ANALYSIS OF 1995 SURVEY DATA AND RIVPACS UPDATE

A summary of the results of a consultation exercise on potential uses of the 1995 General Quality Assessment biological data and their prioritisation

M T Furse
R T Clarke

Institute of Freshwater Ecology
River Laboratory
East Stoke
WAREHAM
BH20 6BB

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1 BACKGROUND

The R&D Project EMA 008, was set up by the Environment Agency (the Agency) in June 1996. The project will be conducted in two phases. Phase 1 is a scoping study whilst Phase 2 will involve the implementations of the recommendations of the scoping phase.

1.1 Overall objectives

The overall objective of the full research programme (Phases 1 and 2) is to:

1 conduct a post-survey appraisal of the 1995 GQA biological survey data, both in terms of its assessment of biological quality, and as a tool for refining the methodology for future surveys.

The overall objective of the current phase, Phase 1, is to:

2 undertake a scoping study for Phase 2 and prepare the principal tool to be used in the data analysis in order that Phase 2, comprising the data analysis and appraisal, will be undertaken most efficiently.

The specific objectives of the current phase are to:

A produce an enhanced version of RIVPACS III and its associated user manual incorporating the error terms detailed in R&D Note 412, for use in the Phase 2 data analysis and for Agency Operational purposes.

B identify and rank the options for further analysis of the 1995 GQA biological survey data and to select those most likely to meet business needs, in consultation with the Project Board and other specialists within and outside the Agency.

C produce a detailed PID and work specification for Phase 2 describing the analyses to be undertaken and the resulting products.

1.2 Specific objective C - Consultation Exercise

In order to meet specific objective C a consultation paper was prepared by IFE, in consultation with the Environment Agency Project Leader, Dr R A Dines (Southern Region).

This document set out a series of options for utilising the biological data collected during the 1995 General Quality Assessment (GQA) of England and Wales. The results of that consultation exercise are set out in this document for the consideration of the Project Board.

The composition of the Project Board is as follows:

Dr R A Sweeting	Chairman, Topic Leader
Dr R A Dines	Project Leader
Dr A J D Ferguson	Project Executive, Head Office rep.
Dr J Murray-Bligh	Technical User
Mr B Hemsley-Flint	RIVPACS Project Manager
Mr D Lowson	Scottish Environment Protection Agency (SEPA) and Northern Ireland representative
Mr M T Furse	Institute of Freshwater Ecology (IFE)

2 THE CONSULTATION PROCESS

2.1 The consultation document

The consultation document was prepared by Mike Furse and Ralph Clarke (IFE) following consultations with the Dr Dines at a project progress meeting held at the IFE River Laboratory on Wednesday, August 28th, 1996.

The document is set out in full as Appendix I of the current document. It contains 15 options for use of the GQA 1995 data, including references to the possible comparative use of biological data collected during the National River Authority's 1990 River Quality Survey of England and Wales.

The titles of the fifteen options are given here as an aide-memoir (Table 2.1). The contents of the document were not considered to be the only potential uses of the data but merely a starting point for discussions.

Table 2.1 The descriptive titles of the 15 options set out in the discussion document

OPTION	TITLE
1	Distribution of taxa in relation to other factors
2	Impact of low flows
3	Distribution of the ecological quality of sites in relation to other factors
4	Statistical comparison of change in the ecological quality of individual sites sampled in both the 1990 River Quality Survey and the 1995 GQA
5	The relationship between temporal changes in ecological quality and losses, gains and changing abundance of individual taxa
6	Incorporation of data into the Countryside Information System (CIS)
7	Development of theoretical taxon distribution maps within CIS
8	Supply of data for IFE studies of the urban environment
9	Relationship between headwater quality and that of the rivers they feed
10	Evaluation of the performance of the 1995 banding system
11	Relationship between environmental factors and family richness
12	Substrate/habitat diversity in relation to family richness
13	Identification of national reference sites
14	Longitudinal patterns of zonation/community structure
15	Definitions of environmental niches of individual taxa and faunal assemblages

2.2 The consultees

The discussion document was circulated to twenty-three people (Table 2.1). These included all Project Board members, all the Agency's Regional Biologists, other relevant Agency staff, a representative Agency Board member, Department of the Environment representatives in Northern Ireland, a researcher with particular interests in the 1995 GQA biological data and colleagues at IFE with involvement in RIVPACS development.

Table 2.2 **An alphabetic list of the people consulted about options for further use of the 1995 GQA biological data. Asterisked replies contained no preferences. Bold replies explicitly state that they result from internal regional consultations.**

NAME	CODE	AFFILIATION	REPLY
Suzanna Allen	SA	Environment and Heritage Service (DoE, NI)	No
Patrick Armitage	PA	Institute of Freshwater Ecology	Yes
Sarah Chadd	SC	Environment Agency - Anglian	Yes
Elizabeth Chalk	EC	Environment Agency - North East	Yes
Bob Dines	RD	Environment Agency - Southern	**Yes**
Ron Edwards	RE	Environment Agency Board Member - Welsh	Yes *
Alastair Ferguson	AF	Environment Agency - Head Office	**Yes**
Elaine Fisher	EF	Environment Agency - North West	No
George Green	GG	Environment Agency - South West	No
Peter Hale	PH	Industrial Research Technology Unit (DoE, NI)	Yes
Brian Hemsley-Flint	HF	Environment Agency - North East	Yes
Shelley Howard	SH	Environment Agency - Midlands	**Yes**
Frank Jones	FJ	Environment Agency - Welsh	Yes
Ann Lewis	AL	Environment Agency - North East	Yes
Paul Logan	PL	Environment Agency - Thames	Yes
Dave Lowson	DL	Scottish Environment Protection Agency	**Yes**
John Murray-Bligh	MB	Environment Agency - Thames	Yes
Tim Pickering	TP	Environment Agency - North West	No
Roy Ramsay	RR	Environment and Heritage Service (DoE, NI)	Yes
Graham Rutt	GR	Environment Agency - Welsh	No
John Steel	JS	Environment Agency - Thames	No
Roger Sweeting	RS	Environment Agency - Thames	No
Bill Walley	BW	Staffordshire University	Yes
Tony Warn	TW	Environment Agency - Anglian	Yes
Neil Weatherley	NW	Environment Agency - Head Office	Yes
John Wright	JW	Institute of Freshwater Ecology	Yes

The summarised results of the consultation process are tabulated on the following double page spread for ease of interpretation.

2.3 Ordering of preferences

The order of preferences expressed by respondents to the questionnaire are given in Table 2.3.

Table 2.3 **The order of preferences listed by the consultees. Numerical rankings are 1 (highest) to 15 (lowest). Alphabetic rankings are H (high), M (medium), L (low) and X (inappropriate). Italicised codes interpreted and not explicitly stated. Lower case codes are conditional. Person codes are given in Table 2.2. Project titles are repeated on the adjacent page.**

PERSON CODE	OPTION NUMBER														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PA	L	M	H	H	?	?	?	H	?	?	*m*	*m*	*M*	*M*	*L*
SC	H	h	M	M	H	L	L	M	h	H	ML	ML	M	MH	M
EC	1	2	7	8	10	13	14	3	11	4	5	12	6	15	9
RD	H	*L*	*?*	*?*	H	h	h	L	h	H	H	L	L	L	L
RE	No preferences expressed														
AF	*M*	*M*	H (linked)			X	X	*L*	m	X	H	H	H	H	H
PH	?	?	H (linked)			?	?	?	H	?	?	?	?	?	?
HF	MH	H	M	MH	H	H	ML	MH	M	H	H	H	ML	L	L
SH	1	4	5	11=	2	11=	7	3	8=	6	11=	15	11=	8=	10
FJ	H	H	?	H	ML	ML	ML	L	L	H	H	L	L	MH	L
AL	?	?	?	h	?	H	?	?	?	?	L	?	?	?	?
PL	H	*L*	*M*	*M*	H	*m*	*m*	*?*	h	H	*l*	*l*	H	h	l
DL	*L*	M	H	H	*L*	*L*	H	*L*	*L*	H	*M*	M	H	H	*L*
MB	6	12	10	3	11	4	5	1	2	8	9	13	14	7	15
RR	No preferences expressed														
BW	Views incorporated in John Murray-Bligh's (MB's) reply														
TW	?	H	?	H	?	?	?	H	?	H	?	?	?	?	?
NW	?	?	H	H	?	X	X	H	?	H	?	?	H	?	?
JW	H	M	H	H	M	H	L	H	L	M	M	M	L	M	L

Table 2.4 Summary of preferences in three categories. HIGH = H, h, *H*, *h*, 1-5 from Table 2.3; MEDIUM = MH, mh, *MH*, *mh*, M, m, *M*, *m*, ML, ml, *ML*, *ml*, 6-10; LOW = L, l, *L*, *l*, X, 11-15; and Don't know" = ?

