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Water Resources Planning: AISC and beyond….

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ABSTRACT

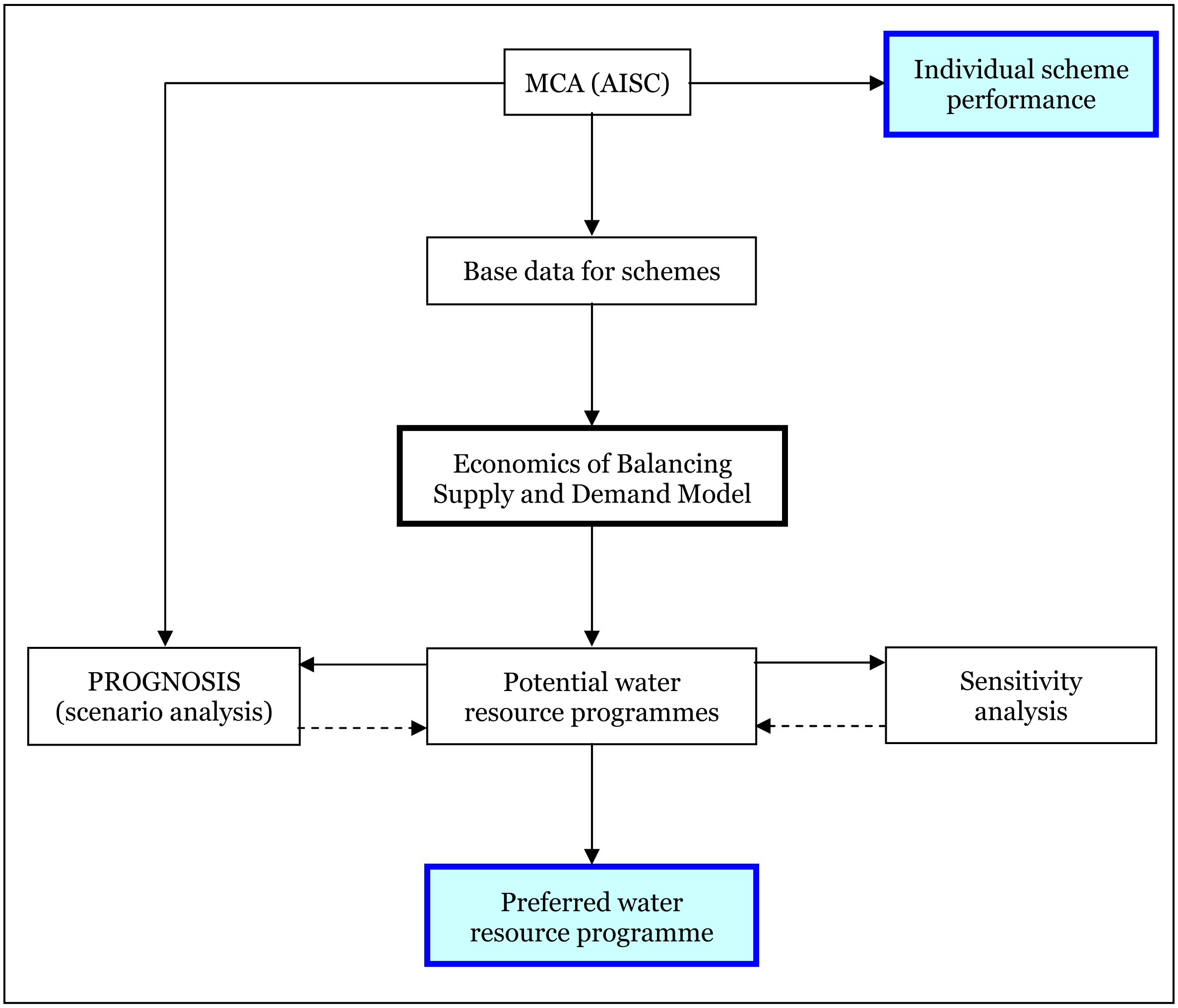
Thames Water has developed an innovative methodology for assessing demand management and water resource options to define a preferred programme to meet forecast demand under a range of future scenarios. The methodology, which is based on a combined BPEO and risk assessment approach, complements the application of Average Incremental Social Cost (AISC), as required by Ofwat and the Environment Agency, by incorporating non-monetisable impacts and benefits into the analysis. A range of demand management and water resource development options were assessed in terms of cost and environmental & social impacts and benefits, and a multi-criterion analysis was carried out, involving conversion of both monetary and non-monetary assessment parameters into a common format to give a single indicator of each option's performance. The output, together with AISC, was used to select alternative programmes of schemes to meet the future predicted supply demand deficit. The robustness of programmes under different future climate change, socio-economic and business scenarios was established in order to permit the company to make informed decisions on future water resource development.

1 INTRODUCTION

Thames Water has a statutory requirement to produce a Strategic Business Plan (SBP) for Ofwat and Water Resource Plan (WRP) for the Environment Agency on a five yearly cycle, known as an AMP (Asset Management Plan) period. The water resource planning part of this process is undertaken with a view to the long term, ie 25 years. In preparing a long-term water resource programme, key future uncertainties need to be considered including: climate change, population growth, per capita consumption and sustainability reductions, in addition to the supply capability of the company.

As part of Thames Water's ongoing strategic water resources planning programme, Cascade Consulting has been updating the Best Practicable Environmental Programme (BPEP) assessment of a range of potential water supply and demand management options for the 4th periodic review (AMP4, 2005 - 2010). The BPEP assessment comprises two elements; firstly the assessment of individual demand management and water resource schemes, and secondly the evaluation of water resource programmes made up of different combinations of the individual schemes, using the PROGNOSIS (Prioritising Resources Given Numerous Scenarios) model. These two elements of the BPEP process fit into the EBSD (Economics of Balancing Supply and Demand) framework as illustrated below.

Figure 1 Schematic of Water Resource Assessment Methodology



The first element of the BPEP assessment comprises the calculation of the Average Incremental Social Costs (AISCs) of the options, as required for water companies' reporting to the economic regulator, Ofwat, and to the Environment Agency. This combines the financial cost with the environmental and social costs of each option which is then divided by yield and discounted to give a comparable unit value, AISC (expressed as £/Ml).

