Draft Final Report R&D Project 253

Economic Changes to the Value of Water Environment

CNS Scientific & Engineering Services
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1.0 SUMMARY & RECOMMENDATIONS

To be written after approval of the draft

2.0 TERMS OF REFERENCE FOR THE STUDY

The overall Terms of Reference for the study were:

> "To review the economic principles and potential methods available to the NRA for ascribing a value to different controlled waters, and to subsequent deterioration or improvement of their environmental quality."

The full Terms of Reference are given in Annex 1.

3.0 INTRODUCTION

Two strands of policy development were brought together in the White Paper on the Environment. One was the long-standing commitment to the "Polluter Pays Principle" and, hence, towards the use of financial penalties and incentives to control pollution; the second was the recognition that all policy should be directed towards the principles of "sustainable" development.

Whilst it is easier to agree to the principle of "sustainable development" than to define it, a principal facet of this principle, as set out by the Brundtland Commission (World Commission on Environment and Development 1987), and later in the 1990 Dublin Summit of the European Community, is to satisfy the needs of this generation whilst taking into account the interests of future generations and those of the less developed countries.

Future policy will, therefore, require to be assessed against the criterion of sustainability. To accomplish this requires broadening the scope of assessments of the impacts of policy beyond those at present normally considered and, indeed, requires the development of criteria of sustainable development. In broad terms, both the UK Government and the Commission of the European Communities, (CEC), are seeking to develop and apply an economic framework for this task where economic analysis can cover all the resource implications of a policy. This framework will operate alongside the existing and developing system of environmental assessment as well as the legal duties towards environmental conservation.

Since all economic analysis is based upon some underlying ethical judgments, the CEC in particular, is funding research to determine whether the principles of sustainability can be adequately incorporated into conventional economic analysis, or whether a new axiomatic basis must be developed.

The objections of groups such as the Nature Conservancy Council (1990) British Association of Nature Conservation (1990) and the Friends of the Earth (1990) towards the application of conventional economic analysis to the assessment of some projects having a major environmental impact, are probably due to their belief that these analyses cannot deal with all aspects of environmental change. While this is true to some degree, unfortunately such objectors have not yet proposed a feasible alternative to the use of the conventional approach.

This report, therefore, approaches economic analysis using the twin criteria of:

(i) does it work and
(ii) does it help?

It also identifies those areas of policy relating to the water environment where economic analysis can help by providing substantive insights.

Whilst many economists have regarded the economics of the environment as a trivial question, merely requiring the application of standard economic tools, it will be argued here that the application of the two above criteria reveal some major outstanding theoretical and methodological problems for economics. Thus, whilst the standard tools of economics can and do provide both valid and useful insights into many aspects of environmental policy, there are, nevertheless, areas where this is not yet possible.

Consequently, this report also identifies those contexts where we believe that economic analysis is not yet useful, or valid, and the reasons why we believe that this type of analysis cannot yet satisfy the twin criteria in these instances. Since our discussion in these areas is critical of conventional economic theory, we outline the problems we perceive with conventional theory when used in these areas.

It should be pointed out that economics has not traditionally been a science in the conventional meaning of the term of a system of study, based upon the hypo-inductive method, and using experimental methods to test the hypotheses thereby derived. Instead, it has developed as a mixture of axiomatic reasoning, akin to mathematics, coupled with deductive analysis. Many of the reservations we express about the applicability of conventional theory to environmental issues arise precisely for these reasons. In particular, whereas in mathematics axioms can be arbitrary and no test of truthfulness can be applied, the intent of economics is to describe and predict human behaviour and the axioms of economics involve assumptions about the nature of human motivation and values. As such, their status is akin to the dictionary definition of an axiom as *"a self-evident proposition, not requiring demonstration, but assented to as soon as stated"*. Whether the existing axioms, derived in the context of choices about individual preferences for things like bags of corn and silver, are wholly adequate or command the required universal acceptance in the context of choices about environmental issues is, we believe, an open question. If the axioms are insufficient, or are not universally accepted, then the results of the analysis based upon those axioms are without applicability. Such analyses will not satisfy the criterion of "does it help?", nor will they be valid in the wider sense of providing an adequate explanation or prediction of human choice and preferences.

In expressing these caveats, it is important to recognise that the search for the excellent should not drive out the good. Economic analysis can help by providing the basis for a rigorous analysis of some environmental issues and some aspects of other environmental issues. That it may be inadequate, as yet, to deal with all aspects of all problems is not a reason to reject its use in those areas where it is valid and can help, particularly where there are no more rigorous tools available. Conversely, no tool should be used blindly without respect for its limitations.

4.0 THE PRINCIPLES AND LIMITATIONS OF ECONOMIC ANALYSIS AS APPLIED TO THE EVALUATION OF IMPROVEMENTS TO THE WATER ENVIRONMENT

4.1 Terminology, definitions and philosophy

The NRA's use of the term "use value", and the use of that term in economics, differ. For clarity, therefore, the NRA's use of the term will be adopted in this report, and the term "access value" will substituted for the economic usage of the term. The NRA use classes are, in summary, shown in Table 1, together with sub-divisions of economic values.

TABLE 1

Summarised NRA use classes
(sub-divided by categories of economic value)

NRA use class	NRA use class
1.0 Basic Amenity 1.1 Amenity 1.2 Development 1.3 Out-of-stream recreation 1.4 In-stream recreation	**5.0 Cyprinid Fishery** 5.1 Specialised recreation 5.2 Non-access values
2.0 General Ecosystem Conservation 2.1 Amenity 2.2 Specialised recreation 2.3 Scientific access values 2.4 Non-access values 2.5 Whole site value (includes values 2.1 to 2.4)	**6.0 Migratory Fishery** **7.0 Commercial Fishery** 7.1 productivity gains **8.0 Commercial Shellfishery** 8.1 productivity gains **9.0 Bathing** 9.1 recreation **10.0 Immersion Sports** 10.1 recreation
3.0 Special Ecosystem Conservation 3.1 Amenity 3.2 Specialised recreation 3.3 Scientific access values 3.4 Non-access values 3.5 Whole site value (includes values 3.1 to 3.4)	**11.0 Potable Water Supply** 11.1 marginal value of water **12.0 Industrial and Agriculture Supply** 12.1 process water 12.2 cooling water 12.3 irrigation **13.0 Augmentation of river flow**
4.0 Salmonid Fishery 4.1 Specialised recreation 4.2 Non-access values	

NOTE: *NRA use classes are shown in bold type. Associated economic values of these classes have been devised for the purposes of this report*

Any system of economic analysis is based upon some underlying ethical judgments or axioms. Conventional economic theory in the western democracies, *viz.* Neo-Classical Economics, is based upon two axioms:

(i) individuals exist to satisfy their desires; technically, each individual seeks to maximise his/her own pleasure or, technically, "utility". Thus the value of something is taken to represent how much pleasure the individual will gain from it. The value of some quantity of some thing is consequently subjective and measures the relative desirability of that quantity of that thing compared with other things. Something will only have a value insofar as at least one individual desires it (to avoid the clumsiness of the phrase "some thing" it is usual to speak of a "good"). The individual may, in satisfying his/her desires use up, or consume, some of that good. However, for other goods, the individual may gain utility simply by accessing the goods, without consuming them (for example, by looking at a landscape), or even simply by knowing that they exist - whales for instance.

(ii) individuals are "perfect" decision makers; each individual always chooses that combination of goods which, in his/her opinion, at that time and, subject to the limited resources available to him/her, will maximise his/her utility. Thus, economic values exist in the context of choices.

Neo-classical economic analysis further assumes that, not only must a person choose between different goods, but that resources are too scarce to allow that person to have all that they desire. Economic analysis, therefore, aims to aid in the selection of the best combination of goods to choose - given scarce resources - and between different methods of making those goods available.

These axioms are important for two reasons. Firstly, if they are not acceptable, then neither should any attention be paid to the results of economic analyses based upon them. Instead, an analysis built upon an alternative axiomatic basis should be sought. Secondly, the axiomatic basis limits the kind of issues with which economic analysis can deal. Thus, as has been stated earlier, whilst some economists regard environmental issues as presenting only trivial theoretical or methodological challenges to economics, in this report it will be argued that major unresolved problems exist.

A more detailed discussion of economic considerations will be found in Annex 2.

4.2 Limitations of economic analysis

The conclusions of economic analyses only have normative force insofar as the assumptions upon which they are based have descriptive validity. Economic analyses will result in false conclusions if the underlying axiomatic basis is not acceptable, the technical assumptions made are false, or the analysis is not rigorously developed. Equally, there are possible social objectives, such as those relating to the distribution of wealth, which economics recognises as being issues to be decided over and above the results of economic analyses.

Thus, if the assumption that values are simply and only given by individuals is not widely accepted, and some people hold that values may be inherent, or arise from society, then neo-classical analysis fails. More generally, economics assumes that there is a wider consensus about the direction of preference for a good, if not its precise value (Green and Tunstall 1990b).

It is possible to determine the values that people have placed upon goods, or those values which they said that they place upon them. However, "is" does not imply "ought" and it is legitimate for anyone to say that, whilst the values may be correctly estimated, people ought to place a higher (or lower) value on the good in question (Green and Penning-Rowsell 1986).

As with other methods of project appraisal and decision support, the results of economic analysis cannot be prescriptive and must be judged in terms of the degree to which they are helpful. A number of criteria for assessing the degree to which economic and other forms of analysis are helpful has been proposed (Green, Tunstall and House 1989a; Lichfield 1964; Nash, Pearce & Stanley 1975) and no one form of analysis is superior against all criteria for all types of decision. For example, other forms of analysis, including Environmental Assessment and Multi-Attribute Utility Analysis (Edwards and Newman 1982) will be superior to economic analysis when dealing with some problems.

A technical assumption of economics is the substitutability of utility between different goods (Green and Tunstall 1990b). Economics will accept that, for example, a cup of tea is not a substitute for a walk by an attractive river. It does, however, assume that the pleasure gained from each can be compared and that in theory, therefore, some number of additional cups of tea could compensate for the loss of the river. In this respect, economics assumes that everything is substitutable by everything else and is concerned with the quantities of different goods which are available rather than specific instances (Green 1991). Rightly or wrongly, the public often appears to disagree with this way of defining the choice about specific instances.

Economics has also been able to assume that changes are reversible *i.e.* that any decision taken to-day does not foreclose future possible options. Therefore, economics encounters some problems when considering unique goods and irreversible changes. Equally, economic theory developed on the tacit assumption that the economic system is an open system *i.e.* the behaviour of the system does not directly affect the availability of resources, but only their prices. Only with the work of Boulding (1966) and Georgescu-Rosen (1971) did the concept of a closed system, with finite resources, begin to become accepted into economic theory.

Again, because it has been possible to assume that changes are reversible, it has been possible to assume that consumption of resources in one period will have no effect upon the resources available in later periods. This assumption is clearly not true for non-renewable resources, or instances where effects are cumulative - in the case of the discharge of heavy metals for example. In these cases, the course of action which is economically efficient in the short term may lead to inefficiencies in the longer term. The criterion of sustainable development, however, requires us to adopt the course of action which is efficient in the longer run. To invoke a criterion of sustainability is much easier than to achieve it.

Equally, economic theory (Willig 1976) holds that the value of a small increase in some good should be equivalent to the value of an equally small decrease in the value of that same good. Thus, in the case of river water quality, the sum an individual is willing to pay for a small improvement in river water quality should be equal to the sum they would require to compensate for an equal worsening of the quality of the water in that river. Empirical studies do not, however, support this hypothesis (Knetsch & Sinden 1984; Cummings, Brookshire & Schulze 1986). Indeed, the individual may state that no sum is sufficient to compensate for the loss or, alternatively, that it is not his or hers to sell. Valuing decreases in environmental quality, where these resulted from an intentional act by society, therefore poses problems, unless and until an adequate theory is developed to explain this difference (Gregory 1986, Hanemann 1986; Hoehn & Randall 1987; Kahneman & Tversky 1979).

Time, itself, presents problems to economists because of the assumption that values are only given by individuals. In theory, the interests of the unborn need to be considered only insofar as individuals in the present generation place a value upon the effects of the change upon the unborn. Conventionally, when a decision has effects over several years, discounting is used to bring the different time-streams of effects to a common base to enable comparisons to be made. There is one theoretically sound reason for discounting *viz.* that no one investment should be undertaken to yield increases in future consumption when there is another equal investment which would produce a greater yield in future consumption. It is, however, quite difficult to determine what this opportunity cost of capital would be (Bradford 1975; Lind 1982; Spackman 1991). Also, a second reason for discounting is usually proposed, *viz.* that we have a simple preference for consumption now rather than later. However, this is thought to be a rather dubious assumption (Green 1991).

Moreover, the setting of a Test Discount Rate (TDR) by the Treasury (1984) sets an arbitrary test standard since more projects are proposed than can possibly be funded by public expenditure. Only those projects which will produce a return greater than or at least equal to the TDR should be considered since the choice of any project which would yield a lower return on public expenditure would automatically displace a project yielding a return higher, or at least equal to, the TDR.

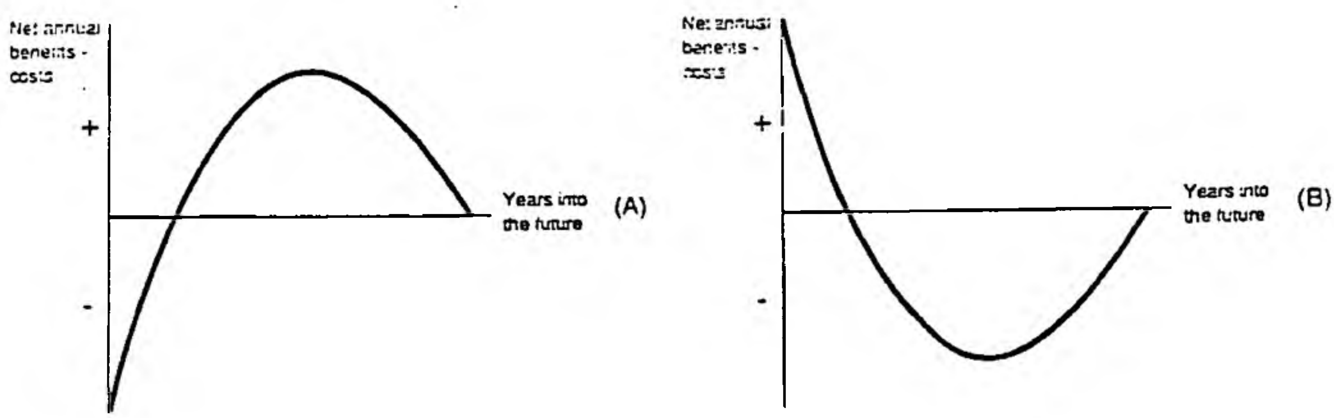
The effect of discounting is that effects in the long term have a very low value when compared with those which are immediate. A number of writers (Nash 1973; Page 1977) have argued that, for this reason, a lower discount rate should be applied to environmental impacts which occur in the future and, also, that inter-generational equity issues should be taken into account.

Markandya and Pearce (1988) have pointed out that applying a lower discount rate does not necessarily result in the option with the least damaging environmental impact being adopted. Instead, they recommended that growth factors should be applied to environmental goods. That is, environmental goods can be expected to increase in real value over time because, as we become richer, we are likely to value them more highly and, because of increased scarcity, since renewable resources, (*e.g.* hedgerows), and non-renewable resources are diminished. This is theoretically correct, but leaves open the major question of how to estimate these growth factors *i.e.* the changes in supply and demand to be expected over, perhaps, the next 60 years.

Therefore, a simpler way may be to calculate the stream of benefits net of costs in each future year until such time that this net figure falls to zero (Figure 1). Whilst on this basis there is no theoretically derived rule which can be used to select between options, the sustainability criteria would imply that those options which have negative benefit streams in the future are unlikely to be satisfactory.

FIGURE 1

Time Profile of Projects



4.3 Recommendations on the use and scope of economic analysis

From the discussion above, it is possible to draw some general conclusions about the contexts in which economic analysis will be both useful and valid - see Table 2 - and the preferred general procedures to adopt. Equally importantly, Table 2 lists some general recommendations as to when economic analysis will either not be valid or will not be useful *i.e.* it will not clarify the issues involved in the choice or simplify the complexity of the trade-offs involved.

TABLE 2

Recommendations on the appropriate current uses of economic analysis

- Economic analysis, like other decision support methods, is a method of simplifying and clarifying the issues involved in a decision: they are not prescriptive and the results should be assessed in terms of how helpful they are.
- Evaluate access values **only** - do not attempt to evaluate non-access values except by surrogate methods - use of other decision support methods is likely to be more appropriate when the major impacts are on non-access values.
- Use economic analysis for options which involve a negative impact on the environment with great caution - principally its use should be to assess the benefits of improvements.
- Apply it **only** to non-cumulative effects of discharges - regulation is likely to be the preferred option for cumulative pollutants.
- Use the Test Discount Rate when assessing distribution of effects over time.
- Assess the future options excluded by adopting each particular strategy - options which exclude least alternative options in the future are to be preferred (irreversible changes obviously exclude future options).
- Plot the time profile of **net** economic impacts of different options - with a presumption that any which shows negative returns in middle and/or longer term should be excluded.

An illustrative example of how environmental values might be applied is contained in the case study, based upon the Water Research Centre's Catchment Water Quality Planning Study, is given in Annex 3.

5.0 STAGES IN THE ECONOMIC ANALYSIS OF CHANGES TO THE WATER ENVIRONMENT

Typically, the decision to be taken involves _changes_ in the _quality_ or _quantity_ of _discharges:_ but the benefits or disbenefits of such a change result from _changes_ in the _receiving water quality,_ where the value that a user of the water, (or adjacent land) gains, is partially dependent upon the water quality.

Thus, whilst the first stage in any analysis is always to identify all the significant impacts, in the case of changes to the water environment, this is usually a two-stage process for economic analysis. First, the changes to the water environment and then the economic impacts consequent upon those changes must be predicted.

The change to the water environment clearly needs to include not only the magnitude of the change but also the area, or stretch, of water affected. Identification of the economic impacts of the change requires the identification of all those activities, the value of which may be partly dependent on the water quality in the area affected. These boundaries should initially be set too widely rather than too narrowly.

