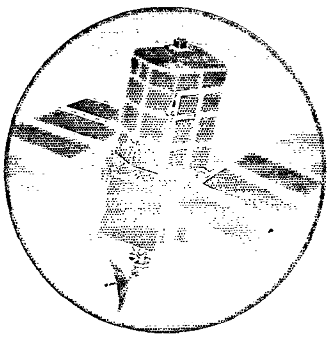
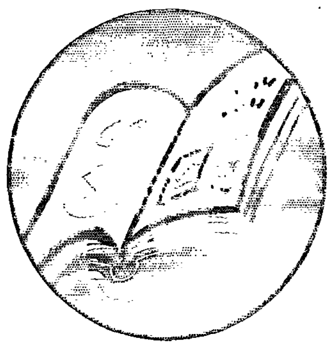
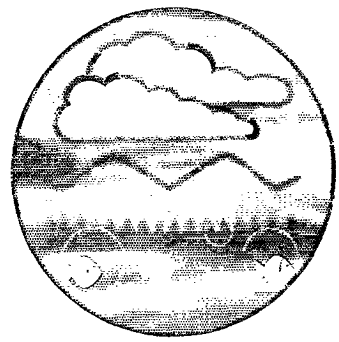
Framework to Assess Environmental Costs and Benefits for a Range of Total Water Management Options

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ENVIRONMENT AGENCY

Framework to Assess Environmental Costs and Benefits for a Range of Total Water Management Options

EFTEC, CSERGE and CES

R&D Technical Report W156

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Framework to Assess Environmental Costs and Benefits for a Range of Total Water Management Options

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Statement of use
This R&D will be of most use to water resources planners who need to understand how environmental values can be elicited in the context of strategic water resources planning. More specifically, it will be of use in applying the *Economics of Demand Management* (UKWIR / Environment Agency R&D project 630 / Technical Report W45) and the Agency's *Water Resources Planning Guideline*.

(1) External distribution is limited at this time to allow consideration to be given to combining the results of this project with a research project recently completed by UKWIR (also on restricted distribution outside of UKWIR).

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EXECUTIVE SUMMARY

Purpose of the Guidelines

Economics of Demand Management (EDM) (UKWIR and EA, 1996) developed a methodology for balancing water supply and demand using an optimal mix of initiatives or schemes selected from the full range of total water management options. Total water management was first defined in the EDM as "the full set of measures for managing supply, including resource management, production management, distribution management and customer side management".

The importance of identifying and measuring environmental effects of total water management options was indicated in EDM and also in the *Water Resources Planning Guideline* (Environment Agency, 1997). However, neither document presented a practical set of guidelines for using methods of monetary valuation within the EDM methodology. To fill this gap, the Environment Agency released a preliminary methodology for estimating environmental costs and benefits of total water management options (RPA, 1998).

The current guidelines provide a different approach to desktop environmental appraisal and monetary valuation. They are intended to guide the user through the thought process of monetary valuation of environmental costs and benefits for a range of total water management options. Therefore it is crucial that at least the main chapters of the guidelines are read before individual appraisals are undertaken.

Who should use the Guidelines?

These guidelines are mainly aimed at practitioners in water companies, the Environment Agency, AMP certifiers, OFWAT and other parties interested in the water environment. Water companies can use the step-by-step guidelines (Chapters 3 and 4) in developing and updating their total water management options, preparing their Asset Management Plans and generally in support of their investment decision making. Regulatory bodies can use the guidelines in reviewing applications from the water companies. The guidelines can also contribute to the switch to a catchment based planning methodology supported by the EU Framework Directive for Water Resources (being prepared). The case study presented in Chapter 5 is an example of this approach.

The guidelines also contain some discussion on important methodological issues, which can be useful in solving some of the problems encountered during practical application. The whole document is intended to be guidance at the initial stages of investment decision making when projects are not fully identified and designed.

Methodology Adopted for the Guidelines

The methodology behind these guidelines lies in the heart of environmental economics: identification of externalities and their measurement in monetary units. External effects are those from which third parties suffer (or benefit) and receive no compensation (or offer payment). We could also refer to an external effect as one that leads to a change in society's

wellbeing. Only environmental externalities are within the remit of these guidelines. Social externalities such as effects of hosepipe bans are not included here.
The measurement of external environmental effects should be in monetary units as far as possible since this facilitates easy comparison between these effects and financial costs and benefits of a total water management option. There are two stages to the methodology:

1. ***Environmental appraisal***, which involves identification of environmental effects and prediction of their likely significance. Considering that these guidelines are aimed at the early stages of decision making when neither the schemes nor their environmental effects may be fully identified, reference should be made to experience with similar schemes elsewhere. Chapter 3 of the guidelines outlines the environmental issues that would need to be considered when identifying potential effects of the scheme in question. Environment Agency and DETR guidance documents are recommended as useful references.

2. ***Valuation***, which involves the identification and measurement of external effects. Identifying whether an environmental effect is external or whether it leads to a change in society's wellbeing is also referred to as the *translation* or *correspondence* issue. Not all environmental effects identified in the first stage of the methodology are perceived as relevant by society. Chapters 3 and 4 explain how to make this translation and this is illustrated with a case study in Chapter 5. As mentioned above, measurement of external environmental effects should be in monetary units whenever possible. However, it is not always possible to do this partly because of a lack of understanding of what the actual environmental effects will be, and, partly because of a lack of literature on monetary valuation studies for such effects. Therefore, we also provide some guidance on non-monetary indicators, which can be used in the absence of monetary valuation.

Figure E.1 presents this two-stage methodology diagrammatically.

Conclusions and Recommendations

The methodology adopted here is recognised as an appropriate way forward for the evaluation of environmental costs and benefits of total water management options leading to full consideration of environmental issues in the decision making process. Application of the methodology will allow a systematic evaluation of all total water management schemes and a basis for judging environmental and social costs within the traditional cost-benefit analysis.

At this time, however, the methodology is hindered by a lack of suitably focused valuation studies. Development of the methodology should be undertaken to establish the following:

- Translation of all environmental effects into 'wellbeing' effects that can be measured in monetary units,
- Additions to the monetary valuation literature in order to fill the current gaps (identified in Chapter 6) so that all potentially significant 'wellbeing' effects can be measured in monetary units.

Environmental Appraisal (Chapter 3)

STEP I
Select the total water management schemes

↓

STEP II
Identify potential environmental issues

↓

STEP III
Predict the environmental effects

↓

STEP IV
Specify the residual environmental effects and their significance

↓

STEP V
Translate residual environmental effects to wellbeing effects

↓

Valuation (Chapter 4)

STEP VI
Is monetary valuation possible?

↓

STEP VII
Identify the valuation study relevant to the appraised scheme

↓

STEP VIII
Identify what adjustments are needed for benefits transfer and perform benefits transfer

↓

STEP IX
Estimate the total monetary cost or benefit as far as possible

↓

STEP X
Allocate non-monetary indicators

↓

STEP XI
Aggregate the monetary and non-monetary results

↓

Input to the EDM calculations

Figure E.1: Overall Methodology

The Structure of the Guidelines

The guidelines consist of seven chapters outlined as follows:

- *chapter 1*: an outline of the guidelines,
- *chapter 2*: overall methodology for identifying and measuring environmental costs and benefits of total water management options. The methodology is also presented in a flowchart, which indicates each step of the methodology which is later expanded upon in Chapters 3 and 4,
- *chapter 3*: a step-by-step guide to the identification of total water management options and basic steps of environmental appraisal,
- *chapter 4*: a step-by-step guide to the monetary valuation and non-monetary indicators of the environmental effects of total water management options,
- *chapter 5*: a case study of a water catchment area with a number of different total water management options in order to illustrate the guidelines presented in the previous chapters,
- *chapter 6*: summary conclusions and recommendations,
- *chapter 7*: references,

In addition, there are nine annexes as follows:

- *annex 1*: a selection from Environment Agency Scoping Guidance note,
- *annex 2*: a brief guide to monetary valuation techniques,
- *annex 3*: an annotated bibliography of some of the valuation studies quoted in Chapter 4,
- *annex 4*: a short guide on the importance of non-use values in this methodology and evidence from the literature as to how to treat them,
- *annex 5*: a more technical look at the methods and caveats of benefits transfer presented in Chapter 4,
- *annex 6*: a short note on the differences between willingness to pay and willingness to accept and evidence from the literature as to which one to use when,
- *annex 7*: guidance on discounting and how it should be applied to environmental costs and benefits together with the relationship between time and willingness to pay estimates,
- *annex 8*: guidance on the application of contingent valuation technique and the use of the results from studies using this technique, and
- *annex 9:* outline of issues generating uncertainty in this methodology and suggestions for dealing with them in practice.

Key Words

Cost-benefit analysis
Economics of demand management
Environmental appraisal
Externality
Monetary valuation
Total water management options

1. PURPOSE OF GUIDELINES

1.1 Background

Economics of Demand Management (EDM) (UKWIR and EA, 1996) developed a methodology for balancing water supply and demand using an optimal mix of initiatives or schemes selected from the full range of total water management options. Total water management was first defined in the EDM as "the full set of measures for managing supply, including resource management, production management, distribution management and customer side management".

The importance of identifying and measuring environmental effects of total water management options was indicated in EDM and also in the *Water Resources Planning Guideline* (Environment Agency, 1997). However, neither document presented a practical set of guidelines for using methods of monetary valuation within the EDM methodology.

A preliminary methodology for estimating environmental costs and benefits of total water management options was developed earlier this year (RPA, 1998). However, in the context of monetary valuation, we have some difficulties with the simple transfer of values from one context to another in the manner suggested by the existing methodology. Given that relatively few valuation studies have been completed, we would suggest that extrapolation of valuation data from one situation (for example a shallow canal system) to another (for example an upland stream) should be undertaken with caution, if at all (see Annex 5). This comment should not be taken as implicit criticism of existing methodologies, rather as an explanation for the different emphasis given in this report.

The focus of the current guidelines is, therefore, to describe in detail a full methodology for assessing environmental effects, and from that basis to allot where practicable a reasonable monetary value to those effects. ***We should stress that full monetary valuation of environmental effects can be achieved with further additions to the existing original monetary valuation studies in existence.***

The current guidelines are intended to guide the user through the thought process of monetary valuation of environmental costs and benefits for a range of total water management options. Therefore it is crucial that at least the main chapters of the guidelines are read before individual appraisals are undertaken.

Figure 1.1 repeats Figure A.1 of the EDM (Practical Guidelines). The shaded boxes indicate the coverage of these guidelines.

1.2 The Potential Uses of these Guidelines

These guidelines are mainly aimed at practitioners in water companies, the Environment Agency, AMP certifiers, OFWAT and other parties interested in the water environment. Water companies can use the step-by-step guidelines (Chapters 3 and 4) in developing and updating their total water management options, preparing their Asset Management Plans and generally in support of their investment decision making. Regulatory bodies can use the guidelines in reviewing applications from the water companies. The guidelines can also contribute to the switch to a catchment based planning methodology supported by the EU Framework Directive for Water Resources (being prepared). The case study presented in Chapter 5 is an example of this approach.

It should be noted that due to reasons discussed later (see Chapters 2 and 4), the results of the environmental cost and benefit analysis cannot always be integrated within the EDM framework as currently specified. We have, therefore, suggested a method for application of these guidelines that will allow an assessment of environmental and social costs alongside the existing EDM reporting format.

The guidelines also contain some discussion on important methodological issues, which can be useful in solving some of the problems encountered during practical application. Although the environmental cost and benefit values quoted in these guidelines are up-to-date to the best of our knowledge, they carry a number of caveats:

- this is a very fast developing literature and hence the values quoted need to be revised periodically,
- most of the environmental effects and resulting costs and benefits of water supply and demand projects are site-specific, which makes the use of standard values very difficult, if not impossible,
- there is no monetary value better than that estimated by an original study, especially when the environmental effects in question are significantly large and/or site-specific, e.g. a unique resource.

Therefore, this document should only be used to guide the initial desktop assessment of total water management options.

1.3 The Structure of the Guidelines

The guidelines consist of seven chapters outlined as follows:

- ***chapter 1*** (this one): an outline of the guidelines,
- ***chapter 2***: overall methodology for identifying and measuring environmental costs and benefits of total water management options. The methodology is also presented in a flowchart, which indicates each step of the methodology which is later expanded upon in Chapters 3 and 4,
- ***chapter 3***: a step-by-step guide to the identification of total water management options and basic steps of environmental appraisal,
- ***chapter 4***: a step-by-step guide to the monetary valuation and non-monetary indicators of the environmental effects of total water management options,
- ***chapter 5***: a case study of a water catchment area with a number of different total water management options in order to illustrate the guidelines presented in the previous chapters,
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In addition, there are nine annexes as follows:

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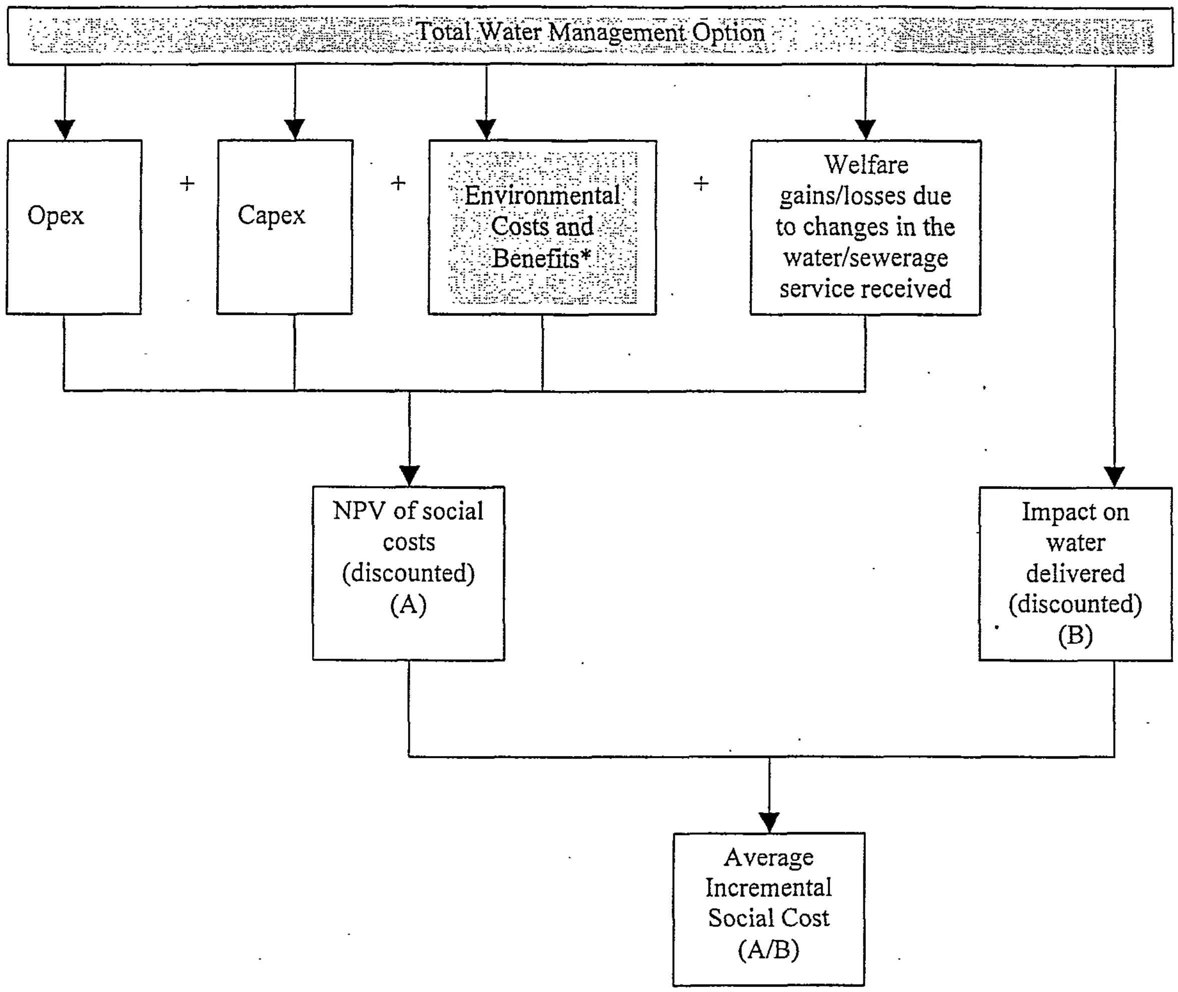
- ***annex 9:*** outline of issues generating uncertainty in this methodology and suggestions for dealing with them in practice.



*: Note that although there is a plus sign before the shaded 'environmental costs and benefits box', the monetary values of external environmental benefits must be 'subtracted' from the financial and social costs.

Figure 1.1: Partial equilibrium social cost benefit framework

2. METHODOLOGY

These guidelines cover the monetary valuation and non-monetary indicators of external environmental effects of total water management options. Effects on commercial fisheries and commercial uses of water (such as irrigation) are excluded as we assume that such effects can be internalised by the water company[1]. Second order effects such as the environmental costs of energy used in pumping stations are excluded from this analysis. Also excluded are the effects of, say, sewage disposal on the marine environment.

Figure 2.1 shows the assessment procedure for determining the environmental costs and benefits of a water management option.

2.1 Environmental Appraisal

The methodology for these guidelines starts with the identification of total water management schemes. A *scheme* is defined as an individual component of a total water management option. A *total water management option* is defined as the control or supervision of all activities affecting the supply and demand balance for water, from source to end-use. Schemes may fall into four categories (UKWIR/EA, 1996 and EA, 1997):

- *Customer-side management*: is targeted at customers' consumption, comprising plumbing losses and end-use e.g. cistern displacement bags[2],
- *Distribution-side management*: is targeted at activities on the distribution side and up to the point of consumption, e.g. leakage control,
- *Production management*: is targeted at activities between the points of abstraction and distribution input, e.g. recycling backwash water, and
- *Resource management*: affects yield, e.g. new abstraction.

While these schemes may be different in nature, there is in principle no difference from the point of view of economic analysis: both have associated costs and benefits. The difference is more one of practical difficulty in assessing the full range of costs and benefits. Customer-side measures may impose costs on households, e.g. possible disruption due to metering in households, and these have typically not been the subjects of monetary valuation studies.

The environmental effects should be assessed following accepted DoE/DETR and Environment Agency guidance as specified in Chapter 3. It is not possible to identify all potential environmental effects of all total water management options within these guidelines. Therefore, we have taken an approach which highlights the main concerns for each category of environmental issue (see for example Annex 1). The user should follow the description of each issue and try to assess the environmental effects of the scheme and whether these are residual (after possible mitigation) and significant.

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[1] External effects are those from which third parties suffer (or benefit) and receive no compensation (or pay no fee). Internal effects are those for which the sufferers (beneficiaries)are compensated (or make payments).
[2] In economic terms, the customer-side measures seek to shift the demand curve for water to the left. Other measures seek to shift the water supply curve to the right.

Environmental Appraisal (Chapter 3)

STEP I
Select the total water management schemes

↓

STEP II
Identify potential environmental issues

↓

STEP III
Predict the environmental effects

↓

STEP IV
Specify the residual environmental effects and their significance

↓

STEP V
Translate residual environmental effects to wellbeing effects

↓

Valuation (Chapter 4)

STEP VI
Is monetary valuation possible?

↓

STEP VII
Identify the valuation study relevant to the appraised scheme

↓

STEP VIII
Identify what adjustments are needed for benefits transfer and perform benefits transfer

↓

STEP IX
Estimate the total monetary cost or benefit as far as possible

↓

STEP X
Allocate non-monetary indicators

↓

STEP XI
Aggregate the monetary and non-monetary results

↓

Input to the EDM calculations

Figure 2.1: Overall Methodology

The final step of environmental appraisal is to translate the environmental effects to wellbeing effects, which are defined as any *change in human wellbeing* brought about by a scheme, programme or policy measure.

This can be problematic when physical effects are described and perhaps measured in a manner which makes them non-amenable to monetary valuation. A common example is measuring water quality changes in terms of biochemical oxygen demand (BOD). Individuals using a river would not 'value' BOD. Rather they would perceive the effects of BOD, i.e. a change in the attributes of the river – loss of biodiversity, appearance, and even smell. So what people are willing to pay for is a change in the perceived quality of the river. Of course, if BOD changes can be expressed as changes in perceived water quality, the link from measured quality to perceived change can be made.

In addition, and the principle reason for existing difficulties with applying this methodology, is that the monetary valuation literature does not cover some of the effects caused by total water management options at this time. These are the reasons why some environmental effects cannot be expressed in monetary units at this time.

2.2 Valuation

Chapter 4 presents steps to identify and measure the changes in the society's wellbeing due to the environmental effects identified in Chapter 3. Such changes can be positive (a *benefit*) or negative (a *cost*). It is important to understand that wellbeing effects need not be associated with an actual cash flow. For example, the experience of disamenity is a cost, and the experience of aesthetic pleasure is a benefit. The former would be measured in terms of individuals' *willingness to pay (WTP)* for avoiding the disamenity, or their *willingness to accept (WTA)* compensation for tolerating the disamenity. The latter would be measured by the WTP to secure the benefit, or the WTA compensation to go without the benefit. While the concepts of WTP and WTA are clearly and deliberately expressed in money terms, there may in fact be no associated cash flow corresponding to them.[3] In short, monetary values used in these guidelines reflect WTP or WTA, which, in turn, reflect people's preferences. More detail on WTP and WTA is given in Annex 6.

As a rule, environmental effects should, wherever possible, be expressed in units that are capable of translation into monetary values. To find monetary values for the resulting effect based on WTP or WTA, certain *monetary valuation techniques* are employed (see Annex 2 for techniques and Chapter 4 and Annex 3 for the literature review). Conducting new valuation studies for each scheme is to be preferred whenever possible. The cost of undertaking new studies should always be seen in proportion to the cost of the scheme, rather than as an absolute cost. The costs of studies tend to be small relative to overall scheme costs for large investments, but can be high for small schemes.

Where it is thought that new studies are too expensive, resort is made to *benefits transfer*, the process of 'borrowing' valuations from studies of other, similar projects. Great care needs to be taken in adopting benefits transfer because the potential for error is significant (See Annex 5).

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[3] But there may be a desire to turn the WTP estimates into actual cash flows, for example, by 'creating a market' in the environmental asset. This could be achieved, for example, by charging an entry fee to an amenity, such as a reservoir. This is known as 'capturing' the monetary value.

New valuation studies designed specifically for the project in question will also have an associated margin of error. There is always uncertainty in the valuations. However, benefits transfer may have larger margins of error. Hence it is always important to present estimates with the relevant *ranges of uncertainty*.

Uncertainty is inherent not only in monetary valuation but also in environmental appraisal and indeed in financial analysis. Therefore, even simple sensitivity analysis in the form of using ranges rather than point estimates, and testing of the influence of various assumptions on the final results, will improve the reliability of the whole exercise. Annex 9 provides some detailed discussion on the issue of uncertainty.

As far as is credible and possible, effects should always be expressed in monetary terms. However, considering the limitations of monetary valuation literature and benefits transfer in the face of site-specific effects from total water management options, it is inevitable that the residual effects will generally be measured partly in monetary terms and partly in non-monetary terms. There are various ways of dealing with these mixed outcomes, which are discussed in detail in Chapter 4.

A final additional element to the guidelines, namely *time and discounting*, is introduced since well-being effects will occur over time. Some may occur only for short periods of time, e.g. temporary disruption and congestion due to leakage repair, whereas some will relate to the whole 'lifetime' of the scheme or beyond, e.g. changes in landscape. Some indicators of WTP/WTA will also relate to different time periods – see Annexes 4, 6 and 7.

Because of the existing paucity of primary valuation studies and, as indicated, consequent problems with fully monetising environmental effects, the guidelines finish by recommending various studies that could usefully progress the application of monetary valuation.

2.3 Applying this Methodology

Chapters 3 and 4 provide the step-by-step methodology outlined in Figure 2.1. An illustration of this methodology is given in the case study reported in Chapter 5. Annexes present technical issues in support of the application of the methodology.

These guidelines are aimed to steer the user away from standard values for environmental effects (such as advocated by FWR, 1996, RPA, 1998 and UKWIR, 1998) towards the application of the full methodology. The latter is more involved and hence may seem more complex. However, it aims to encourage the user to think of the factors influencing original monetary valuation studies and how these can be adapted to fit the case to be considered using site-specific characteristics and environmental effects. Considering that most water related environmental effects are site-specific, site-specific information is likely to generate more reliable estimates than standard values.

As a result, the user of these guidelines needs to keep a clear record of the steps taken in applying the methodology and assumptions made during the process. The following page presents the table form of the methodology outlined in Figure 2.1 and presented in detail in Chapters 3 and 4. The column numbers and headings correspond to the steps in the methodology and are discussed in detail in Chapters 3 and 4. The case study in Chapter 5 shows how this table is completed as each step of the methodology is taken. Assumptions for environmental appraisal should be recorded at the bottom of the table. Remember that each scheme requires a table like this to be filled, even though some cells for some schemes will be empty.

As specified in the relevant Chapters, this methodology is one in a series (including the calculation of capital and operating costs for schemes) that together provide the financial and environmental costs and benefits for input into the EDM studies. Input of the environmental costs and benefits, both monetised and non-monetised, into the EDM framework is seen as the end result for this methodology. Ranking of schemes on the basis of the environmental costs alone is not considered appropriate. A method for integration of the aggregated monetised and non-monetised costs into the EDM studies is given in Chapter 4, and further elaborated in Chapter 6.

Scheme:

STEPS	II	III-IV	V-VI	VII	VIII	IX	IX - X
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on wellbeing**	**Valuation study and unit value**	**Adjustments**	**Specific data requirement**	**Aggregate value and non-monetary indicators**
Water environment							
Biodiversity							
Visual amenity							
Recreation							
Heritage & archaeology							
Traffic							
Noise & vibration							
Waste management & contaminated land							
Community effects							

Assumptions:

3. ENVIRONMENTAL APPRAISAL

This chapter covers the steps highlighted in Figure 3.1, detailing the environmental appraisal procedures that should be adopted when assessing the range of total water management options and schemes to be considered.

For each scheme under consideration, a number of steps are required for environmental appraisal:

- Total water management scheme selection
- Identification of potential environmental issues
- Prediction of environmental effects
- Determination of residual environmental effects (after mitigation) and their significance
- Translation of environmental residual effects to monetary valuation

STEP I: SELECT THE TOTAL WATER MANAGEMENT SCHEMES

Four categories of scheme are detailed in the *Economics of Demand Management* (UKWIR/Environment Agency 1996) and the *Water Resource Planning Guideline* (Environment Agency 1997):

- *Customer-side*: for example cistern displacement bags and metering
- *Distribution–side*: for example leakage control
- *Production-side*: for example recycling water treatment works backwash water
- *Resource Management*: for example groundwater recharge and reservoirs

A full list of potential schemes in each of the above categories is given in Appendix 9 of the EDM report (UKWIR/Environment Agency 1996). For each scheme or group of schemes that are considered together, a description of the scheme(s) should be developed that establishes the construction methods and operational characteristics. This will form the information on which the environmental appraisal is based. In certain cases, for example where a scheme is proposed towards the end of the planning horizon, there may not be a detailed scheme description. Assumptions should be made and clearly stated on the likely effects based on previous schemes in similar circumstances, taking into account location (urban/rural) and proximity to sensitive receptors.

When developing the schemes to be assessed, all of the scheme elements should be considered. For example, a new groundwater scheme may require a new borehole, a pipeline to an upgraded water treatment works, and upgrading of the water mains distribution system. The effects of each of these should be assessed individually within their relevant categories. For example, the borehole is a water resource scheme, the pipeline and mains are distribution schemes and the upgraded water treatment works is a production side scheme.

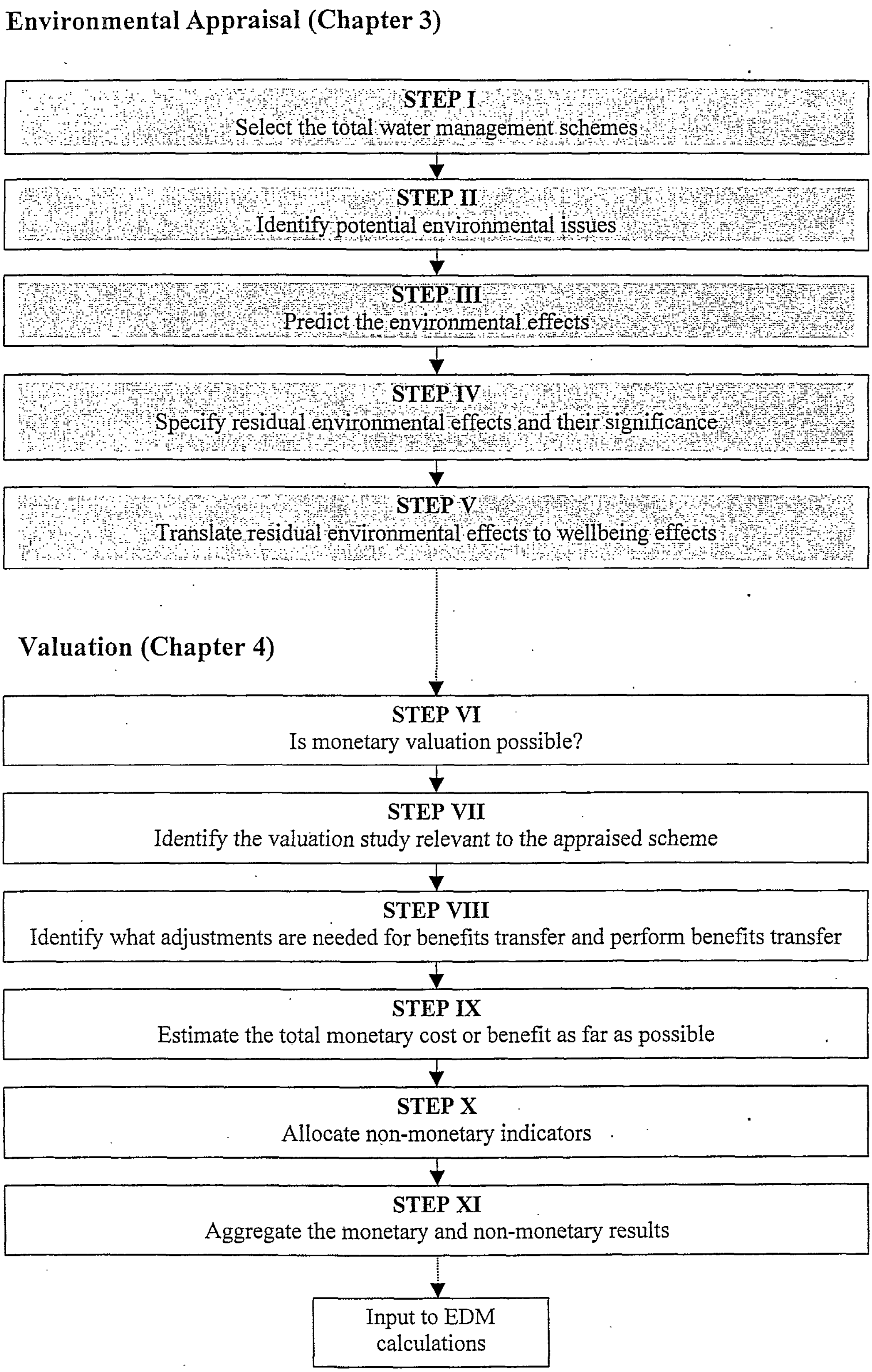

Figure 3.1: Overall Methodology

STEP II: IDENTIFY POTENTIAL ENVIRONMENTAL ISSUES

For each scheme to be appraised, the desk top environmental appraisal should identify all potentially significant effects. It is likely that for each scheme there will be a number of scheme elements, as described above. The identification of potential environmental issues should be undertaken for each element. From the example of the new groundwater scheme, an assessment of the individual elements would include consideration of a new borehole; a pipeline; an upgraded water treatment works, and upgrading of the water mains distribution system.

Only first order effects should be evaluated (UKWIR/EA, 1996), with second order effects from, say, electricity used in water treatment works being beyond the remit of these studies. The list below and Table 3.1 outline the types of environmental issues that may be of concern and should be addressed, although this list should not be taken as exhaustive:

- Water environment – hydrology, hydraulics, groundwater levels, water quantity and quality, channel morphology and sediments
- Biodiversity – aquatic and terrestrial habitats and biota
- Visual amenity – changes in landscape
- Recreation
- Heritage and archaeology
- Traffic – air quality, accidents and congestion
- Noise and vibration
- Waste management and contaminated land
- Community effects – disruption, severance, employment and immigration

The blank table format is given in Chapter 2 and used for the case study in Chapter 5.

Further guidance on the scope of environmental effects to be identified for each scheme can be found in the following documents:

Environmental Appraisal of Development Plans: A Good Practice Guide (DoE, 1993)
Environmental Assessment: A Guide to Procedures (DoE, 1995)
Environmental Assessment: Scoping Handbook for Projects (Environment Agency, 1996)
Environmental Assessment – Special Publication No. 96 (CIRIA, 1996)

The scoping guidance contained within the Environment Agency Scoping Handbook is of particular relevance. It presents a detailed breakdown of the potential issues for a number of relevant schemes, including notes on reservoirs, barrages, pipelines, points of large abstraction and discharge, groundwater abstraction, and inter-basin transfer of flow.

The full list of environmental effects in the Scoping Guidance Notes is contained in Annex 1 together with the issues and effects on which they are based. It should be noted that this list is not exhaustive and other effects may be identified. The Environment Agency is developing the scoping guidance to reflect its new responsibilities for air and waste, which will be available towards the end of 1998.

The environmental appraisal and monetary valuation tables recommended in these guidelines are simplified. Because of the wide range of potential environmental effects that may arise, the template given here should be viewed as an outline only. The categories of environmental issues to be considered should be critically reviewed for each scheme assessed.

STEP III: PREDICT THE ENVIRONMENTAL EFFECTS

Having defined the range of potential environmental issues that should be considered, the likelihood, nature and extent of the effects for each scheme element should be determined based on scheme characteristics and location. This is a transitory step, the purpose of which is to feed into Step 4.

STEP IV: SPECIFY RESIDUAL ENVIRONMENTAL EFFECTS AND THEIR SIGNIFICANCE

After identifying the likely environmental effects of a scheme based on Step III, we need to assess whether these effects are external, residual and significant. Figure 3.2 shows the key stages of this process.