The AISC method is limited in that it only takes account of those environmental and social impacts that can be expressed in monetary terms, ie for which "willingness to pay" or other valuation studies have been carried out. It also excludes consideration of environmental and social benefits. An alternative (and complementary) method was thus developed, based on a multi-criterion analysis (MCA) approach, in order to permit a wider range of impacts and benefits to be captured and taken into account in Thames Water's resource planning programme.

The second element of the BPEP assessment comprises a spreadsheet model, PROGNOSIS, developed by Thames Water and Keith Bowden Consulting, to evaluate the performance of different resource and demand management programmes under a range of differing future scenarios. This was designed to address the issues of uncertainty in long-term supply and demand and to move beyond central case planning.

2 METHODOLOGY

2.1 Multi-Criterion Analysis

Following a review of potential generic scheme types, over 60 potential water supply and demand management schemes were developed and site-specific scheme descriptions were prepared. The schemes were assessed against the range of financial, environmental and social criteria listed in Table 1. The financial objectives in this analysis represent internal costs to Thames Water, while the environmental and social objectives represent external costs and benefits associated with the residual impacts of the schemes.

Table 1 Range of Assessment Criteria used in MCA

Objectives	Criteria	
Financial	Capital cost Engineering contingency Security of supply contingency	Planning contingency Operating cost
Environmental	Aquatic biodiversity Water quality Fluvial Flooding Terrestrial biodiversity	Cultural heritage Resource use & sustainability Agriculture Landscape & visual amenity
Social	Community Risk perception Social exclusion Local economy	Transport Nuisance Recreation & navigation

2.1.1 Environmental and Social Objectives

For each scheme, adverse effects during construction and decommissioning, and adverse effects and benefits during operation were assessed. For water supply schemes, effects on the source of the raw water abstraction, points of discharge, transfer routes and storage areas were considered. Wherever possible, quantitative data were used for the assessment, otherwise it was based on professional judgement and experience gained from undertaking EIAs of similar schemes. The assessment considered residual impacts, ie those likely to remain after reasonable mitigation, such as the use of good construction practice.

The criteria were assessed either quantitatively or qualitatively depending on the availability of information. Those criteria that could be quantified and costed (monetised) were expressed as a monetary value, using the benefits transfer technique for costing both temporary and permanent environmental and social impacts and benefits. Upper, mean and lower costs were assigned to each criterion, based on the range of valuation data appropriate to that impact; where available, the upper values were used to give a worst case assessment.

Criteria that could be quantified but not costed were expressed in the units of measurement for that criterion, for example potential flooding impact was quantified in terms of hectares of land that might be affected per year (ha/y). Criteria that could not be quantified were assessed on the basis of professional judgement using a qualitative high, medium, low or negligible rating, subsequently expressed as values on a linear scale, equivalent to 100, 66, 33 or 0 respectively, to facilitate incorporation into the assessment. The method used for assessing each criterion is summarised in Table 2.

Table 2 Environmental and Social Criteria

Assessment Criteria	Adverse construction impacts	Adverse operational impacts	Beneficial impacts
Environmental			
Aquatic biodiversity	Quantified	Rated	Quantified
Water quality	Rated	Monetised	Monetised
Fluvial	Rated	Monetised	Monetised
Flooding	Quantified	Quantified	Rated
Terrestrial biodiversity	Quantified	Monetised	Monetised
Cultural heritage	Quantified	Rated	Rated
Resource use & sustainability	Rated	Quantified	Rated
Agriculture	Quantified	Quantified	Rated
Landscape & visual amenity	Monetised	Monetised	Rated
Social			
Community	Rated	Rated	Rated
Risk perception	Rated	Rated	Rated
Social exclusion	Rated	Rated	Rated
Local economy	Rated	Rated	Rated
Transport	Monetised	Monetised	Rated
Nuisance	Quantified	Quantified	Rated
Recreation & navigation	Monetised	Monetised	Monetised

2.1.2 Financial Objectives

Capex

The capital costs (Capex) were taken from previous Thames Water reports on individual schemes, which were subject to an external audit to ensure consistency of approach, or calculated by Thames Water using the company's internal cost model, based on unit costs for the infrastructure and water supply elements required. Allowances were made for normal engineering contingency and design and supervision costs where these were not already included in the reported or modelled Capex.

A series of additional contingency costs were also estimated on the basis of a preliminary assessment, to take into account uncertainty associated with the following:

- strategic engineering risk - uncertainty associated with implementing more innovative and less well-proven technologies
- security of supply – uncertainty associated with three aspects of supply:
    - security, ie the degree of control which Thames Water could exercise if water from outside the Thames region is utilised;

    - reliability, ie the physical capability of an option to provide a consistent quantity of water all year round; and
    - flexibility, ie the ability of an option to provide additional water in times of peak demand.
- planning feasibility - the potential difficulties likely to be experienced in promoting an option, including consideration of public perception, and the likely planning processes that may be invoked.

The contingencies were expressed in each case as a percentage of scheme Capex. Provision was also made to include the costs of purchasing land for developing schemes in London and in urban and rural areas within the rest of Thames water's region. Costs for upgrading the water distribution network to accommodate the additional supply, where necessary, were also included.

Opex

Operating costs were calculated for all schemes using unit values provided by Thames Water for the components:

- Abstraction licence charges and water purchase
- Power for pumping
- Water treatment and distribution
- Advanced water treatment
- Additional water treatment chemical costs
- Manpower costs