Given that economics is concerned with the relationship between supply and demand, we can describe all economic relationships in terms of a simple input-output model. A fixed quantity of inputs will usually result in a fixed quantity _and_ quality of outputs, but a potential economic improvement will occur if:

(i) the same quantity _and_ quality of output can be achieved with a decrease in the quantity of inputs; or

(ii) a higher quantity _or_ quality of outputs can be achieved using the same quantity of inputs.

For example, the effect of improving the water quality by, say, reducing the pollution from storm overflows might be:

(i) same number of trout as caught previously but with less effort;

(ii) more trout caught with the same effort as before;

(iii) salmon caught in place of trout for the same angling effort.

The economic value of this improvement in water quality is measured by the ***change*** in the cost of the inputs ***or*** the value of the outputs.

5.1 Identification of preference changes

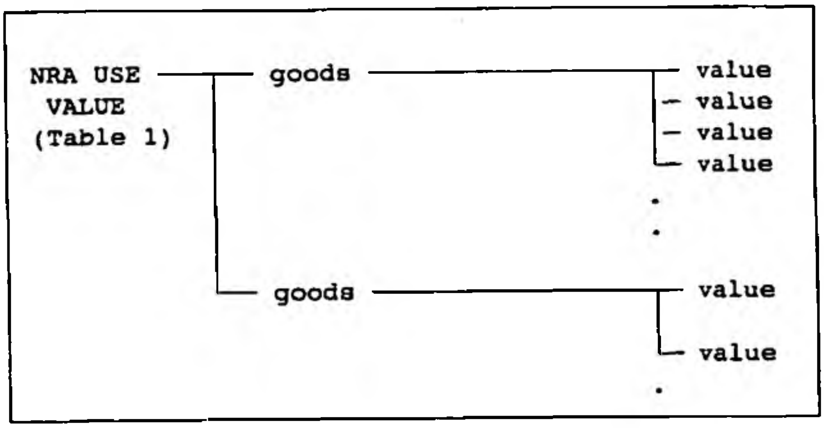
The three questions to be addressed in the identification process are:

* **which preferences** are sensitive to water quality?
* **why** are they sensitive?
* **who** is affected?

The NRA use values are defined broadly: a change in each NRA use value could affect several components of economic value. Figure 2 illustrates the conceptual relationship between the NRA use values and the components of economic value.

FIGURE 2

The relationship between NRA use values and economic values



Each NRA use value relates to some characteristic, or attribute, or combinations of them for which some standard (or quantity) is preferred to another. (For access values, it is simpler to say that some characteristics are preferred for a particular activity). A key stage is, therefore, to determine what characteristics are preferred. For example, in the case of abstraction for process use by the dyeing industry, constant quality of water is preferred to a high quality of water which varies. (Variations in quality cause variations in the colour of the dyed article). Because, in this case, consistency of quality is preferred, it may be regarded as a good in the economic sense and it has a "use" value. Another user may find the water of the stream pleasant to walk or picnic beside, which also are goods.

Any one use value may thus consist of a number of goods, each of which may depend on a different set of water quality characteristics.

The total use value may be assessed using a holistic or piecemeal approach. A holistic approach will evaluate all of the changes in all of the goods affected by the change at the site or source, *i.e.* it will evaluate all of the values. Conversely, piecemeal approaches will evaluate only the changes in one good, and perhaps only one value affected by that change. The results from piecemeal approaches have to be summed in order to evaluate the value of the change as a whole.

Piecemeal approaches are more common. The benefits of new roads are, for instance, assessed by summing the expected reductions in accidents, the savings in fuel costs and the savings in travel time (DTp 1989). In assessing the benefits of flood alleviation schemes, the same piecemeal approach is adopted (Penning-Rowsell and Chatterton 1978). Clearly, the piecemeal approach both assumes that the loss or gain is simply the sum of its parts (Green and Penning-Rowsell 1986). The possibility of double-counting must be guarded against.

Some economic methods can, however, only be used to evaluate particular types of goods because they are partial in their approach, rather than holistic.

5.2 Preference measures

In strict economic terms, a change only results in a gain (or a loss) if at least one person perceives that a change has occurred. Should the change be preferred, it would be counted as a gain, whereas if there were an adverse reaction to the change, it would be counted as a loss. Consequently, the measures which must be used to quantify the magnitude of the change, must reflect those perceptions and preferences. Different measures may, therefore, be necessary for different goods. At the same time, to be useful in assessing the consequences of a change, it must also be possible to predict the magnitude of that change. Hence, it must be possible to relate the preference measures to some variables, (perhaps pH and ammonia), changes in which can be predicted by modelling. A number of such preference-based measures have been proposed (Bascombe, House & Ellis 1989; Couillard & Lefebvre 1985; House and Ellis 1987; Price & Pearson 1979).

For most goods, preference and perception are equivalent. The abstractor who has a preference defined in terms of the volumes and bio-chemical parameters of the abstracted water, will test the water against those parameters. However, the public will generally only have the direct evidence of their senses to inform them as to how the good compares with their preferences. For example, visitors to beaches can only judge the quality of the sea water in terms of what they see and smell, coupled to their past experience and any information they have been given.

Thus, Garber (1960) developed a classification system for sea water quality on the California coast which is essentially a perceived measure of quality (Table 3). This method is believed to have been tried by the Welsh Water Authority. Brown and Campbell (1987) found that when two beaches were compared, the one which visitors perceived as having the dirtier water was also the beach where respondents were more likely to report having seen discarded food or wrappings, bottles or cans, paper litter, chemicals or oil slicks.

TABLE 3

Garber classification of seawater quality

C	Clear water	Clear, no off-colour water or particulate matter
D	Ocean debris	Driftwood, marine organic trash not otherwise classified
K	Sewage debris	Matchsticks, hair, sludge floc, some garbage
H	Human faecal matter	Intact faeces must be differentiated from animal waste. Must determine whether from pleasure boat.
CC	Rubber goods	Condoms and rings, old or new
R	Refuse, including garbage from beach and land use	Domestic trash such as cartons, cans, boxes, bottles and garbage from use of beach recreation areas.
TR	Floating trash and garbage from boats and ships	Similar to *R* above, but judged to originate from boats and ships
S	Seaweed	Any kind of seaweed
B	Dead bird	Any dead marine bird

TABLE 3 continued...

ML	Dead marine life	Usually dead sharks, sea lions, or seals. Sometimes fish or other marine animal.
P	Plankton blooms or rafts	Plankton bloom discolouration of water. Confirmed by plankton counts and analysis.
O	Oil	Mineral oil from ships or other sources. Ship bilge pumping, fuel spills, etc.
OS	Mineral oil scum	Mineral oil slicks associated with natural oil seeps.
G	Particulate grease, sewage outlet	Grease particles or grease balls near waste containing 40% saponifiables.
GS	Grease scum, sewage origin	Slick appearing to originate at a sewage discharge point.
T	Tar	Floating mineral oil tar. Collected and examined physically and chemically to ascertain possible origin.
N	Noxious odours, tivities; fumes or gases. Non-sewage	Mercaptans, sulphides, smog odours from industrial ac-
NS	Noxious odours, fumes or gases. Sewage	Sewage or treated sewage odours present in water or along beach.
M	Murky-dirty	Water dirtied by causes other than plankton blooms, M*1* approx. 5ft. Secchi, M2 approx. 2.5 - 4ft. Secchi, M*3* approx. 2.5ft
F	Outflow of water to ocean from land	Usually storm drain outflow which can affect ocean water condition.

1	Small amount	Traces of the coded material
2	Moderate amount	Some of the coded materials at intervals. Usually not objectionable.
3	Large amount	Enough of the coded materials to be objectionable.

Water Colour:

B	Blue	Predominant colour as noted by the observer. Usually coded with reason for unusual colour, if any.
BG	Blue-Green	
G	Green	
OD	Olive Drab	
BR	Brown	
R	Red	

Source: Garber (1960)

TABLE 4

Indicators of Perceived Water Quality

	perceived water quality scores (1)						
	item seen			item not seen			Somers'd
	mean	std dev	N	mean	std dev	N	
dead fish on surface of water	0.50	0.94	14	2.52	1.75	819	-0.607
can see river bottom	2.74	1.76	457	2.15	1.71	369	0.171
swans on water	2.96	1.41	107	2.41	1.80	729	0.255
green scum on water (e.g. algae)	2.05	1.71	347	2.78	1.73	483	-0.187
water unusual colour (e.g. red)	1.29	1.45	185	2.82	1.70	649	-0.422
people swimming	2.76	1.26	21	2.48	1.77	815	0.146
protruding rubbish (e.g. bedsteads, trolleys, tyres, bicycles etc)	1.81	1.71	405	3.11	1.57	432	-0.398
oily look to water	1.19	1.39	159	2.79	1.70	674	-0.408
can see many fish in water	3.46	1.64	115	2.31	1.73	706	0.277
unusual smells	1.13	1.35	186	2.88	1.67	645	-0.488
coots/moorhens on water	2.76	1.63	161	2.39	1.78	662	0.173
can see pipes discharging into river	1.58	1.64	168	2.71	1.72	660	-0.309
adults fishing	3.00	1.65	100	2.41	1.76	737	0.188
ducks/mallards on water	2.70	1.61	273	2.37	1.82	564	0.169
foam on water	1.34	1.31	193	2.82	1.72	644	-0.388
canoeists	2.76	1.37	41	2.47	1.78	796	0.188
kingfishers flying over river	2.94	1.78	17	2.47	1.76	818	0.071
rubbish on banks	1.96	1.70	422	3.01	1.66	412	-0.275
grebe on water	1.49	1.64	37	2.53	1.76	772	-0.087
dragonflies and damselflies are numerous	2.47	1.69	118	2.48	1.77	716	0.030
plants in water appear dirty	1.90	1.69	369	2.99	1.66	448	-0.276
many different types of plants growing in/on river	2.72	1.72	438	2.21	1.69	375	0.091
columns of midges over water like smoke	1.93	1.57	190	2.65	1.78	642	-0.140
brown, "cottonwool" growing on surface of water	1.33	1.42	39	2.55	1.75	789	-0.258
crowfoot/white lily growing on surface of water	2.06	1.56	53	2.52	1.77	770	-0.058
no plants growing in or on surface of water	2.13	1.73	282	2.68	1.75	544	-0.156
water appears muddy	1.83	1.54	508	3.50	1.60	325	-0.414

Notes:

(i) 1 scaled from 0 "very polluted" to 6 "very clean".

(ii) Somers'd is a non-parametric regression coefficient having a range between - 1 and 1.

Source: Green and Tunstall (1990a)

Similarly, perceptual measures are required for use with fresh waters. The work undertaken in this area in North America has been reviewed by House (1987); and the results of some trials of a potential such perceived index of river water quality are given in Table 4. More detailed discussions of the possibilities and problems of this work are given elsewhere (Burrows & House 1989; Green, Tunstall & House 1989b; Green & Tunstall 1990a; House & Sangster 1990).

In the case of non-access values, the problem of what is the good has a further complexity. Conventional economic theory would suppose that each individual has a specific non-access value for each of 38,000 kilometres of river in England and Wales, and for each of the 5,000 SSSIs and, indeed, for all instances of environmental goods which they might value. *A priori* this seems improbable and that work (Green & Tunstall 1991a) which implies that moral and altruistic concerns drive public preferences for environmental conservation, also suggests that what is valued is the principle rather than the individual instance. That is, people are willing to pay for the principle of conservation and improvement of the environment, and this value is not the sum of the values that they place upon specific improvements to individual sites. If this is correct, it leaves the problem of how to allocate a specific value to a specific improvement at a specific site.

That economic values are subjective and given by the individual, raises potential problems in relation to sites of scientific importance. Strictly, if a site is judged of high scientific importance but the public generally regard it as of being unimportant, its economic value will be low. So too, may a change which is desirable on scientific grounds have a negative economic value if it is not desired by the public. Thus, the public might only have a furry mammal conservation ethic whilst regarding any species of snail as totally expendable.

There is some evidence, however, that river corridors, for example, are valued when they are perceived to provide a rich habitat rather than simply because such corridors are considered to look pretty (Green & Tunstall 1991a). Similarly, there is limited evidence that there is a degree of congruence between those features (Green 1991) which are considered to reflect the scientific significance of an ecological site and those which the public consider are important (Table 5).

The low levels of importance given to the statements "It contains wildlife or plants that are attractive to look at" and "The amount there is to see when visiting", particularly when compared with the strength of agreement with other statements, do not support the hypothesis that the public are only interested in furry mammal conservation, or even only for pretty birds.

5.3 Why are they sensitive?

In many cases, for access values, the quality of the water environment will only be one good out of many, the joint consumption of which the individual has a preference. This is particularly true for recreation and amenity. Whilst the enjoyment a fisherman gets from fishing is partly dependent upon the number and quality of fish caught and, in turn, this is partially dependent upon water quality, other characteristics of the site are also important (Davis & Parker 1982). To take a more extreme case, the enjoyment that a canoeist gets from that activity would frequently appear not to be at all dependent upon the perceived water quality, otherwise some locations such as the River Don in Sheffield, would be avoided. Only that part of the enjoyment of the activity which is contributed by perceived water quality will be affected by any change in it.

The significance of perceived water quality to the enjoyment of informal recreation on rivers has been analysed in some detail as part of wider studies in the UK (Burrows & House 1989). In general, its importance is determined by the belief that improved water quality would result in a wider and richer range of flora and fauna being supported in the river corridor (Green & Tunstall 1990b). Similarly, the significance of perceived sea and beach cleanliness as both an attractor to a beach site and as contributors to the enjoyment gained from the visit are analysed in Penning-Rowsell *et al* (1989).

5.4 **Who is affected? - defining the population that benefits**

With access values, defining the boundaries of the population who benefit is easy; the difficulty may lie in estimating the numbers in that population. Thus, when recreational benefits are being estimated, the value is estimated as the value per individual visitor. However, data on the number of such visitors is often scarce and a visitor count may be a necessary part of the analysis (Tourism & Recreation Research Unit, 1983).

TABLE 5

Preferred features for the preservation of nature reserves

"What do you think are the most important features in deciding which nature reserves should be preserved?"	Response	
	mean	std. dev.
It contains wildlife or plants that are disappearing in the UK	4.53	0.74
It contains a very rare species of wildlife or plant	4.28	0.98
It includes a natural landscape rather than a man made landscape	4.11	1.05
The wildlife or plants it contains have always been rare in Britain	4.06	1.01
The variety of wildlife and plants it contains	3.99	0.91
The wildlife and plants it contains are typical of the countryside as it used to be	3.84	1.05
The reserve contains a large proportion of the plants and animals of that kind in the UK	3.80	1.05
There are no other sites like it locally	3.79	1.16
It contains wildlife or plants that are attractive to look at	3.46	1.21
The amount there is to see when visiting	3.13	1.34
The number of visitors to the site	2.70	1.32

scale: 0 = least important; 5 = most important
N = 327

Source: Green 1991

Where different categories of visitor attach different values to an improvement to the water environment, then the numbers of visitor within in each category must be estimated. These categories might include, for example, the activity undertaken (fishing versus picnicking); the type of visit (day versus long stay); the type of visitor (local versus long distance); or the income and socio-economic status of the visitor. Differences in the values of the different groups may be marked (Green & Tunstall 1990a).

For non-access values, no self-evident boundaries can be set. In theory, there is no reason why a resident of Wick might not place a non-access value on some stretch of the Thames. Thus, it is necessary to determine empirically the boundaries of the beneficial population. The principal expectation of the boundaries must be that the non-access value attached to a specific site, (if there be such specific values), shows attenuation by distance. A US study on the Grand Canyon did not find such attenuation because it is unique and spectacular (Schulze et al 1983) and a UK study on preferences for the protection of coastal sites, such as nature reserves and public open space, found only weak attenuation for households up to 1½ hours' travel distance from the coast - with the marked exception of promenades, for which preference fell away very rapidly. At this stage then, if a site specific non-access value could be validly determined for a sample of the population, it would not be possible to gross this value up by the appropriate population size.

Conversely, we believe that it is possible to derive valid estimates of the value for broad categories of environmental improvements, such as river water quality improvements (Green & Tunstall 1991b). However, this leaves open the question of how to estimate the non-access value of improvements to a specific stretch of river, coast or canal.

5.5 Problems in valuation

Direction of the change

A change in the water environment can be either an improvement or a deterioration. Theoretically, the value of a proposal which results in an improvement to the water environment is measured by individuals' willingness-to-pay. Conversely, the value of a deterioration in the water environment is measured by the sums which individuals would require in compensation for that deterioration. At the present time, the economic value to be attached to proposals which result in a deterioration in the water environment is problematic for three reasons:

(i) Firstly, for small enough changes, conventional economic theory predicts that the value of a change in either direction will be approximately the same (Willig 1976). Thus, conventional theory predicts that an individual will place the same value upon a small increase in enjoyment whilst walking by a river as upon an equal decrease in his/her enjoyment.

In reality, all the empirical studies have shown that individuals require a much larger sum to compensate them for a decrease in the availability of a good, particularly of a public good, but also of private goods, than they would be willing to pay for an equal increase (Coursey & Smith 1984; Cummings, Brookshire & Schulze 1986). Indeed, it is common to find a proportion of the sample of individuals who state that they would require infinite compensation to make up for the loss. Since, logically this implies that any gain in any other good would not compensate for the loss, it is best interpreted as a rejection of this method of taking a decision as a simple weighing on the scales of the gains and losses to different individuals.

A number of explanations have subsequently been proposed to account for the difference (Mitchell & Carson 1989). In the absence of a clear understanding of the reasons for it, the recommended practice has therefore been to define the issue in terms of a gain (Cummings, Brookshire & Schultze 1986). Thus, Walsh, Loomis & Gillman, 1984 asked respondents how much they would pay to avoid part of the existing forest wilderness in Colorado being clear-felled.

Consequently, the evaluation of deterioration should be approached with some caution although there is some evidence that some methods may work (Brown & Green 1981).

(ii) There is a second reason for caution about the valuation of deterioration to the environment: the difficulty of valuing non-access values. If a change involves an improvement, then the comparison is:

$$\textbf{access values} + \textbf{non-access values} \geq \textbf{costs}$$

If access values alone exceed costs, then the improvement is justified and we do not need to estimate non-access values. If access values alone do not exceed costs, then the difference gives some indication of the required order of magnitude which non-access values must have if the change is to be justified. In any event, even without valuing non-access values, some improvements are likely to be justified.