CATEGORY	OPTION NUMBER														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14
HIGH	7	6	7	10	7	5	3	7	5	9	5	2	4	3	1
MEDIUM	3	4	5	4	3	2	4	2	3	3	3	4	4	6	3
LOW	2	3	0	1	2	6	5	4	4	1	5	6	5	3	8
DON'T KNOW	4	3	4	1	4	3	4	3	4	3	3	4	3	4	4

Table 2.1 is repeated here for ease of reference to Tables 2.3 and Table 2.4.

OPTION	TITLE
1	Distribution of taxa in relation to other factors
2	Impact of low flows
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3 WRITTEN COMMENTS

3.1 Option 1: Distribution of taxa in relation to other factors

Patrick Armitage

My experience of trying to use RIVPACS data to derive habitat suitability curves for use in PHABSIM showed that the level of habitat data was far too crude. Only very broad levels of suitability were detectable.

Sarah Chadd

Potentially very useful. Care may be required as not all factors which may influence the macroinvertebrates are necessarily recorded.

This would tie in well with Options 5 and 10.

Elizabeth Chalk

Fundamental, important to extend the species.

Bob Dines

This has to be one of the front-runners. A "handbook" of this sort would be absolutely invaluable.

Alastair Ferguson

We consider options 1 and 2 of obvious interest but of a lower priority compared to some of the others.

Frank Jones

Some biological impacts will not be attributable because of inevitable limitations of chemical data (viz episodic events and impacts by determinands not analyses for).

Paul Logan

I think that this option, linking to dirty water RIVPACS, could be very useful operational tool and is high on the priority list.

John Wright

The analyses will be at BMWP family level only, but the comprehensive nature of the 1995 GQA data-set makes this a worthwhile exercise. Within IFE (Project T04053Z2) we have plans to undertake similar studies at 'species' level using the RIVPACS III/National data-base information, so there is opportunity for useful interaction between the two studies.

3.2 Option 2: Impact of low flows

Patrick Armitage

It might well be worthwhile filtering out a subset of sites which have been subject to low flows but it would be difficult to say that changes were attributable to reduced flows without taking in to account other simultaneous stressors (as you note).

Sarah Chadd

The Agency does desperately need more information on this. Using 1990 and 1995 data is not ideal as both years were affected by low flows.

Elizabeth Chalk

Typical application - timing is right and important to link to other work in progress.

Bob Dines

From my experience of acquiring data from the Resources function of the Agency I have major reservations about whether this is a practicable option. Certainly in Southern Region, I think you would be surprised at how few rivers have any significant gauging data, and I suspect this may also be true of others. If this option were to be put forward, I think you would need to contact all regions (step "f" in the PID) to see how many WQ classified rivers have at least one gauging station. In addition, having listened to Patrick Armitage at a recent meeting, I am not sure how useful this would be - do we have the environmental data that this option would require, and is BMWP family data much use?

Alastair Ferguson

We consider options 1 & 2 of obvious interest but of a lower priority compared to some of the others. One thing to bear in mind in relation to Option 2, is the availability of flow data. This is variable and will have an impact on which sites can be selected, which may not be the ones that will give the most relevant information to meet the aim.

Brian Hemsley-Flint

How does this link with the proposed Low flow R&D being pursued by Patrick Armitage? Maybe it would be better to include this analysis in that project?

Shelley Howard

Some options such as 2 were considered to be high priority even though this region probably does not have the problems that others have, so we have recognised a national need.

Frank Jones

Likely to be difficulties in obtaining flow data for impacted sites for drought periods. Many are unlikely to be routinely gauged because of their small size - this potential problem should be evaluated before proceeding.

Paul Logan

I'm not convinced that invertebrates are the best way to look at low flows so I'm not sure about this one.

Dave Lowson

Options 2 and 12 could be combined to consider the effects of flow extremes (not just low flows) together with substrate structure and stability.

John Murray-Bligh

A study of low flow needs to be much more than this: I give investigation of low flow a high priority, but this is insufficient: should be incorporated in Tim Pickering's project.

John Wright

Worth doing because the data are available, but whereas it may yield some useful pointers because of the large data-set, I suspect that more intensive results from a subset of rivers suffering the impact of low flows will be more informative.

3.3 Option 3: Distribution of the ecological quality of sites in relation to other factors

Patrick Armitage

I am most interested in temporal and spatial change but it needs to be placed in the context of *expected natural variation* . This means that although a comparison of 1990 with 1995 may tell you something it tells you nothing about where these two points are in the 5 year continuum. (Our paper on the 'Eurotunnel' streams addresses this). This may be a good opportunity to encourage the start of analysis of existing long-term data runs?

Analysis in relation to the variables specified (River type - RHS class) should point up some interesting trends. I think this will be the most valuable output of all the suggestions. Note that the link between RHS data and instream ecology has yet to be convincingly demonstrated. I am most interested in this as it has a high degree of relevance to our Frome study.

Sarah Chadd

Interesting but not essential.

Elizabeth Chalk

Application to timing of sampling.

Bob Dines

I am dubious about the value of options 3 and 4. Much of it is the sort of analysis that a Region should be doing, i.e. it is mostly operationally directed. The national and temporal trends would be interesting but I am not sure that the data set is sufficiently extensive, especially temporally, for this to be successful. The ability of samples taken in different seasons to identify trends and changes would be valuable but, of course, we only sampled in spring and autumn. However if we have to do Options 3 & 4 in order to do Option 5, then we had better do them because 5 ranks up there with Option 1. Again, it is the sort of information which would be invaluable on a day to day basis.

Alastair Ferguson

We believe options 3, 4 & 5 these should be linked. We consider these aims to be of high priority.

Peter Hale

Option 5 really follows on from Option 4 and perhaps should be included in a single project. Equally Option 3 could be included in the same project. Both proposals are important.

Paul Logan

With options 3 and 4 I would like to see a comparison between the data and English Natures Natural Areas. I think we should be considering our conservation evaluation of rivers in this context too, see Option 13.

John Murray-Bligh

Builds on work initiated in the Artificial Intelligence project.

Neil Weatherley

Option 3 & 4. Evaluation of fauna in relation to environmental factors in 1995, and 1990 v. 1995. i.e. what's causing the differences between sites and between years. This is fundamental to the management value of the data and may be the top priority. It is important that links to the RHS data are explored as a move towards total ecological quality, the predictive value of the RHS and possible efficiencies through integration.

John Wright

Options 3 and 4 of the highest priority and must be undertaken within this project.

I also agree with the need for a link-up with RHS and have been advocating this, as have others, for some time. Linkages both with the GQA results and also with the RIVPACS III reference sites are needed.

3.4 Option 4: Statistical comparison of change in the ecological quality of individual sites sampled in both the 1990 River Quality Survey and the 1995 GQA

Patrick Armitage

I am most interested in temporal and spatial change but it needs to be placed in the context of *expected natural variation* . This means that although a comparison of 1990 with 1995 may tell you something it tells you nothing about where these two points are in the 5 year continuum. (Our paper on the "Eurotunnel" streams addresses this). This may be a good opportunity to encourage the start of analysis of existing long-term data runs?

Analysis in relation to the variables specified (River type - RHS class) should point up some interesting trends. I think this will be the most valuable output of all the suggestions. Note that the link between RHS data and instream ecology has yet to be convincingly demonstrated. I am most interested in this as it has a high degree of relevance to our Frome study.

Sarah Chadd

Interesting, but there is a danger of creating yet another method of classification and assessing change. It would only be reasonable to incorporate 'efficiency' based on individual laboratories

Elizabeth Chalk

Similar to option 3? Broad group - need to focus. Useful to explore link with RHS, also geology.

Bob Dines

I am dubious about the value of options. 3 and 4 Much of it is the sort of analysis that a Region should be doing, i.e. it is mostly operationally directed. The national and temporal trends would be interesting but I am not sure that the data set is sufficiently extensive, especially temporally, for this to be successful. The ability of samples taken in different seasons to identify trends and changes would be valuable but, of course, we only sampled in spring and autumn. However, if we have to do Options 3 & 4 in order to do Option 5, then we had better do them because 5 ranks up there with Option 1. Again, it is the sort of information which would be invaluable on a day to day basis.

