

Ofwat and UKWIR

Lessons from recent assessments
of benefits of water service
improvements



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Executive summary

This study has its origins in a planning inquiry to determine consents for intermittent discharges in the North West and in the cost-benefit analysis of the Thames Tideway project. The planning inquiry tested the approach to evaluating the benefits of environmental improvements taken at the last Periodic Review, and the Tideway analysis highlighted and solved some of the challenges of survey design. It also incorporates current thinking derived from some of those involved in Periodic Review 2009 (PR09) study design and lessons learnt from recent work on disproportionate costs under the Water Framework Directive. In bringing together all these various aspects, the aim of this study is to assist the water industry as it prepares analyses of investment options for the next Periodic Review.

Those things which people care about

In order to reach any conclusions regarding the estimation of service improvements, it is first of all necessary to define those service improvements in a meaningful way. To this end, we begin by making a number of observations.

- Until one asks consumers what they rate most highly, one cannot know which effects they hold preferences over. The first step of any survey work, therefore, is to establish which aspects of service quality consumers care about.
- It is quite common to find that the present level of service performance received by customers is not measured by management or the economic regulator in dimensions of performance which consumers rate most highly.
- It is also quite common for the standard modelling of asset performance to be a poor predictor of changes in aspects of service that most concern customers. The reason for this is that models have typically been designed to predict the effect of investments on compliance with monitoring regimes. As a result, therefore, these models may not be flexible enough to predict effects that are of concern to consumers.
- Furthermore, the effects predicted by models may only be realised if certain other investments are also made, and this co-dependence or contingency needs to be taken into account in the cost-benefit analysis.

Recommendations

The first challenge is to measure the current quality of service. The second is to estimate the effect of the proposed investment on the quality of service and the third is to translate the effects into impacts which consumers see as being important. This involves some preparatory work to express these impacts in a familiar manner which consumers can assimilate rapidly in a survey context, and to identify the attributes of most concern, and thereby to establish consumers' preferences. Having achieved this, reliable valuation results can only be obtained if consumers are offered fairly simple sets of choices.

In modelling the effects of investment on performance, the modelling should show the effect on impacts that consumers see as being of importance in addition to predicting compliance with sampling and standards regimes.

Those attributes that customers see as being important can be elicited through focus groups, one-on-one discussion and questionnaire debriefing sessions and pilot survey exercises.

It is not necessary for surveys to discuss the issues behind the operational and technical aspects of the proposed change. Typically, all that is needed in order to demonstrate to the customer that an investment plan is credible and that they are being asked to comment on a genuine choice, is for the customer to be told that investment is necessary.

Furthermore, customers should not be asked to express preferences about changes in service levels described in terms of compliance with monitoring standards which have no direct relevance to their health and welfare.

Many previous stated preference surveys have not been designed to elicit risk preferences of respondents. However, focus groups and individual interviews could be used to derive further information on this issue. If it is found to be important, WTP can be mapped across four factors: probability, severity, spatial extent of incidents and increment of improvement.

A common simplified approach to the treatment of risk is to use the expected value. However, research is required to assess how robust this assumption is in deriving WTP since it is not immediately clear that risk preferences are adequately represented by this approach. In the absence of such research, where the benefits of a project are dependent on certain particular events occurring, respondents should be asked only about their valuation of benefits assuming that the contingent event occurs. An appropriate person should then assess how likely the benefits are to be realised, i.e. the likelihood of the contingent event occurring, when making a judgement as to whether to proceed with the project.

Customers may also hold strong ethical preferences, feeling an obligation to reduce some impacts on others. Faced with views such as these which have been obtained from focus groups or elsewhere, care has to be taken in framing the questions. If respondents hold strong preferences over certain outcomes, they may be prepared to pay for nothing short of obtaining that outcome. They should be given the chance to express these preferences.

When a survey is designed to value rare changes, it may only be possible to obtain reliable valuations when those changes are familiar to the respondents.

The framing of survey questions

Frequently, surveys are used in economic valuations of goods where no market prices can be observed. For instance, many of these surveys ask the public to state their preferences over changes in service levels. However, in a survey, there are limitations to the sort of information that can be presented to respondents. Here are some of the issues that have been explored in recent academic research on survey design.

- The design should allow respondents to state their preferences. It is not acceptable to express impacts in terms that respondents struggle to comprehend.
- Respondents should be offered clear descriptions of impacts, particularly where they entail complex matters. There is often a trade-off between the clarity of description and the number and complexity of choices that can be offered within the time available for a questionnaire to be administered. This trade-off has to be made with care. It is important to retain a balanced appreciation by the respondent of the environmental or other non-market impacts and the financial impacts presented in a survey.
- Although consumers may value many attributes, the choices presented to them should be kept to manageable proportions, so that respondents can comprehend them and express their preferences. The maximum number of factors that respondents can handle is around seven, which reduces to four or five where they are offered many choices, such as in a choice experiment.
- Surveys often ask respondents about service features which are rare—that is, they affect only a small number of households. The most reliable responses are obtained from respondents who are familiar with the impacts in question.
- Surveys occasionally ask respondents about projects where the effects of the change are unknown. In this situation, the survey will test respondents' expectations about the effect of the change, but these expectations are of limited use since they may not reflect the real life situation. There may be substantial merit in waiting until more specific information becomes available before attempting a survey.
- Respondents should be asked to value non-market goods in the context of any wider programme of improvements that may be taking place, and also in the context of their household spending and household income.

Recommendations

On some occasions a project's impacts are on the expected level of small risks, for example, the expected frequency of mild stomach upset or days off work, or the number of days per year when water is mildly discoloured, or the increased risk of heart disease and stroke (for lead in drinking water). Unfortunately, respondents have a limited ability to process information about low-level risks. In some of these situations, a pictorial representation of impacts, for example, health risks, can significantly improve the consistency of WTP responses. At the very least, stated preference valuation studies should not present environmental changes using unfamiliar units (for example, certain complex or unfamiliar numeric units).

A common way of avoiding complex numerical descriptions of water quality changes in rivers is to give respondents pictorial information regarding alternative river quality levels, depicting improvements by water getting clearer and containing more plants and animals. Although it is probably true that most individuals feel that this relationship holds, the scientific basis for such an association is far from clear. Overall, there is no simple association, and it is recommended that an alternative approach is taken, for example, using reference to historical environmental status.

If the effects are unknown and respondents are presented with uncertain or incomplete information, they will make assumptions about the true nature of the effects, and their valuations will reflect their guesses, not the true magnitude of the effects. Respondents should not be left to guess the size of the impact.

The complexity of choices presented to respondents in a survey affects the WTP obtained and the consistency of respondents' choices. Complexity in a survey is driven by the number of attributes, the number of levels of provision of those attributes, the number of attributes varying between alternatives, and the number of alternatives. The choices used in surveys should be kept fairly simple.

Although sensitivity analysis is routinely carried out for cost assessment, with optimism bias being a factor that is explicitly considered in many cases, it is not yet routine to perform sensitivity analysis on benefits estimates or to consider sources of optimism or pessimism. Sensitivity analysis should be performed where possible.

When eliciting use values, revealed preference methods, which use observations of actual consumption patterns, such as visit rates to leisure sites, to infer individual valuations across the population, should be considered as an alternative to survey methods. They may be particularly helpful in understanding the relative importance of improvements at alternative sites with different characteristics.

Projects or programmes should be considered jointly with other claims on the household budget, so that estimates are not over-stated and reflect the true WTP. This can be achieved by providing examples of opportunity costs, both in terms of other water industry investments and broader consumption and saving options, by asking respondents to consider what their income will be in the future when the impact of additional costs will be felt, and by recording the socio-economic and preference characteristics of respondents who state they have a zero or very low valuation because of budget constraints.

The scope for benefits transfer using currently-available studies

The Environment Agency (EA) developed its *Benefits Assessment Guidance* (BAG) methodology to estimate the benefits of environmental improvements proposed during PR04 so that they were expressed in monetary terms. This methodology drew upon past studies of the benefits of proposed improvements and applied them to new projects in a process known as 'benefit transfer'. While, in principle, such an approach may be reasonable, as with any analysis, its practical viability depends upon the quality of data available. The case for continuing to use the source studies used in the BAG for benefit transfer is weak on a number of grounds. As will be shown below, the studies used in the BAG are insufficient in their coverage and in most cases inappropriate for the BAG's purpose.

- The source studies in the BAG typically do not test the sensitivity of the monetary values they obtain to the availability of substitute (alternative) environmental resources. This introduces a large degree of uncertainty as to the true value when the benefit figures are transferred to a new location.
- The reliability of the values in the new context depends on the similarity between the sites and the efforts made to adjust for differences. Adjustments can be made by estimating the relationship between site attributes and monetary values in an expression known as a 'value function'. The transfer of a value function rather than simple average monetary values may improve the reliability of benefits transfer. However, none of the source studies used for the BAG is suitable for value function transfer.
- Some of the source studies do not cover a representative sample of sites. The sites selected for those studies may have been selected for atypical attributes which make the study noteworthy but reduce the applicability of its results to other sites.
- Most of the source studies were not designed for use as sources for benefit transfer and some are now quite dated.

Recommendations

There is a lack of studies of benefit transfer from which to assess its applicability. Where it is used, it is preferable to transfer a value function from the original study site. This takes an equation derived from one or (preferably) more original study site(s) and applies it to the policy site, inserting the different substitute availability and population socio-economic characteristics of each study site into the equation to calculate new WTP values for each policy site.

It should be borne in mind when using published studies that there is a potential for bias in the results because published studies may not examine representative sites or changes.

The source studies used for the BAG do not allow the valuation of improvements of a single attribute such as litter, turbidity, water ecology or bacterial load, but combine a number of them. That is because the studies asked people to value changes in environmental states rather than changes in attributes whereas most modelling of projects will be in terms of particular attributes. They were not designed for benefit transfer and should be used with great caution, if at all, in assessing the value of future projects. They are still less suitable for the assessment of improvements to intermittent discharges. It is highly debateable as to whether any of the BAG source studies would yield reliable valuations when used for benefit transfer. To address these deficiencies requires new studies, specifically designed for transfer purposes.

A study of the River Tame is the principal study on which the BAG relies for estimates of non-use value. The study was not designed as a benefit transfer source study and does not yield estimates which can be transferred reliably to other locations and projects. The only way to obtain non-use values for environmental goods is the stated preference method. The stated preference method can also be used to elicit use values, and may yield reliable programme-level results if it is well-designed and the results are interpreted carefully.

Revealed preference methods are likely to provide more reliable estimates of use values for environmental goods, but such methods cannot be used to obtain non-use values.

The appropriate use of programme-level studies

Programme-level stated preference studies, such as those currently being undertaken by some companies in preparation for PR09, may well provide companies with a reliable indication of the values of investment programmes. These studies will allow companies to rank projects within a programme, because they will offer information on the relationship between values and project attributes. Alternatively, the same insights on the use value of project attributes could be gained from revealed preference studies. Revealed preference studies use statistical analysis of the patterns of consumption of environmental goods, such as visit numbers to lakes, in combination with information on the cost associated with that consumption, such as the cost of travel to the lake, to estimate the value gained to a consumer through the use of the environment.

While programme-level studies will provide the tools for strategic programme design, revealed preference studies may offer more detailed insights into the use values of individual projects, and could be particularly useful for comparing projects with different attributes. Revealed preference studies may also provide evidence of the value of a wider range of projects to be tested for disproportionate cost under the Water Framework Directive.

Non-use value is still poorly understood

Non-use has been seen as a particularly important area for study because of claims by some agencies that a major part of the value of environmental improvements is non-use value. There is now greater understanding of the properties of non-use value. However, further research is needed and some of the problems associated with non-use value are set out below.

Non-use value should be included in a cost-benefit analysis, but care should be taken when survey respondents state WTP values for the use of the resources by others. Some of this value may well be counted as use value elsewhere in the analysis and should not be counted twice. In contrast, allowable forms of non-use value, which do not also appear as use value for any present users, include the enjoyment of the knowledge that the natural world is protected and enjoyment of the provision of particular forms of environmental goods to others.

- The process of obtaining non-use valuations from stated preference methodologies remains challenging. Non-use value is a concept that is unfamiliar to the public and may give rise to unreliable responses to questions.
- It is not clear to what extent individuals' non-use values are affected by the importance of the environmental improvement. In particular, how it might vary with the number of people who have access to the environment that is to be improved.

Recommendations

The two types of non-use value that should be included in a cost-benefit analysis are:

- Existence value—individuals may value an environmental good simply by knowing it exists without experiencing it directly;
- Paternalistic altruism value—individuals may value particular forms of provision of environmental goods to other users.

Non-use value must not be confused with the value attributable to non-users. For example, there is the option value of future possible use; this is treated as a use value, whoever holds the value.

There are also altruistic motivations concerning the general wellbeing of others in society, including future generations. This motivation is captured within the use values of those other individuals, and care has to be taken to avoid counting it twice.

To distinguish between these types of non-use value in a survey, all respondents can be asked the extent to which any non-use reflects a concern for the general well-being of the people who will benefit, or whether it reflects a desire for people to have access to improved water quality. The value obtained in response to the first question is counted elsewhere as the welfare of the user and should not be counted again, but the value obtained in response to the second question should be included, at least to some extent. However, the precisely correct manner in which these questions should be asked and the preferences should be counted is not clear. Moreover, the justification for taking this approach warrants further challenge. Thus, this set of issues demands a serious review before firm recommendations can be made that are specific enough to form practical guidance.

If respondents typically do not interact with the environmental good and only derive indirect benefits from it, their preferences are likely to be poorly defined due to unfamiliarity with the good itself. This is a particular concern with non-users and contributes to the unreliability of estimates of non-use value.

It is not clear that the non-use value that respondents hold is attached to a particular environmental good. If instead it reflects general preferences regarding environmental quality then surveys should be carried out on highly aggregated assessments of baskets of goods if they are to capture valuations correctly. Further investigation of the nature of non-use value and appropriate survey design is recommended. As part of this investigation, clarity should be sought as to whether non-use values are affected by the number of users who benefit from an improvement.

Furthermore, particular effort has to be made to avoid non-use choices appearing hypothetical, since in answer to hypothetical questions respondents may exaggerate their WTP because of the moral satisfaction they achieve from reporting a high valuation, rather than because they actually hold a high valuation.

The reference point for measuring an improvement is sometimes important

There has been ongoing contention regarding the correct measure of value, i.e. whether it should be willingness to pay for an improvement; willingness to pay to prevent deterioration; willingness to accept (WTA) compensation for a deterioration in the status quo; or willingness to accept a failure to meet some standard higher than the status quo.