Conversely, if a change involves a deterioration, then it is justified if:

$$\textbf{scheme benefits} \geq \textbf{scheme costs} + \textbf{loss of access values} + \textbf{loss of non-access values}$$

If the magnitude of non-access values is critical to the acceptance or rejection of the proposal, then there is likely to be a lack of consensus as to their magnitude and an invocation by some groups of the *"is does not imply ought"* principle described earlier. In this case, the inevitably challengeable estimate of these values, coupled with evidence that non-access values are closely linked to moral concerns (Green & Tunstall 1991a), is unlikely to help the Authority's credibility.

Instead, the importance of these values needs to be recognised and attention focused first upon the proper estimate of scheme benefits. Scheme benefits must be estimated as national economic efficiency gains, rather than the financial benefits to the firm.

If, for example, a scheme only aids in the competitiveness of one firm versus its UK competitors, then there are no national economic benefits. Suppose there were two paper mills and one is allowed to reduce its costs by reducing the quality of its discharge, it will make additional sales and profits. As is normal in economic analysis, the market is presumed to be in equilibrium so that no increase in demand will result from the reduction in costs, but the competitors' share of the market will, of course, diminish correspondingly. There may be distributional gains either to the firm away from its competitors or regional gains by, for example, attracting development to a declining region away from more prosperous regions. However, there is no change in overall national economic efficiency.

Additionally, the bound for non-access values, which would be sufficient for the scheme to be rejected, can be estimated if there exists a less environmentally damaging scheme option with a lower net present value (NPV)*(NPV = discounted benefits - discounted costs)* (Sadler et al 1980). The difference between the NPV of two schemes is the lowest estimate of the non-access values which would be sufficient for the second scheme to be preferable on national economic grounds. The second option need not be one which the proposer has either considered, nor might it be financially viable to the proposer. For exam ple, the paper mill owner might wish to site a new brewery at site A because of its proximity to a motorway. However, the process at this site would cause severe environmental damage. A site B is suggested which would be less environmentally damaging, but which would be less desirable financially from the owner's point of view. The basis for the comparison of the two schemes is shown in Table 6.

TABLE 6

The economic comparison of two schemes using net present values

Scheme options	Present values						
	scheme benefits financial	economic	scheme costs	loss of amenity value	non-access value	present value to firm (financial)	present value to country (economic)
	1	2	3	4	5	6	7
Scheme proposed	100 000	10 000	5 000	3 000	?	95 000	2 000
Alter-native scheme	80 000	8 000	6 000	1 000	0	74 000	1 000

The benefits to the brewery owner of each of the two sites are the present value of the expected profits (column 1). The national economic benefits are the increased quantities of beer available for export, the remainder being sold on the domestic market. At site B, the brewer's transport costs would be higher and thus his exports would be less.

The figures in column 3 represent the capital costs to the brewer.

At both sites there will be some reduction in the amenity value in the river (column 4).

Column 5 represents the environmental damage; at site A it is an unvalued deterioration in environmental quality, whereas at site B there would be no such deterioration.

Columns 6 and 7 are self-explanatory.

The difference between economic benefits of the two schemes (column 7) = £1,000. Therefore, non-access values (column 5) for scheme B need not exceed £1,000 before scheme A becomes uneconomic from a national point of view.

(iii) Thirdly, a sustainability criterion should be applied to any change which results in an irreversible loss of natural resources. Quite what this criterion should be has yet to be adequately defined.

Prediction of the change

Clearly, it is a prerequisite of economic analysis that it be possible both to establish the present level of availability of the good and to be able to predict the magnitude of the change in availability of the good as a consequence of some action. If, for example, the change in river water quality which would result from some improvement to a discharge cannot be predicted, then neither can the economic value of the change.

The implication is that more monitoring of both receiving water quality and of discharges is required if economic analysis is to be applied. In principle, access values can be valued; the main constraints in practice are limitations of data.

5.6 <u>Relationships between NRA use classes</u>

The NRA use classes are not mutually exclusive and independent.

Amongst the NRA Use classes, several of the categories have access and non-access values whose magnitude is dependent upon their effect upon another use class. Thus, the value of the "Augmentation of River Flows" (Use 13) depends upon the use to which that augmented flow is then put. Similarly, the significance of a "Migratory Fishery" (Use 6) lies in the value of the destinations of those fish: be this Ecosystem Conservation, Angling or Commercial fisheries.

Similarly, for a single stretch of water, the values of two different use class are in some cases more than simply additive. For example, Basic Amenity values (Use 1) are likely to be greater if the water also satisfies General Ecosystem Conservation (Use 2) (Green & Tunstall 1990a; 1991b). However, in at least some instances, the relationship between the potential values of two different NRA uses for a stretch of water are likely to be negatively related: Special Ecosystem Conservation (Use 2) may frequently require the minimisation of human disturbance which will reduce that site's potential Basic Amenity Use (Use 1) value. Similarly, some other uses are mutually antagonistic (eg boating and swimming; boating and angling).

These relationships are shown in Figure 3. When changes at a specific site or to a specific discharge are considered, then several use classes are likely to be affected. Consequently care will need to be taken to avoid double-counting benefits.

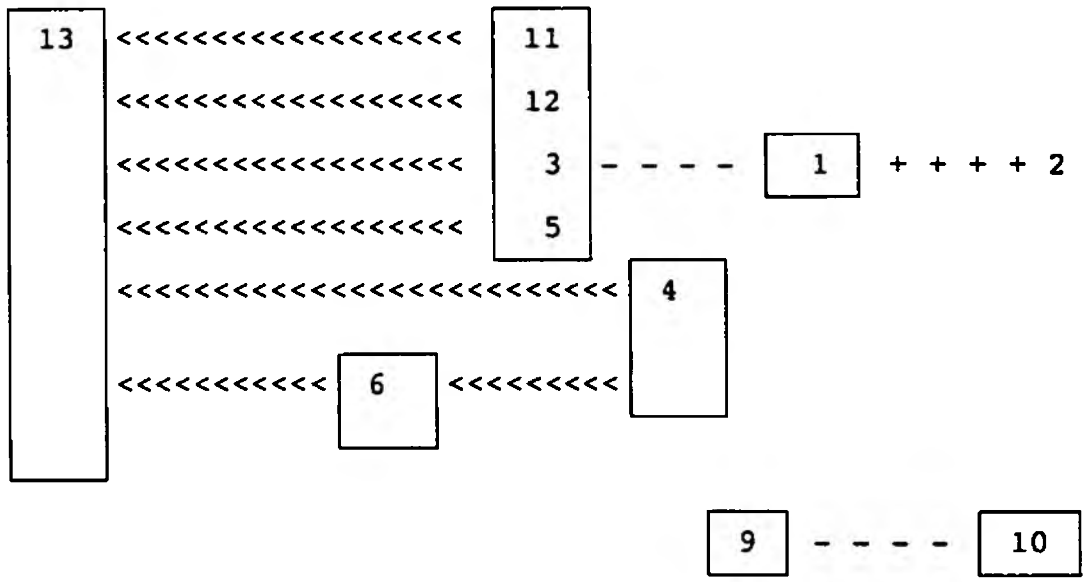
For each use class a number of different categories of economic access and non-access values are likely to be affected by any change. The categories of economic value associated with each NRA use class are summarised in Table 1.

In addition, there are functional linkages between NRA use values and with other NRA functions. Obviously, there is a linkage between abstraction, which reduces the volume of water available to dilute pollutants, and discharges. Similarly, floods both distribute water-borne pollutants on to the land and carry land- and sewer-borne pollutants into the water environment.

These linkages emphasise the need for a catchment management approach and also both for the internal communication patterns within the NRA and its Corporate Information Technology Strategy. Any catchment management approach requires that data be interpreted.

FIGURE 3

Linkages between NRA use categories



<u>Key</u>

< < < < < < < < < <	=	dependent upon
- - - - - - - - - - - - - - - -	=	negative correlation
+ + + + + + + +	=	positive correlation

<u>Note</u>: The value of Use 13 (see Table 1), augmentation, is dependent upon the increase in value of Uses 11, 12, 3, 4 and 6 and, indirectly, Use 5. Augmentation has no intrinsic economic value but is dependent on increases in the values of other activities.

6.0 RESULTS OF PREVIOUS STUDIES

6.1 Estimates of total economic costs

Whilst no estimates of the total economic losses resulting from pollution of the water environment are known for the United Kingdom, estimates have been prepared for other countries, notably the United States (Fisher 1982; Herschaft *et al* 1978; Jordening *et al* 1973; Kneese & Bower 1968; Unger *et al* 1973). Estimates for a number of European countries are given in Table 7. Those for Germany show significant variation but give figures in the range of £1-3 billion of damage per year for groundwater and perhaps close to £5 billion in damages to rivers and lakes. Given that the figures for Germany date from pre-unification, the figures including the former East Germany, would be considerably higher. The low figure for the North and Baltic Seas, compared to other damages, is noticeable. The figures for the Netherlands cover a range of roughly £90 - £280 million a year.

It is impossible to generalise from these figures to the UK. However, as has been pointed out on several occasions, the omission of environmental damages and the pricing of some renewable and non-renewable natural resources at below long-run marginal costs results in a potentially severe distortion of national accounts, such as the Gross Domestic Product. Some analyses conclude that if figures for environmental damages and shadow prices for natural resources were included, the US economy, for example, would appear to have been stagnant in recent years (Daly and Cobb, 1990).

The same factors distort the real rate of return upon capital invested in the private sector, making the estimation of the opportunity cost of capital more difficult.

TABLE 7

Estimates of total economic costs of water pollution

6.0 billion lire/yr	pollution of coastal waters in Italy (Muraro 1974)
19.0 billion lire/yr	pollution of inland water (Muraro 1974)
21,000,000 DM/yr	recreational and amenity benefits from improvements to lakes in West Berlin, Germany (1982)
4,000,000 DM/yr	drinking water production cost savings from improvements to lakes in West Berlin, Germany (1982)
0.3 billion DM	loss of freshwater fishing through water pollution, Germany, Schultz (1986)
14.3 billion DM/yr	"measurable damage" to rivers and lakes, Germany (1986) - Wicke *et al* (1986)
9.0 billion DM	groundwater damage through pollution, Germany, Schultz (1986)
3.0 billion DM/yr	"measurable damage" by contamination of groundwater, Germany (1986) - Wicke *et al* (1986)

TABLE 7 continued ....

> 0.3 billion DM/yr	"measurable damage" to North Sea and Baltic, Germany (1986) - Wicke *et al* (1986)
110-350 million Dfl/yr	recreation losses (swimming & sport fishing), Netherlands, Opschoor (1986)
12-44 million Dfl/yr	additional costs of dredging plus loss of commercial fisheries, Netherlands, Opschoor (1986)
121-398 million Dfl/yr	industrial and residential water supply costs, Netherlands, Opschoor (1986)
45-110 million Dfl/yr	loss of agricultural output, Netherlands, Opschoor (1986)
10-30 million Dfl/yr	materials corrosion costs, Netherlands, Opschoor (1986)

6.2 Estimates of the localised benefits from water quality improvements

A few estimates have been made of the access value of improvements to the water environment for specific sites. These are summarised below for each of the NRA use classes in Table 1. Because the benefits of an improvement to, and the loss resulting from a worsening of, water quality is simply the sum of the change in value to individuals, the first indicator of the relative magnitudes of benefits is the size of the beneficial population. Thus, generally, out-of-stream recreation is likely, in most instances, to generate most of the benefits simply because the numbers involved are so large compared with, for example, those of anglers.

The increase in amenity value derived from living near a river of good water quality (Table 1, Use 1.1) has been estimated (Green and Tunstall 1990). The mean values of these increases ranged between a capital value of £546 per house for an improvement to a level which supported water birds to £582 for a standard which would be safe enough for children to paddle or swim. (Note that there is in this instance a potential risk of double-counting with recreational benefits (see Use 9). The Social Costs of Sewerage (SCAG) manual (Green *et al*, 1989) gives values of 37 - 41 p per adult visit (Use 1.3, (depending upon the type of site)) for improvements in water quality sufficient to support water birds. This quality was roughly equivalent to a National Water Council (NWC) Class 3 or a House Water Quality Index (WQI) of 30 (1987). The lowest value applied to town-centre sites and the highest to local parks. Button & Pearce, 1989, as was described earlier, estimated the potential development possibilities of water quality improvement benefits in one instance (Use 1.2).

No comparable values are known for water quality improvements for coastal situations or canals. Estimates of the number of visits generated by local parks and country parks were given in the SCAG Manual, but there are no comparable methods of estimation available for other locations. One estimate of the number of local visits generated by a beach at Herne Bay has been made (Tunstall *et al* 1990), and in a few isolated cases where specific studies have been undertaken (British Waterways Board, 1986, 1989; English Tourist Board, 1976; Greater Manchester Council, 1985;Pembrokeshire National Park, 1978). In general, estimates of visit numbers are only likely to be available where entrance is controlled either directly or, in the case of sites to which most visitors travel by car, indirectly through car parking availability. The current Department of Employment/British Tourist Authority study (personal communication), will not allow estimation of visits at a lower level of aggregation than the local authority area.

The informal recreational gains from improvements to a standard which would support dragonflies and many fish, including trout, and to allow many different types of plants of plants to grow both in the water and on the edge, are given in the SCAG Manual as between 41p and 48p per adult visit, depending upon the site type (Use 2.1). This standard is roughly equivalent to an NWC Class 2 and a House WQI score of 60.

There is a little evidence of the values associated with more specialised recreational activity associated with such sites. The RSPB (Countryside Recreation Research Advisory Group, 1987), for example, has explored the extent to which people are willing to pay to see particular species of birds (Use 2.2). Hanley (1989) has estimated through a Contingent Valuation Study (CVM) that the total value of preserving three nature reserves varied between £1.18 (Blacktoft Sands) to £2.53 (Handa) per visit. These values included both access and non-access values. Hanley (1991) similarly derived a value of £0.74 per visit for Dorset heathland, again including both access and non-access values. Willis (1990) derived a similar value, again including both access and non-access values, for visits to SSSIs and Nature Reserves of £0.82 per visit. These values also apply to Use 3. However, any change to the SSSI or reserve might not be sufficient to destroy all of this value.

Although a range of functions which a site of ecological significance might fulfil are given in Table A2.1, little information is available on the access values associated with many of these functions. However, Maltby (1986) summarised the various functional values associated with wetlands. A somewhat unsatisfactory estimate of the total value of a particular reserve is given in Nevard and Clear Hill (1985).

Estimates of non-access values associated with sites of ecological significance, as distinct from those combined estimates given above, have been made (Willis 1991). These figures suggest that the non-access value an individual associates with a particular site declines quite rapidly with the distance that the individual lives from the site. Such a pronounced distance-decay function has not been found for coastal nature reserves in general (Green and Tunstall 1991), and should, we suggest, be treated with some caution. All other things being equal, it would imply that the non-access value associated with an SSSI remote from human habitation would be very low simply because there is no one there to value it. More generally, the only theoretical reason which would lead to the expectation of a distance-decay function is if there were substitute sites. Most ecologists (Coker and Richards, 1991) would not accept that any one SSSI is a substitute for any other SSSI.

Not much is available on the access values associated with either *Salmonid* (Use 4) or *Cyprinid* (Use 5) fisheries (Smith & Kavanagh, 1969), but there is some material about the cost of fish kills (Tabruc *et al*, 1990). Also, Consultants in Environmental Sciences (1990) give non-monetised descriptions of the potential benefits of improvements in sea water quality. The likelihood is that access values are likely to be comparatively low for *Cyprinid* fisheries in many areas because of the availability of alternative sites (unless there happens to be a suppressed demand for fishing in the area). In addition, given the relatively small number of visits generated by fishing compared with informal bank-side recreation, the major component of the benefits of an improvement is likely to be the amenity gain discussed earlier (Use 2.1). Conversely, improvements resulting in the establishment of a *Salmonid* fishery could be more significant; the charges for a day's fishing or annual lease providing a baseline estimate of this value.

No studies of the increased productivity of commercial fisheries and shellfisheries, as a result of improvements to river water quality, are known to us. In evaluating the benefits arising from such improvements, it is appropriate, as with other uses, to deduct the environmental damages associated with the activity. In the case of fish farms on inland or coastal waters, this would include the effects of pesticides and waste materials resulting from the activity. Similarly, the negative effects associated with, for example, out-of-stream recreation (littering) should also be deducted from the estimate of the benefits.

Estimates of the value of bathing in coastal and estuarial waters (Use 9) are not available in the UK, although several studies were undertaken in the United States (Wilman, 1984) and in France (Trabuc *et al*, 1989). It is likely that the value of the site will be closely tied to the amenity value of that water. Thus, the potential benefits derived from improvements in the quality of the water are likely to be large simply because of the number of visits to the site.

For inland bathing water, the SCAG study found a peaceful venue that this was only desired for sites like country parks. Generally, visitors wanted peace and quiet and many visitors regarded improvements to bathing water quality as having the disadvantage of attracting noisy activities. For such sites, the value of an improvement in river water quality sufficient to allow bathing and paddling by children was found to be 45p per adult visit (Use 10).

For other immersion sports in inland waters, the scarcity of alternative sites is an indicator of potential benefits. The Regional Sports Councils have published studies which describe the relative regional scarcity of facilities for different sports (Southern Council for Sport & Recreation, 1981; Eastern Council for Sport & Recreation, 1984). There is, for example, a general shortage of waters suitable for canoeing, but many stretches of watercourse are too shallow or narrow to ever sustain much in the way of immersion sports. The same is true for immersion sports in estuarial and coastal waters; again, most regions have published strategy plans (Yorkshire & Humberside Council for Sport & Recreation, 1983, 1987, 1987a).

Little recent work is available on the values associated with these sports for any waters (Kavanagh, 1968). One principal characteristic of such sports is the likely degree of conflict both with other uses and between different forms of immersion sport. As with angling, immersion sports usually conflict with out-of-stream activities in river corridors. There are indications that more sites for out-of-stream activities would be welcomed, especially on wider reaches of rivers - particularly by those who do not at present visit rivers corridors (Green and Tunstall, 1990a).

The upper bound of the value of abstractions of water for potable use is given by the marginal value of water. There have been many studies undertaken which estimate the price elasticity of potable water (Gibbons, 1986; Herrington, 1987; National Metering Trials Co-ordinating Group, 1990), and the current metering studies will give additional data (Use 11).

A number of studies have been undertaken upon the economic losses arising from the contamination of groundwater (Tihansky, 1974; Abdalla, 1990). Hanley, (1989) undertook a Contingent Valuation study of willingness to pay to reduce nitrate concentrations in groundwater.

