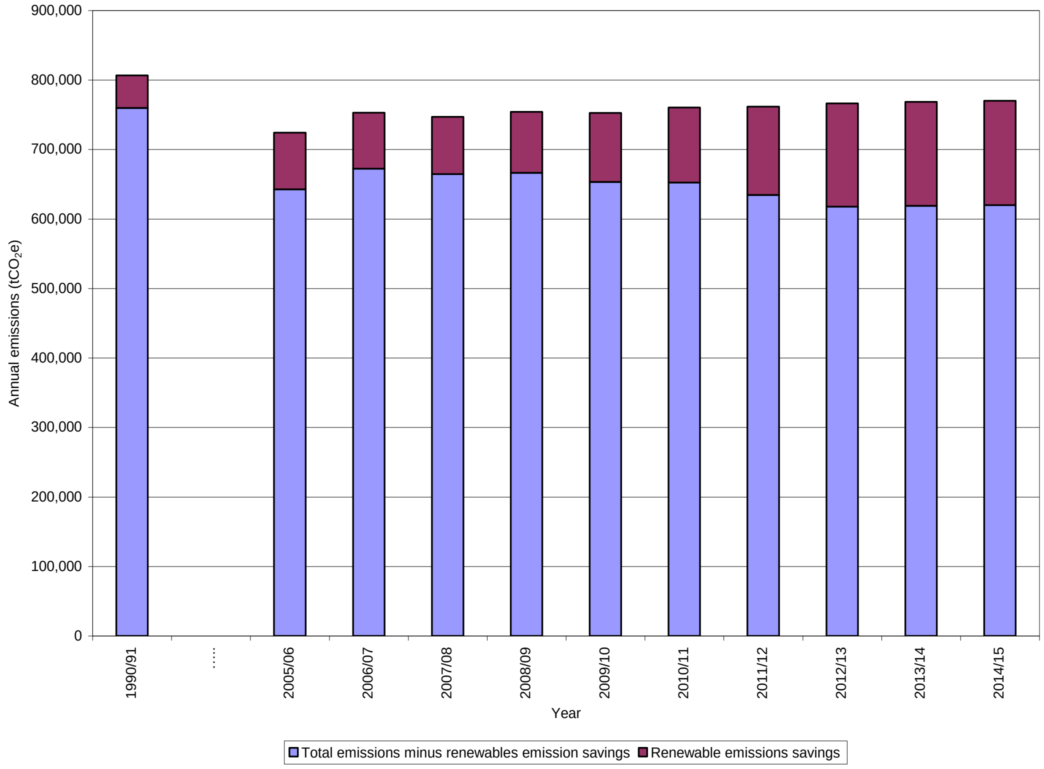


<u>The emission benefits of 30% renewable generation</u>

The FBP will extend our renewable generation from 17% (2008) to 21% by the end of AMP5. We have not included the additional renewables in the FBP due to Ofwat's guidance on what renewable energy generation should be included and the fact that 2.5GwH of hydro generation has not been included on the basis of not being cost effective.