- The measure chosen is important because it affects the size of the value obtained. The relative initial and final levels of consumption or quality of the good in question determine the correct measure of value of a change.
- There may be some circumstances where there is an over-riding concern that the status quo does not reflect an appropriate distribution of property rights. For example, where historical rights to pollute conflict with recent legislation seeking environmental improvement. Here, ethical arguments may come into play. A review of the ethical arguments suggests that a moderate ethical position is associated with a measure of value somewhere between WTP and WTA.
- The values of WTA and WTP can be very similar, so the choice of measure is of no importance, in cases (common in the water industry) where the values constitute a small proportion of income and there are good alternatives available. It is unlikely to be true for unique goods of large value, and the values may diverge where the circumstances involve losses. In all cases the measurement of WTA is more open to bias in questionnaire responses than WTP.

The common practice is to solicit the WTP measure for improvements in service and environmental quality levels. This is uncontroversial for most attributes. In the cases discussed above where WTA is also of interest, care must be taken to discourage survey respondents from over-stating their preferences. Alternatively, WTP can be used and a note about the assumptions associated with the use of WTP figures can be presented as a commentary alongside the cost-benefit analysis.

Recommendations

The initial allocation or perceived entitlement of goods (the reference point) is usually thought to determine the appropriate measure of welfare change. However, if the CBA process is selected by society to resolve environmental issues, it, if anything, serves to *determine* the distribution of rights. This renders the CBA process circular. Furthermore, there are ethical arguments in favour of taking a more moderate position, i.e. lying between WTP and WTA. The common practice of soliciting the WTP measure for improvements (rather than WTA for forgoing an improvement) is to be preferred for most service attributes. Wherever the impacts of the changes on an individual are a small proportion of their income, substitutes are available, and the change is an improvement, the values of WTP and WTA will be very similar and WTP can be used.

Where the above conditions do not hold, or where a loss in environmental quality is considered, it may be worthwhile attempting to measure WTA, if satisfaction can be obtained that respondents' stated preferences will not be exaggerated. Alternatively, in these circumstances, a note about the ethical assumptions associated with the use of WTP figures can be incorporated into the commentary alongside the cost-benefit analysis

Consideration of substitutes is essential

It is extremely important to take adequate account of substitute environmental sites. The programme-level surveys for PR09 will do this, but site-level assessments will also have to be able to take into account substitutes.

- If the value obtained for an environmental improvement at a single location with no substitutes is transferred to a programme of improvements at many locations, the value of the programme will be overstated if the locations are at least partial substitutes for each other.
- The BAG attempts to take account of the effect of substitute sites, but the approach it takes is without empirical support and it relies excessively on an assessor's subjective analysis. It offers no definition of an alternative site and no way of accounting for the quality of alternative sites.

Recommendations

Survey respondents should be presented with choices between programmes of improvements. Alternatively, the whole programme can be disclosed to respondents early in the questionnaire. The individual valuation of projects should be avoided as the basis for estimating the value of wider programmes.

The BAG approach to substitutes should not be used.

Identification of the relevant population is critical

The process used to aggregate individual values across the relevant population—those who benefit—is crucial in determining the overall level of benefits. The extent (geographical size) of the market may well be more important in determining aggregate values than any changes related to the precision of the estimates of per-person values.

- Values decline with distance because the proportion of users in the population falls with distance. Where use and non-use value are considered in combination, there is a stronger distance-decay effect. Use value typically exceeds non-use value and users tend to live closer to the site. Therefore, moving away from the site increases the proportion of non-users to users and reduces the valuation of the average individual, producing a distance-decay relationship.
- For non-use value, it is not clear why distance would be important to valuation, although it is observed as being so, unless there is a sense in which individuals living closer feel a degree of 'ownership' or affiliation which increases their valuation.

A decision always has to be taken about which geographical area to use to aggregate individuals' values. This area is known as the jurisdiction. Two approaches have been taken in the past; the economic jurisdiction, referring to the population which expresses a positive value for a change, and the bureaucratic jurisdiction, which in the water industry is the population served by an individual water company. The use of the economic jurisdiction is to be preferred if the results are to be employed in a cost-benefit analysis. Unfortunately, there is little empirical evidence available currently on how large the economic jurisdiction is likely to be for a range of projects of different types and sizes. It might be problematic to use the bureaucratic jurisdiction if it is obvious that a scheme generates benefits extending outside that area. However, for small schemes it may be acceptable.

- The choice of method can have a massive impact on the aggregate value obtained. The only two reliable approaches are to estimate a 'distance decay' function

(adjusting for the decline in WTP for improving a site as the distance from a respondent's home to that site increase) or to obtain a sample that is representative not only of the socioeconomic and demographic composition of the population, but also of the manner in which values decay across space.

- Care has to be taken when using mean values from surveys and aggregating them over different populations. The correct approach is to take a simple mean from a representative sample and multiply by the relevant population. It is most important that the sample is representative, socio-economically and geographically of the relevant population.

Recommendations

There is obvious merit in including all potential beneficiaries in any assessment. Thus it is correct to use the economic jurisdiction to define the relevant population.

Some, but not all values, are spatially specific. An example of spatially-specific preferences is the consumption of environmental goods from a given site. One should expect average use values to decline with increasing distance. For payment to avoid loss scenarios, we should not expect distance decay of the values stated by non-users (except for any effect due to cultural affiliation with a particular resource). Conversely, for willingness to pay for improvement scenarios, even non-users should exhibit distance decay effects. This is because some of the non-users are enticed to become users when the improvement takes place, and their use value is higher than their non-use value. Furthermore, they are more likely to become users if they live close to the site. Inspection of distance decay trends amongst users and present non-users can be used as a test of the validity of aggregation exercises.

Valuation studies typically report mean WTP, masking great variation between respondents. The only two reliable approaches to aggregation of WTP over distance are to estimate a distance decay function or to obtain a representative sample of the relevant population. The BAG does not use either of these methods, so its approach to aggregation should not be used.

Other recommendations for cost-benefit analysis

There are a number of stages in the compilation of a cost-benefit analysis where practice can be improved.

- The cost of finance is often omitted from cost-benefit analysis. It should always be included. It takes two forms: for private finance, it is the pre-tax market return on the capital tied up in the project; for public finance and it is the social cost of public funds (including the cost of economic distortions involved in raising revenue through taxation).
- Cost-benefit analysis should employ a consistent unit of account for all costs and benefits. The usual unit of account is market prices, which includes all taxes and subsidies on consumption. Water bills and survey WTP figures are in the same unit of account, but the water industry costs are exempt from Value Added Tax. It is a matter for debate whether this is regarded as a subsidy or not. Given this doubt, it is recommended to report costs both with and without VAT.

- There are a number of standard procedures for accommodating time in a cost-benefit analysis to adjust for changes in nominal prices (inflation), income, time preferences and growth in consumption. All of these procedures should be implemented in a cost-benefit analysis. Changes in environmental scarcity and quality may also occur and, because it is a little-explored area, may best be dealt with through a qualitative commentary. In addition, quantitative research into scarcity would be worthwhile.
- Benefits to the local economy should only be counted if they help to address particular social priorities or result in national net increases in economic output. Net increases in output are gained through the relief of inefficiencies in the labour market, improved availability of capital, or improved technology. Water industry investment programmes are unlikely to deliver any of these net increases in economic output.

Recommendations

The cost of financing a project should be included. It reflects the cost of raising funds (weighted average cost of capital) in that market sector. The pre-tax cost of capital should be used.

There are also capital costs associated with operating expenditure. However, these are generally captured by the cost of finance, provided that the total capital employed i.e. capital employed general business functions and working capital as well as capital expenditure, has been identified.

It is of no consequence whether CBA is conducted in the unit of account of market prices (i.e. including direct taxes and subsidies) or factor prices (i.e. excluding them), provided that they are used consistently for all the costs and benefits. Typically, willingness to pay estimates are presented at market prices and so this is the unit generally used. In the case of the water industry, VAT paid is refunded by the Exchequer, which, arguably, should be thought of as a subsidy. Hence, for projects undertaken by the water industry, it may be wise to report cost estimates both with VAT added and without VAT.

No adjustment needs be made for the presence of environmental taxes. Alternative approaches can be taken, but would need to be justified.

Forecasts of the construction prices index should be used to adjust future estimates of construction costs.

Increases in income tend to lead to increases in consumption and WTP. While the simplest assumption to make is that environmental goods constitute a constant proportion of a household's budget, and the evidence on more sophisticated approaches is inconclusive, a fair working assumption is that real valuations of environmental benefits will increase every year by around 0.6-0.8%.

Care should be taken not to confuse price and income increases. Nominal income growth is (approximately) equal to price growth plus real income growth.

If a scheme generates benefits over many years, it may be best to ask respondents what they would be willing to pay on their bill this year, if the benefits were available this year. This removes complex issues associated with timing of benefits and payments from the respondent's decision. These issues can be addressed later during the aggregation stage of the cost-benefit analysis.

The BAG recommends an assessment time horizon of between 15 and 60 years. An alternative and perhaps better approach is to choose an assessment time horizon that is consistent with the life of the assets providing the service improvement.

A final issue concerns the use of cost-benefit analyses in decision-making. A positive net present value is the most reliable indicator that a project is socially worthwhile. Only where resources are scarce may benefit-cost ratios be used, for example where there are political limits to rises in water bills. Even then, they should only be used if all the items defined as costs fall within the constraint on expenditure and if the projects are not mutually exclusive. If those conditions are met, and benefit-cost ratios are used, the hurdle ratio for proceeding should be set at the level which fully exhausts the constraint, for example, to achieve the largest politically-acceptable rises in bills. This hurdle ratio is likely to be greater than unity.

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1 Introduction

1.1 Origin of this study

There have been two major exercises to estimate the monetary value of water quality improvements over the last six months, and both offer useful insights for participants in the next Periodic Review of Water Charges or the implementation of the Water Framework Directive. The first exercise was the appeal by United Utilities of consents for combined sewer discharges to the Rivers Irwell, Douglas and Mersey, and the second was the commissioning of a second survey of the benefits of reducing intermittent sewer discharges to the Tideway for Thames Water's 'Thames Tideway' scheme. In the first case, cost-benefit evidence was presented to the planning inspector, however, the planning inspector reached his decision on grounds other than cost-benefit analysis. In the second case, cost-benefit evidence was presented to Ministers and was taken into account in the decision.

Both these exercises have offered valuable information and insights that may raise confidence in future work. They will also assist water companies now embarking on customer surveys to inform their business plans for the next Periodic Review of Water Charges, PR09. Not only do these relate to similar schemes, they also apply to other service attributes which are major sources of expenditure and public concern, such as sewer flooding, security of supply, and drinking water aesthetics.

1.2 The business case

A report of this type generates the most value if it improves decision-making regarding spending. Given that the amount spent on improvements is at least 100 times greater than the amount spent on the assessment, and the amount spent on the assessment is at least ten times greater still, there is great leverage to be gained in making assessment guidance available.

The second benefit is a saving of time and cost in preparing the assessments for the next Periodic Review. The knowledge presented in this report enable assessors to focus on key areas and sensitivities, obtain more reliable results, and avoid costly revisions to assessments in order to correct errors.

There are further benefits to be gained. The most obvious is the reputational benefit of learning lessons from within the industry and from academia. It may also be easier to reach agreement on the size and shape of future investment programmes if all parties have greater confidence in the assessments themselves.

Although these benefits could emerge of their own accord, they would not all have done so, and probably not within the same time scale. This is because the planning inquiry, although open to the public, was attended by the participants alone. To similar effect, some of the recent Thames Tideway discussions were held in private while the analysis was widely disseminated.

Many of the arguments on environmental benefit relate directly to the main assessment tool used at the last Periodic Review, i.e. the Environment Agency's *Benefits Assessment Guidance* (BAG), which remains to this day the main tool in the Environment Agency's armoury, Environment Agency (2003b). The BAG has been the subject of much comment since it was introduced, particularly on its approach to the aggregation of benefits. By setting out some of the recent advances in thinking, this report builds upon the last Periodic Review and offers further improvements. It does not, however, comment on practice at the last Periodic Review, except insofar as it was relevant to the United Utilities consent appeal and the Thames Tideway appraisal.

1.3 Content

The issues that emerge relate to how best to achieve conceptual correctness of the assessment and to test the sensitivity of the results to assumptions in key areas:

- identifying the environmental or service level change;
- the limitations of relying on existing benefits unit values;
- choosing the relevant population;
- applying existing guidance to intermittent discharges;
- correct accounting for the costs of finance;
- the nature of non-use value;
- revealed preferences;
- the effect of substitutes;
- information presented to respondents;
- the effect of property rights.

The report is intended for a wide audience although, of necessity, the discussion becomes technical in places. The report has been prepared by Vivid Economics Limited in collaboration with Professor Ken Willis, University of Newcastle and Professor Ian Bateman, University of East Anglia. Questions and comments should be addressed to Robin Smale, Director, Vivid Economics or Rowena Tye, Head of Quality Enhancement, Ofwat. We gratefully acknowledge the perceptive comments of Dr Jonathan Fisher of the Environment Agency.

PART ONE: TECHNIQUES

2 Stated preference survey design

This section discusses issues that have arisen recently concerning the presentation of service changes to survey respondents.

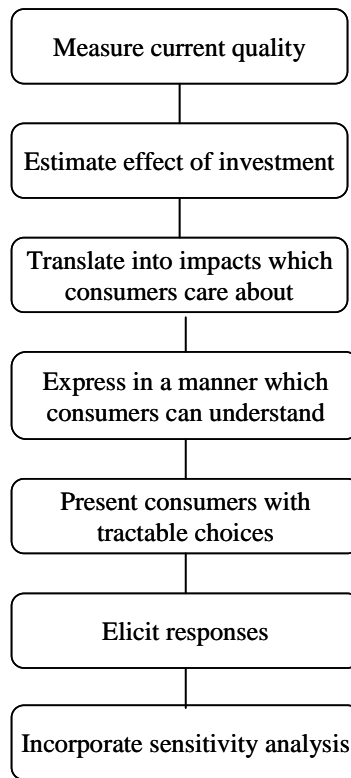
2.1 Meaningful description

Service level changes that are neither described clearly nor in a way which customers can easily comprehend will not elicit reliable responses. This subsection describes the main issues that have arisen recently, and structures the issues into a value elicitation process, summarised in Figure 1. It draws on examples from drinking water quality and sewage discharges.

The first challenge is to measure the current quality of service. The second is to estimate the effect of the proposed investment on the quality of service and the third is to translate the effects into impacts that consumers care about. This involves some preparatory work to establish what it is that consumers care about and to express the impacts in a familiar manner which consumers can assimilate rapidly in a survey context. Having done this, reliable valuation results can only be obtained if consumers are offered fairly simple sets of choices.

Finally, the sensitivity of consumers' preferences to the size of the improvement, the geographical extent of it, and other similar attributes should be tested, and any contingencies between the improvement and other factors should be brought into the cost-benefit analysis.

Figure 1 Stages of value elicitation in which issues have arisen



Source: Vivid Economics

2.2 Measurement of present quality

It is quite common to find that the present level of service offered to customers is not measured using attributes that consumers care about.