Similarly, a number of studies (Gibbons, 1986) have estimated the price elasticity of demand for industrial cooling water (Use 12.1), and of industrial process water (Use 12.2). However, in both cases the overall level of demand has been falling in recent years with the decline of heavy manufacturing industry.

The marginal value of water for agricultural irrigation (Use 12.3), and the gains in agricultural productivity which result, has been explored (Agricultural Development & Advisory Services, 1977; Morris *et al*, 1983; Morris and Day, 1985; Gibbons, 1986). This area of demand is increasing and in many areas has reached the maximum capacity of the local watercourses (Drake and Sheriff, 1987). Some of this demand is inefficient, the marginal improvement in agricultural productivity being well below any sensible estimate of the marginal cost of water (*e.g.* the irrigation of grazing land). The effects of the restrictions upon output, as a result of the reform of the Common Agricultural Policy (CAP), which will shift production to high value added crops will further increase demand. Similarly, climatic change will probably increase the demand for irrigation both directly and through changes in cropping patterns.

Good theory is only the first part of good analysis; good practice is also required. Consequently, that which it is in principle possible to evaluate may not in practice be accurately evaluated.

For most NRA use values, the evaluation of the associated access values pose few major technical difficulties. Nevertheless, there are many classes for which little UK research has been carried out upon which to base estimates of values in specific instances. One major problem in estimating the benefits (or losses) resulting from a change will, in many cases, be in estimating the population across which the benefits are spread in order to aggregate the individual values.

For non-access values, we would be very hesitant about applying economic analysis to the non-marginal, irreversible changes for the worse. At best, it is possible to define bounds to these values. Whilst it is possible to derive estimates of the value of general improvements to aspects of the water environment, it does not yet appear possible to derive valid and reliable estimates of the benefits of improvements at specific sites. Summarising, there are still major theoretical and methodological questions which will have to be answered before satisfactory non-access values can be derived.

7.0 BASIC METHODS OF EVALUATION

There are a number of basic techniques for estimating the economic value of a particular quantity of some good: these are listed in Table 8.

TABLE 8

Basic techniques for the economic evaluation of goods

Technique	uses and limitations
Market prices	only possible for private goods; depends upon the existence of a perfectly competitive market.
Shadow prices	standard method for the valuation of priced goods: prices are "corrected" to those which would occur if the market were to be perfectly competitive. Only applicable to priced goods.
Travel Cost Method	indirect method which can only be used to evaluate recreational benefits.
Hedonic Price Method	indirect method which can only be used to evaluate amenity benefits.
Contingent Valuation Method	direct method which, in theory, can be used to evaluate all goods
Least Cost Alternative/ "Shadow Project"	cost of providing the same good by other means
Case specific approaches	*e.g.* Environmentally Sensitive Area payments: can often be used to set lower or upper bounds on the value of the goods

7.1 Market prices

This is the simplest possibility; under the very restrictive constraints of the perfectly competitive market, the resulting equilibrium prices measure the marginal value of the goods. In a perfectly competitive market, the equilibrium price reflects the cost of supplying the last unit provided and not simply the average cost of providing the total number of units. Equally, the price reflects the marginal value of the last unit consumed. The approach can be either piecemeal or holistic.

Unfortunately, perfectly competitive markets are very unusual. Consequently, market prices are usually only the first stage towards estimating "shadow prices" - those prices which would reflect both the marginal cost of supply and the marginal value of the units consumed.

7.2 Shadow prices

Markets can be imperfect for many reasons, including the effects of monopolies, taxes and subsidies, and imperfect information as to the availability of goods by consumers. In consequence, in almost all cases, market prices have to be corrected. For example, Excise and Value Added Taxes must be removed; so, too, must the effects of subsidies, production and import constraints on prices. Detailed discussion of the problems of deriving such shadow prices are given in the standard texts on project appraisal (Little and Mirrlees, 1974; Squire and van der Tak, 1975).

A particular case where shadow prices are required is for the supply of potable water and the carrying away and treatment of wastewater. The absence of local competition removes the incentives to drive prices down to the marginal cost. Consequently, prices or charges are typically set as average costs and include standing charges. Determination of the economic value of these services requires the determination of the marginal values, or marginal costs of the services. However, in practice, the charges are not levied in this way, but as average or standing charges it is very difficult to calculate what are the appropriate marginal costs, given the capital-intensive nature of both potable and wastewater treatment and transportation (Hanke and Davis, 1973; Turvey, 1976; Conner and Bowland, 1980; Mann, Saunders and Warford, 1980; Dandy, McBean and Hutchinson, 1984; OECD, 1987; Swallow and Marin, 1988).

One area where it is almost invariably necessary to create shadow prices is land values. Agricultural land values are inflated by the existence of the Common Agricultural Policy and most other land prices are distorted by the existence of planning controls.

Both the market price and shadow price techniques can only be used for priced goods. It is sometimes supposed that the creation of a market in a good will necessarily result in an increase in economic efficiency. This is not however true either for public goods as a whole where prices will not lead to economic efficiency, or, in some instances, for private goods. In the case of water supply, the basis of the economic argument as to the desirability of water metering hangs upon whether the cost of creating a market, plus the cost of installing and operating the meters, is less than the cost of supplying the additional water which would otherwise be consumed.

A variant of the shadow price approach is the so-called "dose-response approach". It has, for example, been argued that the maintenance costs for boat hulls is higher when water is polluted than when it is relatively unpolluted (Peskin and Seskin, 1975). If a relationship can be determined between these costs and some indicator of pollution then, given knowledge of the numbers of boats and the cost per boat of maintenance the value of a given improvement in water quality can be estimated.

Similarly, if a relationship between some indicator of the degree to which bathing water is contaminated by disease vectors and the probability and severity of increased health damage can be determined (Cabelli, 1983; Foulin, Maurin, Quoi and Martin-Bouyer, 1983), then it is theoretically possible to estimate the benefits of water quality improvements. These benefits would typically be estimated as the savings in health treatment required to resolve those health effects. However, such costs underestimate the benefits because the treatment does not instantly return the individual to normal health (Green and Penning-Rowsell 1989). Consequently, since an individual rationally prefers being well to being unwell but being treated, the loss of health until recovery is completed should theoretically be assessed.

The approach is usually piecemeal and the shadow prices of the goods affected are estimated. The quantity of goods affected is multiplied by the shadow unit price and the results are summed to give the total value. Since it can only be applied to goods for which there is a market price, it is a partial method, rather than a comprehensive one.

7.3 Travel Cost Method

The Travel Cost Method (TCM) has been used extensively to evaluate recreational benefits from different types of sites, including beaches (Caulkins, Bishop and Barnes, 1986). First proposed by Clawson (Clawson 1959; Clawson and Knetsch 1966), the procedure is limited to the evaluation of recreational benefits of a site as it presently exists, but the value of a change at a particular site may be extrapolated from the values at similar sites. The procedure is basically no more than a regression analysis of visitor rates to the site by visitor origin. The method has two advantages to the analyst: an evaluation is guaranteed and the analyst is able to choose the value. The TCM has been used in a number of studies in Europe to derive estimates of water-related recreation values (Table 9).

TABLE 9

Estimates of water related recreational benefits by the Travel Cost Method in Europe

Amount	Activity
£5.59/day/individual	half day trips to the Lake District (1966)
£9.41/day/individual	full day visits to the Lake District (1966)
£34.58/day/individual	holiday trips to the Lake District (1966)
£3.05/day/individual (1990 prices)	trips to proposed Morecambe Bay Barrage site (Mansfield, 1971).
£2.03-8.12/day/individual (1990 prices)	boating on a reservoir, (Kavanagh, 1960)
£1.88-2.68/visit (1967 prices)	trout fishing at Grafham Water (Smith and Kavanagh, 1969).
£0.07 - 3.04/day/individual (1978 prices)	informal recreation, canal sites (Stabler and Ash, 1978).
£1.34-1.38/visit/day (1975 prices)	day-trippers/holiday makers, beach recreation (Simmonds, 1976).
£0.62/day/individual (1990 prices)	informal recreation, canal sites in the Midlands (Willis and Garrod, unpublished)
£0.12-0.15/day/individual (1990 prices)	informal recreation, canal sites in Lancaster and (Montgomery, 1987; Willis and Garrod, 1990).
£24.80/day/angler	salmon angling, River Gaula, Norway (Navrud, 1991).
£13/day/angler	trout angling, River Hallingdalselv, Norway (Navrud, 1991).
£13/day/angler	trout angling, River Tinnelv, Norway (Navrud, 1991).
£10-14/day/angler	salmon and trout angling, River Vikadaselv, Norway (Navrud, 1991).
£18-23/day/angler	salmon and trout angling, River Stordalselv, Norway (Navrud, 1991).

Applying the method requires the acceptance of several assumptions and confronts the analyst with many problems. These have been reviewed by a number of authors (Common, 1975; Cheshire and Stabler, 1976; Gibson, 1978; Harrison and Stabler, 1981: Duffield, 1984; Green *et al*, 1990). The application of this method for assessing the value of changes in the water environment is not recommended for the reasons given in Table 11.

7.5 Hedonic Price Method

The Hedonic Price Method (HPM) is a technique which has been used to separate out some components of amenity gains or losses out of in-house prices (Rosen, 1974). It has been used, for example, to estimate the effects of aircraft noise on house prices (Nelson, 1979), or the premium that location close to a park or other desirable recreation facility attracts; (Li and Brown, 1980), the effect of flood and other risks (Donnelly, 1989; Shabman and Damianos, 1976), and also for the effects of air or water pollution on house prices (Brookshire *et al*, 1981; Wilman, 1984).

The basic assumption underlying the method is that any house is a bundle of attributes, the price fetched by the house reflecting the desirability of the particular combination of attributes offered by that house. The attributes may, for example, include proximity to a river corridor or a sea view. If the prices fetched by different houses, representing a wide range of combinations of attributes, are regressed upon the values of each attribute then it should be possible to separate out the relative value attached to each attribute. In practice it is not always possible to measure these attributes directly and surrogate measures have to be used.

The methodologically desirable procedure would be carried out in two stages. The first stage to test whether the proposed surrogate measure was a reasonably reliable measure of that which should be measured. Only then would the Hedonic analysis, the second stage, be carried out using the surrogate measures where necessary.

In conclusion, whilst the method has a face validity in a perfectly competitive market, market imperfections are likely to limit its use. Neither, as yet, has a reliable method been established which has been tested by replication. A summary of the advantages and disadvantages of the procedure is given in Table 11.

A variant of this approach is that adopted to assess the benefits of environmental improvements to a canal (Button and Pearce, 1989). Here, local estate agents were asked to estimate how much more the properties would be worth after the change. As in the case of the shadow price method, in the context of changes to the water environment, the Hedonic Price method is partial and piecemeal.

7.5 Contingent Valuation Method

The Contingent Valuation Method (CVM) can be applied to the evaluation of access and/or non-access values for any good. Essentially, it involves a social survey approach; *i.e.* a sample of respondents is asked by way of an interview survey or postal questionnaire what value they place on a particular good. Usually they are asked to do so by stating how much they would be willing to pay, for a clearly specified change in the availability of that goods.

Widely used in the United States, where much of the basic research work was done under contracts from the US Environmental Protection Agency, the US Water Resources Council (1983), and the US Corps of Engineers (Moser and Dunning, 1986), have both published guidelines on its use. However, the Corps guidelines have been extensively criticised (Tunstall, Green and Lord, 1988; Mitchell and Carson 1989). Major methodological and theoretical reviews have been published, largely based upon US experience (Cummings *et al* 1985; Mitchell and Carson 1989; Tunstall, Green and Lord 1988). Recent theoretical and methodological developments are discussed in the papers edited by Petersen (Driver and Gregory, 1988).

Studies in the United Kingdom with the method are listed in Green *et al* (1990); the results of completed studies relating to the water environment are given in Table 10. There are a number of other studies currently underway, including work on the recreational and environmental effects of the proposed Mersey Barrage (Mitchell, private communication). The White Paper (Department of the Environment, 1990), has already started to increase the demand for, and application of, this method. For the reasons discussed below, this is not an unmixed blessing.

Because it is essentially a social survey methodology, the established procedures, including sampling design, fieldwork control and questionnaire design must be adopted (Tunstall, Lord and Green, 1988). So, too, must the social survey practices of establishing a questionnaire's validity and reliability (American Psychological Association, 1954), where validity is the establishment that the questionnaire measures what it is intended to measure (and nothing else), and reliability is the questionnaire's replicability and absence of measurement error.

From a scientific viewpoint, these are basic criteria to be applied to any measurement method and it is a virtue of the CVM, as opposed to the Travel Cost and Hedonic methods, that such tests can be applied. Nevertheless, it is essential, particularly at this stage in the development of the CVM, that all applications embody basic tests of validity and reliability.

TABLE 10

Estimates of water related benefits by the Contingent Valuation Method in Europe

Amount Unit	Access value
£0.09-0.13/visit (1978 prices).	informal recreation, canals (Stabler and Ash, 1978)
£0.10/visit (1975 prices)	beach recreation (1975) (majority of respondents refused to consider paying any entrance fee to a beach) (Simmonds, 1976).
£0.37-0.45/visit (1987 prices)	out-of-stream recreation, river corridors: increase in enjoyment if river water quality improved to one of three standards; results from 12 sites (Green and Tunstall, 1991b).
£0.94/visit scheme A £1.10/visit scheme B (1988 prices)	out-of-stream recreation, river corridor: increase in enjoyment if river corridor were to be improved by planting and other improvements (Coker, Tunstall and Penning-Rowsell, 1989).
£7.72-7.75 (1988/1989 prices)	out-of-stream recreation, beaches: value of enjoyment results from 11 sites (Penning-Rowsell *et al*, 1989).
£1.58-5.55 (1989 prices)	loss of enjoyment if beach eroded: lowest rates from local residents, highest figure for staying visitors (Green and Tunstall, 1991b).

TABLE 10 continued ...

Amount	Access value
£1.83-2.83/household (1988 prices)	willingness to pay by local residents to avoid continued erosion of small unprotected section of cliff (Penning-Rowsell *et al*, 1989).
£15.87/year/household (1987 prices)	willingness to pay for river water quality improvements; river corridor visitors (Green and Tunstall, 991b).
£12.03/year/household (1987 prices)	willingness to pay for river water quality improvements, general households (Green *et al*, 1990a).
£4.90/year/household (1989 prices)	willingness to pay for increased investment in coast protection, beach users (Green *et al*, 1990b).
£21.90/year/household (1989 prices)	willingness to pay to protect coastline against sea level rise, general households (Green *et al*, 1990b).
£15/year/household	willingness to pay to preserve local beach for recreation and amenity against loss through coastal erosion, Aldeburgh (Turner and Brooke, 1988)
12.5 and 26NKr	to avoid (i) "some reduction" and (ii) "considerable reduction" in salmon stock reduction in River Numedal-slagen, Norway (Navrud, 1991).
28NKr/year/household	to avoid fish stock depletion in Oslomarka , Norway (Navrud, 1991)
10-14NKr/day/angler	trout and salmon angling, River Vikadaselv, (Navrud, 1991).
33NKr/year/household	improved water quality, Kristiansand Fjord, Norway (Navrud, 1991)
64NKr/year/household	improved water quality, Inner Oslo Fjord, Norway (Navrud, 1989)
65-115NKr/year/household	preservation of watercourses, Norway (1987)

(NKr = Norwegian krone)

To date, whilst tests of the reliability of the CVM have proved satisfactory, tests of the validity of the CVM have not yet been wholly so (Green and Tunstall 1991). In many cases, the proportion of the differences between respondents' stated willingness to pay (which can accounted for by differences in the theoretically expected causal variables) has been below 20%. A reasonable target, based upon experience in other areas of social survey work (Ryan & Bonfield 1975), would be that 40% explained variance is achievable and desirable.

However, other tests of validity have proved more satisfactory, particularly tests of divergent validity. In this case, the evaluation of different goods using the same willingness to pay questionnaire yields different values rather than the same, and presumably arbitrary, value (Green et al 1990).

At this stage on the learning curve with CVM (Mitchell and Carson 1989), the indications are that the method is basically valid but, as yet, not very accurate. Indeed, one the basic problems with CVM is that, whilst there are many different ways of formulating the question of willingness to pay, there has not yet been a baseline methodology study to determine that form which has the greatest validity and reliability (Green and Tunstall 1991).

In consequence, great care and time is required to undertake CVM studies and the risk of the current White Paper generated growth in demand for CVM studies is that it will be met by a plethora of untested questionnaires and poor survey designs. Some guidelines for the application of the CVM are given in Table 12, and the lessons of UK experience in the use of the CVM are summarised in Bateman *et al* (1991).

As a method, depending upon how the change is defined, it can be used in either a partial or a comprehensive way, either to derive a holistic, or piecemeal, valuation of changes in individual goods.

TABLE 11

Comparison of the advantages and disadvantages of the three main methods of estimating access values

Travel Cost Method	Hedonic Price Method	Contingent Valuation Method
can be used for recreational values only - and application to walkers and non-working population is problematic	can only be used for amenity values and not to rented homes	can be used to value a wide range of goods
difficult to estimate the value of a change	difficult to estimate the value of a change	values of changes can be estimated
convenient surrogate measures can be used when changes in quality require to be valued	surrogate measures must be used for most variables and often necessary to use areal averages	necessary to know in advance of a study what is the good for which the public have a preference
relatively cheap to apply	cheap to apply	expensive to apply
ex ante measure - estimates anticipated value of site before visit	ex ante measure - estimates anticipated value of house before lived in	depending upon the goods defined, can be ex ante or ex post measure
widely accepted by economists - widely used over 30 years	widely accepted by economists - widely used over 20 years	still somewhat controversial - only has been used intensively in the last five years and few experienced users as yet

Table 11 continued ....

