# Analysis of 1995 Survey Data. Phase 2 Post-Survey Appraisal

## Unit II: Changes in Biological Condition

R&D Technical Report E101

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This document presents an analysis of the biological condition and changes in condition of sites in the 1990 River Quality Survey and the 1995 General Quality Assessment. The biological condition and changes in condition of sites are examined in relation to their environmental variables, region, landscape types and types of potential environmental stress or pollution. It will be used by the Agency to help determine the procedures to be used during the 2000 GQA.

**Key Words**
River Quality Survey; General Quality Assessment; biological condition; biological grade; change; environmental stress; RIVPACS III+; RIVPACS DYNAMO

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# EXECUTIVE SUMMARY

Phase 2 of this R&D project aims to provide a comprehensive appraisal of the information content and performance of the 1995 General Quality Assessment (GQA) survey and of the changes between the 1990 River Quality Survey (RQS) and 1995 GQA survey. The implications of its results are to be taken into consideration in formulating the procedures to be used in the 2000 GQA survey.

This phase aims to increase understanding of the spatial and temporal relationships between taxonomic distribution, biological condition, environmental characteristics, Landscape type and the sources of environmental stress and pollution thought to be operating on each site.

The reporting of Phase 2 is divided into three units :

Unit I: Taxon distribution studies : R&D Technical Report E103 (Davy-Bowker *et al.* 2000)
Unit II: Changes in biological condition : R&D Technical Report E101 (Clarke *et al.* 1999) – this report
Unit III: Post-survey appraisal : R&D Technical Report E102 (Furse *et al.* 1999)

Unit I contains:

- a description of the incorporation of the 1990 RQS and 1995 GQA survey biological and environmental data into IFE's Quinquennial Survey Database (QSD). This includes procedures to establish matching pairs of sampling locations for use in analyses of change between surveys
- distribution studies of each BMWP taxon providing information on their geographic distribution, their environmental ranges (in terms of the RIVPACS environmental variables) and their tolerance/susceptibility to particular sources of environmental stress thought to be operating at individual sites

Unit II (this report) contains summaries of the :

- patterns of distribution of biological condition in 1995, especially in relation to RIVPACS environmental variables
- changes in biological condition between matched sites in 1990 and 1995, incorporating measures of the statistical significance of change in biological grade
- changes in biological condition in relation to site environmental characteristics and ITE landscape type
- data obtained from Environment Agency regions on the known or suspected sources of environmental stress operating on each of the GQA sites
- relationships between biological condition or change in condition and the type and severity of any environmental stress or pollution

Unit III contains summaries of the :

- responses to the post-survey questionnaire to Agency staff developed within this project
- results and conclusions from an investigation using the bias specification options in RIVPACS III+ to assess the effect of alternative analytical quality targets for macro-invertebrate samples
- analysis of the 1995 quality audit to determine which factors, if any, can be associated with poor levels of performance
- recommendations for future surveys

The integrated section summaries and conclusions for Unit II (this report) are as follows:

**Assessment of biological condition in 1995 and change in condition since 1990**

Relationships between the biological condition, environmental characteristics and sources of potential environmental stress of GQA sites were based on the 6016 sites for which there were suitably validated spring and autumn macro-invertebrate samples and RIVPACS environmental variables data for 1995.

Analyses of change in biological condition were all based on 3018 “matched” sites for which there were suitable, validated data available for both years taken from the same or adequately close sampling locations, with macro-invertebrate samples for all three seasons in 1990 and for spring and autumn in 1995 (the sampling targets in each year). It was only possible to match a few sites in Wessex Region.

Estimates of biological condition were based on RIVPACS III+ bias-corrected estimates of Ecological Quality Indices (EQI) and biological grade, obtained using the best available Region and year specific estimates of the mean under-estimation of the number of taxa derived from the IFE audit database. These estimated grades are referred to as the (bias-corrected) “face” grades.

Most analyses of biological grade were based on the overall grade, defined to be the lower of the two grades based on number of BMWP taxa ($EQI_{TAXA}$) and ASPT ($EQI_{ASPT}$), and usually referred to as biological GQA grade within the Environment Agency.

In 1995, 61% of all sites in England and Wales were graded as “very good” or “good” (grades a or b), 31% as “fairly good” or “fair” (grades c or d), 7% as “poor” (grade e) and only 1.4% as “bad” (grade f). These percentages are in close agreement with those derived independently by the Environment Agency using their version of the GQA database.

The settings of GQA grade limits for $EQI_{TAXA}$ and $EQI_{ASPT}$ have implications for the overall grade given to sites. The lower EQI limit for grade “a” is 1.00 for $EQI_{ASPT}$ but only 0.85 for $EQI_{TAXA}$. This does not seem logical. This major difference in grade “a” limits is largely responsible for 61% of all sites being graded “a”, based on their number of taxa, but only 32% using their ASPT. The ASPT value for a site, therefore, in practice usually determines whether or not it is classed as overall grade “a”.

