

*Development and Testing of Practical Guidelines for the
Assessment of Environmental and Resource Costs and
Benefits in the WFD (AQUAMONEY)*

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CSERGE Interim report

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Summary

Implementation of the Water Framework Directive represents a fundamental change in the management of water in Europe with a requirement of “good ecological status” for all water bodies by 2015. This interdisciplinary approach is used to consider the anticipated major benefits of the WFD in terms of the non-market recreational use (and potentially non-use) values that implementation of the Directive may generate. A consistent theme throughout the proposed analysis is its spatially disaggregated nature. This is addressed through the use of GIS data and techniques within the non-market benefit analysis.

2. Introduction: The Water Framework Directive

The Water Framework Directive (WFD) (European Parliament, 2000) represents a fundamental change in the management of water quality in Europe. The Directive imposes outcome based targets, requiring a shift away from standards framed in terms of the chemical composition of water in favour of an approach which assesses the ecological quality of water bodies. These standards will be water body specific and hence require differentiated action. However, there is a general requirement to improve all European waters to “good ecological status” by 2015. Although the definition of such status depends upon reference conditions, it is generally agreed that implementation of the WFD will require substantial reductions in pollutant inputs to rivers both from point and diffuse sources (Environment Agency, 2004). However, there is uncertainty with the level of benefit subsequent improvements to the water quality of inland rivers may generate. An important motivation for the WFD appears to be the non-market environmental benefits, such as open-access recreation, which it seems likely to create (see Articles 4, 9 and 11 of the WFD and Environment Directorate-General, 2005). Given this context there is an urgent policy requirement for better understanding of the non-market benefits of WFD implementation, as well their distribution.

The benefits of WFD-induced water quality changes will vary across space in a complex manner, depending not just on the distribution and physical response of catchments, rivers and estuaries, but also upon the distribution of present and potential future beneficiaries. The initial challenge for research is therefore to capture the complex interplay and spatial distribution of the key benefits of differences in river qualities. This project, sets out to assess the non-market benefits associated with the introduction of the WFD and to consider the impacts of alternative implementations of that policy. These impacts will involve geographically varied changes water

quality. Hence the spatial dimension is central to the project's aims and methodology. The project comprises integrated economic and geographical elements designed to allow analysis of the effects of WFD implementation from required changes in ecological status of waterbodies.

The spatial element is central here since it is the type, level and geographic distribution of pollutants entering catchments that are crucial to assessing ecological impact. Indeed, as we discuss subsequently, the spatial dimension is crucial to virtually all aspects of the analysis of the non-market benefits of water quality improvement. Consequently, throughout the project we will make extensive use of spatially sensitive modelling routines and make routine application of geographical information systems (GIS). In subsequent sections this focus upon the spatial dimension forms an underlying and intellectually unifying theme in terms of the estimation of the economic value of the benefits of WFD implementation.

It is claimed that the Directive will deliver substantial benefits (Environment Directorate-General, 2005) although, perhaps surprisingly for such a major and now agreed policy change, there does not appear to have been any formal economic assessment of these benefits. While the policy may generate a number of market benefits, such as reductions in water treatment costs for water companies and manufacturers, the proposed research focuses upon the less immediately tangible, but potentially major, non-market values generated by the WFD. These benefits include use values such as improved opportunities for, and qualities of, informal recreation¹ and (perhaps more contentiously) non-use benefits, such as the values individuals may hold for improvements in wildlife habitat which are not incorporated within recreation and amenity values.

¹ Furthermore, where direct contact with water is likely, such as in bathing areas, then some health risk reduction benefits may arise.

3. Research Objectives

This research concentrates on how the afore mentioned benefits of rivers can be valued in an economic context. Initial objectives include the designation of key study sites within an overall case study area (see Figure 1); the designation of ecological river quality attributes and initial pilot surveys to determine the importance of river characteristics. It is hoped that the methodology and design of this study will provide significant contributions to the field. It is important to remember that benefits valuation methods assess *economic preferences* for environmental goods rather than some abstract philosophical notion of the intrinsic worth of those goods. Where those preferences are well formed (i.e. they are as described in basic economic theory²) then it is a reasonable test of valuation techniques to see whether robust and accurate estimates of corresponding values can be obtained. However, if those preferences are only poorly formed³ (and say internally inconsistent) then it is somewhat unfair and unwise to expect valuation techniques to provide robust and accurate measures of such vague constructs.