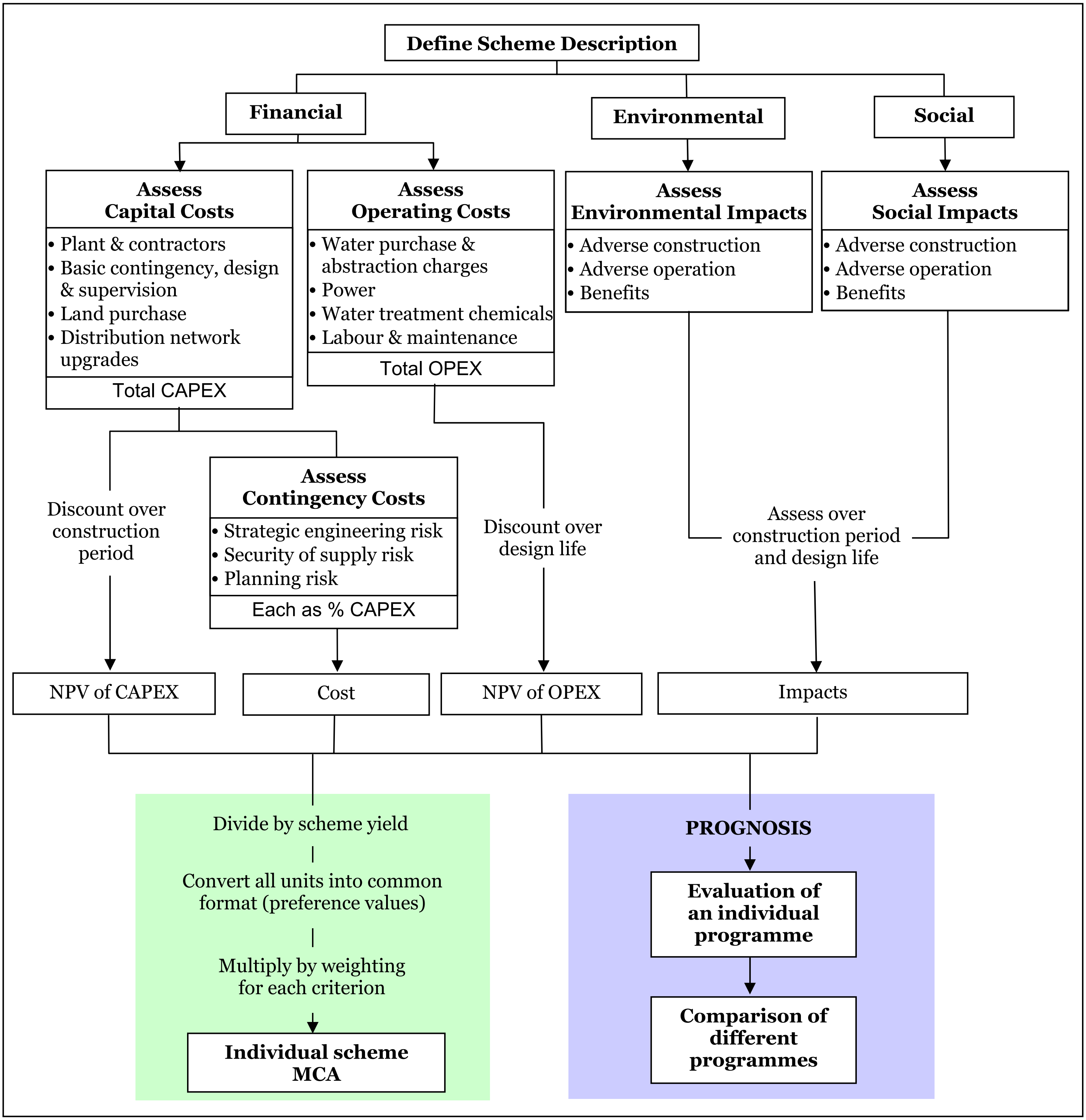
Parts, maintenance costs and sampling costs were excluded from all schemes, with the exception of membrane replacement costs for reverse osmosis and membrane bio-reactor (MBR) treatment for reuse and desalination schemes, which were included.

Discounted Costs

Costs were inflated to represent prices for the third quarter in the financial year 2002-2003, based on the Construction Output Index (COPI). The capital and operating costs were discounted, converting future costs into net present value (NPV). A discount rate of 5.5% was used, as advised to the water companies by Ofwat and the Environment Agency. The construction costs were discounted over the construction period for each scheme. The operating costs were discounted over an 80 year design period, consistent with Ofwat's requirement for design life periods ranging from a minimum of 60 years to a maximum of 100 years.

In order to permit a comparison of cost and impact data from schemes of widely differing magnitudes, the CAPEX, OPEX and impacts/benefits were expressed in terms of the scheme's yield on a per unit resource basis. The yield for each scheme was derived using a set of assumed values to account for losses during transfer, storage and treatment.

Figure 2 Flow Diagram of Steps Involved in MCA



2.1.3 Assessment Methodology

A simplified flow chart showing the steps of the MCA methodology is presented in Figure 2. The initial steps, as described above, produce the baseline cost and impact data for each criterion listed in Table 1 for each of the individual schemes.

However, as can be seen from Figure 2, the results include both cost and impact data that cannot be combined to give a single indicator of the performance of each scheme. In order to be able to compare the disparate values generated by the assessment, the results have to be converted into a common format. This was done using a technique given in DTLR's guidance manual on multi-criteria analysis[1].

The results for each criterion were therefore converted into "preference values", scaled from 0-100%, where the scale covers the range of observed costs, quantities or ratings for a single criterion for all the schemes under consideration. The preference values are thus relative to the schemes under consideration for a specific resource zone/system, rather than being absolute values.

A preference value of 0% indicates the most favourable outcome for each criterion, for example the lowest cost, least adverse impact or highest beneficial impact observed from the range of schemes assessed, whereas 100% indicates the least favourable outcome, ie the highest cost, highest adverse impact or lowest benefit for that criterion from all the schemes. The lowest value for any criterion thus indicates the best performance.

Four sample scale bars are shown in Figure 3 for illustration; note that the benefits scale is inverse. A scale bar is generated for each of the 5 financial criteria, 9 environmental criteria (x 3 for adverse construction impacts, adverse operational impacts and benefits) and 7 social criteria (x 3 for adverse construction impacts, adverse operational impacts and benefits).

Once the results for all criteria have been expressed in terms of preference values, they are then weighted (in accordance with the MCA guidance) and summed to generate an MCA value for each scheme (as shown at bottom left in Figure 2).

Weightings for each criterion were discussed at a stakeholder workshop held in March 2003, in order to give a balance of views from different perspectives[2]. The use of weightings is controversial and a number of stakeholders expressed reservations about the use of weighting in principle, despite its inclusion within the MCA Guidance. This was acknowledged and it was agreed that sensitivity testing would be used to explore the effects of weighting.

The initial weightings set applied was as shown in Table 3.

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1 DTLR (2001) Multi-Criteria Analysis: A Manual. Prepared for the Department for Transport, Local Government and the Regions by NERA.