With the present grading system, sites are far more likely to be given overall GQA grade f because of their lack of taxa (i.e. <30% expected number) than because of their low ASPT (which, in practice usually requires no taxa with a BMWP score above 3).

These apparent effects of the current GQA grade limits may or may not be desirable. One possible interpretation is that most mild stress is from organic pollution, whereas relatively more severe stress is from toxic pollution. For reasons of continuity and consistency in presentation of results for the 2000 GQA, the current grade ranges should be retained for that year, but it is recommended that they should be re-considered for future surveys.

North West Region had by far the highest percentage (5.3%) of grade f sites, which may influence apparent overall associations between poor condition and site environmental characteristics or stress types across England and Wales.

## Biological condition in relation to site environmental characteristics

To aid assessment of associations between biological grade and environmental variables, each variable was divided into six ordered classes with 20% of sites in each, but with the highest class sub-divided so as to separate the 3% of all sites with the highest values.

No strong relationships existed between grade and either altitude or slope, although the 3% of sites above 200m were relatively unlikely to be grades e/f and most likely to be grade b.

16% of sites close to their source (i.e. within 5km) were grade e/f compared to only 5-10% of sites further downstream. The percentage of sites in the highest grade increased dramatically with distance from source, from only 15% for sites within 5km of their source to over 40% for sites over 24km from source. Sites near their source are more likely to be of high quality if they are not at very low altitudes (i.e.<16m).

Discharge was also related to biological grade. Although 47% of all sites sampled in 1995 were discharge class 1, they formed only 31% of all grade "a" sites, but 58% of all sites graded e/f. However, these low discharge streams were most dominant in grades c and d where they represented about two-thirds of all such intermediate quality sites.

Sites graded e/f were relatively more likely to be either narrow (<2m), discharge class 1 sites within 5km of their sources or very wide sites (>10m) with high discharge (classes 9-10). However, a large percentage (38%) of the river sites with the highest discharge classes (9-10) were also of the highest grade.

Although the GQA grading system places more sites in grade "a" using $EQI_{TAXA}$ than using $EQI_{ASPT}$, the tendency for small streams near their source to be of poorer quality is similar when based on either EQI. Thus poor condition "near-source" sites are often reduced in both number and average BMWP score of taxa.

Sites of either intermediate alkalinity ( i.e. 61-182 mg $l^{-1}$ $CaCO_3$) or very high alkalinity (i.e. >284 mg $l^{-1}$ $CaCO_3$) are 2-3 times more likely to be graded e/f than sites with either very low or moderately high alkalinity. This complex pattern merits further investigation.

Sites with substrata dominated by pebbles/gravel are twice as likely to be grade "a" as those with less than 20%. Fine sediment sites with a relatively high percentage cover of sand (i.e. >20%) or silt/clay (i.e. >35%) are twice as likely to be of "poor" or "bad" biological condition (grades e and f) as sites with very little or none, irrespective of the stream size or distance from source. Fine sediment sites are likely to provide a lower diversity of habitats.

## Assessment of change in biological condition after correcting for sample processing biases

As a consequence of the general level of sample bias resulting from under-estimation of number of taxa being greater in 1990 than 1995, it is important to correct for sample bias in estimating change in biological condition. Uncorrected for bias the percentage of sites graded "a" based on their $EQI_{TAXA}$ appeared to increase from 46% in 1990 to 59% in 1995. Once corrected for bias, the corresponding figures were 59% to 64%, a much smaller improvement.

Once corrected for bias, 24% of all sites were upgraded and only 11% downgraded, between 1990 and 1995, on their estimated (i.e. "face") grade based on $EQI_{TAXA}$. The general improvement in "face" grades was greater when based on $EQI_{ASPT}$ (38% upgraded, 10% downgraded), leading to 34% of sites being given a higher overall GQA grade in 1995 than 1990 and only 12% downgraded.

These bias-corrected improvements occurred in all Regions, although they were least in South West Region, probably because such a high proportion (52%) of its sites were already grade "a" in 1990.

### Statistical significance of changes in biological condition

RIVPACS III+ was used to assess the statistical significance of change. Overall 31% of sites were more likely than not (i.e. probability >50%) to have improved in grade, whilst just under 10% were more likely than not to have deteriorated in grade. If the more conventional 95% statistical significance level is used to denote a "definite" real change, then far fewer sites would be classed as having changed, with only 4.2% showing a definite upgrade and a mere 0.7% definitely downgraded. The corresponding percentages of "definite" changes in grade for the chemistry GQA were 10.02% upgraded and 0.66% downgraded.

Amongst sites whose face GQA grade did not change, the RIVPACS III+ estimated likelihood of a change in grade was less than 50% in nearly all cases, which is comforting. Moreover, of those sites which showed a change of one grade, 84% of those showing an improvement and 72% of those showing a downgrade, did so with statistical test probabilities >50%. The observed changes in EQI values between 1990 and 1995 resulting in a change of one grade were therefore more likely than not to indicate a real change in overall GQA grade, but could rarely be determined as having definitely (i.e. >95%) changed.