Travel Cost Method	Hedonic Price Method	Contingent Valuation Method
infers recreational value of time upon basis of estimates of opportunity costs of resources and time taken to travel to site -neither of which are easy to estimate reliably	infers amenity value of a site upon basis of estimates of house prices - but housing market is very imperfect and it may be necessary to use shadow prices	estimates value through direct measurement
essentially a multiple regression analysis - requires simple social survey data + inferred values for time	essentially a social survey multiple regression analysis using readily available "objective" data	social survey method
inductive method - validity must be assumed in order to be used	inductive method - no theoretical basis for choice of explanatory variables or functional form of equation	hypo-deductive method - results sensitive to the form of the question used
functional form of regression has no theoretical - value derived depends critically upon functional form adopted (*e.g.* varies by an order of magnitude)	no standard equation has emerged which can be used to estimate the contributions of all the components of the housing bundle	requires the development of causal explanatory model on a case by case basis to test validity
makes assumptions about recreational behaviour which are not necessarily correct and which have been shown to be false in some specific instances	depends upon assumptions about the nature of the market for housing - which are not necessarily correct, and have been shown to be false in some specific instances	as hypo-deductive method, hypotheses can be tested
guaranteed to provide a value, values can vary widely according to assumptions made	in some cases, derived values have had the wrong sign	to date, validity and reliability of the method have not been fully established

TABLE 12

Methodological requirements for CVM surveys of recreation value

Design of survey instrument

* knowledge of the public's definition (perception) of the good to be valued required - if not known, an exploratory survey is required to determine what is the good
* knowledge of the public's preference for the good is required - if not known, an exploratory survey is required
* include checks on whether preference for the activity associated with the good actually depends upon the availability of the good
* include internal checks of the construct and criterion validity of the survey instrument
* design instrument on basis of underlying model of hypothesised determinants of preferences for the good and constraints and include behavioural correlates of preferences
* include questions on respondent's present and past experience and use of the good
* include at least interval level measures of current enjoyment and either of enjoyment after the change or of the proportional change in enjoyment expected
* specify expected functional form of relationships
* use payment vehicle which corresponds to how the good would actually be paid for
* include check of attitudes towards payment vehicle
* include an appropriate measure of income
* if appropriate definition of the problem is a willingness-to-accept compensation and not willingness-to-pay, then accept that the study will be experimental
* include clear definition of the change in the good being considered (*e.g.* use of drawings/photographs)
* tell respondents what is the current situation including how much they are contributing at present (economic theory specifies that the public should have perfect information)
* legitimate a refusal to pay
* use a filter question as whether the respondent is willing to pay before asking how much
* randomly assign one of several variants of the willingness to pay question
* either use a willingness-to-pay question which has worked before or do an exploratory study to validate new version against known version
* ask respondents the reasons why they were willing to pay and how much they are willing to pay

TABLE 12 continued ....

* follow standard rules about length, wording and question order in designing instrument
* **if it is wanted to determine non-use values**, then determine an overall willingness-to-pay for the good. Do not seek to derive separate estimates of use and non-use values
* **do a pre-test**

SAMPLING

* define the population who may benefit
* define appropriate sub-groups within that population
* use large samples because of high variance expected in willingness-to-pay
* determine representative sample of target populations(s) or times/places/days at which surveys are to be undertaken

FIELDWORK

* use interview surveys (or validate the results of a postal or telephone survey against identical interview survey)
* use experienced fieldworkers
* check quality of previous fieldwork
* give them clear instructions
* brief them in survey and instrument design
* ID cards, letters to police, respondents all required
* check returns for errors in interviews
* make call-back checks to see that those who were said to have been interviewed were interviewed

ANALYSIS

* check for punching errors
* start with Exploratory Data Analysis
* use statistical techniques appropriate to data
* if using parametric statistical analysis, transform data to normality
* check sample is representative of population

TABLE 12 continued ...

- base analysis on underlying model: define both additive and interactive relationships - make sure statistical model is the same as the theoretical model
- check whether results from any analysis both conform to underlying theory and statistically fit adequately (*e.g.* look at residuals) - R^2 is not enough
- Occam's Razor (the simplest answer is usually the best) applies to the inclusion of variables
- if explanations or the fit is poor, throw away the results
- if have to include methodological variables (*e.g.* interviewer), then throw away the results
- check that internal validity checks are satisfactory; if not, throw away the results
- compare values from this survey to values from same instrument used to value different good - if values same, then instrument invalid
- compare results from different willingness-to-pay questions for agreement - should be the same

Source: Green and Tunstall (1991)

7.6 Least Cost Alternative

The value of providing a given quantity of a good one way may not exceed the cost of providing exactly the same quantity and kind of good in the cheapest alternative way. This is a powerful concept for evaluating some goods in some instances, but clearly it is a principle rather than a specific technique. It is also usually used when other methods are not appropriate, or not feasible within the resources available.

It is usually applied to the input side of the input-output relationship described earlier - to determine, for example, what would be the opportunity cost of using other inputs to provide the same quantity of goods. For instance, in evaluating the benefits to agriculture of irrigation water taken from rivers, the cost of providing the same water via pumped groundwater or on-site reservoirs could be used to provide a bound on the value of the river water in terms of gains in agricultural productivity (CNS 1991).

Similarly, in calculating the value of a particular source of abstraction for potable water, rather than to attempt to estimate its marginal value, it may be more feasible to estimate instead the cost of supplying the same quantity of water by the cheapest alternative means (CNS 1991).

The limitation of this method is that it has to be assumed that the marginal value of the goods exceeds the costs of supplying them by the alternative method; otherwise those goods should not be supplied at that cost. Thus, in general, the method gives a bound to the value in question, but it will not be known whether it is an upper or lower bound.

For example, the economic value of land in a National Park is not its market price in its current permitted uses, but that which would pertain if there were no planning controls. The presumption is that the reason for planning controls is that maintenance in its current use has a value at least as great as the value that could be obtained from any other use. Similarly, the land value of an SSSI is not its market value as an SSSI, but its value as the next highest alternative use to that proposed. Again, if an historic building were to be lost as a result of some change then one bound on the value of maintaining that building would be the cost of its disassembly, removal and reconstruction elsewhere.

A special sub-class of the least cost alternative approach is the concept of a "Shadow Project" (Klassen and Botterweg, 1983). This has been developed specifically to apply to the evaluation of changes, particularly damage, to sites of ecological significance. The value of this change is then estimated as the cost of creating, or recreating, the eco-system in question elsewhere. The loss of an area of marshland would thus be valued as the cost of buying the same area and type of land elsewhere, and then establishing the same eco-system.

There are a number of problems with this concept, notably the difficulty of establishing the equivalent eco-system. A second problem is if part of the value of the present site lies in its history or that it has remained relatively undisturbed over a long period of time. The value of Arctic Char in Lake Windermere would not arguably be adequately represented by the costs of re-establishing them in another lake, simply because part of their significance lies in their uniqueness as a relic of the Ice Age.

This method is usually holistic and comprehensive.

7.7 Case specific approaches

Turner and Brooke (1988), when evaluating the benefits of coast protection at Aldeburgh, used payments under the Environmentally Sensitive Areas payments to farmers to estimate the conservation value of agricultural land which might be lost to the sea.

Similarly, the development benefits which would result from improvements in water quality at, say, Salford Docks could be estimated using the approach set out for the development benefits of flood alleviation schemes by the Local Government Operational Research Unit (LGORU) (1971). These benefits can be estimated to equal the reduction in the costs of providing infrastructure and other development costs, plus any reduction in environmental damage, for the proposed site versus the next best site. Any investment attracted from overseas, as opposed to from elsewhere in the country, would be a net gain.

It is not possible to generalise whether this approach typically results in holistic or piecemeal evaluation in practice.

There are a variety of economic methods available to evaluate the goods in different circumstances. Table 13 summarises the contexts and methods which are most likely to be useful.

TABLE 13
Preferred methods of economic evaluation and the contexts for their use

Shadow pricing	where the good is priced, then this method is cheap to apply and will be as accurate as the analytical assumptions
Contingent Valuation Method	preferred method for recreational and other non-priced access values. Expensive and great care must be used at this stage in its development. May eventually be applicable to site specific non-access values.
Least Cost Alternative	currently, with case specific methods, the only available method of estimating site specific non-access values.

8.0 SUMMARY COMPARISONS OF NRA USE VALUES AND METHODS OF ECONOMIC EVALUATION

In Table 14, the different categories of economic value associated with each NRA use class are identified. The table identifies which economic method could be applied to each category value. In addition, following from the conclusions of Section 7 about to the strengths and weaknesses of each economic method and valuation, the preferred method of valuation is highlighted for each category of value.

It can be seen that the use of the Travel Cost and Hedonic Price methods are not recommended for any use. The principal reasons for this are:

(i) in each instance where they might be applied, there is a better alternative;

(ii) both are inductive methods which seek to derive conclusions from data on an a-theoretical basis, rather than embodying classical, scientific methods.

Where their use is possible, both Shadow Price and Least Cost Alternative methods are given as the preferred alternatives; where their use is not possible, the Contingent Valuation Method is preferred. However, great caution should be adopted in the use of the CVM pending the results of the current baseline methodological survey because, whilst the evidence is that the method is valid, it is not yet considered to be very accurate. Nor have the best methodological protocols to be adopted yet been defined. Thus, the recent Workshop on UK experience with the CVM concluded that it was not yet suitable for use, except under carefully controlled research conditions.

At present, it is not generally recommended that an attempt be made to estimate non-access values separately from access values. For sites where non-access values are believed to be high, it is recommended that the whole site value be estimated using the Shadow Project Method.

Table 14 does not cover any obligations set by International Treaty or National Law. In such cases, economic analysis can be used to determine the least cost method of reaching the objectives set by the Law; it cannot be used to determine the value of complying with the Law itself.

Markandya and Pearce (1988) note that the real values of environmental goods, relative to other goods, are likely to increase in the future for two reasons:

(i) increases in real incomes; and
(ii) the increasing scarcity of environmental goods

The first requires estimates of income elasticity of demand for different environmental goods and these are not generally available; nor are defensible estimates readily identifiable of the increased scarcity of different environmental goods. Therefore, in the current state of knowledge, we do not recommend that such "growth factors" be generally applied to estimate the future increases in the value of environmental goods.

Economic values measure small, marginal changes to an existing situation. To estimate the base value of controlled waters requires a comparison of the situation now with some hypothetical situation without the resource - the water environment. For example, instead of abstraction from freshwaters to meet potable and other demands, these would have to be met from desalination and recycling. In general, such changes are fundamental rather than marginal, and the values derived would not be in a linear relationship with those of small changes in the availability of the resource. It is not, therefore, possible to give meaningful base values to controlled waters.

TABLE 14

Economic methods of valuation appropriate to each NRA use value

NRA use class	Method				
	Shadow Prices	Travel Cost Method	Hedonic Prices	Contingent Valuation Method	Least Cost Alternative
1.0 **Basic Amenity**					
1.1 Amenity	-	-	yes	**yes***	-
1.2 Development	**yes***	-	yes	-	**yes±**
1.3 Informal recreation	-	sometimes	-	**yes***	-
1.4 In-stream recreation	**some***	sometimes	-	**yes***	-
2.0 **General Ecosystem Conservation**					
2.1 Amenity	-	-	yes	**yes***	-
2.2 Specialised recreation	-	yes	-	**yes***	yes
2.3 Scientific access values	**some±**	-	-	in theory	**some±**
2.4 Non-access[1] values	-	-	-	in theory	-
2.5 Whole site value (includes values 2.1 to 2.4)	-	-	-	in theory	**shadow project method±**
3.0 **Special Ecosystem Conservation**					
3.1 Amenity	-	-	yes	**yes***	-
3.2 Specialised recreation	-	yes	-	**yes***	yes
3.3 Scientific access values	**some***	-	-	in theory	**some±**
3.4 Non-access values	-	-	-	in theory	-
3.5 Whole site value (includes values 3.1 to 3.4)	-	-	-	in theory	**shadow project method±**
4.0 **Salmonid Fishery**					
4.1 Specialised recreation	**yes***	yes	yes	yes	yes
4.2 Non-access values[1]	-	-	-	yes	yes
5.0 **Cyprinid Fishery**					
5.1 Specialised recreation	**yes***	yes	yes	yes	yes
5.2 Non-access values[1]	-	-	-	yes	yes
6.0 **Migratory Fishery**	---------------- function whose value is determined by that of sites up or downstream of the migratory fishery				

TABLE 14 continued ....

NRA use class	Method				
	Shadow Prices	Travel Cost Method	Hedonic Prices	Contingent Valuation Method	Least Cost Alternative
7.0 **Commercial Fishing**					
7.1 productivity gains	**yes***	-	-	in theory	yes
8.0 **Commercial Shellfishing**					
8.1 productivity gains	**yes***	-	-	in theory	yes
9.0 **Bathing**					
9.1 recreation dose-response for health damage	-	yes	-	**yes**	?
10.0 **Immersion Sports**					
10.1 recreation	**some***	yes	-	yes	**some±**
11.0 **Potable Water Supply**					
11.1 marginal value of water	**yes+***	-	-	yes	**yes+***
12.0 **Industrial and Agricultural Supply**					
12.1 process water	**yes+***	-	-	in theory	**yes+***
12.2 cooling water	**yes+***	-	-	in theory	**yes+***
12.3 irrigation	**yes+***	-	-	in theory	**yes+***
13.0 **Augmentation of river flow**	-----------function whose value is determined by that of the use to which the additional flow is put				

Key:

bold	- best method of valuation
*	- gives best estimate of value
+	- gives upper bound estimate of value
-	- gives lower bound estimate of value
1	- monetary evaluation is not advised for this category of use
yes	- can be used, but is not recommended

9.0 IMPLICATIONS FOR AND APPLICATIONS TO NRA STATUTORY DUTIES

Decisions can only benefit from being based upon the rigorous analysis of the consequences of available alternatives. Thus, it is desirable that the NRA include economic analysis when analysing the choices available. As yet, economic analysis cannot be used to appraise all of the consumption and resource consequences of different options, but it can help to elucidate many of the trade-offs involved in the choice. However, even where it is not possible to evaluate all of the impacts, the rigour of the analysis will itself make the decision more informed.

* Economic analysis must be viewed as a decision support system and not as a substitute for decision making.

* Economic efficiency is not a sufficient criterion for choice between options; it needs to be supplemented by other criteria, which include equity and sustainability.

* Because economic analysis assumes consensus as to value judgments, it embodies and is designed to deal with marginal, reversible changes.

* It is most suited to routine use, with decisions which only have such consequences. (In the case of decisions which have non-marginal or irreversible changes, all of the impacts should be identified and quantified, but economic analysis will not be able to estimate reliably the economic consequences of all of the impacts).

* For irreversible negative changes, the principles of sustainability are likely to be the dominating criterion.

* Where international treaty obligations are involved, the economic issue is to determine the least cost way of complying with those legal requirements.

The principles of economic analysis reinforce principles which also emerge from both hydrological and ecological analyses is that since the water cycle is a closed, and closely coupled system, it must be managed as such. The control of pollution cannot be managed independently of the control of abstractions, not only because abstractions reduce the assimilative capacity of the receiving waters, but also because the abstractions re-enter the cycle as discharges, usually with some polluting load.

Given the high capital costs of water quality improvements and the long lead times involved, it is desirable to list, in order of importance, stretches of river and coastline for improvement, using economic and other analysis. Equally, since it is desirable, on efficiency grounds, to use available assimilative capacity where the resultant loss of quality is less than the cost savings involved, it is essential to identify those priority areas where any reduction in existing quality would have high environmental damage costs. These twin sets of priorities may then guide decisions about how to deal with individual sources of pollution.

It is likely that some time in the future, either under UK national law or Community law, any new regulation may have to be justified upon an assessment of the benefits (and perhaps costs) of that regulation. Similarly, any decision on setting charges for discharges should make them at least equal to the environmental damage costs involved. Where possible and appropriate, these charges should be set using economic analyses of these damages.

At all times economic analysis **must** be used critically.

TABLE 15

Summary recommendations and conclusions

- economic analysis is an aid to informing decisions, it is not a way of making decisions
- economic analysis is best applied to routinising the trivial in order to free time to deal with difficult problems; there, economic analysis can help by clarifying the issues
- all decisions must recognise that both the water cycle and the economic system are closed, rather than open systems. Thus, for example, the system of consents for abstractions and discharges must be integrated and a catchment management approach adopted
- the need for a catchment management approach has implications not only for the breadth of appraisal within individual functions of the NRA, but also for internal communication patterns and the corporate information technology strategy.
- economic analysis of the consequences of a change is only useful in practice if it is possible to predict the nature of that change. A prerequisite for the use of economic analysis is, therefore, the provision of reasonably accurate predictive models based upon adequate environmental data. This implies greater, rather than less importance, should be attached to water quality and other forms of monitoring.
- irrespective of whether it is possible to evaluate in economic terms the consequences of a change, the identification and estimation of the magnitudes of the impacts of the change is a necessary part of the decision-making process.
- economic values should be used where there is a consensus that their use will elucidate the issues involved in the decision.
- currently, we believe that in decision-making it is therefore appropriate to use economic values for access values for both positive and negative environmental changes.
- however, non-access values should, at present, generally only be approximated by the "shadow project" method - and only where the changes in the availability of the good are marginal. The results from such analyses should be considered alongside other criteria such as "minimum safe standards" and "reasonable justification".

TABLE 15 continued ...

* where the good is covered by international treaty requirements, such a condition should treated as over-riding economic efficiency claims.

* on economic grounds, it is desirable, wherever possible, to make the best use of the available assimilative capacity of the receiving waters, for example by the application of discharge permits which vary in allowable discharges by season or by flow.

* the remit of the study excluded questions of charges for discharges or the use of tradeable permits. Irrespective of the broader issues involved, the use of informal trading between discharger and the NRA, between allowable discharges at different points on the same stretch of river or coastline, is likely to be desirable on economic efficiency grounds.

* since the timescales of necessary investments are long, it would be desirable for the NRA to identify those localised areas which are highly sensitive to any change in the local waters, and to specify the water quality (and other parameters), which are important for the maintenance and improvement of water quality in those areas.

* similarly, the NRA should list, in order of importance, for improvement on the basis of the expected benefits.

* the demand for recreation and the value of environmental goods are likely to grow in real terms ahead of the rate of growth in the economy. The standards expected and required will consequently also rise. NRA planning should explicitly recognise that the goalposts will keep moving.

* the principle of sustainability implies a presumption against any change which has irreversible negative consequences or which forecloses future options.

10.0 RECOMMENDATIONS FOR RESEARCH IN SUPPORT OF NRA DUTIES

Table 16 lists those areas where the NRA has a direct requirement for research to support its activities. However, since in a number of instances, there is another organisation which has a primary interest in such research, the areas are also annotated as to whether the NRA is the organisation with the primary interest in such research, a secondary interest in work which is primarily of concern to another organisation (*e.g.* NCC, OFWAT), or a tertiary interest.

In addition, a number of areas are listed where the NRA should monitor developments rather than initiate research. These developments are variously theoretical, methodological and practical. The areas are those where the results of that work could influence the environment in which the NRA operates.