2 Thames Water (2003) Multi-Stakeholder Consultation for Water Resource Planning – Facilitation Report prepared by Maplecroft Consultants and Cascade Consulting.

Figure 3 Sample Scale Bars for Converting Results for each Criterion into Preference Values (0-100%)

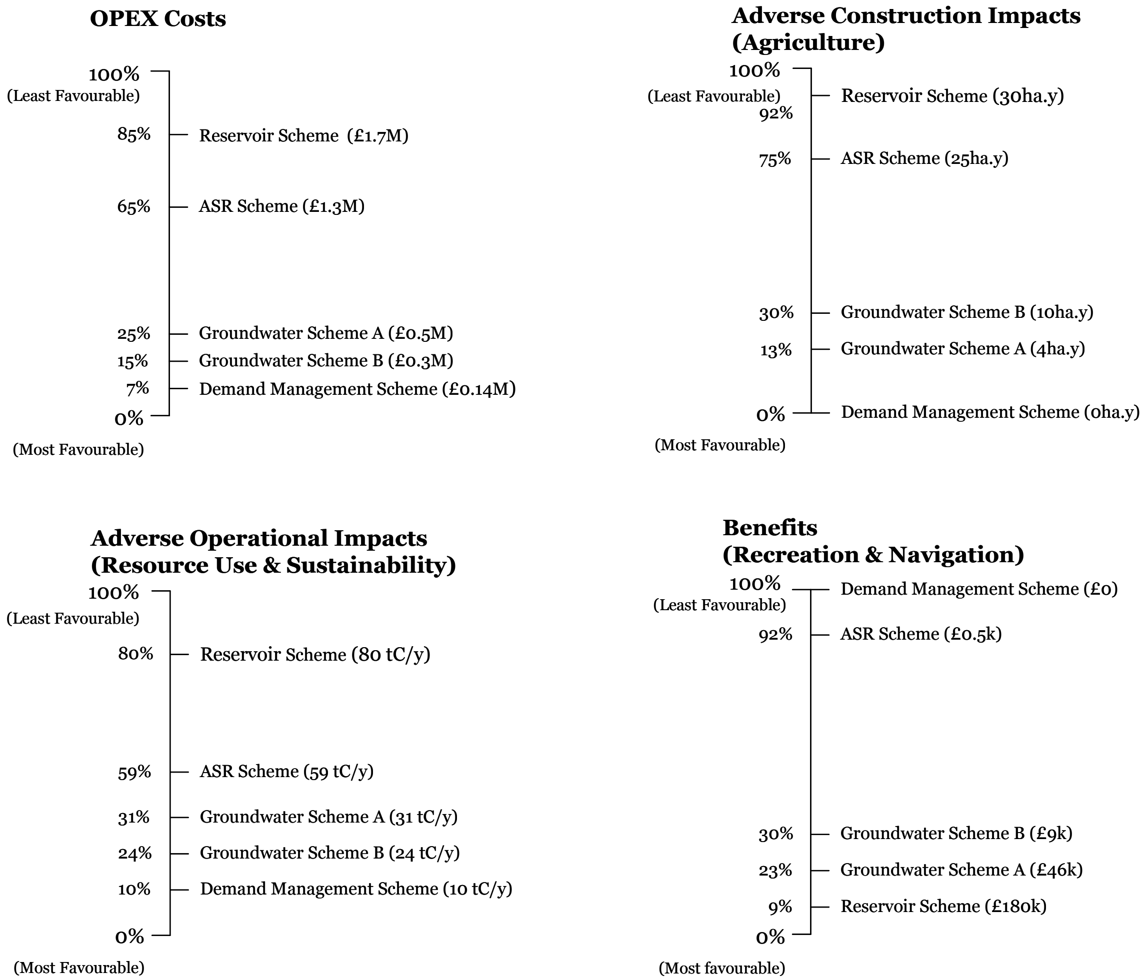


Table 3 Initial Weightings Selected

Financial	**45**	**Environmental**	**35**	**Social**	**20**
Capital costs	12	Aquatic biodiversity	5	Community	2
Engineering contingency	6	Water quality	4	Risk perception	2
Security of supply contingency	8	Fluvial	3	Social exclusion	3
		Flooding	6	Local economy	2
Planning contingency	6	Terrestrial biodiversity	4	Transport	5
Operating costs	13	Cultural heritage	3	Nuisance	4
		Resource use & sustainability	5	Recreation & navigation	2
		Agriculture	2		
		Landscape & visual amenity	3		

Cost was given the greatest weighting because Thames Water is under an obligation to its regulator (Ofwat) and the Environment Agency to use a least cost planning approach to supply water. From a total of 100, the financial objective was therefore weighted at 45, with 12 ascribed to CAPEX, 13 to OPEX and 20 to contingencies. The environmental and social criteria were ascribed a total of 35 and 20 each. The higher weighting for the financial objective is consistent with the approach used by DEFRA for prioritising flood and coastal defence schemes for grant aid, where the economic criterion is given greater weighting (20) than the people (12) or environment (12) criteria[3].

The spread of weightings between the individual criteria beneath each objective was determined through discussion, balancing one potential impact against another. Individual criteria that the stakeholders considered to be more important, and which were therefore weighted more heavily, included flooding, aquatic biodiversity, resource use & sustainability, transport and nuisance.

Stakeholders suggested that temporary impacts should be weighted less than permanent impacts, thus for each environmental and social criterion, the allocated weighting was split between adverse construction impacts (temporary), adverse operational impacts (permanent) and operational benefits in the ratio 2:3:1. Benefits were considered to be an incidental outcome rather than an integral part of a scheme and were thus weighted accordingly.

Sensitivity testing carried out on the weighting process showed that there was little change in outcome with minor variations in weightings – significant changes could only be forced by omitting one of the three objectives altogether, eg financial. The initial set of weightings was therefore retained.

A set of illustrative results from the application of the MCA is given in Section 3 below.

2.2 PROGNOSIS

The second element of the BPEP assessment methodology is PROGNOSIS. This is a spreadsheet model designed to use data from the MCA to evaluate the robustness of individual water resource schemes and combinations or programmes of schemes over a 25 year planning horizon. PROGNOSIS assesses the programmes' ability to meet the demand for water under a wide range of potential future scenarios. The difference between the MCA and PROGNOSIS is the difference in scale (evaluation of programmes as opposed to schemes) and the evaluation of these programmes over a given time frame.