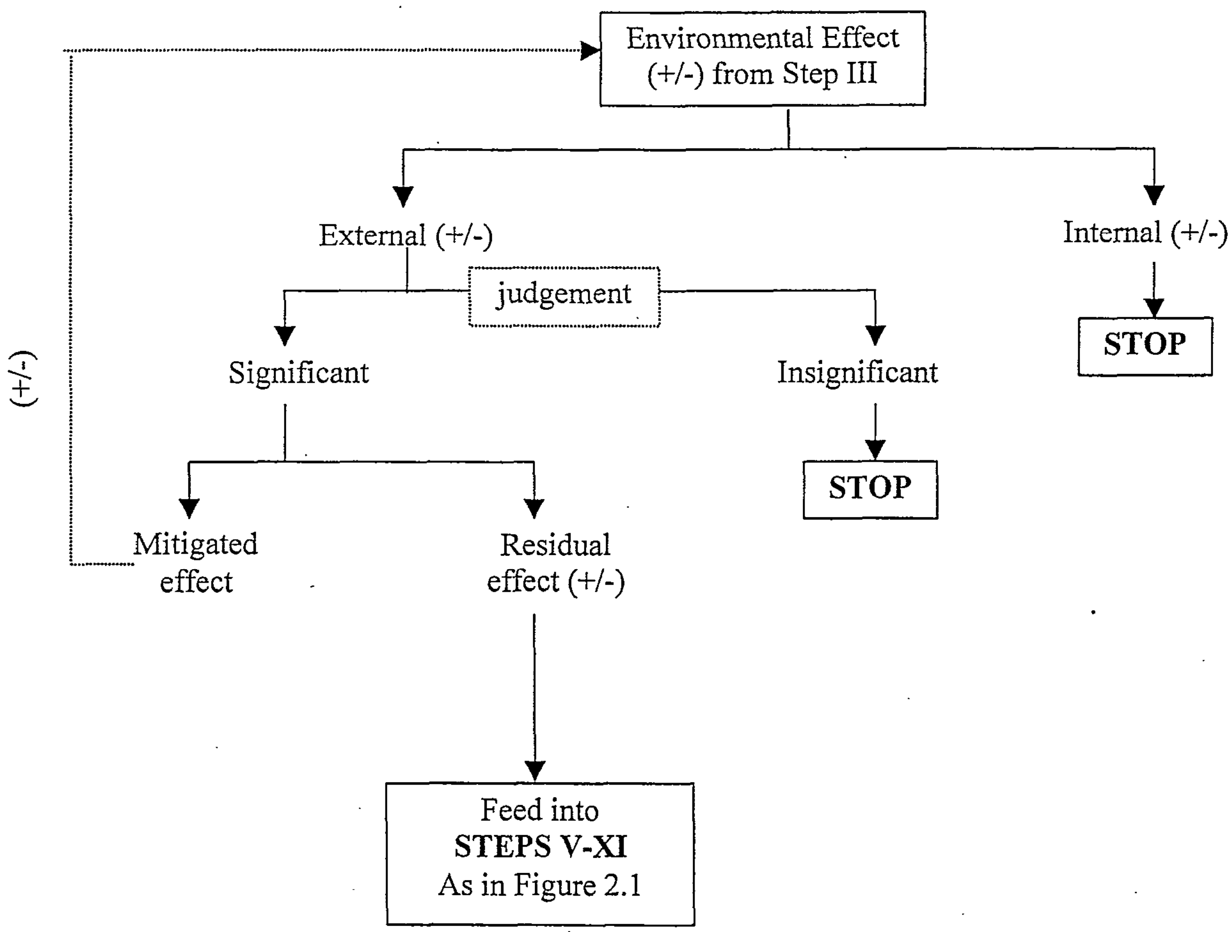

Figure 3.2: Translating environmental effects into economic values

External / Internal Environmental Effects

Environmental effects may be external or internal. External effects are those from which third parties suffer (or benefit) and receive no compensation (or reward). Internal effects are those for which the sufferers are compensated. For example, if a commercial fishery is affected due to water abstraction by a water company, this effect is potentially an external one (since water company receives benefits and the fishery suffers the costs). If, however, the water company compensates the fishermen for the loss of output, the effect becomes an internal one. Similarly, effects on the availability of irrigation water can be settled between the affected farmer and the water company internalising the effect. Only external effects are relevant to this analysis.

Significance / Insignificance of Environmental Effects

External effects may be *significant* or *insignificant*. Only the former are relevant to this appraisal. Inevitably, judgement must be used in deciding what is and is not significant. In order to judge the magnitude and significance of environmental effects, a range of issues may be identified which could:

- affect the natural, human, chemical and physical environment depending on their relative sensitivities
- take place within the confines of the site and beyond (local, regional, national and international scale)
- occur during the construction, operational and post-operational phases
- be reversible or irreversible
- be positive or negative

Prediction of effects should be quantitative (where possible). In many cases the implications of a particular scheme will have been studied in detail and potential effects assessed. For example, the effects of a new groundwater scheme may have been identified using modelling techniques to predict likely drawdown and the cone of depression. Consequent effects on surrounding surface water, biodiversity, land use, etc., can then be quantitatively assessed.

It is important to note that the level of significance of the same effect in different locations can be different. It is also important to note that significance depends not only on the physical indicator used but also on the economic value attached to it. Therefore, monetary values should be checked to see which effects are given high importance by individuals[1].

In the absence of quantitative information, a thorough qualitative assessment should be performed. If qualitative predictions are necessary, the assumptions made must be clearly stated below the scheme tables (see the case study in Chapter 5).

Mitigation Measures

Many of the potential negative environmental effects of the schemes may be avoided by application of suitable mitigation measures. These may range, for example, from ensuring effective application of good practice on site, to designing pumping stations underground thereby reducing visual effects. The scope of mitigation is clearly wide, and note should be

[1] The higher the WTP or WTA estimate for an effect, the more important that effect is.

made of mitigation that would be employed. It may also be possible to develop enhancement opportunities, which could confer a benefit to the scheme.

An important factor when considering mitigation measures is that they should be integrated within the engineering design. In this manner, all mitigation measures should be clearly stated and their costs included in the capital costs of the scheme.

The main outcome of mitigation is to either eliminate or reduce the initial negative environmental effect, even though mitigation itself may have other negative or positive environmental effects. This is shown by the feedback from mitigated effects to environmental effect in Figure 3.2.

If the result of mitigation is to internalise (all or part of) an initially external effect, then the financial cost (or benefit) of this mitigation must be included in the financial analysis. Once the effect becomes *internal*, the analysis of that effect stops. Any environmental effects remaining after application of mitigation measures are termed *residual effects*.

Residual Effects

Each residual effect should be assigned a significance (positive or negative) and reported in one of the following categories:

- major negative
- moderate negative
- slight negative
- negligible
- slight positive
- moderate positive
- major positive

For example, if a scheme will have a permanent negative residual effect on an internationally important wildlife habitat or species then the effect will have a "major negative" significance. Conversely, diversion of a local footpath for a short period may only have a "slight negative" residual effect.

The judgement may necessarily be qualitative, but should be substantiated by the assumptions and uncertainties used in the assessment. The assessment of environmental significance should be undertaken by personnel expert in environmental assessment. To ensure consistency, the specification of significance should be undertaken where possible by the same personnel.

The residual effects are the ones that will be the subject of the valuation.[2] They may be capable of having monetary values attached to them or they may not, depending on:

- the translation problem (Step V)

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[2] Technically, the mitigated effects should themselves be the subject of a benefit-cost appraisal. That is, costs of mitigation should be compared to the benefits of mitigation. It is assumed here that what is mitigated depends on judgements about statutory or legal requirements, and that no cost-benefit appraisal of mitigated effects takes place.

- whether any valuation studies relating to the effect exist: if not, no monetary value can be attached (see Chapter 4)

if the relevant literature exists, the credibility of using this literature in the appraisal, i.e. benefits transfer (see Chapter 4 and Annex 5).

STEP V: TRANSLATE RESIDUAL ENVIRONMENTAL EFFECTS TO WELLBEING EFFECTS

Having established and tabulated the full range and significance of residual environmental effects, monetary valuation should be applied. However, not all residual environmental effects can be valued in monetary terms. The reasons for this are referred to as 'translation problems' in Chapter 2 and further discussed in Chapter 4.

The first stage to identifying whether an effect can be valued in monetary terms is to express it in terms and units that have a meaning in monetary valuation. In other words, effects identified by experts should be defined in a way that will be perceived by the general public. Table 3.1 demonstrates how this is achieved for the most commonly encountered effects.

Table 3.1: Translation of environmental effects to wellbeing effects

Environmental Issues	Residual Wellbeing Effect	Reference in Table 4.1
Water environment	Mixed*	Changes in water quality, quantity and flow (1)
Biodiversity	Biodiversity – loss or change to conservation designations	Habitat preservation (6)
Visual amenity	Visual amenity	Landscape (7)
Recreation	Fishing Boating Walking Other recreation	Fishing (3) General recreation (2) Reservoir (4) Canal related recreation (5)
Heritage and archaeology	Archaeology	None
Traffic	Air pollution Odour Congestion Accidents	Traffic related effects (8)
Noise and vibration	Noise	not available
Waste management and contaminated land	None**	None
Community effects	Disturbance and disruption Change in lifestyle Severance effects	not available

*: changes in surface and groundwater (or water environment in general) may lead to any one of the water related (including odour) effects listed in the rest of this column depending on the site-specific characteristics. Care, therefore, needs to be taken to ensure these effects are not valued twice within different categories (doublecounting).

**: internalised by landfill tax in the UK.

Monetary valuation of the wellbeing effects is described in Chapter 4. Residual environmental effects that cannot currently be monetised should be presented at the same time as the monetised well-being effects. These non-monetised effects should be presented in order of greatest to least residual significance (positive to negative), giving a subjective appraisal of their relative effects. The assumptions relating to the assessment should be clearly stated.

4. VALUATION

This section covers the steps highlighted in Figure 4.1.

The guidelines on valuation in this section follow on from the definitions of environmental effects and the resulting changes in society's wellbeing presented in Chapter 3. It is possible that one environmental effect could lead to a number of changes in social wellbeing: for example a reduction in water quality could affect recreational activities, visual amenity and odour. Conversely, a number of different environmental effects may all lead to the same change in social wellbeing: for example changes in water quality and quantity may both affect the same recreation activity. It is crucial that you start this chapter having completed the assessment of environmental effects and their translation to 'changes in wellbeing'.

The change in the society's wellbeing includes both marketed and non-marketed goods and services. For marketed goods and services (such as commercial fisheries, irrigation for agriculture) this is straightforward: we need to identify and measure the change in the output and multiply this with the real price (market price net of subsidies or taxes). The data needed for these calculations are site-specific and usually available or can easily be found. The calculations themselves should be familiar to a financial analyst and resource planner. It is these calculations that compensation payments to affected parties are usually based on.

These guidelines focus on the less familiar case of changes in the non-marketed environmental goods and services. This chapter and the case study in Chapter 5 aim to explain how to value these changes. However, it is useful to explain here in more detail what we mean by society's wellbeing before presenting the guidelines on valuation.

The monetary measure of the change in society's wellbeing due to a change in environmental assets or quality is called the total economic value (TEV) of the change[7]. To account for the fact that a given environmental resource provides a variety of services to society, TEV can be disaggregated to consider the effects of changes on all aspects of wellbeing influenced by the existence of the resource.

TEV can be divided into *use values* and *non-use values*, the latter also being called 'passive use values'. Use values include:

- direct use values, where individuals make actual use of a resource for either commercial purposes, e.g. commercial fisheries, or recreation such as swimming in a lake;
- indirect use values, where society benefits from ecosystem functions, e.g. watershed protection or carbon sequestration by forests; and
- option values, where individuals are willing to pay for the option of using a resource in the future, e.g. future visits to a wilderness area.

Non-use values can take the form of:

- existence values, which reflect the fact that people value resources for 'moral' or 'altruistic' reasons, unrelated to current or future use; and

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[7] When it is not possible to use monetary values for the changes in society's wellbeing, we have to use weights and scores based on the professional judgement or public opinion. See Section 4.2.

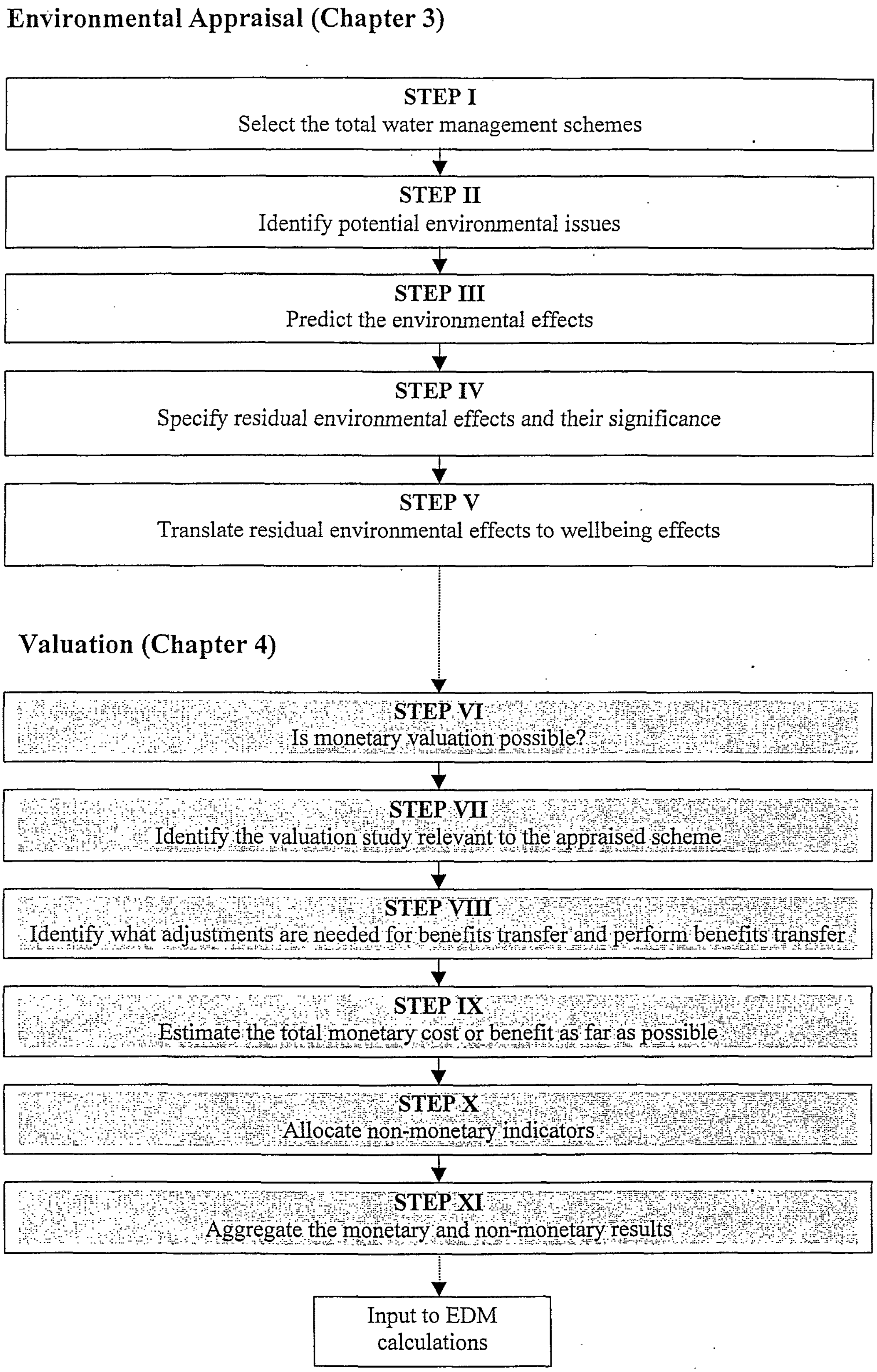

Figure 4.1: Overall Methodology

- bequest values, which measure people's willingness to pay to ensure their heirs will be able to use a resource in the future.

For more information on non-use values see Annex 4.

To arrive at an estimate of the net change in social wellbeing arising from an environmental effect, we must consider each of these elements in turn. The total economic value (TEV) of an effect is the sum of both use and non-use values:

TEV = use values + non-use values

= direct use + indirect use + option + existence + bequest values

As an illustrative example, water resources and aquatic ecosystems provide four main use categories and values (direct and passive use values), as identified by Turner *et al.* (1994):

1. *abstraction sources*: for irrigation or other agricultural purposes, potable water supply and industrial production processes;
2. *fisheries*: commercial fisheries and shell fisheries and non-commercial 'heritage' and recreational fisheries;
3. *recreation*: in-stream recreation (canoeing, sailing and bathing) and out-of-stream recreation such as walking along riverbanks, picnicking, bird watching etc; and
4. *biodiversity and related landscape conservation*: from river corridors up to water catchment levels.

Of these uses, it is the non-commercial ones which are the focus of these guidelines, i.e. commercial and agricultural uses are excluded.

Only a limited number of these different goods and services will be significantly affected by any given total water management scheme. It is also the case that the importance of different uses is likely to vary across different types of water bodies. For example, in-stream recreation is limited on many rivers due to physical characteristics, but much more extensive on lakes.

This chapter is organised in three sections: monetary valuation, non-monetary indicators and how to aggregate the two for a final analysis of environmental effects.

4.1 Monetary Valuation

STEP VI: IS MONETARY VALUATION POSSIBLE?

Whether monetary valuation of environmental effects is necessary and possible is determined by answering the following questions:

1. Is the effect external[8]?
2. If yes, is the effect significant?
3. If yes, what is the residual effect after mitigation if mitigation is possible (if it is not, take non-mitigated environmental effect)?
4. Can the environmental effect be valued in monetary terms?

[8] External effects are those from which third parties suffer (or benefit) and receive no compensation (or pay no fee). Internal effects are those for which the sufferers (beneficiaries) are compensated (or make payments).

These questions are presented in Figure 3.2 as a decision tree and should be answered during Steps IV and V based on the guidance in Chapter 3 and Annex 1. If the answer to question 1 or 2 was 'no', the analysis for that effect should have already stopped. Question 4 can be answered by following Step VII. In fact, Step VI is not a separate step on its own but merely a transition from environmental appraisal to valuation. It helps us to remember to ask the relevant questions before embarking on to valuation.

STEP VII: IDENTIFY THE VALUATION STUDY RELEVANT TO THE APPRAISED SCHEME

Table 4.1 presents a summary of currently available monetary valuation literature from Europe and North America related to the most commonly encountered changes in social well-being resulting from the environmental effects of total water management options. When a UK study exists, it should be the first choice for benefits transfer in the next steps. The table is comprehensive but by no means exhaustive. The literature is expanding rapidly and, due to the lack of a formal database of valuation studies, some studies may have been left out[9]. This is especially so for studies which are not published in journals or elsewhere and may explain the bias in the review towards studies originating in the USA and the UK. Periodic reviews of the literature with the purpose of adding to what is summarised here are of great importance.

Some of the studies in Table 4.1 are summarised in more detail in Annex 3. However, even the studies here have different levels of reliability or suitability for benefits transfer. Those with larger samples and smaller standard errors or ranges of estimates are statistically more reliable.

By looking at the studies in Table 4.1 (especially 'location' and 'effect valued' columns), we should be able to answer the following questions in order to identify the suitable study(ies):

- Are there any studies measuring the effect appraised at the site appraised?
- Are there any studies measuring an effect similar to the one appraised at the site appraised?
- Are there any studies measuring the effect appraised at another site similar to the one appraised?
- Are there any studies measuring an effect similar to the one appraised at another site similar to the one appraised?

Notice that the above questions indicate two important factors in identifying the valuation study relevant to the appraised scheme:

- The type of environmental effect, and
- The characteristics of the site

[9] In fact, we have reviewed a larger number of studies than those summarised here. Some have been left out either because the methods they used were not as reliable as others, e.g. some mail contingent valuation surveys as opposed to face-to-face surveys as recommended by NOAA (See Annex 8), or were not feasible for benefits transfer, e.g. some studies in the USA using travel cost method for types of recreation or site that do not exist in the UK.

The more similarities between the current context and a study from the literature you can identify, the more relevant will that study be for the current context[10]. The ideal situation is when both factors are identical in both the current context and the study, i.e. to be able to answer 'yes' to the first bullet point above.

If the answer to the first bullet point is 'no' but you can answer 'yes' to at least one of the other questions, then 'benefits transfer' will be necessary and possible. This involves using the results of a previous monetary valuation study in order to estimate the economic costs and benefits of the environmental effects of the option being considered.

If the answers to all four questions are 'no', then monetary valuation will not be possible. The alternative is to use non-monetary indicators, which are discussed in Section 4.2.

STEP VIII: IDENTIFY WHAT ADJUSTMENTS ARE NEEDED FOR BENEFITS TRANSFER AND PERFORM BENEFITS TRANSFER

There are three types of benefits transfer:

- *Transferring an average WTP estimate:* this involves taking an average (or median) estimate from a study and applying it to the effect in hand. In most cases, this type of transfer is the easiest to implement but generates the least reliable estimates, since differences between the study site and the effect and the current site and the effect may be significant;

- *Transferring adjusted WTP estimates:* this is more detailed than the first type. It recognises that one or more of the following variables in a previous study may differ from those in the appraised scheme:

  - average income,
  - population size and characteristics,
  - background conditions,
  - levels of effect relative to the background conditions, and
  - other determinants for which there are accessible data for the appraised scheme.

  The most commonly used adjustment is the first one especially when a study from another country is transferred to the appraised scheme. There is no consensus method for estimating adjustment factors for differences in other variables. The simplest way is to assume a linear relationship. For example, assume that an original study estimates that the monetary cost of a x% decline in water level in a river is £y per year and the decline in the appraised scheme is 2x%, a linear relationship would imply a monetary cost of £2y in the appraised scheme (other things being equal). However, original studies rarely estimate this relationship. See RPA, 1998 for non-linear adjustment factors for different natural flows.

- *Transferring WTP (or demand) functions:* this is the best of the three types of benefits transfer in terms of producing reliable estimates. It involves using an econometric equation from the original study, which estimates WTP or WTA as a function of independent variables. This will usually take the form of:

[10] More detail on each study summarised here is given in Annex 3.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n$$

Where Y is WTP or WTA, $X_{1...n}$ denote determinants of WTP such as socio-economic variables, site quality variables, etc., and $\beta_{0...n}$ are coefficients showing the relationship between the variables (Xs) and the valuation outcome (Y).

In theory, this can be used to estimate WTP at the current site. However, using this technique involves collecting data from the current site for each of the variables that determine the WTP estimate in the original study. This is made difficult by the fact that not all original studies present the full WTP function and that collecting data may be time consuming and costly.

In all three types of benefits transfer, the WTP estimate can be from a single original study, a number of similar studies or the results of a meta-analysis.[11] Annex 5 presents more detail on benefits transfer.

It should be noted that there is nothing better than an original study. This is especially true if it is thought that the current scheme will lead to environmental effects and hence changes in social well-being (especially negative changes or costs) that are highly significant, irreversible and politically difficult to get acceptance. An original study will make the assessment considerably more robust.

STEP IX: ESTIMATE THE TOTAL MONETARY COST OR BENEFIT AS FAR AS POSSIBLE

Calculating Costs and Benefits

At the end of steps VI-VIII, we should have a unit estimate of monetary value. This step is straightforward in that we need to multiply this unit monetary value with the physical quantity of the effect that leads to the change in the society's wellbeing, or the affected human population. The last column of Table 4.1 presents the information needed for estimating the total cost or benefit. The following are examples of this:

Total monetary value =	**Unit monetary value (adjusted from the original study if necessary)**	**X**	**Effect or affected population**
Examples:			
£ per year =	£ per person per trip (for recreation)	X	Total no. of trips per year (or no. of persons times no. of trips per person per year)

[11] Meta-analysis provides a means of synthesising the results from a number of studies in order to gain a better understanding of the consequences of the underlying modelling process. It is a statistical analysis, which combines the data, the functional form and the results of a number of original studies, and estimates a summary functional form and result to reflect all. Therefore, it is most suitable for transferring WTP functions. However, it is an involved technique, which can be implemented in methodological studies but not in practical project appraisal.

£ per year =	£ per household per year (for conservation)	X	No. of households affected by a change in the society's well-being
£ per year =	£ per vehicle km (for transport related effects)	X	Total no. of vehicle kilometres travelled

Note that an increase in society's wellbeing or an improvement in environmental quality is a benefit and hence takes a positive sign. On the other hand, a decrease in society's wellbeing or deterioration in environmental quality is a cost and hence takes a negative sign.

Although the actual estimation of total monetary values is straightforward, the assumptions behind this can be complex. First of all, it can be difficult to identify the affected population. For use values, this is relatively straightforward, as it is the population of users which is relevant, although data on user numbers may be difficult to obtain. Aggregation of non-use values is less straightforward. There are at least three assumptions that have been made in the literature (for more on this see Annex 4):

- applying the sample mean WTP to the whole UK population, if the resource affected is thought to be unique,
- applying the sample mean to some administrative area population, e.g. population served by the water company, and
- applying the sample mean to an area beyond which it is thought that WTP tends to zero, which can only be defined on a case-by-case basis. This could be larger or smaller than the two above and should be based on a 'distance-decay function' similar to that presented in Annexes 3 and 4.

Double counting can be a serious problem if we do not identify the different changes in the society's wellbeing clearly. This is part of the translation problem referred to in Chapters 2 and 3. There is another possibility when double counting may be a problem and that is if an original study measures people's WTP for more than one change in society's wellbeing but does not distinguish between the different causes clearly or fully. This should also be kept in mind and can be somewhat clarified by a careful look at the summaries in Annex 3 and the studies themselves.

Costs related to traffic movements both during construction (temporary effects) and operation (permanent effects) could be more easily generalised than effects related to the water environment. Therefore, a more detailed explanation of how the total transport related costs should be estimated is provided below.

Traffic related costs fall into two categories: road closures (partial or whole) and extra flow on the roads.

1. Road closures or narrowing: The main cost of road closures or narrowing is that of delay and inconvenience to vehicles using the roads. Estimation of this cost with any degree of accuracy requires complex traffic flow modelling, and will not be examined here. For a desktop appraisal a simplified estimate can be found as follows:

$$\textit{cost of road closure} = af \,.\, ejt \,.\, d \,.\, [(wt \,.\, aw) + (lt \,.\, lw)] \,.\, occ$$

af = average traffic flow (vehicles/day)
ejt= extra journey time per vehicle (% of an hour), which depends on whether closure is partial or whole
d = number of days of closure
wt= fraction of traffic which is work-related
aw= average wage per hour
lt = fraction of traffic which is leisure-related (1 - fraction work-related)
lw= 43% of average wage per hour, or the cost of leisure time lost
occ= occupancy rate in the UK is 1.6 for passenger vehicles

Average traffic flow on different roads is reported in Table 4.1. Other variables need to be estimated separately for each option and location such as average wage in different regions.

2. **Damage due to extra traffic flow:** This concerns the extra HGV traffic during the construction period of most schemes and private car movements during the operation of some schemes, notably reservoirs.

$$\text{Cost of extra flow} = v \,.\, kmd \,.\, d \,.\, p$$

v = number of vehicles per day
kmd = kilometres driven per vehicle per day (round trip)
d = total number of construction days for HGV and total number of travelling days for private cars
p = damage cost per kilometre driven

The damage cost per kilometre is made up of the following components:

$$p = ap + ra + c$$

ap = air pollution
ra = increased risk of accidents
c = cost of increased congestion

It is theoretically possible to add the monetary costs of noise due to HGV traffic to the damage cost per kilometre driven (p) above. However, the existing valuation studies measure the effect of permanent increases in noise. This is not a relevant measure we can use in these guidelines since the significant increases in noise levels due to total water management schemes are temporary. Similarly, transport related effects on pedestrians are excluded from the analysis here since these effects are believed to be negligible. The estimates for all three variables are presented in Table 4.1[12].

Discounting

Table 4.2 shows that monetised and non-monetised benefits and costs will occur in various years. Failure to record effects in this way can easily result in under or over-estimation of effects. Thus, if some effects are assumed to occur throughout the lifetime of the project but in fact only occur in a

[12] The literature on the environmental and social costs of road transport is vast. It is not possible to report all of it here. Therefore, we have chosen the estimates best suitable for the purposes of these guidelines, considering that transport related costs rarely form a large proportion of the external costs of a total water management option.

limited number of years, there will be overestimation of the effects. Moreover, the layout of Table 4.2 is required for purposes of discounting, the process whereby future effects are afforded less weight than current effects. The rationale for discounting is given in Annex 7.

Table 4.2: Displaying environmental costs and benefits over time

Year →	1	2	3	4...	n
£ benefits	B_m1	B_m2	B_m3	B_m4...	B_mn
£ costs	C_m1	C_m2	C_m3	C_m4...	C_mn
£ (benefit-cost)	B_m1-C_m1	B_m2-C_m2	B_m3-C_m3	B_m4-C_m4...	B_mn-C_mn
Non-monetary benefit and cost	$B_{nm}1$ $C_{nm}1$	$B_{nm}2$ $C_{nm}2$	$B_{nm}3$ $C_{nm}3$	$B_{nm}4$... $C_{nm}4$...	$B_{nm}n$ $C_{nm}n$

m denotes monetary values and nm denotes non-monetary indicators.

Note that the final aggregation of monetised environmental costs and benefits with other economic costs and benefits (or Net Present Value (NPV) calculation) follows the above rule of discounting. In other words, since both are in the same unit of £ per year, both environmental costs and benefits, and economic costs and benefits can be added together for each year that they occur.

It should be noted that WTP may change over time as incomes and environmental conditions change. Although there is no indication as to how the latter change takes place, the change based on income levels can be incorporated into the discounting process outlined in Table 4.2. One way of doing this is to assume that there is a direct relationship between income and WTP. See Annex 5 for a method of doing this.