The expected timescale to pay-off is also given: long timescales are also associated with uncertainty as to the nature of the pay-off, whilst those projects for which a short/medium timescale is foreseen are regarded as having a fairly certain pay-off.

TABLE 16

Research recommendations
(likely time to pay-off given in brackets)

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* the evaluation of the access values associated with sites of ecological significance should be explored (short) - secondary

* determination of those characteristics of river and other sites which affect the public's preference for them as sites of recreational and amenity use - (medium) - primary/secondary

* refinement of use-related water quality classification methods and development of such methods for estuaries (short/medium) - primary

* determination of the marginal values of water for agricultural, industrial and potable water use (short) - secondary

* development of methods for assessing the required time for the system to recover from pollution incidents, and of assessing the economic damages resulting from such incidents (short/medium) - primary

* development of methods for assessing the environmental damage from non-point sources of pollution (short/medium) - primary

* development of methods for evaluating the development and amenity benefits of water quality improvements (short) - primary

* determination of the numbers of visitors to different categories of site and, particularly, the development of methods of scaling up from short period counts (short) - secondary

* determination of the access values to visitors for water quality improvements, other than "out-of-stream" visitors, to river corridors, to coasts and to other controlled waters (short/medium) - primary

* calculation of the shadow prices of commercial fish and shellfish, net of any environmental disbenefit associated with those activities (short) - secondary

TABLE 16 continued ...

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* the monitoring of research on non-access values for ecological and other sites (continuous: medium/long) - tertiary

* the monitoring of critiques of the application of neo-classical economic analysis to environmental goods (continuous: medium/long) - tertiary

* the monitoring of developments in the methodology of the Contingent Valuation Method (continuous - short/medium) - tertiary

* the monitoring of proposed recreational and amenity developments adjacent to controlled waters (continuous) - tertiary

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Key:

short - less than 2 years
medium - 2 to 5 years
long - over 5 years

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11.0 REFERENCES

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TERMS OF REFERENCE

Overall objective

To review the economic principles and potential methods available to the NRA for ascribing a value to different controlled waters, and to subsequent deterioration or improvement of their environmental quality.

Specific objectives

1. To describe the basic economic theory whereby "use" and "non-use" values relating to human interaction with controlled waters can be determined.

2. To review the critical features which affect environmental quality of controlled waters, and the different economic techniques available for evaluation of impacts on the water environment.

3. To recommend the best available techniques for ascribing a base value to different controlled waters and for evaluation of impacts in (2) above. To show how such values can be extrapolated/discounted into the future.

4. To identify the requirements for, and to provide where available, a data base of economic values and parameters for different uses of controlled waters.

5. To identify any improvements to these techniques and available data which would benefit the NRA in carrying out its statutory duties.

6. To identify any existing research currently underway related to (3), (4) and (5) above, and any further research which would be cost-effective for the NRA to undertake.

7. To provide examples of the application of (3) and (4) above.

The study will focus on issues associated with the NRA's duties in control of pollution of rivers and coastal waters.

ECONOMIC BASIS OF ANALYSIS

Nature of economic value, costs and prices

From the axioms, it follows that no good has an economic value unless at least one individual desires it in some quantity and any thing which at least one individual desires has an economic value. The former condition excludes explicitly other possible bases by which a good might be attributed a value, notably the attribution of value by a societal rather than an individual decision, or by inherent right of existence in the case of living systems. The latter concept of value (Holland and Cox 1991) has been proposed by a number of ecologists (Brennan 1988; Callicott 1985; Fox 1990; Regan 1981; Rolston 1985). No wider concept of "scientific value" is admitted, other than by the degree to which possibly a small group of scientists, as individuals, value something.

Notably, market prices do not define economic values, but represent only one way of estimating them. Market prices result from the balance of supply and demand but, nevertheless, some goods may have a high value without having a high price. Adam Smith (1982) uses the example of air as an illustration of this fact.

Economic values are *relative*, rather than absolute, and *sacrificial*. Economic values are relative because they derive from choice and the comparison of alternatives. Equally, they measure how much of a good the individual would be willing to give up in order to have more of another good, or how much of other goods the individual would be willing to sacrifice for more of the goods in question (Green and Tunstall 1990a).

Because values are given by individuals, the goal of a social choice is usually argued to be the maximisation of some aggregate of individual preferences. Usually, this goal is applied in practice by the Potential Pareto Principle; a simple balancing scale principle of testing whether the total value of the gains exceed the total value of the losses, however these gains and losses are distributed amongst individuals. In benefit-cost analysis, the use of the benefit-cost ratio and net present value (NPV) criteria embody the Potential Pareto Principle.

In the same way that market prices do not define values, neither do they define costs. Instead, "costs" are defined as the opportunities sacrificed in choosing one good in preference to another. The opportunity cost of using resources to supply one good rather than another is thus the value of the second good which could be created using the resources. If the market conditions are such that it can be described technically as "a perfectly competitive market", then these opportunity costs can be estimated by the market prices.

The conditions for the existence of a perfectly competitive market are very restrictive, but this type of market has two very desirable characteristics. Firstly in comparison to all other goods, it is homeostatic *i.e.* it responds to changes in supply and demand by reaching a new equilibrium, expressed as prices. Secondly, and again in comparison to all other goods, these prices are such that the price of a good represents both the value of a small increment in the available quantity of that good and the opportunity cost of making that additional quantity available. The result is economic efficiency because no other combination of goods would yield a higher total value within the limits of available resources.

Thus, the market price of timber, for example, reflects not only the value of the different purposes which that timber could be put, but also the value of the alternative uses of the labour, land and capital used to grow that timber. For the market to be described as perfect, these values should also reflect the value of the recreation, wildlife and other features of the forests from which the timber was cut.

Where such values are not included in the market price, because they have no market price, then the market will be imperfect and market prices will not reflect opportunity costs. A consequence of this distortion will be the inefficient use of resources; more of the under- or un-priced resources will be used than is efficient.

Such "externalities" can occur equally on either the output side of production, (or consumption), or on the input side. If discharges or emissions either cause a loss of utility to some person, or reduce the amount or quality of resources available, and these effects are unpriced, then an externality is said to occur. Again, economic inefficiency is likely to result.

Measuring economic value

Money is used only as a yardstick, or numeraire, to estimate economic values but, although not every good has a market value, this does not imply that it has no economic value. The technical problems of estimating economic values are easier when a good is bought and sold in a market because it can be shown that, under the very restrictive conditions of a perfectly competitive market, market price equals economic value for a restricted class of goods, known as "private good".

Unfortunately, markets are rarely perfect. Market prices must usually be adjusted and the "shadow price" of goods determined, in order to estimate their economic values. Thus, because agricultural prices are distorted by the existence of the Common Agricultural Policy, shadow prices, rather than market prices, must be estimated for all transactions associated with agriculture. This includes not only agricultural production, but also the value of water for irrigation and of agricultural land. Market prices must be corrected to take out taxes such as VAT and excise duties. In general, it is unusual to be able to use unadjusted market prices in economic analyses.

Only some goods are bought and sold in a market and, consequently, have prices. For it to be possible to sell a good, and thus create a market, it must be possible for one person to prevent any other person from gaining access to or having use of that good. That it is possible for a seller to prevent those who wish to use the good from so doing, is the first characteristic of a "private goods".

There is, however, a second category of goods, *i.e.* "public goods", where it is not easily possible to constrain access to the goods. However, the more important feature which distinguishes public goods from private goods is that the use of the goods by one individual does not reduce its availability or value to any other individual. The classic example of a pure public good is a lighthouse. Should one ship-owner build a lighthouse in order to reduce the risk of his ships being wrecked upon a rock, he has no way of preventing the ships of other owners also using the lighthouse to avoid the rocks, nor does the use by the other owners in any way reduce its value to him.

In reality, goods vary in the degree to which they possess either characteristic. A beach, for instance, is a public good until congestion becomes such that it reduces the enjoyment of the users. More importantly, even where it is possible to restrict access to a good, the creation of a market will result in economic inefficiencies if the value of a good to one individual is not reduced by its use by others. The same quantity of resources must be used to provide the good for many individuals as for one individual; consequently, the cost of provision for each additional user or use - the marginal cost - of the good is zero. Since economic efficiency is achieved when the price is set at the point where the marginal cost equals the value of an additional use, the price should be set at zero. Thus, were it possible to establish a market for such a good, the price charged for that good could not be used to infer its value.

Almost all changes to the environment involve a public good. Economic analysis developed around the analysis of demand and supply of private goods. Where the amount of a good available to other consumers is reduced by the amount consumed by one consumer then, given the axiomatic basis of neo-classical economics, there is no need to explore why the individual consumer prefers one good rather than another. By assuming that individuals are the best judges of their own self-interest, then we need simply to observe the behaviour of such judges in order to determine values.

The analysis of the demand for, and the value of, public goods is more complicated. First, since provision for one person makes it available to others, individuals may desire the provision of the good for reasons other than the pleasure they gain by consuming or accessing that good. They may gain altruistic pleasure through the knowledge that it is available to others, whom they believe will gain utility from its existence - for example, by preserving an environmental good for future generations. Similarly, they might simply value the existence of a species just for its existence (whales, for example). Thus, economists (Arrow & Fisher 1974; Brookshire, Eubanks & Sorg 1986; Brown 1984; Krutilla 1967; Krutilla & Fisher 1975; Madnaga & McConnell 1987) have speculated that there are a number of possible motivations which might influence people to value environmental goods over and above the value they place upon consumption or access to that good. However, since these motivations cannot be exhibited in choices concerning private goods, (Margolis 1982), economists have not previously had to determine them.

These motivations do not depend for their satisfaction upon the consumption of, or access to, the good in question. For this reason, and because the real motivations behind the demand are not yet known, it is preferable here to term these "non-access values", or, in economic terms, "non-use values". Whilst speculating freely as to nature of these motivations and, referring variously to "bequest", "existence" and "intrinsic" values, there is very little empirical evidence as yet about validity of these speculations. In the words of Brookshire and Smith (1987): *".... we do not have a clear understanding of exactly how individuals arrive at value ....., in the case of non-use values, we impose arbitrarily chosen motives"*. This, however, has not stopped some economists from seeking to estimate the non-access values associated with particular goods.

The motivations underlying non-access values may well be the crucial issue in determining decisions about the preservation and enhancement of environmental goods. There are indications that both altruistic and moral concerns are involved (Table A2.1). But, in an absence of empirical evidence to confirm these speculations, (Green and Tunstall 1991a), direct methods of estimating them cannot presently be applied. Only inferential techniques (see Section 7.7) for setting bounds on these values should, therefore, be adopted.

The development of hypotheses relating to environmental goods has also resulted in the derivation of special categories of access value. Thus, it is suggested (Schmalensee 1972) that individuals may value the "option" of future access. In other words, they may be willing to sacrifice some quantity of other forms of consumption in order to preserve the option of accessing some environmental good in future, even though they do not do so at present. They might do so because they foresee that their preferences and circumstances might change. It is the economic equivalent of "never throwing anything away because you never know when it might come in useful".

A variant of option value is "quasi-option value" (Arrow & Fisher 1974; Henry 1974). This is the value of the additional information which might be obtained by deferring a decision as to the availability of the good. It is directly equivalent to the concept of information value in Bayesian Analysis (Moore & Thomas 1988).

In summary, the value of some supply of a good, when aggregated across the population who gain or lose from a change in the supply of that good is:

value = access value + option value + non-access value

Identifying values

A particular good, such as a river with good water quality, can give rise to a range of access values as well as non-access values. It may, for instance, have a recreational value for fishing, canoeing, and out-of-stream recreation as well as amenity value to the local residents. Access values measure its relative significance in regard to each and every distinct purpose it may fulfil. In order to assess the value of some change in the availability of a good, it is necessary to identify all of the purposes that good may serve.

Table A2.2, for example, lists the access values which might arise from a site of ecological significance. The value of a particular site will then be the sum of all the values associated with the individual purposes, provided always that these purposes are mutually exclusive.

TABLE A2.1

Non-access values - issues and problems

* overall, the public places high non-access values on the environment
* however, it is usually necessary to derive a value for a *specific* site rather than for some general feature of the environment: it is not clear that people hold such site specific non-access values, as opposed to a general value
* moreover, there are indications that non-access values are derived from *moral* concerns rather than utilitarian concerns
* it is difficult to determine the population who would benefit through non-access values, and thus the total benefits from improvements at a particular site
* those features which lead to a particular site being highly valued by the public may not be those which are regarded as important on scientific grounds; nor may those changes which are desired for ecological reasons be those which the public desire

TABLE A2.2

Access values which may be associated with a site of ecological significance

Access values

* contains a gene pool (*e.g.* as a potential source of nitrogen-fixing genes for bio-engineering into commercial species)
* as a monitor of environmental change
* as the basis for predicting the consequences of environmental change
* recreational and amenity value
* potential source of drugs/chemicals/pesticides
* air/water purifier
* educational value *e.g.* school visits as part of the National Curriculum
* necessary link in the life cycle of some species of fauna (breeding site, migration route, roosting site, reservoir for the surrounding area
* source of predators of pests

CASE STUDY

This case study is solely intended to be illustrative of how environmental values might be applied. The case study is based upon the Water Research Centre's Catchment Water Quality Planning illustrative example (Figure A3.1). However, to make that model more realistic, a number of additional uses have been added (Figure A3.2), which are broadly typical of those that would normally be found in such an area. Similarly, a number of projected developments have also been assumed (Figure A3.3).

The basic WRc model specifies that Town A has a population of 10,000: a local park is assumed which attracts 25,000 visits per year. On the river between the two towns there is assumed to be a Country Park downstream which attracts 250,000 visits a year. Town B has a population of 50,000; two local parks are assumed, attracting 30,000 and 60,000 visits a year respectively. Town C has a population of 100,000 and attracts 250,000 visits a year. The visit figures for the local parks and country park are based upon the data given in the Social Costs of Sewerage Manual; the figures of visits to the coast resort are based upon the figures estimated for Herne Bay (Tunstall *et al* 1990) . In general, the land uses associated with the river are based upon those determined in an earlier case study of Macclesfield, described elsewhere (Tunstall *et al*, 1990).

The estimates of visits and the benefit per visit, as well as other estimates of benefits, if not taken from the Social Costs of Sewerage Manual and associated publications (Green and Tunstall 1990; Green *et al* 1990; & Tunstall 1991a), are arbitrary. An attempt has been made to make them plausible: the value assigned to the shell fishery is, for example, based upon the estimated turnover of the oyster fishery in the Solent, and the gross margin on the marina from mooring fees in that area. Other estimates are essentially arbitrary given the lack of more detailed data: to estimate the potential additional irrigation benefits, it would be necessary to know the volumes that could be extracted and the possible farming patterns in the area.

The WRc illustration (Figure A3.1) compares three options for dealing with existing problems in the area. Option 1 proposes the treatment of all effluents at a central inland site; option 2 caters for separate treatment at each population centre and option 3 proposes centralised marine treatment These problems include significant intermittent failures (Figure A3.4). Table A3.1 summarises the estimated effect of each of the three options upon each of the activities or uses assumed to exist in the area. Tables A3.2 - 4 then summarise the projected economic benefits consequent upon those improvements. It can be seen that in a number of cases the "Least Cost Alternative" approach has been used to evaluate these effects: for example, the gains to the SSSI have been estimated as the reduction in the costs which would otherwise be expected to protect that SSSI against the both pollution plugs and accidental spillages of, for example, pig slurry.

Tables A3.2 - 4 also give the total annual estimated benefits for each of the options. These figures are partial and cannot be directly compared to the estimated costs of the project for several reasons. The first of these is that both the costs of each of the scheme options and each of the benefits is likely to be phased in over time; proper comparison requires setting up a discounted cash flow table.

Secondly, a number of major benefits are omitted from the comparison, notably any associated reductions in flooding and sewer collapse. Combined storm overflows (CSOs) are frequently expedients which have been adopted in the past to deal with flooding problems, and it is quite probable, from experience, that in a real example sewage flood alleviation benefits would be substantial.

In addition, where it is the operation of CSOs that cause non-compliance with mandatory standards, such as CEC Directives, the correct estimate of the benefits of the scheme options given is with the performance of the system without CSOs (*e.g.* with any additional flooding or tanking).