3.1 The Study Area

The Humber basin, (Figure 1) was chosen as the case study area, on the basis of data availability and it being a large and heterogeneous area, comprising 25,000 km² most of which is put to diverse agricultural ends and in which over 10 million people live. The basin drains 28% of England, mainly via its two principal river catchments, the Ouse and the Trent.

The Humber is an ideal case study area as it captures a full range of emission levels of key pollutants such as phosphates, nitrogen and pesticides. In addition to its overall size and

² For example, they are transitive; if A is preferred to B and B preferred to C then A should also be preferred to C. Full description of such theoretically consistent preferences are given in most good economics textbooks and only such consistent preferences can form the basis of economic decision making techniques such as cost-benefit analysis.

³ For example, if the value of a good varied according to factors which are deemed irrelevant, such as in the presence or absence of an inferior substitute (Bateman et al., 2005). Notice however, that such effects can occur for market priced goods (Doyle et al., 1999) leading to the likelihood that double standards are applied to valuations depending upon whether they are elicited within or without markets. Indeed Shogren (2001) argues that all values, market or otherwise, are contextual and therefore to some degree maleable according to the frame in which they obtained.

significance, the contrasting characteristics of sub-catchments across the Humber basin provide useful variation for subsequent extrapolation.

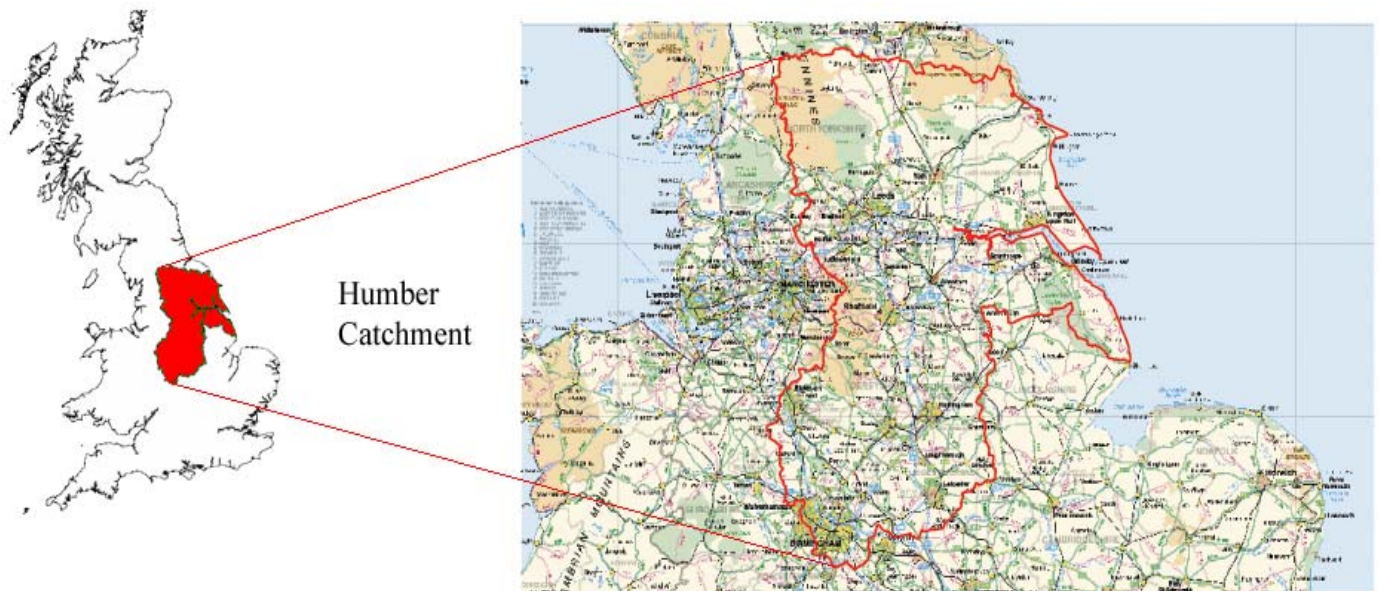


Figure 1: The Humber catchment case study area

The benefits provided by rivers may well provide examples of both well-formed and poorly-formed preference. For example, high-intensity, recreational users of waterways, such as anglers, seem likely to have well formed preferences for river resources and have robust values for the any changes in river quality. Following Plott (1996), it is the high degree of consumption (use) experience which has led such anglers to ‘discover’ robust, theoretically consistent, economic preferences. Following this logic it seems likely that the absence of such experience is likely to mean that preferences for the non-use benefits of rivers are less well formed and therefore derived values are more liable to exhibit anomalies relative to standard theoretical expectations. Arguably, these problems might be exacerbated by the fact that, unlike use values, non-use values can only be elicited through ‘stated preference’ (SP) methods (Hanley, et al., 1998; Louviere, et al., 2000; Bateman et al., 2002; Champ, et al., 2003). These apply surveys designed to directly ask a