A face change of two of more grades is "definitely" (i.e. $P>0.95$) a real change in grade for the majority of such sites.

This implies that when the face grade changed, even by only one grade, it more likely than not indicated that there had been a real change in GQA grade (as presently defined). Thus the errors and uncertainty in the whole RIVPACS III+ procedure are not so great as to lead to most of the observed changes in GQA face grade being merely due to chance and uncertainty in the whole system

It was therefore relative easy to identify changes of the size which occurred between 1990 and 1995 as statistically significant at the 50% probability level (i.e. "more likely than not"), but difficult at the 95% level (i.e. to be very confident a change has really occurred).

### Change in biological condition in relation to environmental and landscape characteristics

When classified by ITE Landscape type, 33% of all sites in "marginal/upland" landscapes were grade "a" in 1990 compared to only 21% in arable landscapes. However, by 1995 one-third of all "arable" landscape river sites had more likely than not improved in grade, compared to only 22% of those in the 'marginal/upland' landscapes.

Changes in biological grade did not seem to be consistently associated with any particular environmental types of site.

## Biological condition in relation to potential environmental stresses

A questionnaire sent out to the Environment Agency regional staff was used to provide information on the type and character of environmental stresses thought to be influencing the biological condition of each GQA site in 1995. The proportion of GQA sites for which information was provided and the detail of the responses was both impressive and encouraging. Responses were received for a total of 6570 GQA sites, which included practically all of the 6016 sites used for analysis of site quality and taxon distribution in 1995. The 154 individual stress types catered for within the questionnaire were grouped into 32 major stress types.

The frequencies of particular stresses were assessed in relation to biological grade in 1995 and change in grade since 1990. Variations between Regions, and Areas within Regions, were also assessed.

A rather surprising lack of any recorded farming-related stresses in one Area of Anglian Region acts as a reminder that recorders and Regions may have varied in what they considered to be a concern and worth treating as a site-specific stress problem. Thus regional variations in the frequency and perceived severity of particular stresses should be interpreted with some caution.

The most widely reported major type of stress across England and Wales was from sewage treatment works (STW) (41% of all sites). STW was the most commonly recorded major stress type in every region except Anglian, South West and Wessex Regions where stresses from general “farming” were even more common.

Impacts related to STW were dominated by the effects of treated STW effluent (25% of all sites) and combined or storm sewer overflow (14%). At least two-thirds of sites graded d-f were considered to be prone to environmental stress from STW and, surprisingly, also 22% of the highest grade sites. Where present, the impact of treated STW effluent was thought to be severe at nearly 23% of all such sites, but it was most often considered to have only a ‘light’ impact (39%).

Farming in general was recorded as the next most common environmental stress, affecting more than 25% of all sites in Anglian, North West, Midlands, South West, Thames and Wessex Regions. Stresses from farming were common in all except the very poorest grade of site. The most commonly recorded individual farming-related stress was from fertilisers (11%), followed by pesticide, herbicide and insecticide use (jointly 9%). Impacts from fertilisers were considered to be a potential stress at nearly 60% of sites in Anglian Region, far higher than any other Region; they were rarely recorded as a problem in either Welsh or, surprisingly, Thames Region.

Stresses from industrial discharge and run-off problems, especially in urban areas, were rare in high grade sites, but were increasingly common in very poor grade sites. Roughly half of all sites graded d-f in 1995 were considered to be affected by run-off problems, especially from urban areas.

Sediment problems, especially from siltation, were recorded at nearly 8% of all sites, an important feature for macro-invertebrate habitats. However, sediment-related stresses were equally common across all biological grades.

Over 50% of the sites in Anglian Region (far more than elsewhere) were considered to have some form of stress related to channelisation.

There was "no perceived problem" at 11% of sites, most of which were grade "a", and none were worse than grade c, suggesting that the local Environment Agency ecologists have an understanding of what was causing the stress in nearly all sites in their Region which were not of the highest grade.

For the GQA sites in 1995, the frequency and severity of many types of environmental stress were more common amongst the poorer quality sites.

However, few stresses showed any strong tendency to be less frequent amongst sites that had improved in grade or more frequent amongst sites which had deteriorated For example, stresses related to STW occurred in about half of all sites which had "definitely" changed in biological condition, irrespective of whether they had deteriorated or improved.

A likely explanation is that many of the sites which were subject to a particular stress at the time of the questionnaire in 1995 were also subject to the same stress in 1990. Some of the sites with this stress may have improved, others may have stayed in the same condition or even deteriorated.

An exception was stresses from industrial discharges which were most frequent amongst sites which had very likely improved in biological condition. However, such stress also occurred at severe and moderate intensities in relatively high frequencies amongst sites which had very likely deteriorated in condition.