Alastair Ferguson

We believe options 3, 4 & 5 these should be linked. We consider these aims to be of high priority. We are particularly interested in Option 4 and the linkage to the environmental factors listed. Extra considerations could be the pollution incident record at selected sites ie by type, impact, duration etc. and whether there is a long term chemical data set, for example, Harmonised Monitoring sites which have a long term and wide ranging data record.

Peter Hale

In my opinion two options clearly stand out from the rest. These are the detection and quantification of change (Option 4) and the relationship between the chemical and ecological quality of headwater streams and the reaches that they feed (Option 9). The former is attractive because it is integral to classification and the underlying trends that effect real rather than perceived change. Option 5 really follows on from Option 4 and perhaps should be included in a single project. Equally Option 3 could be included in the same project. Both proposals are important.

Brian Hemsley-Flint

An analysis of this element will enable better interpretation of the results of such comparisons in the future.

Shelley Howard

This option was not given a particularly high priority because there was doubt over the quality of the 1990 data. To explore the temporal changes we would prefer use of a selection of sites which have at least two samples every year for a number of years. This could be provided.

Frank Jones

This option important to enable more objective methods of determining significant changes in quality. Quality of data in 1990 for some Regions likely to be a constraint (screen out?).

Anne Lewis

Option 4 is important, although the dubious quality of the 1990 data set may make comparison difficult. I know it does for this area.

Paul Logan

With options 3 and 4 I would like to see a comparison between the data and English Natures Natural Areas. I think we should be considering our conservation evaluation of rivers in this context too, see Option 13.

John Murray-Bligh

Additional option 20 (Chapter 4) is a prerequisite to this.

Neil Weatherley

Option 3 & 4. Evaluation of fauna in relation to environmental factors in 1995, and 1990 v. 1995. i.e. what's causing the differences between sites and between years. This is fundamental to the management value of the data and may be the top priority. It is important that links to the RHS data are explored as a move towards total ecological quality, the predictive value of the RHS and possible efficiencies through integration.

John Wright

Options 3 and 4 of the highest priority and must be undertaken within this project.

I also agree with the need for a link-up with RHS and have been advocating this, as have others, for some time. Linkages both with the GQA results and also with the RIVPACS III reference sites are needed.

3.5 Option 5: The relationship between temporal changes in ecological quality and losses, gains and changing abundance of individual taxa

Sarah Chadd

This would tie in well with Options 1 and 10.

Elizabeth Chalk

Does this option link with others?

Bob Dines

If we have to do Options 3 & 4 in order to do Option 5, then we had better do them because 5 ranks up there with Option 1. Again, it is the sort of information which would be invaluable on a day to day basis.

Alastair Ferguson

We believe options 3, 4 & 5 these should be linked. We consider these aims to be of high priority.

Peter Hale

Option 5 really follows on from Option 4 and perhaps should be included in a single project. Equally Option 3 could be included in the same project. Both proposals are important.

Brian Hemsley-Flint

Although of high priority the analysis will be limited due to the restricted nature of the taxonomic data.

Paul Logan

In Thames Julie Bywater carried out an extensive study of the abundances of the different families in 1990 and a similar list for 1995 would be very useful. Even a simple league table of how many samples each family was found in placed in order is of value.

3.6 Option 6: Incorporation of data into the Countryside Information System (CIS)

Sarah Chadd

Not of direct benefit to PPC in the Agency.

Elizabeth Chalk

Depends how essential this is to address questions asked in other options!

Bob Dines

Providing this can be done relatively easily (I would not want it to take more than, say, 5-10% of the project time) I am all in favour - your points about increasing the availability of data, particularly in DoE circles, are important.

Alastair Ferguson

This option should not be considered at present as the Agency is developing a strategy for GIS and data handling. However it is important that this project is kept informed of progress in this field as it may have a valuable contribution to make to its development.

Brian Hemsley-Flint

A very worthwhile piece of work.

Shelley Howard

Some doubts were expressed over Options 6 & 7 partly because everyone thinks its about time the agency sorted themselves out over GIS policy and are wondering how CIS can fit into any agency plans and whether some of the distribution work is also being done within Bill Walley's project.

Frank Jones

Difficult to see benefits of proposal. No mention of representation of chemical data on maps.

Paul Logan

I like the idea of theoretical taxa distributions but how well will this work at the family level? It may be a good idea to have an expression of river invertebrate diversity in the CIS to give some indication of value.

John Murray-Bligh

I'm concerned about following the CIS route, because I think that GIS is so important to RIVPACS that it must be done properly. If CIS work could serve as a modular building block to full GIS, I would increase its ranking. If taking up this option stifles work in a proper GIS base for RIVPACS, I would rank this, and option 7 last.

John Wright

This is a worthwhile mechanism for making the 1995 GQA results more widely accessible and used alongside other data-sets. Both the incorporation of the GQA results into CIS and the development of maps showing the distribution of taxa in individual 1km squares were within the Environmental Diagnostics proposal.

3.7 Option 7: Development of theoretical taxon distribution maps within CIS

Sarah Chadd

As we have RIVPACS is this really needed?

Elizabeth Chalk

Depends how essential these are to address questions asked in other options!

Bob Dines

Without the other links to river habitat features, I am not sure of the ultimate value of this. I can see the point but I would have thought the information would need amalgamating with RIVPACS, which would be a major project, if it was to be of real value. Perhaps you are just seeing this option more clearly that I am able to.

Alastair Ferguson

This option should not be considered at present as the Agency is developing a strategy for GIS and data handling. However it is important that this project is kept informed of progress in this field as it may have a valuable contribution to make to its development.

Shelley Howard

Some doubts were expressed over Options 6 & 7 partly because everyone thinks its about time the agency sorted themselves out over GIS policy and are wondering how CIS can fit into any agency plans and whether some of the distribution work is also being done within Bill Walley's project.

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John Murray-Bligh

I'm concerned about following the CIS route, because I think that GIS is so important to RIVPACS that it must be done properly. If CIS work could serve as a modular building block to full GIS, I would increase its ranking. If taking up this option stifles work in a proper GIS base for RIVPACS, I would rank this, and option 6 last.

Neil Weatherley

Many would agree with the need to have these data on a GIS such as the CIS. However, I think this might be premature at the moment because the Agency is currently reviewing its data and data handling needs and a new GIS is likely to arise from this. We might therefore have to wait for other decisions before knowing the best way forward.

John Wright

I am not convinced that the use of the land class approach would necessarily provide reliable outputs for theoretical taxon distribution maps which would then have practical application. In the second paragraph, the validity of the outputs would be highly dependent upon the variables chosen, and as in the first paragraph, different stream size categories would have to be stipulated.

3.8 Option 8: Supply of data for IFE studies of the urban environment

Patrick Armitage

This is already underway and we have screened out urban sites from the 1990 set. The Environment Agency have expressed some desire to collaborate with IFE in relation to urban freshwater ecology. Apart from the two data sets I would expect that they would provide information on further surveys and any data relevant to the Urban environment. There may be a case for some extra sampling in specific areas if the money is available.

Sarah Chadd

Relevant to the wider role of the Agency.

Elizabeth Chalk

Important to develop this aspect and links well with NERC work.

Bob Dines

This seems very worthwhile to me and I would give it quite a high priority, but I would question whether it should be part of this project. We will be including time for acquisition and preparation of other data sets in phase 2 - should the NERC study not also allow for this if they wish to use the GQA data set?

Peter Hale

I pass no comments on Option 8 other than in questioning whether or not sufficient data are included in the national database? NI does have BMWP data for a number of urban streams over the past 4-5 years which could probably be made available, subject to the agreement of Environment and Heritage Service.

Brian Hemsley-Flint

An area for collaboration here.

Paul Logan

We can provide the data do we need to do more?

Neil Weatherley

Characterization of urban environments. For environmental and socio-economic reasons this would be a valuable use of data. As most impacts are worst in urban areas, including all the chemicals from small point and diffuse sources that we don't usually monitor, ecological assessment should be a useful tool.

John Wright

Given that this is NERC funded, here is a useful example of the additional uses to which GQA survey data can be put, and where NERC outputs from this programme should be of benefit to the Environment Agency.

3.9 Option 9: Relationship between headwater quality and that of the rivers they feed

Sarah Chadd

Interesting, but are there enough suitable sites?

Elizabeth Chalk

Useful to understand extent of influence of headwaters, but that should not stop us improving them now.