representative sample of respondents about their values for some change in the provision of a good, such as increases in the quality of river water and the consequent effects upon flora and fauna. SP studies typically obtain these values via one of two methods:

- (i) a choice experiment: here each respondent is asked to answer a number of questions in each of which they choose between two or more options, each described by a series of attributes of the river and typically including some cost attribute. This approach allows trade-offs to be observed and values for river attributes inferred from the choices made;
- (ii) a contingent valuation: here respondents are asked directly their willingness-to-pay (WTP) or willingness-to-accept (WTA) compensation for changes in the provision of some good such as water quality.

Each approach has strengths and weaknesses. However successful SP analysis of benefits has the potential to provide a rich diversity of information about such values. Extending the Plott argument, it may be possible for individuals to ‘discover’ robust, consistent preferences and develop an understanding of contingent and choice markets as they progress through a valuation experiment. Techniques to promote such learning in valuation studies offer some promise here, including those pioneered by Bjornstad et al. (1997) and our own work on the transparency of valuation tasks (Bateman et al., 2004). The proposed research will seek to extend prior work in this respect.

3.2 Experimental Design

Related to these valuation study design issues is the challenge of providing adequate information to respondents in a manner which they find readily accessible. Here a useful line of research is provided by work in the psychological sciences showing that, relative to using numeric and textual approaches, the presentation of information in visual form can substantially reduce

choice errors (Lipkus and Hollands, 1999; Slovic et al., 2002; Hibbard et al., 2002; Hibbard and Peters, 2003). Indeed our own work on the use of virtual reality visualisations as a medium for enhancing understanding and eliciting values for land use change may provide a useful avenue for research here (Dockerty et al., 2006; Bateman et al., 2006). Throughout such exercises the key test will be to assess the comparative stability and theoretical consistency of preferences both before and after the application of such preference discovery and visual information tools. In addition to the above the description of river quality attributes will be based on ecological literature relating ‘good ecological status’ to recognisable attributes such as fish and plant species (see Table 1). This link will allow WTP measure to be compared across measurable levels of quality thus allowing for the comparison of benefits across quality thresholds. As part of the design process a water quality index will be constructed to enable each respondent to visualise the overall ecological qualities of each particular site.

Table 1: A theoretical example of the water quality index

Quality Index	Description	Ecological Status
A	Fish species 1, 2 & 3	Good
B	Fish species 2 & 3	Fair
C	Fish species 3	Poor
D	No fish	Bad

It seems clear that non-use, rather than use, preferences are likely to be less well formed and therefore more difficult to assess. Whether or not research effort should be directed toward an expansion of the project to include non-use values remains, at present, an open question. However,

the greater robustness of users' preferences does suggest that these provide a good target for applying these techniques.

3.3 The Spatial Aspect of Stated Preferences

One of the most appropriate and commonly applied revealed preference (RP) techniques is the travel cost random utility model⁴. This examines data on visitation choices of recreationalists selecting visits from a variety of sites offering different recreational experiences. These experiences are characterised by the attributes of water quality and accessibility. Water qualities vary from site to site as do the economic costs incurred visiting each site (in terms of varying direct travel expenditures, different travel time, etc.). Accordingly, visitation choices reveal how recreationalists are prepared to trade-off between site attributes and costs. This approach can be extended to give a spatial element to our stated preference experiment and in turn allows us to frame our choice experiment in a familiar context for respondents. The choice to have sites of different qualities within a particular proximity to ones home is likely to be influenced by the distance to be travelled to reach each particular site (see Figure 2).

⁴ Such methods actually rely upon the same underlying random utility model of behaviour (McFadden, 1974) as SP approaches. However, the RP use of observed behaviour is often viewed as an advantage. Whether this aura of respectability is completely deserved is a point of debate as RP methods are dependent upon a number of assumptions holding (see, for example, Randall, 1994; Champ et al., 2003).