Take drinking water as an example. The proportion of samples failing standard chemical and biological tests of drinking water quality does not provide a direct indication of the number of households affected by poor drinking water, nor the durations of quality lapses. This is because the duration, in terms of the time between the event occurring and the sample failing the test may be unknown in many cases, and the time from the test failure to remedial action may also be unknown. Furthermore, the pattern of sampling water at different points of the water supply network may make it difficult to estimate the numbers of customers being affected. Hence the impact of the number of samples failing the drinking water quality test, in terms of household numbers and impact on households, might be unknown.

A similar problem is found with river water quality. River quality monitoring regimes reflect a combination of the feasibility of monitoring (i.e. they are based on standardised water quality sampling regimes and chemical tests, such as River Ecosystem (RE) classification), an interest in the health of the ecology (for example, Fundamental Intermittent Standards), and the statutory responsibilities of the regulatory authority. In practice, this means that knowledge of the present status of the river ecology and the pressures on it is patchy, although it is improving.

2.3 Effect of investment

Some of the standard modelling that is typically used to estimate the effect of investment on service levels was originally designed to predict the effect of investments on compliance with monitoring regimes. It may not be flexible enough to predict other effects that matter to consumers. Furthermore, the effects it predicts may only be realised if certain other investments are also made, and this co-dependence or contingency needs to be taken into account in the cost-benefit analysis.

In sewerage network modelling, the modelling may address, for example, the magnitude of water quality changes at the 90th percentile concentration in a standardised sampling regime, or the 99th percentile concentration. There may be no direct link between the modelled objective parameters of water quality or ecological standards, and the subjective factors which explain individuals' preferences. Furthermore, the statistical relationships between water quality measures and ecological measures may be poor and highly non-linear, Hutchins et al (2007).

Let us explore this case further. The commonly-used manual on water quality modelling for urban pollution management and the EA's Benefits Assessment Guidance (BAG) were designed for different purposes, Foundation for Water Research (1996). The modelling is designed to estimate the number of hours of failure of a sample standard, and from this determine the RE Class. However, in the economic studies upon which the BAG relies, a change in continuous level of water quality was assumed. An intermittent discharge causes occasional excursions of water quality and may cause a greater increase in the likelihood that a random sample will fail a quality ceiling than the increase it would cause in the expected mean water quality. We do not know how the eco-system responds to occasional quality excursions and nor do we know how the public values occasional excursions in quality relative to changes in mean quality.

A further complication is that some of the benefits may be contingent on other improvements taking place. For example, a reduction in the load of oxygen demand entering a river from a sewage treatment works may only generate benefits of improved fish populations if the load of pesticides from agricultural sources is also reduced. The way in which such contingencies are often handled in other spheres is for customers to be asked about their valuation of benefits assuming that the contingent event occurs. An appropriate person then has to take into account how likely the benefits are to be realised when making a judgement about whether to proceed with the project, Little and Mirrlees (1994). In this example, the appropriate person has to have knowledge of the likelihood that regulatory measures will be put in place and deliver the expected improvement.

2.4 Impacts that consumers care about

Until one asks consumers what they care about, one cannot know which effects they hold preferences over. The first step of any survey work is to establish which aspects of service quality consumers care about.

There are several lessons from recent experience. Firstly, the ways in which those attributes that customers care about can be elicited are through focus groups, one-on-one discussion and questionnaire debriefing sessions and pilot survey exercises.

Secondly, there is a temptation, especially perhaps for experts, to relate operational and technical aspects of the proposed change to customers. While it is tempting to describe these engineering challenges in a survey, typically all that is needed in order to demonstrate to the customer that an investment plan is credible and that they are being asked to comment on a genuine choice, is for the customer to be told that investment is necessary.

Thirdly, there are striking examples in which customers have been asked to express preferences about changes in service levels described in terms of compliance with monitoring standards which have no direct relevance to their health and welfare.

Drinking water provides us with an example. In previous surveys, consumers have been offered an improvement in drinking water quality expressed as a proportion of samples taken by the water company which pass the standards set by the Drinking Water Inspectorate. Let us explore whether respondents can interpret this metric in terms of their health and welfare. Drinking water standards encompass many dimensions of quality including microbial contamination, colour, metals, odour, acidity, poly-aromatic hydrocarbons and so on. They also involve a prescribed protocol for testing. All of this detail is unknown to most survey respondents. Even if they were aware of it, almost all respondents would have no idea of the effect of non-compliance on their health or enjoyment of the drinking water. Furthermore, the extent of non-compliance of failing samples, i.e. whether they fail marginally or by a wide margin, is not communicated to the respondents.

It might be better to explain the expected level of health risk customers face, for example, the expected frequency of mild stomach upset or days off work after immersion in bathing waters, or the number of days per year when a river runs dry due to drought, or the increased risk of heart disease and stroke as a result of lead in drinking water. This approach has been taken in a number of past studies.

How customers view outcomes will depend upon their risk preferences. This may require WTP to be mapped across four factors: probability, severity, spatial extent of incidents and increment of improvement. Evaluating all these dimensions is a challenging task, made more problematic by the fact that many respondents in stated preference surveys experience great difficulty in dealing with probability questions, often generating inconsistent answers (see below). Many previous stated preference surveys have not been designed to elicit risk preferences of respondents, but focus groups and individual interviews could be used to determine whether this issue is important for the case being examined.

Similarly, the water company may wish to probe preferences for events with different degrees of severity. This will allow them to attach values to and prioritise investment schemes generating different changes in outcome. For example, the severity of internal flooding of properties by sewage may range from (a) damp patch

in an unused cellar, and occasional restriction of toilet use, (b) damp patch (of no measurable depth) in unused cellar but with frequent restricted toilet use, (c) measurable depth of sewage water in unused cellar, (d) sewage water of any depth in under-floor space, utility cellar, cellar at business premises, and integral attached garage, to (e) sewage water in living accommodation. The Yorkshire Water study, Willis et al (2005) provided WTP information on the number of customer properties where flooding from a mains sewer has entered the building within which the level of incidence varied (number of properties affected per year). However, each incidence level was assumed to have 100% chance of occurrence; and only one specified level of severity (e.g. sewage water of a measurable depth in a customer's living accommodation). Thus, it did not address either the issue of severity or the issue of risk. This was, however, addressed in a subsequent separate choice experiment study to map utility and WTP by probability and severity of occurrence Scarpa and Willis (2003).

A common simplified approach to the treatment of risk is to use the expected value. This avoids the need to assess customers' WTP for changes in probability and risk. Research is required to assess how robust this assumption is in deriving WTP: it is not immediately clear that risk preferences are adequately represented by this approach, Kahneman and Tversky (2000).

Customers may also hold strong ethical preferences, feeling an obligation to reduce some impacts on others. For example, in a focus group of customers discussing intermittent sewage discharges, a number of individuals were surprised to learn that raw sewage regularly discharges when storm drainage capacity is filled, Smale (2006a). Some of the participants felt that, whatever the environmental impact might be, it was not acceptable for any raw sewage discharges to be taking place. Faced with focus group views such as these, care has to be taken in framing the questions. If they hold strong preferences over the presence of raw sewage discharges, they may be prepared to pay for nothing short of complete cessation of raw sewage discharges. They should be given the opportunity to state such preferences in the survey.

2.5 Express changes in a manner which consumers can understand

One of the objectives of survey design is to express impacts in terms that respondents can comprehend. Numerical expressions in particular can lead respondents to make inconsistent choices and to be unable to state their proper preferences. A commonly adopted solution is to use a pictorial presentation of impacts and to make reference to familiar goods.

The comprehensibility of numerical data has been examined in academic studies. It is known that respondents have difficulty in responding to small changes in probabilities in expressed preference surveys (Jones-Lee et al 1985). For example, the chance of stomach upset for 2 days per year might be, say, 1 in 1000 households or less. Some recent experimental evidence shows that individuals react with lower sensitivity to changes in the magnitude of the improvement, as the denominator

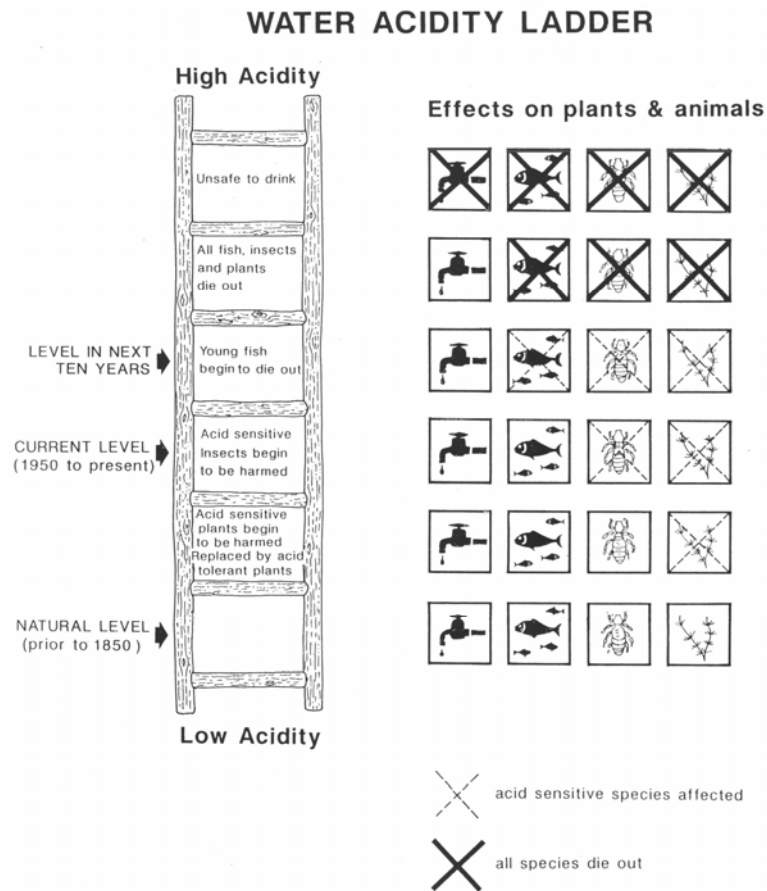
used to convey a probability change. For example, consider a risk reduction (A) from 4/100 to 3/100 as opposed to a risk reduction (B) from 40/1000 to 30/1000. The research finds lower changes in value for B than for A, yet they are the same risk changes. This is an ongoing challenge for survey design. Therefore the wording of a question is critical. A survey question which states the probability that a customer might experience a service failure and one which states the total number of customers facing a service failure may obtain different valuation estimates. A pictorial representation of impacts, for example, health risks, can significantly improve the consistency of WTP responses, Metcalf (2007).

A recent study suggests that some of the extent of the WTP and WTA asymmetry observed in some stated preference studies may be due to an effect which occurs when respondents are presented with information which they do not fully comprehend. Specifically, when stated preference valuation studies present environmental changes using unfamiliar (especially numeric) units then respondents may not realise that some of these changes are (say) quite modest. Instead they 're-code' even fairly small reductions in environmental quality as losses while small increases are recoded as gains. Subsequently, those respondents invoke a loss-aversion rule of thumb to make sense of these labels. In effect, respondents are simplifying continuous numeric information into binary gains or losses and over-reacting to the latter. The result is that objectively small reductions yield subjectively large reactions. In one paper, which contrasts WTP with equivalent loss, the presentation of the same information using alternative numerical and visual virtual reality representations of land use change resulted in differences in values between gains and losses, with numeric representations yielding much higher differences, Bateman et al (2006a).

A common way of describing impacts of water quality changes in rivers without resort to numerical descriptions is to give respondents pictorial information regarding alternative river quality levels. Some studies have depicted improvements as clarity of water and number of plants and animals. This is not a wholly accurate representation of the science. There are better alternatives available, such as in the example below.

In a study of lakes, an alternative pictorial presentation was offered, shown in Figure 2. This combines information about quality status historically and ecological status, and avoids the use of water clarity as a proxy for quality.

Figure 2 Depiction of water quality in a study of lakes



Source: Bateman et al (2005b).

If the effects are unknown and respondents are presented with this uncertainty, respondents will make assumptions about the true nature of the effects, and their valuations will reflect their guesses as to the true magnitude of the effects. The first Thames Tideway survey offers a lesson on this point, Thames Water (2005). It produced large values for health benefits by asking a question about health benefits which described the effect as 'days of elevated health risk' for water sports participants. There was little indication of the severity of the health risk or the number of people affected. When compared to epidemiological evidence on health risks prepared for second Tideway survey, the results suggest that respondents to the first survey assumed much larger health impacts than existed in reality. If impacts are unknown, there is little point in asking people to state their preferences about them. The solution adopted in the second Tideway survey was to provide a more precise description of the expected health impacts, based on epidemiological evidence. Another alternative is to ask people to value precise outcomes, which are then used in scenarios tested in a cost-benefit analysis.

2.6 Present consumers with tractable choices

Consumers should be presented with clear information on impacts, especially where they entail complex matters. The choices should also be kept to manageable proportions. Although consumers may value many attributes, the choices presented to them have to be kept fairly simple.

There are a number of studies which show that complexity of choices presented to respondents in a survey affects the WTP obtained and the consistency of respondents' choices. Complexity in a survey is driven by the number of attributes, the number of attributes varying between alternatives, and the number of alternatives.

- An increase in the number of attributes increases the error in estimating WTP, DeShazo and Fermo (2002). Miller (1956) suggested that the maximum number of factors is about 7, and above that level respondents focus on a sub-set of the most important factors. The maximum reduces to 4 or 5 if respondents are to achieve consistency when offered many choices, as in a choice experiment study.
- Wardman suggests that the marginal WTP for any given attribute declines as the number of attributes increases, Wardman (forthcoming).
- An increase in the number of attributes that differ across alternatives substantially increases the error in WTP. If attribute levels in each alternative are randomly mixed, there will be a greater variance in the WTP reported compared with experimental designs where small numbers of attributes are varied at one time.

2.7 Sensitivity analysis

Although sensitivity analysis is routinely carried out for cost assessment, with optimism bias being a factor that is explicitly considered in many cases, it is not yet routine to perform sensitivity analysis on benefits estimates or to consider sources of optimism bias. Ideally, in a stated preference situation, respondents would be asked to express their valuation over a range of outcomes. The Treasury's guidance on appraisal clearly supports the use of sensitivity analysis: 'The need for sensitivity analysis should always be considered, and, in practice, dispensed with only in exceptional cases', HM Treasury (2003).

3 Revealed preferences

An alternative to new stated preference surveys and to benefit transfer is revealed preferences. Revealed preferences use observations of actual consumption patterns, such as visit rates to leisure sites, to infer individual valuations across the population. A simple survey of visitors records the number of visitors, the purpose of their visit, the place they began their journey and socio-economic characteristics. The journey information is converted to a journey cost comprising transport cost and cost of travel time, and this information is converted into an estimate of individual valuations across the population.

When revealed preference studies are carried out on a sample of sites with varying characteristics, the data collected allows statistical relationships between site attributes and individual values to be identified and tested. The method is data-intensive, but it relies upon actual rather than hypothetical behaviour to obtain valuations of changes in site characteristics. The method may be especially helpful in understanding the relative merits of sites when prioritising investment. A substantial limitation of revealed preference approaches is their inability to estimate non-use value. It is not the role of this report to explore the pros and cons of revealed preference methods further.