Numerous sites were known to be affected by drought in both 1990 and 1995. However, low flow problems showed an association with sites which had deteriorated in condition. Moderate and severe stresses from low flow problems were more common amongst sites which had declined to grades e or f by 1995 than for sites which were already in such poor condition in 1990.

Together, these results support the general view that poor biological condition resulting from low flow problems is an increasing problem whereas many previously severe problems of environmental stress from industrial discharge and urban run-off have been partly alleviated since 1990.

The results of this, the first attempt to assemble and analyse information on environmental stresses has indicated the potential value of the exercise. The analyses also illustrated the importance of collecting consistent change information on environmental stresses in order to help interpret, and ultimately predict, their impact on macro-invertebrate assemblages.

### Implications of the current research for the development of a predictive version of RIVPACS

The current research programme, R&D Project E1-036 provides the basic data sets required to establish and test a dynamic version of RIVPACS (RIVPACS DYNAMO), of operational use in predicting faunal response to organic pollution.

The early availability, to IFE, of biological, environmental and chemical data from the 2000 GQA data is seen as important in the development and testing of RIVPACS DYNAMO, as is the availability of appropriate 1990 RQS and 1995 GQA chemical data.

It is recommended that the collection of environmental stress data be continued in association with the 2000 GQA in order to provide dynamic information on changes in occurrence or intensity of individual stresses. These data are necessarily subjective but protocols and definitions should be established in order to minimise differences in interpretation and recording of stresses and their character and intensity.

In the current R&D Project E1-007, one aim is to investigate the potential for developing a dynamic version of RIVPACS which can be used to predict faunal response to changing physical conditions, particularly flow. If such a system is to be effective then more detailed temporal information on the magnitude and variability of flow, within and between years will be required.

The current investigations have re-emphasised the apparently poor overall condition of headwaters. A series of research proposals, concerned with headwater streams, is provided for the Environment Agency's consideration.

# 1 INTRODUCTION

## 1.1 Background and Terminology

The Environment Agency (as the then National Rivers Authority - NRA) carried out national surveys of the chemical quality and biological condition of the rivers in England and Wales in 1990 and again in 1995.

The biological condition of river sites in both the 1990 River Quality Survey (RQS) and the 1995 General Quality Assessment (GQA) was assessed through the use of the RIVPACS (River InVertebrate Prediction And Classification System) approach, as developed by the Institute of Freshwater Ecology (IFE).

In 1990, 19628 macro-invertebrate samples were collected from 7633 sites in England and Wales. At most sites sampling was undertaken in spring, summer and autumn. In 1995 a total of 13294 samples was collected from 6713 sites, with most sites sampled in spring and autumn. Well in excess 3000 sites were common to both surveys, although not all were sampled in each of the relevant seasons in each survey.

Since 1990 the NRA/Environment Agency and IFE have operated a system of quality audit, whereby IFE routinely monitor and assess the efficiency of Agency staff at sorting and identifying the samples.

RIVPACS predicts the macro-invertebrate fauna to be expected at a river site in the absence of ecological stress, using information on the site's environmental characteristics. The observed fauna is compared with the expected fauna to derive indices of biological condition. These assessments are made using taxa identified to the Biological Monitoring Working Party (BMWP) level of identification, which is mostly to family level. In particular two indices are derived, the ratio (O/E) of the observed (O) to expected (E) number of BMWP taxa and the O/E ratio of ASPT (Average Score Per Taxon) values. Hereafter number of BMWP taxa will be referred to as simply "number of taxa". These two ratios are usually referred to as Ecological Quality Indices (EQI) and this terminology will be used here. The EQI based on number of taxa and ASPT will be denoted by $EQI_{TAXA}$ and $EQI_{ASPT}$ respectively.

To simplify understanding, synthesis and presentation of results following their 1995 GQA survey, the Environment Agency also developed a system of grading all river sites into one of six classes (a-f) on the basis of their EQI values (Table 1.1). Each site was assigned to a class using its EQI value, $EQI_{TAXA}$, for number of taxa and then separately assigned a class using its EQI value, $EQI_{ASPT}$, for ASPT. The class for the overall biological condition a site was taken as the poorer of its classes based on number of taxa and ASPT. These "classes" have variously been referred to as "biological quality bands", "ecological quality bands", "biological grades" and "ecological grades". In this report the term "biological grade" will be used throughout.

The objectives of such national surveys include reporting on the condition of Britain's watercourses and the temporal and spatial patterns of change in biological condition that are occurring in them. Both of these objectives require a knowledge of the reliability of the results derived and the confidence that can be put in their interpretation. However until two years ago, a lack of knowledge on the errors inherent in sampling and sample analysis meant that it was not possible to place confidence limits on index values and biological condition classifications, nor to adequately assess change between surveys.