2.2.1 Input Data

PROGNOSIS utilises the environmental and social base data for individual schemes from the MCA and assesses the aggregated data for each combination of schemes, ie each water resource programme tested. In doing so, programme preference curves are calculated, allowing the programmes to be ranked and compared. Cost data from the MCA, comprising capital, operating and

[3] http://www.defra.gov.uk/environ/fcd/policy/grantaid.htm

contingency costs for each of the schemes, are also used as input data for PROGNOSIS.

To assess the performance of a water resource programme, PROGNOSIS requires the provision of a demand and supply forecast enabling it to identify when future deficits appear, and the subsequent need for further resource or demand management options. Headroom (a "safety margin" required for dry summers) is not included explicitly within the evaluation as the uncertainty associated with headroom is captured within the scenario categories.

2.2.2 Scenarios Tested

Once a water resource programme has been devised, its performance under a range of future scenarios is assessed. The scenarios or 'futures' are based on combinations of three aspects which may influence the future environment: Socio Economic (SE), Climate Change (CC) and Business Approach (BA). Scenario Workshops were held in the early stages of the project with an 'expert group' comprising Thames Water staff and external consultants. The group identified and agreed the scenario categories and sub-categories to be adopted (as defined in Table 4).

Each sub-category is assigned a 'scenario factor'; a multiplier reflecting the impact which that scenario sub-category is predicted to have in the future. For example, under a National Enterprise future, planning regulations are predicted to be weaker than at present and as a result new development would be likely to be approved more readily. Planning risk would therefore be expected to be less of a constraint to the implementation of a water resource programme under this scenario. Combining all the scenario sub-categories gives over 60 potential permutations of future conditions.

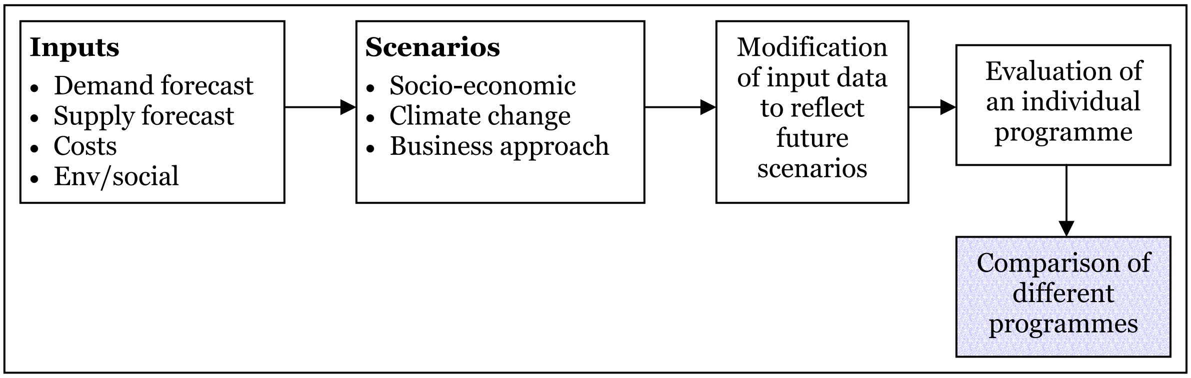
Table 4 Future Scenarios Tested using PROGNOSIS

Scenario Category	**Scenario Sub-categories**
Socio Economic (based on Dti Foresight Scenarios)	Status Quo National Enterprise World Markets Global Sustainability Local Stewardship
Climate Change (based on UKCIP 2002 scenarios)	Low Medium High High
Business Approach (based on internal review)	Status Quo Encouraging Change Driving Change

2.2.3 Evaluation and Outputs

PROGNOSIS evaluates water resource programmes by collating input information and exposing this to the influence of the different scenarios over a 25 year planning period. The evaluation process is undertaken in two phases, firstly by considering the performance of individual programmes and secondly by comparing the performance of different programmes against each other (Figure 4). Illustrative results are given in Section 3 below.

Figure 4 Flow Diagram of Steps involved in PROGNOSIS



3 ILLUSTRATIVE RESULTS

3.1 Multi-Criterion Analysis

Illustrative results obtained using the MCA technique for assessing individual schemes are given for a resource zone in Thames Water's region in Figure 4 below. Schemes are ranked in order of preference according to their MCA value in the list to the right, with the corresponding AISC value given for comparison. The two datasets are plotted against each other in the graph, with preferred schemes lying nearest to the origin.

