Benefit Assessment of Water Quality Improvements

The Environment Centre
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R&D Technical Report P39

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This report is provided for information only, it provides details of a study to define the benefits of water quality improvements, within the urban corridor of the River Aire, as it passes through the Leeds conurbation.

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ABBREVIATIONS

BOD	Biochemical Oxygen Demand
CMP	Catchment Management Plan
CV	Contingent Valuation
CVM	Contingent Valuation Methodology
DC	Dichotomous Choice
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
GQA	General Quality Assessment
HDC	Hicksian Demand Curve
LEAP	Local Environment Agency Plan
MLE	Maximum Likelihood Estimation
OLS	Ordinary Least Square (procedure)
STW	Sewage Treatment Works
WTA	Willingness to Accept
WTP	Willingness to Pay

EXECUTIVE SUMMARY

Background

The aim of this project is to define the benefits of water quality improvement within the corridor of the River Aire as it passes through the Leeds conurbation. This empirical study forms part of a broader initiative by the Environment Agency to develop techniques and approaches to the assessment of the societal benefits which are normally unquantified in environmental investment appraisals.

Empirical Study

Predictive river water quality models were assessed to define the feasible scenarios of water quality improvement, within the lower reaches of the river, resulting from investments in waste water treatment and integrated catchment control. The assessment of benefits of water quality improvement was undertaken using a contingent valuation (CV) survey on a defined corridor between Esholt and Knostrop. The survey acquired data on the socio-economic and demographic characteristics of the respondent population to enhance transferability of the information acquired. Interviewees were requested to classify present river water quality according to a six part (A to F) ladder which broadly parallelled current Environment Agency classification. The survey also revealed that the river was used by a number of those questioned for formal and informal recreation. A novel aspect of this survey was the development of a methodology which linked commercially available post code address files with a geographical information system to select the surveyed population. In addition to the CV survey, a supplementary study was conducted to assess the nature and the intensity of public use of the river for recreational activities.

A parallel survey of property prices, rents and land values was conducted to determine changes in these characteristics that might be attributable to historical water quality improvements.

Results

The current perception of respondents (80%) was that the River Aire water quality lay in class D (i.e. moderate pollution with poor fish stocks and reduced use potential) or lower. This indicates that the public perception of present water quality is pessimistic. The main recreational activities of those surveyed, under present water quality conditions, were walking, bird watching, nature appreciation and angling.

An 87% response rate of the random sample selected was achieved. These 333 respondents exhibited a mean "willingness-to-pay" of £3.91/month/household to effect a water quality improvement to facilitate direct contact recreational activities such as swimming with excellent fish stocks (i.e. from a mean perceived level of D to a new level of A). A considerable proportion of respondents (48%) recorded a "willingness-to-pay" (WTP) of zero. This may have been influenced by adverse publicity concerning the Regional Water Company during the survey period and the publics' perception that pollution remediation is outside their direct financial responsibility. Whilst the existence of 'zero value' responses are common in economic valuation of public goods, it does present certain statistical problems. This was particularly evident in the least squares regression analyses which exhibited generally low explanation. Partly to address these problems, further statistical tests were carried out. These tests revealed that independent variables are capable of predicting WTP values.

Further analyses were conducted using logistic regression, logit and probit analyses to validate estimated WTP values using dichotomous choice variables. The integration of the logit bid curve resulted in a estimated "willingness-to-pay" of £8.68/month/household, higher than the open-ended questionnaire derived figure of £3.91/month/household. Other studies have also observed this generally higher "willingness-to-pay" estimates from dichotomous procedures.

Assuming the true "willingness-to-pay" is bounded by these figures (i.e. £3.91-£8.68) and using the total household number in the surveyed corridor (i.e. 25,000) this would indicate a gross figure of £97,750- £224,500 per calendar month to effect water quality improvement as defined in 8 above. It should be noted that this does not include the broader catchment residents which might have an interest in water quality in the River Aire. If it were assumed, for example, that all City of Leeds residents were willing to pay the lower monthly contribution this would generate a revenue of approximately £800K per month. Some wider regional projections of "willingness-to-pay" monthly totals are presented in Table 4.1. However, an attempt to treat the mean values as a price for the good in question should be treated with caution.

The property survey showed that whilst property values in the City of Leeds doubled in the period 1985 to 1995, values in the surveyed corridor exhibited a 2.5 fold increase, principally due to residential development in the city centre. The displacement of industrial land uses with prestige residential and commercial activities suggests increasing importance of water quality to the property sector in the central zone of the city of Leeds. The range and intensity of recreational activities taking place by the river are greater on Sundays than during the mid-week at all sites. The most popular sites were those which possessed amenity facilities or were adjacent to residential areas. The most common activity taking place in the vicinity of the river is walking. Both surveys demonstrated that the river's main use is limited to non-contact water activities due to the poor water quality.

Conclusions

This project has demonstrated the feasibility of initiating empirical investigations to define the "willingness-to-pay" of the population for environmental improvements through the application of widely accepted contingent valuation methods. The linking of post code address information with geographical information systems offers an effective means of sample selection and survey design in contingent valuation analysis.

Building society, and other data sources, offer considerable potential for assessing the relative movement in property values adjacent to and distant from sites of environmental quality change although the present investigation was unable to isolate the contribution of water quality to this observed trend in the Leeds area. Notwithstanding the proportion of zero value returns, the survey has demonstrated a significant financial commitment of the surveyed population to effect water quality improvements in this historically polluted urban watercourse.

KEYWORDS

Benefit assessment; River Aire; Water quality; modelling; Contingent valuation; Willingness to pay; Property values.

1. BACKGROUND

1.1 Introduction

The main objective of this study is to quantify the benefits attributable to water quality improvement in the River Aire. The Contingent Valuation (CV) method was used in this study to estimate consumers' willingness to pay (WTP) for improved water quality in the river. An alternative method of examining environmental improvement is to measure the value attributed to other goods, for example land values, which occur as a result of the proposed improvement.

This study provides an empirical application of CV methods and an investigation into land value changes in the River Aire corridor in Leeds.

1.2 Objectives of the Study.

The study objectives are:

- to develop an empirical technique, based on underlying economic theory, to measure the welfare changes associated with an environmental improvement;
- to translate theoretical concepts and definitions into operational techniques, providing guidance on how to apply these techniques to other urban areas;
- to apply the techniques outlined in the Interim Manual of the Foundation for Water Research (FWR, 1994), to the River Aire watershed in Leeds, West Yorkshire; and,
- to test different econometric and analytical techniques designed to measure the willingness to pay for improvement of water quality.

1.3 The City of Leeds : Development and Environment

The River Aire catchment area is 1100 km^2 with an estimated population of 1.1 million, the majority of whom live in the urban areas of Skipton, Keighley, Bingley, Bradford, Leeds and Castleford (Figure 1.1). The focus of this study, the city of Leeds, is the major urban centre on the catchment. The city is committed to environmental improvement and is the largest metropolitan area in Britain to be designated an 'Environment City'. Leeds has a population of 700,000 people and provides employment for 300,000.

The River Aire is a focal point for development and regeneration in the city centre. This has formed part of the Leeds City Council Development Plan. Indeed, the corridor of the River Aire in the centre of Leeds has been given high development priority and holds the council designation of 'Riverside Quarter'. Recent riverside developments include the commercial offices of major companies such as ASDA and KPMG. Developments have also included tourist attractions (e.g. The Royal Armories) and residential accommodation. Away from the city centre the river is important to the local community for its amenity value, examples of which are Armley Mills and Kirkstall Abbey.

1.3.1 Development

Economic development is a key element in the development plans of Leeds and Bradford Metropolitan District Councils. Both aim to provide the necessary infrastructure to strengthen the existing economic base and to maintain balanced, and diversified, development. The councils recognise that the economic structure is changing continually. It is envisaged that the decline in manufacturing industry will continue and, in response, both councils are encouraging economic activities in the retail, commerce, leisure and hospitality industries.