4 Benefit transfer

4.1 Limitations of benefit transfer

The basis of the EA's BAG was the application of values from one study to a new situation. The reliability of the values in the new context depends on the similarity between the sites and the efforts made to adjust for differences. Although value functions which relate values to site and customer characteristics may improve the reliability of benefits transfer, none of the source studies for the BAG are suitable for value function transfer.

Benefit transfer involves taking information on the value of a good derived in one context and using it to estimate the value of a good in another context. Unfortunately, there is a lack of studies of benefit transfer from which to assess its applicability. For example, very few if any studies consider key issues such as:

- quality changes between sites;
- substitution effects;
- socio-economic variation;
- spatial variability in both of the above.

Jones et al report some success in addressing these questions for woodland visitors, Jones et al (2002). Benefit transfer predicted visits reasonably well. However, a very basic data requirement for benefits transfer is the availability of estimates of visitor numbers. There is little data on this apart from the England Day Visits Survey collected by Natural England. This important resource is, to our knowledge, completely unused as a tool for assessing benefit transfer work to date.

There are a number of ways in which benefit transfer can be implemented. The simplest is to transfer an unadjusted mean WTP estimate (mean value transfer) for the good from the original study site. The EA adopted the simplest form of benefit transfer in the BAG: transferring unadjusted mean values. Transferring simple mean WTP values is considered by some to be the most unreliable form for benefit transfer where there are potential differences between the source and policy site and surrounding populations. In such cases, benefit transfer errors are usually quite considerable; Brouwer (2002) reveals typical errors in transferring simple mean WTP values of 40% or more.

A more sophisticated approach would be to transfer a value function from the original study site, Bateman et al (2000a). This 'value function transfer' (VFT) takes an equation derived from the original study site and applies it to the policy site, inserting the different socio-economic characteristics of the population surrounding each study site into the equation to calculate new WTP values for each policy site. Only the coefficients denoting the relative weight of the characteristics are assumed to be constant between sites, rather than the characteristics themselves. More

sophisticated VFT adjusts the WTP value to account not only for differences in the socio-economic composition of the populations surrounding both sites (the original study site and the policy site to which a value is to be transferred), but also differences in characteristics of the two sites and differences in the availability of substitute sites in the two areas.

Research suggests that, if one defines the value function to contain only variables which are relevant at all of the sites being transferred to and from, then VFT outperforms simple mean transfers, Brouwer and Bateman (2005). Further research, in the form of a which collects data for multiple sites and then tests the performance of VFT between them, would address an important gap in our knowledge.

4.2 Selection and publication bias

Benefit transfer studies may have selected sites for atypical attributes which make the study noteworthy and reduce the applicability of its results to other sites.

Source studies are subject to selection effects. Research sites are more likely to be selected if they are expected to show that there is an effect from the factors being investigated. Sites are not typically selected for research to demonstrate that values can be, or are, small, or that factors have no effect. Case studies are therefore an unrepresentative sample likely to produce biased and exaggerated results relative to the average site.

Furthermore, the selection of a study on which to base benefits is likely to be subject to publication bias. Publication bias arises because only those studies that reveal a positive relationship tend to be published or placed in the public domain. Studies revealing a negative relationship or no statistical relationship are less likely to be published because they are deemed less interesting to readers of academic journals. Publication bias can be substantial, and has been recognised in legal cases, see, for example, Givens, Smith and Tweedie (1997). Florax (2002) notes publication bias in the analysis of price changes in the water industry with over-representation of larger effects.

Although it is difficult to maintain robust methodologies without relying on published studies because of the cost of primary research, it is necessary to bear in mind that there is a probability of overestimation and bias when considering the results.

4.3 Validity of BAG source studies

The BAG relies on a set of source studies most of which were not designed for use as sources for benefit transfer, and some of which are now quite dated.

The source studies used for the BAG do not allow the valuation of improvements of a single attribute such as litter, turbidity, water ecology or bacterial load, but combine a number of them. That is because the studies asked people to value changes in environmental states rather than changes in attributes. They described a change involving improvements in a number of attributes, and obtained a single

willingness to pay estimate for the change. In contrast, there are some other studies that are narrowly focussed on individual attributes, such as algal blooms and diatom die-back. This makes the benefits transfer sources unsuitable for application to dissimilar changes. Unfortunately, there is often insufficient detail in the published studies to identify the characteristics of the site or the nature of the change examined, and hence it is unclear whether or not the changes are similar to those in the policy site. What is clear is that none of the BAG source studies examine intermittent discharges.

Observations on each of the source studies are made below.

4.3.1 Amenity value–Dornbusch (1974)

This study was undertaken in the US and therefore contains preferences of a population from a different cultural background and generation. It will not accurately reflect the drivers of the UK property market. The consistency of the BAG methodology and the study are also questionable since Dornbusch was concerned with large rivers and attributed amenity value to properties hundreds of metres from the river while the BAG instructs the assessor to count only the number of properties adjacent to the river.

4.3.2 Informal recreation–Coker et al (1990)

The Coker et al study is concerned with recreational benefits from improved aesthetic quality for a stretch of the River Maidenhead. The original survey site, a small flood relief ditch, Coker et al (1990), is unlikely to be suitable for transfer to other sites. Of those respondents surveyed who were familiar with the Maidenhead ditch, 'less than a third found the site attractive even to some extent'. Three quarters of those who claimed they knew the ditch found it unattractive or unpleasant.

At the same time, extensive improvements were considered including the introduction of drained and surfaced paths, landscaping and the introduction of seating. These amenity and access improvements were bundled together with environmental improvements and were not valued separately. Few sites and schemes are likely to have similar characteristics.

4.3.3 Informal recreation–Green and Tunstall (1991)

Green and Tunstall's study was not intended as a source study for use in benefits transfer, but rather to investigate benefits assessment methods. Data were not obtained for a particular river, but for a sample of river corridor visitors, making assessment of its suitability for transfer difficult. Improvements to the river that were presented to respondents represented a substantial increase in quality, for example to support water birds, many fish and to be safe for children to swim, Green and Tunstall (1991). Finally, the authors acknowledge that they cannot separate the use and non-use components of the valuation estimates they report.

4.3.4 *Angling–Green and Willis (1996)*

This study was commissioned for inclusion in the FWR Manual (1996) and was never published. Its applicability is impossible to assess.

4.3.5 *Non-use value–Georgiou et al (2000)*

This study of the River Tame is the principal study on which the BAG relies for estimates of non-use value. The study was not designed as a benefit transfer source study and the following points are worth noting if the results from it are to be used in benefit transfer.

- The river was in a ‘very poor’ condition according to the EA. Improvements presented to respondents were at three levels, encompassing both small and large improvements, the latter implying major increases in informal recreation and other benefits categories. Consequently, transfer of values to rivers with already fair or good status may lead to exaggerated valuations.
- While non-use motivations were identified, use and non-use benefits were not separately valued. After re-analysis at the Peterborough seminar, Environment Agency (2003a), it remained unclear the extent to which current non-users reflected potential use value in their responses.
- The river is located in an urban environment with few substitutes which may lead to higher individual WTP than appropriate for rivers in a rural environment with more substitutes.
- The Tame study was designed to study the sensitivity of WTP to changes in the level of improvement offered, and to compare contingent valuation and contingent ranking methodologies. It was not intended for benefit transfer, and in particular it did not take a representative sample of the population.
- It was not made entirely clear to respondents what they were being asked to value and in general the impression was of a substantial improvement over the full length of the river, which is unlikely to be the case for other schemes.
- Distance-decay estimates from the study suggest non-use values falling to zero at between 20 and 28 km depending on the scale of the improvement, Georgiou et al (2000). These are relatively small distances, reflecting the urban nature of the site and the small stretch of river, and may not be transferable.

5 Comparison of techniques

The question facing water companies (and regulators) who are preparing for PR09 is how to make best use of valuation techniques to inform the investment decisions they will present to regulators and Ministers. There are three observations from the preceding discussion of techniques.

- It is highly debateable as to whether any of the BAG source studies would yield reliable valuations when used for benefit transfer. To address this would require new studies, specifically designed for transfer purposes.
- The only way to obtain non-use values for environmental goods is the stated preference method. The stated preference method can also be used to elicit use values, and may yield reliable programme-level results if it is designed well and the results used carefully.
- Revealed preference methods are likely to provide reliable estimates of use values for environmental goods, but such methods cannot be used to obtain non-use values.

Programme-level stated preference studies may provide companies with a reliable indication of the values of investment programmes. These studies may allow companies to compare projects within a programme, because they will elicit the relationship between values and project attributes. Alternatively, the revealed preference technique could be used, although it would only deliver use values.

PART TWO: VALUE MEASUREMENT AND AGGREGATION

6 Use and non-use value

When a person values an improvement in an environmental or other quality enhancement without directly benefiting from it, it is termed non-use value. Isolating non-use value from use value is difficult and there is considerable confusion over when and how it is applicable to benefits assessment. Eliciting accurate non-use valuations is one of the most challenging and important components of a benefits assessment.

6.1 The importance of non-use value

Non-use has been seen as particularly important because of claims that the great majority of the value of environmental improvements is non-use value. Such claims have been the focus of academic debate and formal challenges to decisions.

The reason why non-use value is important is that previous approaches have claimed that a very large proportion of benefits are non-use. For example, in PR04, 75% of total benefits estimated by the EA for water quality improvements were classified as non-use value, Environment Agency (2004). Similarly, in the United Utilities inquiry, the EA presented benefits estimates using the BAG that were composed of 69% non-use value, Fisher (2006a). Revisions later reduced this figure to 28% of total benefits, which remained an important contribution. The revisions involved an adjustment for substitutes Fisher (2006b). Table 1 shows the results for the three schemes examined in the UU Public Inquiry.

Table 1 Composition of benefits estimates using the EA's BAG, percentage

	Informal recreation	Angling	Amenity	Non-use
Lake Windemere	2	1	1	97
River Douglas (CHR0021)	4	3	2	91
Princess Parkway (MAN0020)	100 (includes angling)	-	-	-
Rosendale (ROS0030)	2	25	1	72

Source: Smale (2006b), Bateman I. (personal communication)

6.2 The origins of non-use value

Non-use value should be included in a cost-benefit analysis. However, care must be taken to avoid the double-counting of use values.

The two types of non-use value that should be included in a cost-benefit analysis are:

- Existence value—individuals may value an environmental good simply by knowing it exists without experiencing it directly;
- Paternalistic altruism value—individuals may value particular forms of provision of environmental goods to other users.

It is important to clarify that the concept of non-use value is distinct from the value attributable to non-users. For example, there is the value of future possible use; this is treated as a use value, whoever holds the value.

Finally, there are altruistic motivations concerning the general wellbeing of others in society, including future generations. This motivation does not fit into any of the categories above, McConnell (1997). Since these users' benefits will also be captured among use benefits, Jones-Lee (1992) recommends that they should be excluded from the aggregation of non-use benefits, to avoid double counting.

Note that the definition of paternalistic altruism used within this report is the more common one currently used within the environmental economics literature; where this refers to an individual paying for a change in provision of goods which they believe will benefit another, irrespective of the preferences of that other. Note that Jones-Lee (writing in the context of health risk reduction) terms such values as 'safety-focussed altruism' while using 'paternalistic altruism' to refer to a form of double-counting. This change of terminology has caused some confusion. We deliberately adopt the more current usage of terms. Here paternalistic altruism refers to a value expressed by some individual to ensure a change of consumption of good by another individual, irrespective of the preferences that other person's preferences. An environmental example would be where one individual feels that improving the quality of rivers near to the (distant) home of another individual will be good for the well-being of that other person, irrespective of whether that other person professes a prior interest in river quality.

To date relatively little work has been undertaken to distinguish between these types of non-use value in a survey (and hence control for double counting). Further research is needed to devise and test ways in which this can be done. One avenue for such research would be to ask survey respondents about the extent to which any non-use reflects a concern for the general well-being of the people who will benefit, see Bateman (2002, chapter 12).

6.3 Applicability of non-use value

Any assessment should consider whether the nature of the improvement will generate non-use benefits; for example, by asking whether there is likely to be non-use value associated with changes in drinking water quality, sewer flooding and drought restrictions. Environmental improvements may create non-use benefits, but (private) improvements delivered to individual houses may not (with the possible exception of sewer flooding). This is because some improvements have no impact on the environment or on the availability of essential services such as safe drinking water.

The United Utilities planning inquiry in November 2006 raised the issue of whether aesthetic improvements such as the clearing of litter from a site would generate non-use value. There is no empirical evidence either way and the broader question of what types of change generate non-use benefits is worthy of research.

6.4 Challenges in measuring non-use values

The process of obtaining non-use valuations from stated preference methodologies remains challenging. Non-users are less familiar with the goods and may tender unreliable responses to questions.

If the nature of non-use value is that respondents typically do not interact with the environmental good and only derive indirect benefits from it, their preferences are likely to be poorly defined due to unfamiliarity with the good itself. The link between experience and the robustness of preferences against anomalies in stated preference surveys is illustrated in a paper by Bateman et al (2005a). This shows that low experience is associated with higher anomalies. Arguably, non-use valuations are more hypothetical than use valuations. When reporting non-use value, there are therefore few constraints or reference points that individuals can use. As a result, non-use valuations may be less reliable than use values.

It is not clear that the non-use value that respondents hold is attached to a particular environmental good. If instead it reflects general preferences regarding environmental quality then only highly aggregated assessments conducted at a highly aggregated scale are likely to capture valuations correctly. However, these may have difficulty in capturing information such as distance decay rates which may in turn be important for the allocation of resources between competing investments.

6.5 Benefits transfer and non-use value

It is not clear whether non-use values are affected by the number of users who benefit from an improvement.

The problems of transferring use benefit estimates from one site to another were discussed in Section 4. An additional complexity appears when transferring paternalistic values. In this context a question arises as to whether people hold a non-use value 'per person' that increases with the number of people that benefit, or whether they hold a fixed value that is independent of any local population or the number of users. If non-use values do depend on the population benefiting, then the question of how the budget constraint features in creating diminishing valuations as the number of users increases will be of prime importance.

7 Property rights and ethics

This section discusses the welfare (economic) measures used to value a change. The choice of measure may, in some circumstances, affect the valuation.

7.1 How to measure value

The relative initial and final levels of consumption of the good in question determine the correct measure of value of a change. The choice of measure may affect the value obtained.

The initial allocation or perceived entitlement of goods (the reference point) determines the appropriate measure of welfare change, Kahneman and Tversky (1979). If individuals hold rights to a clean environment, then it is correct to ask what compensation they will accept to transfer some of those rights to polluters. Conversely, if polluters hold rights to carry out polluting activities, individuals' valuation of environmental benefits are correctly assessed by their willingness to pay for improvements, since it is from society to polluters that monetary transfers will have to be made. This achieves consistency between the holders of property rights and the party receiving payment. It would not be feasible to consider a scenario where polluters held the right to pollute, but nevertheless had to compensate the rest of society for their actions. This would be tantamount to saying that such a right was meaningless.