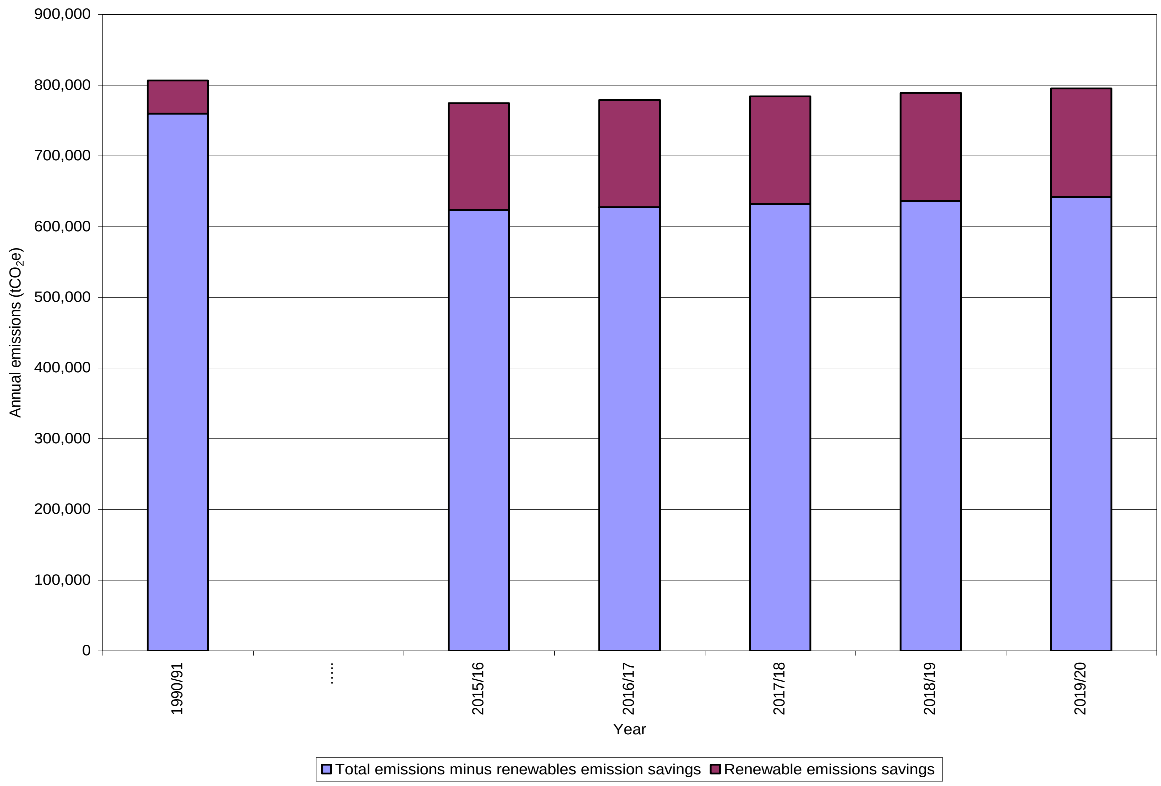
However, we are committed to the 30% by 2012/2013 target as one way of delivering KSI 4. The graph in 8.6.1 showed how this 277 GWh pa generation would be met. The graph below shows the benefit in net emission reduction within AMP5 from meeting the target by 2012/13. There would be an additional net emission saving of some 46.3 ktCO_2e per annum from 2012/13 giving a total of some 149 ktCO2e per annum to the end of AMP5.

Annual STW forecast emissions against 1990 base year with 30% renewables by 2013 having been achieved



The net emission saving will be ongoing beyond AMP5 and this is shown in the graph below.

Forecast of annual ST emissions post AMP5 against 1990 base year with 30% renewables by 2012/13 having been achieved



The table below compares the FBP (21% renewables) forecast percentage reduction in emissions with performance having 30% renewables, against the government targets. The lower reduction by 2020 forecasts is due to the increase in upward pressures and the table clearly shows the benefit that would be gained by increasing the renewables proportion.

Comparison of net emission reductions between FBP and 30% renewables

Government reduction target	STW FBP (21% renewables)	Severn Trent (30% renewables)
CO_2 20% reduction by 2010	32%	32%
GHG 12.5% reduction by 2012	17.7%	23.4%
GHG 26% reduction by 2020	14.7%	20.5%

Appendix 1 – Comparison of bill impact and discounted cash flow approach

The table below shows that assessing the NPV of costs using the impact on customer bills, as proposed by Ofwat in letter PR09/08, produces a very similar result to using equivalent annual costs through discounted cash flow, as we have done in our FBP. In the example below, for a 20-year life asset, our approach produces an NPV less than 2% higher than the Ofwat approach.