Bob Dines

I rate this high priority provided the GQA site network includes sufficient headwater sites to make it worthwhile. There are probably lots of sites on 1st order streams but I am not sure how many are within 2.5 km of source. Of our 526 GQA sites, 90 are inside 2.5 km and I imagine the majority are 1st order. If this picture is roughly the same for all regions then it is probably a good option.

Alastair Ferguson

We need to examine the link between the proposed project and the headwaters study. How much of the work on headwaters can be linked to the GQA reach network. If this is substantial, then go ahead as a medium priority option.

Peter Hale

In my opinion options 4 and 9 clearly stand out from the rest. Option 9 transcends the boundaries between pollution control and conservation therefore satisfying the combined needs of both lobbies. From my background in pollution detection it is important to have the means to identify problems and quantify their impacts in smaller streams and hence my support for proposal relating to studies of these types of habitat.

Brian Hemsley-Flint

This may be restricted by the lack of relevant data in the 1995 data set.

Frank Jones

Limited by amount of data on headwaters and relative positions of GQA sampling sites.

Paul Logan

I would like to see the data used for protection of headwaters but do we have enough sites in the data set to make this worthwhile?

John Wright

My understanding is that there are few headwater sites within the 1995 GQA data-set. Comparisons made between non-GQA headwater sites (mostly sampled in one season only) and 1995 GQA receiver stream sites may not be ideal. To determine the role of poor quality at headwater sites on the receiver streams also requires knowledge of all other impacts on the receiver streams. That is, reliable conclusions need detailed catchment studies rather than extensive comparisons based on lots of diverse sites.

3.10 Option 10: Evaluation of the performance of the 1995 banding system

Sarah Chadd

I have been leading a Regional operational investigation to quantify the relationship between STW effluent quality and biological quality. This relationship is implicit in the use of macroinvertebrates and the BMWP scoring system. The data set we were able to compile was not sufficiently large, nor covered a wide enough range of effluent impacts, to be able to describe a clear relationship. One suggestion was to compare biological and chemical GQA data in order to define the relationship. The GQA data set offers an opportunity to look at a large number of sites, covering a wide range of chemical quality based on the key effluent determinands (DO, BOD and ammonia) where biology and chemistry sampling points are suitably matched. Perhaps this could be undertaken under Options 1, 5 and 10 combined?

Elizabeth Chalk

This sounds as if it ought to be important! Personally, think abundance should be explored.

Bob Dines

A must-do. Part of the overall objective of the project is to refine the methodology for future surveys and this is it!

Alastair Ferguson

We don't feel that this option should be considered at present. We believe that the bandings should be left as they are for the time being, to enable us to evaluate results over the next few years based on the 1995 baseline, as the most complete and robust data set. We are also sceptical about the linkage between the chemical and biological bandings, as they are designed to meet specific aims. For example the chemistry is assessed over three years, for good statistical reasons, while biology is based on one years data. It may be misleading to draw too many conclusions from such a comparison.

Peter Hale

While I totally agree that any future classification scheme should include relative abundance data, I wonder how often we can change the classification system without being accused of cooking the river environment books. However if that is the way the EA see river biology progressing then I would assume that Scotland and Northern Ireland will ultimately go the same route if we are involved throughout the development process.

Shelley Howard

This option was considered important, particularly the work to incorporate abundance factors. However this region would like to see some work on the use of single season samples over a longer period of time, e.g. average value over three years but this would require data to be provided for other years. This region could provide this data for most of the GQA sites. It is thought that the use of multiple single sample assessments would have more applicability operationally and in LEAPS etc. This would also ease use of abundance within assessments.

Frank Jones

Important to fully evaluate biological classification system.

Paul Logan

This would be especially useful in the context of the work I have been doing with standardisation. For me this is a high priority.

John Murray-Bligh

To be attempted once revised BMWP-score system has been devised: low score because not a priority yet: but once new system has been devised, a top priority.

I don't think that we should evaluate the performance of Q14 without comparing it with Bill Walley & Bert Hawkes' quantitative derivative of ASPT. There is no point in comparing it with Bill & Bert's existing quantitative ASPT because this was never intended to be definitive, and is best viewed as interim. I suspect that both may be useful, but that they may indicate different things. I suspect we may get more out of both if they were complementary rather than developed to measure the same or overlapping phenomena. Both of them need to be considered with N-taxa. Low N-taxa and low abundances is associated with different quality determinants than low N-taxa and high abundances.

What is definitely needed is a protocol for dealing with abundance for combined seasons data. This may require a re-think of how season's data is combined at the moment. It may be better not to simply pool it as this looses information. Maybe a sum and variance, 3 * 1 or 3 * 3 matrix or a 3-axis vector may be best for each 3-season parameter.

I proposed that IFE should do this in the proposed project to re-appraise BMWP-score system. It would enable Q14 to be used in GQA situations, as well as quantitative ASPT. Maybe we need quantitative N-taxa too.

Neil Weatherley

Evaluating the biological banding system. Having not been involved in the development I'm not sure how confident we are of the system but it would seem important to ensure that we review it and gain a better understanding of the links to the chemistry GQA.

John Wright

There are several separate issues here.

1. On the question of development of banding systems, I understand your unease over a new system in which the detailed basis on which it has been developed has not been made explicit. On the other hand, as long as the lower limit of band A is well chosen and there aren't so many additional bands that between-year changes in banding are mainly due to noise, then the main thing is to stick to the same protocol in later years to allow valid year by year comparisons.

2. Distribution of taxa by chemical and biological bands plus chemical band within each biological band. Worth doing, but surely, there is a limit on the extent to which the patterns can be interpreted without examining the data on a site by site basis.

3. Add-on value of Q14. I am very keen to see this area explored and as you know, this is part of the future RIVPACS proposal. The first thing to be done within the new RIVPACS project will be calculation of the critical limits for Q14 based on the 614 RIVPACS III sites. This, coupled with the development of one or two more indices of the form W(B1,B2), followed by testing have always been seen by Brian Hemsley-Flint as important items to be addressed early on in the new project. (Once complete, I would like to seen this written up for publication in a scientific journal).

3.11 Option 11: Relationship between environmental factors and family richness

Patrick Armitage

Options 11 and 12 are likely to produce some interesting characterisations but will I am sure require some habitat specific studies in the selected areas. (As in our mesohabitat studies and Harper's work).

Sarah Chadd

Interesting, but I believe that conservation value is far better based on species presence and richness. Although family richness obviously reflects this to some extent I feel that it is too coarse a tool for assessing conservation value.

Elizabeth Chalk

Important in biodiversity/conservation terms.

Alastair Ferguson

We are particularly interested in the set of options 11-15.

Brian Hemsley-Flint

Although of high priority the analysis will be limited due to the restricted nature of the taxonomic data.

Frank Jones

Should lead to improvements in predictive capacity for these sites.

Paul Logan

Is the family a sensible taxon to investigate in this way?

Dave Lowson

Options 13 and 11 could be combined.

Anne Lewis

I have a potential worry about Option 11. There is an understandable tendency among biologists to equate increasing richness and diversity of invertebrate fauna with high quality. I suspect that in oligotrophic waters, low level nutrient enrichment causes a "blooming" of the invertebrate fauna which should not necessarily be considered desirable or natural - whatever that means.

John Murray-Bligh

To be attempted once revised BMWP-score system has been devised: low score because not a priority yet: but once new system has been devised, a top priority.

John Wright

I have an active interest in this topic through the RIVPACS/National Database information and through work done for the Conservation Agencies.

We know the mean taxon richness per RIVPACS III classification group and have probed the relation between 'species', family and BMWP family richness (3 seasons combined) for the 614 RIVPACS III sites in a recent manuscript presented at the 1995 SIL Congress (currently in press).

New insights are now required on those particular environmental features which promote high taxon richness. The raw data for such an exercise could include appropriate sites from RIVPACS III but also a subset from the 1995 GQA survey. This work is not within a future RIVPACS contract, but I would envisage it being part of the future work within T04053Z2. A RIVPACS-River Habitat Survey link might prove to be useful along with the use of GIS to enable us to draw on a wider range of site/catchment attributes.

3.12 Option 12: Substrate/habitat diversity in relation to family richness

Patrick Armitage

Options 11 and 12 are likely to produce some interesting characterisations but will I am sure require some habitat specific studies in the selected areas. (As in our mesohabitat studies and Harper's work).

Sarah Chadd

Better based on species presence and richness.

Elizabeth Chalk

Not so critical - overlaps with option 11?

Brian Hemsley-Flint

Although of high priority the analysis will be limited due to the restricted nature of the taxonomic data.