Both Leeds and Bradford local authorities have identified changes in the social life-style and demographic structure of the population. In consequence, each recognises the need to provide more single person accommodation. In addition, there are a considerable number of older houses in poor condition which are close to the end of their viable life and will therefore need to be replaced. It is estimated that an additional 54,000 houses will be built on the River Aire catchment between 1991 and 2006. These will comprise 30,500 houses in Leeds, 23,000 in Bradford and almost 1000 in the Craven District.

1.3.2 Environment

Environmental policies are prominent in the district and county development plans covering the Aire catchment. General policies in the Leeds and Bradford development plans make firm commitments to environmental protection and improvement. More specific policies include those concerning wildlife protection, pollution to air and water, flooding and flood defence, protection of urban green space and the protection of urban green corridors.

The policy concerning the protection of green corridors is particularly important to this study because the River Aire through Leeds is designated as an urban green corridor. As such, the nature conservation and amenity aspects of the river are high on the agenda for development. Clearly, water quality within the river will be critical in the promotion of the River Aire as an urban green corridor.

Within the Leeds area, the River Aire plays a limited role in recreation, conservation and amenity. Nevertheless, the river is a key feature of the city and, since it is readily accessible to a large number of people, there is great potential to develop it as a focal point for amenity.

1.4 River Aire Water Quality

According to the 1992 National Water Council (NWC) classification[1] (NRA 1993), water quality in the river can be classed as follows;

- Class 1 231.7 km
- Class 2 68.7 km
- Class 3 121.5 km
- Class 4 14.4 km.

[1]This NWC classification of river quality has now been replaced by the General Quality Assessment (GQA) Scheme and the River Ecosystem Scheme.

Much of the poorer water quality occurs in the lower reaches of the catchment, particularly in the 45 km of main river downstream of Keighley. The major threat to water quality is the effluent from the 40 sewage treatment works within the catchment which account for 65% of dry weather flow. Two thirds of the sewage effluents, by volume, are produced from the sewage treatment works (STWs) at Marley, Esholt and Knostrop. Other sources of pollution of the river include: sewage and silage liquor from agricultural activities, combined storm water overflows, public/private surface water sewers, chlorides from minewater wastes and toxic pollutants from the chemical and textile industries.

Improvements in water quality will also contribute toward urban regeneration of the Riverside Quarter. More specifically, water quality may be an important factor in the attraction of non-manufacturing industry and residential developments to the area. Whilst in the past manufacturing industry may have had little concern for water quality, the leisure (Royal Armories) and commercial (ASDA, KPMG and associated services) developments adjacent to the river may be more influenced by environmental quality. The development of high quality residential accommodation has taken place close to the river itself. In these areas, water quality may influence the quality of life and hence property values in the area.

1.5 The Catchment Management Plan (CMP)

Water quality in the River Aire is managed through a process of catchment planning. Integrated catchment planning gathered pace with the creation of the National Rivers Authority (NRA) in 1989 (now Environment Agency) culminating in the 'River Aire Catchment Management Plan' (NRA, 1993). The plan was developed through wide consultation with other organisations to create an integrated and balanced approach.

The Environment Agency is developing a number of policies aiming to improve further the water quality in the catchment. These include; improvements of effluent quality from STWs, regulation of combined storm water overflows, imposing strict consent limits on industrial discharges, and the implementation of a rigorous sampling and monitoring program to identify transgressions of consents and licenses.

1.6 The Relevance of River Water Quality Models

River models have been used to predict the effect of discharges on downstream water quality. Such models can be used to set consent limits which aim to ensure that water users are not affected adversely by polluting discharge. This can be achieved by establishing the required Environmental Quality Objectives (EQO) or Environmental Quality Standards (EQS). EQOs are the result of setting objectives appropriate to the specific receiving water and then defining numerical standards to be complied with.

In this context, river water quality and sewage effluent quality are seen, not as ends in themselves but, as means of enabling rivers to be used for the purposes required of them. Hence, it will be possible to protect the aquatic environment to the degree that the public requires and also maintain the vital function of the river as a carrier for treated sewage and other effluents.

TOMCAT (Temporal/Overall Method for CATchments) is a water quality model developed by Thames Water in 1982 to review collectively the quality requirements of all effluents discharging

to a catchment (Brown, 1986). It is a relatively simple model which uses a mass balance approach to simulate movement of pollutants downstream. The mass balance approach involves modelling the mixing effect of the predicted wastewater discharge with an appropriate quantity of river water to give an estimate of the resulting downstream water quality. The model is relatively simple to use and requires only data collected from routine surveys.

CATNAP is a one dimensional segmented model for non-tidal rivers (McDonald *et al.*, 1994). The determinants included in the model are flow, biochemical oxygen demand (BOD), ammonical nitrogen, dissolved oxygen and temperature. To allow for the seasonally and randomly varying nature of these determinants, a Monte Carlo framework is used. This also allows assessment of compliance against a percentile target, which is the method by which UK consents are assessed. The model contains processes of mass balance, reaeration, self purification and thermal exchange. To calibrate the model, flow and quality data from monitoring stations can be inputted and compared with predictions using the Kolmogrov-Smirnov test. These tests, which can specify the determinants to be examined, are carried out across the whole of the probability distribution. Due account is taken of the number of data items representing the observed distribution. The model runs can be automatically refined to carry out either flow or quality calibrations only, or for both together.

The Urban Pollution Management (UPM) Programme was initiated in 1985 to develop methodologies for the management of urban water quality under wet weather conditions (Urban Pollution Management Manual, 1994). The programme considers three major elements of urban wastewater disposal, the sewerage system, the sewage treatment works and the receiving water. The improvement of water quality is dependent on capital works at various points in the disposal system. This investment can be made more efficient by employing tools which allow detailed investigation of each aspect of the urban wastewater disposal system. A group of mathematical models have been developed by the water industry in the UK, during the last two decades, for simulating pollutant flows in sewerage systems (MOSQITO) (Shamash 1993), sewage treatment plants (STOAT) (Deadly and Dickson, 1992) and receiving waters (MIKE 11) (Danish Hydraulic Institute, 1992).

These models were originally designed to permit detailed studies of water quality and for the planning of sewer rehabilitation schemes. However, initial attempts have also been made to apply them in an integrated manner to pollution modelling within catchments. The models produced acceptable results. These complex dynamic models require more detailed input and a higher level of expertise than is needed to run TOMCAT. MIKE 11 has three main modules which provide an aid to consent setting for intermittent discharge. The software is available in either MS-DOS or UNIX developed by the Danish Hydraulic Institute. There are a number of constraints in the use of MIKE 11. They are basically the assumptions made on using the hydrodynamic model. Modelled catchments which have a combination of very steep slopes, low flows and major in-river structures are likely to be affected by the assumptions. In catchments where these conditions on assumptions do not hold true, problems may be encountered.

1.7 Water quality improvement scenarios and CMPs

Proposals for improvement of water quality is one of the main aims of CMPs. This can be achieved by defining water quality improvement scenarios. EQOs are aimed at setting objectives appropriate to the specific receiving waters and defining numerical standards. TOMCAT, CATNAP or MIKE

11 predictions should ensure that consent levels for polluting discharges maintain water quality at an acceptable level in receiving waters.

Model predictions have formed one element in water quality scenario assessment for the CMPs. Environment Agency staff have been consulted on the output from these exercises which were used in defining feasible improvement scenarios.

2. ESTIMATING THE BENEFITS OF WATER QUALITY IMPROVEMENT

2.1 Introduction

Welfare economics is concerned with the relationship between the well-being of people and how the productive resources available to society are used.