Table 4.1: Summary of water related valuation literature

Study	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
1. Changes in water quality, quantity and flow				
1. Garrod and Willis (1996)	UK, River Darent / CVM	WTP for • increasing flows in Darent • maintaining present flows in Darent • maintaining present flows in 40 low flow rivers (including Darent) • increasing flows in 40 low flow rivers (including Darent)	£6.80/resident household/yr £5.28/visitor household/yr £3.26/non-user household/yr £11.09/resident household/yr £7.79/visitor household/yr £4.19/non-user household/yr £18.44/household/yr £11.99/household/yr	Assess how close the situation assessed is to the situation of River Darent. There is no adjustment factor for different levels of flows at present other than that suggested in RPA, 1998. no. of resident households, no. of visitor households, no. of non-user households
2. Green and Turnstall (1991)	UK / CVM	WTP for improvement in water quality • to standard A • to standard B • to standard C	£0.60/person/visit £0.71/person/visit £0.61/person/visit	no. of visitors and no. of visits per person or total number of visits per year
3. Brown and Duffield (1995)	USA, five Montana rivers / CV	WTP for low flow alleviation single river • users • non-users	£8.49/person/yr £2.96/person/yr	no. of visitors population affected by change

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
4. Daubert and Young (1981)	USA, North Colorado / CV	WTP for recreational benefits associated with different flows flow level (cfs) 100 200 300 400 500 600 700 800 900	 £15.94/day £27.98/day £36.24/day £40.74/day £41.46/day £38.39/day £31.62/day £21.04/day £6.63/day	transfer is doubtful due to location differences but change in flow levels and number of visit days
5. Hanley (1989)	UK / CVM	WTP to guarantee water supplies with nitrate levels not exceeding 50mg/l	£17.14/household/year	no. of households affected by a change in nitrate levels of water
Green and Willis (1996)	UK / CVM	WTP of anglers for improvements in water quality • new relatively poor coarse fishery • new good coarse fishery • new good trout fishery Non-use value for improvements in quality • from poor to medium • from medium to good	 £4/angler/visit £6.4/angler/visit £16.8/angler/visit £0.0056/household/km/yr £0.0021/household/km/yr	no. of anglers and no. of visits per angler per year or total number of visits no. of households close to the stretch of river (km) affected
ERM (1997)	South West Region of the EA, UK / CVM	WTP for alleviation of low flow in six rivers: • Malmesbury Avon • Tavy	 £5.7/household/year £6.81/household/year	No. of households affected by the (alleviation of) low flow
Desvouges et al. (1983)	USA / CVM	WTP to prevent the loss of a river for recreation • use values • non-use values	 £19-49/household/yr £42/household/yr	transfer is doubtful due to location differences but no. of households visiting no. of households affected

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
Middlesex University (1994)	UK / value of enjoyment	WTP of anglers for benefits of low flow alleviation • rural river • urban river non-use value for improvements in quality • from very poor to moderate • from moderate to good coarse fishery • from good coarse fishery to trout • from trout to salmon fishery WTP for low flow alleviation • River Misbourne • River Wey • River Ver	£5.5/angler/visit £9.8/angler/visit £144,000/km/yr £15,500/km/yr £17,700/km/yr £3,550/km/yr £1.2/visitor/visit £0.9/resident/visit £9.6/angler/visit £1.6/resident/visit £5.6/angler/visit	METHOD NOT RECOMMENDED – not comparable with the results of other valuation methods no. of anglers and no. of visits per angler per year; total number of visits stretch of river (km) affected stretch of river (km) affected stretch of river (km) affected stretch of river (km) affected no. visits, no of visits by residents, no. of visits by anglers
Lant and Roberts (1990)	USA	WTP for improvements from poor to fair water quality • recreational value • 'intrinsic' value	£22/person/yr £29/person/yr	establish that this change applies to the situation assessed no. of visitors no. of affected population
Postle and Carpenter (1997)	USA	WTP for low flow alleviation • fisheries benefits in a river in Colorado • river recreation • reservoir recreation	£0.01/m^3 of water £0.04/m^3 of water £0.03/m^3 of water	the WTP estimates are additive. m^3 of change in the water flow

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
2. General Recreation				
6. Walsh et al. (1992)	USA / meta analysis	WTP of recreationalists for • camping • picnicking • swimming • sightseeing • boating – motorised • boating – non-motorised • hiking • cold water fishing • anadramous fishing • non consumptive fish + wildlife • wilderness • average – all activities + others	 £16.88/day £15.00/day £19.88/day £17.56/day £27.32/day £42.14/day £25.17/day £26.51/day £46.75/day £19.22/day £21.28/day £29.39/day	location may be a concern but number of recreation days for each type of activity – See British Waterways, 1997 for canoe and unpowered boat visitation
7. Creel and Loomis (1992)	San Joachin Valley, CA US / TCM	WTP per person per year for wildlife related recreation at different water levels current water quantity • viewing • fishing • viewing/fishing optimum water quantity • viewing • fishing • viewing/fishing	 £105/person/year £87/person/year £279/person/year £119/person/year £103/person/year £324/person/year	location may be a concern but average number of visits per person per year for each activity
3. Fishing				
8. Radford et al. (1991)	UK – original NRA regions (salmon and sea trout)	total expenditure by anglers on recreational fishing activities	average of £17.18/angler/day or £548/angler/year	identify which region - regional disaggregation is also possible: see Annex 3 for further details
9. Davis and O'Neill (1992)	UK - Northern Ireland / CVM	WTP for angling licenses • median WTP over and above license price	£40.54/annual permit	number of anglers

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
10. Loomis (1996)	USA, Elwha River, Washington State / CV	WTP for removing dams to restore salmon fishery • local households • households in the rest of the state • households in the rest of the USA	 £41/household/yr £50/household/yr £47/household/yr	transfer is doubtful due to location differences but no. of households in the local area no. of households in the count no. of households in the rest of the UK
11. Harpman et al (1993)	USA / CVM	Mean WTP of anglers for their average catch of brown trout, and hypothetical additions to this number of fish caught 1 2 3 4 5 6 7 8 9 10 11 12	 £16.0/day £17.4/day £18.2/day £18.8/day £19.4/day £19.8/day £20.1/day £20.5/day £20.7/day £21.0/day £21.2/day £21.5/day	no of anglers, average catch, expected change in average catch – note that the difference between the WTP for, say, 2 and 3 fish a day is the marginal WTP per fish at that level.
12. Provencher and Bishop (1997)	USA / TCM	WTP for angling on Lake Michigan • derby trip • non-derby trip	 £60/person/trip £25/person/trip	total number of angling trips per year
ECOTEC (1993)	UK / CVM	creation of a new trout fishery • economic rent • consumer surplus	 £4.4-12.2/angler/visit £2.2-6.7/angler/visit	no. anglers and visits per angler per year or total annual angling visits
Radford (1983)	UK, River Wye	WTP of anglers for salmon fishing	£16.4/angler/visit	no. anglers and visits per angler per year or total annual angling visits
Hannemann et al (1991)	USA / CVM	WTP to increase Chinook salmon population	£136-253 per household per year	No. of households affected by the change
Olsen et al (1991)	USA / CVM	WTP to double salmon and steelhead runs in the Columbia River	£37.6 per household per year	no. of households affected by the change

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
Sanders et al (1990)	USA / CVM	WTP to preserve the undammed portions of three rivers in the USA, thereby preserving their fisheries	£40.3 per household per year	no. of households affected by the change
4. Reservoir Recreation				
13. Pearson (1992)	UK – Rutland Reservoir / CVM	WTP to maintain water quality at a standard high enough to support boating and recreational activities (see Annex 3 for more detailed estimates, e.g. for different activities)	£18.83/household/year	No. of households visiting the reservoir - See British Waterways, 1997 for canoe and unpowered boat visitation
14. Loomis (1987)	USA, Mono Lake, California	WTP for a higher water level	£12-27/household/yr	need to define the scale of change in water level no. of households affected
15. Ward (1987)	USA, Rio Chama River, New Mexico / TCM	• gross recreational benefits • opportunity cost of alternative use	£0.7-0.8/m^3 of water £0.03/m^3 of water	the WTP estimates are additive. m^3 of change in the water flow
16. Parsons et al. (1994)	USA / random utility model	Mean benefit from visiting lakes in Wisconsin – random utility model based on travel costs only	£1 per visit	no. of visits to similar natural lakes
17. Cordell et al (1993)	USA / CVM	WTP for annual access to a reservoir for recreational purposes at different water levels (four different reservoirs studied) • current management • near full 1 month longer • near full 2 months longer • near full 3 months longer	 £29/person/year £35/person/year £45/person/year £52/person/year	no. of visitors annually, expected change in time reservoir is near full
Smith, 1971	UK, Grafham Water, Huntingdon/Clawson method (early TCM)	total annual gross benefits from angling - no. of visitors to be provided	£74,000-83,000/yr	multiply the ratio of no. of visitors to Grafham Water and the reservoir in question - not recommended for BT
Anderson, 1975	UK, Hellifield, NW England/Clawson method (early TCM)	total annual recreational benefits - no. of visitors to be provided	£2.3-2.6 million	Multiply the ratio of no. of visitors to Hellifield and the reservoir in question not recommended for BT

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
5. Canal Related Recreation				
18. Adamowicz et al. (1995)	UK - canal network / CVM	WTP to preserve canal network in a state fit to support boating activities and maintain towpath facilities	£8/British household/year	Applies to entire UK population for maintenance of the entire network.
19. Willis and Garrod (1991)	UK - canal network / CVM	WTP for use of open-access facilities associated with the canal network • locals • non-locals	 44.3 p/visit 54.0 p/visit	no. of visits for non-commercial activities, e.g. including walking along the towpaths, but excluding fishing and boating activities
6. Habitat Preservation				
20. Brouwer et al. (1997)	30 studies from USA, UK and the rest of Europe / meta analysis	mean WTP including indirect use and non-use values: • average for all types of wetlands • average for flood control • average for biodiversity • average for USA • average for the UK • average for the rest of Europe (see Annex 3 for other estimates)	 £29/household/year £44/household/year £36/household/year £47/household/year £17/household/year £15/household/year	the average UK figure seems to be the most appropriate. Total loss of a wetland would mean total loss of this value. No estimate for the relationship of percentage lost and WTP changes. Assess the threshold level of loss. Assess the population affected. (See RPA,1998).
21. Bateman et al. (1992) and (1997)	UK, Norfolk Broads / CVM	average WTP to preserve present landscape • use values • non-use values of local population • non-use values of the rest of GB	 £78-105/person/yr £14.7/person/yr £4.8/person/yr	no. of visitors no. of local population (non-visiting) no. of the rest of the GB (non local-non-visitor)
22. Kosz (1996)	Austria, Donau-Auen riverside wetlands / CVM	mean WTP to preserve the wetlands	£20/person/yr	no. of people affected
23. Tapsell *et al.* (1992)	UK / value of enjoyment	WTP for recreational values • present condition • some improvement towards natural conditions • recovery to full river condition	 £1.88/user/visit £1.45/resident/visit £2.67/user/visit £2.23/resident/visit £3.31/user/visit £3.16/resident/visit	METHOD NOT RECOMMENDED choose which change applies no. of visits by non-residents no. of visits by residents

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
Willis (1990)	UK, Derwent Ings, Yorkshire / CVM	WTP for the preservation of the current state of the wetlands • total use value • total non-use value	 £44/ha £807/ha	the estimates are additive. No adjustment factor is available no. of ha affected no. of ha affected
Hanemann et al. (1991)	USA, San Joachin Valley, California	WTP for • maintenance • improvement	 £125/household/yr £205/household/yr	chose which change applies no. of affected households no. of affected households
Whitehead (1990)	USA, Clear Creek, Kentucky	aggregate benefits	£13-84/ha	no. of ha affected
Stone (1992)	Australia, Barmah wetlands	mean annual WTP for wetlands protection	£85-109/ha	no. of ha affected
7. Landscape				
24. Willis and Garrod (1993)	UK, Yorkshire Dales / CVM	WTP of both visitors and residents to preserve present landscape	£30/person/yr	no. of visitors plus the no. of local residents
25. Hanley et al	UK, ESAs in Scotland/CVM	WTP to preserve the Breadalbane ESA • residents • general public • visitors	 £31.43/household/year £22.02/household/year £98/household/year	No. of households affected by the loss of ESA.
26. Willis et al (1995)	UK / CVM	WTP to preserve ESAs in England Somerset Levels and Moors ESA • residents • visitors South Downs ESA • residents • visitors • general public	 £18.44/person/year £12.46/person/year £28.96/person/year £20.49/person/year £38.56/person/year	number of people affected
Hanley (1991) in Willis *et al.* (1993)	Flow Country, UK / CVM	Preservation value of the Flow Country	£19.84/household/year	No. of households affected

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)		Data needed for aggregation
Benson *et al.* (1990)	UK / TCM	Recreational benefits of			No. of visits that will be lost due to a change in the landscape
		New Forest	£2.07/visit		
		Cheshire	£2.77/visit		
		Loc Awe	£4.80/visit		
		Brecon	£3.77/visit		
		Buchan	£3.28/visit		
		North Yorkshire Moors	£2.60/visit		
		Aberfoyle	£3.94/visit		
		South lakes	£1.94/visit		
		Newton Stewart	£2.33/visit		
		Lome	£2.09/visit		
		Castle Douglas	£3.49/visit		
		Ruthin	£3.65/visit		
		Dean	£3.25/visit		
		Thetford	£3.86/visit		
8. Traffic Related Effects					
27. Newbery (1992)	UK / various methodologies	HGV traffic marginal cost of congestion on different types of road (pence/HGV km)	Motorway	0.57	No. of kilometres which will be driven on each type of road
			Urban central peak	79.56	
			Urban central off-pk	63.94	
			non-central peak	34.69	calculations should be based on the methods shown in Step X, Chapter 4
			non-central off-pk	19.12	
			small town peak	15.07	
			small town off-pk	9.19	
			other urban	0.18	
			rural dual carr.way	0.15	
			other trunk/principal	0.42	
			other rural	0.11	

Study (cont.)	Location/technique	Effect Valued	Unit Value (£1997)	Data needed for aggregation
Newbery (1992) ctd.		Passenger car traffic marginal cost of congestion on different types of road (pence/passenger car km)	Motorway 0.33 Urban central peak 45.46 Urban central off-pk 36.54 non-central peak 19.83 non-central off-pk 10.93 small town peak 8.61 small town off-pk 5.25 other urban 0.10 rural dual carr.way 0.09 other trunk/principal 0.24 other rural 0.06	No. of kilometres which will be driven on each type of road calculations should be based on the methods shown in Step X, Chapter 4
28. Maddison et al. (1996)	UK	health effects of air pollution	32.6 p/HGV km	No. kilometres
29. DETR (1997)	UK	national average daily flows on built-up major roads: non built-up major roads:	trunk – 19580 principal – 15110 trunk – 15640 principal – 7460 minor – 1390 motorway – 62430	No. kilometres driven on each type of road
30. based on DETR (1996)	UK	accident risks and costs associated with vehicle travel in the UK • HGVs • cars	5.4 pence/km 3.0 pence/km	Total number of kilometres driven

Note: Studies which are summarised in Annex 3 are those that are numbered in this table.

4.2 Non-monetary Indicators

STEP X: ALLOCATE NON-MONETARY INDICATORS

A number of environmental effects cannot be monetised at this time, principally because of a lack of suitable valuation studies. Qualitative judgement is, therefore, needed to identify these non-monetised positive and negative effects for a given scheme. This will also provide some level of comparison of the likely environmental effects.

As described in Chapter 3, each residual environmental effect should be allotted significance, ranging from negligible to slight, moderate or major. The level of significance is specified according to the sensitivity of receptors to the given effect.

Each option or scheme element may have a number of significant residual effects that cannot be monetised. Having monetised the residual effects that have appropriate monetary valuation information, the non-monetised residual effects should be tabulated. The residual effects should be listed from the largest positive effect down to the largest negative effect. To aid in the visual presentation of the non-monetised residual effects, each level of significance should be displayed as follows:

Major positive	○○○
Moderate positive	○○
Slight positive	○
Slight negative	●
Moderate negative	●●
Major negative	●●●

Most of the significant residual effects are site-specific and judgement on many is necessarily qualitative. At the present time, there is no agreed way of aggregating the residual effects of non-monetised indicators. A number of reports have been published that have attempted to set a framework for aggregation, with debate ongoing into the veracity of adding and/or weighting environmental effects. Of particular relevance are:

- *Environmental Appraisal of Development Plans, A Good Practice Guide* (DoE, 1993)
- *Multi-attribute Techniques for River Water Quality Improvements: Scoring and Weighting Systems for River Quality Improvements* (Environment Agency, 1998)

At the present time, no consensus view on aggregation and scoring/weighting systems has been reached, and more research is necessary into the application of these techniques. Furthermore, with further development of the monetary valuation literature in the future, there should be fewer non-monetised effects to be considered qualitatively in this way.

For the purposes of this methodology, therefore, given the absence of any detailed studies on weightings for the full range of potential effects for water resource schemes, we would recommend that summation of non-monetised indicators is avoided.

As the non-monetised indicators will not be added to give one figure, there may be some difficulty in applying these into the EDM framework. Recommendations on how to integrate the non-monetised effects into the EDM studies and consequent scheme selection are given in Section 4.3.

4.3 Aggregation

STEP XI: AGGREGATE THE MONETARY AND NON-MONETARY VALUATION RESULTS

This final stage of the guidelines summarises the aggregation of the monetary values and non-monetary indicators for each scheme. For each scheme there are three possible outcomes: all environmental effects have monetary values; all environmental effects are non-monetised; and, some environmental effects are monetised and some are non-monetised (mixed outcome). This section explores how each of these outcomes should be dealt with in the context of the EDM studies.

The first point to note is that it is not correct to rank schemes on the basis of their environmental costs and benefits information alone, since what matters for ranking is both the financial and environmental costs and benefits (see Figure 1.1). The user should follow the guidance presented here in combining and comparing environmental effects with financial costs and benefits within the framework of EDM. Although the EDM framework does not contain information on non-monetary indicators, as much detailed information as possible is presented for this both in this and the following chapters.

4.3.1 Monetary valuation only

Where all positive and negative effects are measured in monetary terms the aggregation is simple. Subtract the total costs from total benefits, which will give you the total net benefits:

$$NPV = B_m - C_m > 0 \text{ or } (B_m > C_m) \rightarrow \textit{Proceed with the option}$$

$$NPV = B_m - C_m < 0 \text{ or } (B_m < C_m) \rightarrow \textit{Reject the option}$$

Where B_m is all benefits (financial and environmental) over time expressed in monetary units (discounted values) and C_m is all costs (financial and environmental) over time expressed in monetary units (discounted values).

Amongst those options which are not rejected, the one with the highest net benefit (or NPV) should be most preferred. The rest of the options should be ranked according to their net benefits. The option with the smallest net benefit (or NPV) should be the least preferred option.

4.3.2 Non-monetary indicators only

It is also possible that the environmental effects of some options can only be expressed qualitatively as in Section 4.2. In this case, no environmental costs or benefits will be added to the financial costs and benefits for consideration in the EDM studies. During the EDM ranking process, all of the non-monetised environmental effects will be assessed qualitatively against the AISC ranking.

4.3.3 Mixed outcomes

However, in most cases, it is more than likely that appraisal of each option will generate mixed outcomes, with some effects expressed in monetary units and some effects assessed qualitatively.

First, compare all monetised costs and benefits as above (this should include financial and environmental costs) and list the non-monetised effects. Note that a non-monetised negative indicator constitutes a cost and a non-monetised positive indicator constitutes a benefit. There are then four ways of dealing with mixed outcomes within the context of the EDM studies:

1. If monetised benefits exceed monetised costs and the non-monetised indicators are judged mainly to be positive, then proceed since benefits more than outweigh the costs.

2. If monetised benefits exceed monetised costs and the non-monetised indicators are judged mainly to be negative, then compare net monetised benefits with the non-monetised costs. *Using professional judgement, ask if the non-monetised costs are likely to be greater than the net monetised benefits. If they are, the scheme is not worthwhile. If they are not, then the scheme is potentially worth pursuing.*

3. If monetised costs exceed monetised benefits and the non-monetised indicators are judged mainly to be positive, then compare net monetised costs with the non-monetised benefits. *Using professional judgement, ask if the non-monetised benefits are likely to be greater than the net monetised costs. If they are, the scheme is potentially worth pursuing. If they are not, then the scheme is not worthwhile.*

4. If monetised costs exceed monetised benefits and the non-monetised indicators are judged mainly to be negative, then the scheme is not worth pursuing.

Table 4.3 summarises these four possible outcomes.

Table 4.3: The treatment of mixed outcomes

	$B_m > C_m$	$B_m < C_m$
$B_{nm}>0$	*1.* ***Proceed since benefits more than outweigh costs***	*3.* *Judge if* $B_{nm} > [C_m - B_m]$ **If so, proceed.** *Judge if* $B_{nm} < [C_m - B_m]$ **If so, reject.**
$C_{nm}>0$	*2.* *Judge if* $[B_m - C_m] > C_{nm}$ **If so, proceed.** *Judge if* $[B_m - C_m] < C_{nm}$ **If so, reject.**	*4.* ***Reject since costs more than outweigh benefits***

m denotes monetary estimates and nm denotes non-monetary indicators.

As noted in Section 4.2, it is not possible to provide generalised guidelines for the professional judgement required in outcomes 2 and 3. This judgement is site and scheme specific and should be assessed on that basis. So long as assumptions behind such judgements are clearly stated and can be debated by different parties to the appraisal, the outcome should be efficient.

The above methodology will determine whether a given scheme should be considered for ranking in the EDM studies. Clearly, if in the expert opinion of the reviewer the scheme is not financially or environmentally sustainable, on the basis of Table 4.3, then the scheme should not be included in the overall ranking.

In determining the ranking of approved schemes within the EDM framework, we suggest that the first phase compares the Average Incremental Social Cost (AISC) for each scheme, including all of the monetised environmental costs and benefits. A second phase should then consider the outstanding non-monetised environmental effects of the scheme. This will of necessity involve professional judgement.

Where re-ranking of the schemes on the basis of the non-monetised environmental effects is being considered, the relative significance of non-monetised effects against those that have been monetised should be assessed. Similarly, as the environmental appraisal is at a strategic level, the environmental sensitivity of the schemes under review may warrant more detailed environmental investigation to optimise the ranking procedure.

4.3.4 Customer- and distribution-side management options

Customer- and distribution-side water management options require a separate note. The environmental effects of these options are more or less well identified in physical terms but not all of them are monetised. In addition to costs and benefits that directly arise from these options, there is a further benefit from water resource saving that will need to be considered. This arises because they either:

- Avoid the need for alternative production or resource management schemes[14], or
- Postpone the need for the alternative production or resource management scheme.

The first step of the benefit assessment, in this case, is to identify this alternative production or resource management option, where 'alternative' refers to both planned and existing management options. It is recommended that this alternative option to be avoided or postponed should be the most environmentally sensitive one in a given water resource zone. Secondly, the costs and benefits of this alternative option should be estimated following steps II to XI. The (avoided) costs of the alternative become the benefits of the customer- or distribution-side option. The (avoided or lost) benefits of the alternative, if any, should be added to the costs of the customer- or distribution-side option.

Whether in practice the alternative is totally avoided or only postponed depends on the amount of water saved. However, this should not affect how the benefit of the customer- or distribution-side scheme is calculated since the benefit is, in fact, 'permanent' and should be

[14] Note that distribution-side schemes would avoid the need for some future repair work as well as reducing water consumption. Any reduction in future repair work would mean a reduction in traffic related environmental effects.

credited to the scheme over the whole of its economic life[15]. Essentially, *with* the customer- or distribution-side scheme water flows are higher; *without* it, flows are lower. The fact that demand increases may return flows to the 'without' customer- or distribution-side scheme is not a reason to reduce the credit to this scheme. The flow would have been *even lower* had the demand increase occurred without the customer- or distribution-side scheme.

[15] For a scheme that is postponed, the costs and benefits of this scheme should be entered into the analysis at the year that they are expected to occur rather than at the beginning of the planning timeframe.

5. CASE STUDY

The following case study presents a selection of the types of total water management schemes that may be encountered during implementation of these guidelines. The case study represents a simplified water resource zone featuring several possible schemes. It should be noted that the assessments undertaken here are necessarily generic. It is anticipated that water companies would have more detailed information on where, when and how their potential schemes would be developed, allowing a more detailed site-specific appraisal of potential environmental effects.

To comply with the requirements of the Water Resources Planning Guideline an example of each of the four categories of total water management options is considered. To illustrate the application of these guidelines each step of the guidelines is highlighted within each scheme and references made to the previous chapters. To aid clarity, each of the schemes will be considered in isolation for this hypothetical example. The schemes are as follows:

Scheme 1: Resource Management
- Reduction in groundwater abstraction from Poolhill

Scheme 2: Customer Side Management
- Compulsory metering

Scheme 3: Distribution Side Management
- Mains replacement

Scheme 4: Production Side Management
- Upgrading a Water Treatment Works (WTW)

Scheme 5: Resource Management
- New groundwater source

Scheme 6: Resource Management
- New reservoir

Assuming that a customer or distribution side scheme leads to a reduction in water resource requirement, the benefit of leaving that volume of water in the environment should be added to the benefits of that scheme. This can be done by calculating the benefits of delaying a new water resource development and/or by a reduction in resource allocation from an existing source. In this hypothetical example, Scheme 1 is the avoided alternative if Schemes 2 or 3 go ahead (this is not a separate scheme – see below).

Note that monetised environmental costs are given a negative sign and monetised environmental benefits are given a positive sign so that they are in line with the financial costs and benefits of each scheme. Also note that the time period over which temporary costs or benefits are expected is indicated next to the relevant estimate. Permanent effects are assumed to occur every year for the duration of the scheme or beyond depending on the severity of the effect.

Both monetary values and non-monetary indicator estimates for each scheme are summarised in Sections 5.2-5.7. Detailed appraisal and valuation information can be found in Tables 5.1

to 5.6 accompanying the scheme assessments. The format of these tables is useful in organising the translation between environmental effects and monetary valuation and hence recommended for use. A blank version of these tables is presented in Chapter 2.

For ease of comparison, here is a list of the 11 steps of the methodology presented in these guidelines:

STEP I:	Select the total water management schemes
STEP II:	Identify the potential environmental issues
STEP III:	Predict the environmental effects
STEP IV:	What are the residual environmental effects and are they significant?
STEP V:	Translate residual environmental effects to well-being effects
STEP VI:	Is monetary valuation possible?
STEP VII:	Identify the valuation study relevant to the current context
STEP VIII:	Identify what adjustments are needed for benefits transfer and perform benefits transfer
STEP IX:	Estimate the total monetary cost or benefit as far as possible
STEP X:	Allocate non-monetary indicators
STEP XI:	Aggregate the monetary and non-monetary valuation results and compare them

Finally, a comparison between schemes at this stage would not be satisfactory or indeed correct. The comparison and ranking of schemes has to be done once assessment here is added to or compared with the financial costs and benefits of each option together with information on water available for use from each scheme. For this, the EDM report (UKWIR/EA, 1996) is the best guidance. Although not included in these guidelines, engineering feasibility and risk and other factors important in each schemes' implementation must also be taken into account.

5.1 Description of the Hypothetical Water Resource Zone

The hypothetical water resource zone is based in the catchment of the River Fuller (see Figure 5.1). The city of Washbridge is situated on the River Fuller and has a population of 200,000. There are a number of other small centres of population, the largest of which is Snobham on the Neverstream Beck with a population of 30,000. The total population in the water resource zone is 250,000.

Water supply for the water resource zone comes from the River Fuller, abstracting upstream of Washbridge, and a groundwater aquifer at Poolhill. The Poolhill abstraction is close to Neverstream Beck, and on occasion responsible for low flows in 20km of the beck. The beck is a mixed coarse fishery (with an RE class 4). 10,000 people use the area for walking and bird watching. An average of 20 anglers per day use the beck. The Poolhill abstraction is considered to be the most environmentally sensitive water resource in the water resource zone.

The most significant development planned for water supply in the zone is an impoundment reservoir called Fuller Reservoir.

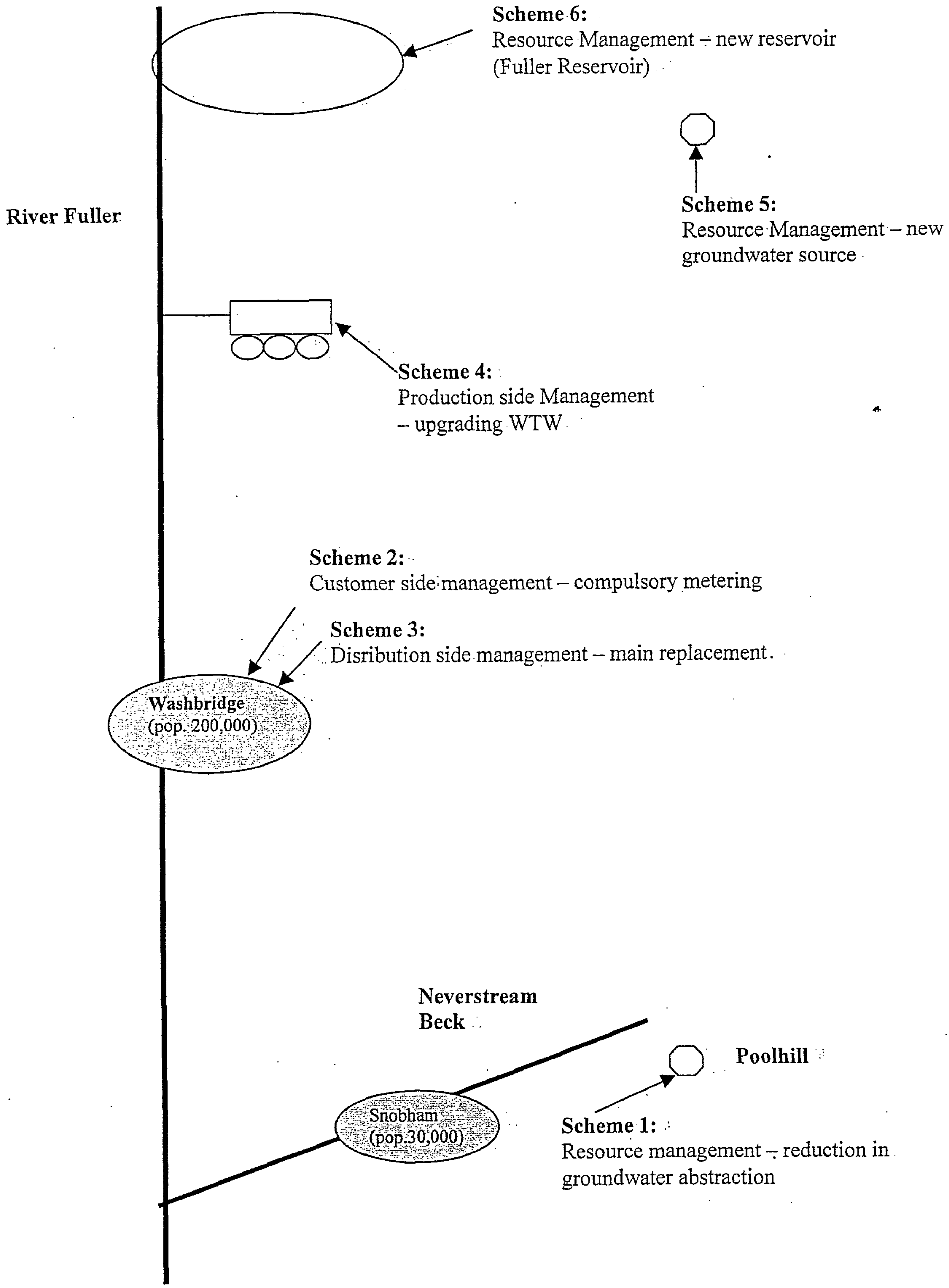

Figure 5.1: Hypothetical Water Zone

5.2 Scheme 1: Water Resource Management – Reduced Groundwater Abstraction at Poolhill

STEP I:

Groundwater abstraction at Poolhill is contributing to low flows in the Neverstream Beck during the summer. Given the opportunity, through reduction in water demand, it is proposed to reduce the groundwater abstraction to alleviate these problems.

STEP II:

The full range of potential environmental issues and their potential effects are identified in columns one and two of Table 5.1.

STEP III AND STEP IV:

Steps III and IV of the process require that the residual environmental effects of the scheme are identified. For the purposes of this case study it is assumed that the effects of the given scheme have been identified and the mitigation measures prescribed. The residual environmental effects are defined in the relevant column of Table 5.1.

STEPS V-VI:

There are two positive well-being effects from the reduced abstraction at Poolhill:

(i) Improvements in a coarse fishery
(ii) Non-use value from an improvement in river water quality

Care has been taken to ensure that these effects are not double counted, as both of them appear in the column 'residual well-being effects' in two places: the fishery improvement appears under 'biodiversity' and 'recreation', and the water quality improvement appears under 'water environment' and 'biodiversity'.

STEP VII:

Both of these effects occur due to increased flow in the river resulting from reduced groundwater abstraction. The main UK study which estimates the benefits of low flow alleviation in the UK is that by Garrod and Willis (1996) (no.1 in Table 4.1). However, their case study examined the River Darent which suffers from extreme low flow problems and is a well-recognised river, therefore it has been judged inappropriate for benefits transfer in this case. Other candidate studies include those by Middlesex University, however these use the 'value of enjoyment method' which obtains estimates which are not strictly comparable with WTP estimates due to methodological differences.

Finally, Green and Willis (1996) (Table 4.1) estimate WTP by anglers and non-users for improvements in water quality. When a river is not suffering from severe low flow problems, changes in quality and quantity of water are essentially the same: one causes the other but they occur simultaneously. Therefore in this case a study measuring WTP for changes in quality could be applied as the perceived difference will be the same. This study is the only UK study to provide such estimates and will therefore be used.

For changes in the fishery, the same study by Green and Willis (1996) may again be used. In fact, there are no other UK studies which measure WTP for improvements to non-salmanoid fisheries (as distinct from the creation of new fisheries, where WTP estimates can be expected to be different). This study will therefore be used to estimate this change also.

However, for purposes of comparison, the study by ECOTEC (1993) estimates WTP for a new trout fishery may be used. This study measures the total WTP for a new trout fishery, rather than the value of an improvement from a coarse to a trout fishery, and therefore should be treated as an overestimate.

STEP VIII:

As these are UK studies, we have not made any adjustments to the average WTP estimates. Neither study provides a WTP function which can be used for benefits transfer.

STEP IX:

(i) <u>Benefits to Fishery</u>: The improvement in water quality is expected to improve the fishery in Neverstream Beck from 'mixed coarse' to trout. Green and Willis (1996) estimate the WTP of anglers for improvements in a fishery to be £16.80/angler/visit for a good trout fishery, and £6.40/angler/visit for a good coarse. The difference between the two, £10.40/angler/visit, is therefore the WTP for an improvement from coarse to trout. Using the on-site estimate of 20 angling visits per day, we estimate:

annual benefits	= average WTP/angler/day * no. anglers/ day * no. days
of fishery	= £10.40 * 20 * 365
improvement	= £75,920 per year

For comparison, we use the ECOTEC (1993) WTP estimate of £4.40 to £12.20 per angler per visit to a trout fishery. The same calculations give:

annual benefits	= average WTP/angler/day * no. anglers/ day * no. days
of fishery	= £4.40 to £12.20 * 20 * 365
	= £32,120 to £89,060 per year

(ii) <u>Non-use values of improvement in water quality</u>: People who do not use the river may also derive enjoyment from the fact that the water quality of Neverstream Beck has improved. These non-use values of water quality improvements form 'poor' to 'medium' were estimated to be £0.0056/household/km/yr in the same study by Green and Willis (1996). As Neverstream Beck is a UK river of significant size but without national importance, similar to the one in the study, we assume that the average WTP will be the same at the two sites. The relevant population is assumed to be the local population of 250,000, again since the river is not well-known nationally. Total non-use values of water quality improvements is therefore estimated as follows:

annual non-use benefits	=	£0.0056/hh/km/yr * 250,000 people / 2.5 people per hh *
of quality improvement		20 km of improved water quality
	=	£11,200 per year

The environmental effects of this option emphasise the importance of avoiding double counting. For example, improvements in water quality improve the aquatic biodiversity of the river, and appear in the residual effects column under biodiversity effects. However, these values have already been included, under 'recreation' for users, and under 'water environment' for non-users.

STEP X:

The significance of the non-monetised indicators is given in the final column of Table 5.1. The permanent benefits of reducing abstraction at Poolhill include moderate improvements in baseflow of the beck and associated groundwaters, and major benefits to biodiversity, visual amenity and recreational uses.

STEP XI:

The total monetary and non-monetary effects of the reduced abstraction are shown below. This is a summary of the full assessment given in Table 5.1.

Monetised Residual Effects	Monetary Value
Temporary	
Fishery benefits	+£76,000 per year (£32,000 to £89,000)
Non-use value	+£11,200 per year
Non-Monetised Residual Effects	**Level of Significance**
Permanent	
Improved habitat availability and species richness	ooo
Improved visual amenity of Neverstream Beck	ooo
Increased recreational opportunities	ooo
Improved summer baseflow in the beck	oo
Improved groundwater levels	oo
Temporary	
None	

Table 5.1: Scheme 1: Resource Management - Reduced Groundwater Abstraction at Poolhill

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
Water environment	Change to base flow of Neverstream Beck	Moderate increase in base flow for Neverstream Beck. Beck increases its perennial length by 3 km	benefit from improved flow in Neverstream Beck				oo
	Change in dilution capacity of Neverstream Beck	Moderate improvement in Neverstream Beck water quality below Snobham, increasing from RE Class 3 - 4 to RE Class 1-2	non-use value of improvement in water quality on river	*Green and Willis, 1996* non-use values for improvements in quality £0.0056/ household/km/yr	None as UK study of similar site	Affected population assumed to be Washbridge, Snobham and surrounds = 250,000 people / 2.5 people/ household = 100,000; improved length of river = 20km	+ £11,200
	Change in groundwater flow and direction	Moderate benefit to local groundwater flow and direction, and increase in groundwater levels	moderate benefit to local groundwater levels				oo
Biodiversity	Change in biodiversity of the Neverstream Beck	Improvement in biodiversity of fich: river can now support trout	Improvement in fishery of Neverstream Beck (see under Recreation)				
		Enhanced water dependant habitats	Major benefit to water dependant habitats				

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
Visual amenity	Altered landscape and aesthetic value	Major improvement to 20km of Neverstream Beck through increased flow	visual improvement of Neverstream Beck	-	-	-	ooo
Recreation	Change to recreational amenity	Major improvement in recreational amenity during the summer Change of fishery from "mixed coarse" to "trout".	Major benefit for recreational users in summer Improvement in fishery of Neverstream Beck	*Green and Willis, 1996* Average WTP of £10.40/angler/ visit for improvement from coarse to trout fishery or *ECOTEC 1993* average WTP of £4.40 to £12.20 per angler per day for trout fishery	None as UK study	Number of anglers = 20 per day	ooo + £76,000 per year +£32,000 to £89,000 per year
Heritage & archaeology	None	-	-	-	-	-	-
Traffic	None	-	-	-	-	-	-
Noise & vibration	None	-	-	-	-	-	-
Waste management & contaminated land	None	-	-	-	-	-	-
Community effects	None	-	-	-	-	-	-

A benefit is indicated by + sign and o. A cost is indicated by – sign and •.