Alastair Ferguson

We are particularly interested in the set of options 11-15.

Paul Logan

Is the family a sensible taxon to investigate in this way?

Dave Lowson

Options 2 and 12 could be combined to consider the effects of flow extremes (not just low flows) together with substrate structure and stability.

John Wright

Given the importance of substratum, it is worth a try. Would you examine the results for each RIVPACS classification group (or supergroup) separately?

3.13 Option 13: Identification of national reference sites

Patrick Armitage

Long data runs yes but choice of sites should include longitudinal series ie whole river length. Information from a single site on a river system will reveal change but will not help to explain the reasons underlying the change.

This links to option 14.

Sarah Chadd

Good first step in identifying important sites. Care is required not to overlook sites which are relatively poor with respect to taxon numbers but have rare, restricted fauna.

Elizabeth Chalk

Links to option 11, and completed headwaters work. Appropriate timing in relation to current interest in biodiversity.

Alastair Ferguson

We are particularly interested in the set of options 11-15. Any help in identifying reference sites is welcome. We will be reviewing the whole monitoring network in the future, with a particular emphasis on selecting sites for total ecological assessment.

Brian Hemsley-Flint

This analysis will be limited due to the restricted nature of the taxonomic data. I suspect also that the samples from 1990 will not be in the condition necessary for further identification.

Frank Jones

Is the quality of 1990 samples good enough (specimens may be damaged by initial sort?) for specimens to be identified to species level? Is repeat sampling a better option?

Paul Logan

This option is important to feed into biodiversity work and well worth doing.

Dave Lowson

Options 13 and 11 could be combined.

Neil Weatherley

Identification of national reference sites. Our current review of all monitoring being carried out by Alistair Ferguson et al. will determine whether we want to establish a new reference network of some kind. I think there could be a good case for this and if so this option could be part of the development.

John Wright

I am unsure whether the need for this has been thought through and whether two season BMWP data can deliver what is proposed. Recognition of 'high richness' has to be on the basis of high richness for a site of a given type. Presumably this is implicit in the suggestion of having representative sites for each RIVPACS group. As for making decisions on future SSSIs, the Statutory Conservation Agencies have to take on board many considerations, and in future I assume that SERCON will play an increasing role to ensure that a wide range of attributes are incorporated into the decision-making process.

I can see that there could be merit in flagging high richness sites in Local Environment Agency Plans but (now playing devil's advocate!) why should high richness sites be added to the ECN suite of sites rather than sites of average richness.

3.14 Option 14: Longitudinal patterns of zonation/community structure

Patrick Armitage

This relates to the Urban links and to option 13. "Longitudinality" is a thread which runs through most of the projects. Hopefully the 1990 and 1995 data-sets will have good series of samples taken along rivers.

Sarah Chadd

Interesting and probably useful in providing proof of what experienced biologists know already.

Elizabeth Chalk

Too general a description. Best focused on headwaters at present?

Alastair Ferguson

We are particularly interested in the set of options 11-15.

We will be reviewing the whole monitoring network in the future, with a particular emphasis on selecting sites for total ecological assessment. Option 14 in particular could give us valuable information to help us in the selection process.

Other initiatives could tie into this area of research. For example in another R&D project, Improved Environmental Monitoring, software is being written to examine spacial trends along a river, based on biological parameters. (Lapwing for Biology). This tool, when available, could help in identifying sites along rivers which are key indicators of a change in quality. We would also like to look at how representative a site is of the reach it is supposed to characterise. We would need to select reaches where there is data at more sites that just the GQA sampling point, and compare the results. We realise that extra monitoring may be needed to meet this aim.

Paul Logan

This option links with work already being undertaken in Austria and could provide a basic building block for our theories on how river ecosystems work. In this work it would be interesting to see how feeding strategies change downstream (can this be done at family level?)

John Wright

Within T04053Z2 we have plans to undertake this approach using at least the RIVPACS III data-set. The analyses would be at 'species' level

Within the future RIVPACS contract we plan to examine the 614 RIVPACS data-set to look for pattern in the occurrence of macroinvertebrate assemblages and functional groups (FTGs) in relation to a series of environmental variables.

Allied studies based on the GQA data-set (limited to the sites in the highest quality band?) at BMWP level would be of considerable interest.

3.15 **Option 15: Definitions of environmental niches of individual taxa and faunal assemblages**

Patrick Armitage

This relates to option 1 above. I really can't see the RIVPACS data being used to describe environmental niches of species except in very crude terms. However the habitat requirements of a site specific (as opposed to habitat specific) faunal assemblage may be a useful goal. It's basically what RIVPACS does and its hard to see how "fundamental understanding" of the nature of faunal assemblages would be increased.

A tighter description of faunal assemblages with site variables could be worthwhile.

Sarah Chadd

Interesting, but again usefulness is restricted by family level data.

Elizabeth Chalk

I suspect this could be important - need to expand ideas.

Alastair Ferguson

We are particularly interested in the set of options 11-15.

Brian Hemsley-Flint

Nice but does not have immediate operational relevance.

Frank Jones

Taxon level (family) and precision of environmental descriptors likely to constraint in developing PHABSIM type model.

Paul Logan

Is the family a sensible taxon to investigate in this way?

John Wright

I have given this a low priority, not because I don't think it is important, but because I would anticipate that the Environment Agency would expect NERC to take the lead on such a topic. In addition, I'm not convinced that we have the appropriate environmental data for this type of exercise and given that the GQA data are at BMWP family level, we can't determine the requirements of individual taxa.

4 ADDITIONAL OPTIONS RECOMMENDED BY THE CONSULTEES

4.1 Option 16: The effects of particular pollutants. (Shelley Howard)

More generally, there is a need to explore the effects of certain types of pollution such as acidification, eutrophication, pesticides, metals, ammonia, on the EQIs and to develop the ability to predict the change in the fauna and the EQI if a consent is varied or new input anticipated.

This links to Alastair Ferguson's comments under option 4 and to the following suggestions which are incorporated under the same option although the Project Board may wish to disaggregate them again.

(Brian Hemsley-Flint): It would be useful to analyze changes in taxa/quality with different types of discharges/pollutants, e.g. size of sewage works & stream size; minewater discharge; heated effluents; pesticides; etc. on a national scene. Could this be an added option, Mod-High priority.

(John Murray-Bligh): It would be of great value if the reasons for poor biological quality (and maybe also exceptionally high biological quality) were known for every site in the 1995 survey. This task will help in the development of dirty water RIVPACS, the next stage of the Artificial Intelligence Project, and further refinements of BMWP-score system.

I undertook precisely this exercise whilst I was in South West Region for the Regional report of the 1990/91 survey, so I know that it is feasible. Regional and Area biologists will presumably have to do the same for 1995 anyway. Sources of information include the biologists' sample and site comments, and information from wardens and water quality officers.

The activity or industry causing the problem, nature of pollutants, duration/periodicity, and an evaluation of the severity would be useful. Physical habitat degradation such as channelisation should also be recorded.

After this, I would use pattern recognition (AI or other) to recognise faunal assemblages associated with each natural / pollution type and severity combination.

I would put this suggestion as the highest priority for further analysis of 1995 data, followed by revision of BMWP-system and then by the IFE options 10 and 11.

(Phil Smith via Bob Dines): Identification of the causes of poor biological quality at sites falling in the worst two biological classes. This relates to the 1997/8 Corporate Plan objective to "bring about a reduction in the length of river and canal in the worst two classes by around 20% .....between 1 April 1996 and 2005". *(Comment from Bob Dines - "Again, I suspect this is more operational than R&D.")*

4.2 Option 17: Assessment of the extent of eutrophication and other chemical impacts (Tony Warn)

Could there be scope to examine overlays of P, N, DO, BOD, ammonium on biology and to tease out the impact of P (eutrophication)?

4.3 Option 18: Assessment of extent of acidification (Frank Jones)

There are sites in Welsh Region (and doubtless elsewhere) where alkalinity has been reduced by surface water acidification. This RIVPACS gives a lower prediction of taxon richness than might be expected if alkalinity were at a "natural" level. This leads to EQI's which do not fully reflect the impact of acidification. The extent of this problem could be assessed and a policy could be defined for dealing with such sites.