In simple terms, the resource allocation that provides a group of goods and services, which is preferred to a previous group because it provides a higher utility to individuals, is said to increase the individual's welfare. This basic concept of welfare change, as a result of an improvement of a good, has been used in developing a methodology for the measurement of benefits associated with water quality improvements.

2.2 Justifying Water Quality Improvement Scenarios

Water quality improvements in the River Aire catchment have been identified as a high priority as part of the regeneration of the Aire corridor in terms of commercial and residential developments, tourism (including national museums), recreation (including water based), amenity and conservation. The NRA developed CMPs to drive the continuing improvement in the quality of rivers through the control of pollution. CMPs also enabled the optimum deployment of investment and resources to achieve efficient and effective operation. Therefore, water quality improvement scenarios require justification in terms of benefits, priorities and appropriate standards. Since the formation of the Environment Agency in April 1996 CMPs have been replaced by Local Environment Agency Plans (LEAPs) which reflect the integrated nature of the newly formed Agency by taking account of the Organisation's full regulatory duties within the scope of each plan.

However, the non-market nature of water quality improvement hinders the use of traditional cost-benefits analysis to measure efficiency. Further, there are numerous other non-market values attached to the water quality in the river which cannot be measured in monetary terms. Therefore, using traditional economic means, these non-market goods are inappropriately valued at zero pounds.

The estimation of welfare gains from such commodities is possible through non-market means such as surveys, questionnaires, bidding games, and voting procedures. Even if market-related measures of water quality benefits are available, estimations derived through non-market techniques are useful as a check on the consistency of the estimation procedures.

Procedures for measuring benefits from non-market data involve revealing people's preferences for the provision of public goods. There are a few established approaches to the problem of preference evaluation. One commonly used method is to ask individuals to state their Willingness To Pay (WTP) for the environmental commodity (Mitchell and Carson, 1989). The CV method is accepted as the best technique available to quantify non-market values in monetary terms.

Justification of water quality improvement scenarios is therefore dependent on the estimation of benefits of water quality by an accepted economic method such as CV.

2.3 Contingent Valuation Methodology (CVM)

Contingent Valuation (CV) is a widely used method of estimating the value of non-market goods such as water quality improvement. The basic assumption is that although the markets for these goods are not well defined in usual economic terms they do exist. The CV method enables the market for such a good to be simulated and described, and then asks individuals what they would be willing to pay for that good within the given market. The monetary values estimated are those that are contingent upon the existence of a market.

The ultimate aim of a CV study is to obtain an accurate estimate of the benefits of a change in the level of provision of a public good such as water quality. The notion of benefits from public goods is somewhat different from other types of benefits. Many people may consume a particular public good; however, one person's consumption does not preclude another person's consumption. Furthermore, it is difficult to identify beneficiaries for environmental goods.

The total benefits from a public good are the sum of the benefits to all who consume the good. However, the measurement of benefits associated with public goods seems somewhat difficult relative to the estimation of costs.

CV can provide an estimate of the benefits, which may be used for many planning and policy activities dealing with environmental goods. CV is the only method which is capable of establishing general environmental values (FWR, 1994).

2.3.1 The theoretical framework underlying CVM

CV methodology is unique among benefit measurement techniques for its ability to obtain detailed distributional information. CV is also consistent with the consumer sovereignty assumption. According to the underlying theory, an agent's spending behaviour in a market is a sufficient signal of his preferences for various goods. CV methodology provides the information to evaluate benefits by a variety of criteria.

The CV method provides the only way of directly measuring both WTP and Willingness To Accept (WTA). Depending on which measure a researcher wants to obtain, the elicitation question of the CV survey is phrased in terms of either WTP or WTA. The appropriate measure to evaluate the benefit cost of water quality improvement in the River Aire watershed is the Consumer Surplus as defined by the Hicksian measures (Hicks, 1939).

During the last two decades, considerable research effort, in the economics of public goods, has been devoted to problems of estimating demand. A major part of this research effort has been devoted to finding a mechanism for direct questioning of consumers to reduce mis-representation of their preferences for public goods.

2.3.2 Variation in CVM elicitation designs

CV methodologies simulate a market for a non-market good. The process estimates the respondent's consumer surplus for the environmental good and the maximum amount the non-market good is worth to the respondent. The best way to do this would be to ask individuals their willingness to pay for the good and record the answer. This is called an open-ended CV format

because the respondent is not given a price to accept or reject. Respondents often find it difficult to assign a value spontaneously without some form of assistance. As a result, many open-ended CV formats tend to produce an unacceptably large number of non-responses or protest zero responses to the WTP questions.

On the other hand, closed-ended CV surveys (also known as referendum surveys) have recently become very popular as a technique for eliciting the value of water resources. The closed-ended format involved a Dichotomous-Choice (DC) question, where the respondent is presented with a value and gives a yes or no answer as to whether or not they would pay this amount.

There are a few widely used elicitation techniques that attempt to overcome the weaknesses of general CV in both open-ended and closed-ended formats. Many CV researchers have accepted these techniques as capable of reducing non-responses and making it easier for respondents to complete successfully the valuation process.

- Until recently, the most widely used CV method was the **bidding game** (Davis, 1964). The process is identical to normal auctions and, therefore, is likely to be familiar to respondents. This is normally modelled on a real-life situation in which individuals are asked to state a price for the environmental non-market good. This bidding game format is best adapted to personal interview surveys, but it also may be used in telephone surveys. The interviewer iteratively changes the stated amount of money to be paid or received until the highest amount the respondent is WTP, or the lowest amount the respondent is WTA, is precisely identified. Many researchers have demonstrated that starting-point bias occurs when the bidding game format is used.

- The **payment card method** was developed as an alternative to the bidding game (Mitchell and Carson 1981, 1984). This method maintains the properties of the direct question approach while increasing the response rate to WTP questions by providing respondents with a visual aid. This is a more sophisticated direct questioning technique, which specifies the increment or decrement in value for the non-market good to be provided in quantitative terms. Furthermore, this method provides substantial details about the institutional structure of the hypothetical market. The payment card procedure avoids the need to provide a single starting point and offers the respondents more of a context for their bid than is provided by the direct question method.

- The third CV elicitation method is the **discrete choice** (also known as dichotomous choice, take-it-or-leave-it and referendum), which was developed by Bishop and Heberlein (1979). Only the closed-ended type of questions can be used in the dichotomous choice format. This approach uses a large number of predetermined prices chosen to bracket expected maximum WTP amounts of most respondents for the non-market good. The most desirable form of CV elicitation is the use of a dichotomous question that asks respondents to vote for or against a particular level of taxation, as occurs with most real referenda. Most consumers are familiar with being confronted by a posted price for a good and the need to make a decision to purchase at that price. The main obstacle of this method, relative to other elicitation methods, is that many more observations are needed for the same level of statistical precision in sample WTP estimates. Another problem is that analysis is dependent on some assumptions about how to parametrically specify either the valuation function or the indirect utility function to obtain the mean WTP. Logistic or probit regression curves could be fitted to the percentages of

respondent's willingness to pay each of the randomly assigned prices. Integrating the area below the logistic curve, would provide the equivalent measure to the mean WTP. It is also possible to obtain the mean WTP directly from the parameters of a probit equation.

- The fourth and widely used elicitation process is the **discrete choice with a follow-up approach** (Carson and Mitchell, 1986). If the respondent says yes to the discrete question, another question is asked using a higher price randomly chosen from a pre-specified list. If the respondent says no, a lower price is used in the follow-up question. Although this procedure offers potential for considerable gains in efficiency, the inherent problems of discrete choice still remain. Further, the follow-up questions used in this method are similar to the iterative procedures of the bidding game. The main disadvantage is that this method is not suitable for mail surveys because of the follow-up approach.