A simple example will help to make the argument clear. A seller who has the initial property rights to a good will only sell the good if the price offered exceeds her or his willingness to accept (WTA) compensation for the loss of the good. Similarly, a buyer who has no property rights over the good initially can purchase the good if her or his WTP exceeds the price. Thus, for the seller the WTA is relevant, but for the buyer the WTP is relevant.

Pearce (2002) uses a table to summarise the choice, shown as Table 2.

Table 2 The choice of welfare measure

	Policy makes individual worse off	Policy makes individual better off
Property rights for the status quo	WTA (to tolerate loss)	WTP (to secure gain)
Property rights for the new situation	WTP (to avoid loss)	WTA (to forego benefit)

Pearce (2002)

The choice between these four welfare measures is determined by the present level of the good and the final level of the good, as shown in Table 3. Q_0 represents a lower level of provision of the good and Q_1 a higher level.

Table 3 Four welfare change measures

Measure	Initial level of good (reference level of the good)	Proposed final level of the good	Proposed change in provision	Does the change in provision actually occur?	Actual final level of the good	Reference level of utility	Formal term for measure
WTP to secure a gain	Q_0	Q_1	Gain	Yes	Q_1	U_0	WTP (compensating surplus)
WTP to avoid a loss	Q_1	Q_0	Loss	No	Q_1	U_1	Equivalent loss
WTA to tolerate a loss	Q_1	Q_0	Loss	Yes	Q_0	U_1	WTA (compensating loss)
WTA to forgo a gain	Q_0	Q_1	Gain	No	Q_0	U_0	Equivalent gain

Source: Bateman (personal communication)

Within standard economic theory the two WTP measures are equivalent as are the two WTA measures. However, the WTA measures are larger than the WTP measures. As a consequence of WTA being larger than WTP a few losers can outweigh a larger number of people who gain, even when all respondents would have the same WTP for a gain of a unit of provision, Sugden and Kahneman (2005). Furthermore, research has shown that loss aversion (individuals' heightened sensitivity to a unit loss as opposed to a unit gain), Kahneman and Tversky (1979), causes empirical measures of all four values to depart from standard theoretical expectations such that we see a ranking of these measures as follows, Bateman et al (1997):

$$\text{WTP to secure a gain} < \text{WTP to avoid a loss} < \text{WTA to forgo a gain} < \text{WTA to tolerate a loss}$$

This 'reference dependency' problem results in a bias against change. Some commentators argue that this is a reason for ignoring stated preference measures and adopting an approach to cost-benefit analysis that counts what people actually pay rather than what they would be prepared to pay, Sugden (2005a). However, this would be a fundamental departure from the usual objective of cost-benefit analysis, which is to identify improvements to social welfare.

7.2 The ethics of choosing between measures of value

An appeal can be made to ethics to resolve the question of which measure of value to use. The ethical arguments suggest that the use of either WTP or WTA implies an extreme ethical stance. A moderate ethical position results in a measure of value somewhere between WTP and WTA.

In order to choose between WTP and WTA, we have to address the question of where rights over environmental goods reside. While the prevalence and continuation of polluting activities suggests that companies have at least a *de facto* right to pollute, that right is being increasingly challenged. Environmentalists claim that regardless of what activities have been carried out historically and at present, these are transgressions of an inherent right held by individuals and society for a clean environment. Manifestations of this perspective are increasingly evident in the application of the 'polluter pays principle' and legal challenges to polluting activities under specific environmental protection legislation. From a pure economic perspective (the Coase theorem) and providing transactions costs are zero, it does not matter whether victims or polluters hold the rights, providing that the authorities are willing to enforce a bargain addressing the externalities. However, in practice, both because transactions costs are not zero and because of political pressure, the polluter pays principle has become increasingly persuasive.

Alternatively, it can be argued that because individuals cannot sell their rights to environmental goods, the right is really a collective one held by society as a whole, Mitchell and Carson (1989). Consequently, society must collectively bear the cost of maintaining environmental standards and the clean-up of historic pollution, whether through the costs of producing goods or taxation. Since these costs must be met somehow, individuals will have to pay for environmental goods. The use of WTA, while perhaps consistent with the distribution of theoretical rights, is inconsistent with the actual payments that must take place.

Environmentalists might respond by claiming that maintaining the environment need not be inherently costly, and that clean-up is only necessitated by past violations of social property rights. Therefore, WTA is still the appropriate measure of valuation, reflecting individuals' true rights.

Let us turn to a comprehensive treatment of property rights and the environment for assistance. Raymond (2003) sets out five theories of property rights. The logic of these, their implications when applied to the question of environmental rights and their implications for the use of WTP or WTA is detailed in Table 4.

Raymond concludes that there are few circumstances where the ethical views point strongly towards an allocation of property rights where the rights are vested solely with the polluter or solely with the pollutee. More often than not, both parties are legitimately able to claim some entitlement to use of the environmental good. He finds that it is difficult to reach a conclusion on which of WTA and WTP are more appropriate without taking an extreme ethical viewpoint.

Further complication is introduced by the purpose of the valuation. Since a CBA determines only whether an abatement project takes place and involves no formal transfer of property rights (although a failed CBA may implicitly allow pollution to continue), it is not analogous to the market-based example provided earlier. If rights are not really at stake, then it is not clear whether they can be used to determine the appropriateness of WTA versus WTP.

To push this argument further, if the CBA process is selected by society to resolve environmental issues, it, if anything, serves to *determine* the distribution of rights. Thus, a CBA leading to abatement effectively asserts society's right to prohibit the pollution in that instance. A failed CBA permits the polluter to continue their activities, effectively granting the polluter the right to do so. However, if the CBA effectively determines property rights, then the valuations on which its outcome depends cannot rely on those property rights. This would make the CBA process circular.

Table 4 Theories of property rights

Theory	Belief	Implications for environmental rights	WTA versus WTP
Possessory (Hume)	Property rights are agreed and enforced by society as a means to allow trade to increase individual wealth for all. The initial allocation can only be agreed if the outcome is a Pareto improvement.	A possessory view would allocate the rights to the environment to the historic polluter, and require the beneficiary of an environmental improvement to compensate the polluter if the rights were revoked or transferred. This view assumes the polluter has always existed. However, new firms and businesses arise which would not necessarily have pollution rights, so that WTA could apply to these new firms.	WTP
Intrinsic (Locke)	Property is not a social construct but is an innate right gained through prior use and labour input	An intrinsic view would probably be similar, but might in circumstances where the polluted party has substantial interests (leisure or work) in the environment divide the rights to use the environment between the polluter and those exposed to pollution according to the quantities of their respective uses of the environment.	Depends on existing use patterns.
Instrumental (Cohen)	Property is an instrument of society allowing society to achieve its goals of equity and wealth. Society imposes duties on individuals to respect property. There is no innate right to property but instead society itself may redistribute property from time to time as it sees fit.	An instrumental view would allocate rights in a pragmatic way that enabled the improvement to be brought about politically, and would try to ensure a more egalitarian result.	?
Egalitarian (Proudhon)	Property must be allocated in equal shares for all.	The pure egalitarian approach would allocate the rights equally between all consumers, both final customers of the polluter (if a company) and individuals affected by the pollution.	?
Dialectical (Hegel)	Begin with an intrinsic starting point and move towards a more instrumental outcome through political dialogue.	A dialectical approach suggests that rights evolve over time according to political settlement; thus, property rights could be altered at any point. In the present political climate of the 'polluter pays principle', this may suggest that polluters have few, if any, environmental rights.	WTA, but subject to change.

Source: Vivid Economics based on Raymond (2003).

7.3 The significance of the choice of value measure

WTA and WTP may be similar for cases (common in the water industry) where the values are a small proportion of income and there are good substitutes available. It is unlikely to be true for unique goods of large value and they may also diverge for losses. However, in all cases the measurement of WTA is more open to bias in questionnaire responses than WTP.

Knetsch and Sinden (1984) argue that 'the magnitude of a change in welfare...is probably independent of the permissive or prohibitive nature of existing legal rights.' In other words, they do not believe there will be a significant difference between WTA and WTP. However, there are a number of empirical studies which report significant differences, and the following effects are believed to cause them: income effects, an aversion to loss of assets and strategic behaviour in answering questionnaires.

- If a person's income after a change is much less than what it was before, as a result of paying for the change, then WTP will be less than WTA. This effect will not be present if the value of the good is small relative to income, as is usually the case for water company investments, Willig (1976).
- As noted above, individuals have a psychological and behavioural aversion to losses. In short, they attach a greater value to avoiding losing a dollar than to gaining a dollar. This finding applies primarily to gains and losses of money, but has also frequently been observed with changes in allocations of goods, Kahneman et al (2005). It has also been argued that individuals have two sets of preferences, one for existing consumption and one for future consumption. There is experimental evidence to support these ideas, Thaler (1980).
- To the extent that participants believe their answer will affect actual decisions, they gain from strategically over-reporting their WTA and under-reporting their WTP in order to influence the decision, Carson et al (2000). To the extent that participants do not believe their answer will affect actual decisions, they are not motivated to report accurate figures and individuals have little boundary to draw on when assessing their minimum WTA, but a clear boundary when assessing their maximum WTP, i.e. income. These combine to bias stated WTA upwards, and may bias WTP upwards or downwards. It is known as hypothetical payment bias.

In summary, the value of the good relative to income, aversion to losses, strategic answering of questionnaires, and presentation of numeric data can all lead to WTA exceeding WTP. It may be possible to conclude that WTA and WTP are unlikely to diverge significantly for many water company investments, since the investments have little impact on household income and the choices all involve higher levels of service and hence no losses in service quality, so long as data is presented in a meaningful fashion and questionnaire designs do not permit strategic answering.

7.4 Voting

Survey data can be used to determine what proportion of respondents would vote in favour of a change if the change were to come at a specific price, see Willis (2006). It is sometimes suggested that this should be used to inform the decision whether to proceed with the

change. However, it must be remembered that the voting outcome is wholly different to the economic approach which looks at strength of preference expressed via WTP.

7.5 Conclusions

The common practice is to solicit the WTP measure for improvements in service levels. This is uncontroversial for most service attributes. However, for environmental quality, there are ethical arguments in favour of examining a more moderate position lying between WTP and WTA. Wherever the impacts of the changes on an individual are a small proportion of their income, substitutes are available, and the change is an improvement, the value of WTP and WTA will be very similar and WTP can be used. However, where these conditions do not hold, and a loss in environmental quality is considered, loss aversion may drive a wedge between WTP and WTA, and it may be worthwhile attempting to measure WTA, if satisfaction can be obtained that hypothetical payment bias will not be too severe. Alternatively, in these circumstances, a note about the ethical assumptions associated with the use of WTP figures can be incorporated into the commentary alongside the cost-benefit analysis.

8 Substitutes

8.1 Independent valuation and summation

If the value obtained for an environmental improvement at a single location is applied to a programme of improvements at many locations, the value of the programme will be overstated if the locations are at least partial substitutes for one another. A solution is to present survey respondents with choices between programmes of improvements, or to disclose the whole programme to respondents early in the questionnaire.

At the United Utilities consent appeal, the cost-benefit analysis of the schemes was conducted on the basis of evidence from individual scheme valuations. The benefit transfer source studies asked individuals to value improvements at single sites, and those values were applied to single sites before being aggregated to a whole programme. This is known as Individual Valuation and Summation (IVS).

IVS appears to be satisfactory when applied to non-environmental service improvements, such as sewer flooding or reliability of drinking water supply. This is because there are no close substitutes for these service changes. However, IVS is not valid where consumers must trade-off between goods to maximise their utility, Hoehn and Randall (1989), a trade-off that is highly likely with environmental goods because environmental resources are scarce.

The trade-off between environmental resources arises as follows. In some cases, goods may be complements such that provision of one improvement raises the value of a second improvement. For example, adjacent river stretches could provide a pleasant walking area connecting two villages if both river stretches improved. More commonly, environmental resources are substitutes. As increasing numbers of improvements are made in an area, the value of further incremental improvements falls.

Stated preference surveys may avoid IVS bias by allowing customers to simultaneously trade-off different schemes or service factor improvements. This was the rationale for the study by Willis et al (2005) for Yorkshire Water. The consequence, described in Willis (2004), was that the benefit-cost ratios for the improvements were considerably lower than estimated using the BAG, Willis (2004). An alternative approach was suggested by Hanley et al (2003), using a methodology which forces the respondent to consider the context of alternative or additional improvements. Another approach to reducing IVS in a survey, taken by Bateman et al (2004), is to disclose the whole programme of choices to a respondent before presenting them with choices. This considerably reduces overall mean WTP compared with a stepwise disclosure in which the realm of the choice set is unfolded as the survey proceeds. Finally, there is the option of the sequential valuation of improvements, but this carries a risk that the value generated is dependent on the path taken, Willis (2004).

8.2 Evidence on the degree of over-estimation

There is evidence that IVS results in substantial over-estimates of the value of environmental improvements of individual projects where wider programmes of improvements are to be undertaken. IVS should therefore be avoided as the basis for estimating the value of wider programmes.

In any individual case, the degree of over-estimation will depend on the availability and quality of substitutes, the number of improvements that are approved, and any biases introduced by benefits transfer. Numerous empirical studies have confirmed the bias and reported the degree of over-estimation incurred, Carson et al (1998).

- Hanley, Schläpfer and Spurgeon (2003) found that the WTP for improving all rivers in the Thames region was 4.1 times less than the WTP for improving a single river (the River Mimram) multiplied by the number of rivers in the region.
- Bateman et al (2005a) demonstrated declining WTP for the non-use value of improvements to additional lakes.
- Peiing (1991) reports that the IVS procedure leads to valuations approximately double those of a simultaneous or sequential valuation procedure (see below).
- Although not readily allowed for by economic theory, awareness of a wider set of alternative improvements can affect the stated value for any given option. Bateman et al (2004) noted that the valuation of a given scheme declined as awareness of available alternative schemes increased.

8.3 The approach taken in the BAG

The BAG attempts to take account of the effect of substitute sites, but the approach it takes is without empirical support and it relies excessively on an assessor's judgement.

The BAG suggests accounting for substitute sites by adjusting the expected number of visitor numbers as follows, Environment Agency (2003b). In the presence of n existing sites of equal or better quality in addition to the study site, the number of visitors expected should be divided by a factor of $n + 1$. There is no evidence that this adjustment is correct, and it does not adjust the bias in the values attributed to individual visitors. There are further problems with the BAG approach:

- there is no definition of an alternative site or guidance as to whether upstream and downstream reaches of a river should be counted as alternatives;
- the quality of sites varies substantially, with sites of lower quality attracting some visitors and those of higher quality attracting a disproportionately larger share of visitors;
- new substitute sites may be generated by other improvement projects.