**Table 1.1 GQA biological grade lower limits and text labels for each grade as used by the Environment Agency**

| Grade | Label | EQI for ASPT | EQI for TAXA |
|---|---|---|---|
| a | very good | 1.00 | 0.85 |
| b | good | 0.90 | 0.70 |
| c | fairly good | 0.77 | 0.55 |
| d | fair | 0.65 | 0.45 |
| e | poor | 0.50 | 0.30 |
| f | bad | - | - |

The problem has been solved using the results of two R&D programmes undertaken by IFE on behalf of the NRA/Environment Agency. The first of these, NRA R&D Project 504 (Furse *et al.* 1995), quantified the variation, errors and biases associated with collecting, sorting and identifying macro-invertebrate samples for the RQS and GQA type surveys and with obtaining the environmental data required for RIVPACS predictions of the expected fauna. Sampling variation was quantified using a replicated sampling programme across a wide range of types and qualities of site. The sample processing errors and resulting biases in the recorded values of the observed fauna were based on data obtained from the quality audits. The project derived statistical methods to integrate the separate sources of "uncertainty", enabling overall error terms to be attached to EQI values and changes in EQI values.

The second R&D contribution by IFE was made in the first Phase of the current project when the results and statistical methods developed in project 504 were incorporated in an updated version of the RIVPACS software system, called RIVPACS III+ (Clarke *et al.* 1997). RIVPACS III+ uses statistical simulations based on the estimated error components to derive confidence limits for EQI values and probabilistic assessments of the likelihood of a site belonging to each biological grade. Moreover, RIVPACS III+ provides a statistical test of whether the change in EQI values between two surveys is likely to be real or simply a result of uncertainty in the individual index values. It also provides an assessment of the likelihood of a real change in biological grade.

The RIVPACS III+ software system was released to the Environment Agency and the Scottish Environment Protection Agency (SEPA) in July 1997, following a training course by IFE for at least one biological representative from each region. In 1999 further training courses have been provided for the Environment and Heritage Service (Northern Ireland) and for 20 biologists from the Environment Agency South West Region.

It is intended that similar methodology, based around RIVPACS, will be used to assess biological condition of UK rivers in the next quinquennial survey in 2000 and beyond, as well as providing the basis for setting Biological Quality Objectives (BQO) for rivers.

## 1.2 Objectives and Agreed Research Tasks

Phase 2 of the current R&D project aims to provide a comprehensive appraisal of the information content and performance of the 1995 survey and of the changes between the 1990 and 1995 surveys. The implications of its results are to be taken into consideration in formulating the procedures to be used in the 2000 GQA survey.

This phase aims to increase understanding of the spatial and temporal relationships between taxonomic distribution, site biological condition, environmental characteristics and the types of environmental stress and pollution thought to be operating on each site.

The reporting of Phase 2 is divided into three units :

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Unit I contains:

- a description of the incorporation of the 1990 RQS and 1995 GQA survey biological and environmental data into IFE's Quinquennial Survey Database (QSD). This includes procedures to establish matching pairs of sampling locations for use in analyses of change between surveys
- distribution studies of each BMWP taxon providing information on their geographic distribution, their environmental ranges (in terms of the RIVPACS environmental variables) and their tolerance/susceptibility to particular sources of environmental stress thought to be operating at individual sites

Unit II (this report) contains summaries of the :

- patterns of distribution of biological condition in 1995, especially in relation to RIVPACS environmental variables
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- changes in biological condition in relation to site environmental characteristics and ITE landscape type
- data obtained from Environment Agency Regions on the known or suspected sources of environmental stress operating on each of the GQA sites
- relationships between biological condition or change in condition and the type and severity of any environmental stress or pollution

Unit III contains summaries of the :

- responses to the post-survey questionnaire to Agency staff developed within this project
- results and conclusions from an investigation using the bias specification options in RIVPACS III+ to assess the effect of alternative analytical quality targets for macro-invertebrate samples
- analysis of the 1995 quality audit to determine which factors, if any, can be associated with poor levels of performance
- recommendations for future surveys

# 2 DETERMINATION OF THE INDEX VALUES AND GRADES OF BIOLOGICAL CONDITION OF SITES IN THE 1995 RQS AND 1995 GQA

## 2.1 Methods

### 2.1.1 Availability of suitable validated sites

As part of Stage 1 of Phase 2 of this project, the environmental and biological data used in the 1990 River Quality Survey (RQS) and the 1995 General Quality Assessment (GQA) surveys were made available to IFE from the Agency. Careful checks and corrections were made to the data, especially the environmental attributes data used to make RIVPACS predictions for each site. The validated data were incorporated into IFE's Quinquennial Survey Database (QSD) holding IFE's version of the 1990 RQS and 1995 GQA data. This is described in further detail in a separate R&D Technical Report E103, to which the reader is referred (Davy-Bowker *et al*. 2000).

The analyses of relationships between the biological condition of sites in 1995 and the environmental characteristics of sites (described in section 3 of this report) were based on 6016 GQA sites for which there were suitably validated spring and autumn macro-invertebrate samples and RIVPACS environmental variables data (Table 2.1).