Assumptions

- *All effects are permanent or operational unless stated as "During construction" or "Temporary"*

5.3 Scheme 2: Customer Side Management – Compulsory Metering

STEP I:

The meters would be installed within the fabric of each house, and would take 2 hours to fit. Lorry movements associated with metering would be low.

It should be noted that there is a saving in water resource from this scheme. The consequent reduction in water requirement would allow a reduction in water resource requirement or the deferring of a planned water resource scheme to a later date. Each of these schemes would confer a benefit that should be estimated and included in the project appraisal. For the purposes of this case study, the benefits conferred by a reduction in groundwater abstraction at Poolhill is considered as the environmental benefit of this scheme. The full assessment of this scheme is described in Section 5.2.

STEP II:

The full range of potential environmental issues and their potential effects are identified in columns one and two of Tables 5.1 and 5.2.

STEP III AND STEP IV:

Steps III and IV of the process require that the residual environmental effects of the scheme are identified: For the purposes of this case study it is assumed that the effects of the given *scheme have been identified and the mitigation measures prescribed. The residual* environmental effects are defined in the relevant columns of Tables 5.1 and 5.2.

STEPS V-IX:

The costs of meter installation in terms of disturbance to households cannot be translated into monetary value at this time as there have been no suitable valuation studies. Transport related effects are assumed to be minimal in this case.

However, reduced abstraction at Poolhill gives rise to several well-being effects that can be valued. These are valued in Scheme 1 (Section 5.2) and the reader should refer to steps V-IX in that section.

STEP X:

The significance of the non-monetised residual effects is given in the final columns of Tables 5.1 and 5.2. Installation of water meters is likely to have only a slight effect due to community disturbance and may have a limited potential for health effects from changes in household water use.

The permanent benefits of reducing abstraction at Poolhill include moderate improvements in baseflow of the beck and associated groundwaters, and major benefits to biodiversity, and recreational uses.

STEP XI:

The total monetary and non-monetary effects of compulsory metering are shown below. It should be noted that the table incorporates the effects of meter installation with the benefits derived from reduced abstraction at Poolhill.

Monetised Residual Effects	**Monetary Value**
Permanent	
Fishery benefits	+£76,000 per year (£32,000 to £89,000)
Non-use value	+£11,200 per year
Non-Monetised Residual Effects	**Level of Significance**
Permanent	
Improved habitat availability and species richness	ooo
Improved visual amenity of Neverstream Beck	ooo
Increased recreational opportunities	ooo
Improved summer baseflow in the beck	oo
Improved groundwater levels	oo
Public health implications of reduced water usage	•
Temporary	
Disturbance during meter installation	•
Social inconvenience of meter installation	•

Table 5.2: Scheme 2: *Customer Side Management* – Compulsory Metering

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effects on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non monetary indicators**
Water environment	None	-	-	-	-	-	-
Biodiversity	None	-	-	-	-	-	-
Visual amenity	None	-	-	-	-	-	-
Recreation	None	-	-	-	-	-	-
Heritage & archaeology	None	-	-	-	-	-	-
Traffic	During installation: Traffic in an urban area	Negligible effect on traffic	-		-	-	-
Noise & vibration	During installation: Nuisance, due to increased noise levels.	Negligible noise and vibration effect	-	-	-	-	-
Waste management & contaminated land	None	-	-	-	-	-	-
Community effects	During installation: Restricted house hold access Potential public health effects from reduced usage	Inconvenience from restriction of access and disturbance during installation Small chance of increased health problems in specific communities	inconvenience disturbance during meter installation possibility of health effects	-	-	-	• • •

A benefit is indicated by + sign and o. A cost is indicated by – sign and •.

Assumptions

- All effects are permanent or operational unless stated as "During construction" or "Temporary"
- Installation within the house
- Noise and vibration levels below statutory limits, but still elevated leading to disturbance. Installation would take 1 to 2 hours
- Benefit to the environment from the reduced water demand is presented in Scheme 6.

5.4 Scheme 3: Distribution Side Management – Leakage Control by Mains Replacement

STEP I:

Leakage control is proposed for the urban centres of Washbridge and Snobham. 25km of supply mains would be replaced, comprising 5km of mains in urban areas over 12 weeks and 20km of mains in suburban areas over a total of 48 weeks. The urban mains are thought to run through an area of previous heavy industrial use. The mains are generally aligned with roads, although several parks and playing fields are crossed adjacent to a large housing estate. Suburban mains replacement may encroach on a site of archaeological interest.

It is assumed that construction traffic would be routed away from sensitive areas such as schools and old peoples' homes and that a Code of Good Construction Practice would be implemented.

It should be noted that there is a saving in water resource from this scheme. The consequent reduction in water requirement would allow a reduction in water resource requirement or the deferring of a planned water resource scheme to a later date. Each of these schemes would confer a benefit that should be estimated and included in the project appraisal. For the purposes of this case study, the benefits conferred by a reduction in groundwater abstraction at Poolhill is considered as the environmental benefit of this scheme. The environmental effects and monetary valuation of this scheme are described in Section 5.2, and included here for completeness.

In addition, this scheme will avoid the need for some future emergency repair work and associated road closures, and these benefits should be offset against the present costs.

STEP II:

The full range of potential environmental issues and their potential effects are identified in columns one and two of Tables 5.1.and 5.3.

STEP III AND STEP IV:

Steps III and IV of the process require that the residual environmental effects of the scheme are identified. For the purposes of this case study it is assumed that the effects of the given scheme have been identified and the mitigation measures prescribed. The residual environmental effects are defined in column 3 of Tables 5.1 and 5.3.

STEPS V-VI:

Three environmental costs of mains replacement can be monetised using monetary valuation techniques:

(i) disruptions to traffic due to road closures;
(ii) damage due to vehicle emissions and increased road congestion from HGV requirements; and
(iii) avoided disruption due to avoided emergency repairs.

In addition, reduced abstraction at Poolhill give rise to two well-being effects that can be valued. These are valued in Scheme 1 (Section 5.2) and the reader should refer to steps V-IX in that section.

STEP VII:

(i) and (iii) disruptions to traffic due to road closures: Statistics from the DETR (1997) can be used to estimate average daily flows on each type of road affected.

(ii) damage due to vehicle emissions, risk of accidents and increased road congestion from HGV requirements: There is a vast literature on valuation of air pollution and congestion costs associated with traffic. Since these costs generally account for only a minor part of total environmental effects of water management options, only a few recent UK studies have been summarised in these guidelines. Maddison et al (1996) is used to estimate the air pollution costs, Newbery (1992) to estimate congestion costs, and statistics from the DETR (1996) to estimate increased risk of accidents.

Please refer to Steps V-IX in Section 5.2 for estimating the benefits of the scheme.

STEP VIII:

As all of the above are UK studies giving UK average figures, no adjustment is needed.

STEP IX:

(i) Road closures: The cost of road closures can be estimated following the procedure in Section 4.1, Step IX, using the equation given there:

$$\textit{cost of road closure} = af \, . \, ejt \, . \, d \, . \, [(wt \, . \, aw) + (lt \, . \, lw)] \, . \, occ$$

af = average traffic flow (vehicles/day),
ejt= extra journey time per vehicle (% of an hour), which depends on whether closure is partial or whole,
d = number of days of closure,
wt= fraction of traffic which is work-related,
aw= average wage per hour,
lt = fraction of traffic which is leisure-related (1 - fraction work-related),
lw= 43% of average wage per hour, or the cost of leisure time lost, and
occ= occupancy rate in the UK is 1.6 for passenger vehicles.

In this case, the average daily flows on these roads are not known, therefore UK average flows for different types of roads are used. The relevant figures from DETR (1997) (no. 29 in Table 4.1) are: trunk roads in built-up areas = 19580 vehicles per day; principal roads in built-up areas = 15110; and minor roads = 1390.

The number of days of road closure is obtainable from the environmental appraisal as follows. Closures will involve one trunk road in a built-up area for 7 weeks, a principal road in a built-up area for 12 weeks, and minor roads for 24 weeks. Delays to traffic are assumed to be 5 minutes on the major roads, and 2 minutes on the minor roads. It is assumed throughout that

50% of traffic is work-related and that the average wage in this area is the same as the national average. These estimates give costs as follows:

cost of trunk road closure	= 19580 vehicles * 5/60 of an hour * 49 days * [(0.5*£8.93) + (0.5*0.43*£8.93)] * 1.6 = £816,780
cost of principal road closure	= 15110 vehicles * 5/60 of an hour * 84 days * [(0.5*£8.93) + (0.5*0.43*£8.93)] * 1.6 = £1,080,540
cost of minor road closures	= 1390 * 2/60 * 70 * [(0.5*£8.93) + (0.5*0.43*£8.93)] * 1.6 = £33,130
total cost of closures	= £816,780 + 1,080,540 + 33,130 = approximately £1,900,000 (1^{st} year only)

(ii) Damage due to HGV traffic (emissions, accidents and congestion): Damage due to HGV traffic used during the construction phase of a project may be calculated following the procedure in Section 4.1, Step IX:

$$\textit{Cost of extra flow} = v \, . \, kmd \, . \, d \, . \, p$$

v = number of vehicles per day,
kmd = kilometres driven per vehicle per day (round trip),
d = total number of construction days for HGV and total number of travelling days for private cars, and
p = damage cost per kilometre driven.

In this case, 3 to 5 HGVs will be required, driving a 20 km round trip over rural roads. The construction period will be 56 weeks, of which 12 weeks will be in a central urban area and 44 weeks in suburban areas. The damage cost per kilometre is made up of the following components:

$$p = ap + ra + c$$

ap = air pollution,
ra = increased risk of accidents, and
c = cost of increased congestion.

The cost of air pollution is estimated to be 32.6p/km (Maddison, 1996) (no. 28 in Table 4.1) and that of increased risk of accidents 5.4p/km (DETR, 1996) (no. 30 in Table 4.1). The cost of increased congestion will vary according to location and time of day. These costs have been estimated for 11 different time-location combinations (Newbery, 1992) (no. 27 in Table 4.1).

In the present case, we have traffic travelling at both peak and off-peak hours, along urban central and non-central roads. The relevant congestion costs and total costs are therefore:

Type of road	Congestion cost	Total cost (congestion + accident risk + health)
central peak	79.56 p/km	117.56 p/km
central off-peak	63.94 p/km	101.94 p/km
non-central peak	34.69 p/km	72.69 p/km
non-central off-peak	19.12 p/km	57.12 p/km

Total damages can then be estimated using the equation above:

monetary damage of HGV traffic

central urban = (3 to 5 HGVs/day * 10 km/HGV off-peak * 72 days * £1.019/km) +
(3 to 5 HGVs/day * 10 km/HGV peak hrs* 72 days * £1.176/km)
= £4,741 to £7,902

non-central = (3 to 5 HGVs/day * 10 km/HGV off-peak * 264 days * £0.571/km) +
(3 to 5 HGVs/day * 10 km/HGV peak hrs * 264 days * £0.727/km)
= £10,281 to £17,135

total cost = approximately £15,000 to £26,000 (1st year only)

(iii) Avoided disruption due to avoided emergency repairs: this effect can be estimated using the same procedure as in part (i) above. It is expected that mains replacement will prevent two days of emergency road closures on each type of road concerned per year. Using the same figures for traffic flow and delays, this will lead to a permanent benefit of approximately £60,000 per year.

STEP X:

The significance of the non-monetised residual effects is given in the final columns of Tables 5.1 and 5.3. Mains replacement has a number of slight to moderate environmental effects related to construction and consequent disturbance. No permanent effects are likely.

Permanent benefits accrue from reducing the abstraction at Poolhill, include moderate improvements in baseflow of the beck and associated groundwaters, and major benefits to biodiversity, and recreational uses.

STEP XI:

The total monetary and non-monetary effects of mains replacement are shown below. It should be noted that the table incorporates the effects of mains replacement with the benefits derived from reduced abstraction at Poolhill.

Monetised Residual Effects	Monetary Value
Permanent	
Avoided emergency road closures	+£60,000 per year
Fishery benefits	+£76,000 per year (£32,000 to £89,000)
Non-use value	+£11,200 per year
Temporary	
Disruptions to traffic due to road closures	-£1,900,000 (1st year only)
Damage caused by vehicle emissions (health and ecosystem damage) + congestion and accidents	-£15,000 to £25,000 (1st year only)
Non-Monetised Residual Effects	**Level of Significance**
Permanent	
Improved habitat availability and species richness	ooo
Improved visual amenity of Neverstream Beck	ooo
Increased recreational opportunities	ooo
Improved summer baseflow in the beck	oo
Improved groundwater levels	oo
Potential cleanup of contaminated land	o
Potential loss of archaeology	•
Temporary	
Increased turbidity of watercourses	•
Decreased biodiversity	•
Severance from local amenities	•
Change to the appearance of the landscape	•
Disruption to recreation	••
Construction noise and vibration	••

Table 5.3: Scheme 3: Distribution Side Management - Leakage Control by Mains Replacement

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
Water environment	During construction: Change in runoff characteristics	During construction: Slight increase in the runoff turbidity to adjacent watercourses and the River Fuller	Temporary visual cost - change in the appearance of watercourses	-	-	-	•
Biodiversity	During construction: Change in the ecosystem of the local watercourses Noise disturbance during trenching	During construction: Slight deterioration in local biodiversity	temporary negative effect on aquatic biodiversty	-	-	-	•
Visual amenity	During construction: Altered landscape and aesthetic value	During construction: Moderate intrusion on surrounding landscape during construction and recovery period	temporary visual effect - change in the landscape	-	-	-	•
Recreation	During construction: Closure of local playground and pitches	During construction: Moderate temporary disruption to on recreation	temporary effect on recreational amenity	-	-	-	••
Heritage & archaeology	Damage and/or loss of unknown archaeological features	Disturbance of unknown archaeological features. Benefit delineating the extent of discovered archaeological remains for county records	potential loss of archaeology	-	-	-	•
Traffic	During construction: Congestion and heavy traffic in urban and suburban areas	During construction: Moderate disruption to existing traffic over construction period. Avoided future emergency road closures Slight increase in volume of traffic over construction	Disruptions to existing traffic due to road closures Avoided future traffic disrptn Damage caused by vehicle	*DETR, 1996* average daily traffic flows: trunk roads = 19580; principal = 15110; minor = 1390; *Maddison, 1996* health cost 32.6p/km	No adjustment needed	delays = 5mins major roads, 2 mins minor roads; 50% of traffic work-related; road closure on trunk = 7 wks; principal = 12 wks; minor = 10 weeks; avoided delays: 2 days each rd 3-5HGVs/day; 20 km	- £1,900,000 1st year only +£60,000 - £15,000 to

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
		period	emissions (health + ecosystem damage) plus costs of congestion + accidents	*DETR, 1996* accident risk: 5.4p/km *Newbery, 1992* congestion: urban central peak = 79.56; off-pk = 63.94; non-central peak = 34.69; off-pk = 19.12		round trip; 50% peak hours; 12 weeks urban central; 44 weeks non-central	- £25,000 1st year only
Noise & vibration	During construction: Nuisance, due to increased noise levels. Disturbance to visitors and local habitats	During construction: Noise and vibration below statutory limits and within specified working hours. Slight effect as noise and vibration levels would be elevated leading to disturbance on housing estate	temporary noise and vibration disturbance	-	-	-	••
Waste management & contaminated land	Possibility of finding contaminated land Disposal of waste material	Benefit in clean up of any contamination found. Possible use of landfill void	health and amenity benefits	-	-	-	o
Community effects	During construction: Restriction in access to shops and amenities	During construction: Limited disruption to access	temporary severance	-	-	-	•

A benefit is indicated by + sign and o. A cost is indicated by – sign and •.

Assumptions

- All effects are permanent or operational unless stated as "During construction" or "Temporary"
- Replacement of 5km of mains in central urban area (3 km of which is in a major road, 2 km in foot pavement); Construction time 12 weeks; Length of road work 7 weeks; ADF 15,000; Partial closure of road for 6 days; Full closure on Sundays.
- Replacement of 10km of mains in inner suburban area (5 km of which is in a major road, 2 km in foot pavement, 3 km in unpaved); Construction time 20 weeks; Length of road work 12 weeks; ADF 10,000; Partial closure of roads throughout work.
- Replacement of 10km of mains in outer suburban area (8km in minor road, 2km in foot pavement); Construction time 24 weeks; Length of road work 10 weeks; ADF 15,000; Partial closure of road throughout work
- Traffic generated by the construction work; 3-5 HGV per day. Round trip of 20 km, (50% off peak 50% peak)
- Route construction traffic away from sensitive receptors, i.e. schools and listed buildings
- Follow Environment Agency Guidelines for Good Construction Practice
- Code of practice on conservation, access and recreation, the details of which water supply undertakers are expected to follow under the Water Industry Act 1991. Damage to designated sites would therefore be avoided.

5.5 Scheme 4: Production Side Management – Upgrading of Water Treatment Works

STEP I:

Treatment capacity of Washbridge WTW would need to be improved in the event of extra potable water resource requirement. All construction work would be undertaken within the curtilage of the works. However, some construction would take place on land that is currently undeveloped. Increased capacity of the works would lead to discharge of greater volumes of backwash water to the River Fuller. Previous potentially contaminative uses at the site may lead to discovery of contaminated land.

For simplicity, this scheme considers upgrading of the WTW in isolation. When considering Total Water Management options, any water treatment works upgrading would probably be undertaken in conjunction with a water resource scheme (for example a reservoir or groundwater scheme) together with the supporting distribution side infrastructure and upgrading of waste water treatment facilities which should be taken into account separately.

STEP II:

The full range of potential environmental issues and their potential effects are identified in columns one and two of Table 5.4.

STEP III AND STEP IV:

Steps III and IV of the process require that the residual environmental effects of the scheme are identified. For the purposes of this case study it is assumed that the effects of the given scheme have been identified and the mitigation measures prescribed. The residual environmental effects are defined in the relevant column of Table 5.4.

STEPS V-VI:

For this scheme, there is one environmental effect that can be valued given the current literature:

(i) Damage caused by HGV traffic.

STEP VII:

The relevant valuation studies are as follows: air pollution costs – Maddison et al (1996) (no. 28 in Table 4.1); congestion costs – Newbery (1992) (no. 27 in Table 4.1); accident risks – DETR (1996) (no. 30 in Table 4.1).

STEP VIII:

As all of the above are UK studies giving national average unit valuations, no adjustments are needed.

STEP IX:

In this case, it is estimated that 1 to 2 HGVs will be required, travelling 10 km round trip daily along non-central urban roads over nine months. It is estimated that half of this traffic will be travelling at peak times, the remainder at off-peak hours. Following the same procedures as for Scheme 2, this gives damage costs of -£1,500 to -£3,000 (1st year only).

STEP X:

The significance of the non-monetised residual effects is given in the final column of Table 5.4. Upgrading of the Water Treatment Works results in few temporary effects. Permanent effects include moderate visual intrusion and a slight local decline in water quality and ecology.

STEP XI:

The total monetary and non-monetary effects of upgrading the WTW are shown below.

Monetised Residual Effects	**Monetary Value**
Temporary	
Damage caused by vehicle emissions (health + ecosystem damage) + congestion and accidents	-£1,500 to -£3,000 (1st year only)
Non-Monetised Residual Effects	**Level of Significance**
Permanent	
Potential cleanup of contaminated land	o
Slight reduction in water quality of the river Dent	•
Slight change to River Fuller ecosystem	•
Loss of open space within curtilage	•
Change in the visual appearance of an existing site	••
Temporary	
Increased turbidity in watercourse during construction	•

Table 5.4: Scheme 4: Production Side Management - Upgrading Washbridge WTW

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
Water environment	During construction: Change in runoff characteristics. During operation: Increase in discharge of backwash water to the River Fuller	During construction: Slight increase in turbidity of runoff where work undertaken near to the River Fuller. During operation: Slight reduction in water quality of the River Fuller through discharge of backwash water Negligible effect on infiltration and runoff response from paving of 0.2ha.	temporary visual cost negative permanent effect on water quality	-	-	-	• •
Biodiversity	During operation: Possible change in ecosystem in the River Fuller due to increased backwash water Loss of habitat	Slight change to ecosystem through discharge of backwash water Moderate loss of open green space within curtilage of WTW	negative effect on River Fuller ecosystem loss of open space	-	-	-	• •
Visual amenity	Altered landscape and altered aesthetic value	Moderate change in appearance of the WTW. From new structure on an existing site	change in the visual appearance	-	-	-	••
Recreation	During construction: Disruption to amenity	None, all construction within curtilage of works	-	-	-	-	-
Heritage & archaeology	Damage and/or loss of unknown archaeological features	None, construction on terraced land (i.e. previously disturbed)	-	-	-	-	-
Traffic	During construction: Congestion and heavy vehicles in an urban area	During construction: Slight increase in vehicle movements	Damage caused by vehicle emissions (health + ecosystem damage) + costs	*Maddison, 1996* health 32.6p/km; *DETR, 1996* accident risk 5.4p/km *Newbery, 1992*	No adjustment necessary as UK study	1-2 HGVs @ 10 km, 9 months; non-central urban roads, 50%	-£1,500 to -£3,000 1st year only

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
			of congestion + accidents	congestion costs non-central urban peak: 34.69p/km; off-pk: 19.12p/km		peak, 50% off peak	
Noise & vibration	During construction: Nuisance, due to increased noise levels. Disturbance to habitats and visitors	Noise and vibration below statutory limits and within specified working hours. Negligible effect as not close to sensitive receivers	-	-	-	-	-
Waste management & contaminated land	Possibility of disturbing contaminated land Disposal of waste material	Slight benefit in clean up of any contamination found Slight negative effect from possible use of landfill void giving slight effect	health and amenity benefits	-	-	-	o
Community effects	None	-	-	-	-	-	-

A benefit is indicated by + sign and o. A cost is indicated by – sign and •.

Assumptions

- All effects are permanent or operational unless stated as "During construction" or "Temporary"
- Traffic generation during construction: (9 months): 1 –2 HGVs per day, round trip of 10 km on urban roads
- Visual effect mitigation:
  - Grouping and design of structures to minimise intrusion
  - Use of non-reflective materials and dull colours for cladding
  - Restriction on lighting
  - Retention of landscape features
  - Screening
- Route construction traffic away from sensitive receptors (e.g. schools and listed buildings)
- Follow Environment Agency Guidelines on Code of Construction Practice
- Code of practice on conservation, access and recreation, the details of which water supply undertakers are expected to follow under the Water Industry Act 1991. Damage to designated sites would therefore be avoided.

5.6 Scheme 5: Water Resource Management – New Groundwater Source

STEP I:

A new groundwater water source is proposed 20km north of Washbridge, adjacent to a number of small watercourses. The well head would be constructed on agricultural land, and would consist of a small building in an otherwise flat agricultural landscape.

For simplicity, this scheme considers the groundwater abstraction in isolation. When considering Total Water Management options, any new abstraction would probably be undertaken in conjunction with supporting distribution side infrastructure and upgrading of sewage treatment facilities, which should also be assessed.

STEP II:

The full range of potential environmental issues and their potential effects are identified in columns one and two of Tables 5.5.

STEP III AND STEP IV:

Steps III and IV of the process require that the residual environmental effects of the scheme are identified. For the purposes of this case study it is assumed that the effects of the given scheme have been identified and the mitigation measures prescribed. The residual environmental effects are defined in the relevant column of Table 5.5.

STEP V-VI:

For this scheme, there is one environmental effect that can be valued given the current literature:

(i) Damage caused by HGV traffic.

STEP VII:

The relevant valuation studies are as follows: air pollution costs – Maddison et al (1996) (no. 28 in Table 4.1); congestion costs – Newbery (1992) (no. 27 in Table 4.1); accident risks – DETR (1996) (no. 30 in Table 4.1).

STEP VIII:

As all of the above are UK studies giving national average unit valuations, no adjustments are needed.

STEP IX:

In this case, it is estimated that 1-2 HGVs will be required over three months, plus 3-5 HGVs over six months, with a round trip of 20 km along rural roads. Following the same procedure as in the previous schemes, this puts damage costs in the region of £4,000 to £7,500 (1^{st} year only).

STEP X:

The significance of the non-monetised residual effects is given in the final column of Table 5.5. A new groundwater abstraction would probably result in few significant construction effects, and only slight permanent effects on local water courses. Depending on location there could be a slight effect on landscape and visual amenity.

STEP XI:

The total monetary and non-monetary effects of a new groundwater abstraction are shown below.

Monetised Residual Effects	Monetary Value
Temporary Damage caused by vehicle emissions (health + ecosystem damage) + congestion and accidents	-£4,000 to -£7,500 (1st year only)
Non-Monetised Residual Effects	**Level of Significance**
Permanent	
Reduction in the base flow of local watercourses	•
Reduction in water quality due to reduced dilution	•
Change in the aquatic ecosystem of local watercourses	•
Potential damage to archaeological features	•
Change in the landscape due to a new structure	•
Temporary None	

Table 5.5: Scheme 5: Resource Management - New Groundwater Abstraction at Terraspar

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
Water environment	Change in base flow of local watercourses and the River Fuller Change in dilution capacity of local watercourses and the River Fuller Change in groundwater flow and direction	Slight reduction in base flow of local streams. Slight reduction in dilution capacity in local streams Slight decrease in groundwater flow level	mixed (slight negative effects from change in base flow and water quality of watercourses, and lower groundwater levels); also reduced dilution	-	-	-	• •
Biodiversity	Change in aquatic ecosystem of the River Fuller and local watercourses Loss of terrestrial habitat due to construction of well head	Slight reduction in biodiversity of local watercourses Loss of 0.5 ha of agricultural land grade 5	negative effect on the aquatic ecosystem	-	-	-	•
Visual amenity	Altered landscape and aesthetic value.	Slight negative effect through change in landscape from new building on agricultural land	visual cost from change in landscape	-	-	-	•
Recreation	During construction: Disruption to amenity (e.g. walking,)	During construction: Negligible effect as agricultural area not used extensively for recreation	-	-	-	-	-
Heritage & archaeology	Damage and/or loss of unknown archaeological features.	Slight negative effect from potential disturbance of unknown archaeological features.	potential loss of archaeology	-	-	-	•

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual effect on well-being**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
		Slight benefit from delineating the extent of discovered archaeological remains for county records.					
Traffic	During construction: Congestion and heavy traffic in a rural area	During construction Moderate negative effect from traffic congestion and disruption	Damage caused by vehicle emissions (health + ecosystem damage) plus costs of congestion + accidents	*Newbery, 1992* - congestion rural roads: 0.15p/km *Maddison, 1996* health 32.6p/km *DETR, 1996* accident risk 5.4p/km	none required as UK studies	1-2 HGVs per day over 3 months plus 3-5 HGVs per day over 6 months, round trip 20 km, rural roads	- £4,500 to - £7,700 1st year only
Noise & vibration	During construction: Nuisance due to increased noise levels. Disturbance to habitats and visitors	Noise and vibration below statutory limits and within specified working hours. Negligible disturbance as away from sensitive receivers	-	-	-	-	-
Waste management & contaminated land	Possibility of disturbing contaminated land Disposal of waste material	No history of contaminative uses, and little risk of contaminated land	-	-	-	-	-
Community effects	None	-	-	-	-	-	-

A benefit is indicated by + sign and o. A cost is indicated by – sign and •.

Assumptions

- All effects are permanent or operational unless stated as "During construction" or "temporary"
- Traffic generation: During construction (3 months): 1-2 HGVs per day, round trip of 20km on rural roads
- Visual effect mitigation measures include grouping and design of structures to minimise intrusion, use of non-reflective materials and dull colours for cladding, restriction on lighting retention of landscape features and screening
- Route construction traffic away from sensitive receptors (e.g. schools and listed buildings)
- Follow Environment Agency Guidelines for Code of Construction Practice
- Code of practice on conservation, access and recreation, the details of which water supply undertakers are expected to follow under the Water Industry Act 1991. Damage to designated sites avoided.

5.7 Scheme 6: Water Resource Management – New Reservoir

STEP I:

A new impoundment reservoir, Fuller Reservoir, is proposed in the head waters of the River Fuller. The reservoir would fill during the winter months and provide increased augmentation during summer. The River Fuller would be used as a conduit to supply raw water to the town of Washbridge.

The proposed reservoir area is currently not used for recreation, however, 200 ha of agricultural land would be displaced. It is anticipated that the reservoir would be used for recreation with a projected 500,000 visits per annum.

STEP II:

The full range of potential environmental issues and their potential effects are identified in columns one and two of Table 5.6.

STEP III AND STEP IV:

Steps III and IV of the process require that the residual environmental effects of the scheme are identified. For the purposes of this case study it is assumed that the effects of the given scheme have been identified and the mitigation measures prescribed. The residual environmental effects are defined in the relevant column of Table 5.6.

STEPS V-VI:

Four environmental effects of the reservoir construction can be monetised given the current literature:

(i) change in appearance and biodiversity of the landscape;
(ii) creation of a new reservoir with recreational facilities;
(iii) damage due to vehicle emissions, risk of accidents and congestion from HGV requirements; and
(iv) damage due to vehicle emissions and risk of accidents from visitor traffic to the reservoir.

STEP VII:

(i) <u>change in appearance and biodiversity of the landscape</u>

We consider two UK studies which could both potentially be used to estimate the value of a change in the landscape: those of Willis and Garrod (1993) (no. 24 in Table 4.1) and Hanley *et al.* (1998) (no. 25 in Table 4.1). Both of these are based in the UK and consider changes in various landscapes including agricultural landscapes.

Willis and Garrod estimate people's WTP to preserve their 'most preferred' landscapes, as well as 'today's landscape' in various different areas. It is significant that in their study they found that semi-intensive and intensive agricultural landscapes were not chosen as the 'most preferred' by any respondent. However, their estimate of 'WTP to preserve today's landscape irrespective of its type' included some agricultural landscapes, and for this they found a figure of £24/person/year.

Hanley *et al* estimate the value of conservation benefits of an ESA in Scotland, an area of special landscape and conservation interest, where traditional farming methods are practised. They derive an estimate of £22/household/year, which is very close to that of Willis and Garrod. Since the type of landscape is more closely matched in this case, we have chosen to use this estimate, recognising that it is likely to be an overestimate given that the agricultural land in our case study is not a designated ESA.

(ii) creation of a new reservoir with recreational facilities

In this case, there is only one UK study which estimates WTP for reservoir related recreation: that of Pearson (1992) (no. 13 in Table 4.1). The fact that this study is based on a site in the UK makes it preferable to the existing US studies for the purpose of benefits transfer.

(iii) and (iv) damage due to vehicle emissions, risk of accidents and congestion from traffic

The relevant valuation studies are as follows: air pollution costs – Maddison et al (1996) (no. 28 in Table 4.1); congestion costs – Newbery (1992) (no. 27 in Table 4.1); accident risks – DETR (1996) (no. 30 in Table 4.1).

STEP VIII:

(i) landscape: Neither of the landscape studies actually examine WTP for a reservoir landscape and therefore it cannot be deduced whether a reservoir landscape is preferred to agriculture or vice versa. However, in practice when a new reservoir is under consideration, there are often strong local lobbies opposed to the new construction. Therefore it is desirable to have some indication of the maximum social costs such construction is likely to entail.

In order to achieve this, we assume that agricultural landscape is preferred to a reservoir by all residents. It is recognised that in practice this is unlikely to be the case, and that some people would prefer a reservoir. However, obtaining an indication of local opinion would require some sort of public consultation process. This, if undertaken, could provide more accurate estimates of the relevant affected population.

(ii) reservoir: Since Pearson (1992) is a UK study, no adjustments need be made for income. It is assumed that the mix of activities on the two reservoirs will be similar. However, Rutland Reservoir which is the site of the Pearson study has become a SSSI and one of the most attractive reservoir sites in the UK, and therefore the WTP estimates obtained should be treated as an upper bound.

(iii) and (iv) traffic: As the studies obtain UK average figures, no adjustments are required.

STEP IX:

(i) landscape change:

We assume that the people affected by the change in landscape are the 250,000 people (or 100,000 households) in the resource zone. Multiplying the affected population by the average

WTP of £22 per household per year, the change in landscape could involve well-being costs up to 100,000 * £22 = £2,200,000. The 95% confidence interval quoted in the study (£14.50 - £29.54) gives us a range of £1,450,000 to £2,954,000.

(ii) <u>reservoir</u>

It is estimated that the new reservoir will attract 500,000 visits per year after the full completion in year 7. In reality there would be a gradual increase in the number of visitors but this has been omitted for simplicity. This estimate needs to be adjusted to derive the number of visiting households. On average in the UK there are approximately 2.5 people per household. Pearson (1992) found that on average each household visited the reservoir 12 times per year. Using both of these estimates, the number of visiting households would be 16,700 (=500,000/(12*2.5) approximately). Multiplying this by the average WTP of £18.83 per household per year gives a total benefit of £314,461 per year. Using the standard deviation given in the study, this gives a range of approximately £0-£1,115,000.

(iii) <u>HGV traffic</u>

In this case, it is estimated that 10-20 HGVs would be required over 6 years, with a round trip of 50 km along rural roads. Following the same procedure as in the previous schemes, this puts damage costs in the region of £60,000 to £120,000 (for each year of construction).

(iv) <u>visitor traffic</u>

Estimating the environmental effects of increased visitor traffic requires an estimate of the number of vehicle journeys induced. Pearson (1992) estimates average visiting party size to be approximately 3.36 persons. Assuming one return car journey of 20km per visiting party this gives:

number of passenger car journeys	= 500,000 visits / 3.36 people per car = 148,810 car visits
number of kilometres driven	= 148,810 car visits * 20 km per car visit = 2,976,200 kilometres

Using the health cost of 2.2p per passenger car kilometre (Maddison et al, 1996) and the cost of increased risk of accidents of 3p/km (DETR, 1996) gives a total damage as follows:

external cost of vehicle traffic	= 2,976,200 km * £0.052 per km = approximately £155,000 (from year 7 onwards)

STEP X:

The significance of the non-monetised residual effects is given in the final column of Table 5.6. A new reservoir would probably result in some significant construction effects.

STEP XI:

The total monetary and non-monetary effects of a new reservoir are shown below.