At the United Utilities consent appeal, the EA has suggested that the approach used above for use value should be applied to non-use value, Fisher (2006b). The procedure identifies zones of non-users radiating out from policy sites and divides the population in the areas where these zones overlap by the number of zones. The EA suggests that this can account for customers 'overall concern and value for the benefits of all [projects] within their 30 km zone'. This procedure can reduce aggregate valuation estimates obtained using the BAG by between one and two orders of magnitude. There is no empirical evidence to support the use of the method. Even if the method were supported with empirical evidence, it is difficult for an assessor to identify sites that are substitutes for users and more difficult still to identify substitute sites for non-users. Furthermore, if non-use value exists for a general class of

goods, the question arises as to how much of that value is attributable to a single site. Most surveys do not ask this question.

9 Relevant population

9.1 Introduction

The correct aggregation of individual values across the relevant population is crucial to determining the overall level of benefits. The extent of the market may well be more important in determining aggregate values than any changes related to the precision of the estimates of per-person values.

Ideally, benefits assessment should identify all individuals affected by a scheme and those who derive a benefit from it, no matter how small. There are two geographic populations (jurisdictions) that are commonly discussed. The economic jurisdiction covers all these individuals who have a positive value for a given project. The bureaucratic jurisdiction comprises all individuals within an exogenously determined area (such as a water company operational area).

There are obvious merits of using an economic jurisdiction to ensure all potential beneficiaries are included. Otherwise, overall benefits will be underestimated. There may be good reason to assess the bureaucratic jurisdiction as well, particularly where this group must bear the full cost of any improvements, and where assessing distributional and political implications is important. Both were presented in the results of the Thames Tideway appraisal. However, economic theory is clear that a sufficient case for a scheme to go ahead can be made on the basis of the economic jurisdiction. In practice, the degree of divergence between the two estimates will depend on the number of beneficiaries who reside outside the bureaucratic jurisdiction.

9.2 Distance decay of values

Values decline with distance because the proportion of users in the population falls with distance. Non-use values may also decline, more slowly, or not at all.

Some, but not all values, are spatially specific. An example of spatially-specific preferences is the consumption of environmental goods. One should expect average use values to decline with increasing distance. This is not because the particular individuals expressing values have lower values. Rather it is because the proportion of households holding use values declines with increasing distance. Expectations regarding non-use values are more complex and depend upon the proposed change in provision.

For an example of a good where individuals do not exhibit spatially-specific preferences, consider drinking water. If drinking water standards were improved, it is likely that this improvement would be uniform across the area concerned, and there would be no distance decay. In such cases standard approaches to aggregation are adequate – one needs to select a sample that is representative in terms of income, demographics, etc, but not in terms of where they live in relation to the improvement. Distance decay is present when there are spatially-confined changes in the allocation or quality of goods. This applies to cases such as improvements to water amenity sites.

Recall the following two measures:

- equivalent loss (WTP to avoid loss): here the final provision of the good is the same as the present provision (you pay your money and the good does not deteriorate);
- compensating surplus (WTP for gain): here the final provision of the good is greater than the present provision (you pay your money and the provision of the good improves).

Let us consider what pattern of distance decay we would expect to find. While a mixed sample of users and non-users is liable to exhibit distance decay in mean household values, patterns of decay for non-users are dependent upon the chosen welfare measure. In particular, for payment to avoid a loss scenarios, a lack of change in resource quality means that we should not expect distance decay of the values stated by non-users (except for any effect due to cultural affiliation with a particular resource). Conversely, for willingness to pay for improvement scenarios, the postulated increase in resource quality should induce some present non-users nearer to the site to become users, thereby raising their values and resulting in distance decay effects being observed. This is the case so long as the survey is unable to detect that the non-users who switch to become users are now stating use values. Table 5 collates results from the literature. As can be seen, this literature appears to bear out these expectations. Therefore inspection of distance decay trends amongst users and present non-users could be seen as a further test of the theoretical validity of aggregation exercises.

Table 5 Distance decay in overall and present non-user WTP responses

Study	Good	Welfare measure			
		Equivalent loss (WTP to avoid loss: final quality = present quality)		Compensating surplus (WTP for gain: final quality > present quality)	
		All responses	Present non-users only	All responses	Present non-users only
Sutherland & Walsh (1985)	Preserving water quality	✓	✗	-	-
Imber et al., (1991)	Preserving Kakadu Conservation Zone	n/r	✗	-	-
Loomis (2000)	Preserving endangered species	✓	n/r	-	-
Bateman et al (2000a)	Preserving wetlands from saline flooding	✓	✗	-	-
Bateman et al (2005b)	Preserve remote mountain lakes	✓	✗	-	-
Loomis (2000)	Preserving endangered species	✓	n/r	-	-
Pate & Loomis (1997)	Increasing the area of wetlands	-	-	✓	n/r
Pate & Loomis (1997)	Increasing bird numbers	-	-	✓	n/r
Hanley et al (2003)	Improving river flows	-	-	✓	✓
Mouranaka (2004)	Improving forests	-	-	✓	n/r
Bateman et al. (2006)	Improving a river	-	-	✓	✓

Notes: - = not applicable, n/r = not reported, ✓ = significant distance decay, ✗ = no significant distance decay.

Source: Adapted from Bateman et al (2006).

The questions of the relevant population and individuals' valuations cannot be separated entirely. Valuation studies typically report mean WTP, masking great variation between respondents. The most important dimension of variation, for both use and non-use value, is proximity to the site subject to improvement. Hanley, Schapfler and Spurgeon (2003) provide empirical evidence that there is a 'distance-decay' effect for both use and non-use value, and that this is somewhat stronger for use value, Hanley et al (2003).

9.2.1 Case study: Lakes in Scotland

A recent study surveyed respondents from the highlands of Scotland to the south coast of England concerning their WTP to avoid deterioration in the quality of remote highland lakes, Bateman et al (2005b). The study was primarily concerned with the values of non-users. It found that the values held by users sampled on site were higher (although not significantly

so) than those of non-users sampled in Scotland, i.e. nearby and with considerable cultural identification with the resource. However, both groups had significantly higher WTP than English respondents who were more distant from, and had less cultural identification with, the lakes. Table 6, adapted from Bateman et al (2005b), details these differences.

Table 6 Differences in mean willingness to pay to avoid loss (£) across survey locations

Comparisons	Differences in mean 'WTP to Avoid Loss' values (£) ¹
On site (in Scotland) versus Scottish off Site	2.17 to (0.40)
English versus Scottish off Site	4.38* to 7.77**
On site (in Scotland) versus English	6.55** to 7.37**

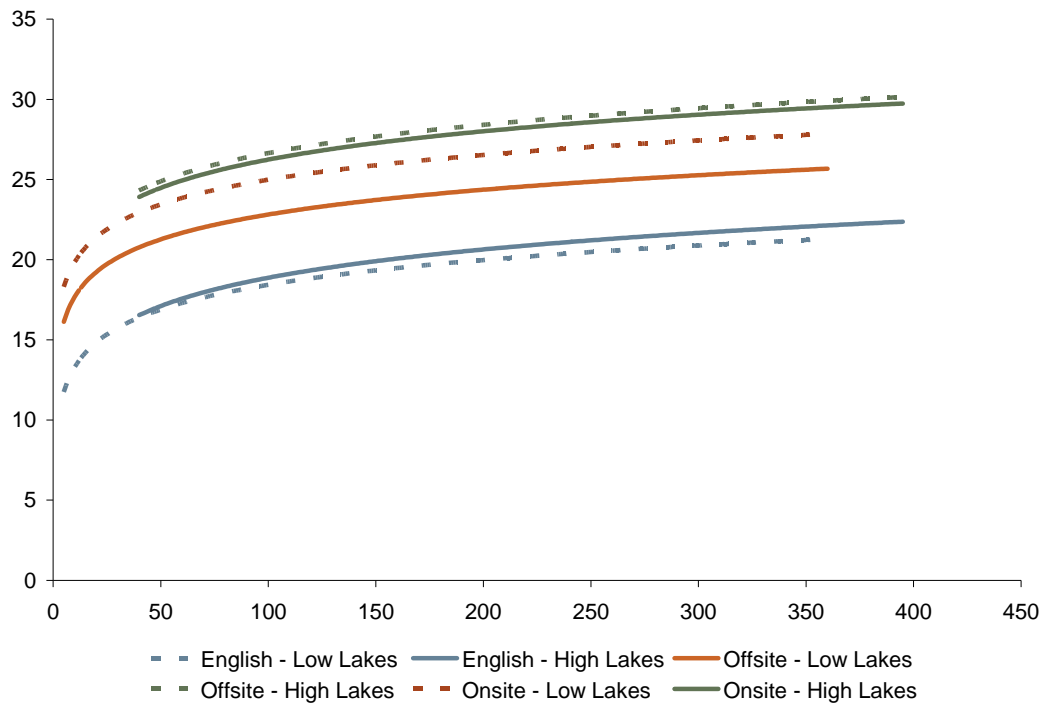
Notes: * and ** indicate 5 and 1 percent levels of significance respectively. Parenthesis denotes a negative value.
 1. The study adopts more than one methodology for eliciting valuation responses, hence the various values reported in each row of this column.

Source: adapted from Bateman et al (2005b).

Figure 3 illustrates the scope sensitivity in these values, Bateman et al (2004). It shows three findings:

- the intercept shifts (the major vertical differences) show the substantial effects of switching between samples (i.e. from users to nearby non-users to distant non-users);
- within each of these groups the more minor intercept shifts show the effect of changing valuation methodology (see Bateman et al, 2005, for details);
- the slope of the lines, varying from initially very steep for improvements to new sites among an initial small group, to much flatter for improvements to subsequent sites, shows a steeply declining marginal WTP for extra sites. Once a sufficient set of sites are improved, the value of additional improvements declines very markedly. This illustrates the error that would be introduced by omitting substitution effects.

Figure 3 Scope sensitivity in the 'WTP to avoid a loss' of water quality in Scottish lakes



Source: Bateman et al. (2004).

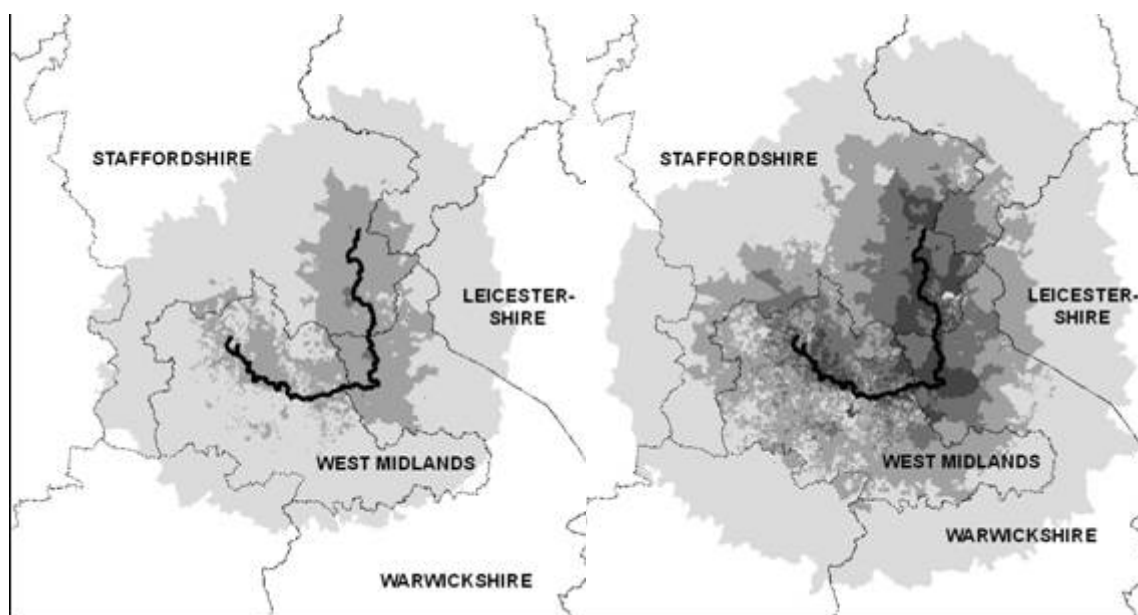
In Bateman et al (2006), a sample of people was taken from a large area centred on the River Tame in Birmingham. Respondents were asked for their WTP for three levels of improvement to that river. Statistical analysis of the responses yielded a model of WTP incorporating distance decay. The model can be used to calculate the edges of the economic jurisdiction (where marginal WTP falls to zero) for each of the three levels of improvement. The size of the jurisdiction increases with the level of improvement. This is shown in Table 7.

Table 7 Size of the economic jurisdiction

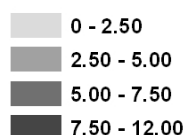
Size of improvement	Radius of economic jurisdiction (km)
Large	28
Medium	24
Small	20

These results are shown in map form in Figure 4.

Figure 4 WTP for a small (left) and large (right) water quality improvement



WTP (£ per annum)



Source: Bateman et al (2006)

The above example concerns a single site (or rather river length) improvement. These value maps and the aggregate sums they imply would be very different for multiple site improvements of the type envisaged by the WFD. There is no information available on how distance decay rates change in such circumstances. This is a vital research necessity for decision makers, who risk serious misallocation of resources in its absence. Armed with better evidence on patterns of distance decay and the variation of WTP with site attributes, assessors would be able to make more robust transfers of values from source study valuations to new sites.

9.2.2 Summary of case studies

To summarise, for non-use value it is not clear why distance would be important to valuation, although it is often observed as being so, unless it is because individuals living closer feel a degree of 'ownership' or affiliation which increases their valuation. Where use and non-use value are considered in conjunction, there is a much stronger distance-decay effect. Use value typically exceeds non-use value and users tend to live closer to the site. Hence, moving away from the site increases the proportion of non-users to users and reduces the valuation of the average individual, producing a distance-decay relationship. This analysis also supports a reason for distance decay among non-users. Where improvements in environmental quality are being delivered (rather than existing goods simply being preserved), non-users close to the site may anticipate becoming users and

therefore report a higher valuation than those further away that are unlikely to become users.

9.3 Options for aggregating values

There have been several ways in which values have been aggregated over distance in the past. The choice of method has a massive impact on the aggregate value obtained. The only two reliable approaches are to estimate a distance decay function or to obtain a representative sample of the relevant population.

Taking account of the preceding discussion, Bateman et al (2000b) identify three aggregation methods:

- Sample mean WTP and national population—If a survey sample is representative of the national population, then the distance decay effect is not relevant and a mean valuation from the sample can simply be multiplied by the total population. This approach has been used in, for example, Willis and Garrod (1996). The main difficulty lies in obtaining a truly representative sample.
- Banded distance zones with WTP varying by band—This method was applied in Bateman and Langford (1997) and takes some account of the distance decay relationship. Mean WTP is obtained for each banded zone and multiplied by the population in that zone.
- Benefit function—The use of geographic information system (GIS) models permits greater precision in accounting for distance decay, with each individual having a predicted valuation based on their distance from the site. These valuations are then aggregated. In addition, socio-economic data can also be incorporated to account for known relationships such as that between income and WTP that also vary across the population.