**Table 2.1 Number of sites involved in analyses of biological condition**

| Analysis of : | No. of sites |
|---|---|
| Quality in 1995 | 6016 |
| Change in quality between 1990 and 1995 | 3018 |

### 2.1.2 Selection of suitable matched sites

All analyses of change in biological condition between 1990 and 1995 (sections 4 and 5) were based on all the Environment Agency sites for which there was suitable, validated data available for both years, taken from the same or adequately close sampling locations in both years. More specifically, such sites had spring, summer and autumn macro-invertebrate samples in 1990 and spring and autumn samples in 1995 (the standard sampling regime targets for each respective year).

Sites were considered to be matched if they shared the same site reference number, as used in the Thames Region "Biology System" database (Davy-Bowker *et al*. 2000).

A total of 3018 suitably paired sites were identified and these are hereafter referred to as "matched sites".

### 2.1.3 Environmental data for the matched sites

After discussion with John Murray-Bligh (Thames Region), it was agreed that for the purposes of assessing biological condition in 1990 and 1995, and hence the change in condition, the same values of the RIVPACS environmental variables for a site would be used to set the RIVPACS expected (or “target”) fauna for both years. In particular, the value for a RIVPACS environmental variable for a site was taken as the average of the corresponding values for each of the two years, 1990 and 1995. For example, the width of a river at a site should be measured in each of the three RIVPACS seasons in a year and then averaged to provide the value for the RIVPACS predictor variable “stream width” for the site for that year. The resulting “stream width” values for 1990 and 1995 were then averaged to provide a single value of width for that site to be used in predictions of biological condition for both years. This approach was also adopted by the Environment Agency in its assessment of the changes in biological condition between 1990 and 1995 (Warn 1996). The approach was also compatible with the proposed concept of setting a long-term fixed target fauna for a site using the long-term average values of the environmental variables at the site (Furse *et al.* 1995).

### 2.1.4 Correction for sample processing biases

During the sorting and taxonomic identification of a macro-invertebrate sample, there is some tendency to miss or mis-identify a few taxa. This leads to an under-estimation of the number of taxa for the sample. Since 1990, IFE have operated a sample audit programme whereby a target number of all the RIVPACS macro-invertebrate samples taken by the Agency in one year are re-assessed by IFE experts. The target is at least 60 samples per Region and at least 20 samples per Area. For each audited sample, IFE record the taxa present in the whole sample but not recorded as present by the Agency (termed “gains”) and the taxa recorded as present but not found in the sample (termed “losses” and generally relatively small). The differences (gains minus losses) is the net under-estimation of the number of taxa in the sample and is referred to as the sample bias.

Any bias in estimating the observed number of taxa in a sample will lead to an under-estimation of the RIVPACS O/E ratio for the sample and hence of the site’s biological condition. In addition, if the sample bias differs between years then estimates of temporal change in condition will also be biased. Some apparent changes may merely be due to differences in bias. It is also important to correct for varying sample biases in deriving summaries of the general temporal trends in river quality for a whole Region or nationally. It is well known that analytical quality improved between 1990 and 1995 in many parts of the Environment Agency (see below).

In RIVPACS III+ (Clarke *et al.* 1997), the average bias for two season combined samples is estimated as 51% of the sum of the two individual seasons’ sample biases; for three season combined samples the average bias is estimated as 37% of the sum of the three individual seasons’ sample biases (see section 7.3.2 in Clarke *et al.* 1997). Thus, to estimate the average bias for combined season samples, it is sufficient to input the same estimate of the average single season sample bias for each of the three RIVPACS seasons (see sections 2.7, 6.9, 6.11 in Clarke *et al.* 1997).

The best available estimates of the sample biases for each NRA Region in 1990 are obtained from a report on an analysis by IFE of the audit results for 209 samples from the 1990 RQS (Furse *et al.* 1995). Table 3.6 of Furse *et al.* (1995) gives the average bias for samples from each region for each season. In 1990 relatively more of the samples taken in spring (at the start of the national survey) were audited and much less from the autumn. It transpired that sample biases were also higher for spring samples. Thus taking a simple average of the biases for all of the audited samples in 1990 would lead to an over-estimate of the average single season sample bias over all three seasons. A better approach, which was adopted, is to estimate the average bias over a whole year by the simple average of the estimated biases for each season.

Table 2.2 gives the simple averages of the three individual season biases in 1990 for each region (taken from Table 3.6 of Furse *et al.* 1995). In all analyses in this report, these values were used in RIVPACS III+ to correct for sample biases in 1990.