Monetised Residual Effects	Monetary Value
Temporary	
Damage caused by vehicle emissions (health + ecosystem damage) + congestion and accidents	-£ 60,000 to £120,000 (for each year of construction)
Permanent	
Reservoir as a recreational amenity	+ £320,000 per year (£0 to £1,115,000) (year 7 onwards)
Landscape loss	-£2,200,000 (year 1) (-£1,450,000 to -£2,954,000)
Visitor traffic	- £155,000 per year (year 7 onwards)
Non-Monetised Residual Effects	**Level of Significance**
Permanent	
Creation of aquatic ecosystem	ooo
Change in water quality of River Fuller	oo
Reduction in risk of flooding of River Fuller	o
Change in micro-climate	•
Potential damage to archaeological features	••
Loss of land of agricultural/development value	••
Change in the terrestrial ecosystem (from reduction in flooding)	••
Change in hydrological regime	•••
Temporary	
Change in runoff characteristics	••

Table 5.6: Scheme 6: Resource Management – New Reservoir

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual economic effect**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
Water environment	During construction: Change in runoff characteristics.	During construction: Slight increase in turbidity of runoff where work undertaken near to the River Fuller.	Non monetised effect: Moderate negative temporary effect in the appearance of watercourses	-	-	-	●●●
	During operation:	During operation					
	Impoundment: Changed flow velocity; changed surface water runoff; change bank/bed stability	Major change in hydraulic regime (creation of standing water); Major change in bank/bed stability (creation of shoreline)	Non monetised effects: Major negative permanent change in hydraulic regime				●●●
	Release Regime into River Fuller: Changed flow regime; changed magnitude, frequency and duration of flooding; changed dilution capacity	Moderate change to overall quality of the River Fuller, reduced dilution capacity during winter increased dilution capacity during the summer. Slight change to flooding regime	Moderate positive permanent effect on water quality of the River Fuller;				oo
			Slight positive permanent effect, reduction in the incidence of flooding				o
Biodiversity	During operation: Change in aquatic ecosystem of the River Fuller due to changed flow	Major change to fauna and flora composition in the River Fuller	Non monetised effects: Major negative effect on River Fuller ecosystem		-	-	●●●

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual economic effect**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
	regime; creation of an aquatic ecosystem Loss of terrestial habitat due to flooding	Major loss of habitat 200 ha (Grade 5, Agricultural Land) Major change of aquatic ecosystem creation of Fuller Reservoir	Major negative effect through loss of terrestrial habitat (see under visual amenity); Major positive effect through creation of aquatic habitat				ooo
Land Use	Loss of land of value to agriculture or alternative development	Loss of low grade agricultural land	Moderate negative effect from loss of land				••
Visual amenity	Altered landscape and altered aesthetic value	Major change in visual amenity, valley flooded.	Major negative effects from change in the landscape appearance	Hanley et al (1998) £22/hh/yr to preserve existing landscape	recognise this is likely to be an overestimate	number of people affected by landscape change – assumed to be 250,000	£2,200,000 (£1,500,000 to £3,000,000)
Recreation	During operation: Creation of water environment	Creation of water amenity, Fuller Reservoir	Amenity value of reservoir	*Pearson, 1992* average recreation benefit of £18.83 /household / yr	None required as UK study	Anticipated 500,000 visits p.a.	+ £320,000 per year (£0 to £1,115,000)
Heritage & archaeology	Damage and/or loss of unknown archaeological features	Disturbance of unknown archaeological features. Benefits delineating the extent of discovered archaeological remains for count records	Moderate negative effect through potential loss of bronze age site	-	-	-	••

I	II	III-IV	V-VI	VII	VIII	IX	X-XI
Environmental issues	**Potential environmental effect**	**Residual environmental effect**	**Residual economic effect**	**Valuation study and unit value**	**Adjustments**	**Specific data requirements**	**Aggregate value and non-monetary indicators**
Traffic congestion, accidents & air quality	During construction: Congestion and heavy vehicles in an urban area	During construction: Major increase in HGV movements	Damage caused by HGV emissions (health + ecosystem damage) + costs of congestion + accidents	*Newbery, 1992* *Maddison, 1996* *DETR, 1996* Average of £0.3815p/HGV km (rural roads)	No adjustment necessary as UK study	10 - 20 HGVs @ 50 km, 6 years; rural roads	-£ 60,000 to -£120,000 for each year of construction
	During operation: visitor traffic	During operation: increase in passenger car movements (visitors to reservoir)	damage caused by emissions and risk of accidents	*Maddison, 1996* *Newbery, 1992* average of 5.2p/km	No adjustment necessary as UK study	150,000 car visits, average round trip 20km	-£155,000 per year
Noise & vibration	During construction: Nuisance, due to increased noise levels. Disturbance to habitats and visitors	Noise and vibration below statutory limits and within specified working hours. Negligible effect as not close to sensitive receivers	Non monetised effect: Negligible effect	-	-	-	-
Waste management & Contaminated land	None	-	-	-	-	-	-
Community effects	Change in micro-climate	Increased incidence of mist /fogs and higher humidity	Non monetised effect: Sight negative effect for local community	-	-	-	•
	Change in local business	Increase in local economy from visitors	Moderate positive effect for local retail outlets				OO

A benefit is indicated by + sign and O. A cost is indicated by – sign and •.

Assumptions

- All effects are permanent or operational unless stated as "During construction" or "Temporary"
- Traffic generation during construction: (6 years): 10 –20 HGVs per day, round trip of 50 km on rural roads
- Visual effect mitigation: Grouping and design of structures to minimise intrusion, Use of non-reflective materials and dull colours for cladding, Restriction on lighting, Retention of landscape features, Screening
- Route construction traffic away from sensitive receptors (e.g. schools and listed buildings)
- Follow Environment Agency Guidelines on Code of Construction Practice
- Code of practice on conservation, access and recreation, the details of which water supply undertakers are expected to follow under the Water Industry Act 1991. Damage to designated sites avoided.

5.8 Summary

This case study aims to illustrate the application of the methodology in a desktop evaluation. The procedure is intended to give a first approximation of the likely magnitude of environmental effects, and feed environmental considerations into the EDM process. The case study highlights the present interim status of monetisation of environmental effects, and the limitations with the literature that are currently being experienced.. This is manifest in the proportion of non-monetised environmental effects in the case study. On a positive note, monetary valuation is moving along rapidly, as are the number of valuation studies that are being reported, and we are hopeful that many of the gaps in the methodology should be filled relatively quickly. To this end we have suggested the main areas that require immediate attention in our recommendations (Section 6).

The methodology presented in these guidelines will, however, allow environmental consideration to be integrated into the EDM ranking exercise. As the case study stands there are no financial costs for the schemes, which would require more detailed engineering evaluation and cost appraisal to determine capital and operating costs, and no expected yield figures – both would be needed to calculate the Average Incremental Social Costs on which the EDM ranking is based. When incorporating the environmental effects into the EDM studies, the financial costs and yields will be known and the mixed outcomes considered here will be incorporated as specified in Section 4.3.

Note that monetary values correspond to Bm and Cm, and non-monetary indicators to Bnm and Cnm in Section 4.3. The summaries at the end of each scheme should be incorporated into or compared with financial costs and benefits as suggested in Section 4.3 (especially Table 4.3).

Sensitivity analysis has been undertaken wherever possible in order to take this uncertainty into account. However, on occasion this is not possible due to either a lack of studies so that only one estimate may be used, or because the existing study does not report confidence intervals.

If accurate estimates of environmental costs and benefits of a scheme are needed for a full scale assessment of environmental costs and benefits at a later stage of the planning process, in most cases we would recommend an original study. With the current batch of studies that are reported, there is often insufficient information to accurately transfer monetary valuation estimates from one situation to another which may not be directly comparable. Great care is needed in transferring monetary values to a site-specific project that any adjustments are appropriate and defensible.

6. CONCLUSIONS AND RECOMMENDATIONS

The methodology adopted here is recognised and recommended as an appropriate way forward for the evaluation of environmental costs and benefits of total water management options, leading to full consideration of environmental issues in the decision making process. Recognising the interim developmental status of the methodology, we have highlighted certain issues that need careful consideration, and suggested a number of areas in which further work should be undertaken to improve the literature.

6.1 Environmental Appraisal

Environmental appraisal procedures recommended here are well documented and tested. For the purposes of these guidelines, it is recommended that the user undertaking the appraisal should be experienced in the environmental assessment of total water resource schemes. Many of the schemes considered may not be fully developed to detailed design and will require qualitative assessment. Any significant effects must be established in view of the need to translate the environmental effects into a form suitable for monetary valuation. This translation is a key process and one that needs further refinement and development, as discussed in Section 6.3.

6.2 Valuation

6.2.1 Valuation methodology and literature

All monetary valuation methodologies can be used to estimate people's preferences for or against water related environmental effects. Although contingent valuation continues to be debated, its application is widening and gaining credit (for details on this method see Annex 8).

It is clear that due to both time and budget limitations, it would not be possible to conduct an original monetary valuation study for each scheme appraisal. Indeed, it may not even be desirable to do this when the environmental effects of a scheme are not deemed sufficiently significant. These contexts are especially suited to benefits transfer, which involves using the results of an earlier study in the analysis of the scheme in question. In fact, these guidelines rely on benefits transfer. However, benefits transfer has its own problems. For a reliable benefits transfer, the location and characteristics of the environmental resource valued and the population whose values are elicited in the original study should be similar to those related to the scheme in question. If similarities are lacking, the original estimate can be adjusted to fit the characteristics of the location and population affected by the scheme in question. However, there are very few suggestions as to what these adjustments should be such as income and distance-decay functions. Therefore, benefits transfer especially if the original studies are from outside UK, can only be a first indication of the environmental costs and benefits of a scheme.

However, benefits transfer is not always possible due to insufficient number of original valuation studies. Although the literature on monetary valuation is expanding, the majority of studies are still from the USA and biased towards recreational use of water resources. The ecosystem functions of groundwater and habitat function of surface waters for wildlife is not as well studied in the monetary valuation literature. In addition social costs such as disruption or life style changes due to some customer-side schemes are not assessed in monetary terms at all. This leaves the only option as the use of non-monetary indicators for measuring some environmental effects.

Non-monetary indicators have already been used extensively within environmental assessment. They lack the advantage of being in monetary units and hence cannot be easily compared with financial costs and benefits. They are also subjective judgements based on the expertise of one or more professionals and risk being arbitrary. It is not correct to suggest standardised scores for an environmental effect regardless of the location or the scheme that gives rise to it. Therefore, we have made only some suggestions as to what factors should be considered in assigning significance, and give examples of this in the case study in Chapter 5.

The ideal for a complete cost-benefit analysis of total water management options would be to express all environmental effects in monetary units and compare them directly with financial costs and benefits. Given that this is not possible at present, we have suggested how the mixed outcomes of environmental appraisal, i.e. some monetised and some non-monetised effects, can be dealt with and compared to the financial costs and benefits (see Chapter 4).

6.2.2 Double-counting

As stated in Chapter 2, these guidelines cover the external environmental effects only. We have touched upon situations where the practitioner could be internalising the external environmental effect either by mitigation or by paying compensation to the affected parties. To avoid double-counting, if there is such an internalisation, the costs of this should be included in the financial side of the analysis with corresponding reduction in or the elimination of the external effect in the environmental appraisal.

There is another case in which internalisation may occur: the taxation system. There are a number of taxes such as the landfill tax which are explicitly placed to internalise the environmental externality from landfilling waste. There are other taxes such as fuel excise tax which are mainly revenue raising but include an environmental component. Some argue that these taxes go someway to internalise the externality, say from fuel emissions, and we should only be concerned with the remaining, or net, externality. It could also be argued that externality taxes should be imposed independently of prevailing taxes. In which case, we should ignore the prevailing taxes.

If there is a new tax, e.g. a water charge, it should be based on the remaining externality after the prevailing taxes are taken into account. In the context of appraising a new investment that reduces externality what is important is that benefits (or reduced externality) are greater than the costs (or foregone benefits). The prevailing taxes remain transfer payments and hence do not enter into this comparison of costs and benefits.

6.3 Recommendations

First of all, it is important to remind the user that these guidelines are intended only for the initial stages of appraising the environmental effects of a total water management scheme. For later stages of the appraisal when more information is available on the technical characteristics, location and hence environmental effects of a scheme, more detailed benefits transfer and, ideally, where necessary, original valuation studies should be implemented.

The recommendations to the Environment Agency for taking this type of analysis forward and to the individual users for fuller application of these guidelines are summarised below:

Immediate Priorities

1. Introduce a qualitative element to scheme ranking: The Environment Agency published the EDM and Water Resource Planning Guideline to assist water companies in the management of the water resources. This guideline relies heavily on a quantitative assessment of environmental effects in the ranking of the Average Incremental Social Costs AISCs, for the selection of total water management schemes. In the calculation of AISCs, CAPEX & OPEX and the monetised environmental effects are treated equally. At present there is no allowance for non-monetised effects. This causes bias in the ranking of schemes and favours total water management schemes that have monetised fewer environmental effects. As new studies are undertaken further effects would be monetised. However, the introduction of a qualitative element to the ranking of total water management schemes as suggested here (Section 4.3) or EA, 1998, would make the selection of total water management schemes more balanced.

General recommendations

2. Undertaking environmental appraisals: There clearly is a "translation problem" between the description and measurement of environmental effects and those that can be perceived and valued by the individuals. We called the latter 'changes in the society's wellbeing' and gave examples of what these may be in Chapters 3 (see Table 3.1) and 4 (see the last column of Table 4.1: information needed to complete benefits transfer). It is recommended that the required translation and use of information on environmental effects of total water management schemes is kept in mind when this information is being collected and presented. This should ensure that the translation problem is minimised.

   We would recommend that a study is undertaken to define the links between environmental effects and the consequent human perception of wellbeing.

3. Accurate costing of important environmental effects: Most environmental effects of total water management schemes are site and scheme specific. As a result, as mentioned above and elsewhere, benefits transfer is limited. Therefore, especially if a scheme is located in a sensitive location or expected to lead to significant changes in society's wellbeing, then original studies would provide a much better indication of the people's preferences for environmental changes. Where this is not possible, the adjustments made must be clearly stated and appropriate.

Future Research

4. On-going literature reviews: The monetary valuation literature is expanding very rapidly. This is why it is important that the register of valuation studies presented in Table 4.1 and Annex 3 are revised periodically. This may involve searches and reviews of the literature for the latest original studies, as well as commissioning new studies to fill the gaps in current literature. The latter relates to the next two recommendations.

5. Topics for future research: There are currently a range of effects of total water management options for which no valuation studies exist. Some of these, such as costs of temporary disturbance due to the voluntary installation of water meters, may be assumed to be insignificant and in fact are potentially compensated by reduction in water bills if the schemes are voluntary. However, a range of effects for which no valuation studies exist may be significant. The only way to determine people's preferences are on these issues is to conduct original studies. The table below summarises the main effects for which no valuation studies exist.

Effects for which there are no existing studies	
Social costs of customer side measures	• health effects of metering / cistern replacement
	• change in lifestyle
	• disturbance / disruption due to metering and leakage repair
	• hosepipe bans
Community effects	• severance / disruption
Need for increased number and coverage of studies	
Water quality	• marginal (not step) changes in water quality
Flow	• marginal changes in river flow
	• need for multi-site research
Landscape	• marginal changes
	• value of different features
Fisheries	• marginal changes to fishery

It is important to emphasise that the effects for which there are existing studies, are often examined as *discrete* rather than *marginal* changes to environmental goods. In other cases, the existing studies are insufficient in number or coverage to make benefits transfer possible.

6. Presentation of future research results: Almost all studies in Table 4.1 and Annex 3 are published in easily accessible publications and hence it should not be difficult to obtain more information on any of them. However, there is a genuine lack of clear presentation of WTP (or demand) functions in these studies which makes it difficult to transfer functions. The lack of transferable WTP functions explains why we have not summarised these functions for all the studies. Expressing site characteristics and WTP functions in a clear fashion suitable for benefits transfer should be one of the objectives when implementing and reporting a new valuation study.

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ANNEX 1: ENVIRONMENT AGENCY SCOPING GUIDANCE NOTES

Guidance notes have been produced by the Environment Agency to encourage a consistent approach to scoping in the Environment Agency Regions for projects and activities which may affect the water environment.

These guidance notes are not intended to replace consultation with specialists from the Environment Agency, nor are they intended to cover all environmental issues. They are of a general advisory nature and should be used without prejudice in considering project proposals.

Scoping guidance has been produced for 61 types of development or activities which are likely to affect the water environment interests.

A checklist format is used to ensure that impacts are considered in a systematic way and provide a framework for discussions.

A list of the types of developments or activities covered by the guidance is given in Table A1.1.

Table A1.2 presents a range of 12 issues relevant to water related concerns. Potential impacts resulting from these issues are presented in the second column of Table A1.2. Table A1.3 presents the standard range of issues as they relate to 'groundwater abstraction'. The specific activities that will give rise to potential impacts are called the 'source of impact' and presented in the second column of the table. The table is presented as a quick check for the groundwater abstraction case in Chapter 5.

Please note that the classification of environmental issues recommended in Chapters 3 and 5 is a reorganisation of the issues presented here to fit within the focus of these guidelines, i.e. external environmental effects.

TABLE A1.1: Development types for which Scoping Guidance Notes have been produced

1. Generic Impacts of Construction Work
2. Reservoirs
3. Marinas
4. Barrages
5. Fish Farms
6. Pipelines
7. Sea Outfalls
8. Points of Large Abstraction
9. Points of Large Discharge
10. Sewage Treatment Works - extension & installation
11. Large residential Developments
12. Large Industrial/Manufacturing Developments and Operations
13. Golf Courses
14. Power Stations
15. Wind Farms
16. Hydroelectric Power
17. Oil Refineries/Oil Exploration
18. Forestry
19. Redevelopment of Contaminated Land
20. Waste Management
21. Mineral Extraction - Mining and Quarrying
22. Restoration of Mineral Extraction Sites
23. Roads and Road Widening
24. Railways
25. Airports
26. Cemeteries
27. Navigation Issues
28. Navigation Works
29. Channel Works
30. Flood Diversion Channels
31. Fluvial Dredging
32. Bank Protection
33. Flood Storage Area
34. Flood Embankment
35. Culverts and Tunnels
36. Barriers/Bridges/Weirs
37. Off Line Ponds and Reservoirs
38. Coastal Protection
39. Beach Nourishment
40. Suction Dredging
41. Restoration and Enhancement of River Channels
42. Conservation Enhancements
43. Water-Based Recreation
44. Off Road Recreation Activities
45. Vegetation Management
46. Deliberate Introduction of Species
47. Groundwater Abstraction
48. Interbasin Transfer of Flow
49. Agriculture
50. Kennels, Catteries and Stables
51. Intensive Livestock/Poultry Units
52. Tipping/Dumping
53. Camping and Caravan Sites
54. Septic Tanks/Cesspits etc
55. Vehicle Parks/Plant Hire
56. Swimming Pools
57. Chemical Storage Units
58. Petrol Stations
59. Peat Extraction
60. Bait Digging
61. Pest Species Control

TABLE A1.2: Issues and impacts on which Scoping Guidance Notes are based

Issue	Potential Impacts
Surface Water Hydrology/Hydraulics	Changed surface water runoff Changed flow velocities Changed magnitude of flooding Changed frequency of flooding Changed duration of flooding Convergence/divergence of flow Changed hydraulic roughness Regulated flow Low flows Wave - generation Reduced tidal flow/flushing/mixing Riparian drainage affected Changed flow regime
Channel Morphology/ Sediments	Changed bank/bed stability Degradation/erosion of bed or banks Deposition/situation Change of bed slope Change of platform/pattern Disturbance to bed forms (pools, riffles) Downstream erosion Changed channel size Changed suspended sediment load Changed bed load Contaminated sediment
Groundwater Hydraulics	Changed flow Changed infiltration Changed direction of flow Change in water-table (level) Barrier to flow Change in pressure potential Changed storage capacity
Surface Water Quality	Altered salinity Change in quality Chemical pollution Eutrophication Changed turbidity Microbial Contamination Stratification Re-suspension of contaminated sediments Rubbish/trash Changed dilution capacity Organic pollution Chang in residence/flushing time Change in oxygen content Change in electrical conductivity/pH/acidification Change in temperature

Issue	Potential Impacts
Groundwater Quality	Movement of contaminated water Change in quality Saline intrusion Chemical Pollution Organic Pollution
Aquatic Ecology	Changed fish biomass Changed invertebrate biomass Changed species diversity Effect on fish behaviour Change in the fish community Barrier to fish migration Fish kill Effects on fish spawning Disturbance of sensitive species Loss of rheophilic flora and fauna Barrier to mammals Loss of sensitive species
Terrestrial Ecology	Altered habitat Tree removal Loss of wildlife habitat Wetland changes Change in plant biomass Change in animal biomass Changed riparian habitat Disturbance of sensitive species Changed species diversity
Human-Related	Change in noise levels Increased vibration Adverse odour Disrupted access Safety risks Health risks Nuisances Changed flood risk Changed water resource Change in the commercial nature of fisheries Disruption to commercial navigation Flooding
Land Use Change	Arable intensification Increased urban area Deforestation Afforestation Loss of riparian land Change in grade of agriculture land Restriction to future developments Development of floodplain

Issue	Potential Impacts
Visual Amenity	Altered aesthetic value Altered habitat/landscape
Recreation-Related	Alterations to access Altered facilities Change in fishing quality Disruption to users of water environment Changed boat use
Heritage & Archaeology	Disturbance and damage of known/unknown features Change to historic landscape

ANNEX 2: MONETARY VALUATION TECHNIQUES

This Annex presents the methodology used to measure environmental costs and benefits in monetary units, and summarises the most commonly used valuation techniques that have been applied.

The practical problem with monetary valuation is one of deriving credible estimates of people's preferences in contexts where there are either no apparent markets, or very imperfect markets. In the case of marketed goods, price is the measure of willingness to pay and can be readily observed. For example, if an environmental effect causes a change in production of a marketed good or service, the value of that change is the increased (decreased) output times the market price of the output. It is important to note that for the market price to correctly reflect people's preferences, it should be nondistroted by subsidies or taxes. Therefore, using shadow or real prices, i.e. market prices net of subsidies or taxes, is recommended.

However, in the case of non-marketed goods and services, which are the focus of these guidelines, we need to elicit this value in different ways. There are two broad approaches to valuation, each comprising several different techniques, as illustrated in Figure A2.1.

- **Revealed preference techniques** which infer preferences from actual, observed, market-based information. Preferences for environmental goods are revealed indirectly when individuals purchase marketed goods which are related to an environmental good in some way.
- **Stated preference techniques**, which attempt to elicit preferences directly by use of questionnaires, such as contingent valuation. All estimation of non-use values depends on these techniques.

We consider each of these approaches in turn, highlighting when each could be used, their advantages and drawbacks. Section A2.4 presents a choice of valuation techniques for use in original valuation studies in the face of different environmental effects.

A2.1 Revealed Preference Techniques

The essence of revealed preference techniques is that they infer environmental values from markets in which environmental factors have an influence as either substitutes or complements to the marketed goods. In this way people's actions in actual markets reflect, to a certain extent, their preferences for environmental assets.

There are four main revealed preference techniques, which are considered in the sections that follow.

1. Averting behaviour
2. Hedonic pricing (of property and labour)
3. Travel cost method
4. Random utility and discrete choice modelling

A2.1.1 Averting behaviour

The basis for the averting behaviour technique is the observation that marketed goods can act as substitutes for environmental goods in certain circumstances. When a decline in environmental quality occurs, expenditures can be made to mitigate the effects and protect the household from welfare reductions. For instance, expenditure on sound insulation can indicate households' valuation of noise reduction; expenditure on household water filters can be applied to estimate values of clean water.

The method is applicable in situations where households spend money to offset environmental effects. It requires data on the environmental change and its associated substitution effects. Fairly crude approximations can be found by simply looking directly at changes in expenditures on the substitute good resulting from some environmental change.

Advantages of these models are that they have relatively modest data requirements and can provide theoretically sound estimates based on actual expenditures. However, they can give incorrect estimates if other important aspects of individuals' behavioural responses are ignored. For example, individuals may engage in more than one form of averting behaviour in response to any one environmental change. Additionally, the averting behaviour may have other beneficial effects which are not considered explicitly, for example sound insulation may also reduce heat loss from a house. Furthermore, averting behaviour is often not a continuous decision but a discrete one: for example, a smoke alarm is either purchased or not. In this case the technique will tend to underestimate the value of the environmental good.

A2.1.2 Hedonic pricing

This technique depends on analysis of existing markets where environmental factors have an influence on price. The example most frequently used is that of the housing market, as the environmental attributes of a property will vary according to its location. For example, noise levels will be higher close to an airport and, other characteristics being equal, this can be expected to lower the price of a property in the area. Rent market in developing countries show that houses with piped water (guaranteed supply of better quality water) fetch higher prices than houses without piped water (see North *et al.*, 1993). The difference can be viewed as the value attached to the difference in air quality as measured by willingness to pay (WTP).

The hedonic property price (HPP) method can be used even when properties differ in many factors other than environmental quality provided that data are detailed enough. With the use of appropriate statistical techniques, the hedonic approach attempts to (i) identify how much of a price differential is due to a particular environmental difference between properties, and (ii) infer how much people are willing to pay for an improvement in environmental quality that they face and what the social value of the improvement is. The same technique has also been applied to labour in the valuation of work-related risk in hedonic wage (HW) studies. Identification of wage differentials due to differences in safety risks, for example, will give an indication of willingness to accept compensation (WTA) for incurring these risks, which can be used as a measure of the benefits of improving safety.

A2.1.3 Travel cost method

Many natural resources are used extensively for the purpose of recreation. It is often difficult, however, to value these resources because no prices generally exist for them. The travel cost approach is based on the fact that, in many cases, a trip to a recreational site requires an individual to incur costs in terms of travel, entry fees, on-site expenditures and time. These costs of consuming the services of the environmental asset are used as a proxy for the value of the recreation site and changes in its quality.

Clearly, because travel cost models are concerned with active participation, they measure only the use value associated with any recreation site. The method is now well-established as a technique for valuing the non-market benefits of outdoor recreation resources. It is useful because it is based on actual observed behaviour. However, the technical and data requirements are such that it may not be readily applicable.

A2.1.4 Random utility or discrete choice models

While the travel cost method is useful for measuring total demand or WTP for a recreational site, this technique is less useful for estimating the value of particular features or assets of the site which may be of interest. Random utility models have been developed for this purpose.

The emphasis of random utility or 'discrete choice' models is on explaining the choice between two or more goods with varying environmental attributes as a function of their characteristics. This can be useful where, for example, polluting activity causes damage to some features of a recreational site but leaves others relatively unharmed.

This can be illustrated using a simple example from a choice of transport mode. Supposing that, when undertaking a given journey, an individual faces the choice of travelling by taxi or by public transport. A taxi will take 20 minutes and cost £5, whereas public transport will take an hour but cost £2. If the individual chooses to travel by taxi, it can be inferred that s/he judges the difference of 40 minutes in time to be worth at least the £3 difference in fare. In other words, the value of the individual's time is at least £4.50 per hour.

Another example is the choice between bottled water and tap water for drinking. The former is more expensive but associated with better quality. Therefore, the price difference between bottled and tap water is an indication of the value of risk in this context.

A2.2 Stated Preference Techniques

Direct valuation or stated preference (SP) techniques enable monetary values to be estimated for a wide range of commodities which are not traded in markets. In addition, these techniques are the only methods by which it is possible to estimate non-use values of environmental resources. These valuation methods are generally based on a questionnaire. Here, we consider two approaches:

1. Contingent valuation
2. Contingent ranking

A2.2.1 Contingent valuation

In contingent valuation (CV) studies, people are asked directly to state or reveal what they are willing to pay for a benefit or to avoid a cost, or, conversely, what they are willing to accept to forego a benefit or tolerate a cost. A contingent market defines the good itself, the institutional context in which it would be provided, and the way it would be financed. The situation the respondent is asked to value is hypothetical (hence, 'contingent') although respondents are assumed to behave as though they were in a real market. Structured questions and various forms of 'bidding game' can be devised to assess the maximum willingness to pay. Econometric techniques are then applied to the survey results to derive the average bid value, i.e. the average WTP.

There are three basic parts to most CV survey instruments. First, a hypothetical description of the terms under which the good or service is to be offered is presented to the respondent. Information is provided on the quality and reliability of provision, timing and logistics, and the method of payment. Second, the respondent is asked questions to determine how much s/he would value a good or service if confronted with the opportunity to obtain it under the specified terms and conditions. These questions take the form of asking how much an individual is willing to pay for some change in provision (open-ended) or whether the respondent would agree with a given amount (dichotomous choice). Respondents are reminded of the need to make compensating adjustments in other types of expenditure to accommodate this additional financial transaction. Finally, questions about the socio-economic and demographic characteristics of the respondent are asked in order to relate the answers respondents give to the valuation question to other characteristics of the respondent, and to those of the policy-relevant population.

CV is likely to be most reliable for valuing environmental effects when familiar goods are considered, such as local recreational amenities. Additionally, CV and contingent ranking are the only technique with the potential for measuring non-use or passive use values. While the accuracy of results also depends on careful construction of the survey, a set of guidelines for applying CV to derive reliable estimates of non-use values has recently been developed by the US National Oceanic and Atmospheric Administration (NOAA) panel. This is now being extended to cover all CV studies. See Annex 8 for more information on this technique.

A2.2.2 Contingent ranking

The contingent ranking (CR) or conjoint analysis (CA) technique is also a survey method, but involves asking individuals to rank alternatives rather than explicitly express a WTP or WTA. The inclusion of prices in some of the alternatives enables rankings to be converted to monetary values. Other aspects of the CR questionnaire are the same as that used in contingent valuation.

A2.3 Dose-Response Functions

Dose-response functions are used extensively where a physical relationship between some cause of damage, such as pollution, and an environmental effect or 'response' is known and can be measured. Once the relationship has been estimated, then WTP measures derived from either conventional market prices (nondistorted prices net of subsidies or taxes) or revealed/inferred prices (where no markets exist) using one of the techniques described in the previous section. The physical damage is multiplied by this shadow price, or value per unit of physical damage, to give a 'monetary damage function'.

The approach is theoretically sound, and can be used wherever the physical and ecological relationships between a pollutant and its output or effect are known. The specification of the dose-response function is crucial to the accuracy of this technique, and is the main source of uncertainty. Difficulties and uncertainties may arise in: identifying the pollutant responsible for the damage and all possible variables affected; isolating the effects of different causes to determine the effect on a receptor (e.g. synergistic effects where several pollutants or sources exist); identification of damage threshold levels and the long term effects of low to medium levels of pollution. All these problems make it difficult to determine the appropriate empirical specification of the functional form. Additionally, there is the further complication that evidence of a physical response may not be economically relevant if individuals are not concerned about it and, therefore, do not attach a value to avoiding it. For these reasons, large quantities of data may be required and the approach may be costly to undertake. If, however, the dose-response relationships already exist and the effects are marginal, the method can be very inexpensive and provide reasonable first approximations to the true monetary value measures. Unfortunately,dose-response functions for water pollution are rare.

A2.4 Appropriate Use of Valuation Techniques for Original Valuation Studies

Figure A2.2 provides a simplified guide to choosing an appropriate technique for a given environmental effect. The flow chart begins with an environmental effect and asks if there is a measurable change in wellbeing (including changes in both marketed goods and services and environmental quality). Depending on the answer, it shows the most commonly-used techniques used to estimate monetary values for each kind of effect.

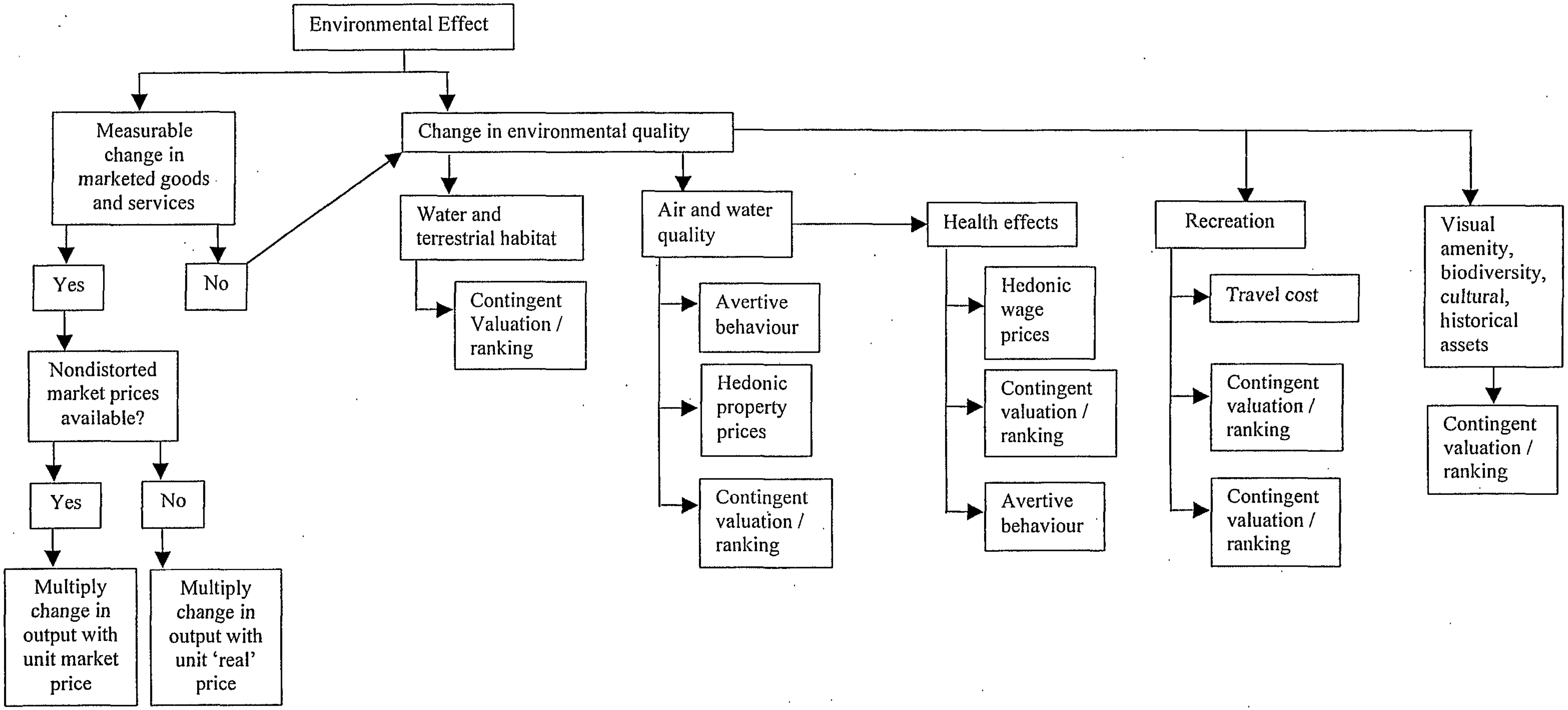

Figure A2.2: Choice of valuation technique

Note that dose-response functions apply wherever a relationship between a unit of pollution and its effect is possible to identify.