Option A

Option B

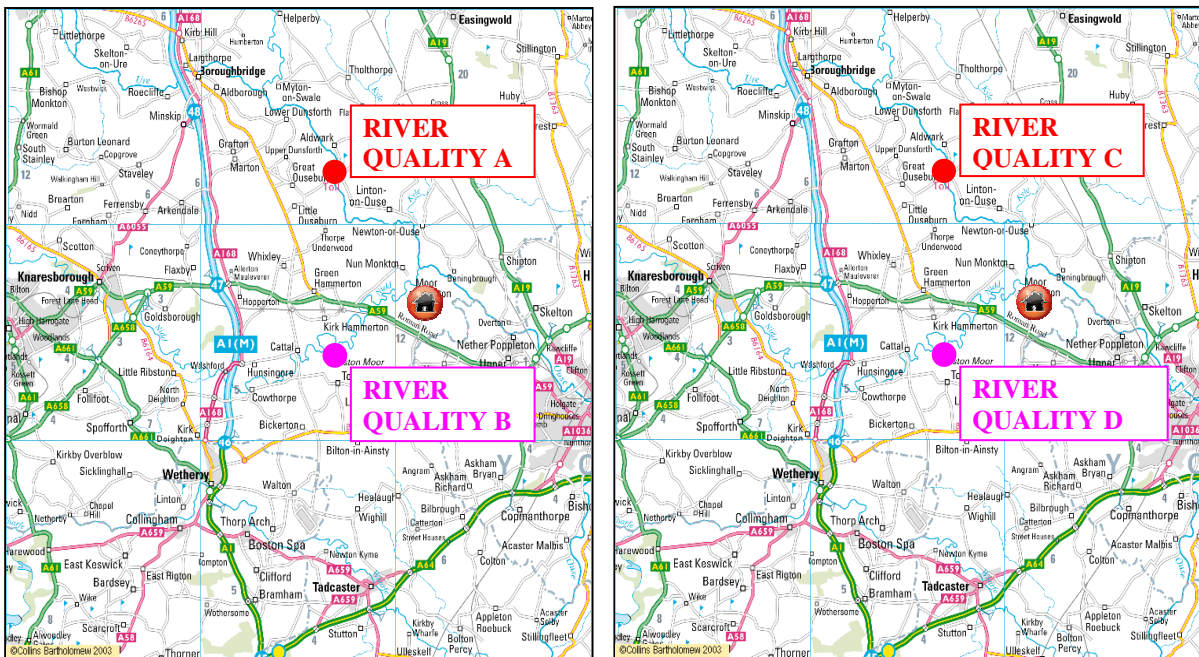


Figure 2: Example of scenarios as part of a stated preference survey, respondents are asked to select their preferred option.

This analysis is inherently spatial and is therefore highly amenable to the analytic opportunities afforded by application via a GIS. The technique explicitly recognises that recreationalist's choices are made in the context of numerous substitute and complementary sites. Inadequate incorporation of all pertinent alternative sites is liable to result in inaccurate estimates of benefit values, these being either too high or too low depending upon the balance of whether substitutes or complements are overly ignored. By showing maps that detail all site options available to individuals (see Figure 2) we hope to obtain robust estimates of the benefits associated with differing water qualities. Furthermore, the modelling of this data will seek to assess the cross-substitution effects of improvements in the water quality not just of one waterway but, as envisaged under the WFD, multiple and perhaps all waterways. As each site is improved to 'good ecological status' so the marginal value of improving the next site declines. Incorporating this shift is vital to the accurate estimation of total values.

4. Benefits Aggregation

As noted, the value an individual holds for the improvement of a certain site will vary according to numerous spatially variable factors, such as the substitution issues discussed above. Furthermore, when aggregating across individuals, their characteristics also vary spatially (for example, those with higher values and/or higher incomes may live closer to a given set of sites, etc.). A consideration of space is therefore vital to the accurate aggregation of benefit values for improvements to amenity waterways (and indeed most spatially confined environmental resources). The spatial analytic capabilities of a GIS provides an ideal medium for harmonising the diverse data necessary to undertaking such an aggregation exercise (Bateman et al, 2000). In particular a GIS readily allows the researcher to specify a valuation function which varies across space according to a variety of factors including: (i) the distribution of rivers, lakes, estuaries, etc., (ii) the change in quality to those resources, with improvements tending to convert former non-users into users in a spatially non-random manner; (iii) the accessibility of complementary and substitute assets; (iv) the distribution and socio-economic/demographic characteristics of the population. The inclusion of such factors allows the analyst to observe any ‘distance decay’ in values as we progressively consider households which are more remote from a given improvement. Furthermore, once such a valuation function is estimated, by applying it within a GIS to data detailing all explanatory variables for all locations we can define the appropriate ‘economic jurisdiction’ (that area within which values are non-zero) for calculating total benefit values (Bateman et al., forthcoming). This avoids common aggregation problems associated with artificial ‘political jurisdictions’ typically defined by convenient administrative areas rather than the benefits generated by a scheme⁵.