4.4 Option 19: The reasons for differences between biological and chemical site evaluations (Phil Smith via Bob Dines)

Comparison of biological and chemical class, and analysis of reasons for differences, at 1995 survey sites. This would involve liaison with operational Environment Agency staff and, in highlighting what the biology tells us that the chemistry doesn't, would clearly show that the biology adds another dimension to the chemical classification. *(Comment from Bob Dines - "I am not sure whether this is R&D or an operational job for the Agency. If it can pull out general conclusions (e.g. the link between poor chemistry and slow flowing rivers with DO/BOD problems) it could be useful.")*

This option could be considered an integral part of consultation option 10.

4.5 Option 20: Comparison of 1995 with 1990 results (John Murray-Bligh)

This needs to be investigated further with a view to deriving a robust protocol for analysing changes in quality observed in quinquennial surveys. Measuring these changes are the key purpose of the surveys.

Tony Warn has gone a considerable way down this route, and the error module developed for RIVPACS will also be of great help in the future. What has not been done yet is to screen the data used in these surveys to ensure that only changes in biological quality owing to changes in water quality are reported. Such a protocol will be needed for all future surveys.

There was a substantial revision of the monitoring network prior to the 1995 survey. The 1990 survey was the first major survey to which RIVPACS was applied, and some of the sites were not ideal for RIVPACS. These sites have been replaced by sites which better monitor the quality of the stretch / reach that they are intended to characterise.

We need a ranked list of upgrades/downgrades in EQIs (or better still, class), and in RIVPACS predictions.

A ranked list of RIVPACS suitability would also provide useful information. Bill Walley may be able to determine combinations of characteristics which are unusual or dissimilar to those in the original RIVPACS data set. This would not only indicate which sites may have produced less reliable survey results, but would also highlight site types that should be targeted for inclusion in future versions of RIVPACS.

Many of the upgrades (and possibly a few downgrades) are likely to be because sites monitoring the stretches were changed.

This list would indicate clearly the magnitude of the problem, if any exists, in using 1995 predictions on 1990 data for assessing changes in biological quality for the 1995 survey, which was perceived by the biologists.

Comparison of this list with the class upgrades / downgrades would be very useful for removing howlers, i.e. significant up or downgrades owing to movement of the site, independent of water quality.

Such a list would substantially reduce the work that biologists will have to do to check that the site characteristics are the same. Sites with very different predicted values could be stripped-out automatically.

Abnormal 1990 sites, such as Welsh Region's brackish water 1990 sites which were replaced by freshwater ones in 1995, should end up high on the lists. Conversely, sites that Regions are concerned about, but where predicted values are similar and there are no water quality problems (such as 1990 site downstream and 1995 upstream of a sewage works) could be left in. We don't want holes in the data unless there is good reason.

What is a significant difference in RIVPACS predicted values? This would be useful to know, because it is inevitable that sites will sometimes have to be relocated.

This could be decided on looking at the lists, having first stripped out data for reaches where the biological site had changed. It could be done according to: a) cause class change b) outside 95% confidence limits given by RIVPACS c) don't bother defining anything: use biologist's opinion as to where effects start.

This suggestion is considered by John Murray-Bligh to be a pre-requisite to any analysis of changes in biological quality between 1990 and 1995 (consultation options 4 and 5).

4.6 Option 21: Use of GIS in RIVPACS (John Murray-Bligh)

Investigate whether GIS could replace all environmental data in RIVPACS.

This option may better be accommodated within IFE's RIVPACS R&D programme with the Agency.

4.7 Option 22: Benefits of collecting additional information in 1995 (John Murray-Bligh)

Look at additional data collected by individual Regions to evaluate the usefulness of collecting this additional data (CDC index NW); abundance categories other than log (Midlands, Thames, North West) further taxonomic differentiation (NW, Midlands, others?); identification of other taxocenes (macrophytes, algae, environmental data).

Some of these measures may be useful in evaluating the banding system used in the 1995 GQA.

4.8 Option 23: Analysis of the 1995 quality audit data (John Murray-Bligh)

To try to determine the factors that influence analytical quality. It is important to know what causes poorer quality, so that the overall quality of the Agency's work can be improved. There are a multiplicity of factors that should be investigated, such as geography, site type (RIVPACS class), analyst's experience, workload, specialisation, live/dead analysis. Most of the data needed for such an analysis has been collected. Particular account should be given to the performance of biologists moving to different laboratories.

4.9 **Option 24: Publish the results of the biological and chemical 1995 survey (John Murray-Bligh)**

This will enhance our influence in Europe by providing a clear demonstration of the benefits of the methods that we have adopted. The non-publication of such a report in 1990 (for biology) and 1995, and in particular the statistical aspects of the 1995 survey, will not assist in our promotion of RIVPACS.

4.10 **Option 25: Correction of the GQA database (John Murray-Bligh)**

Bill Walley has identified a large number of errors and potential errors in the biological and chemical databases. These need correction, by EA staff, followed by re-auditing to ensure that errors have been corrected. More important, we need to ensure that chemical site NGRs are corrected. Rivers group decided that they did not want to take this work on. A good quality database is vital.

This suggestion is a prerequisite to any comparison of biological and chemical quality, or investigation into spatial and temporal distributions, if a full data set is desired. Bill's "Match database" may serve in the interim.

This process is believed to be underway.

4.11 **Option 26: Determination of analytical quality targets (John Murray-Bligh)**

Could we use the error module in RIVPACS to determine what our analytical quality target for BMWP sorting and identification should be? If we could, I think that this would be a useful exercise. The current target is not based on an analysis of what we need to achieve, but on other criteria (see R&D Project Record 504/6/S).

4.12 **Option 27: Determination of downstream limits for the ecological evaluation of ecological quality using freshwater macro-invertebrate assemblages (Shelagh Wilson via Bob Dines)**

Would it be possible to look at the downstream end of rivers to see if there is a boundary below which the inverts type quality assessment breaks down?

Bob Dines believes she is thinking of rivers such as the Great Stour where there is no physical tidal limit.

5 GENERAL COMMENTS

Elizabeth Chalk

Four general comments were made.

- Some options appear to overlap and quite difficult to tease apart.
- It is difficult to 'size' each option.
- The Agency need to get most out of collaborative opportunities.
- Each option needs to be expanded to detail key outputs, purpose and application.

Shelley Howard

There was no indication on the list of the time required for each option, there may be a need later on in the project to reassess the priorities if the work has to be limited. However, if you require clarification of these comments or additional data for the years 1991 to 1994 for the temporal work, let me know.

Bob Dines

I am concerned at your concerns about our lack of a sensible site coding system.....and completely agree with you. I attended a meeting last week - part of the input to a National Project to guide Agency IS strategy - and I raised exactly this question. If we are ever to do more with our data than just stick it on an archive and forget it, a river coding system is essential. And this applies to all the "water" functions of the Agency.

Should an initial step in Phase 2 be for you to code all the GQA sites? Is this feasible? How long would it take?

Neil Weatherley

I favour what appear to be the more immediately practical options as I think that further analysis of the basic data, though important, can come later, or perhaps be done under alternative funding. This data set is a huge resource and I hope wide use can be made of it.

APPENDIX 1

The full text of the consultation document

ANALYSIS OF 1995 BIOLOGICAL SURVEY DATA - LISTING OF OPTIONS FOR ADDITIONAL USES OF THE DATA-SET

by Mike Furse and Ralph Clarke (IFE River Lab)

INTRODUCTION

During the 1995 General Quality Assessment (GQA) macro-invertebrate samples were collected from a substantial number of running water sites throughout Great Britain. The exact number is not known but it is likely to be equal to or greater than the 8,600 sites, including 7,633 in England and Wales, reported to have been sampled in the 1990 River Quality Survey (RQS). Many sites were common between the two surveys.

Supporting environmental data were collected from each biological sampling point, including National Grid Reference, distance from source, altitude, slope, discharge category, width, depth, surface velocity and substratum composition.

During both surveys substantial chemical sampling also took place. Chemical and biological sampling sites were often not at the same location although attempts have been made to relate pairs of chemical and biological sites to defined sections of river, or "reaches". Some chemical sites have been matched to more than one biological site and vice versa.

The macro-invertebrate data collected from each site were used to evaluate the biological condition (= ecological quality) of the reach. The software package, RIVPACS (River In-Vertebrate Prediction and Classification System) was used to make evaluations. These were based on the ratios of the observed to expected (ie RIVPACS predicted) Biological Monitoring Working Party (BMWP) index values. Separate ratios were calculated for BMWP score, number of scoring taxa and Average Score Per Taxa (ASPT). Each ratio was termed an Environmental Quality Index or EQI. In this process expected index values were derived through use of the environmental data collected for each site, including measured or derived values of total alkalinity.