- An extension to the discrete choice procedure is known as the **modified dichotomous choice** method (Steven *et al.*, 1991). In this approach, the respondent is confronted with the specified amount of money, he or she would contribute toward continued existence of the resource. The amount of money is randomly selected within fixed intervals over a range. Also, all respondents are given an opportunity to bid an amount less or greater than the specified amount of money. Responses, therefore, could be viewed as originating from either an open-ended or a closed-ended dichotomous choice bidding format. Unlike the discrete choice follow-up approach, this method can be used in mail surveys.

2.3.3 Open-ended and close-ended formats

An open-ended and discrete choice with a follow-up method was used for the evaluation of benefits associated with the River Aire water quality improvement. Among the alternative CV question formats, DC is emerging as the preferred method because it successfully elicits individual participation and is free of starting-point bias.

2.3.4 Open-ended format used in the River Aire study

The open-ended format allowed the respondent to specify a monetary figure for water quality improvement. Values provided by respondents were direct estimations of WTP. Respondent's average WTP for water quality improvement is the dependent variable of the CV model. The independent variables of the bid curve are specified as levels of gross income, age, present and expected level of water quality, education, family size, membership of an environmental organisation and sex. The distance to the River Aire from the land on which they live is also used as an independent variable. The model equation presented in Wattage *et al.*, (1997) provides the relationship between the WTP value and each independent variable. Because there was no information *a priori* about the choice of a functional form, the bid curve can be estimated using Ordinary Least Square (OLS) procedures. To find the inverse Hicksian Demand Curve (HDC), it is necessary to differentiate the bid curve. This demand curve is unique to the reference welfare level.

2.3.5 Closed-ended DC format used in the River Aire study

This procedure involves first establishing the attributes of the water resources and then asking the respondents about their WTP a single specific sum, for keeping water resources clean. As

previously outlined, the questioning strategy is attractive because it generates a scenario similar to day-to-day market transactions. A pre-tested hypothetical value can be tested to determine whether the respondents would agree to take it or leave it at that price. In this format the respondents were asked to give one of two responses, yes or no, to the following question:

- *Assume that the **current water quality** level that you indicated in Q#7 is to be changed to the **best** level, that is to level "A". If you indicated that the current water quality is already "A" then assume that this level will be maintained indefinitely.*

- *Would you be **willing to pay £10** each month over the coming year as more taxes for this level of change to be achieved and/or maintained?*

The relationship between the other variables and the WTP for water quality can be observed in the sample survey responses to the above question.

2.4. Estimating the Benefits of Water Quality Improvements

The objective of this study is to measure the benefits of protecting water resources from industrial river pollution using the framework of welfare economics. As outlined above, there are strong theoretical grounds to use a survey based CV methodology for this purpose. The field survey was used to assess people's perception of water quality, possible uses of the river, respondents socio-economic background, and to obtain the individual's WTP measures for having clean water in the river.

2.4.1 Survey design and methods

In order to carry out the CV study, a sample survey was designed and applied to the River Aire catchment between Esholt and Knostrop sewage treatment plants in Leeds. There are major recreational areas in this corridor such as Kirkstall Abbey, parks, canoe sites and canal based recreation. There are also several areas suitable for wildlife and nature appreciation. The study focused on the River Aire as it runs through Leeds and the people it is likely to affect along this stretch. This is the section of poorest water quality with the most to gain from any improvements. Although those who are living relatively close to the river would be affected immediately by any improvements, the impact of total benefits may be more widespread over the catchment. However, given time and resource constraints, the study was limited to an area of 1km either side of the river in which the most significant impact of water quality improvement might be expected. A sample of 384 was calculated to be adequate to gain statistically meaningful results.

2.4.2 Questionnaire design

The questionnaire, presented in the accompanying Project Record (Wattage *et al.*, 1997), was designed to be easily understood and completed within 10-15 minutes. There were six sections to the questionnaire. Each section began with a transition statement explaining why that section's questions were being asked. Sections included in the questionnaire were location and use of the River Aire, water contact activities, potential sources of water pollution, surface water quality and WTP values, property values, and respondents' socio-economic and demographic attributes. A first draft of the questionnaire was sent out to the Agency Management Group and colleagues for

comment and discussion. The questionnaire was pre-tested with a target group and modified before the final draft stage. Field interviewers were trained and tested in the class room and in the field before the final survey.

2.4.3 Execution of the survey

The first communication with the respondents was a personalised letter indicating the objectives of the survey and the importance of their participation for the success of the study. Respondents were informed in advance that a representative from the Environment Centre, University of Leeds would visit them to complete a questionnaire. The letter identified the university departments involved, the funding institution, and the topics addressed, and explained how their name was selected, why their participation was important and their guaranteed anonymity. In addition to the questionnaire, a set of photos describing good and bad aspects of river water quality was used to provide the interviewee with descriptive information on the river.

The main problem encountered during the survey involved the targeted respondents being unwilling or unavailable to respond to the questionnaire for a variety of reasons. The slow response rate experienced meant that the time allocated to complete the survey extended beyond the planned period. Several factors concerning the organisation of the survey helped achieve a high response rate. Future surveys should give attention for targeting interviews to the most fruitful time of the day, and selecting an accurate address database. The final response rate to the survey was 87 % - a total of 333 out of 384 questionnaires were accepted for analysis.

2.4.4 Descriptive statistics

Statistical analyses were carried out using the SPSS 6.1 Windows version. The sample distribution of various activities was studied and respective sample percentages were calculated. Estimates of population parameters were not made using the sample distribution. Therefore, the analysis presented here is based on the investigated sample not the total population. The database used for the analysis was created in EXCEL. All relevant information, under each of the variables, was carefully examined to check for outliers. Minimum, maximum and mean values were calculated to provide an initial examination of the collected data. In addition to SPSS and EXCEL analysis of data, the sample addresses and WTP values were analysed for spatial patterns using MapInfo, which suggested an even spread of WTP zero values.

Recreational activities

The survey revealed that the river was used by a number of those questioned for formal and informal recreation. The main recreational activities (see Wattage *et al.*, 1997) of those who use the river under present water quality conditions, were walking (46%), bird watching (9%), nature appreciation (8%) and angling (6%). In addition to the survey, a supplementary study was conducted to assess the nature and the intensity of public use of the river for recreational activities (Appendix VII, Wattage *et al.*, 1997). It was also apparent that improvements in water quality would increase recreational activities and therefore enhance the amenity value of the river. Indeed, the increase in contact activities is most notable, for example canoeing increases by more than 8-fold, sailing increases by 5 times, and angling increases by more than 50%. This may be attributed to the perceived decrease in health risks associated with improvements in water quality.

Pollution perception

The public perception survey showed that all categories of pollution sources listed were thought to have some impact on the water quality of the River Aire. Pollution sources were ranked in a scale of one to five, with five considered to be the highest significant rank. The main sources of pollution perceived to be in the river were effluents from industry (ranking 4.16) and sewage treatment works (ranking 4.07). Those perceived to be of least significance were run-off from roads (ranking 2.51), building developments (ranking 2.43) and mine drainage (ranking 2.42). Over 80% of those surveyed thought that current water quality in the River Aire through Leeds was level D or lower. However, it was the opinion of almost 90% of those surveyed that levels of acceptable water quality should be at level B or better.

Willingness to pay

Almost half of those surveyed (48%) were not willing to make any form of financial contribution toward water quality improvements in the River Aire. The mean willingness to pay was £3.91, with 95% confidence intervals of £0.77. There were only four who were willing to pay £40.00 or more with a maximum willingness to pay value of £75.00 per month.

A wide number of reasons were given by the 160 people surveyed who were unwilling to contribute financially towards the improvement of water quality of the River Aire. The most common reason (19% of non-payers) was that the water utility company (Yorkshire Water plc) should pay for the necessary improvements. This was followed by 13% of the nonpayers believing that they cannot afford payment and another 13% stating that they do not use the river.