Ofwat - Bill impact approach								EAC calculation	
Year	Capex	CCD	RCV	Return	Bill impact	Discounted @ 3.5%		Capex	EAC @ 5%
0	-100							-100	
1		5	97.5	4.875	9.875	9.541			7.642
2		5	92.5	4.625	9.625	8.985			7.642
3		5	87.5	4.375	9.375	8.456			7.642
4		5	82.5	4.125	9.125	7.952			7.642
5		5	77.5	3.875	8.875	7.473			7.642
6		5	72.5	3.625	8.625	7.016			7.642
7		5	67.5	3.375	8.375	6.583			7.642
8		5	62.5	3.125	8.125	6.170			7.642
9		5	57.5	2.875	7.875	5.778			7.642
10		5	52.5	2.625	7.625	5.406			7.642
11		5	47.5	2.375	7.375	5.051			7.642
12		5	42.5	2.125	7.125	4.715			7.642
13		5	37.5	1.875	6.875	4.396			7.642
14		5	32.5	1.625	6.625	4.093			7.642
15		5	27.5	1.375	6.375	3.805			7.642
16		5	22.5	1.125	6.125	3.532			7.642
17		5	17.5	0.875	5.875	3.274			7.642
18		5	12.5	0.625	5.625	3.028			7.642
19		5	7.5	0.375	5.375	2.796			7.642
20		5	2.5	0.125	5.125	2.576			7.642
NPV						110.625			NPV of EAC discounted at 3.5% = 112.415

Appendix 2

RAND Response to Ofwat Comments on DBP Willingness to Pay Analysis

The Ofwat feedback on the DBP raised some issues on the approach to assessing willingness to pay. The issues raised by Ofwat are shown in italics below, followed by the response from RAND, who carried out the analysis for us.

Ordering effect and cognitive burden

We are concerned that the order the blocks were shown to respondents in your questionnaire was not randomised. This could have led to an 'ordering effect' which may have influenced choices and could affect the relative priorities of blocks against others. When considered with the issue of cognitive burden this may have had a significant impact on the WTP for the block asked last.

This issue is compounded by the significant cognitive burden of your survey due to the number of blocks and choices shown to respondents. The subsequent lack of investigation of this means it is difficult to know the true impact of this design issue.

Please confirm if the order of blocks was in fact randomised and if any assessment of cognitive burden was undertaken. If not then you will need to investigate further this issue and its potential impact on your results.

The ordering effect could lead to changes in rationality of responses across the four blocks of experiments, through boredom, or respondents focusing on the price attribute more closely in later bocks. While a randomised ordering is theoretically preferable, this can increase the complexity of the task facing the interviewer.

The order the blocks were shown to respondents was not randomised. However, two diagnostic econometric results were used to assess the impact of a non-randomised ordering of blocks. The first of these relates to the results of the packaging experiment. By asking customers, in the fifth experiment, to consider attribute changes in one block while simultaneously presenting them with all four blocks, the packaging experiment allowed us to consider whether respondents felt that, on reflection, they had been too generous in an earlier (or later) experiment.

The scaling factors derived from the packaging experiment raise the possibility of some ordering effect; with the attributes in first experiment requiring larger adjustments than the later experiments when viewed holistically, rather than as a lower order experiments. However, the effect has been corrected through the scaling factors derived from the packaging experiment.

We can also examine whether the quality of responses degraded (through, for example, boredom) with successive experiments by looking at the relative sizes of the error variances derived from each of the four lower order experiments. The variance of the unobserved error does not increase significantly over the series of lower level experiments (in fact the values of the scales for the first and fourth experiments are remarkably similar in both the business and residential models), which suggests that there is no significant increase or decrease in the difficulty that respondents had in responding. As such we judge that the order of the experiments has had very little impact on the quality of responses across all four blocks.

The scaling factors used are shown in the table below.

Experiment	Business scaling factors	Household scaling factors
1	76.6%	54.7%
2	108.8%	85.2%
3	82.3%	75.4%
4	118.3%	88.4%

Econometric Modelling

You have not supplied sufficient information to support the econometric modelling used to produce marginal WTP values. You only provide the results of one model, multinomial logit (MNL), and mention one other, nested logit. However, recent choice experiment research has pointed toward random parameter logit (RPL) models as the best fit. It would be useful if you could provide further details on the justification for using the MNL model, such as why it was considered superior to the nested logit model and whether any others, such as RPL models, were looked at.