EQIs were sub-divided into value ranges or bands of ecological quality. EQI bands for individual BMWP indices can be integrated into an overall band of ecological quality for a site. Different band widths and procedures for their amalgamation were used for the 1990 RQS and the 1995 GQA.

Between these two national surveys the National Rivers Authority (NRA) commissioned the Institute of Freshwater Ecology (IFE) to undertake research on the errors, variation and biases associated with collecting, identifying and interpreting the biological material and measuring the environmental data used for assessing the condition of reaches.

This research is now complete and has provided mechanisms for attaching variance terms to EQIs, for assigning sites to bands of ecological quality in a probabilistic manner and for assessing whether there has been a statistically significant change of ecological quality and banding between sites or at the same site over time.

RIVPACS III, the version used in conjunction with the 1995 GQA, is currently being modified by the IFE to incorporate a module for calculating error terms and for making statistical comparisons between sites.

The data collected during the 1990 and 1995 survey are stored in a central data-base held by the Thames Region of the Environment Agency. Beyond the use of the biological data for evaluating the condition of sites, no other systematic national use of the extensive data holding, which includes family occurrences and, often, abundance values, has yet been made.

This document includes a preliminary listing of the potential further uses which can be made of the data and forms the initial contribution to a scoping study on the subject. The following list is not considered to be definitive. It is intended as a discussion document for circulation within the Environment Agency and Agency staff are invited to comment upon the options presented within it. They are also invited to submit outlines of alternative suggestions and new lines of research which will enable the Agency to maximise the value of the data in support of their core functions.

This scoping study and the upgrading of RIVPACS III to incorporate the "errors module" form the two parts of an Agency R&D project with the IFE entitled "Analysis of 1995 Biological Survey Data and RIVPACS Upgrade".

OPTIONS FOR FURTHER USE OF THE 1995 GQA MACRO-INVERTEBRATE DATA

Distribution of taxa in relation to other factors

The use of the 1995 GQA macro-invertebrate sampling programme only to index and band the ecological quality of sites fails to take advantage of the substantial information held on the distribution and relative abundance of the full range of aquatic macro-invertebrate families

OPTION 1 *To obtain a better understanding of the environmental factors which govern the distribution of taxa.*

Knowledge of the environmental range and tolerances of individual taxa is fundamental to interpretation of the results, not only of GQAs but of a wide range of environmental stresses and pollution incidents investigated by the Agency. This is demonstrated by the development of specialised algorithms to detect the impact of specific stresses such as acidification and diffuse agricultural pollution.. Yet no clear documentation exists which draws together the known ranges and tolerances of individual taxa in a coherent and concise fashion.

The 1995 GQA data provides the ideal data-set for developing the basic framework of such a document at the BMWP family level which can later be amplified with specific species level information from other sources.

The most relevant factors for each species are likely to be:

- RIVPACS predictor variables
- Pairs and other combinations of RIVPACS variables
- Chemical determinands (from the chemical survey and other routine Agency analytical programmes)
- Site/catchment geology, soil type and land cover
- Season

Impact of low flows

One environmental factor which has assumed particular concern in recent years is low flow.

OPTION 2 *To examine the impact of low flows on the distribution, frequency and abundance of individual taxa and on the ecological quality of individual sites.*

The programme would examine spatial differences between rivers differentially impacted by the drought in 1995 and temporal differences between sites sampled in both 1990 and 1995.

Selection of rivers would be based on directly gauged discharge, wherever possible, and comparisons between the 1995 annual mean flows and long term averages for the same gauge sites. It would take account of differences in analytical quality control and regional audit results in different regions and between surveys. It would also need to take account of any compounding, independent environmental stress in the selection of sites for comparison.

Evaluation of temporal and spatial changes in the biological condition of sites

The main purposes of national surveys are to periodically evaluate the condition of watercourses on a national basis and to assess changes in condition between surveys. The development of firstly the BMWP score system and secondly RIVPACS has provided far greater credibility to biological assessments of watercourse condition than had been achieved prior to 1990.

OPTION 3 *Evaluation of the distribution of the ecological quality of sites in the 1995 GQA in relation to a range of environmental factors.*

Option 3 provides a means of making spatial comparisons between sites sampled within the same year. Now the development of the errors module within RIVPACS allows more meaningful temporal comparison of biological samples than has been possible hitherto.

OPTION 4 *Comparison of samples collected at the same sites in the 1990 RQS and the 1995 GQA in order to detect and quantify significant changes in the ecological quality of sites.*

Some of the error terms developed for the NRA/Environment Agency by IFE have already been adopted for use in the report on the 1995 GQA, and have been used to present changes in the ecological quality of sites between 1990 and 1995. However the current project provides scope to examine trends and changes in far greater detail than is possible in the GQA report.

Comparisons can be made between sites sampled in different seasons or combination of seasons providing sampling has been undertaken using standard RIVPACS methodology. If required, comparisons can take account of different known levels of sorting and identification efficiency, as assessed by internal and/or external auditing of performance. The extent of changes can be expressed at different levels of probability. The analysis of change will provide a more thorough assessment of local and national trends than was previously possible.

Once meaningful spatial and temporal comparisons are available on a site-by-site basis then any regional trends or temporal changes, including seasonal changes of quality within a given survey year, can be examined in relation to a number of external factors. This will provide a sounder basis for use of the data for other purposes, such as the development of Local Environment Agency Plans (LEAPs).

Amongst the many background variables against which the ecological quality of sites can be assessed, the following are prime candidates:

•River type

Are problems concentrated in particular types of river such as low alkalinity moorland streams, small lowland watercourses, chalkstreams, individual RIVPACS groups, etc.?

•Distance from source.

Is there a tendency for the most significant changes to be taking place near to or far from source? Are there particular problems with headwaters, middle reaches or large slow flowing rivers?

•Geology and soil type

Is the poorest ecological quality and are the greatest temporal changes occurring in catchments of particular geological or soil types? If so, what are the underlying causes?

•Land cover

Diffuse and point source pollution from agriculture can have important repercussions for the biological condition of watercourses. Can recent trends in changing ecological quality of streams be associated with particular types of agriculture and changing patterns of land cover? If so, what are the implications for targeting pollution control and for managing sustainable agriculture within an ecologically acceptable framework?

•River Habitat Survey class

In addition to national surveys of the ecological and chemical quality of rivers, the Environment Agency has made substantial investment in a new form of national survey, the River Habitat Survey. RHS is a more holistic appraisal of the condition of the entire river corridor, including the water course and its riparian zones. It is strongly conservation-centred. In order to maximise the return from the investment in both the GQA and River Habitat Surveys it is suggested that changes in ecological quality of the watercourse are analyzed in relation to the results of the RHS programme in order to examine the links between the two.

Trends in family loss/gain with changes in biological condition

Closely allied to changes in indices of overall biological condition are changes in the occurrence of individual families.

The data-sets for the 1990 RQS and the 1995 GQA provide information on changes in assemblage composition as well as overall biological condition.

OPTION 5 *An examination of the relationship between temporal changes in ecological quality and the losses, gains and changes in abundance of individual families.*

Which families are lost and gained as the ecological and/or chemical quality of watercourses change? Are the gains as conditions improve mirrored by identical changes as conditions worsen or are the rates of deterioration different from the rates of recovery? Are there different regional patterns of taxon losses and gains for the same degree of change in ecological quality? Which taxa appear to be declining or increasing in frequency of occurrence and can these changes be linked to quantifiable changes in features of their immediate habitat or of the site catchment?

How can these changes be used to predict changes in the composition or relative abundance of faunal assemblages in response to an anticipated change in environmental conditions (eg the improvement of effluent quality from a known discharge, reduction in flow due to abstraction)?

Incorporation of GQA data in the Countryside Information System (CIS)

In many of the previous options reference has been made, directly or indirectly, to geology, soil type and land cover. The examination of the role of these factors is best achieved by use of a Geographic Information System (GIS). The cost of both acquiring and holding geological, soils and land cover data and for developing the GIS would be relatively high. An alternative is to make use of the Institute of Terrestrial Ecology (ITE) Land Classification and the CIS software package.

OPTION 6 *To incorporate the results of the 1995 GQA in the Countryside Information System (CIS)*

The CIS is a software package developed largely through Department of the Environment (DoE) funding and is likely to be influential in their policy forming procedures. It was originally designed to carry, display and analyze the results of the Countryside Survey 1990. Since then its remit as a data platform has considerably widened.