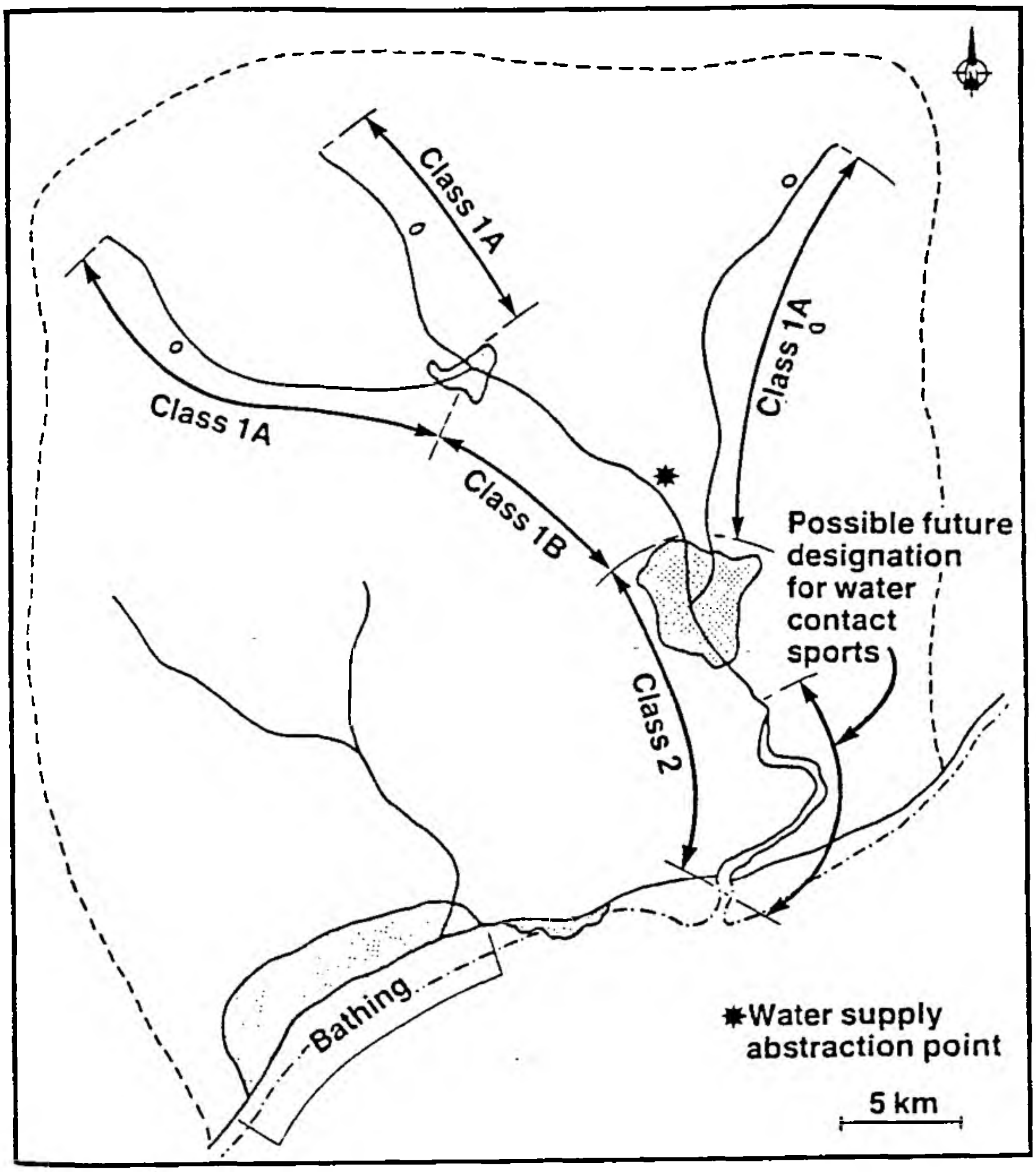
TABLE A3.1

Impacts of the alternative options being considered

Use	Impact compared to present: Option 1	2	3
Local Park A	increases amenity	increases amenity	increases amenity
Country Park	increases amenity	some increase in amenity	increases amenity
Potable water abstraction	reduces risk of pollution closure & treatment cost	reduces risk of pollution closure & treatment cost	reduces risk of pollution closure & treatment cost
Agricultural abstractions river 3	increases permissible abstractions	increases permissible abstractions	increases permissible abstractions
Trout fishing river 3	reduces costs of restocking; increases productivity; attracts new visitors	reduces costs of restocking; increases productivity; attracts new visitors	reduces costs of restocking; increases productivity; attracts new visitors
SSSI designated wetland	reduces costs of emergency protection	reduces costs of emergency protection	reduces costs of emergency protection
Local Parks B	increases amenity	some increase in amenity	increases amenity
Bathing C	increases amenity	increases amenity	increases amenity
Boating C	increases amenity; small increase in visits	increases amenity; small increase in visits	increases amenity; small increase in visits
coastal mudflats	increases feedstuff to birds	increases feedstuff to birds	decreases feedstuff to birds

FIGURE A3.1

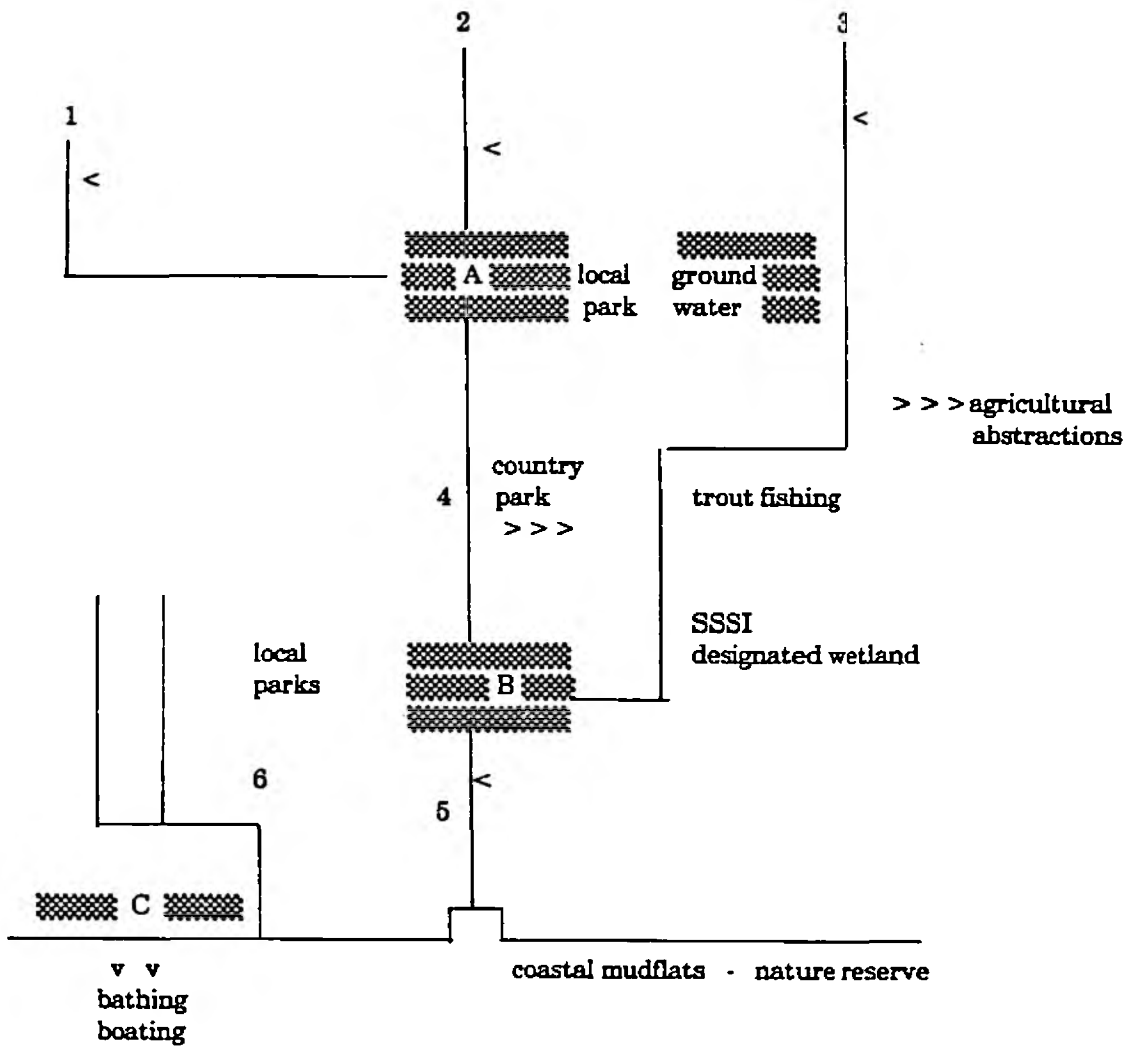
Hypothetical Catchment Area - environmental quality objectives



Source: Water Research Centre

FIGURE A3.2

Hypothetical Catchment Area - current uses

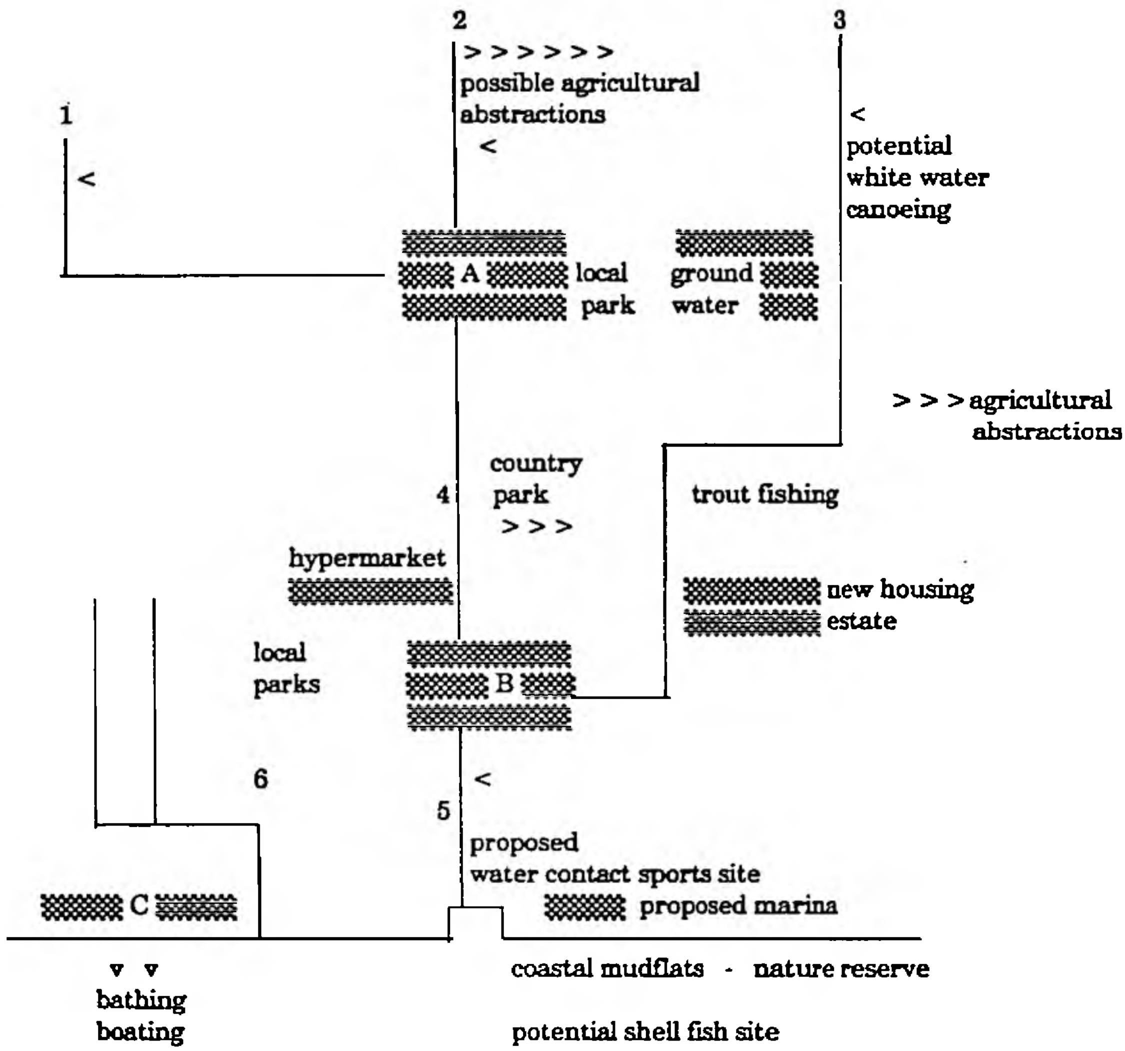


Key:

< discharges
> > > abstractions

FIGURE A3.3

Hypothetical Catchment Area - potential uses

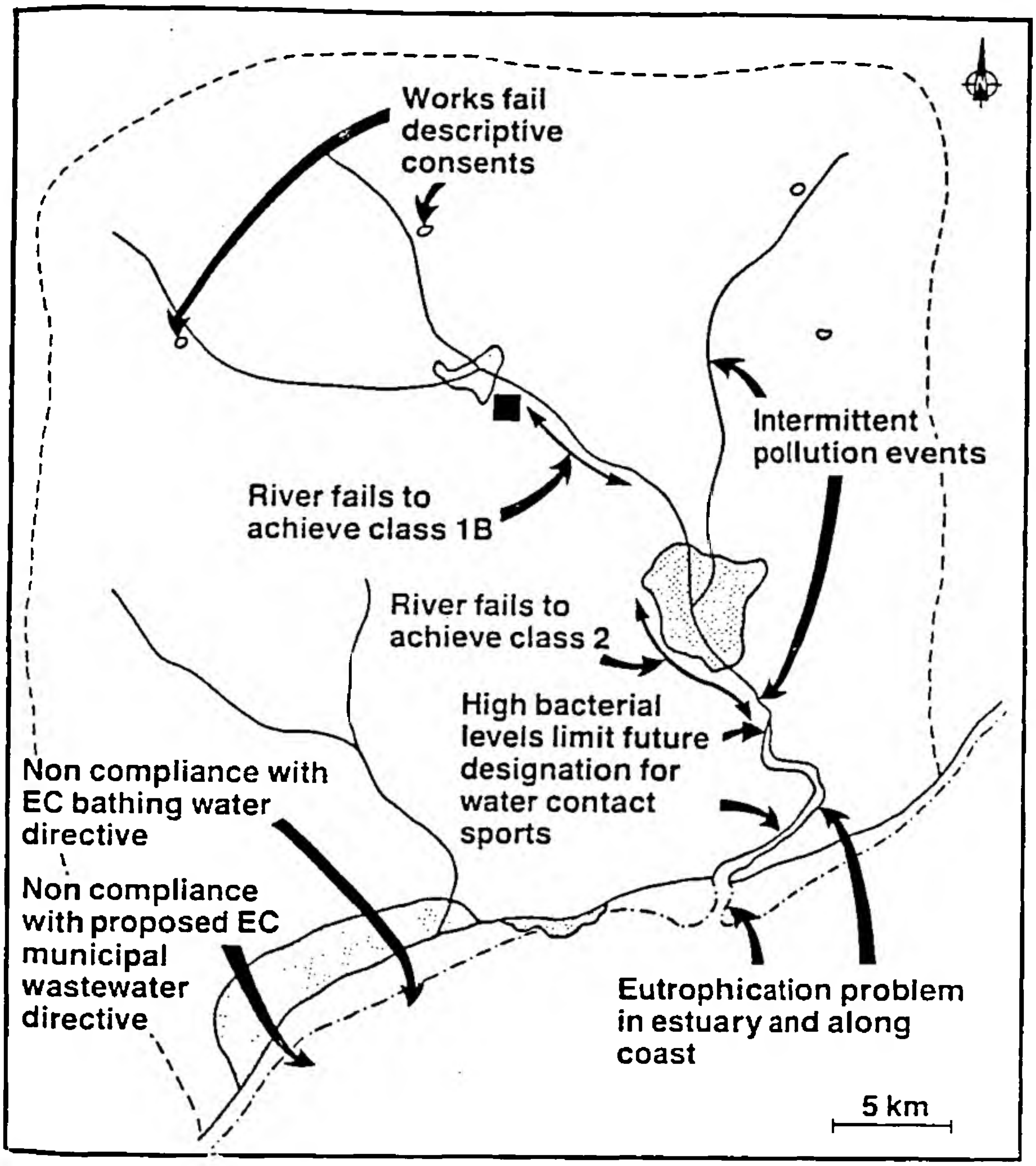


Key:

< discharges
> > > abstractions

FIGURE A3.4

Hypothetical Catchment Area - current failure areas



Source: Water Research Centre

Table A3.1 continued ....

Use	Impact compared to present:		
	Option		
	1	2	3
possible agricultural abstractions 2	makes abstraction possible	makes abstraction possible	makes abstraction possible
potential white water canoeing 3	increases the number of days on which canoeing possible	increases the number of days on which canoeing possible	increases the number of days on which canoeing possible
new housing B	increased amenity	some increase in amenity	increased amenity
new out of town shopping centre	increased amenity	some increase in amenity	increased amenity
town centre	increased amenity	some increase in amenity	increased amenity
proposed water contact sports site	achievable	not achievable	achievable
proposed marina	not possible	possible	possible
potential shell fish site	not possible	not possible	possible

TABLE A3.2

Benefits of option 1

Use	Impact compared to present: Option 1
Local Park A	25,000 x 48 = £12,000 pa
Country Park	250,000 x 41 = £102,500 pa
Potable water abstraction	reductions in expected cost of pollution incidents plus reductions in treatment costs = £180,000
Agricultural abstractions river 3	additional productivity valued at £200,000 pa less evapo-transpiration plus additional diffuse runoff and costs of pumping from groundwater in order to maintain water table at the SSSI at £20,000 pa = £180,000
Trout fishing river 3	expected value of reduced restocking costs £3,000 pa; additional enjoyment to fishermen estimated as £1 per visit by 10,000 visits = £13,000 pa 2,000 additional visits generated at £1.50 per visit = £3,000 pa
SSSI designated wetland	expected value of reduced emergency protection costs (booms, oxygenation) = £5,000 pa
Local Parks B	90,000 x 48 = £43,200 pa
Bathing C	250,000 visits x 80p per visit for improved beach and sea cleanliness = £200,000 pa
Boating C	12,000 visits x 10p per visit = £1,200 pa increased visits: 2,000 x 40p per visit = £800 pa
coastal mudflats	least cost method of providing same increase in food supply = £36,500 pa
possible agricultural abstractions 2	additional productivity valued at £160,000 pa minus additional runoff at £10,000 pa = £150,000 pa

Table A3.2 continued ....

Use	Impact compared to present: Option 1
potential white water canoeing 3	risk of water being unusable decreased from 0.05 to 0.01 for some 1000 visits per year, cost of aborted trip: £4 = £160 pa
new housing B	200 houses x £562 = £112,400 (capital sum)
new out of town shopping centre	30,000 x 42p = £12,600 pa
town centre	100,000 visits at 42p visit = £42,000 pa
proposed water contact sports site	estimated 36,000 visits generated per year with a launching fee of £2 = £72,000 pa
proposed marina	nil
potential shell fishery	nil

TOTAL ANNUAL BENEFITS = £1,053,960 pa
(plus a capital sum of £112,400)

Benefits and costs excluded:

(i) any capital and operating sums resulting from an upgrading of the potable water treatment plant to met mandatory drinking water standards where these could be avoided through improvements to river water quality.

(ii) changes in nuisance, odour and noise from waste treatment works.

(iii) changes in flooding and sewer collapse costs as a result of the new interception sewers.

(iv) non-access values consequent upon improvements to river and tidal waters.

(v) reduction of scheme capital and operating costs by VAT and exercise taxes.

TABLE A3.3

Benefits of option 2

Use	Impact compared to present: Option 2
Local Park A	25,000 x 48 = £12,000 pa
Country Park	250,000 x 41 = £102,500 pa
Potable water abstraction	reductions in expected cost of pollution incidents plus reductions in treatment costs = £180,000
Agricultural abstractions river 3	additional productivity valued at £200,000 pa less evapo-transpiration plus additional diffuse runoff and costs of pumping from groundwater in order to maintain water table at the SSSI at £20,000 pa = £180,000
Trout fishing river 3	expected value of reduced restocking costs £3,000 pa; additional enjoyment to fishermen estimated as £1 per visit by 10,000 visits = £13,000 2,000 additional visits generated at £1.50 per visit = £3,000 pa
SSSI designated wetland	expected value of reduced emergency protection costs (booms, oxygenation) = £5,000 pa
Local Parks B	90,000 x 42 = £37,800 pa
Bathing C	250,000 visits x 80p per visit for improved beach and sea cleanliness = £200,000 pa
Boating C	12,000 visits x 10p per visit = £1,200 pa increased visits: 2,000 x 40p per visit = £800 pa
coastal mudflats	least cost method of providing same increase in food supply = £36,500 pa
possible agricultural abstractions 2	additional productivity valued at £160,000 pa minus additional runoff at £10,000 pa = £150,000 pa

Table A3.3 continued ....