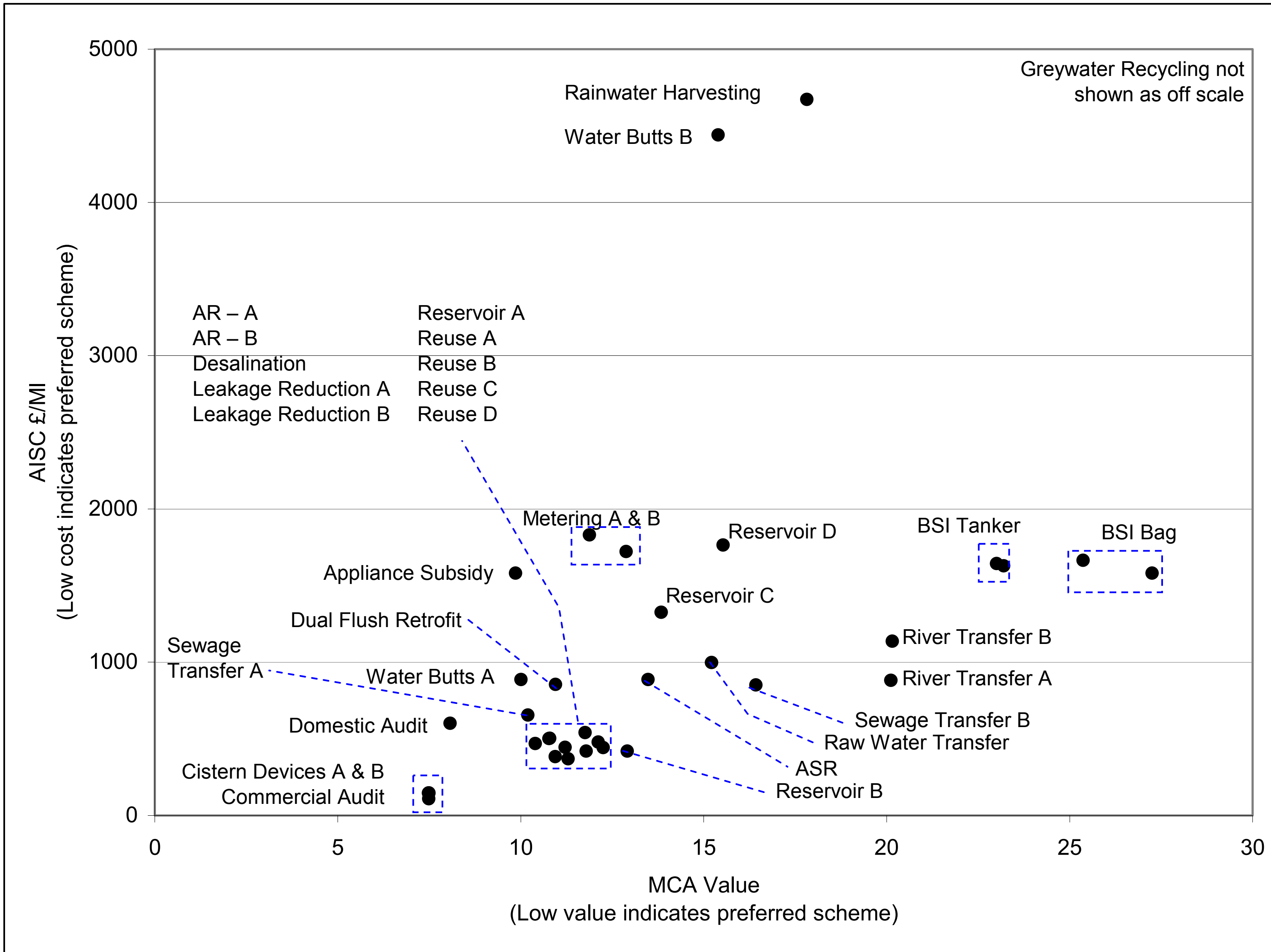
On the basis of the total MCA value, a number of low cost, low impact demand management schemes are identified as preferable, including cistern displacement devices (eg Hippos), audit, appliance subsidy and water butts A. Sewage transfer A, artificial recharge (AR), reuse, dual flush retrofit, leakage, desalination, metering and reservoirs A-C are mid-ranked schemes. Schemes with higher MCA values, and thus less preferred, include the remaining reservoir and transfer schemes, bulk sea imports (BSI) schemes by either tanker or bag, and demand management measures including rainwater harvesting and greywater recycling.

Greywater recycling appears as an outlier on the basis of its financial element, because although it involves significant CAPEX and OPEX it gives only a very low yield (0.6Ml/d) and thus has a very high unit cost. This scheme is thus the least preferred.

Although in absolute terms the impacts arising from the different schemes differ widely, the unit impacts (ie impacts per Ml/d of water generated) are in many cases quite similar. However, in general the transfer schemes tend to have the highest environmental unit impact and demand management schemes the highest social unit impact.

Amongst the preferred schemes, there is generally good agreement with the AISC values, with the exception of metering A and appliance subsidy, which would be viewed as high cost on the basis of the AISC value, and to a lesser extent water butts A and dual flush retrofit. These options have comparatively few impacts and thus, despite their slightly higher unit costs, are identified as preferred options by the MCA technique.

Figure 4 Comparison of MCA and AISC Values for a Water Resource Zone



Scheme	MCA Total	AISC £/Ml
Cistern Devices A	7.5	147
Cistern Devices B	7.5	146
Commercial Audit	7.5	108
Domestic Audit	8.1	601
Appliance Subsidy	9.9	1,580
Water Butts A	10.0	887
Sewage Transfer A	10.2	655
AR – A	10.4	470
Reuse A	10.8	501
Reuse B	10.8	503
AR – B	10.9	383
Dual Flush Retrofit	10.9	855
Reuse C	11.2	444
Leakage Reduction A	11.3	369
Desalination	11.8	541
Reservoir A	11.8	420
Metering A	11.9	1,830
Reuse D	12.1	479
Leakage Reduction B	12.3	442
Metering B	12.9	1,722
Reservoir B	12.9	418
ASR	13.5	886
Reservoir C	13.8	1,325
Raw Water Transfer	15.2	996
Water Butts B	15.4	4,440
Reservoir D	15.5	1,765
Sewage Transfer B	16.4	850
Rainwater Harvesting	17.8	4,671
River Transfer A	20.1	882
River Transfer B	20.2	1,136
BSI Tanker A	23.0	1,644
BSI Tanker B	23.2	1,629
BSI Bag A	25.4	1,664
BSI Bag B	27.3	1,581
Greywater Recycling	43.5	15,167

3.2 PROGNOSIS

3.2.1 Scheme Evaluation

The AISC/MCA data are used to select preferred schemes, which are then combined in series to form a range of different potential water resource programmes. Each individual programme is subject to scenario testing using PROGNOSIS to assess its performance under the full range of potential future scenarios over the 25 year planning horizon. As PROGNOSIS evaluates programmes over the long term, the performance of a programme over the first five years is not taken into consideration because of the low level of risk in the short term. By reviewing the programme's ability to meet demand over the remaining planning period under a range of scenarios, the user is able to decide on a level of risk to plan to, or how many scenario demands need to be met.

The key output is a supply/demand graph produced for each programme. This is illustrated in Figure 5 for an example programme comprising existing water resources (the base case) plus four new schemes implemented in years 6, 12, 17 and 18. The schemes in years 6 and 18 are high yielding schemes, while those in years 12 and 17 are smaller schemes. This programme was tested under all scenarios but for clarity, only five scenarios are depicted in Figure 5.

The supply/demand graph (Figure 5) illustrates the ability of the sample programme to meet demand over the planning period under each of the five representative future scenarios. The Status Quo line represents central case planning, with little change from the present situation apart from the impact of climate change. Scenarios 1-4 represent the performance of the programme under different combinations of socio-economic conditions, climate change and business approach (see Table 4).