2.4.5 Analysis and discussion

Analyses of the WTP responses and related statistics were carried out using different econometrics techniques. The object of this approach was not only to obtain WTP values but to compare and analyse various estimation techniques and their suitability under different situations. The two main estimation methods are linear regression and maximum likelihood analysis. Either is suitable for this type of analysis (FWR, 1994).

- First, the mean bid values of WTP were estimated for River Aire water quality improvements. The same analysis was extended to obtain the influence of other independent variables to the WTP values using the OLS procedures.

- Further, a WTP function was estimated using limited dependent variables. The dichotomous choice dependent variable (yes = accept WTP value stated) takes only two values, either 0 or 1. The analysis of such variables can be performed using the Maximum Likelihood Estimation (MLE). The second analysis involves estimating a Logistic Regression Model, Logit, and Probit using MLE procedures.

- The third approach is quite different from the first two. The numerical integration of the area under the cumulative density function is used to estimate the WTP values for DC dependent variables.

2.4.6 Bid values - OLS procedures

Data were further interrogated to produce a number of models from which the economic benefit of the water quality improvement can be derived. The value of benefits (WTP) from the improvement of water quality in the River Aire depends on a number of factors that affect the decision on how much a respondent would be willing to pay. These can be expressed in a multiple-regression equation. An iterative process of repeated multiple regression analysis identified that the most important variables for predicting the maximum willingness to pay were gross annual income, acceptable water quality and the perceived distance to the river from their household. Additional variables, for example age, contributed little to the model and did not have the appropriate significance values. Most of the other predictor variables such as the present water quality, level of education, household size and gender were not significant and were excluded from the model. Multiple regression models inclusive of all independent variables are given in Wattage *et al.* (1997).

The coefficient of determination, R^2 represents the proportion of the variation in the dependent variable "explained" by the independent variables. This R^2 value for the model is low, indicating that most of the variation in WTP was not explained by the predictor variables. There are two reasons for the poor relationship between the variables. The major reason was the very large number of zero value returns attributed to the dependent variable. This indicates an unwillingness to pay anything for water quality improvement by a large proportion of respondents. The other reason is the estimation error. The existence of the disturbance term, coupled with the fact that its magnitude is unknown, makes calculation of these parameters impossible. For cross-sectional data, typical R^2s are not generally high.

The global 'F Statistic' is the test of overall significance of the regression. This tests the hypothesis that all the coefficients are zero. The constrained regression in this case would have only an intercept component. The F test is a formal test of $R^2 = 0$ and tests the explaining power of the model. High values of the F statistic leads us to reject the null hypothesis that the constraints are true. Using the critical values of the F distribution table for the 0.05 level, with degrees of freedom 3 and 329 then the critical value is 2.60. The computed F value is 8.2, which is in the rejection region. The null hypothesis that all the regression coefficients are zero is therefore rejected. The alternative hypothesis is accepted indicating that not all the regression coefficients are zero. From the practical standpoint this means that the independent variables do have the ability to explain the variation in the dependent variable (WTP). This is to be expected. Logically the acceptable level of water quality, gross income and distance to the river have a significant impact on WTP for water quality. The global test of whether the multiple regression model is valid assures us that they do.

2.4.7 Estimation of non-linear models

The linear specification of the model is quite restrictive and has the unattractive property that marginal WTP is constant. It is quite likely that a more flexible form is preferable (FWR, 1994). This section outlines the estimation of parameters for the logistic, Probit and Logit models and the problems associated with the estimation procedures. The dependent random variable Y in this model is assumed to be binary, taking two values, say 0 and 1. The outcomes on the dependent variable are assumed to be mutually exclusive and exhaustive.

Logistic regression

In logistic regression, the parameters of the model are estimated using maximum-likelihood, in which the coefficients that make the observed results most likely are selected. The non-linear logistic regression model uses an iterative algorithm for parameter estimation. An iterative process of repeated logistic regression used willingness to pay £5 (WTP5) as the dependent variable. The reason for selecting the five pound level as the dependent variable was that is the closest choice value to the average WTP of £3.91. An iterative process of repeated logistic regression analysis identified that the most important variables for predicting the willingness to pay £5 were current water quality, perceived distance from the river, gross annual income and household size. Additional variables contributed little to the model. The low chi-square value of the model indicates that the model is a good fit. Model variables are significant and the signs of the estimated parameters follow standard economic theory.

Logit analysis

Probability models are, as a rule, estimated from survey data, which provide large samples of independent observations with a wide range of variation of the regressor variable. One of the preferred methods of estimation is Logit analysis. This permits the estimation of the parameters of almost any analytical specification of the probability function; in addition, it yields estimates that are consistent and asymptotically efficient with ready estimates of their asymptotic covariance matrix.

Logit uses an iterative scheme, which is supplemented by starting values for the parameter vector and by a convergence criterion to stop the process. As for the convergence criterion, the iterative process stops when successive parameter values are nearly equal or when the score vector comes quite close to zero. This should be achieved in five or, at the most, ten iterations. However, using SPSS 6.1 for windows convergence of the Logit in this study was reached after 13 iterations. This was due to the nature of the raw data which may be ill-conditioned with an almost singular regressor matrix, with regressors of widely different order of magnitude, or with the sample frequency of the attribute under consideration very close to 0 or 1. However, in some cases of Probit and Logit the number of iterations was below 10. The Logit equation for River Aire water parameter estimation is given in Wattage *et al.*, (1997).

There is no universally accepted goodness-of-fit measure for probit or logit estimation (Kennedy, 1994). The most common is the likelihood ratio index, which was not produced by the software used in this analysis. An alternative way of reporting goodness of fit, is a table giving the number of y=1 values correctly and incorrectly predicted, and the number of y=0 values correctly and incorrectly predicted, where an observation is predicted as y=1 if the estimated prob(y=1) exceeds one-half. Although, it is tempting to use the percentage of correct predictions as a measure of goodness of fit, the table was not produced by the SPSS computer package. Many computer packages, for example SAS and LIMDEP produce the likelihood ratio and the table. The purpose of the chi-square goodness-of-fit test is to determine how well an observed set of data fits an expected set. If there is an unusually small expected frequency in the data set, chi-square might produce erroneous conclusions.

Chi-square values of the two logit models are 31.09 and 13.46. This measures the accuracy of the model in terms of the fit between the calibrated probability and the observed response frequencies. A high chi-square value and low probability value indicate that the fit of data is not very

satisfactory.

Probit analysis

Probit model parameter estimation is another step in estimating the nonlinear probability model. In both Logit and Probit cases, the parameter estimation are not much different illustrating the behaviour of the variables. When the dependent variable is qualitative, the accuracy of the model can be judged either in terms of the fit between the calculated probabilities and observed response frequencies or in terms of the model forecast to observed responses. In the case of a binary dependent variable such as WTP, the direct chi-square (χ^2) measure can be used for this purpose. However, the estimated chi-square indicate that the model observed responses and expected responses are different. Moreover, the estimated P-value is equal to zero. This indicates that the fitted model for that data may not be significant. Note that the predicted value of WTP is a probability, whereas the actual value is either 0 or 1. The correlation between the WTP binary dependent variable and a probabilistic predictor are measured by the R^2 values are not that meaningful. The expected signs of the estimated parameters are correct according to the standard economic theory.