⁵ *The typical problem here arises when survey sampling is predefined to occur in a set area which is not representative of the economic jurisdiction. In such cases aggregation approaches which do not rely upon valuation functions but instead use survey sample means may (although this is not inevitable) result in substantial bias. For example, if sampling is confined to an area close to a site but the sample mean is applied to a larger aggregation area then total value assessments may be upwardly biased.*

5. Benefits Transfer

The estimation of spatially sensitive valuation functions also allows us to investigate the potential for ‘benefit transfers’ (Brouwer, 2000; Barton, 2002; Ready et al., 2004). Here value functions, estimated using data such as that described above, are applied to generate values for policy relevant sites which may not of themselves have been part of the valuation survey exercise. In theory, once a robust valuation function has been estimated the researcher need only know the attribute levels and improvement scheme which characterises an unsurveyed site in order to estimate (via the valuation function) the benefit generated by improving that site. However, in practice the track record of benefits transfer work is strewn with failure as the majority of analyses fail recognised tests of transfer validity.

Despite the empirical problems of benefit transfer, its potential to obviate the need for conducting individual site surveys each time an environmental improvement is to be assessed makes this an attractive proposition. Indeed this approach underpins contemporary Environment Agency assessments. However, at present these are conducted not via a value function transfer but rather by transferring mean values from a relatively small pool of existing studies, few if any of which were conducted for such a purpose. Transferring well specified functions (if they can be estimated) rather than mean values allows the analyst to obtain a value which is adjusted for the characteristics and environment of the site in question. The key issue therefore is to determine the robustness or otherwise of the valuation function to be transferred. This is typically undertaken by taking a function estimated from one subset of observations and using it to estimate values for an alternative set of sites for which independent value estimates are already held. The proposed research will investigate such robustness analysis. In so doing we will be guided in part by our recent findings which suggest that the transfer of statistical ‘best-fit’ functions may inflate value

estimation errors (Brouwer and Bateman, 2005). This is because such functions may include site specific contextual factors which are not relevant to those sites the function is transferred to. Conversely the specification of functions on the basis of those general factors identified in core economic theory (e.g. income levels, usage parameters, etc.) can produce valid transfers which outperform simple mean value approaches in terms of the errors generated.

5.1 Distributional Analysis

A final advantage offered by our spatially sensitive, GIS-based, methodology is an ability to examine the distributional implications of the water quality improvements offered by the WFD. While valuation studies often note an association between WTP and household income, the implications of this association are rarely explored. Furthermore, given that the distribution of benefits is likely to be both spatially and socially uneven, the potential exists that some groups will fare better than others in capturing the non-market benefits of the Directive. The estimation of a value function which varies across space and socio-economic dimensions allows us to use the GIS to link between census measures of deprivation and corresponding WFD benefit values. It seems likely that many environmental benefits, such as those generated by National Parks, are captured by the richer sections of society. This may be the case with water quality benefits; however the case is less clear cut. Informal waterway recreation is open to all and, unlike National Parks, is much more widespread and accessible. Furthermore, if the WFD is indeed implemented as it stands then it seems likely that the benefits and beneficiaries may be clustered within urban and surrounding areas. However, while this Directive seems potentially redistributive in terms of its benefits, their urban concentration contrasts markedly with the predominantly rural incidence of WFD costs.

6. Concluding Remarks

This project sets out to deliver a high research and policy return. The investigation of key non-market potential benefits of river use with SP methods to assess non-market values will be a central theme within our research. Such values can be a major factor in policy decisions. The programme of research is highly interdisciplinary and policy orientated but, as the discussion above indicates, it also addresses current frontier issues in the literature on, non-market benefits analysis, and it's spatial aspects. We contend that the project's clear focus upon a defined and contemporary policy relevant issue, combined with new approaches to established research problems, constitutes a useful contribution to knowledge in this area.

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