Initially, a series of multinomial logit (MNL) models were estimated but in the latter stages of development a range of more complex model structures were tested. In total, sixty three different model specifications were tested in the development of the models that provided the best fit to the residential data and eighty one different model specifications for the business data.

The tests revealed that the fit of the residential model was not improved significantly by incorporating a nested model structure, and that the implied structure was not consistent with utility theory, i.e. the structural parameters were greater than 1.0. As a result, the MNL model structure was retained for the subsequent analysis of the residential data. Similar tests on the business model revealed that a nested model structure provided a better model fit to the business data than the MNL model, which implies within this dataset the respondents treated the two new alternatives as more similar than the “as now” alternative. A nested logit model specification was therefore used for the business model.

We have not looked at RPL models within this study. RPL models are relatively complex: although under certain circumstances the functional form has some advantages, the specifications should be used with considerable care, there being many potential pitfalls for the analyst. Issues such as the specification of the assumed parameter distribution, the number of random parameters specified and type of random draws used to simulate these (which can result in the unintentional introduction of correlation between the draws), and the number of random draws used during the simulation undertaken in model estimation can all have a significant impact on the model results. These issues are frequently brushed over in the desire to obtain models of a more complex specification, with the result that erroneous implications are drawn from the modelling.

Whilst RPL models typically provide a better fit to the data, it is sometimes questionable whether the model that provides this improvement in fit is theoretically sound. For example, poorly defined distributions can result in some respondents having a positive cost coefficient, which implies all things being equal they would have a desire to pay more for their water services. Considerable care is required to ensure that the models specified are both theoretically sound and correctly estimated.

It is questionable whether, in the context of these issues, RPL models do provide better insights for a given modelling investment. It should be noted that the correct estimation of RPL models is a time-consuming effort and whilst the functionality of these models exists in many standard packages, the correct estimation of these models requires significant consideration. RPL models are typically used as a way of capturing unobserved taste heterogeneity, but in our study, heterogeneity in respondents' preferences is captured through socio-economic interaction terms within the MNL and NL models. It is also worth noting that capturing observed heterogeneity (rather than relying on modelling unobserved heterogeneity) within the model specification provides insights into how the willingness to pay varies across the sample, which in many cases is more useful for policy decisions than the outputs from an RPL model that show that the values vary, but typically give little or no insight into who has the higher or lower willingness to pay.

Given the balance of these issues we have taken the decision to focus our resources on a modelling effort that aims to capture as much observable taste heterogeneity as possible.

We are also concerned by your statement that certain business responses were excluded from the final dataset as this improved the fit of the model. We are concerned by this approach, which appears to attempt to find the best set of data to fit the model as opposed to the opposite i.e. find the model that best fits the data set. Please provide further explanation to support these exclusions and how it affects the results. Alternatively, you may wish to reassess this approach and consider whether another model better fits the data.

The MNL residential model and the NL business models were developed using all of the usable data from the surveys. The models were selected on the basis that they provided the best fit to the full dataset (and not the 'best set of data being used to fit the model'). However, typically within a stated preference study a small number of respondents may exhibit *extremely* different responses to those of the rest of the sample which could have a substantial impact on the model results. This can arise if there were respondents that were either significantly different in some immeasurable way that we could not discover from the characteristics we have available for the models or respondents that were responding to the choices in a less rational way than other respondents. In such cases, it is good practice to remove such outliers thus to avoid biasing the results.

The presence of outliers was examined in a formalised (rather than *ad hoc*) way. The existence of outliers was tested by examining the forecasts of the model and outputting those observations that had a very low predicted probability of choosing the alternatives they were observed to choose, i.e. those for whom the model did not adequately represent their choices. Tests were then run to examine the impact of excluding these respondents from the analysis. These tests suggested that there were a small number of outliers in the business sample. Tests were run to detect those observations that had choice probabilities less than 0.1%. From these tests it was decided to drop data from 9 business respondents that had multiple choices with a probability of less than 0.1%. These outliers represent just 2% of the usable business sample.

Similar tests for outliers in the residential sample revealed that there were no choice observations that failed the outlier test at a probability of less than 0.1%. As a result no observations were excluded from the residential model on the basis of this test.