Numerical integration procedure

Based on the responses to each WTP value five bid amounts were chosen for the estimation of logit bid curve. In a deliberate attempt to avoid the 'fat tail' problem in the Logit curve, we set the highest bid amount equal to £40.00 per month. The highest reported WPT value in the open-ended survey was £75.00 per month. A logit CDF was estimated from the estimated logit data set, using only an intercept and bid value as explanatory variables. Values for parameters α and β are -1.55 and 0.18 respectively. The estimate of slope parameter β is positive and is smaller than one, implying that E(WTP) is finite. This indicates less a 'fat tail' problem; the integral of the CDF in this case is bounded. Using the integration procedure, we have the E(WTP) value of £8.68, which is somewhat larger than the WTP value obtained from the open-ended questions. Several authors have found that respondents to DC valuation questions will give answers that imply WTP values that are higher than those stated by respondents to open-ended questions (Kristom 1993, Kealy and Turner 1993).

2.4.8 Validity, reliability and the biases of the methodology

The use of the CV approach to value public goods has grown dramatically in the last 25 years, with more sophisticated survey designs being the major improvement. The issue of random behaviour and the approaches to establishing the validity and reliability have been emphasized in CV methodologies. Random behaviour is the antithesis of validity and reliability. The validity is dependent on the difference between that which one wished to measure and that which one actually measured. The reliability is the error term of the estimated equation. If the estimated value of the error term is a non-random variable, then a bias is likely to be present.

One exercise in validity testing is to examine whether the measures produced by the estimated model relate to other measures as predicted by theory. We have seen in the multiple regression model equation, that the CV measure conforms to theoretical expectations (theoretical validity) and also the CV measure is correctly correlated with other measures of the water quality (convergent validity). A further variant of this approach is to examine the explanatory power of bid functions (Bateman and Turner, 1993). However, the large number of zero WTP values and

the high variance associated with CV, have resulted in a low R^2 value of 0.07. Mitchell and Carson (1989) suggest an R^2 value of 0.15 as minimum. However, psychologists point out that the very nature of social survey techniques make R^2 statistics of limited use (Bateman and Turner, 1993).

According to standard economic assumptions, the strategic behaviour in CV will be a function of the respondents perceived payment obligation and the respondents expectations about provision of a public good. Because of strategic behaviour, respondents tend to give a WTP amount that differs from their true WTP amounts in an attempt to influence the provision of the public goods. Samuelson (1954), in his original article on the provision of public goods, maintained that individuals could not be expected to reveal their true WTP for strategic reasons. There are some tests available to overcome strategic behaviour. We noticed in the field survey that CV estimates are unlikely to be over estimates, although money (i.e.,WTP amounts) does not actually change hands at the time of the survey. A simple strategy we practiced in the survey was to use both open-ended and closed-ended questions. Although the good is desired, we have not experienced particularly large WTP amounts. We also note that if the payment is thought to be probable there is a tendency to give a zero WTP value. We experienced a large number of zero responses, which might be expected under the circumstances in which the survey was carried out, i.e., public discontent with the water company after adverse media attention. Mitchell and Carson (1989) pointed out that the percent of respondents giving very large monetary amounts is very small, while the percent of respondents giving a zero WTP amounts is fairly large.

The CV approach suffers from a variety of theoretical and practical difficulties. There are several potential sources of bias given the nature of the CV technique and the survey instrument. Among the more important biases are hypothetical, strategic, starting point, information, sample-related, and the vehicle biases (Edward and Anderson 1987). The iterative bidding game technique, used in the closed-ended format of the present survey, generally suffers from starting-point bias. An iterative bidding procedure begins with some arbitrary initial value. If the respondent agrees to that value, the bid value is increased until a negative response is reached. If the initial value is a negative one, the bid value is revised downward until reaching an acceptable response. The final bid value is equivalent to the Hicksian compensating or equivalent surplus. In general, starting-point bias occurs because the value selected to initiate the bidding game has an appreciable impact on observed final bids. This impact could take place in two ways. First, if the starting point is far away from the true value, the procedure terminates before the true bid is reached. The average true WTP value reported in the sample is £3.91, which is not far away from the starting point. The starting value also conveys information to the respondent about expected or reasonable bids and, thereby, influences the final bid outcome. The information transfer effect is related directly to the initial or starting bid amount. Although, the respondent may anchor to an initial point in a bidding experiment, we have noticed that only very few accepted the initial bid amount of £10.

When respondents are asked how much in increased taxes they would be willing to pay versus how much they would pay via other methods, the response may be significantly different. This difference in WTP, dependent on the method of payment, is known as vehicle bias. Generally, the vehicles used in CV are utility bills, entrance fees, taxes, user fees, and higher prices. At times, respondents do not understand the scenario in the way intended by researchers because of the gap between plausibility and understandability. Therefore, the payment vehicle is either misperceived or is itself valued in a way unintended by the researchers. We realised in the survey that an increase in taxation would be the best payment vehicle in this study given the present water crisis.

Respondents also may change their values depending on the amount of information they are given about the environmental commodity or situation. For example, if information on present tax expenditures is given, the respondent may provide a different value than they would were they not informed about the tax expenditure. This phenomenon is termed information bias. An information overload effect can occur whereby respondents ignore important information and focus on and possibly misinterpret unimportant information. The definition of the population, decisions about the sampling frame, and attempts to obtain valid WTP responses and non-responses are some of the decisions to be made. Although the theoretical and practical problems associated with sampling errors should not be taken lightly, non-response is probably a much greater source of bias in survey research (Cochran 1983). Whether or not sampling errors exist, systematic differences between respondents and non-respondents will usually invalidate inferences based solely on data from respondents. This could be evaluated by sub-sampling at least 10 percent of the non-respondents when testing for sampling bias. Although, we did not investigate a sub-sample, it would be a good area to explore in a future study.

Sample selection bias concerns differences in behavioural parameters that weight the determinants of behaviour. This occurs when the probability of obtaining a valid WTP response among sample elements is related to the respondent's value for the good. Field interviews are generally free of sample selection bias because there is less potential for non-respondents to be consciously self-selected. Edwards and Anderson (1987) demonstrated various sources that could influence the sample selection bias and two parametric procedures that test for their occurrence. However, we do not see the relevance of conducting such tests in this study. They also provide an illustration of the magnitude of non-response bias in estimates of aggregate benefits. Mitchell and Carson (1989) demonstrated various sources of bias and their magnitude along with methodological problems and possible treatments. At the design stage of the survey questionnaire, we made an attempt to reduce bias problems to an acceptable level. The questionnaire was modified significantly, following the pilot survey and individual comments.

2.4.9 Total economic value

The total value comprises direct use values and passive use values. Direct use can be most easily defined as requiring the agent to experience physically the commodity in some fashion. For example, the use of the river for swimming is a direct use. Passive use value is synonymous with the non-use value associated with a multi-attribute environmental asset. Passive use values are more problematic to estimate. These values are not associated with actual use or even an option to use. Instead, such values are taken to be entities that reflect people's preferences. Total economic value is then made up of actual use values, option values (future personal recreation) and existence values (preserving biodiversity). However, in a CV study of water quality improvement, the component of total benefits (use and non-use) cannot simply be aggregated. There are often trade-offs between different types of use values and between direct and indirect use values. Similarly, partitioning of use and non-use values may be problematic. Aggregation of use and non-use values has to be used with great care and with a full awareness of its limitation. This is one of the future research areas required within CV. However, this study was not designed to explore this specialist subject.

2.5 The Total Benefits of Water Quality Improvement

The survey methods used in this study have facilitated an estimate of the benefits of water quality improvement in the River Aire. We have estimated two different WTP values using two different types of valuation question to assess individual preferences of water quality. The difference in mean WTP values for the open-ended and closed-ended formats may be that respondents often find it difficult to pick a value out of the air, as it were, without some form of assistance in the open-ended format. As a consequence, it tends to produce an unacceptably large number of nonresponses or protest zero responses to the WTP questions (Desvousges *et al.*, 1983). The estimation procedure used in the analysis for the open-ended format is quite different to the procedure that is adopted in the closed-ended format. The selection of the right functional form, and the selection of the method that is suitable for the data is a significant factor in getting an acceptable WTP measurement.