**Table 2.2 Estimates of average net under-estimation of the number of BMWP taxa (termed the bias) in single season samples taken from each NRA/Agency Region in the 1990 RQS and 1995 GQA surveys**

| Regions in 1990 | Bias in 1990 | Regions in 1995 | Bias in 1995 |
|---|---|---|---|
| Anglian | 3.40 | Anglian | 1.98 |
| Northumbrian | 2.67 | North East | 1.45 |
| Yorkshire | 1.13 | | |
| North West | 3.13 | North West | 2.18 |
| Severn-Trent | 3.77 | Midlands | 1.64 |
| Southern | 1.57 | Southern | 1.02 |
| South West | 1.13 | South West | 1.42 |
| Wessex | 3.93 | | |
| Thames | 1.97 | Thames | 1.78 |
| Welsh | 1.95 | Welsh | 1.73 |

Since 1991, IFE has produced annual reports to the Agency summarising the results of their audit of that year's samples. Each report contains a table giving the mean net under-estimation of the number of taxa (in a column labelled "mean net effect on no. of taxa") for each Agency Region and Area within Region. These are the best available estimates of the average single season sample biases. In the current study, for any particular site in the 1995 GQA survey, we have estimated its single season sample biases for all three seasons by the published appropriate regional mean bias for 1995, extracted from, for example, Table 8 of Gunn *et al*. (1996) and given here within Table 2.2.

The average biases were lower in 1995 than 1990 for every Region except the old NRA South West and Yorkshire Regions which had the least sample processing errors in 1990. The laboratories and Regions with poor performance in 1990 had generally improved by 1995.

Unless explicitly specified otherwise, all the assessments of the biological condition and grades of sites given in this report are based on EQI values corrected for bias as specified in Table 2.2. These bias-corrected estimates of the biological condition of sites should provide the most meaningful comparisons of change in condition between 1990 and 1995.

### 2.1.5 Seasons to be used in the estimation of biological condition

In the 1990 RQS, the majority of sites were sampled in each of spring, summer and autumn, as then recommended. Site condition, defined by EQI, was based on a comparison of the observed and expected BMWP index values for the three season combined sample. Subsequent commissioned research on the 1990 survey data (Clarke *et al.* 1992), showed that very similar estimates of EQI values for sites were obtained using two seasons' combined samples as when using three seasons' combined samples. The average correlation between two season and three seasons combined EQI values was 0.95. Also the vast majority of sites (86%) were given by same biological grade (using the four grade "5M" system then in operation). Spring and autumn were found to be, marginally, the best pair of seasons, in that they gave results most similar to those from using three seasons' combined samples.

Clarke *et al.* (1992) also concluded that reducing the level of sampling still further to one single season sample for each site would not necessarily adequately estimate the overall quality of a site for a year. The average correlation between EQI values based on any single season sample and those based on the three seasons combined sample was only around 0.87 for both $EQI_{TAXA}$ and $EQI_{ASPT}$. Also about 30% of all sites were assigned a different grade using a single season sample than their grade based on their three seasons' combined sample.

This research result was at least partly responsible for the NRA deciding that the standard and target sampling regime for the 1995 GQA biological survey was to only sample in spring and autumn and estimate the biological condition of sites from the EQI values based on the spring and autumn combined season samples. This helped reduce the cost per site of the biological component of the 1995 GQA survey.

Because RIVPACS can be used to make predictions of the expected fauna in samples from each individual season or specific combinations of seasons, it is still possible to make comparisons and assessments of change between two EQI values based on different seasons and numbers of seasons.

The precision of EQI values, the uncertainty in assigning sites to biological grades, and the accuracy of estimates of change in biological condition, do depend on the number of seasons involved in estimating each EQI value (Clarke *et al.* 1997; Clarke in press). RIVPACS III+ allows for the number of seasons involved when incorporating the effects of sampling variation and bias-corrections for sample processing errors in its assessments of the uncertainty in estimates of EQI values and biological grades.

However, to provide uniformity of precision, all analyses of biological condition throughout this report are based on those sites with a spring and autumn combined sample in 1995. Similarly, all assessments of change in biological condition between the 1990 RQS and 1995 GQA surveys are based on those sites with a three season combined sample in 1990 and a spring and autumn combined sample in 1995.

## 2.2 Overall Variation in Biological Condition and Changes in Condition in Terms of EQI Values

Figure 2.1 provides an initial impression of the range and variation in EQI values obtained across all the 3018 matched sites. These have been corrected for bias.

**Figure 2.1 Frequency distribution amongst the matched sites (n=3018) of values of (a) $EQI_{TAXA}$ and (b) $EQI_{ASPT}$ in 1995; and of the differences (1995 minus 1990 values) in (c) $EQI_{TAXA}$ and (d) $EQI_{ASPT}$. All EQI values and differences corrected for sample bias.**