Use	Impact compared to present:
	Option 2
potential white water canoeing 3	risk of water being unusable decreased from 0.05 to 0.01 for some 1000 visits per year, cost of aborted trip: £4 = £160 pa
new housing B	200 houses x £546 = £109,200 (capital sum)
new out of town shopping centre	30,000 x 37p = £11,100 pa
town centre	100,000 visits at 37p visit = £37,000 pa
proposed water contact sports site	nil
proposed marina	estimated gross margin per mooring of £400 for 400 boats = £160,000 pa
potential shell fish	nil

TOTAL ANNUAL BENEFITS = £1,170,060
(plus a capital sum of £109,200)

Benefits and costs excluded:

(i) any capital and operating sums resulting from an upgrading of the potable water treatment plant to met mandatory drinking water standards where these could be avoided through improvements to river water quality.

(ii) changes in nuisance, odour and noise from waste treatment works.

(iii) changes in flooding and sewer collapse costs as a result of the new interception sewers.

(iv) non-access values consequent upon improvements to river and tidal waters.

(v) reduction of scheme capital and operating costs by exclusion of VAT and exercise taxes.

TABLE A3.4

Impacts of option 3

Use	Impact compared to present: Option 3
Local Park A	25,000 x 48 = £12,000 pa
Country Park	250,000 x 41 = £102,500 pa
Potable water abstraction	reductions in expected cost of pollution incidents plus reductions in treatment costs = £180,000
Agricultural abstractions river 3	additional productivity valued at £200,000 pa less evapo-transpiration plus additional diffuse runoff and costs of pumping from groundwater in order to maintain water table at the SSSI at £20,000 pa = £180,000
Trout fishing river 3	expected value of reduced restocking costs £3,000 pa; additional enjoyment to fishermen estimated as £1 per visit by 10,000 visits = £13,000 2,000 additional visits generated at £1.50 per visit = £3,000 pa
SSSI designated wetland	expected value of reduced emergency protection costs (booms, oxygenation) - £5,000 pa
Local Parks B	90,000 x 48 = £43,200 pa
Bathing C	250,000 visits x 80p per visit for improved beach and sea cleanliness = £200,000 pa
Boating C	12,000 visits x 10p per visit = £1,200 pa increased visits: 2,000 x 40p per visit = £800 pa
coastal mudflats	least cost method of maintaining same level of food supply as at present = - £18,000 pa
possible agricultural abstractions 2	additional productivity valued at £160,000 pa minus additional runoff at £10,000 pa = £150,000 pa

Table A3.4 continued ....

Use	Impact compared to present: Option 3
potential white water canoeing 3	risk of water being unusable decreased from 0.05 to 0.01 for some 1000 visits per year, cost of aborted trip: £4 = £160 pa
new housing B	200 houses x £562 = £112,400 (capital sum)
new out of town shopping centre	30,000 x 42p = £12,600 pa
town centre	100,000 visits at 42p visit = £42,000 pa
proposed water contact sports site	estimated 36,000 visits generated per year with a launching fee of £2 = £72,000 pa
	sub-aqua diving estimated 1,000 visits per annum with CVM estimated value of £10/visit = £10,000 pa
proposed marina	estimated gross margin per mooring of £400 for 400 boats = £160,000 pa
potential shell fish	estimated gross margin on fishing, discounted back from date when will be effective = £125,000 pa

TOTAL ANNUAL BENEFITS = £1,294,460 pa
(plus a capital sum of £112,400)

Benefits and costs excluded:

(i) any capital and operating sums resulting from an upgrading of the potable water treatment plant to met mandatory drinking water standards where these could be avoided through improvements to river water quality.

(ii) changes in nuisance, odour and noise from waste treatment works.

(iii) changes in flooding and sewer collapse costs as a result of the new interception

(iv) non-access values consequent upon improvements to river and tidal waters.

(v) reduction of scheme capital and operating costs by VAT and exercise taxes.

Conclusions

It should be emphasised that this is an artificial example largely using artificial, but plausible data. It is intended to illustrate the variety of different economic benefits which might be found to result from an improvement in water quality, rather than to be a typical or average case.

In this example, none of the possible options discussed by the Water Research Centre is economically justified solely by the resulting water quality improvements. This might not be the case if the other benefits of the individual schemes, such as any reduction of sewage flooding, were also to be taken into account. Such an analysis should also take into account the economic disbenefits of each option, including those caused by the engineering works and the operation of the associated plant.

No general conclusion about the likely economic efficiency of improvements can be drawn from this example. Indeed, the purpose of economic analysis is to separate individual schemes into the desirable and undesirable, as opposed to making sweeping generalisations.

The example illustrates broadly that the application of economic analysis to improvements to the water environment does not pose major problems for access values. The exception to this is likely to be where commercially sensitive data, such as that associated with potable water abstractions and treatment costs, is required.

SUMMARY OF THE LITERATURE ON THE BENEFITS OF IMPROVEMENTS TO THE WATER ENVIRONMENT

The development of methods of evaluating environmental changes began in the United States some twenty years ago (Davis, 1963); in recent years Presidential Directive 12291, requiring a benefit-cost analysis to be conducted on all proposed Federal Rules and the Bureau of the Interior's rule on environmental damages (Department of the Interior, 1986), have added impetus to these developments. The amount of work relating specifically to the water environment is consequently large (Mitchell and Carson, 1969); both the US Water Resources Council (1983) and the US Corps of Engineers (Moser and Dunning, 1986) publishing guidelines for the valuation of environmental effects of water schemes and the application of the CVM respectively.

The greatest amount of relevant work in Europe has been undertaken in Norway (Navrud, 1991), mainly that already described on the evaluation of angling benefits. In France, whilst Henri (1976) has been one of the theoretical pioneers of environmental economics, few practical evaluation studies appear yet to have been conducted: Bonnieux (private communication) is in the process of undertaking a CVM study of the recreational benefits of sea angling. Other work has focused upon the evaluation of the loss of fish killed by pollution incidents and the benefits of pollution reduction in terms of the costs of potable water supply (Trabuc *et al*, 1989). There has been a great deal of analysis of the problem from the policy makers' viewpoint (Trabuc, 1989).

In Germany, work has concentrated upon deriving gross estimates of environmental damage: Faber (private communication) analysing the losses from water pollution, in addition to the previously described work by Schulze (Pearce and Markyandya, 1989) on the benefits of improvements to the water quality of lakes in west Berlin. Work was similarly undertaken in Italy some years ago to estimate the national loss through water pollution (Muraro,1974), and more recently in the Netherlands (Opschoor, 1986).

Interest in evaluation began in the UK with the Trent study (Water Resources Board, 1973), and Turner (1968) prepared the first review of water quality benefits. The remainder of the work in the UK has been described in the text, with the exception of a report prepared for the DOE whose title describes it as covering both the benefits and costs of discharges of sewage to the sea (Consultants in Environmental Sciences, 1990). As yet we have not been able to get a copy of this report, but contacts at DOE say that it has little to say on the benefit side of the equation.

Elsewhere, some early work using the CVM was undertaken by Harris (1983) to evaluate recreational benefits in the Waikato basin in New Zealand. Sinden (1990) has also undertaken an assessment of the recreational benefits for the Ovens and King basins in Australia.

Much of this work has not been published except as reports or dissertations and, consequently, it is quite likely that some relevant material has been missed.

General reviews of the economics of wetlands have been published by Maltby (1986) and on the economics of the coastal zone by Edwards (1987).

Overall, the literature on environmental economics is vast. The best single non-technical text is probably:

Pearce D W, Markandya A and Barbier E B 1989 *Blueprint for a Green Economy*, London: Earthscan

For a somewhat more technical introduction, see

Pearce D W and Turner R K 1990 *Economics of Natural Resources and the Environment* Hemel Hempstead: Harvester Wheatsheaf

The best introduction to the economics of water is still probably, in spite of its age:

Howe C W 1971 *Benefit-cost analysis for water system planning*, Water Resources Monograph 2, Washington: American Geophysical Union

The US Water Resources Council guidelines are however also an excellent introduction to both the issues and basic approaches to economic evaluation:

US Water Resources Council 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, Washington: Dept. of the Interior

Good critiques of the bases of economic analysis are scarce. However, Shrader-Frechette is commendable:

Shrader-Frechette K S 1981 *Science, Policy, Ethics and Economic Methodology*, Dordrecht: Reidel

Whilst it is directed largely towards the economic appraisal of road schemes, the critique prepared for the NCC by Hopkinson, Bowers and Nash, is to-day the nearest to a position statement on economic analysis by the NCC:

Hopkinson P G, Bowers J and Nash C A 1990 *The treatment of nature conservation in the appraisal of trunk roads*, Peterborough: the Nature Conservancy Council

The collected papers of a Workshop on Ecological Evaluation and Economic Valuation are one of the few instances of discussions between ecologists and economists as to the nature of value:

Coker A C and Richards C 1991 *Valuing the Environment*, London: Bellhaven

GLOSSARY OF TERMS

Access value
this is used as a synonym of the economic term "use value". It represents the value arising from access to, including consumption of, an environmental good. Access values arise, for example, from activities such as recreational visits to a river corridor; abstraction of water from a body of water, or simply living near a desirable water feature.

Benefits
the returns on the investment in the project; the gains, or the avoided losses, in consumption which it achieves.

Benefit cost ratio
the ratio of the present value of benefits to the present value of the costs.

Capitalised value
the sum of the discounted income flow; its Present Value (*q.v.*).

Consumer surplus
the difference between the total amount an individual must pay for a given quantity of a good and the value the individual puts upon the availability of that given quantity of the good.

Consumption
in economics, it is usual to speak of the "consumption" of a good by an individual. This usage illustrates economics derivation from the examination of private goods, where a good is literally consumed by being used. The usage is normally extended to public goods where access to or use of that good by an individual does not reduce the availability of the good.

Contingent valuation method
method of evaluating goods using social survey methods.

Cost
the resources or alternative consumption which must be sacrificed for the end in view to be achieved.

Direct methods of evaluation
methods of estimating the value of a good either by asking individuals or by observing their behaviour in relation to the consumption of that specific good.

Discounting
different decision options may yield varying streams of benefits and costs in future years. In order to compare these different streams, it is necessary to bring them to a common base. Conventionally, this is done by discounting these streams to their present values using the Test Discount Rate.

Economic analysis
considers the changes in the flows of all goods and resources, whether or not they are priced, to all individuals and organisations in society.

Economic efficiency
occurs when there is an optimal allocation of goods and resources, as defined by some objective function, subject to any relevant constraints technical or other. A Pareto optimum allocation occurs when any change would leave at least one person worse off.

Environmental goods
un-renewable resources usually, but not necessarily, natural which have some or all of the following characteristics: they are unique and constitute public goods; decisions concerning their availability have irreversible consequences; and they are valued less for their access value than for other reasons.

Equity
the distribution of resources and goods which is excluded from the concern of economic efficiency analysis. Distributional questions may, therefore, require to be taken into account along with the results of the economic analysis.

Evaluation
assessment of the relative importance or significance of a site, or species, in scientific or other non-economic terms. As distinguished from "valuation" wherein the assessment is made in economic, or monetary terms.

Existence value
one term used in economics for "non-use" values (*q.v.*). The term "non-use" value is preferred because the reasons why individuals value goods other than for their use value is unknown. For consistency with other terminology in this report, the term "non-access value has been adopted.

Expected value
when the decision maker has to choose between a number of alternative actions and does not know for certain which of several possible outcomes will result from each possible action, then the expected value of each action is the sum of the probability times the value of each possible outcome.

Financial analysis
considers only the changes in the flows of cash or goods, the latter being valued at their market prices, to the organisation for whom the analysis is being undertaken.

Good
any commodity or service of which the individual would prefer to have more (or less). The commodity or service may be composed of a bundle of attributes, the individual preferring to have more (or less) of each of these attributes or goods.

Indirect methods of valuation
method of inferring the value of one good by evaluating the consumption of another good or a bundle of goods with which the first good is necessarily linked.

Inherent value
the concept that a species or a member of a species has a right to existence irrespective of any human preferences for the existence of that species.

Intangibles
any consequence of a scheme option for which it has not been possible to estimate the economic value of that change.

Inter-generational equity
a concern for the rights of future generations when the quantity and nature of goods, particularly environmental goods, available to them will be determined by the actions of the present generation.

Intrinsic value
synonym for "non-access" value (*q.v.*).

Joint product
the goods resulting from some production process are said to be intrinsically joint products if it is not possible to produce one good without also producing the others.

Marginal cost
the change in total production costs resulting from a one unit change in the quantity of goods produced: the rate of change of costs with respect to output.

Market price
that price for which a good is bought and sold in a market. If restrictive conditions are satisfied, this price may be used to estimate the economic value of the goods. Alternatively the market price may need to be corrected, a "shadow price" (*q.v.*) derived, in order that the economic value of the good can be estimated.

Net present value
the sum of the present values of all the benefits less the sum of the present value of all costs.

Non-access value
used as a synonym for the more usual economic terms of "non-use", "existence" or "intrinsic" value. The latter are defined as the value attributed to a good by people for reasons other than access value. These reasons might include moralistic or altruistic or other concerns as well as a simple preference for the continued existence of, for instance, a species.

Non-priced goods
those goods which are not bought and sold in a market and for which, consequently, there is no market price from which to estimate their value.

Non-use value
the value given to a good over and above the value that an individual attaches to that good.

Numeraire
a yardstick whereby the different impacts of a project can be compared with each other and with those of alternative projects. In economic analysis, money is used as the numeraire.

Opportunity cost
value placed upon the most highly valued of the rejected opportunities or uses of the resource.

Option value
The value an individual places upon reserving the right to access a good in the future although he/she does not wish to access the good now.

Opportunity cost of capital
it is not desirable to invest in one project when alternative projects would yield a greater stream of future increases in consumption. The return in consumption from such alternative investments (in theory, after adjusting for externalities) is the opportunity cost of capital; this is the basis for discounting.

Pecuniary externality

a change which simply has the effect of transferring resources from one person, firm or sector to another without affecting the total supply of goods and resources.

Perfectly competitive market

a model market based on restrictive assumptions which results in prices which are economically efficient.

Piecemeal analysis

a method of analysis which can evaluate only one, or some, of the access and non-access values associated with a change. The results of several piecemeal analyses must therefore be summed to estimate the total value of the change.

Present value

the value of a benefit or cost occurring at some future date discounted to some base date.

Private good

one which if used by one person is not available to others.

Production function

the technical relationship between the maximum amount of production possible for each and every possible combination of quantities of different inputs. It is defined for the given state of technological knowledge.

Production frontier

the maximum output possible for given possible combinations of quantities of different inputs.

Public good

one which cannot be marketed because the producer cannot restrict the consumption of the good to particular individuals, and nor does its consumption by one individual diminish the availability of the good to others.

Quasi-option value

the value of the additional information which would be gained as to the consequences of an action by deferring taking that action

Quasi-public good

one which has some of the characteristics of a public good, whilst also having some of the features of a private good.

Rationality

in economics, rationality refers to the consistency or reliability of decisions, rather than the process by which these decisions are made. The "rational economic man" is axiomatically assumed to maximise his utility.

Revealed preference methods

method of inferring individuals' preferences or, by observing their behaviour, the value that they place upon a good.

Risk

where the outcome of a decision is not known with certainty, risk is the probability associated with each possible outcome.

Risk aversion

someone is said to be risk averse when they prefer certainty to any risk, however small.

Sensitivity analysis
procedure for testing how robust are the conclusions of an analysis to uncertainties.

Shadow prices
if a market in a good is not perfectly competitive then market prices will not equal the prices which would occur in an efficient economy. It is, therefore, necessary to estimate those prices which would occur in an efficient economy.

Shadow project
the method of evaluation applied to the loss of a site, usually of ecological significance, as the cost of providing a site of equivalent significance elsewhere to replace that which would be lost.

Social time preference
common assumption in economics that the individual prefers the consumption of some good now, rather than at some later date. Since social choices should simply reflect individual preferences, social time preference is simply that of the individuals who comprise that society. One of the two reasons why benefits and costs occurring in the future are discounted.

Substitute goods
goods which fulfil identical or very similar wants.

Sunk cost
a cost incurred in the past and which cannot be recovered whatever decision is now taken.

Sustainability
The philosophy that economic development should take into account the rights of future generations and those of the less developed countries, particularly in the use of non-renewable natural resources. Alternatively, it may be defined as use which does not diminish the size and value of a resource, taking into account any replacement that may occur *e.g.* replanting trees which have been felled on the same site or elsewhere.

Technological externality
occurs when a decision by one person or organisation affects the utility of another and those economic consequences are not borne by the decision maker.

Test discount rate
the minimum rate of return which a project must achieve and which is set by the Treasury.

Time-dependent preferences for consumption
the difference in the level of utility from the consumption, or use, of the same quantity of a good at different times by an individual. Individual time preference, as embodied in "social time preference" (*q.v.*), reflects one possible form of time-dependent preference.

Transfer payment
see pecuniary externality.

Uncertainty
the degree of ignorance about the consequences of some action, either as a result of scarcity of data, possible inadequacies in the modelling techniques used, or simply because we cannot control the future.

Use value

the classification adopted by the National Rivers Authority as to different purposes to which the water environment can be put. Distinct from the usage of the term in economics which is here substituted by the term "access value".

Utility

the subjective gain an individual receives from the use or the existence of a good.

Value

the desirability of one good (relative to some other good) to some individual or organisation. In economic analysis, money is used a "numeraire", or yardstick, to compare the desirability of different goods. In a perfectly competitive market, the prices of different goods exactly reflect their relative desirability.

Variable cost

when production volume is changed, the quantities required of some inputs changes proportionally; consequently, so do the costs associated with these inputs vary with the quantity of output. In the long run, all inputs can be varied, but in the shorter term, inputs differ in the degree to which they can be adjusted to match output.