The estimated average value of the individual WTP for water quality improvement under the open-ended format is £3.91 per month per household. Using the integration of the Logit bid function, we have expected WTP value of £8.68, which is somewhat larger than the WTP value obtained from the open-ended format. In comparing the mean WTP values from open-ended and closed-ended questioning, it appears that the respondents were thinking in the same monetary region to assign a value for improved water quality. The high level of estimated mean values obtained in the closed-ended format, may reflect considerable concern felt by the respondents or the greater probability of respondents agreeing to higher values than they would willingly state themselves.

Policy makers investing in water quality improvements can take these values into consideration in their decision making process. Assuming the true "willingness-to-pay" is bounded by these figures (i.e. £3.91 - £8.68) and using the total household number in the surveyed corridor (i.e. 25,000) this would indicate a gross figure of £97,750- £224,500 per calendar month to effect water quality improvement as defined above. It should be noted that this does not include the broader catchment residents which might have an interest in water quality in the River Aire. If it were assumed, for example, that all City of Leeds residents were willing to pay the lower monthly contribution this would generate a revenue of approximately £800K per month. Some wider regional projections of "willingness-to-pay" monthly totals are presented in Table 4.1.

CV can provide information on some of the environmental and social benefits of water quality improvement. The benefit information provided here can be compared with actual expenditure to facilitate analysis of cost and benefits using the discounting approach. However, this step was not part of the present study.

3. PROPERTY VALUE ESTIMATION

3.1 Introduction

Economic theories suggest that land / property values may be influenced by environmental quality. Furthermore, economic assessments of such a phenomenon may be measured because environmental quality varies in space and time. Hence, it is possible to formulate relationships between differences in water quality and spatial and / or temporal variations in property values.

3.2 Factors Affecting Property in Leeds

Leeds is a large regional urban centre accommodating a population of 700,000 people and providing employment for 300,000. The city also houses the regional administration offices of major companies as well as many cultural and media facilities. Consequently, in comparison to other urban areas in the region, property values in Leeds are higher than average. However, as observed throughout the country in recent years, property values in Leeds are also subject to fluctuations which result from changes occurring in the national economy.

Property development in Leeds is controlled by the planning department of Leeds City Council and promoted through the Leeds City Development Corporation. There is a commitment of these two agencies to develop and regenerate the riverside in the city centre.

The water quality of the River Aire will only impinge on the value of properties in close proximity to the river. Hence, the focus of the investigations was directed to property within a 200 metres corridor of the river.

This narrow corridor area of the River Aire in Leeds encompasses a variety of property types; residential (inner city), residential (suburban), industrial, commercial, retail and leisure. The categories of property which would most probably benefit from water quality improvements are residential, commercial and retail and leisure. The benefits gained by industrial property is considered to be limited because of the adverse impacts which industrial sites have on general environmental quality.

3.3 Impacts of Water Quality on Property Values

In this study an investigation into the effect of water quality on property values adjacent to the River Aire was carried out. Particular attention was paid to the time period between 1985 and 1995. Two approaches were taken to elucidate the relationships between water quality and property values; a survey of estate agents and property surveyors and interrogation of the Housing Database of the Halifax Building Society.

3.3.1 Estate Agent Survey

A number of the main estate agents and property surveyors were selected from the Leeds edition of the Yellow Pages. They were asked to complete a copy of a questionnaire with respect to the particular property type(s) they dealt with. The agents selected handled a wide range of property types, but were dominated by those concerned with commercial and residential uses. The aim of

the questionnaire was to investigate the perception, by the agents, of the influence that the River Aire had on property values.

3.3.2 Results and discussion

Satisfactory responses to the questionnaire were obtained from 19 of the agents. These covered all property categories and geographical areas in the vicinity of the river in Leeds. Most of the agents covered by the survey dealt with more than one category of property (89.4%) and two dealt with all five categories mentioned above.

- Most agents (58.4%) considered that water quality in the River Aire was at level D, i.e. fair with poor fish stocks. However, 89.4% considered that water quality had improved in the last 10 years.

- In terms of marketable attributes; economic benefits, and development potential, the opinions of the agents suggest that the water quality improvement of the River Aire is more important for residential and commercial property than industrial; retail and agricultural property.

- In general, agents opinion suggested that the greatest level of water quality improvement was required for commercial and residential property (Level B: Good water quality with excellent fish stocks). Water quality did not appear to be as important for industrial and agricultural uses where most agents suggested that water quality did not need to be improved.

It was not possible to quantify these benefits in economic terms because most agents were not able to provide accurate figures on property values, particularly where retrospective information was required. Furthermore those companies with reliable sources of information, in the form of archived databases, did not hold data with sufficient detail for statistical analysis. Indeed, this was a major limitation on the information. Furthermore, some agents approached in the survey were not able to / or declined to make any comment at all. However, those who were able to raised a number of interesting points, particularly with respect to commercial property.

3.3.3 National economy

The common theory held by agents and surveyors was that rents and purchase values tend to double over a 10 year period. However, national economic factors have had a marked affect on this pattern in recent years. For example, office space in Leeds city centre is presently quoted at £12-£15 per sq.ft, but in the mid 1980s similar accommodation would have been in the region of £25-£30 per sq.ft.

3.3.4 Commerce location

The main factor influencing the location of most enterprise is client proximity. Environmental factors became more relevant when the importance of client proximity to an enterprise has reduced. Many national companies were able to negotiate office rents at levels which were much lower than quoted prices. This was particularly so for enterprises with large interests in London. Hence, within the same building, different companies may pay differing rent levels although the facilities provided are identical.

3.3.5 New developments

In areas adjacent to the River Aire there are a number of developments which provide first class accommodation for residential, commercial and amenity use. The cost of these developments, combined with their high quality has resulted in properties with values higher than elsewhere in the city.

Comments regarding such accommodation indicated that those residing in these developments chose to do so because of the quality of the accommodation and the city centre location. The influence of the river was uncertain. Furthermore, these new developments had higher rates of occupancy when compared to other properties.

3.3.6 Marketability

Suggestions were made that the quality of the river, and associated improvements, had not been brought to the attention of the public by either the Environment Agency or Yorkshire Water. Hence, using the improvements in the river as part of a marketing campaign would prove very difficult.

Compounded with this is public confusion in the perception of water quality. While improvements in chemical parameters may be apparent, the public still identified poor water quality with litter which was visible from the accumulations of bankside litter. This perception was reinforced in summer months when odours were apparent.

The amenity value of the river was a marketable attribute. However, with the exception of the city centre, access was restricted and there were deficiencies in the provision of secondary amenity facilities such as car parks. Such issues have also been raised by the Eye on the Aire group (Eye on the Aire, 1992).

3.3.7 Halifax Building Society Data

The Halifax Building Society holds a unique database of information relating to the purchase of residential properties. Data were purchased from the Group Statistical Services of the Society for the second part of the property value investigation.

Property value data were selected for a number of post-code sectors in the city of Leeds. Those chosen represented areas that were either adjacent to the river or at a distance away which would act as a control group. Data were obtained over a number of annual time periods these being; 1985; 1987; 1989; 1991; 1993 and 1995 and for the following property categories; one bedroomed flats, 2 bedroomed flats, 3 bedroomed semi detached houses, 3 bedroomed terraced houses and 4 bedroomed terraced houses. These categories were chosen because they provided sufficient data for the post-code sectors and the time periods selected to facilitate statistical analysis.

Comparisons were made between the average property values comparing properties adjacent to the river and the control group using paired t-tests. This was done for each property category and each time period of study. Property price indices were calculated to identify temporal trends in property values adjacent to the River Aire and in the control group. Indices of average property values adjacent to the river as a proportion of the average property value in the control group were calculated.