ANNEX 3: MONETARY VALUATION STUDIES RELATED TO TOTAL WATER MANAGEMENT OPTIONS – A SELECTED ANNOTATED REVIEW

The number of each study corresponds to its number in the summary Table 4.1 in Chapter 4. The studies summarised here have different levels of reliability or suitability for benefits transfer. Those with larger samples and smaller standard errors or ranges of estimates are statistically more reliable. The suitability of a study for benefits transfer depends on the similarity of site characteristics and the environmental effect valued between the original study and the scheme in question.

Note that the WTP estimates in the summaries here are reported in the money values of the year the study was published unless otherwise stated. In order to use the estimates here, the relevant figures may have to be adjusted to the appropriate year and currency. Translating a value in pounds sterling from the original year (x) to another is quite straightforward. The original value should be multiplied by the value of the UK GDP deflator for the transfer year and divided by the value of the deflator for year (x). The UK GDP deflator is given as column b in Table A3.1, and the scaling factor needed to obtain 1997 values is given in column c, i.e. the deflator in 1997 / deflator in year x. If the original figure is in dollars, it should be translated into pounds sterling using the exchange rate given in column a. For other currencies, the appropriate PPP exchange rate should be used.

Table A3.1 Adjustment of unit values to 1997 values

Year	Enter Value to be adjusted (x)	PPP Exchange Rate (£/$) (a)	UK GDP Deflator (b)	Scaling factor to obtain 1997 value (c = 125/b)	Value in £1997 = x . c (if x is in £) = x . a . c (if x is in $)
1978		0.447	40.9	3.06	
1979		0.470	46.1	2.71	
1980		0.511	54.6	2.29	
1981		0.519	60.1	2.08	
1982		0.527	64.3	1.94	
1983		0.534	68.0	1.84	
1984		0.536	71.6	1.75	
1985		0.549	75.5	1.66	
1986		0.553	77.4	1.61	
1987		0.563	81.3	1.54	
1988		0.575	86.2	1.45	
1989		0.590	92.8	1.35	
1990	e.g. $100	0.602	100.0	1.25	£75.25
1991		0.637	105.8	1.18	
1992		0.612	111.1	1.13	
1993		0.637	114.9	1.09	
1994		0.647	116.4	1.07	
1995		0.670	118.8	1.05	
1996		0.675	122.6	1.02	
1997		0.677	125.0	1.00	

A3.1 Changes in Water Quality, Quantity and Flow

1. *Authors:* Garrod G D and KG Willis
Year: 1995
Title: Estimating the Benefits of Environmental Enhancement: A Case Study of the River Darent
Background: Uses the River Darent as a case study to assess the benefits of low flow alleviation. Respondents were asked their WTP to improve flows on the Darent as well as their WTP to improve flows in all 40 low-flow rivers in Britain.
Methodology: contingent valuation survey (WTP).
Site description: River Darent in South East England, one of the most severely affected of all the low flow rivers. In some years it has dried up completely along certain stretches in the summer months, severely curtailing recreational and fishing activities
People surveyed: 325 resident households, 335 non-resident visitors, and 758 households at 44 locations within 60km of the River Darent to estimate non-user values
Results, Assumptions and Confidence Intervals:

WTP for low flow alleviation

	WTP to Maintain Flows				**WTP to Increase Flows**			
Household	**Mean Annual WTP (£1993)**	**SD**	**Median**	**No.**	**Mean Annual WTP (£1993)**	**SD**	**Median**	**No.**
WTP for all 40 low-flow rivers								
resident	18.45	24.37	10	227	12.32	18.07	10	215
visitors	15.06	20.37	10	237	9.76	13.99	5	218
non-visitors	17.18	23.38	10	490	12.92	19.60	10	474
WTP for River Darent								
residents	10.19	19.80	4.00	225	6.25	12.40	1.93	214
visitors	7.16	16.81	1.93	233	4.85	11.19	0.97	215
non-visitors	3.85	8.19	1.45	468	3.00	8.45	0.50	454

- aggregate annual benefits of LFA on the Darent therefore estimated (using population data) to be £22,359,708 (using mean estimates), or £6,606,177 (using median estimates)

Regression analysis results: Visitors' WTP

Variable	**Maintain all 40 LFAs**	**Improve all 40 LFAs**	**Maintain Darent**	**Improve Darent**
intercept	12.795 (6.19)	6.520 (1.22)	7.873 (3.07)	-0.820 (-0.36)
income > £40,000	13.294 (3.09)	11.425 (3.57)	8.056 (2.57)	8.169 (3.35)
income < £15,000	-6.001 (-2.28)	-4.756 (-2.34)	-	-2.539 (-1.70)
household size	-	-	-1.756 (-2.35)	-
no. adults in household	-	-2.109 (-1.98)	-	-
no visits to Darent per yr	-	0.105 (1.81)	0.120 (1.97)	0.162 (3.73)
respondent on daytrip	-	-	-	4.263 (1.88)
age leaving education	-	0.363 (1.67)	-	-

WWF membership	-	-5.962 (-1.87)	-	-4.436 (-1.82)
DPS membership	46.697 (4.22)	21.452 (2.21)	91.308 (8.62)	22.926 (3.12)
Greenpeace/ FoE	8.266 (1.88)	-	-	-
local wildlife trust	-	-	10.307 (2.12)	-
cycles by Darent	-	-6.908 (-1.92)	-	-
camps by Darent	-11.86 (-1.68)	-9.803 (-1.69)	-17.67 (-3.12)	-9.546 (-2.15)
birdwatches by Darent	9.542 (3.04)	-	-	3.516 (2.10)
watches wildlife by Darent	-	4.621 (2.51)	-	-
short walks along Darent	-	-	3.459 (1.68)	-
photos by Darent	-6.706 (-2.07)	-	-7.247 (-3.04)	-
enjoys Darent villages	3.989 (1.49)	-	4.322 (1.99)	-
R^2 (adj)	0.177	0.192	0.333	0.185

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2. ***Author:*** Green C H and S M Turnstall

Year: 1991

Title: The Evaluation of River Water Quality Improvements by the Contingent Valuation Method

Background: summary of three CV studies to determine benefits of water quality improvements in river corridors, focusing on increase in enjoyment to visitors due to water quality improvement and amenity value to residents of water quality improvement, over and above recreational value

Methodology: Contingent Valuation

Site description: 12 sites stratified according to purpose of use, distinguishing between corridors where activities were likely to be typical of a local park; town or city centre; or country park. Sites were further stratified according to other features of the river corridor and water quality; water quality defined as:

A: good enough for water birds (swans, coots, ducks, etc) to use the water

B: good enough to support many fish, including trout; dragonflies; many types of plant within the water and on the edge

C: safe enough for children to paddle

People surveyed: 386 visitors to river corridors

Results, Assumptions and Confidence Intervals:

WTP for improvements in water quality

			value of increased enjoyment (1991 pence/visit)*				
water quality standard	**% who would enjoy more**	**% who would visit more often**	**log mean**	**log SD**	**mean**	**SD**	**n***
A	83	66	1.78	0.37	51	209	388
B	83	80	1.82	0.40	60	230	464
C	71	77	1.85	0.39	52	220	311

*valid cases for those who would get more enjoyment

- No explanation is given for why WTP for standard C should be lower than that for standard B, which is a counterintuitive result.

- Regression work is not transparent enough to be used for benefits transfer, e.g. the potential values for some variables such as 'attractiveness of site at present' are not defined. Nor is it capable of sufficiently explaining WTP.

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3. *Authors:* Brown TC and JW Duffield

Year: 1995

Title: Testing Part-Whole Valuation Effects in Contingent Valuation of Instream Flow Protection

Background: This is a test of part-whole valuation effects (or embedding), i.e. the notion that information about substitutes has an effect on stated WTP for a good. The study focuses on protecting instream flow in rivers, using the quantity of rivers as an argument.

Methodology: three different dichotomous choice CV surveys

Site description: Respondents were asked their WTP to protect instream flows on one to five Montana rivers.

People surveyed: 582 residents in the regions where the target rivers were located

Results, Assumptions and Confidence Intervals:

Individual donations as a function of number of rivers protected

WTP per person per year	**Welfare measures**		
	Number of rivers	**75th percentile ($1988)**	**Median ($1988)**
Individual donation	1	4.02	1.63
	2	6.40	2.59
	3	8.39	3.40
	4	10.18	4.12
	5	11.82	4.78
Marginal individual donation	1	2.69	1.09
	2	2.14	0.87
	3	1.87	0.76
	4	1.70	0.69
	5	1.58	0.64

WTP (per person per yr) to an Instream Flow Trust Fund by user type and survey type

	Single River			**Five Rivers**		
	WTP ($1988)	**SE**	**No.**	**WTP ($1988)**	**SE**	**No.**
Users	10.18	2.57	153	18.02	4.97	116
Non-users	3.55	2.04	197	2.02	1.14	57
Total	6.70	1.58	368	12.43	3.11	186

- average respondent would donate more if more rivers were protected, although amount for each individual river was declining (declining marginal utility)
- users' WTP was sensitive to quantity of rivers protected, non-users' WTP was not

- authors conclude that difference between users and non-users is perceived degree of substitutability between rivers rather than embedding effects; this explains non-sensitivity of non-users' WTP to number of rivers protected.

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4. *Authors:* Daubert JT and RA Young
Year: 1981
Title: Recreational Demands for Maintaining Instream Flows: A Contingent Valuation Approach
Background: Aimed to estimate the total and marginal WTP for instream flow in a Colorado river in order to help resolve water allocation problems.
Methodology: contingent valuation
Site description: Cache de la Poudre River, located in the mountains of northern Colorado. This is a popular recreation area, with white-water rapids for kayakers and rafters, and is an excellent trout fishery. More than 100,000 user days are experienced annually by recreationalists visiting the canyon. Optimal fishing conditions occurred when the instream flow approximated 500cfs. Normal maximum yearly flow was approximately 1500cfs.
People surveyed: 134 users in the summer of 1978 (fishermen, shoreline recreationalists, and white-water enthusiasts)
Results, Assumptions and Confidence Intervals:

Estimated total and marginal values of instream flows for fishing activities
Normal yearly flow was estimated to be 1500 cfs

	Total WTP/day (\$1978)		**Marginal Value WTP/cfs/day (\$1978)**	
Flow (cfs)	**Individual**	**Aggregate**	**Individual**	**Aggregate**
100	11.67	2661	0.102	23.23
200	20.48	4669	0.074	16.94
300	26.53	6049	0.047	10.65
400	29.82	6799	0.019	4.35
500	30.35	6920	-0.009	-1.94
600	28.10	6411	-0.036	-8.23
700	23.15	5274	-0.064	-14.52
800	15.40	3507	-0.091	-20.82
900	4.85	1110	-0.119	-27.11

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5. *Authors:* Hanley N
Year: 1989
Title: Problems in Valuing Environmental Improvements Resulting from Agricultural Policy Changes: the Case of Nitrate Pollution
Background: Excess nitrate levels in receiving waters are associated with eutrophication leading to fish kills and health risks associated with human consumption of high nitrate drinking waters
Methodology: Contingent valuation
Site description: Survey to estimate the value to householders in Anglia Water's

supply area of an undertaking to guarantee water supplies with nitrate level not exceeding 50mg/l.

People surveyed: 400 households were interviewed and told that if the policy implemented all the households would pay the mean WTP estimate.

Results, Assumptions, Confidence Intervals:

Protest bids (zero WTP on account of objections to the study design, or on account of other reasons not compatible with a zero value being placed on the policy change) were omitted from the mean bid of £12.7 per household per year. Bid size was positively related to disposable income level and no evidence of strategic behaviour was found.

A3.2 General Recreation

6. *Authors:* Walsh RG, Johnson DM and JR McKean

Year: 1992

Title: Benefit transfer of outdoor recreation demand studies, 1968-88

Background: Aims to provide a range of benefits estimates for outdoor recreation activities. Reviews 120 US studies pre-1989, obtaining 287 estimates of net economic value per day for various activities.

Methodology: constructed an empirical model to explain variation in benefits estimates and indicate what adjustments might be required to effect benefits transfer

Results, Assumptions and Confidence Intervals:

Net economic values per recreation day - TCM and CV studies, 1968-88 (USA)

Activity	Mean ($1987)	SE	Median ($1987)	No
camping	19.50	2.03	18.92	18
picnicking	17.33	5.08	12.82	7
swimming	22.97	3.79	18.60	11
sightseeing	20.29	3.73	19.72	6
boating - motorised	31.56	10.36	25.67	5
boating - non-motorised	48.68	15.85	25.36	11
hiking	29.08	5.82	23.62	6
winter sports	28.5	4.48	24.39	12
resorts, cabins	12.48	-	-	2
big game hunting	45.47	3.47	37.87	56
small game hunting	30.82	3.51	27.48	10
migratory waterfowl hunting	35.64	5.87	25.27	17
cold water fishing	30.62	3.24	28.49	39
anadramous fishing	54.01	11.01	46.24	9
warm water fishing	23.55	2.46	22.50	23
salt water fishing	72.42	14.05	53.35	17
nonconsumptive fish and wildlife	22.20	2.30	20.49	14
wilderness	24.58	6.10	19.26	15
other recreation	18.82	3.65	16.06	9
Total	**33.95**	**1.67**	**27.02**	**287**

- the authors also construct an empirical model to explain variation in benefits estimates and indicate what adjustments might be required to effect benefits transfer, however they suggest it should not be used for this purpose before it is further refined

- results suggest that differences in estimates between studies arise from: omission of travel time cost; use of individual observation approach; use of in-state samples at sites where there are out-of-state visitors; TCM studies omitting cross-price substitution effects

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7. ***Authors:*** Creel M and Loomis J
Year: 1992
Title: Recreation Value of Water to Wetlands in the San Joaquin Valley: Linked Multinomial Logit and Count Data Trip Frequency Models
Background: Linked models of recreation site choice and trip frequency to quantify the economic benefits of water to wildlife viewers, anglers and waterfowl hunters in the San Joaquin Valley (SJV), California
Methodology: Travel cost method
Site description: Waterfowl hunting, fishing and wildlife viewing at 14 recreational resources in SJV including the National Wildlife Refuges, the State Wildlife Management Areas and six river destinations.
People surveyed: 1141 usable reports, about two-thirds of which reported zero trips to SJV recreation sites
Results, Assumptions and Confidence Intervals:

WTP per person per year (no. of trips for each activity is not reported and hence it is not possible to calculate a WTP per visit from the study report).

Activity	**Current Water Quantity**		**Optimum Water Quantity**	
($1992)	Model 1	Model 2	Model 1	Model 2
Viewing	128	152	150	173
Fishing	137	126	161	149
Hunting	159	149	185	174
Viewing / fishing	403	405	478	471
Viewing/hunting	441	446	500	503
Fishing/hunting	438	409	525	492
Viewing/fishing/hunting	562	557	655	648

- Model 1 pools all activities, while model 2 separates the participants in nonconsumptive recreation exclusively (wildlife and birdwatching) from participants in any form of consumptive activity (fishing or hunting).

The values in the table are the sample average of estimated total values for each discrete activity divided by the number of participants in each discrete activity, which differ by activity. Estimated total use benefits were calculated by raising the prices of each site to a choke price such that there was virtually no predicted visitation to any site for any individual. Note that for individuals who participate in multiple activities, total benefits are the sum of benefits from all discrete activities participated in.

A3.3 Fishing

8. ***Authors:*** Radford AF, A Hatcher and D Whitmarsh
Year: 1991
Title: An Economic Evaluation of Salmon Fisheries in Great Britain
Background: Project aimed to provide estimates of the value to England, Wales and Scotland of their salmon and sea trout fisheries, covering both commercial and recreational elements. For recreational fisheries, they aimed to estimate and categorise the expenditure anglers incurred on goods and services in pursuit of their sport.
Methodology: Mail survey
Site description: Salmon and sea trout fisheries in Britain.
People surveyed: Random sample of anglers in possession of fishing licenses in 1988. 182 usable responses.
Results, Assumptions and Confidence Intervals:

Expenditure by anglers on goods and services (incl. travel costs) in pursuit of their sport

	Total expenditure - all anglers (£1988)	Expenditure per angler per year (£1988)	Expenditure per angler per day (£1988)
All regions	16,449,731	377.91	17.18
Northumbria	1,033,226	309.07	13.79
North West	4,992,744	435.21	17.83
Severn-Trent	419,854	261.43	10.32
Southern	277,481	924.94	65.46
South West	3,164,366	422.65	25.04
Welsh	5,993,749	322.35	14.74
Wessex	496,330	467.35	22.60
Yorkshire	71,881	332.78	26.67

- data are also given for each of eight regions individually, including: breakdown of expenditure; average salmon catches in each river; number of fishing licenses by NRA region (1988).
- values of commercial fisheries and rod fisheries are also estimated, and data on these operations is provided, including for example revenue and contribution to employment.

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9. ***Authors:*** Davis J and O'Neill C
Year: 1992
Title: Discrete-Choice Valuation of Recreational Angling in Northern Ireland
Background: Freshwater angling in the province: WTP for permits and licences compared to the actual prices paid
Methodology: Contingent valuation (discrete choice)
Site description: Northern Ireland's angling sites
People surveyed: A survey of 700 anglers was carried out with 22% response rate. The only question was that of WTP. Distribution of other factors which affect the WTP response was assumed to be close to that of the population
Results, Assumptions and Confidence Intervals:

For any group of customers, the average maximum WTP a bid level of B was established using a model of the form: $Pr = a-bB$, where Pr is the probability of a positive WTP response, and a and b are parameters to be estimated.

WTP for game season permits

	Anglers who had purchased the previous year	**Anglers who had not purchased the previous year**
Pr =	2.4821-0.055B	1.2599-0.029B
t-values (all significant at 5%)	(5.21) (4.17)	(3.5) (2.91)
Median WTP (£1992)	36.04	26.06
Actual price (£1992)	28.50	28.50

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10. *Authors:* Loomis J B

Year: 1996

Title: Measuring the Economic Benefits of Removing Dams and Restoring the Elswha River: Results of a Contingent Valuation Survey

Background: Survey to measure the total nonmarket value for restoring the Elswha River and its fisheries to residents of Clallam county (the county where the Elswha is located), the state of Washington, and to the rest of the United States.

Methodology: Contingent valuation (dichotomous choice)

Site description: Elswha and Glines Canyon dams (Washington State) were built in 1913 and 1927, respectively, without any fish passage facilities and block 70 of the Elshwa River's 75 miles to migrating salmon. Most of the River flows through a National Park and hence is not subject to other pressures. Therefore, the removal of the dams would result in substantial increases in salmon and steelhead populations.

People surveyed: Mail survey to 600 households in Clallam County (77% response); 900 households in Washington State (68% response) and 1,000 households in the rest of the USA (55% response)

Results, Assumptions and Confidence Intervals:

WTP to restore Elshwa River fisheries

	Clallam County	Rest of Washington	Rest of USA
Mean WTP per person per year ($1996)	59	73	68
95% confidence interval	21-333	60-99	56-92

- The payment vehicle for the WTP questions was an increase in the federal taxes for the next 10 years – the mean estimate is valid for these 10 years. The annualised values should be used if WTP estimate is to be transferred to longer periods.
- The study reports similarities between these and other results which are reported below:

Study	Good - Location	Results
Hanemann et al (1991) – CVM	Increasing Chinook salmon population, San Joaquin River, CA	$181-336 per household per year
Olsen et al (1991) – CVM	Doubling salmon and steelhead runs in the Columbia River	$50 per household per year including use, option and existence values
Sanders et al (1990) - CVM	To preserve the undammed portions of three rivers in the USA	$58 per household per year ($1994)

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11. Authors: Harpman D A, Sparling E W and Waddle T J

Year: 1993

Title: A Methodology for Quantifying and Valuing the Impacts of Flow Changes on a Fishery

Background: The three objectives of this study were to develop a framework for predicting fish population as a function of stream discharge, to estimate the economic use value of these fish and to demonstrate the use of this framework for the analysis of alternative reservoir release regimes. Only the second objective is reported here.

Methodology: Contingent valuation (dichotomous choice)

Site description: Taylor River in Colorado, which is characterised by low winter flows with extreme high flows occurring during the spring runoff period. The flows in the river are controlled by the releases from Taylor Park reservoir which has a live storage capacity of 1.31×10^8 m^3. The fishery in the river is composed of both brown trout and rainbow trout. The focus of this study was the former.

People surveyed: 287 anglers were asked four WTP questions each: WTP for their average catch and for hypothetical additions to their average catch of one fish, three fish and seven fish of average size, respectively. The WTP options ranged from 10 cents to $65 per day.

Results, Assumptions and Confidence Intervals:

Individual WTP per day for catch by Stream Anglers:

Fish caught	Mean value $1993	Marginal value $1993
1	23.06	Not available
2	25.05	1.98
3	26.28	1.23
4	27.19	0.91
5	27.92	0.73
6	28.53	0.61
7	29.05	0.52
8	29.51	0.46
9	29.92	0.41
10	30.29	0.37
11	30.63	0.34
12	30.95	0.31

The study reports a probability equation for saying yes to a given WTP bid. This cannot be transferred directly to estimate a WTP in the policy site. However, it is worth mentioning that the variables thought to affect the respondents' WTP were price, total catch per day, the respondent's age and family income.

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12. ***Authors:*** Provencher B and Bishop R C

Year: 1997

Title: An Estimable Dynamic Model of Recreation Behaviour with an Application to Great Lakes Angling

Background: The study estimates a model of recreation behaviour which covers the salmon and trout fishing on Lake Michigan considering factors such as the weather, the opportunity to participate in fishing derby and time elapsed since the last fishing trip

Methodology: Travel cost method

Site description: Lake Michigan

People surveyed: Data were collected through a survey of Lakeridge Boat Club members.

Results, Assumptions and Confidence Intervals:

Selected parameter estimates from the angling demand estimate are as follows. For example, the first coefficient suggests that a one degree Fahrenheit increase in temperature increases the value of a fishing trip to Lake Michigan by $1.67.

Variable	Coefficient	Standard error
Temperature (degrees Fahrenheit)	1.67	0.243
Wind (mph)	-3.52	1.458
Time elapsed from last trip (days)	-15.16	1.621
Participation in fishing derby	162.63	9.499
Mean catch	1.04	0.653
Over 75 years old?	-68.93	9.359
Fish on weekend if working	-70.66	7.565
Expected catch	0.73	0.363
Current site-wide catch	0.48	0.952

The overall results showed among other things that retired anglers took an average of 18.8 non-derby trips per season. Dividing the seasonal value of retired non-contestants by this figure yields $39 as an approximation of the value placed by retired anglers on non-derby trips. Similar calculations for employed anglers yield $88 for a derby trip and $37 for a non-derby trip. The value of a non-derby trip is virtually the same for retired and employed anglers.

A.3.4 Reservoir Recreation

13. ***Authors:*** Pearson M

Year: 1992

Title: Recreational and Environmental Valuation of Rutland Water

Background: Rutland reservoir was closed for all water-based recreation for a period of 13 months (September 1988 to October 1989) due to cynobacterial problems. The main cost was that to recreational users. This was a survey to determine: WTP for various recreational activities on the reservoir and the total value of on-site recreational activity

Methodology: contingent valuation survey to estimate users' values;

Site description: Rutland is the largest reservoir in England, and an AONB. It is extensively used for day trips. Recreational activities include cycling, sailing, angling, birdwatching, walking. WTP was asked to prevent algal blooms and closure of the reservoir.

People surveyed: 641 interviews completed on-site (users)

Results, Assumptions and Confidence Intervals:

Average WTP to preserve recreational and amenity benefits

Reason for visit	Number	Mean WTP (£ 1992)	Standard deviation
sailing - hired boat	1	100.00	0
sailing - private boat	19	23.61	36.55
windsurfing/canoeing	22	24.77	31.38
boat cruise	12	3.83	8.79
boat fishing	30	31.60	96.28
bank fishing	17	10.65	15.96
disabled angler's pontoon	0	0	0
adventure playground	4	18.75	37.5
walking <2 miles	27	11.96	21.48
walking >2 miles	50	28.39	75.15
walking dog (any distance)	24	10.93	16.84
picnic	47	7.35	15.15
football/ kite/ children	28	10.95	20.64
relaxing/ enjoying scenery	133	9.61	18.24
birdwatching	20	16.00	34.26
nature watching	8	11.56	18.06
cycling - hired cycle	95	23.62	105.22
cycling - own cycle	76	13.11	38.84
church museum	2	5.50	6.36
Barnsdale Drought Garden	4	2.50	5.00
other	21	39.29	131.38
Total	**641**	**16.74**	**59.46**

- average number of visits per party per year = 10.23
- average party size = 3.36
- average household size of sample = 2.83
- average distance travelled = 44 miles
- relevant population: visitors; number of visits estimated to be 900,000 p.a., or (using survey data on party size and average number of visits) 31,136 visiting households
- total use value of Rutland estimated to be £521,225 p.a.

14. ***Authors:*** Loomis JB

Year: 1987

Title: Balancing Public Trust Resources of Mono Lake and Los Angeles' Water Right: An Economic Approach

Background: Abstraction of water from the major streams feeding Mono Lake resulted in a substantial lowering of the lake level, which, when coupled with drought, created an ecologically stressed condition at the lake. It would be possible to abstract water from elsewhere, but at a higher cost. This was a survey to determine WTP for three different water levels.

Methodology: CV study, dichotomous choice

Site description: Mono Lake is a relatively unique saline lake in Eastern California. It is a productive habitat for brine shrimp and brine flies and these food sources, along with two islands and dozens of islets provide habitat for nearly 100 species of birds. The WTP scenarios described changes in (i) height of lake (recreational access and visual effects); (ii) change in water quality and effect on shrimp; (iii) implications for bird populations and biodiversity; and (iv) effect on severity of dust storms (visibility, health effects).

People surveyed: 164 residents of California in 1985 via mail questionnaire

Results, Assumptions and Confidence Intervals:

State residents' WTP for protection of Mono Lake (alternative 1 = highest water level)

	Generalise sample to state		**Conservative**	
	monthly household average ($1985)	**annual aggregate ($1985)**	**monthly household average ($1985)**	**annual aggregate ($1985)**
alternative 2 vs. 3	21.78	2584	9.58	1137
alternative 1 vs. 2	7.43	882	3.27	388
total	29.21	3466	12.85	1525

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15. ***Authors:*** Ward FA, Roach BA and JE Henderson

Year: 1996

Title: The Economic Value of Water in Recreation: Evidence from the California Drought

Background: The authors aimed to investigate how recreational values change with reservoir levels. Data on visitors were collected by origin and destination. Because lake levels varied widely over the sample period, the effect of water level on visits could be isolated. In these cases, lake levels affected aesthetics, the expansion of mud flats, fish and bird habitat and recreational facilities such as boat ramps which were occasionally inoperative.

Methodology: regional travel cost model

Site description: Ten US Army Corps of Engineers reservoirs in California's Sacramento district

People surveyed: visitors to the reservoirs during 1983-85
Results, Assumptions and Confidence Intervals:

- marginal values of water are derived for each of the 10 lakes individually, at levels from 10% to 100% full: marginal values are generally declining as water level falls
- three main factors influence the marginal values of water: visitor use, reservoir size and reservoir bank slope
- in general it is more economically valuable at the margin to hold water in a lake when it is nearly full than when it is nearly empty, which has important implications for water resource management in multiple-use river basins

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16. ***Authors:*** Parsons G R and M J Kealy
Year: 1994
Title: Benefits Transfer in a Random Utility Model of Recreation
Background: Lake recreation benefits to two non-overlapping samples were estimated, benefits from one to the other were transferred to test whether the transferred value is similar to the true model.
Methodology: Random Utility Model
Site description: The model includes recreation activities in 1133 of Wisconsin excluding lakes less than 100 acres large, Lake Michigan and Lake Superior. The respondents were asked to identify and estimate the number of trips taken to each lake they visited. No person was questioned about more than six lakes. In addition to their answers, the characteristics of the lakes such as acreage, depth, water quality and measures of access such as the presence of boat ramps were included in the regression analysis.
People surveyed: A 1978 telephone survey of 603 individuals who visited lakes in Wisconsin, 117 of whom were from Milwaukee County and 486 of whom were from outside the county.
Results, Assumptions and confidence intervals:

Although the results include three types of benefits transfer under different assumptions about the data available to the respondents, we only report the results from the true Milwaukee model. Mean benefit per visit was (in \$1978) \$0.67 with 95% confidence interval of 0.54-0.80.

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17. ***Authors:*** Cordell H K and Bergstrom J C
Year: 1993
Title: Comparison of Recreation Use Values Among Alternative Reservoir Water Level Management Scenarios
Background: This study was commissioned by the Tennessee Valley Authority to evaluate the recreational benefits of alternative reservoir water level management strategies.
Methodology: Contingent valuation
Site description: Four lakes in the region were included in the study. Lake Catuge and Lake Fontana are more commercially developed, e.g. providing

	water skiing facilities more dependent on water levels than Lake Hiwassee and Lake Santeetlah and attract users who are better able to pay for higher water levels
People surveyed:	460 interviewees over 1988 and 1989 seasons were asked to suppose that everyone using the reservoir in question would be required to purchase a personal annual recreation pass for that reservoir

Results, Assumptions and Confidence Intervals:

Estimating mean WTP was a two step procedure.. First, the following logit function estimated:

$$Y = \frac{1}{1+e^{-(b0+b1LPRICE+b2X)}}$$

Where Y takes the value of 1 for 'yes' and 0 for 'no'. (Variables other than LPRICE are included within the vector X.)

Estimates for the coefficients and their standard errors are given in the table below. After estimating the logit function, mean WTP was estimated by the integral:

$$MWTP = \int_0^{300} \frac{1}{1+e^{-(b0+b1LPRICE+b2X)}}dp$$

Variable	Definition	Coefficient (Standard error)
dependent variable	natural logarithm of WTP	
B_0	intercept	2.6557 (0.3024)*
LPRICE	natural logarithm of offer price for the annual pass	-0.8652(0.367)*
LSPEND	natural logarithm of % of annual household income spent on outdoor recreation	0.0921 (0.460)+
LYEAR	natural logarithm of years of participation at the reservoir/age	0.1034 (0.446)+
SEX	sex of respondent	0.4117 (0.1216)*
R	Dummy variable for reservoirs All zero for Chatuge R1=1, R2=0, R3=0 for Hiwassee R1=0, R2=1, R3=0 for Santeetlah R1=0, R2=0, R3=1 for Fontana	R1=-0.4541 (0.1364)* R2=-0.6746 (0.1494)* R3=-0.1267 (0.1271)

S	Dummy for management alternatives All zero for current system S1=1, S2=0, S3=0 for 1 S1=0, S2=1, S3=0 for 2 S1=0, S2=0, S3=1 for 3	S1= 0.2592 (0.1403)++ S2=0.5914 (0.1398)* S3=0.8134 (01406)*

L: natural log, * significant at 0.01 level, + significant at 0.05 level, ++ significant at 0.1 level. The regression analysis resulted in the following WTP estimates:

	Annual WTP per individual ($1993)			
Reservoir	Current management	1: near full 1 month longer	2: near full 2 months later	3: near full 3 months later
Chatuge	48.99	58.65	73.10	83.85
Fontana	44.56	53.71	67.25	77.68
Hiwassee	35.26	42.63	53.94	62.83
Santeetlah	30.54	37.14	47.12	55.11
Average across all reservoirs	41.70	51.15	64.58	75.05

A3.5 Canal Related Recreation

18. ***Authors:*** Adamowicz W L, Garrod G D and KG Willis

Year: 1995

Title: Estimating the Passive Use Benefits of Britain's Inland Waterways

Background: aims to (i) assess values that visitors to canals place on their visits; (ii) estimate passive use values of those who do not visit; (iii) assess relative importance of different canal attributes, i.e. those associated with boating v. those associated with towpaths and wildlife v. loss of all canal features

Methodology: Contingent Valuation

Site description: all canals in Britain

People surveyed: sample of 758 households across Britain

Results, Assumptions and Confidence Intervals:

WTP for maintenance of boating and towpath facilities at all British canals

Respondent Category	Mean Annual Household WTP (£1991)	Standard Deviation	Median (£1991)	Valid Responses
all responses	6.66	12.27	0.75	331
strategic answers removed	6.78	12.16	1.00	281
canal visitors	8.86	15.68	1.00	115
non-visitors	5.55	10.01	0.75	204

- aggregate annual preservation value estimated to be £145,377,000 (95% confidence interval £114,930,000 to £175,825,000)

19. *Authors:* Willis KG and GD Garrod

Year: 1991

Title: Valuing Open Access Recreation on Inland Waterways: On-site Recreation Surveys and Selection Effects

Background: aims to estimate the economic benefits of public good forms of recreation along inland waterways and canals in Britain, e.g. walking along the towpath, but not fishing or boating which may involve some kind of payment

Methodology: Contingent valuation and travel cost method

Site description: Surveys conducted on 24 different sites on canals in England

People surveyed: 1502 questionnaires completed, covering 3941 visitors

Results, Assumptions and Confidence Intervals:

WTP for public good visits to canals

	locals (<10 miles)	**non-locals** (>10 miles)
WTP per visit (1989 pence)	32.86	40.12

- average WTP for different canal-side activities is also given for certain individual canals (Newark, Anderton, Weaver, Gloucester, Midlands) but no general model is given
- aggregation gives lower bound estimate of WTP for open-access recreation of £61,969 million

A3.6 Habitat Preservation

20. *Authors:* Brouwer R, Lanford I H, Bateman I J, Crowards T C and Turner RK

Year: 1997

Title: A Meta Analysis of Wetland Contingent Valuation Studies

Background: Two objectives of the study are: to assess the values attributable to the individual use and non-use values associated with ecological, biogeochemical and hydrological functions provided by wetlands and applying an advanced multi-level modelling method to achieve the first objective

Methodology: A Meta Analysis of 30 Wetland Contingent Valuation Studies

Site description: Two thirds of the studies analysed are from the USA, while the rest is from Europe, half of which are from the UK. Other European countries are Sweden, Austria (summarised below) and Netherlands. Only two of the wetlands are coastal

People surveyed: Sample sizes, survey method, payment vehicle and the format of the WTP question vary across the studies analysed.