Bateman et al (2000) compared these approaches in a case study. They found that the national population approach produced a much higher aggregate valuation than the banded zones approach, which in turn produced a much higher valuation than the benefit function. This result may not read across to other cases, but the study clearly demonstrated how beneficial it is to take care in measuring the mean WTP and in the aggregation across the relevant population.

9.4 Rare changes

Surveys often ask respondents about service levels which are rare—that is, which affect only a small number of households. This may lead to inaccurate statements of WTP and may make the WTP figures unsuitable for aggregation in a cost-benefit analysis.

Investment programmes in water services concern improvements in a wide range of service attributes. For example, Yorkshire Water's customer survey in 2003 covered 14 attributes, as shown in Table 8. In many of the cases shown in Table 8, a random sample for a survey will contain few respondents familiar with the issue, because the issue only affects a small proportion of households.

Table 8 Number of customers experiencing proposed changes in levels of service in Yorkshire Water study for PR04

Service levels	Customers affected in a random sample
security of supply restrictions	most
interruption to supply	most
samples failing drinking water standards	-
drinking water discolouration	few
leakage	most, but no direct effects on customers
inadequate pressure	minority
lead in drinking water	minority
sewage escape into property	few
sewage escape into land	few
odour and flies	few
unplanned pollution incidents	few
ecological quality of rivers	most
ability to use inland waters for recreational use	few
bathing beaches water quality	minority

Source: Vivid Economics

When a survey is designed to value rare changes, it may be possible to obtain reliable valuations if those changes are familiar. In order that the results may be used, care should be taken to separate the expression of use and non-use values, and to aggregate the use values over the expected number of use beneficiaries rather than the whole population. If the changes are unfamiliar, then it may be necessary to survey separately the minority of customers who are familiar with the changes.

9.5 Conclusions

Values decay with increasing distance from a site. This is primarily driven by a decline in the proportion of users to non-users as distance increases. Aggregation using a simple sample mean multiplied by the relevant population leads to incorrect valuations and gross over-estimates. Most studies compound this problem by over-sampling near to sites, where values are highest.

A decision has to be taken over which jurisdiction applies: should the survey sample over the economic or bureaucratic jurisdiction? The use of the economic jurisdiction is to be preferred if the results are to be employed in a cost-benefit analysis. Unfortunately, there is little empirical evidence available currently on how large the economic jurisdiction is likely to be for a range of projects of different types and sizes. It might be problematic to use the bureaucratic jurisdiction if it is obvious that a scheme generates benefits extending outside that area.

10 Weak budget constraint

For a survey to generate credible results, the impacts in question have to be set in context.

This issue overlaps with the previous discussion of independent valuation and summation (IVS). In the previous discussion, the point being made was that the value obtained for a single project could not be applied to a whole programme of projects. Here, a separate but similar point is being made, which is that if the project or programme is considered in isolation of other claims on the household budget, then the estimates may be over-stated and not reflect the true WTP.

Kemp and Maxwell (1993) wrote, 'Our study demonstrated clearly that placing the subject commodity within a wider budgetary context of other public goods for which households may have values lead to much-diminished estimates of the mean household WTP for any one public good'. Surveys should make efforts to avoid this criticism, by providing a context for the valuation.

The most effective means of addressing weak budget constraints is to present schemes as part of a programme and together with other household expenditures. The survey designer should consider:

- Providing examples of opportunity costs, both in terms of other water industry investments and broader consumption and saving options. It is possible to emphasise and reveal trade-offs through the use of survey designs which present choices between bundles of goods.
- Reminding respondents of the level of water bills and the impact on water bills of other water industry investments. This has to be weighed against the risk that bill figures will anchor respondents' stated WTP.
- Recording of the socio-economic and preference characteristics of respondents who state they have a zero or very low valuation because of budget constraints.

PART THREE: PREPARATION OF A CBA

11 The cost of finance

The cost of finance should be included in cost-benefit analysis. It comes in two forms: for private finance, it is the pre-tax market return on the capital tied up in the project; for public finance, it is the social cost of public funds (the cost of economic distortions caused by taxation).

Within the current guidance, i.e. the BAG and the Green Book, there is ambiguity about the best way to account for the costs of finance. If the cost of finance is not adequately accounted for in the CBA, this will result in an overestimation of the net present value and the benefit-cost ratio, especially where capital costs are a large proportion of total costs and where the cost of finance is high relative to the social discount rate.

11.1 Private finance

In arriving at a decision as to whether to proceed with a project, the benefits should be weighed against the total costs that will be incurred. These costs include capital expenditure, replacement and maintenance expenditure and operating expenditure. They also include the cost of finance. If consumers paid only the efficient capital, replacement and operating costs associated with a project, then investors would earn no return on their investment, Oxera (forthcoming). This return on investment should be considered as a financing cost. It is a payment to the investor in compensation for the risk accepted in financing the project and for governance services in overseeing the management of the company. The cost of finance is equal to the market return that an investor can earn elsewhere.

The value created in this transaction is, on the one hand, the transfer of risk to the party most willing to bear it and, on the other hand, action taken by the investor to ensure that the management runs the company efficiently, thereby lowering the costs of the project.

The cost of financing a project should reflect the cost of raising funds (weighted average cost of capital) in that market sector. Only in the case of unusually complex projects will an adjustment be needed to reflect higher risk. The pre-tax cost of capital should be used.

There are also risks associated with operating expenditure. However, these are generally captured by the cost of finance, provided that the total capital employed i.e. capital employed general business functions and working capital as well as capital expenditure, has been identified.

11.2 Public finance

For projects financed by the tax payer, the imposition of taxes imposes costly distortions on the economy, Dreze and Stern (1990). The cost of tax distortions (social opportunity cost of public funds) should also be included, Pigou (1947).

12 Treatment of taxation

Cost-benefit analysis should employ a consistent unit of account for all costs and benefits. The usual unit of account is market prices, which include all taxes and subsidies on consumption. The water industry receives a rebate on VAT. Hence, wherever water industry cost estimates used in cost-benefit analysis exclude VAT one set of results should include costs up-rated by the rate of VAT. There can then be a discussion as to whether the VAT exemption is a subsidy. No adjustments should be made for environmental taxes.

In order for CBA to give a true reflection of a project's desirability, it must reflect only real costs and not transfers. Taxes are transfers. Although it is not usual to exclude direct taxes, since it is practically impossible to estimate taxes involved in the production of intermediate goods, indirect taxes on final consumption can be removed, although it is often not necessary to do so.

The direct taxation of individuals, for example, income and inheritance tax, transfers resources from individuals to the government. Excluding their distorting impact on labour supply, savings and investment, they are not a true cost. Indirect taxation, such as VAT, is also a transfer payment from consumers to government.

It is of no consequence whether CBA is conducted in the unit of account of market prices (i.e. including direct taxes and subsidies) or factor prices (i.e. excluding them), provided that they are used consistently for all the costs and benefits. Typically, willingness to pay estimates are presented at market prices and so this may be a more appropriate unit to use. One argument for nevertheless using factor prices is that the absolute numbers reflect the real resource costs and benefits, which are potentially more useful and meaningful than values which include an amount of revenue accruing to the government. The water industry provides an interesting case because the VAT paid by the water industry is refunded by the Exchequer. Thus, water bills do not contain VAT, and the market price for water equals factor cost.

Professor Sugden has outlined the adjustments necessary to accommodate differential tax rates, and these are largely an extension of the treatment of final consumption indirect taxes Sugden (1998 and 2005b). In the Thames Tideway study, NERA adjusted the willingness to pay figures by the ratio to GDP of taxes less subsidies on products. NERA took data from the Annual Abstract of Statistics 2006 Edition. GDP at market prices for 2004 was £1,165 billion, and deduction of taxes on products net of subsidies gave Gross Value Added at current basic prices of £1,034 billion. Based on these estimates, NERA reduced the WTP estimates by 11.3%.

The current practical guidance in the Green Book is that 'costs and benefits should normally be based on market prices since they usually reflect the best alternative uses to which the goods or services could be put (the opportunity cost). However, market prices may need to be adjusted for tax differences between options', HM Treasury (2006, paragraph 5.11). It continues by saying 'The adjustment of market prices for taxes in appraisal is appropriate where it may make a material difference to the decision. ... where the tax regimes applying to different options vary substantially, this should not be allowed to distort option choice. In

such cases, it is important to adjust for any differences between options in the incidence of tax arising ... Options attracting different VAT rates, for example, should be compared as if either the same VAT payments, or no payments were made in all cases', HM Treasury (2006, paragraph 5.55).

When customers are asked for their WTP for an improvement via water bills, they express their preferences in market prices. It so happens that, since no VAT is chargeable on water bills, their preferences are identical in the factor cost and market price units of account. However, the VAT waiver on water bills could be regarded as a subsidy, presumably justified by the public interest in providing universal access to water for hygiene and drinking, and also for sanitation and environmental management. If one takes the view that a subsidy is present, then it is correct to gross up estimates of costs, to take net costs and add on the subsidy. This involves using estimates of costs gross of VAT (as if VAT were payable) for both purchases and the water company's own inputs. This is our preferred approach. Alternatively, if one takes the view that the VAT waiver is not a subsidy, then one may wish to use the impact of costs as they appear on consumer bills, i.e. without VAT, and compare them directly against WTP figures. NERA takes a third approach. It reduces the WTP figures while leaving the cost estimates unadjusted. It is not clear what the justification is for NERA's approach.

Some taxation is not intended merely to accrue revenue to the government, but rather to correct distortions introduced by the existence of externalities (Pigovian taxes). It is arguable whether, in these cases, the externality should be counted as a cost of production if the tax has already been counted. There are two possible approaches. One is to treat the tax like any other tax, as a transfer, and to count the environmental damage as a cost. This is equivalent to saying that the outcome of the environmental tax could also have been achieved through a normal tax and the implementation of a trading scheme with grandfathered permits. The alternative approach is to treat the tax as a charge for services – disposal of pollutants to the environment – and then not to account for the environmental damage in addition. If the first approach is adopted, it will be necessary to decide whether to make a special adjustment for the environmental tax, or whether to treat it as part of general taxation and include it as part of the market prices unit of account. We suggest that environmental costs should be counted separately and no adjustment should be made for the presence of environmental taxes. This is because there are very few true Pigovian taxes in the UK. Many taxes have been implemented for revenue-raising reasons, later to be labelled environmental taxes, or to encourage particular behaviour, rather than to internalise externalities.

13 Time-related issues

There are a number of standard procedures for accommodating time in a cost-benefit analysis to adjust for changes in nominal prices (inflation), income, time preferences and growth in consumption (discounting). Changes in environmental scarcity and quality may also occur which are difficult to predict, but may merit qualitative consideration and some quantitative research.

Often, the bulk of the costs of a water improvement occur at the start of its lifetime while the benefits accrue throughout its lifetime. Accurate accounting for changes in prices, incomes and preferences over time is part of the process of comparing costs and benefits. Uncertainty over future improvements in the environmental baseline complicates the *ex ante* assessment of benefits.

13.1 Changes in nominal prices (inflation)

A common adjustment made within cost-benefit analysis is the indexation of prices so that monetary values are expressed in a common price base, typically the year in which the assessment takes place. This accounts for the effect of nominal price inflation which might otherwise suggest that benefits were larger further in the future simply because they were recorded in nominal terms. Consistency in the price base of cost and benefit values is particularly important when undertaking a net present value calculation. When conducting stated preference surveys for benefits accruing in the future, respondents should be asked to report their preferences in consistent prices, preferably at today's prices.

The choice of index for price adjustment must be tailored to the good being valued, since anticipated inflation for different types of goods varies considerably. In particular, for construction and maintenance costs, the Construction Outputs Price Index (COPI) is higher than wider measures of inflation such as Retail Prices Index or Consumer Prices Index because it includes a premium for the historic and expected future faster increases in the price of construction services relative to retail prices. COPI should therefore be used for appropriate costs expected to be incurred in the future.

13.2 Income

Benefits estimates may not evolve at the same rate as measures of inflation. Earnings growth tends to outstrip price growth meaning that real earnings increase over time. As with most goods, increases in income tend to lead to increases in consumption. Since the improvement in question will be competing with other schemes whose benefits may evolve at a different rate, it is important that these effects be incorporated.

The simplest assumption to make is that environmental goods constitute a constant proportion of a household's budget. WTP will then increase in line with income, barring any reason for a change in preferences, which is discussed below. When projecting benefits estimates forward over the life of an improvement, estimates of current WTP can then simply be up-rated by projected income growth.

However, if environmental goods are luxury goods, they will take up an increasing proportion of individuals' incomes as income increases. The argument for this is that wealthier individuals report a significantly higher WTP in cross-sectional data. It is not quite this straightforward. Increasing wealth may allow an individual access to a wider range of environmental goods (through travel, for example) which reduces the value of the original set of goods consumed. The empirical evidence is inconclusive. Kristrom and Reira (1993) argue that environmental goods are typically normal rather than luxury goods. When an adjustment is to be made, it can be based on the relationship between WTP and income within the cross-sectional survey data, which can then be extrapolated over time for projected income growth. Alternatively, it can be based on literature sources. Increased willingness to pay for environmental goods is linked to income growth by a factor referred to as the 'income elasticity' of willingness to pay. However, the relationship between income elasticities of demand and willingness-to-pay for an environmental good can be complex as shown by Flores and Carson (1997). Loomis and Walsh (1997) argue that elasticity for environmental recreational activities is between 0.31 and 0.47. Combined with income growth of around 2% each year (which has experienced a relatively stable trend over many years), HM Treasury (2003), this implies that real valuations of environmental benefits will increase every year by around 0.6–0.8%. At a seminar convened by the EA in May 2003 to discuss non-use valuation, the Georgiou et al. (2000) and Garrod and Willis (1999) studies were presented with values uplifted to 2001 income levels, using an increase of 0.6% per annum, Environment Agency (2003).

Care should be taken not to confuse price and income increases. Nominal income growth is (approximately) equal to price growth plus real income growth.

13.3 Aggregation of preferences for continuous or future improvements

When designing stated preference surveys a choice has to be made whether to ask respondents to value changes today and in the future, potentially with benefits lasting many years, or whether to ask them to value a change today leaving the assessor to roll forward that benefit, applying discount factors and adjustments to income levels and preferences. It is not a straightforward choice because there are a number of factors that respondents may factor into their responses about the future, including aversion to risk in delivery of outcomes, personal pure rate of time preference, personal expectations of income growth, and a personal rate of increase of utility with consumption. The question then becomes how to apply these results over time. When the objective of an exercise is social cost-benefit analysis, it may not be appropriate to use aggregate personal preferences relating to time and increases of utility with consumption, particularly when the benefits of a scheme span more than one generation, i.e. are greater than 25 years.

One way in which these problems can be avoided, at least to some extent, is to ask respondents how much they would be willing to pay on their bill this year, if the benefits were available this year. This removes the issues associated with timing, which can then be included during the aggregation stage of the cost-benefit analysis.