Appendix 3 – Valuation of pollution incidents

1. Our approach

We have included proposals to reduce pollution incidents in our Final Business Plan but we do not have a willingness to pay value for pollution incidents. In order to value pollution incidents, we have reviewed results from other surveys. We have also reviewed the results of our own post-DBP customer survey which obtained customer reaction to our DBP proposals.

2. Other studies

The Thames Tideway cost-benefit analysis study gives willingness to pay of £1.50 per year for reducing fish kills by one per year. This is a relatively serious incident and can be taken as a value for Category 1 and 2 incidents. This was based on a choice experiment in the form of face-to-face surveys involving 1,214 Thames Water customers.

Extract from Thames Tideway Strategic Study Cost-benefit Working Group Report, February 2005

Table 1: WTP Results	(£/Household/year)
Choice Modelling	
a) Sewage Litter (per % point of total litter)	1.8 (1.4 – 2.2)
b) Health Risk (per day of increased health risk)	0.4 (0.3 – 0.4)
c) Fish Population (per potential fish kill)	1.5 (0.7 – 2.4)
Aggregate WTP for best improvement scenario	
(baseline = 8 fish kills) = (a)*10+(b)*120+(c)*8	76.4 (66.7 – 86.1)
(baseline = fish kills) = (a)*10+(b)*120+(c)*4	70.4 (62.7 – 78.2)
No. of Observations (No. of respondents)	8,311 (1,039)
Contingent valuation	58.9 (51.9 – 66.0)

* Figures in brackets represent the confidence intervals for each of the attributes)

United Utilities' willingness to pay survey showed a similar value of £1.41 for reducing Category 1 and 2 pollution incidents.

3. Applicability of results

We used these figures in the DBP but stated that we would review the valuation of pollution incidents. In the Annex submitted in October we used a lower value, following review of the transferability of the United Utilities (UU) results. In assessing suitability of WTP values for transfer, we considered WTP relative to levels of bills and incomes in the companies for which we had WTP values (United Utilities and Thames).

- In the case of Thames, higher income levels might be expected to yield slightly higher WTP than would apply in the Severn Trent area. In addition, surveys such as the Thames Tideway survey, covering a limited range of issues, might be expected to produce higher valuations than a general survey of the type which we carried out.
- For the United Utilities area, bills are higher and incomes lower, which might be expected to produce a lower value than would apply to Severn Trent. (UU average bills in 2007/08 were £333, compared with £278 in Severn Trent; 18% of households were regarded as income-deprived (DCLG Index of Multiple Deprivation 2007) compared with 13% in Severn Trent).

Although lower values might be expected for UU customer WTP, actual UU results are almost all significantly higher than the values from our own WTP analysis. We have therefore scaled down the value used to reflect the generally lower results from our survey. On average, UU WTP values were 5.5 times our values, so we have divided the results by 5.5. Comparisons are shown in the table below.

Customer Willingness to Pay – (WTP)
United Utilities' valuations from their Strategic Direction Statement (December 2007)

Service measure	Current level of service	Alternative level of service	WTP (average per customer)		
			Average for new service level	WTP per unit of improvement	
				UU	Severn Trent
Interruptions to supply (properties off supply for more than six hours each year)	5,000	3,000	£8.50	£4.25 per 1,000 reduction	£0.52 per 1,000 reduction
External flooding from sewers (incidents each year)	3,500	1,750	£6.79	£0.39 per 100 reduction	£0.11 per 100 reduction
Internal flooding from sewers (properties affected each year)	1,100	550	£21.48	£3.85 per 100 reduction	£0.55 per 100 reduction
Odour from sewage treatment works (number of complaints each year)	1,000	500	£6.71	£1.34 per 100 reduction	£0.09 per 100 reduction
Security of Supply (frequency of hosepipe bans in years)	20	30	£6.15	61p per year	2p per year
Drinking water discoloration (customer complaints each year)	22,000	12,000	£5.45	55p per 1,000 complaints	£1.54 per 1,000 complaints
Environmental river quality (miles of rivers in good quality each year)	2,600	2,700	£2.88	£2.88 per 100 miles	55p per 100 miles