Results, Assumptions and Confidence Intervals:

Some of the average annual WTP per household per year estimates for different wetland characteristics. The study reports more detailed results..

WTP for different wetlands characteristics

Wetland characteristics	Mean (SDRs)	Standard error	Min. SDRs	Max. SDRs
Salt water wetland	56.2	27.2	19	137
Fresh water wetland	58.9	6.1	1	267
Salt and fresh water	237.5	106.2	131	344
Flood control	92.6	24.4	24	177
Water generation	21.5	6.8	3	59
Water quality	52.5	5.9	9	174
Biodiversity	76.1	12.8	1	344
Very large	86.9	17.6	19	177
Large	70.3	21.6	12	344
Medium	67.0	8.9	3	267
Small	29.5	13.2	1	137
Very small	53.4	13.8	24	105
Value types				
Use value	68.1	8.4	9	344
Non-use value	35.5	4.8	12	78
Use and non-use value	63.8	12.9	1	267
Region				
Ill.,Iowa, Wisconsin, Kentucky	28.6	5.0	3	88
Canada	70.6	19.7	22	112
Colorado, new Mexico	35.4	11.7	2	106
New Hampshire, Mass., Penns.	43.9	7.4	9	137
Washington, Oregon	52.7	6.2	47	59
California	164.3	17.6	43	267
Georgia, Louisiana	187.0	54.5	99	344
UK	34.9	15.8	1	177
The Netherlands	25.9	3.0	169	40
Austria	17.6	-	17.6	17.6
Sweden	55.6	23.2	32	79

21. ***Authors:*** Bateman I J and I H Langford

Year: 1996

Title: Non-users' Willingness to Pay for a National Park: An Application and Critique of the Contingent Valuation Method

Background: aimed to (i) detect any relationship between distance and stated value, e.g. does WTP decline with distance of home residence away from the site, and (ii) to detect socio-economic valuation gradient, i.e. did WTP alter across social class, income, and/or other socio-economic characteristics.

Methodology: Contingent Valuation

Site description: Norfolk Broads, a wetland area of recognised international importance; most is a designated ESA, contains 24 SSSIs and two sites notified under the international RAMSAR convention.

People surveyed: four sampling zones were defined, according to distance from the

Broadlands. Areas were further divided according to socio-economic characteristics. 344 mail surveys were completed and returned.

Results, Assumptions and Confidence Intervals:

WTP and distance decay

Distance zone (km)	**No. of respondents**	**Mean Annual WTP (£1995)**	**SD**
0-40	58	39.34	94.81
41-150	66	27.67	86.15
151-260	139	13.97	27.41
260+	47	14.72	28.69
All	310	21.75	60.94

WTP and visitation

Visit Experience	**No. of respondents**	**Mean Annual WTP (£1995)**	**SD**
holiday	118	27.86	70.92
day trip	82	25.65	77.37
never visited	110	12.29	26.83

- results show marked decay with distance
- non-visitors have a substantially lower WTP than those who have visited
- authors conclude that study is incapable of isolating a non-use value, due to factors such as self-selection of respondents and unrepresentative nature of final replies

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22. ***Authors:*** Kosz M

Year: 1996

Title: Valuing Riverside Wetlands: the Case of the 'Donau-Auen' National Park

Background: WTP survey as the determinant of the respondents' choice to be in favour or against the 'Donau-Auen' national park to be used in a cost-benefit analysis comparing the different uses of this wetland area.

Methodology: Contingent valuation

Site description: 12,000 hectares of wetlands (floodplain forests) eat of Vienna along the River Danube to be protected as an internationally acknowledged national park.

People surveyed: 962 Austrians were interviewed face to face and asked their WTP as entrance fees to the park and motives for their payment. Information on size and the uniqueness of the park, endangered species, international acknowledgement and the necessity for protective measures was provided.

Results, Assumptions and Confidence Intervals:

WTP for visits to national park

Project	WTP in ATS per respondent	WTP in ATS per respondent including zero responses
1	919.8 (1,594.63) [500]	329.25 (1,050.32) [100]
2	694.9 (1,308.35) [300]	122.21 (607.96) [0]
3	689.85 (1,426.19) [200]	69.63 (496.62) [0]

(standard deviation in brackets), [median WTP in brackets]

Three optional projects the respondents was asked their WTP to avoid were:

1. 'Donau – Auen' national park over an area of 11,500 ha,
2. Hydroelectric power station Wolfsthal-Bratislava II including a national park over an area of 9,700 ha,
3. Hydroelectric power station Wildungsmauer including a national park over an area of 2,700 ha.

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23. ***Authors:*** Tapsell S, Turnstall S, Costa P and M Fordham

Year: 1992

Title: Ravensbourne River Queen's Mead Recreation Ground Survey

Background: survey of park users and residents in the Queen's Mead area to determine
public attitudes about two options for changing the river values of recreational use of the park

Methodology: 'value of enjoyment' method to estimate users' values

Site description: Popular park situated near town centre of Bromley, with river cutting through the middle. River has been channelled for flood prevention, resulting in concrete-lined walls and riverbed, with little ecological value. The park is used mainly for walking (including passing through for access to town), the children's playground, sports/games. Options considered: (A) do nothing; value of enjoyment under current conditions; (B) change course of river slightly and introduce new plants; (C) new meandering channel with new wetland areas.

People surveyed: 357 park users and 352 residents within 0.5 mile radius

Results, Assumptions and Confidence Intervals:

WTP for changes to river in local park

Option under consideration	People surveyed	Value of enjoyment (£1992 per visit) median value	mean value	std deviation	no. cases
Option A	users	0.50	1.67	4.96	210
	residents	0.50	1.29	2.24	183
Option B	users	1.00	2.37	5.85	202
	residents	1.00	1.98	2.99	175
Option C	users	1.00	2.94	6.98	203
	residents	1.00	2.81	4.04	177

- relevant population: assumed to be those residing within 1 mile of the park
- number of visits: taken from *London Borough of Merton's Park Users Survey 1984* to be around 50,000 per year;
- value of different changes does not take into account increase in visitor numbers

A.3.7 Landscape

24. *Authors:* Willis K G and Garrod G D

Year: 1993

Title: Valuing Landscape: a Contingent Valuation Approach

Background: To evaluate the preferences of residents and visitors for various landscapes, including today's landscape, through WTP for that landscape.

Methodology: Contingent Valuation

Site description: The landscape of Yorkshire Dales comprises fells and dales (valleys), rivers, waterfalls, dry stone walls, meadows, stone barns, small woods, stone-built villages, archaeological remnants, limestone caves, sinks, pavement and scars. In addition to today's landscape, the respondents were given the choice of the following landscape types: abandoned, semi-intensive agriculture, intensive agriculture, planned, conserved, sporting and wild. These landscapes were described using literary descriptions and paintings.

People surveyed: 300 households from the 12 largest parishes in the Craven district of North Yorkshire during the last four months of 1990 and 300 visitors some of whom had travelled up to 350 miles to visit the Dales.

Results, Assumptions and Confidence Intervals:

The results were reported in two ways:

1. Total expenditure on preservation and enjoyment of countryside and WTP to preserve landscapes (£ per year at 1990 prices)

	Visitors	Residents
Total countryside budget	126.18 (225.16)	59.20 (130.87)
WTP to preserve most preferred landscape	27.08 (44.04)	25.09 (48.48)
WTP to preserve today's landscape when most preferred	22.12 (32.21)	26.03 (57.06)
WTP to preserve today's landscape compared to abandoned landscape (when today's landscape is not the most preferred)	26.21 (50.02)	21.71 (54.0)
WTP to preserve today's landscape whether most preferred or not	24.56 (42.93)	24.05 (55.64)

Standard deviation in brackets.

Total countryside budget includes any donations made to countryside causes, membership fees for countryside organisations and car park and entry fees for visits.

2. WTP to preserve landscapes most preferred by each respondent (£1990 per year)

Landscape	Visitors	Residents
Abandoned	23.75 (17.68)	7.67 (13.33)
Semi-intensive	-	-
Intensive	-	-
Planned	18.18 (22.07)	13.38 (30.24)
Conserved	34.96 (64.50)	27.44 (42.79)
Sporting	33.67 (57.45)	22.50 (32.29)
Wild	34.2 (35.5)	29.75 (28.88)
Today's	22.12 (32.21)	26.03 (57.06)

Standard deviation in brackets.

The study reports aggregated values as well. These are not reported here. However, for example, aggregate WTP to preserve today's landscape can be found as follows: the number of visitors (plus residents) multiplied by their respective average WTP (from the first table), multiplied by the proportion of the relevant population who gave this landscape as their first preference choice.

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25. ***Authors:*** N Hanley, D MacMillan, RE Wright, C Bullock, I Simpson, D Parsisson and B Crabtree

Year: 1998

Title: Contingent Valuation Versus Choice Experiments: Estimating the Benefits of Environmentally Sensitive Areas in Scotland

Background: Study aims to estimate the value of conservation benefits of an ESA

	in Scotland. ESAs are designated areas in the UK which are of special landscape and/or conservation interest, where traditional farming methods are considered to be essential to maintaining this wildlife and landscape quality.
Methodology:	Two different techniques are used for comparison: contingent valuation (dichotomous choice) and choice experiments.
Site description:	Breadalbane ESA in Highland Perthshire, comprising 180,000 ha of mountain and valley lands. Land cover is made up of grasslands, heather, moorland, wetlands, and birch and ash woodlands, and conifer in upland areas. Changes were described in terms of three criteria: biodiversity, presence/absence of key indicator species and relative rarity.

Results, Assumptions and Confidence Intervals:

WTP for Breadalbane ESA (£/household/year)

	Mean WTP	95% CI for mean	Sample size
Residents	31.43	20.62-42.24	325
general public	22.02	14.50-29.54	249
Visitors	98	53-135	235

26.	***Authors:***	Willis K G, Garrod G D and Saunders C M
	Year:	1995
	Title:	Benefits of Environmentally Sensitive Area Policy in England: A Contingent Valuation Assessment
	Background:	The objectives of the paper are to: determine the benefits the public derives from ESAs and assess whether ESAs are efficient, by comparing the costs of ESA provision against their benefits to the general public. Only the former is summarised here. The impact of ESA policy is the difference between the landscape. Wildlife and the preservation of archaeological and historical features with ESAs compared to the continuation of intensive agriculture in the designated area.
	Methodology:	Contingent Valuation
	Site description:	South Downs ESA has high scenic value, characterised by open rolling downland, important wildlife habitats, particularly wildflowers and insects. Somerset Levels and Moors comprise an open, low lying and generally flat landscape, characterised by small rectangular fields separated by ditches and often lines of pollarded willows.
	People surveyed:	Three groups of people were surveyed: residents within the two ESA areas and visitors to the ESAs for their use value and the general public in England for their non-use value.

Results, Assumptions and Confidence Intervals:

WTP for ESAs

	Population	Mean WTP per person per year	Standard deviation	Median WTP per person per year
Somerset Levels and Moors ESA				
Residents	212	17.53	73.97	3.63
Visitors	243	11.84	39.86	5
South Downs ESA				
Residents	218	27.52	74.49	6
Visitors	220	19.47	64.87	5
General Public	534	36.65	72.71	10

A3.5 Traffic Related Effects

27. ***Author:*** Newbery D
Year: 1992
Title: Economic Principles Relevant to Pricing Roads
Background: Study which estimates the marginal cost of congestion for various types of roads in the UK.
Site description: UK
Results, Assumptions and Confidence Intervals:

Marginal costs of congestion in the UK (1990 pence per km)

	HGV	Passenger vehicles
motorway	0.46	0.26
urban central peak	63.65	36.37
urban central off-peak	51.15	29.23
non-central peak	27.76	15.86
non-central off-peak	15.30	8.74
small town peak	12.06	6.89
small town off-peak	7.35	4.20
other urban	0.14	0.08
rural dual carriageway	0.12	0.07
other trunk/principal	0.33	0.19
other rural	0.09	0.05

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28. ***Authors:*** D Maddison, DW Pearce, O Johansson, E Calthrop, T Litman, E Verhoef
Year: 1992
Title: The True Costs of Road Transport
Background: Provides estimates for a variety of different externalities associated with traffic, including air pollution, contribution to global warming, noise, congestion and accidents.
Methodology: Variety of different methodologies, some original work and some reviews of existing estimates.
Site description: UK

Results, Assumptions and Confidence Intervals:

External costs of road transport – UK average (1993 pence per km)

	HGV	Bus/coach	Passenger car
health costs*	30	36	2
noise costs	1.96	1.31	0.66

* pollutants considered: PM10, SOx, NOx, VOCs, lead, benzene

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29. *Authors:* Department of the Environment, Transport and the Regions
Year: 1997a
Title: Road Statistics Great Britain 1997 Edition
Background: Average daily traffic flows for different types of roads
Site description: UK
Results, Assumptions and Confidence Intervals:

Average daily flows on different UK roads, 1996

Type of Road	Average daily flow
motorway	62430
built-up area: trunk	19580
built-up area: principal	15110
non built-up area: trunk	15640
non built-up area: principal	7460
minor	1390

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30. *Authors:* Department of the Environment, Transport and the Regions
Year: 1997b
Title: Road Accidents Great Britain: 1996 The Casualty Report
Background: Statistics on HGV related accidents
Site description: UK
Results, Assumptions and Confidence Intervals:

Cost of Accidents Associated with HGV Traffic

a	total fatalities due to HGVs per year	580
b	total serious injuries due to HGVs per year	3460
c	total vehicle kilometres by HGVs (billions)	30.7
d	average risk of fatality per vehicle km for HGVs (a/c)	$1.89*10^{-8}$
e	average risk of serious injury per vehicle km for HGVs (b/c)	$1.13*10^{-7}$
f	cost of serious injury	£98,510

using these figures in conjunction with an estimate for the value of a statistical life

g	value of a statistical life	£2,300,000
h	total cost of fatality per vehicle km for HGVs in pence/km (d*g)	4.3
i	total cost of serious injury per vehicle km for HGVs in pence/km (e*f)	1.1

Cost of Accidents Associated with Cars

a	total fatalities due to cars per year	2969
b	total serious injuries due to cars per year	41,696
c	total vehicle kilometres by cars (billions)	362.4
d	average risk of fatality per vehicle km for cars (a/c)	$8.19*10^{-9}$
e	average risk of serious injury per vehicle km for cars (b/c)	$1.15*10^{-7}$
f	cost of serious injury	£98,510
g	value of a statistical life	£2,300,000
h	total cost of fatality per vehicle km for cars in pence/km (d*g)	1.9
i	total cost of serious injury per vehicle km for cars in pence/km (e*f)	1.1

ANNEX 4: NON-USE VALUES: A GUIDE TO THE ISSUES

A4.1. Defining Non-use Value

Non-use value (NUV) is a potentially important category of economic value, but it is also a debated one.

Chapter 4 showed that economic values can be divided into *use values* and *non-use values*. Consider a wetland area. Birdwatchers are willing to pay to conserve the wetland area because they derive enjoyment from watching birds: they make *use* of the wetland. Wildfowlers will also be WTP for their use of the area, as are boaters, hikers and general recreationists and tourists. But there may well be people who are willing to pay to conserve the wetland even though they make no use of the wetland at all. Moreover, they may intend never to make use of it. Such individuals are said to have a *non-use* value.

Differentiating use and non-use is not easy. Does someone who does not visit the wetland, intends never to visit it, but who enjoys seeing TV films about it have non-use or use value? This is probably use value because the individuals in question leave a '*behavioural trace*' in the markets for TV films. Compare this to just contemplating the beauty of the wetland and feeling satisfied that the flora and fauna are there. This would appear to be non-use.

The dividing line between use and non-use value is fuzzy but has something to do with whether or not we can identify changes in behaviour associated with the wellbeing derived from the thing being valued.

A4.2 Terminology

The idea of 'pure' non-use value is that the individual values the *existence* of the good (asset) in question, so that non-use value most divorced from any connotation of use value is known as *existence value*. Until recently, this was the term generally used but *passive use* value has tended to supersede it. Some writers include *bequest value* in non-use value, so that:

$$\textit{non-use value} = \textit{passive use value} = \textit{existence value} + \textit{bequest value}$$

where bequest value is intended to capture one of the *motives* for NUV, namely the desire to leave environmental assets to future generations. In most cases it is not essential to differentiate bequest and existence values. Indeed, not much is gained from trying to make the distinction.

Typically, NUV can only be estimated using questionnaire approaches (contingent valuation and contingent ranking). Since these techniques still attract controversy, this may be an added reason for supposing that NUVs will have a wider margin of error than the error attached to use values, although the evidence for assuming this is not substantial.

A4.3 The Practical Importance of Non-use Value

The practical importance of NUV can be partly determined by looking at the available estimates of NUV in relation to use value, but only partly because there are disputes about the validity of some of the estimates of NUV. In other cases, it is clear that what is estimated is not just NUV but some mix of NUV and use value.

Not many studies have attempted to 'decompose' economic value according to use and non-use elements. Table A4.1 reports a number of available studies, ignoring those studies where 'total' values are estimated without attempts to decompose and ignoring those studies where *only* NUV is sought. Important lessons from these studies are as follows:

- Both the US and UK studies suggest that *non-use values can be very important* with fractions of total (use plus non-use) value being anything from 50 to 98%. However, there are several reasons to be cautious about this initial impression.

- The vast majority of benefit or damage estimation studies make no attempt to measure NUV. The reasons for this are: (i) it was not intended to be part of the study design, (ii) because the investigators felt that such 'decomposition' was not valid, and (iii) it was thought NUVs would not be important.

There is a fairly firm suggestion in the literature that *NUV is only likely to be significant when the object of value is itself scarce or unique in some way,* e.g. the Norfolk Broads. As with any good, values are likely to be smaller, the greater the availability of substitutes (see below). This is as likely to hold for NUV as for UV. *For the vast majority of water improvements, then, NUV is not likely to be important.* The caveat here is that more empirical tests for NUV are needed before we can be very confident about this statement.

- The size of NUV in some studies is open to question. This is not so much because the unit valuations are themselves questionable, but because of the process of *aggregation.* Aggregation means taking the mean (or median) WTP or WTA of the sample of the population surveyed and applying it to the population as a whole. But to what population should the mean value be applied ? Various assumptions have been made in the literature: (i) applying the sample mean WTP to the whole UK population, (ii) applying the sample mean to some administrative area population, e.g. population served by the water company, and (iii) applying the sample mean to an area beyond which it is thought that WTP tends to zero.

Table A4.1: (a) Non-use values, USA studies

Study	Nature of good being valued	Non-use value as % of total value
Kaoru, 1993	Water quality in Massachusetts	59%
Loomis *et al.*, 1993	Forest protection in Australia	>67%
Stevens *et al.*, 1991	Endangered wildlife, USA (a) Atlantic salmon (b) Bald eagle, wild turkey, coyote	(a) 85% (existence) (b) 82% (intrinsic + bequest)
Walsh *et al.*, 1984	Wilderness in Colorado	42% (existence + bequest)
Sutherland and Walsh, 1984	River water quality in Montana	72% (existence + bequest)
Greenley *et al.*, 1981	River water quality in Colorado	34% (existence + bequest)
Brookshire *et al.*, 1983	Grizzly bears and bighorn sheep	Existence values close to user WTP for grizzlies; and about one-third for bighorn sheep
Madariaga and McConnell, 1987	Water quality in Chesapeake Bay	70% of users and 69% of non-users said they would prefer improved water quality even if access denied

The only defensible approach is (iii) but this means that it is necessary to obtain some idea of how WTP varies with the distance to the environmental asset in question (reservoir, wetland etc). Comparatively little information is available on these *distance decay* functions so that there is added uncertainty in estimating total NUV (see below). Small values over very large groups of people may account for the substantial size of NUV estimates.

Table A4.1: (b) Non-use values, European studies

Study	Nature of good being valued	Non-use value as % of total value
Fredman, 1994	White-backed woodpecker in Sweden	No monetary estimate but existence value 'important'
Garrod and Willis, 1996	Alleviating low flow in River Darent, UK	91% NUV/TV for non-users within 60km of river
Willis *et al.*, 1996	Wildlife enhancement scheme on Pevensey Levels, E.Sussex, UK	NUV = 75% TV for non-users within 60km radius NUV = 97% TV for non-users extrapolated to all UK households
Bateman *et al.*, 1992	Conservation of the Norfolk Broads	76 - 91% or 57 - 66% *
Willis, 1990	3 SSSI sites	75-80%

Note: * percentage depends on range of use values and the treatment of 'near Broadland' mail respondents. In latter case, these people could be visitors or potential visitors and hence not 'non-use'. In the figures shown they are first excluded altogether and then included in use values.

A4.4 Distance-Decay Functions

The obvious way to set a realistic limit to the geographical boundary for NUV is to observe how NUV varies with distance. One would anticipate that WTP will decline with distance both for users (as confirmed by the Travel Cost Method) and non-users. This is so-called 'spatial discounting'. The rationale for spatial discounting, i.e. for expected NUV to decline with distance from the site is:

- people's interests in and knowledge of the site are less the further away is the site. Bateman and Langford (1997) confirm that there is a lower survey response rate as distance increases, indicating that people are less motivated to complete questionnaires the further away they are from the site in question. The same behaviour was also observed in some earlier US studies,

- even among respondents, people's WTP is less likely to be greater than zero the further away they are from the site, and

- among those respondents who are WTP an amount greater than zero, there is a lower WTP the further away the respondent is from the site.

Very few studies anywhere control for spatial discounting. There is one study only in the UK where there is a detailed investigation of 'distance-decay' in WTP. This is the Norfolk Broads study (Bateman and Langford, 1997) in which there was a mailed questionnaire to people across Great Britain to see what the WTP was for the conservation of the Broads. The essential findings are:

- the analysis was able to determine *user and non-user value* rather than *use and non-use value*. That is, the WTP estimates come from those who visit (use) the site and from those who, at the time of the questionnaire, did not visit the site. But it is clear that some users had non-use values, i.e. would have WTP something even if they did not visit; and that non-users also had some use value because they had visited some time in the past. The suspicion that the latter is true is revealed in the high 'self-selection' in the responses to the mailed questionnaire, i.e. more than a quarter of respondents had been in Broadlands at some stage or another. This is too high to reflect a random sample of the population. Nonetheless, those who had never visited the site had significantly lower WTP than those who had visited the site:

Previous experience	Mean WTP £ per household per year
Holiday	27.9
Day trip	25.7
Never visited	12.3

- non-user value definitely declined with distance as shown below, although there is the suggestion of a constant WTP beyond 150 kms:

Distance (radius)	Mean WTP £ per household per year
0-40kms	39.3
41-150kms	27.7
151-260kms	14.0
260kms +	14.7
Overall mean	*21.8*

- while the values elicited are annual, it is important to understand that respondents varied in the extent to which this annual sum would be committed over time. That is, some were willing to pay the sum for just one year, some for 2-5 years and some for a lifetime. The exact distribution for non-users is shown below:

Commitment time (years)	% Respondents (rounded)
1	5
2 - 5	20
6 - 10	35
11- 20	19
21- 50	10
Lifetime	10
Don't know	1

Taking the 'lifetime' of an investment or policy measure at 20 years, the table suggests that only around 20% of the WTP would last that period (the percentages over 20 years). Around 40% of WTP would last more than 10 years, and 75% more than 5 years. If annual WTP values are being used and are being compared with annual or lifetime costs, then great care needs to be taken in allowing for the tailing off of commitment. Use of the time matrix in Chapter 4 helps to avoid this error.

A4.5 Uniqueness and Substitutability

NUV is likely to be high in contexts where the asset in question is non-substitutable. Bateman and Langford (1997) elicit evidence for this. Taking seven separate studies and subjectively giving the assets substitution ratings, they show that WTP is low for those with high substitutes and high for those with low substitutes. *User* WTP is markedly influenced by substitutes as one would expect. Non-user WTP, which is lower per respondent than user values (see above), also varies with substitutes.

The same analysis controlled for 'change of provision' by which is meant the degree of change in the asset in question. The higher the change (the bigger the proportion of area affected, for example) the higher the WTP.

A4.6 An Example of Benefits Transfer based on NUV: The Axford Inquiry

The abstraction licence application for the River Kennet made by Thames Water was resolved at the Axford Inquiry, a case between Thames Water and the Environment Agency. Both sides used monetary values of environmental effects of further abstraction from the River as evidence. The monetary values were based on the results of a study on another low flowing river, River Darent. The benefits transfer which was performed by both sides to estimate the costs of abstraction was one of the most contentious points in the inquiry. There are a few factors to consider in analysing this outcome[1]:

- *Was the use of a WTP estimate from the River Darent appropriate?* As is well known, at the time of the study River Darent was under enormous stress from low flow, drying totally at

[1] Criticism can be made of estimates for use values provided by either party, for example such as the effect of water levels on property prices, from the Kennet. However, this is not the topic of discussion here.

places. Environmental assessment of abstraction from the Kennet does not show such a drastic outcome. Therefore, one can only transfer a fraction of Darent WTP if we know what a benefit transfer function looks like. See the discussion on this in Annex 5. Although there does not seem to be an indication of what this fraction should be, a sensitivity analysis could have been performed testing different fractions.

- *Which central tendency measure of the WTP estimate should have been used?* The Environment Agency evidence at the Inquiry was based on the average WTP estimate of £0.13 per person. Thames Water, however, argued that the distribution of WTP bids in the Darent study was skewed and hence it was better to use the median WTP estimate of £0.25 per person. Statisticians recommend that when the distribution is skewed (which is generally the case), the median is likely to be a better indication of the WTP estimate which is acceptable to the majority of the population. See Annex 9 for the choice of central tendency measures. In fact, the inspector accepted the higher figure of £0.25p per person.

- *What is the population over which the individual WTP estimate should be aggregated?* The discussion about three levels of population that can be used for aggregation is discussed above, namely the whole UK population, population within the water company service area, or population defined by a distance-decay function. In a way, the choice of population depends on the significance or uniqueness of the resource in question. Neither party at the Inquiry argued that River Kennet was sufficiently unique to require an aggregation of NUV over the whole UK population. The Environment Agency argued that the second population was relevant, i.e. 3 million customer connections in the Thames Water service area. Thames Water, on the other hand, saw the local population of 100,000 households as the concerned population. This discrepancy is the main cause of the significant difference between the total damage estimates of the two sides. The theoretically correct way of aggregating the individual WTP would have been to use a distance-decay function. There is only one such function available in the literature Bateman *et al.* 1997, which is discussed above and in Annex 3. Although this function is not fully recommended by the authors for wider use, what was valued in that study is not a similar good to River Kennet, the distance decay function could have been tested to see the different results. However, considering the characteristics of the Kennet, local population seems to be a more appropriate choice.

In summary, the experience at the Axford Inquiry shows the importance of original valuation studies when the outcome of benefits transfer is likely to be unreliable or easily disputable. However, the choice of population over which the WTP estimate is aggregated would remain to be critical even for an original study.

A4.7 Conclusions: Should NUVs be Included in Cost-Benefit Appraisals ?

There is a debate as to whether NUVs should be included in benefit-cost appraisals. The following are some arguments for and against this inclusion.

For: Resource Allocation

NUVs appear to be wholly legitimate components of human wellbeing: many people disapprove of and are genuinely upset by losses to environmental assets they do not personally use. As such they should be included in any cost-benefit analysis, since cost-benefit analysis is defined as the procedure for aggregating gains and losses in human wellbeing.

Against: Inconsistent Motivation

Some writers have argued that because NUVs arise out of some form of altruism they are not consistent with the self-interest that is thought to underlie the individual's valuations in a cost-benefit analysis (Milgrom, 1993). This is sometimes expressed in terms of '*warm glows*' or '*moral satisfaction*', or '*impure altruism*', i.e. people are willing to pay to feel good about something. The implication is that this is not the same thing as the value of a public good. Bateman and Langford (1997) find evidence of a 'social norm' in the non-user WTP for the Norfolk Broads. (This shows up in a high significant constant term, a, in the equation WTP = a + bDistance + cIncome), i.e. respondents have some idea of what they feel they *should* pay. But the motivation for NUV is not a criticism of economic valuation. All that matters is that there is a utility function of some form. It does not matter what motivates the individual which could be self-interest, concern for others, concern for non-human species etc.

Against: Reliance on Contingent Valuation

Some critics object to NUV not because of any conceptual reason but because, at the moment, its estimation comes almost entirely from the use of questionnaire approaches (mainly, but not exclusively, contingent valuation). These are thought to be unreliable. The debate on CVM is too large to be summarised here - see Carson *et al.*(1995) and Hausman (1993) but an outline of it is presented in Annex 8.

Against: Commitment and Lexical Orderings

Commitment occurs when the motivation for NUV is simply that something is 'right' or the outcome of some moral imperative. If the source of NUV is commitment, should this be included in a cost-benefit analysis ? As noted above, motivations for WTP may not matter, but two issues of potential significance emerge: lexical ordering, and inconsistent ethical underpinnings in cost-benefit analysis. If NUV is the result of some moral imperative, one implication is that individuals expressing this value are not willing to trade-off the environmental value against any other monetary sum. They cannot, in fact, be compensated. Yet, the concept of compensable losses is fundamental to cost-benefit analysis. The issue is often put in terms of *lexicographic orderings*, i.e. preference orderings which are always dominated by one object of value, just as a dictionary 'orders' words according to the first, then second letters of the alphabet, and so on. It is often thought that these 'committed' individuals show up as *protest votes* in a contingent valuation study, i.e. as people who refuse to cooperate with the questionnaire. The reasons for protest votes vary substantially and it cannot be assumed that all protests are due to lexical orderings.

A further problem is that the evidence for lexical preferences is very ambiguous. Those studies that claim to have identified lexical orderings are themselves open to criticism. In some, the trade-off context is not realistic. The more people recognise that they may actually have to pay, the less likely it is that lexical orderings will occur. This suggests in turn that there may not be lexical orderings at all, but merely very high economic values. These are important, but they do not constitute an unwillingness to state any price.

ANNEX 5: BENEFITS TRANSFER

A5.1 Types of Benefits Transfer

All available guideline documents make extensive use of 'benefits transfer', i.e. taking existing monetary valuation studies and applying them outside of the site contexts where the study was originally carried out. There is in fact no alternative to this procedure if any use at all is to be made of benefit valuation techniques. However, *caution* needs to be exercised in using benefits transfer estimates. The sources of this caution can be explained by looking at how benefits transfer (BT) is carried out.

A5.1.1 Transferring average WTP from a single study to another site which has no study

The basic idea is to 'borrow' an estimate of WTP in context i (usually called the study site) and apply it to context j (usually called the policy site), but making adjustments for the different features of the two contexts. A widely used formula is:

$$WTPj = WTPi. (Yj/Yi)^{e}$$

where Y is income per capita, WTP is willingness to pay, and 'e' is the income elasticity of demand, i.e. an estimate of how the demand for the environmental attribute in question varies with changes in income. In fact, this formula is misleading since what matters is not the income elasticity of demand but the elasticity of willingness to pay with respect to income[1]. 'e' should therefore be this latter elasticity, and this is usually less than the income elasticity of demand (Carson, 1998).

A typical example of this approach is given by Krupnick *et al.* (1996) who transfer US WTP for various health states to Eastern Europe using the ratio of wages in the two areas and an income elasticity of demand of 0.035. The significance of the procedure can be realised since the wage ratio raised to e=0.035 produces a WTP in Eastern Europe equal to only 8% of that in the USA.

A second, common adjustment is for population size and, less frequently, for the distribution of population characteristics, e.g. age.

Note that the transfer is 'assumed' to be correct: no separate validation is carried out. The *fact* of transfer cannot therefore be used as evidence that the transfer is *justified.*

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1 The income elasticity of demand is given by $\Delta Q.Y/\Delta Y.Q$ where Q is the quantity of the environmental asset, Y is income and Δ means 'small change in'. Unfortunately, this income elasticity of demand is not the same thing as the income elasticity of the *WTP* for a good. This latter is given by $\Delta WTP.Y/\Delta Y.WTP$. Calling the income elasticity of demand ε and the income elasticity of WTP β, the result, not proven here, is that $\beta = \varepsilon.\Delta WTP.Q/WTP.\Delta Q$. Great care therefore needs to be taken when 'transferring' WTP estimates.

A5.1.2 Testing the equality of means at two sites where studies exist

Where there are two sites both with actual WTP estimates we can obtain some idea of the validity of benefits transfers by comparing the two mean WTPs. We wish to know if they are statistically the same. If they are, then there is some reason to feel confident that the results from a given site can be transferred to another site, as in Section A5.1.1 above.

Where the underlying distribution of WTP is thought to be normal, parametric tests can be used, e.g. t-tests to determine if the mean WTP results at the two (or more) sites are statistically the same. Where this restriction is thought to be unreasonable, then non-parametric tests are required. More sophisticated testing can be done, e.g. to find out if the two underlying WTP distribution (not just the means) are statistically the same.

A5.1.3 Transferring benefit functions

A more sophisticated approach is to transfer the *benefit function* from i and apply it to j. Thus if we know that WTPi = f(A,B,C,Y) where A,B,C are factors affecting WTP at site i, then we can estimate WTPj using the coefficients from this equation but using the values of A,B,C, Y at site j.

Alternatively, we can use *meta analysis* to take the results from a number of studies and analyse them in such a way that the variations in WTP found in those studies can be explained. This should enable better transfer of values since we can find out what WTP depends on. Whole functions are transferred rather than average values, but the functions do not come from the single site i, but from a collection of studies.

How do we know if transferring functions is a valid procedure ? As with the procedure under Section A5.1.1, we have no direct test that the result is 'correct'. The literature has proceeded by taking estimated demand functions at site i and site j and then comparing them to see if, statistically, they are the same. This involves at least testing for the equivalence of the coefficients in the two functions, e.g.

$$WTP_i = x + a_1A + b_1B + c_1C$$

$$WTP_j = x + a_2A + b_2B + c_2C$$

so that we require $a_1 = a_2$ etc, where equality here is statistical equality (Loomis, 1992).

Recent literature has suggested that even if it is valid to transfer *benefit functions*, based on statistical equality of coefficients, the resulting estimates of *benefits* may be in error. This is because benefits may not be a linear function of the coefficients. Downing and Ozuna (1996) take demand functions for 8 sites in Texas and conclude that around 50% of functions are transferable (have the same coefficients) but that only a small minority would yield reliable benefit estimates. This has led Bergland *et al.* (1995) to suggest that both valuation functions and benefits estimates must be transferable (see the 'protocol' below).