13.4 Changing scarcity

Other than income, which is discussed above, the principal factor shaping future WTP is the scarcity of environmental goods. On the one hand, there is concern that continuing neglect or

over-exploitation of environmental goods might lead to irreversible damage, implying increased WTP. On the other hand, growing attention to environmental issues has led to improving stewardship and environmental investment programmes.

Second, although capital goods increasingly provide leisure and aesthetic benefits as alternatives to environmental goods, increased produced capital stock tends to increase the productivity of natural capital too, making the environment more valuable, World Bank (2006).

Finally, the level of ambient water quality in a river affects the valuation of incremental changes in quality and may change over time as the WFD is implemented. Using the BAG, future ambient quality scenarios affected the benefits estimates by around +/-50% for intermittent discharges examined in the UU Planning Inquiry.

13.5 Time horizon

The BAG recommends an assessment time horizon of between 15 and 60 years. The assessment time horizon should be consistent with the life of the assets providing the service improvement.

You will also need to establish the time frame for the assessment. This should usually be matched to the life of the capital assets that would be required under a scheme (which may vary from say 15 to 60 years). Where information on the life of the assets is not available you should consult the Water Company of concern or Ofwat, Environment Agency (2003b, page 34).

Ofwat conducted a study into the appropriate asset life assumption, and its consultants returned the estimates in Table 9 for several expenditure categories.

Table 9 Asset life assumptions for enhancement expenditure

Asset type	Assumed life (years)	Quality expenditure (%)	Growth expenditure (%)	New development expenditure (%)
Infrastructure	n/a	63	33	90
Long	60	0	0	0
Medium/long	40	12	33	0
Medium	20	21	28	0
Short	10	2	6	10
Very short	5	3	0	0

Source: Competition Commission (2000).

Montgomery Watson Harza provided estimates of asset design lives in the United Utilities public inquiry, shown in Table 10.

Table 10 MWH asset design life assumptions

Item	Assumed life (years)
Civil below ground and concrete	60
Steelwork	25
Buildings	25
Mechanical plant	25
Electrical plant	25
ICA	15

Source: United Utilities (2003, pages 14–5).

Ofwat assumes an average 43-year asset life for enhancement expenditure (EA 2003a), and accurate estimates can be achieved by considering the nature of the proposed improvements.

14 Local economic benefit

Benefits to the local economy should only be counted if they help to address particular social priorities or result in national net increases in economic output. Net increases in output come about through the relief of inefficiencies in the labour market, improved availability of capital, or improved technology. Water industry investment programmes are unlikely to deliver any of these net increases in economic output.

The challenge when assessing any benefits to the local or regional economy is to avoid double-counting, since the benefits must be *additional* to the direct benefits accruing to users and non-users assessed through existing methodologies.

HM Treasury's Green Book supports the inclusion of regeneration benefits: 'where programmes have multiple objectives...these other additional benefits (and any associated costs) should be covered in the appraisal, together with employment impacts', HM Treasury (2003, paragraph 25). However, the Green Book urges caution in this area: 'The success of government intervention in terms of increasing output or employment in a given target area is usually assessed in terms of its 'additionality'...the geographical focus of regeneration projects means that it is particularly important to assess displacement effects at both the local and national levels', HM Treasury (2003, Annex 1, paragraphs 12 and 25). Thus, if the expenditure by new visitors at one site simply reduces their expenditure elsewhere, then the local economic expansion is offset by economic decline elsewhere. While there may be strong equity or distributive arguments in support of these effects, care must be taken to avoid reporting all benefits to the local economy as net economic benefits.

The EA suggests one source of local economic benefit from water quality improvements is 'creating and sustaining economic activities based on leisure and recreation and tourism', Fisher (2006, paragraph 51). This suggests that employment in managing the site may increase, local businesses involved in the leisure sector may gain from additional business, and suppliers to these businesses will also enjoy growth. Further, it implies that these additional benefits should be reflected in any CBA, Fisher (2006, paragraph 51).

To identify whether there is a real economic benefit arising from an improvement, it is necessary to look beyond local outcomes, and assess the productive capability of the economy, which is the primary determinant of GDP. As the Department for Transport's Standing Advisory Committee for Trunk Road Assessment (SACTRA) argued, 'in the long run, output growth depends on growth of the economy's productive potential, that is in the *supply-side* of the economy', Department for Transport (2003, paragraph 3.16). HM Treasury's Green Book gives examples: 'interventions that promote supply-side benefits include improving the working of markets and economic institutions, strengthening capabilities, and facilitating greater participation in the workforce', HM Treasury (2003, Annex 1, paragraph 12). Only if there is an increase in one or more of the inputs of labour, capital and technology will economic output increase—for example, as measured by GDP. The practical aspects of each input are now considered in turn.

14.1.1 Labour

Water improvement works can create jobs in the local area and this can lead to real increases in employment in that area. However, this will not translate into a net increase in employment and economic output if there are offsetting reductions in employment in other areas. Since labour is scarce, in a competitive labour market wages are set by the opportunity cost of labour and at this wage level there is an equilibrium level of employment. Any increased demand for labour in one location arising from an improvement will simply lead to reduced employment elsewhere. The overall level of employment and output is unchanged. SACTRA concluded:

‘With full and instantaneous market clearing, the economy is always at its equilibrium level of employment and any increase in employment or output at one location must be matched by an offsetting reduction somewhere else in the economy’, Department for Transport (2003, paragraph 3.59).

In practice there are a number of imperfections in the labour market that may lead to wage rates diverging from the opportunity cost of labour and may lead to higher unemployment. SACTRA states that ‘Only in this case of a discrepancy between wages and opportunity costs of labour is it appropriate to consider valuation of the employment effects of transport schemes as a possible source of benefits additional to those already captured by the transport benefits’, Department for Transport (2003, paragraph 3.50). The same could be said of water improvement schemes.

Imperfect labour markets create scope for improvements to increase the efficiency of the labour market, for example by increasing labour market participation or the speed with which workers are matched with suitable job vacancies. Since these are supply-side improvements in the labour market, it leads to real gains in employment and output. It is unclear, however, the extent to which water improvements can create these kinds of efficiencies, particularly given their relatively small scheme size, for example compared to major transport schemes. Moreover, quantification in individual cases may be extremely difficult to estimate accurately.

14.1.2 Capital

Capital is scarce and, like labour, there is an opportunity cost to investing capital in an improvement. Only if the project improves asset utilisation or risk allocation, which is most likely where capital markets are less developed or where there are significant market imperfections, will there be an additional benefit to the economy. These cases are unlikely to apply to water improvements.

14.1.3 Technology

Technology combines labour and capital in the most productive ways, and there is an argument that public investment can spur innovation which supports technological development and higher productivity. The empirical evidence of this link is contested, and is likely to vary greatly depending on the nature of the project. SACTRA concludes ‘that this evidence cannot be used to support the case for a significant positive effect of public infrastructure on private economic activity, over and above that which would be suggested by cost benefit studies’, Department for Transport (2003, paragraph 4). There is no reason to

believe that water improvement projects are especially likely to generate technological spillovers.

In summary, the conditions under which improvement schemes can deliver a significant net increase in the supply of labour, capital or technology are likely to be limited. The Green Book argues that 'the effect on net employment and net output is likely to be much smaller than the direct employment and output effects of the project'.

Particularly in the context of assessing environmental improvements, these considerations also point towards a greater emphasis on separating real externalities, such as environmental costs or benefits, from pecuniary externalities, which reflect the knock-on effects of economic activity through market adjustment, but no net impact on economic activity.

14.1.4 Water improvements as part of a package of regeneration

In some circumstances water improvements form part of a package of public and private investments being undertaken in the local area. The following arguments are sometimes made:

- in areas of decayed urban infrastructure and poor environment, improving the water environment is a component of programmes for urban regeneration;
- a good water environment helps sustain socio-economic activity in an area;
- it is important for creating and sustaining economic activities based on leisure, recreation and tourism, Fisher (2006, paragraph 51).

Care is required, since benefits assessment methodologies may have taken into account these benefits, for example, by counting the benefits to walkers or to participants in water-based activities. If there are good reasons to believe that some benefits have not already been incorporated, it is nevertheless important not to attribute the total benefits of a regeneration package to individual improvements. Any benefits that would arise if the improvement did not take place but the other investments did should be excluded, HM Treasury (2003, Annex 5, paragraphs 16 and 19). In practice, isolating the contribution of individual projects to the benefits of a package is extremely challenging.

It may be particularly difficult to account for such intangible factors as the 'image' of a town or city. While a large number of local improvements may cumulatively contribute to the image of the UK or a region, the dominant impact of any change in image is likely to be redistributive between local sites.

14.1.5 Distributive and equity issues

Even if net benefits to the UK cannot be identified, locally-generated benefits may attract additional weighting in a cost-benefit analysis if there is an explicit objective to redistribute economic opportunities and resources to a particular area or section of society. For example, providing jobs in a deprived area with high rates of unemployment may be desirable even if the national unemployment rate remains unchanged because of job losses elsewhere. This requires an assessment of the geographical distribution of benefits. It is unlikely to be appropriate except for major strategic schemes.

15 Decision rules

A positive net present value is the most reliable indicator that a project is socially worthwhile. Where resources are scarce, for example, there are political limits to water bill price rises, benefit–cost ratios may be used, if all the items defined as costs fall within the constraint on expenditure, and only if the projects are not mutually exclusive. If benefit–cost ratios are used in this way, there is no rationale for setting a hurdle rate equal to unity. The hurdle rate should be set at a level where the constraint is met and fully exhausted.

15.1 Decision rules

In theory, government should implement all projects, policies and programmes that pass cost-benefit analysis. In other words, it should execute all those that have a positive net present value calculated using the social time preference rate (STPR). In practice, this does not happen if there are political restrictions on the bill increases that can be imposed on water customers.

Although cost–benefit analysis works on the basis that projects should proceed if they generate net benefits to society, there are in fact three candidate rules for choosing between projects. They are the net present value, the benefit–cost ratio and the internal rate of return, Pearce et al (2004).

The net present value (NPV) shows the amount of social benefit that a project will generate. All other things being equal, it is better for society to carry out every project which generates net social benefits, and wherever projects are mutually exclusive, to carry out that set of projects which offers the largest combined NPV.

A popular decision rule, and one which is often used within government, is the benefit–cost ratio (BCR). This rule, as it is usually applied, is to accept a project where the ratio is greater than unity or some other specified figure where that other figure is selected to take account of missing costs or benefits, and returns available from alternative projects.

The BCR must be used with caution, because it has two serious shortcomings. Firstly, it requires a classification of impacts into costs and benefits although it is not always clear when an impact should be treated as a cost or a benefit, particularly when a cost to one party is a benefit to another. Secondly, it is unsuitable for mutually exclusive options, where a project that delivers a greater net present value may be rejected in favour of a smaller project which delivers a lower net present value but offers a higher BCR.

Defra has supported the use of BCRs for decision-making.

DEFRA has indicated that, for the purposes of the Periodic Review and Agency proposals for non-statutory expenditure, it may be preferable to have scheme data presented in terms of BCRs as this will allow a more ready means of prioritising schemes, Environment Agency (2003b, Part 6, page 6)

The internal rate of return is the discount rate at which the net present value of a project is zero. It is an extremely popular measure among commercial finance directors, but gives rise to some serious problems since it has a tendency to make bad projects look better and to make good projects look excellent. In addition, it may generate results that are inconsistent with delivery of the greatest NPV. The main problem with the IRR is that it assumes that interim cashflows generated during the life of the project can be reinvested at the IRR calculated for the project. Although the IRR can be modified to overcome this problem, it is also sensitive to economic life, and occasionally generates multiple results.

The one reliable rule is that a scheme with positive NPV will improve social welfare. Schemes can be ranked according to their BCRs if, and only if, the schemes are not mutually exclusive and the costs in the BCR are defined as those costs that are in rationed supply. For water industry investment programmes this means the costs that will be passed through to customers' bills. While the EA has stated that a BCR of greater than one shows that a scheme is economically worthwhile, only the NPV should be used to make this judgement.

A BCR that is greater than one shows that the benefits exceed the costs, hence, the scheme is considered economically worthwhile. Environment Agency (2003b, page 7)

The BAG identifies an 'absolute decision rule' which 'rejects any project with a negative net present value (or a benefit-cost ratio less than one)', Environment Agency (2003c), suggesting a hurdle ratio of at least unity. It also uses a 'relative decision rule' to prioritise projects with a higher BCR. In presenting the results of its cost-benefit analysis, the EA chose to recommend all schemes with a BCR of greater than 1.2, and schemes with BCRs of between 1.0 and 1.2 where additional unvalued benefits would also arise.

'the Agency has been conservative in recommending for implementation only those schemes where the monetised benefits are at least 20% greater than the costs. We have only recommended 'borderline' schemes (those where the costs and benefits are within 20%) where they have been identified as being regionally important with important additional non-monetised benefits and considerations', Environment Agency (2004, page 12).

In practice, a large number of schemes which have claimed a BCR greater than unity have not been approved. As the following quote from the EA shows, a significant number of schemes (229), with an average BCR of 1.7 (981/562), were excluded from the PR04 environmental quality programme.

'Compared to the original proposed programme for England, 229 schemes costing over £562m would not be implemented. Whilst these costs would be saved, benefits of £981m are foregone... This reflects the criteria set out in Principal Ministerial Guidance, which decided that a number of policies were not a priority for PR04', Environment Agency (2004, page 17).

15.1.1 Ofwat's Hurdle ratio

To provide quick approval to certain schemes that were very likely to be worthwhile, Ofwat indicated in 2004 that it would support such schemes where costs were not more than twice the identified use benefits, which generally meant a hurdle BCR of 0.4 (excluding non-use

value). Later in the PR04 process, Ofwat used a hurdle BCR of 1.2 (including non-use benefits). Ofwat justified its support for the hurdle as follows:

‘Compared with other areas of investment appraisal a benefit to cost ratio of 1.2 is a relatively low hurdle. ... The net present values were calculated over a common 25 year time horizon ... If a longer time horizon is used, there should be a review of the appropriate ratio to use in the sift of potential projects’, Ofwat (2006, page 15).

The EA has expressed its support for the use of a relatively low hurdle ratio, particularly in comparison with other government departments. There is no guidance advocating the equalisation of hurdle ratios across government, and there may be valid reasons for this. The setting of a hurdle ratio should reflect the political constraint on the rate of increase in customers’ bills, as well as the reliability of the BCR and NPV estimates.

15.2 Incremental value

In both the UU planning inquiry and in the Thames Tideway study, a range of scales for the proposed solutions were presented. Different scales for storage or tunnelling were associated with different cost and benefit profiles. Once the baseline BCR has been calculated for a particular scale of provision, a BCR for the incremental change in costs and benefits from a change in scale can be calculated. Where this incremental BCR is greater than the hurdle rate, the new scale may be preferred.

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