The key requirement for a water resource programme is that it closes the deficit between supply and demand. For comparison, therefore, two planning cases for meeting demand are shown in Figure 5. Planning Case 1 represents meeting 90% of all potential demand under the suite of scenarios being examined. Planning Case 2 represents a varying planning case in which 90% of demand is met at the beginning of the planning period but only 80% is met in the later part of the planning period, thus acknowledging greater uncertainty in the future. In the example illustrated, the programme can be seen to meet 90% of demand under three future scenarios (ie the plot lines for these scenarios lie above the Planning Case 1 line), but fails under the remaining two.

The accompanying supply capability graph in Figure 5 illustrates the probability of demand being met under all of the scenarios tested over the 25 year period. The example programme illustrated shows a low probability of meeting demand under all scenarios until the fourth resource scheme is implemented in year 18.

3.2.2 Programme Evaluation

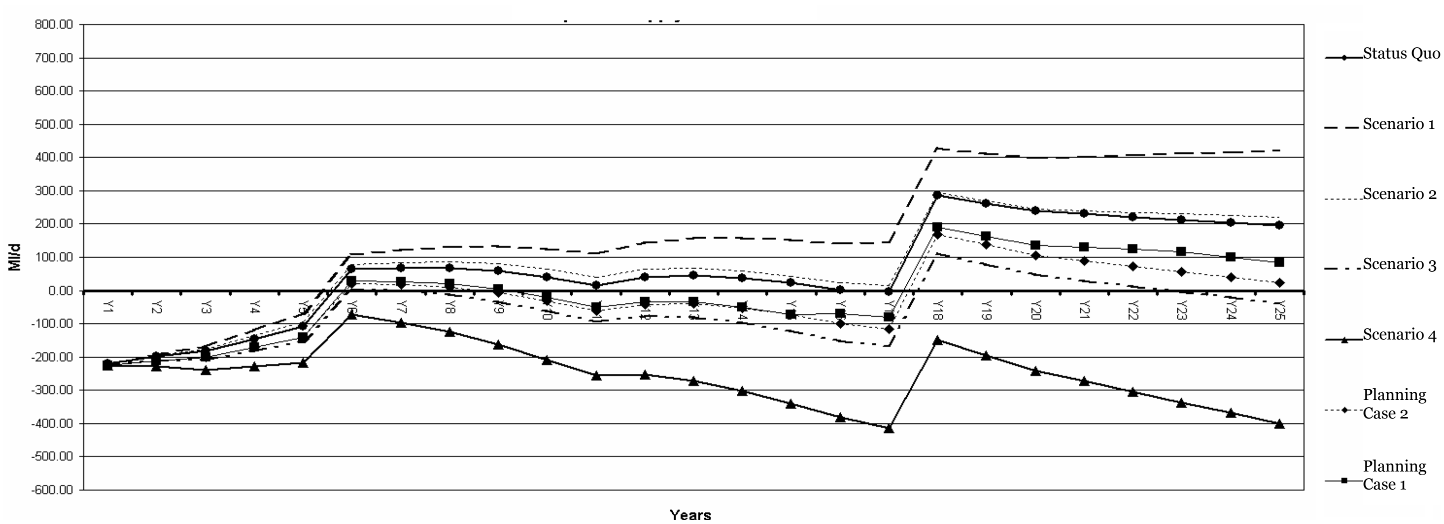
The example output in Figure 5 illustrates the information produced by the model for individual water resource programmes. However, the purpose of the BPEP is to identify the preferred water resource programme, which can only be achieved if a comparison is made with other water resource programmes, as shown in Figure 6. The second stage of PROGNOSIS thus involves assessing the data from a range of different programmes to enable a comparison to be made of the key variables, as shown in Figure 6 below.

Figure 6a illustrates four sample programmes' capability to meet demand under all scenarios, enabling the user to choose the most appropriate programme based on level of risk. For example, if the level of risk to be adopted requires that 90% of all future demand is met, the programme with a plot line closest to this point over the 25 years would be the most preferred. On this basis, of the programmes shown in Figure 6a, programme 4 would be preferred.

The costs, environmental and social values for these programmes are shown in Figures 6b, 6c and 6d respectively. The maximum and minimum values for these criteria under all the scenarios tested are represented by the vertical lines. The horizontal bars represent the central 50% of values obtained for each variable under the scenarios over the 25 year planning period.

The graphs show that although meeting demand consistently, Programme 4 is comparatively costly and has considerably higher potential environmental and particularly social impacts than the other programmes tested. This information can thus be used to determine its overall suitability for adoption within the water resource plan.

Figure 5 PROGNOSIS Supply/Demand and Supply Capability Graphs for a Water Resource Programme