Generally, *the literature testifies to the unreliability of transferring benefit functions* (Loomis, 1992; Downing and Ozuna, 1996; Bergland *et al.*, 1995; Parsons and Kealy, 1994). Most studies seem to suggest that transferring functions is better than transferring average values, but that both are subject to significant margins of error (Kirchhoff *et al.*, 1997).

A5.1.4 Validating benefits transfer

The test in Section A5.1.3 above involves taking actual demand functions and seeing whether they are statistically the same and will produce similar benefit estimates. Another test would be to take a WTP estimate from i and apply it to j using a simple procedure such as the one set out in Section A5.1.1 above. Then, a full WTP study would be carried out in j and the mean WTP result would be compared with the 'transferred' WTP.

Navrud (1997) has done this for minor impaired health states to see if WTP estimates from the USA can be transferred to Norway. He concludes that the transferred estimates significantly overstate the 'actual' WTP as derived from a contingent valuation study in Norway.

Alberini *et al.* (1995) make this test of benefits transfer using two US contingent valuation studies of a 'restricted activity day' due to a head cold and transferring the results to Taiwan. In this case the transfer multiplier was (Yj/Yi) which implies e=1. They then carry out a contingent valuation of the morbidity effect in Taiwan. The results were statistically the same, i.e. the simple benefits transfer approach accurately predicts the policy site study results.

A5.1.5 The Bergland-Magnussen-Navrud protocol

[This section may be omitted without loss of continuity]

Bergland *et al.* (1995) recommend testing for benefits transfer in four stages:

1. test that mean $WTP_i = WTP_j$, using parametric and non-parametric tests depending on the assumed underlying distribution of WTP,

2. estimate WTP'_j where WTP'_j using estimated parameters from i and the actual values of explanatory variables at j. Test for the equivalence of $WTP'_j = WTP_j$, i.e. we require

$$WTP'_j = f(b_i, X_j) = WTP_j$$

   and correspondingly for WTP'_i,

3. compare parameters b in each study, with the requirement that $b'_i = b_j$ and $b'_j = b_i$ where b'_j comes from estimating the function $WTP'_j = f(b_i, X_j)$ above, and correspondingly for b'_i,

4. test for the proposition that the two benefit functions come from one underlying function with parameters b such that $b = b_j = b_i$.

A5.2 Criteria for Successful Benefits Transfer

It appears generally agreed that successful benefits transfer requires:

1. adequate data for those studies included in the analysis,
2. sound economic and statistical techniques,
3. studies with regressions of WTP on determining variables,
4. similar populations in the compared sites,
5. similarity of the environmental good to be valued
6. similar sites, and
7. similar distributions of property rights.

See, for example, Brouwer and Spaninks (1997).

A5.3 Conclusions

The literature on benefits transfer is small. The attractions of benefits transfer are very clear: without it, one has to resort to primary valuation studies. This is both expensive and time consuming. It would not matter for 'micro' problems where it is often possible to carry out such studies, but it is a problem for 'guidelines' type studies which necessarily have to use 'borrowed' estimates.

At the moment, the literature reports mixed results with the balance of opinion expressing considerable caution about benefits transfer. The error is likely to be reduced substantially wherever meta analysis can be done and meta-functions can be applied. Even here, there are some doubts about the validity of transfer.

ANNEX 6: WILLINGNESS TO PAY VERSUS WILLINGNESS TO ACCEPT

Chapter 2 indicated that two concepts are used to derive monetary values: willingness to pay (WTP) and willingness to accept (WTA). Which one should be used ?

A6.1 The Guidance from Economic Theory

For a long time, economic theory suggested that WTP and WTA should not differ very much, typically the range of error should be within 5%. The reason for this is that both concepts are essentially measuring the same thing. Table A6.1 below summarises this.

Table A6.1: Theoretical background to the WTP and WTA

	project makes the individual better off	project makes the individual worse off
'compensating variation'	WTP for the project	WTA for tolerating the project
'equivalent variation'	WTA to forego the project	WTP to avoid the project

The terms 'equivalent' and 'compensating' surplus are technical terms for gains and losses and are introduced here simply to show that WTP and WTA reflect an underlying economic theory. When an individual gains (gets a benefit) the two relevant measures are what s/he is willing to pay for the benefit or what s/he is willing to accept to forego the benefit. Given that the increment (the benefit) is the same in each case we should not expect the difference between WTP and WTA to be large. Where the project confers a cost on the individual he/she will be willing to accept compensation for putting up with the project or be willing to pay to avoid it. Again, the two should not differ much. In each case, the idea is that the measures reflect what is required to make the individual no worse off than he/she was before, or no worse off than he/she would have been without the project.

A6.2 The Complication of Practice

In practice, we do observe differences in WTP and WTA that are significant. WTA will often exceed WTP by factors of four to five times WTP. Clearly, if WTA is used it *might* substantially alter the estimate of project benefits compared to the situation when WTP is used. Why might WTA and WTP differ ?

- *the 'one-short' phenomenon* (Coursey et al, 1987): most of the evidence suggesting WTA and WTP differ comes from contingent valuation studies where individuals are asked directly whether they are willing to pay some sum of money or willing to accept some sum of money. Contingent valuation tends to be a 'one-off' valuation: respondents are asked once about their valuations, but they are not asked again. (Where respondents are asked again, there is evidence that they tend to lower their estimates of WTP this is known as 'giving respondents time to think'). But contingent valuation tries to 'mimic' the market place and most market transactions are not one-off transactions - they are repeated several times and often many times. The issue arises therefore as to whether WTP and WTA differ so much simply because the respondent is faced with a one-off situation which is unlike most market transactions. There is some evidence from experimental work that WTP and WTA initially diverge and then converge as WTP/WTA questions are repeated. If this is correct, it would be wrong to use the large values obtained from the initial situation. It might be better to average the estimates of WTA and WTP;

- *lack of substitutes* (Haneman, 1991): the second feature of contingent valuation studies is that they often relate to assets with few substitutes (significant rivers, major wetlands, well-known scenic landscapes). In such contexts it has been shown that we can expect WTP and WTA to diverge. The supposition, then, is they will not diverge much if the asset in question does have substitutes, and

- *prospect theory*: some commentators argue that WTP and WTA will diverge even when there are substitutes. This is because people regard losses as being conceptually distinct from gains. Our WTP to improve water quality by one classification may well not therefore be the same as our WTA compensation to tolerate a reduction in water quality by one classification. Individuals may adopt a benchmark of the situation they are in now. This becomes the 'reference point' (Knetch, 1984) Reduction in wellbeing compared to the reference point is treated quite differently to moves that improve wellbeing relative to the reference point. Psychological 'prospect theory' suggests this phenomenon is widespread and is not confined at all to environmental contexts.

A6.3 Guidance on WTP vs WTA

The arguments above suggest that in most contexts WTP and WTA should be similar. They are likely to differ when there are few substitutes for the asset in question, i.e. the more 'unique' the asset is. In such cases, if both WTP and WTA results are available both should be reported and the sensitivity of the outcome to the different estimates should be shown.

Where there are substitutes, WTP and WTA may be similar, in which case no problem arises. If they differ, the issue becomes one of deciding if the divergence is due to lack of repetition in the context for securing the estimate (the 'one-shot' phenomenon), or if there is a genuine difference. There are several reasons for preferring the WTP estimates:

- theory suggests they should not differ when there are substitutes, i.e. recorded differences may well be an artefact,

- WTP estimates in contingent valuation studies are generally supported by other valuation techniques based on revealed preference, so that the higher WTA estimates become 'outliers', and

- Adopting WTP amounts to adopting conservative valuations and this may be important if there is reason to expect that respondents exaggerate their WTP because of the hypothetical context of contingent valuations.

Overall, WTP estimates are to be preferred unless there is clear evidence that higher WTA values are unbiased.

ANNEX 7: GUIDANCE ON TREATING TIME

Chapter 4 set out a matrix of costs and benefits over time. It was noted that failure to consider the matrix may lead to over- and under-estimation of costs and benefits because not all benefits and costs will occur in each year of the scheme, nor will they necessarily have the same value in each year. The issue is further complicated by the requirement to *discount future costs and benefits*.

A7.1 Temporary Costs and Benefits

Some costs and benefits will occur in the short run only. Examples include congestion and air pollution caused by road works for the laying of new pipes or mending of old ones, construction traffic for new reservoirs etc.

A7.2 Changing Environmental Values

All the values entering the matrix of costs and benefits should be in *real terms*, i.e. no account should be taken of inflation. But some costs and benefits may rise faster or slower than the general price level. They are said to have rising (falling) *relative price levels*.

In general, it is thought that the values attached to the environment will have rising relative price levels. This is because environment is thought to be a 'luxury good', one which tends to be bought in larger and larger quantities as incomes grow. Put another way, it is suspected that expenditure on amenity and environment will be such that it is a rising proportion of individuals' income over time.

In practice, not very much is known about this relationship between environmental expenditures and income (known as the 'income elasticity of demand'). At the country-wide level, some expenditures certainly rise significantly with higher incomes and this is thought to account for the declining environmental impacts for some pollutants as economic development takes place. Other studies at the more 'micro' level suggest that income elasticities are of the order of 0.3 or 0.4, i.e. a 1% increase in (real) incomes gives rise to about a 0.4% rise in environmental expenditures.

If a scheme is fairly long-lived and if environmental values for a given year are found to be fairly large, then it will be important to include some adjustment for the growth of these values through time. As an example, if the income elasticity of demand is 0.4, then an economic value of £100 in year 1 should have a value in year 2 of

$$£100 \times (1.04) = £104$$

and in year T it would have a value of

$$£100 \times (1.04)^T$$

A7.3 Discounting

Since people are generally impatient, accepting the basic value judgement that people's preferences should count, justifies discounting. This means that any benefit (B) or cost (C) should be given a lower weight the further it is into the future. It is not possible then simply to add benefits and costs as they accrue over time (t). A weighted sum is required :

$$w_t \cdot (B_t - C_t)$$

where the weight in any period can be written:

$$w_t = \frac{1}{(1+i)^t}$$

i is then the social discount rate and the whole expression for w_t above is the discount factor. There are varying views about how i is to be determined.

A7.4 The Social Time Preference Rate

There are two concepts that may be subject to discounting:

1. future *consumption* may be discounted because of some judgement that it will generate less 'wellbeing' (or utility) than current consumption. This is consumption discounting;

2. future wellbeing or utility may be discounted because people simply prefer their pleasures (benefits) now and their costs later. This is utility or wellbeing discounting.

The *social time preference rate* incorporates both elements of discounting with the result that

$$s = \rho + \mu g$$

where s is social time preference rate of discount, ρ is 'pure time preference', i.e. the rate at which utility is discounted, μ is elasticity of the marginal utility of consumption schedule, i.e. the rate at which marginal utility declines as consumption increases, and g is the expected growth rate of consumption per capita in the economy.

A7.5 The Social Opportunity Cost of Capital

The second main candidate for estimating the social discount rate is the social opportunity cost of capital (SOC), sometimes called the producer discount rate. In practice producer discount rates, like consumption discount rates, tend to reflect individuals' discount rates, whereas a social rate may differ if individual and social values differ. Assume for the moment that we can equate social rates of discount with private rates. The argument then is that investment will yield a rate of return, r, such that £1 invested today will yield (1 + r) in one year's time, $(1+r)^2$ in two years' time, and so on. This is nothing more than compound interest. How much, then, is £1 in one year's time worth now ? The answer must be that it is worth 1/(1+r) now. To see this, invest 1/(1+r) now at r%. It will become

$$\frac{1}{(1+r)} \cdot (1+r) = 1$$

next year. In other words, we should be indifferent between £1 now and £1+r next year, or, the same thing, £1/(1+r) now and £1 next year. The rate of return, r, is nothing more than the marginal productivity of capital. Now suppose we are faced with a project yielding z% rate of return. Should we invest in it ? It depends if z% is greater or less than r%. If z is greater than r, then it is clearly a good investment because z% is higher than we could get in some alternative use of the funds. If z is greater than r, then the investment is not worthwhile. We can now see why r is called the (social) opportunity cost discount rate. It is the rate we could get if we did not use the money for this particular investment.

Cost-benefit appraisals often relate to public sector investments and public decision-making. The value of r could then the marginal product of capital in the public sector, but it is more typically the marginal rate of return in the private sector. The rationale for using a private sector rate of return to discount public sector costs and benefits is that public investment is likely to be at the expense of the quantity of investment in the private sector. This usually reflects a judgement about the effects of 'crowding out' private sector investments. r is then the marginal opportunity cost of investing in the public sector.

A7.6 The Relationship Between s and r

We now have two candidates for the social discount rate: s, the social time preference rate and r, the opportunity cost rate. While in theory s and r should be the same, for various technical reasons they tend not to be. Various factors conspire to 'drive a wedge' between s and r. One very fundamental reason for their divergence is the presence of taxation. Consider company taxation. Shareholders will expect a rate of return at least equal to r%, their own time preference rate. Companies have to pay a tax rate t% on their profits. Hence to provide shareholders with i%, companies must earn i/(1-t)%. For example, if shareholders want 10% and there is a company tax rate of 40%, then the company must earn 0.1/(1-0.4) = 16.7%. But this is the return on investment, i.e. the marginal productivity of capital. Hence r cannot equal s. This is an example of 'second best', i.e. we cannot have the best solution, so we must choose some inferior option.

A7.7 Estimating the Social Time Preference Rate

Lower and upper bounds of the social time preference rate are shown in Table A7.1. The estimates come from Pearce and Ulph (1995).

Table A7.1: Values of a social time preference rate for the UK

Estimates	ρ	L'	μ	g	s
Lower Bound	0	0	0.7	1.3	0.9
Best Estimate	0.3	-1.1	0.8	1.3	2.4
Upper Bound	0.5	-1.2	1.5	2.2	5.0

Note: L' denotes any increase (or decrease) in the risk to life. It the risk gets worse through time, then this makes for a higher rate of time preference, whereas if they get better then this is an argument for a lower rate of time preference.

The best estimate of the social time preference rate is 2.4%. A range of 2-4% for s would seem to be appropriate. To go much above 4.0% one would either have to (i) be very pessimistic about future survival probabilities for mankind, while at the same time being very optimistic about prospects for consumption growth in the meantime; or (ii) be prepared to discount future generations at a very high rate; or (iii) be very much more egalitarian than people seem to be in terms of the tax policies they are prepared to vote for.

A7.8 Estimating the SOC Discount Rate

How might r be estimated ? Recall that r is the foregone rate of return on an investment that is displaced by the one under consideration. The value of r might thus be estimated as the weighted average of returns to debt and equity in the private sector. Debt could be represented by government bonds where relevant, or by interest rates on bank loans and advances. Rates of return in the private sector will be higher than the public sector due to the fact that the private sector has to pay tax, as noted previously. This 'tax wedge' puts private rates of return above the rate of return to government bonds. In the United Kingdom, for example, it is suggested that the difference is between 3-4% on government borrowing and 4-6% for the marginal rate of return in the private sector.

As a general rule, then, r can be approximated by the weighted average of the returns to equity and the returns to debt. The former can be calculated by looking at the historical evidence on dividend yields and adding capital growth to it. This might then be adjusted for any judgmental change in expected yields and capital growth. The return to debt can be obtained by looking at government bonds ('gilts') or bank loan interest rates.

A7.9 UK Treasury Practice

The figures shown here are below those recommended by the UK Treasury which uses a 6% rate (UK Treasury, 1997). The Treasury is concerned not to bias investment away from the private sector to the public sector. Use of a low rate of discount for the public sector would tend to encourage investment in the public sector since more investments would pass a cost-benefit test. This places great emphasis on the rate of return earned in the private sector and the Treasury puts this at above the 4-5% that they think the public sector might achieve.

The reality, then, is that estimates of *social* discount rates vary. The UK Treasury adopts a high rate (6%) compared to what others have estimates (2-4%).

A7.10 Water Company Discount Rates

The relevant discount rate from society's point of view is the *social* discount rate. This is not the same as the *private* discount rate that, say, a water company would use to reflect its own concerns. Here the relevant discount rate is simply the (real) rate of interest at which companies can borrow.

The relevant discount rate for projects that lead to a change in the well-being of the society is the social discount rate, which is estimated to be between 2% and 4%.

ANNEX 8: ISSUES IN CONTINGENT VALUATION

Of all the economic valuation techniques, contingent valuation is the most controversial. It is therefore important to have some idea of the reliability of contingent valuation results if they are to be used in benefits transfer.

A8.1 The NOAA Guidelines

Because contingent valuation is controversial, the US National Oceanic and Atmospheric Administration (NOAA) established an expert panel which reported in 1993 on the validity of contingent valuation (Arrow *et al.*, 1993). They reported that it was an acceptable economic valuation methodology, but that certain guidelines needed to be followed before a contingent valuation study could be held to be reliable. It concluded that:

'under those conditions, CV studies convey useful information. We think it fair to describe such information as reliable by the standards that seem to be implicit in similar contexts, like market analysis for new and innovative products and the assessment of other damages normally allowed in court proceedings.'

In outline, the Panel's recommendations were:

- *sample size* should be 1000 +,
- *response rate* must be 'reasonable', and this implies that respondents should not be over-burdened with exacting informational demands,
- *personal interviews* rather than mail interviews should be used. Telephone interviews are acceptable,
- *tests for interviewer effect* should be conducted, i.e. the fact that the interview may give rise to bias because protecting the environment is thought generally to be a 'good thing',
- *reporting* of results should include a reproduction of the questionnaire, a database which others can replicate, and specific information on sample size, non-response rates etc.,
- respondents should be allowed to express *no opinion* as a legitimate response but should be carefully questioned as to the source of their view,
- there should be a *conservative bias* by using WTP rather than WTA. Conservative bias eliminates extreme responses,
- the format of the question should be a *vote on a referendum*, i.e. a 'yes/no' answer to a stated amount of WTP.: also known as *dichotomous choice*,
- there should be adequate *information* conveyed as to what the environmental change at issue actually is,

- the effects of using any *photographs* should be explored,
- respondents must be reminded of any *substitute commodities*,
- questions should be asked at different points in time to different samples to test for any trend in responses,
- *income and attitudinal questions* should be asked so that WTP can be cross tabulated with these factors,
- respondents must be reminded that any WTP for the environmental good in question will reduce their available expenditure on other goods, and
- Finally, 'burden of proof' rests with the advocates of contingent valuation. They must show that there is an adequate response rate, that respondents understand questions, and that answers are sensitive to *scope*, WTP should vary with the amount of the environmental good in question (this is still known as the 'embedding' problem).

A8.2 Does Contingent Valuation Exaggerate ?

It is popularly held that contingent valuation results exaggerate 'true' willingness to pay. This is thought to arise because WTP is being expressed in a hypothetical context, whereas what matters is what people would be willing to pay in a real world context. Virtually by definition, we cannot compare real and hypothetical WTP because if a medium for discovering real WTP existed we would not need to engage in contingent valuation in the first place. Nonetheless, a few experiments where actual sums of money (or some real good) are traded does suggest that Contingent Valuation answers may exaggerate actual WTP.

Notice that comparisons of hypothetical and real WTP must be based on a context where the real WTP is itself valid. Donations to good causes are not good indicators of real WTP because 'free riding' will occur, i.e. individuals will express lower than true WTP in the expectation that others will bid sufficient for the asset or service in question to be realised. Put another way, if hypothetical WTP exceeds actual WTP this does not necessarily mean the hypothetical WTP is exaggerated.

There are other reasons for suspecting that the claim of exaggeration in contingent valuation is itself exaggerated:

- Carson *et al.* (1996) have shown that hypothetical WTP is consistent with revealed preference estimates,
- Carson *et al.* (1996) also show that many CV studies pass a 'scope' test, i.e. WTP varies with the quantity of the good demanded. Moreover, good questionnaire design minimises the risk of scope bias, and there is some evidence that scope bias is confined to mail questionnaires and short telephone interviews. Scope bias does appear to exist with questionnaires dealing with 'low probability' risk events.

Overall, the presumption that contingent valuation results are exaggerations of 'true' WTP is based more on folklore than real evidence. Nonetheless, the scope for exaggeration remains in some countries.

ANNEX 9: DEALING WITH UNCERTAINTY

A9.1 Risk and Uncertainty

All estimates of the monetary value of environmental effects are uncertain. In itself, uncertainty is *not* a reason to reject the estimates. Uncertainty is the norm, not the exception. Nevertheless, it is important to recognise that uncertainty exists, to identify its sources, and to account for it. It is not legitimate to neglect or ignore uncertainty.

Risk is defined as some combination of the probability of an event occurring, and the scale of the event. Thus, if an event with an impact valued at £100 occurs with a probability of 0.1, one approach might be to multiply the two numbers so that risk equals £10. This is an example of an *expected value* approach to representing risk. Other approaches may be preferred - see below.

Uncertainty arises when the probability distribution is not known and the scale of the event, if it occurs, may be known accurately or only imperfectly. Thus, it may be known that there is a possibility of a £100 loss, but the probability of that loss is not known. Or it may be that the scale of the event is known in only qualitative terms, and the probability is not known at all.

The distinction between risk and uncertainty can be important because the means of dealing with them may well be different.

A9.2 Subjective and Objective Risk

Risks may be presented as 'objective' risks, e.g. there is a 1 in 10,000 probability that a person will die in an accident or have their lives prematurely shortened because of air pollution induced illness. Such risks are objective because they tend to result from analysis of scientific data. This does not mean that they are certain - there is likely to be a range of probabilities, for example. Objective risk is to be contrasted with subjective risk which relates to the *perceptions* of the person at risk. Individuals often perceive risk quite differently to experts. For example, it is known that individuals tend to 'exaggerate' the importance of catastrophic events that are likely to occur with an extremely small probability (so-called *zero-infinity* problems), often ranking these as being more important than events with higher probabilities and lower impact. Put another way, individuals will not necessarily rank risks according to their expected values.

Subjective risks cannot be dismissed simply because they appear to be 'unscientific' or inconsistent with expert assessments of objective risks. People will behave according to their perception of risk. Designing a project or policy that ignores people's views about risk could seriously damage the prospects of its success. Adopting a project where perceived (subjective) risk is high and objective risk is low, may simply result in public opposition to the project.

A9.3 Sources of Risk and Uncertainty

To focus discussion, consider contexts in which there are environmental problems related to waterborne emissions from some activity.

Risk and uncertainty arises because:

- the precise nature and quantity of the effects may not be known with certainty (*effect uncertainty)*;
- effects may vary from one period of time to another, so they will differ according to which time period is chosen (*time sensitivity)*;
- effects may vary from one location to another. Since damage done tends to be related to the source of the effects and the sensitivity of the receptor area, there will be uncertainty due to the geographical location of effects (*geographical sensitivity*);
- the link between the effect itself and the 'end point' may be uncertain. Thus, the link between water pollution concentrations and, say, an intestinal illness may be known only with a margin of error (*dose response uncertainty*);
- the willingness to pay to avoid this change in wellbeing may be known only imperfectly (*valuation uncertainty*);
- related to the last bullet point, there will be uncertainty in the valuation estimates arising from *benefits transfer*.

Clearly, there are many sources of uncertainty.

Common fallacies in dealing with this kind of multiplicative uncertainty (because one source of uncertainty is applied to another source) need to be noted. The main one involves rejecting the final estimates altogether because the uncertainty may result in wide ranges of estimates. For example, it may be argued that the monetisation stages should be omitted because they simply add more uncertainty to the methodology. This might be an acceptable outcome if the remaining uncertainty can be addressed satisfactorily. The reason monetisation is used is to 'reduce' essentially non-comparable outcomes to comparable ones.

Omitting monetisation does not therefore resolve this problem. It simply transfers the burden of resolving it to some other procedure for making outcomes comparable. One might, for example, substitute some 'weighting and scoring' approach for the monetisation stage. But unless we can be sure the weighting and scoring approach has *less* uncertainty attached to it than monetisation, all that has happened is that one set of uncertain outcomes has been substituted for another set. In practice, it is difficult to say whether uncertainty has been reduced. It may be reduced in terms of ranges of error bounds, but this may nonetheless be at the cost of employing what may be arbitrary procedures.

A second fallacy relates to the 'folklore' that monetary valuations derived from questionnaire approaches are inherently more uncertain that WTP estimates from revealed preference sources. Accordingly, it is quite common practice to 'discount' contingent valuation estimates to allow for this higher degree of uncertainty.

But whether contingent valuation estimates of WTP are more uncertain or not is a testable proposition. It is therefore important to focus on the scientific literature dealing with this issue rather than on hearsay and folklore. In fact, it has been shown that contingent estimates are compatible with revealed preference estimates of WTP where both techniques have been to used to derive estimates (Carson *et al.*, 1995). This test of internal consistency is one of the tests for determining accuracy in contingent valuation (See Annex 8).

A9.4 Dealing with Risk

A9.4.1 Probability distributions

Risk contexts are defined as those in which it is possible to define a *probability distribution.* For example, consider the distribution of willingness to pay sums for a given improvement of water quality. Such measures of WTP might be derived from a contingent valuation questionnaire, for example. In this context, the probability distribution tends to be known in considerable detail and any good CVM reports that distribution. In other cases, distributions will be known only crudely. Distributions can be characterised by some measure of central tendency (average or mean, median and mode), a measure of the 'spread' of the distribution (dispersion), and a measure of how 'skewed' it is.

The most familiar distribution is the *normal* or *Gaussian* distribution in which the measures of central tendency are the same. The arithmetic mean is simply the sum of the WTP values each weighted by the probability that they occur. The mode defines the most frequently occurring WTP value. The median defines the WTP value such that 50% of values lie above this value and 50% below it.

In practice, distributions may be skewed. In such contexts it is often expedient to convert the distribution to one that approximates a normal distribution. For example, a distribution skewed to the left could be converted to a normal distribution by taking the logarithms of the values, producing a *lognormal distribution.* Note that the underlying distribution has values for the mean, median and mode, which are different, so that it now matters which measure of average is chosen. It is common to exhibit at least the median and mean values to show the sensitivity of outcomes.

Other distributions may reflect the fact that there are few observations of the event in question. Common forms include the *triangular distribution* in which mean, median and mode are the same but there are defined 'limits' to upper and lower values.

Other distributions are possible and reference should be made to a standard text on statistics (see, for example, Granger Morgan and Henrion, 1990).

A9.4.2 Allowing for dispersion: expected utility

Indicators such as expected value may not capture the public's perception of risk. The expected value idea does not seem to capture the relevant concerns about the outcomes of the project. In particular, expected value seems not to capture our likely concerns about the extremes of the outcomes. People tend to be more averse to some negative outcomes (risk aversion).

It seems more likely that the individual will attach some weights to outcomes. The result is the *expected utility* approach rather than the expected value approach. In simple terms, this is the idea that an individual will not necessarily be indifferent between two events with the same expected value. For example, consider a gamble in which there is a 50% chance of winning £1,000 and a 50% chance of losing £950. The expected value of this bet is £25. However, it is perfectly reasonable that a person would prefer to accept a certain £25 than accept the bet. In other words, his or her 'expected utility' of the certain money exceeds the expected utility of the gamble.

The term 'utility' can be translated as meaning 'wellbeing'. Expected utility then has the same formula as the expected value approach but this time utilities rather than values are substituted. So, if we are very averse to a loss we might weight it more heavily.

One advantage of the expected utility approach is that it seems able to handle the problem of 'disasters', e.g. a major flood, since what would happen is that we would attach a large utility value (or 'disutility' value if it is a loss) to the outcomes we most like or dislike.

A9.4.3 Problems with expected utility

The expected utility model is attractive, but extensive research suggests that it does not describe how people actually behave. Psychologists and economists have uncovered all kinds of behaviour which is inconsistent with expected utility theory. Just a few are listed below:

- people seem regularly to confuse probability with plausibility. The more they think it could happen ('it seems reasonable') the higher the probability they attach to it occurring. This *conjunction fallacy* is especially important if the event in question is described in some detail, e.g. houses disappearing because of coastal erosion;

- the 'it can't happen to me syndrome'. Because it hasn't yet happened, people think it won't happen. This is the *fallacy of optimism*;

- as noted earlier, people often do not 'correctly' perceive low probabilities. Many seem to ignore them altogether, and much depends on how the risk is described. In many other cases, people exaggerate the low probabilities, believing some accidents to be more likely than, say, the risk of fatality in a road accident. This is the *under or over-weighting of low probabilities* issue;

- people seem 'anchored' to wherever they are at the point in time they are asked to make a decision. This is their 'reference' point, and people value risks with reference to that point rather than in abstract in the way the expected utility approach assumes. They value losses more highly than equivalent gains (the phenomenon of *loss aversion*). People also tend to make the risk problem simpler than it really is, as if they cannot cope with a more complex issue. These features of decision-making, together with the distortion of low probability perception, define *prospect theory;*

- prospect theory also suggests that people put the various contexts for valuing risk into separate mental boxes, or '*mental accounts*'. They then have little difficulty of weighing up costs and benefits within each account, but find it difficult to make comparisons across mental accounts. If this is true then it goes some way to explaining how people can seemingly entertain contradictory notions at the same time;

- much also depends on the context of risk. A risk of being injured or catching a disease is regarded as being very different if it is *involuntarily* borne as opposed to being *voluntary.* So, the risk of dying from lung cancer through smoking (a voluntary process) is often seen as being less than the risk of cancer through exposure to nuclear radiation (involuntary), even though the former risk is substantially greater than the latter. The context issue can be complicated. Risks in the future are usually thought to be less important than risks now (the phenomenon of 'discounting'), but recent research suggests that people often tend to value future risks more highly than present risks, and future benefits more highly than present benefits. This is because they sometimes like to 'leave the best to the last' (in the case of benefits), or dread being vulnerable when they are older and perhaps less capable of looking after themselves (in the case of risks).

All in all, the issue of how people actually behave in the presence of uncertainty and risk turns out to be complex. It seems fairly clear that neither expected value nor expected utility are adequate to explain that behaviour, even if expected utility can accommodate many issues, such as disaster aversion.

Other theories of risk-taking - such as prospect theory - have been developed to account for the inadequacies of expected utility. They tend to suggest that the context of the risk is important, and that we cannot advocate a single rule to deal with all risk and uncertainty contexts. The issue of risk context means that we cannot analyse low probability, high damage events in the same way as we value 'everyday' risk. Somehow we have to account for perceptions of low probability events.

Finally, new theories of uncertainty suggest all kinds of ways in which people can be encouraged to deal with risk. As just one example, in some countries it is fairly usual to compensate people if a project perceived as risky is located in their vicinity. This might be a nuclear power station or even a waste landfill site. Compensation may work as a means of getting a more 'rational' appraisal of risk not just because bearing the risk is itself compensated, but because the compensation creates a new context of sharing in risk compared to the uncompensated case in which the owner of the landfill site or the nuclear power station is seen to be 'imposing' the facility.

A9.5 Dealing with Uncertainty

The simplest approach to uncertainty is to adopt *sensitivity analysis*. This involves showing how the outcome of the evaluation varies according to the adoption of different values for some key parameter, for example a discount rate. Sensitivity analysis by itself resolves nothing: it simply shows the sensitivity of the cost-benefit calculation to changes in assumed values of parameters. It simply focuses attention on the values of the parameters in question. Several situations might emerge:

- benefits exceed costs for the project regardless of the value chosen for the key parameter. Then the result is *robust*.
- costs may exceed benefits for the project regardless of the value chosen for the key parameter. Again the result is robust.
- the project may pass (or fail) a cost-benefit test for some values of the parameter but not for others. This forces the decision maker to express a judgement as to which value of the parameter is 'most likely'. Effectively, an uncertainty problem is converted to something akin to a risk problem by the assignment of judgmental probabilities.

Notice that the outcome in the last situation is not 'definite' in the sense that it requires a judgement on someone's part. But this is no more than can be expected for uncertainty problems since, by definition, probabilities are not known. Uncertainty is also subject to all the concerns about expected utility noted above.

More sophisticated approaches to uncertainty can be applied by employing *decision analysis*.

This involves constructing a *payoff matrix*. While the approaches are sophisticated, it has to be stressed that payoff procedures also rest for their validity on the 'personality' of the person making the judgement.

A payoff matrix is constructed as follows (recall that probabilities are not known). Let the objective be net benefits so that the numbers in the matrix record values of net benefits. These net benefits depend on what decision (D), e.g. D1 is to undertake a mitigation measure and D2 is not to undertake this measure, is made, and what the 'state of nature' (S) is. The state of nature simply reflects the possibilities that may occur, e.g. a given economic context, a given weather pattern etc. The probabilities attached to the states of nature are not known.

Payoff Matrix

	S1	S2
D1	+ 100	-15
D2	+ 90	+30

If S1 occurs, the best decision is D1. But choosing D1 is risky because S2 could occur and there could be a loss of 15. The following decision rules are possible:

Maximax: choose D1 because it has the highest benefit (payoff). This criterion would be chosen by an optimist since there is a risk that S2 would occur and losses would be incurred.

Maximin: choose the option that minimises losses. The minimum payoffs are -15 and +30, so the decision-maker maximises these minima, i.e. chooses D2 to secure 30. The decision maker using this criterion is cautious: he or she avoids the worst outcomes.

Other criteria focus on what would happen if the wrong decision is made. To determine this first construct a *regret matrix*. The regret payoff is defined as the difference between what is actually secured and what could have been secured had the correct decision been made. For example, choosing D1 with S1 occurring involves no regret since D1 has the highest payoff. Choosing D1 with S2 occurring involves foregoing 30 (had the correct decision, D2 been made) and losing 15, a regret of 45. D2,S1 yields 90 but had D1 been chosen it could have been 100, so the regret is 10. D2,S2 involves getting 30 but D1,S2 would have produced -15, so the regret is zero. The regret matrix is shown below.

Regret Matrix

	S1	S2
D1	0	45
D2	10	0

A criterion for choice is now *minimax regret*. This involves taking the maximum regrets from the regret matrix (10 and 45) and minimising these (choosing 10), i.e. D2.

A9.6 Guidelines on Risk and Uncertainty

The preceding sections suggest some basic guidelines:

- never ignore risk and uncertainty
- distinguish risk and uncertainty contexts
- when probability distributions of outcome are known, report the distributions and their characteristics
- report mean and median values where distributions are not normal, and show how results vary with the choice of central tendency
- report measures of variance
- check the list in Section A9.4.3 to see if any of the recorded 'failures' of the expected utility approach are likely to apply: record these in statement form;
- if the context is one of uncertainty, at least report sensitivity analysis on values for key parameters and combinations of sensitivities
- if the context is one of uncertainty, construct a payoff matrix and investigate the application of decision analysis rules.