The system is based on each 1km square in Britain being allocated to one of 32 land classes devised by the ITE. Specific survey and census data can be held for each square or each square can be assigned the Land Class mean value for an attribute (eg average percentage cover of wheat or average frequency of occurrence of a given animal).

In addition to carrying summary statistics on the land cover of each class, the CIS can also be used as a mechanism for carrying a substantial range of other land class mean, survey or census statistics, including geographical, ecological, sociological and economic factors. It can also carry the 1990 Land Cover Map of Great Britain, developed by ITE from satellite imagery, and any other information that can be expressed on a 1km square basis. The distribution of taxa and the location of sites and their ecological quality could be mapped for individual 1km squares, or expressed as land class means. Either form of data could be displayed and interpreted against a back-drop of the other forms of data the system can hold.

CIS thus acts as a more accessible and less expensive form of GIS which can not only provide a vehicle for carrying the results of the 1995 GQA but also as a mechanism for interpreting their results in relation to other factors. The inclusion of the results of national river surveys will increase the likelihood that these will be taken into consideration in DoE policy developments.

OPTION 7 *Development of theoretical taxon distribution maps within the Countryside Information System (CIS)*

The CIS allows data to be held on a given attribute for each 1km square in Great Britain. Amongst the land class mean data which could be held for each square are the probabilities of capture of each family of aquatic invertebrates in any watercourse in that square. The probabilities of capture of taxa in streams of different size categories (eg headwaters, upper reaches, middle reaches, lower reaches) could be held separately. National probability of capture maps could be developed for each principal taxon. These could be compared and contrasted with the observed mean frequency of capture of each taxon in each category of river size in each land class. Areas where particular taxa are under the most severe pressure can hence be mapped.

Given knowledge of the soils, geology, altitude etc of each square, habitat suitability models could be developed which allow more detailed maps of probability of capture under unstressed conditions to be developed, in a manner akin to graphic RIVPACS predictions.

In addition to helping interpret survey data these forms of output would be useful in the broader aspects of Agency work, such as developing LEAPs.

Distribution of taxa in the urban environment

The Countryside Survey series provides a substantial body of information on the state of the British Countryside. However, the surveys paid relatively little attention to large urban areas for which a specific classification system had not been developed.

In an attempt to rectify this omission and to develop a better understanding of the urban environment, the Natural Environment Research Council (NERC) is funding a new study entitled "Environmental Characterisation of Urban Environments". The programme will involve three component institutes of the Centre for Ecology and Hydrology, IFE, which will be responsible for studies of urban waterbodies, ITE and the Institute of Hydrology (IoH).

The main aim of the study is to:

> "develop a stratification of urban areas based on geographical, socio-economic and environmental characteristics which takes account of pattern and scale and which will provide a framework and stimulus for urban ecosystem process studies and for the management of urban areas in an ecologically sustainable manner"

The research programme includes the recognition that:

> "developing a stratification of urban environments based on an improved understanding of the relationship between occurrence and pattern of particular land and water cover types and their associated floras and faunas is an appropriate first step in the development of a comprehensive urban ecosystem study"

An improved understanding of the processes governing sustainability of the urban environment has practical operational benefits for the Environment Agency. The aims of the NERC research programme would, in turn benefit greatly from the availability of a consistent, quality-controlled data-set of macro-invertebrate information from a wide variety of urban watercourses. The 1995 GQA data can meet that need.

OPTION 8 *To develop a sub-set of the 1995 GQA macro-invertebrate survey containing sites in the urban environment and to apply those data to the objectives of the NERC "Environmental Characterisation of Urban Environments Programme" in order "to develop and extend the interdisciplinary knowledge base required to plan and achieve more sustainable urban environments".*

The impact of loss of quality of headwaters upon their receiver streams

Recent findings of the "Faunal Richness of Headwater Streams" project have shown that these small watercourses, within 2.5km of source, are in generally poorer biological condition than the downstream reaches that they feed. In reports emanating from that project it has been postulated that the water quality of headwater sites will have a detrimental impact on their receiver streams. The extent to which this is true and the magnitude and nature of that impact upon faunal assemblages can be examined in detail using the results of the 1995 GQA.

OPTION 9 *An examination of the relationship between the chemical and ecological quality of headwaters and that of the downstream reaches that they feed*

Evaluation of the biological banding of sites

Considerable effort and inter-change of ideas and viewpoints went into the development of bands of ecological quality of sites based upon EQI value ranges for ASPT and number of scoring taxa. Similar attention was given to the integration of the two separate EQI bands into an overall biological banding for the site. A text description was developed for each of the overall bands based on presumed features of the macro-invertebrate assemblages at each band level.

The mathematical band ranges and text definitions devised for the 1995 GQA have not been subjected to an *a posteriori* evaluation of their adequacy for the purposes of the survey.

OPTION 10 *To evaluate the performance of the biological banding system devised for the 1995 GQA as a means of assessing the ecological quality of sites and for representing definable changes in the structure of macro-invertebrate assemblages.*

This option would also include an analysis of the separate distributions of taxa by chemical and biological bands and also the distribution of taxa by chemical band within each biological band to better understand the relationship between the two banding systems and the mismatches that arise between them.

Comparison will also be made between the biological bands based upon EQI values and the values of the abundance index Q14, included in RIVPACS III, and any other appropriate abundance-based banding system.

Assemblage structure

The 1995 data-set would enable features of assemblage structure other than individual taxon distribution and ecological quality to be examined in relation to environmental factors. Only sites of the best ecological quality would be used in analyses.

OPTION 11 The relationship between environmental factors and family richness

Earlier analyses of the RIVPACS data-set and of the macro-invertebrate data collected as part of the "Faunal Richness of Headwater Streams" project highlighted the fact that several sites had exceptionally high taxon richness, even in relationship to the RIVPACS predictions for sites of their own environmental type. The causes of exceptional species richness are not well understood but are significant in the light of the Agency's duty to "further conservation".

The 1995 GQA data-set, together with supporting environmental and chemical data, provide good opportunities to examine the distinctive features of family-rich sites and to start to develop predictive models.

This programme overlaps with possible research being planned for the development of RIVPACS and may be better undertaken under that heading. Overlap of effort should be avoided and if species richness studies are undertaken under both programmes then they must be carefully planned to be complementary to each other.

OPTION 12 Substrate/habitat diversity in relation to species richness

This is a variation on the previous theme in which the data collected on the relative abundances of four substratum particle categories, as used in RIVPACS, would be examined in relation to the family richness at the site.

OPTION 13 Identification of national reference sites of particularly high taxon richness

Examination of family richness at individual sites could be used to identify national reference sites of high bio-diversity. Representative sites could be selected for all the major RIVPACS groups. The fauna of 1990 RQS samples from these sites, held in store at IFE Wareham could be further examined at species level. Sites could be recommended for notification as SSSIs or for special status under the European Habitats directive or UK Biodiversity Action Plan. They could form the nucleus of regular monitoring programmes akin to that adopted by the UK Acid Waters Monitoring Group or added to the Environmental Change Network (ECN) suite of sites.

OPTION 14 Longitudinal patterns of zonation/community structure

The 1995 survey data could be used to examine the patterns of change in aquatic communities along watercourses and to examine the relevance of current ecological theories to the business needs of the Environment Agency.

OPTION 15 The definition of the environmental niche of individual taxa and faunal assemblages

Multi-variate techniques could be used to determine the environmental niche size/shape of individual taxa and discrete faunal assemblages in a manner akin to the determination of habitat suitability curves or the application of PHABSIM to individual taxa. The extent of overlap between taxa or faunal assemblages, however determined, could be examined by this procedure. The research programme would be targeted at a fundamental understanding of the nature of faunal assemblages rather than at any specific operational requirements of the Agency. However, ultimately, it is through this form of fundamental understanding that the problems faced by the water industry can be best understood and acted upon.

FOOTNOTE

Each of the listed options depends upon the availability of a validated and reliable data-set of biological data. Many also require an equally reliable environmental data-set.

A key requirement is that each site and sample are correctly spatially referenced. Unique identifiers are required for each sample and, ideally, these identifiers should contain encoded spatial information, linking the sample to one or more administrative regions (eg Environment Agency region, Hydrometric Area etc) and to the site, reach and river system in which they were collected. They should also cross-reference to the equivalent chemical data-sets.

As stated above, the development of a multi-functional GIS system would improve the accessibility of the data and options for its analysis.

It is not the purpose of the current R&D programme to develop data-bases and GIS but attaining its objectives would be helped greatly by the availability of both reliable data and appropriate mechanisms for its storage, extraction and manipulation.