This form of analysis is termed relative shift analysis. We examined the shift in values of the property / land of interest relative to the shift experienced in the control. Unlike normal controls we have no expectation that this control will remain unchanged. Relative shift has been used in the past to examine land use trends within and without structurally protected flood plain land.

3.3.8 Results and discussion

Residential property values in the control group doubled in the period 1985 to 1995. In the same period, values of property adjacent to the river increased by 2.5 times. In both groups most of the increase occurred in the period between 1987 and 1989. This increase in value was not sustained in the following years for property in the control group. However, property values adjacent to the river continued to increase, although not at the same rate, in the following years. It is suggested that environmental quality, including aspects of improved water quality, may have played a role in maintaining rising property values adjacent to the river.

Paired t-test analysis demonstrated that there were no significant differences in property values ($p. < 0.05$), for any of the time periods investigated, between properties adjacent to the river and the control group. However, probability values were close to significance in 1987 ($p. = 0.15$) and 1995 ($p. = 0.17$). Closer investigation revealed that, in 1987, property values in the control group were higher than those adjacent to the river for all property categories. In addition, property values, in all categories, were higher for property adjacent to the river in 1995. These differences in property values coincide with periods of apparent poor and improved water quality respectively.

Comparative index values also illustrated this trend. Values for 1985 to 1993 showed that values in the control group and the group adjacent to the river were similar. However, in 1995 property values adjacent to the river were over 30% higher than those in the control group.

A large proportion of the increase in value of property adjacent to the river may be attributed to the residential developments in the city centre. These developments provide high quality residences in pleasant surroundings. However, water quality must be considered to be an integral part of the overall environmental quality of the area.

3.4 River Water Quality and Property Values in Leeds

From the two investigations it is evident that water quality in the River Aire has been, and will continue to be, of importance to property values in its vicinity. This conclusion is supported by information gathered from the opinions of estate agents and data from the Housing Database of the Halifax Building Society.

The opinions of estate agents indicate that the types of property which would most probably benefit from water quality improvement are commercial and residential properties. It was difficult to quantify this in financial terms, because of a number of other influential factors. However, it was clear that occupancy rates of property close to the river were greater than in other parts of the city (i.e. such property did not remain vacant for long periods of time). Water quality was also considered to be an important marketable attribute for property close to the river. However, to maximise the benefits of water quality improvement the Environment Agency must first publicise past improvements and facilitate further improvements to allow property owners to gain full economic benefits.

Data from the Halifax Building Society, on residential property, indicated that there were no statistical differences in property values adjacent to the river compared with the control. However, there was a trend of increasing property values close to the river which had become apparent in recent years. It was estimated that, at present, average property values adjacent to the river are 31% higher than property away from the river. Over a similar period water quality in the River Aire has improved. There is an apparent correlation here, although no causation can be proved.

4. SUMMARY AND CONCLUSION

4.1 Background

The aim of this project was to define the benefits of water quality improvement within the corridor of the River Aire as it passes through the Leeds conurbation.

This empirical study forms part of a broader initiative by the Environment Agency to develop techniques and approaches to the assessment of the societal benefits which are normally unquantified in environmental investment appraisals.

4.2 Empirical Studies Undertaken

Predictive river water quality models were assessed to define the feasible scenarios of water quality improvement within the lower reaches of the river resulting from investments in waste water treatment and integrated catchment control.

A contingent valuation survey was undertaken based on a defined corridor between Esholt and Knostrop to quantify the "willingness-to-pay" for water quality improvement. The survey acquired data on the socio-economic and demographic characteristics of the respondent population to enhance transferability of the information acquired. Interviewees were requested to classify present river water quality according to a six part (A to F) ladder which broadly paralleled current Environment Agency classification.

A novel aspect of this survey was the development of a methodology which linked commercially available post code address files with a geographical information system to select the surveyed population.

A parallel survey of property prices, rents and land values was conducted to determine changes in these characteristics that might be attributable to historical water quality improvements.

The nature and intensity of the public use of River Aire in Leeds was examined to assess the recreational and amenity values of the river. An additional survey was carried out at 10 locations along the river.

4.3 Results

The current perception of respondents (80%) was that the River Aire water quality lay in class D (i.e. moderate pollution with poor fish stocks and reduced use potential) or lower. This indicates that the public perception of present water quality is pessimistic.

An 87% response rate was achieved of the random sample selected. These 333 respondents exhibited a mean "willingness-to-pay" of £3.91/month/household to effect a water quality improvement to facilitate direct contact recreational activities such as swimming with excellent fish stocks (i.e. from a perceived level of D or lower to a new level of A).

A considerable proportion of respondents (48%) recorded a "willingness-to-pay" of zero. This may have been influenced by adverse publicity concerning the Regional water company, Yorkshire

Water plc, during the survey period and the publics' perception that pollution remediation is outside their direct financial responsibility.

Whilst the existence of 'zero value' responses are common in economic valuation of public goods, it does present certain statistical problems. This was particularly evident in the least squares regression analyses which exhibited generally low explanation. Partly to address these problems, further analyses were conducted using logistic regression, logit and probit analyses.

Using a dichotomous choice procedure followed by integration of the bid curve resulted in a estimated "willingness-to-pay" of £8.68/month/household, higher than the open-ended questionnaire derived figure of £3.91/month/household. Other studies have also observed generally higher "willingness-to-pay" estimates from dichotomous procedures.

Assuming the true "willingness-to-pay" is bounded by these figures (i.e. £3.91-£8.68) and using the total household number in the surveyed corridor (i.e. 25,000, this would indicate a gross figure of £97,750- £217,000 per calendar month to effect water quality improvement as defined above. It should be noted that this does not include the broader catchment residents which might have an interest in water quality in the River Aire.

If it were assumed, for example, that all City of Leeds residents were willing to pay the lower monthly contribution this would generate a revenue of approximately £800K per month. Some wider regional projections of "willingness-to-pay" monthly totals are presented in Table 4.1. However, an attempt to treat the mean values as a price for the good in question should be treated with caution.

Table 4.1 Speculative projections of regional monthly "willingness-to-pay"(£)

	Open-ended Average WTP (£) Minimum-end	**Average WTP(£)**	**Closed-ended and Integration Procedure WTP (£) Maximum-end**
Per household values	3.91	6.45	8.98
Corridor values (25,000 households)	97,750	16,125	224,500
City values (200,000 households)	782,000	1,290,000	1,796,000
Agency region values (2,500,000 households)	9,775,000	16,125,000	22,450,000

Whilst property values in the City of Leeds doubled in the period 1985 to 1995, values in the surveyed corridor exhibited a 2.5 fold increase, principally due to residential development in the city centre. The displacement of industrial land uses with prestige residential and commercial activities suggests increasing importance of water quality to the property sector in the central zone of the city of Leeds.

The range and intensity of recreational activities taking place by the river are greater on Sundays than during the mid-week at all sites. The most popular sites were those which processed amenity facilities or adjacent to residential areas. The most common activity taking place in the vicinity of the river is walking. Both surveys demonstrated that river main use is limited to non-contact water activities due to the poor state of water quality.

4.4 Conclusions

This project has demonstrated the feasibility of initiating empirical investigations to define the "willingness-to-pay" of the population for environmental improvements through the application of widely accepted contingent valuation methods.

Linking of post code address information with geographical information systems offers an effective means of sample selection and survey design in contingent valuation analysis.

Building society, and other data sources, offer considerable potential for assessing the relative movement in property values adjacent to and distant from sites of environmental quality change although the present investigation was unable to isolate the contribution of water quality to this observed trend in the Leeds area.

Notwithstanding the proportion of zero value returns, the survey has demonstrated a significant financial commitment of the surveyed population to effect water quality improvements in this historically polluted urban watercourse.

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