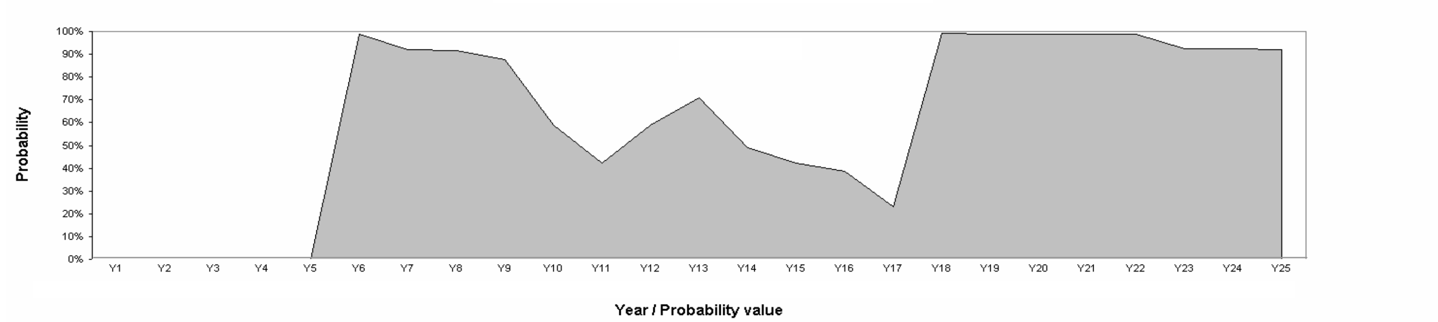
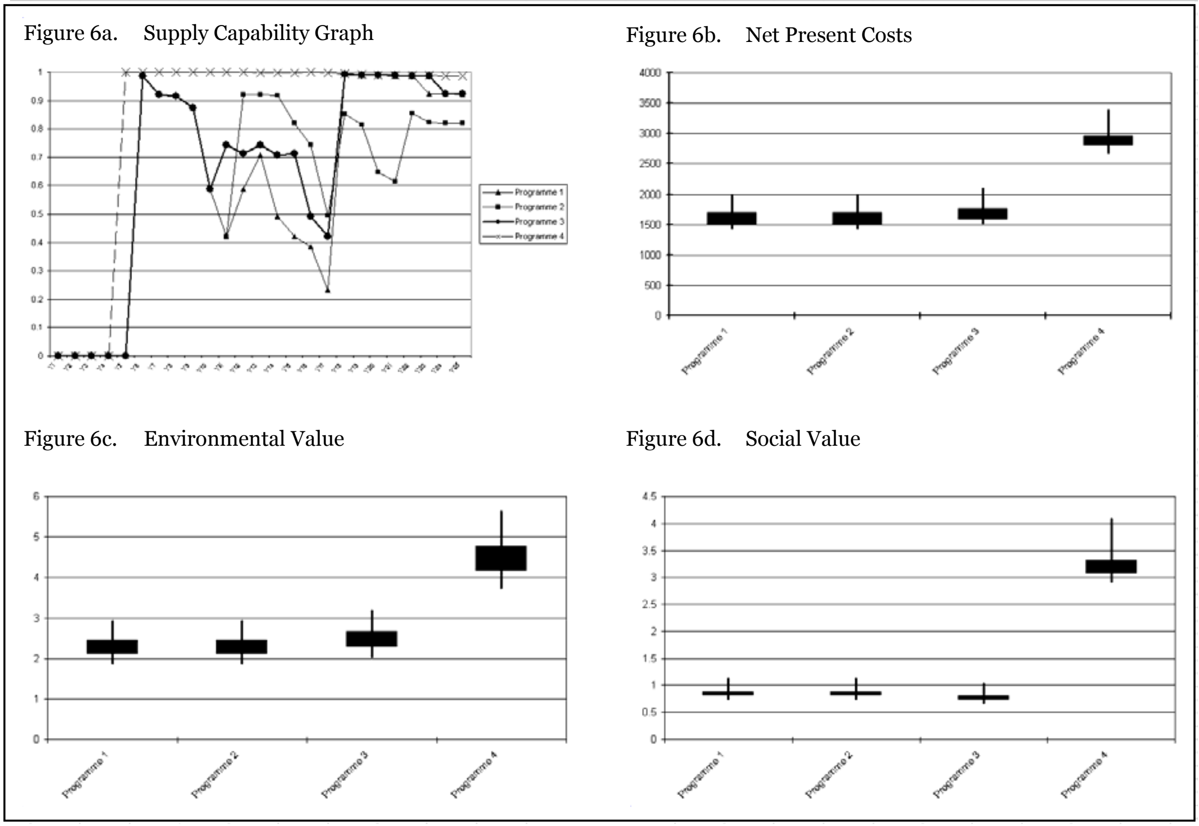


Figure 6 Comparison of Water Resource Programmes using PROGNOSIS



4 DISCUSSION

Application of the AISC and MCA techniques to assess individual demand management and water resource schemes gives broadly similar results. Both techniques include consideration of the most significant impacts, since these have been subjected to primary studies e.g. to determine "willingness to pay", and are thus monetisable. However, because of its greater breadth of impact and benefit assessment, the MCA tends to emphasise lower impact options, such as some of the demand management schemes, in preference to lower unit cost options.

Both the MCA and AISC results are being used by Thames Water to assist in prioritising schemes for inclusion in their water resource development programme. Other factors, such as implementation timescales, are also being taken into account. The base data from the MCA are being used as input data to the PROGNOSIS model.

PROGNOSIS allows decisions to be taken on the suitability of programmes using a range of variables. Ultimately, for a water company, ability to meet demand is the most important of these. Where programmes have a similar supply capability, PROGNOSIS can be used to differentiate between them by reviewing their performance in other areas, for example environmental impact.

PROGNOSIS has been used in Thames Water's recent SBP submission to explore the robustness of the proposed water resources plan under a variety of future scenarios. The Company recognises that it is both impracticable and unreasonably costly to design a water resources plan that can ensure supply under all possible scenarios, however identifying the conditions under which a deficit can emerge has proved instructive in constructing the plan. The model has also been used to investigate the robustness of a suite of 'alternative' plans and has made the benefits of the proposed plan more explicit. During its development, the model has been demonstrated to both Ofwat and the Environment Agency; both of whom considered that it showed useful potential as a planning tool.

To date, PROGNOSIS has been an invaluable tool for investigating the potential impacts of changing the timing of resource schemes. Since programmes are evaluated over a 25 year period, altering the start date of schemes can have a number of repercussions, not just associated with an increase or decrease in cost but also the level of environmental or social impact that could be incurred and the ability to meet demand throughout the planning period. Key findings to date highlight the implications of changing the timing of certain resource schemes, and the effect of this on cost and level of risk.

5 CONCLUSIONS

- A two phase BPEP assessment methodology has been developed to assist Thames Water in its water resources planning process; comprising a Multi-Criterion Analysis (MCA) technique to assess individual schemes and PROGNOSIS, a spreadsheet model developed to assess the robustness of programmes of schemes over a 25 year planning horizon.

- By incorporating non-monetisable impacts and benefits, MCA gives a more complete assessment of potential schemes than the standard AISC methodology. Results using the two techniques are broadly comparable, but MCA tends to emphasise the use of lower impact options such as some of the demand management schemes.

- The MCA technique provides comparative data for individual schemes which can be used in constructing potential water resource programmes for scenario testing using PROGNOSIS.

- PROGNOSIS evaluates and compares the performance of programmes under various future potential scenarios over a 25 year planning horizon. Where programmes have a similar supply capability, PROGNOSIS can be used to differentiate between them by reviewing their performance in other areas, for example in terms of potential environmental or social impact.

- PROGNOSIS has been demonstrated to the water industry regulators as part of a model development process and has been used to inform the Company’s water resources plan and strategic business plan submissions.

- With growing uncertainty in water resource planning, there is an increased requirement for tools such as PROGNOSIS to examine a variety of futures.