Service measure	Current level of service	Alternative level of service	WTP (average per customer)		
			Average for new service level	WTP per unit of improvement	
				UU	Severn Trent
Pollution to rivers (number of serious pollution incidents each year)	15	10	£7.03	£1.41 per incident	

4. Calculation of the value

Using a figure of £1.41 per incident, then reducing Category 1 and 2 incidents has a value:

£1.41 UU valuation
x 3,467,000 customers
/ 5.5 reduction factor
= £0.88m per incident per year.

We do not have a value for Category 3 incidents but the EA definition of incident categories indicates that the value should be very much less. We have used a value of 5% of the Category 1 and 2 incident value. This would mean that, nationally, eliminating all Category 3 incidents would have a similar value to eliminating all Category 1 and 2 incidents. The resulting value for Category 3 incidents is £44,000 per incident per year (or 7p per customer).

A further set of questions in the UU survey sought to establish the overall bill increase customers would find acceptable. For the customers surveyed this was £75 on average. This compares with a figure of £41.80 in the Severn Trent survey. Although the results are not directly comparable, as the service improvements within the package were different, this may suggest that a reduction factor of 5.5 is too great.

5. Post-DBP customer research

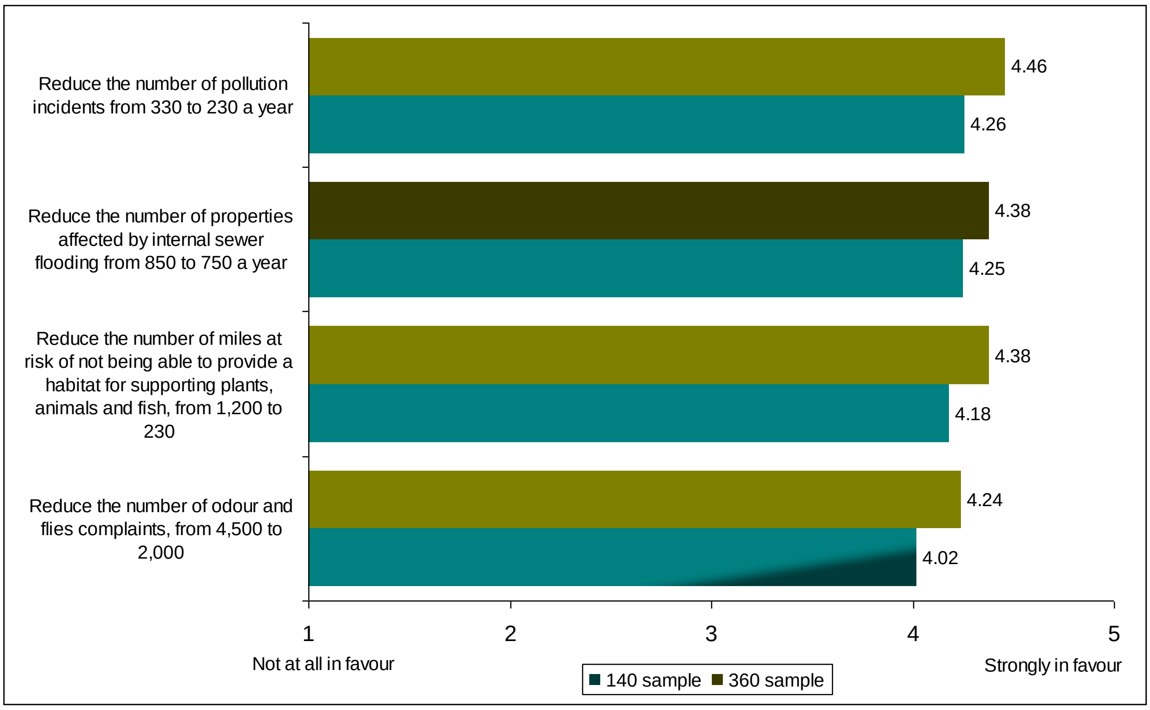
We included a reduction in pollution incidents in our customer research carried out after publication of our DBP. This consulted on the following service measures for sewerage:

CURRENT SERVICE LEVEL	PROPOSED SERVICE LEVEL 2015	Change in bill per year by 2015
1. Reduce the number of odour and flies complaints At the moment there are 4,500 customer complaints about the problem of odour and flies from sewage treatment works.	Reduce the number of complaints about odour and flies from sewage treatment works from **4,500 to 2,000 complaints**	22p
2. Reducing pollution incidents On average there are about 330 pollution incidents every year from sewers or sewage	Reduce the number of pollution incidents from sewers and/or sewage treatment works from **330 to**	44p

treatments works that affect land and/or rivers.	**230 a year**	
3. River water quality improvements for the Water Framework Directive (WFD) At the moment there are 1,200 miles of river in the Severn Trent area which are at risk of not being able to provide a habitat for a good range of plants & animals nor support salmon and trout; this is as a result of water being taken out of the river.	Undertake sewage treatment improvements across the STW region reducing the number of miles of river which are not able to provide a habitat for a good range of plants & animals nor support salmon and trout - from **1,200 miles to 230 miles**	£7.10
4. Reduce properties at risk of internal flooding from sewers At the moment there are 850 properties which suffer from internal sewer flooding every year	Reduce the number of properties experiencing internal sewer flooding from **850 to 750 properties** per year	£80p
	Total additions per year	£8.56

The data has been presented split by two sample sizes: 140 sample and 360 sample. The 140 sample represents those who were asked for their willingness to pay for improvements in service (based upon the actual cost of the improvements in the DBP) without being told the net effect that efficiency savings to the sewerage service would have on any bill increases. The 360 sample were asked to consider their willingness to pay for improvements but **were** told the net effect that efficiency savings on their sewerage service would have on any bill increases, resulting in lower increases than those shown to the 140 sample size.

Customers regarded our overall plan as acceptable, and the reduction in pollution incidents was given a higher ranking than other potential improvements in the sewerage service.



The results for pollution are shown in more detail below.

			Total
Sample	**140**	**360**	500
Not at all in favour	**2** 1%	**6** 2%	8
Not really in favour	**3** 2%	**8** 2%	11
Neither	**22** 16%	**49** 14%	71
Quite in favour	**43** 31%	**77** 21%	120
Strongly in favour	**70** 50%	**220** 61%	290
Mean	**4.26**	**4.38**	**4.35**

This does not give a WTP value but it puts a floor on what people are willing to pay – the results show that people are generally prepared to pay at least 44p for a reduction of 100 incidents, i.e. 0.44p per incident.

Additional analysis of WTP for pollution incidents

Professor Bateman, our peer reviewer, commented on the scale of adjustments made to the UU figures and questioned:

- Are there methodological differences which account for the changes?
- What is the justification for the scaling factor used to scale down from major pollution incidents to Category 3 incidents?

We do not have the information to analyse the methodological differences. We have, however, obtained further information from an anonymised study carried out by ICS. This shows results for pollution incidents for two other companies. These results have the advantages that:

- Category 3 pollution incidents are included, so there is no need for a scaling factor,.
- Results are more similar to our own WTP results than is the case for UU (an example comparison is shown below for interruptions to supply).

These results, when applied to our customer base, would give

3.685m customers x £0.026 (average of 2 results) = £91,000. This is well over the value we have used of £44,000 and we consider, therefore, that the value we have used may be an understatement.

Company	WTP (£ per customer)	Number of interruptions			WTP per 1,000 interruptions
		Current service	New level	change	
Company A	1.86	5,000	500	4,500	0.41
Company B	3.52	13,000	7,000	6,000	0.59
United Utilities	8.50	5,000	3,000	2,000	4.25
Severn Trent	3.98	11500	3500	8,000	0.50
Company	**WTP (£ per customer)**	**Number of pollution incidents**			**WTP per pollution incident**
		Current service	**New level**	**change**	
Company A	0.72	130	100	30	0.024
Company B	2.31	130	50	80	0.029