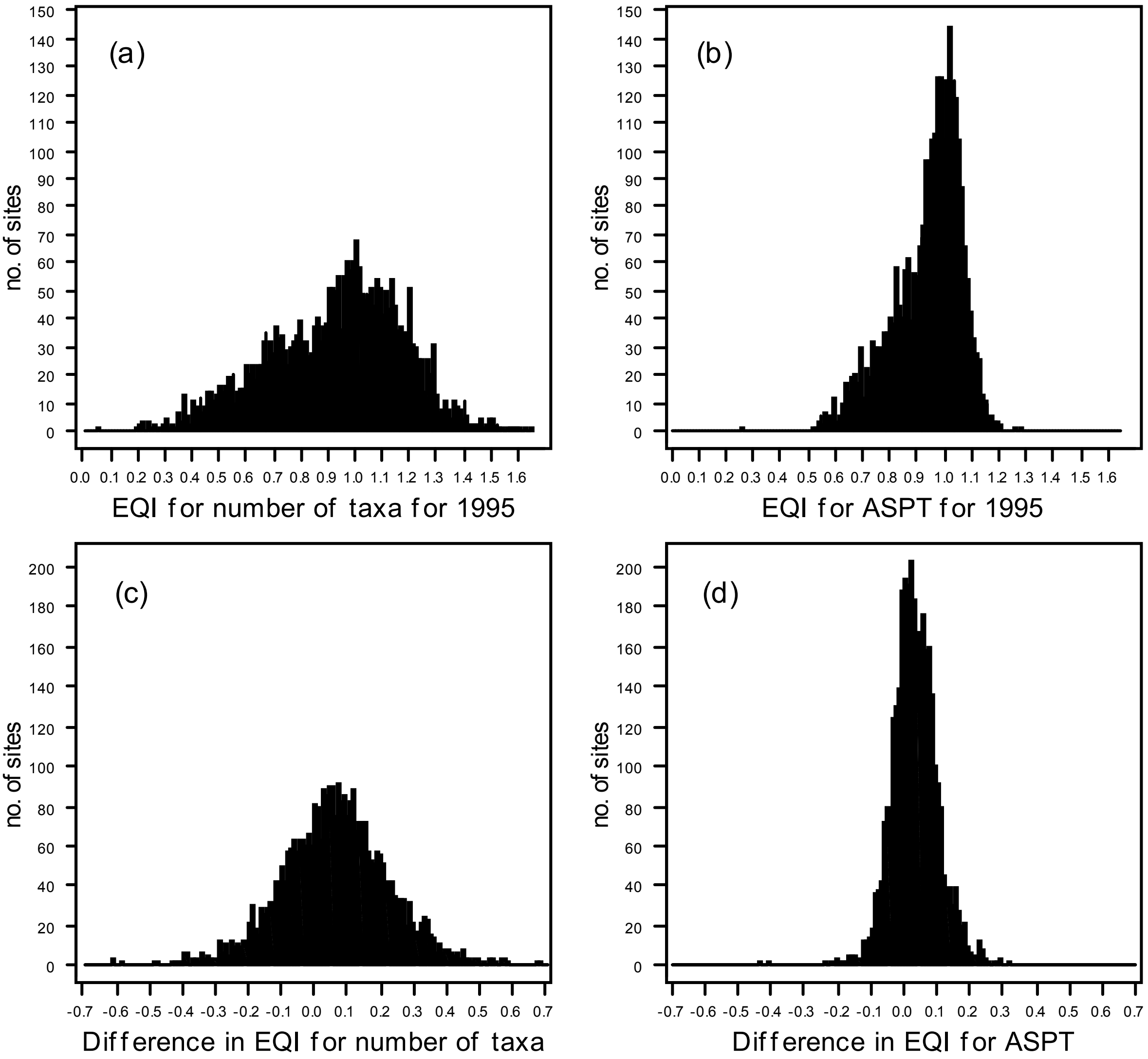


Figure 2.1 (a)-(b) shows the frequency distribution of the EQI values based on number of taxa and ASPT for all the matched sites in 1995. Figure 2.1 (c)-(d) and Table 2.3 show the distribution of the changes in EQI values for number of taxa and ASPT between 1990 and 1995.

**Table 2.3 Percentage of the 3018 matched sites with changes in $EQI_{TAXA}$ and $EQI_{ASPT}$ (corrected for bias) greater than various critical values**

| | Change in EQI greater than : | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.15 | 0.20 | 0.30 |
| $EQI_{TAXA}$ | 88.7 | 79.4 | 71.0 | 63.7 | 55.8 | 48.2 | 38.1 | 24.6 | 9.4 |
| $EQI_{ASPT}$ | 73.2 | 54.7 | 40.4 | 28.8 | 19.6 | 13.6 | 7.5 | 2.5 | 0.3 |

This provides a reminder that the EQI values for ASPT are considerably less variable than those for number of taxa. For example, even most very poor quality sites have observed ASPT values greater than 60% of their RIVPACS expected ASPT, so that only 1% of all the 3018 matched sites have bias-corrected EQI values for ASPT less than 0.6. In contrast, 11% of all sites have less than 60% of their expected number of taxa.

## 2.3 Summary

Earlier research (Clarke *et al.* 1992) had shown the biological condition of a site for any particular year could still be adequately estimated by taking a sample in only two, instead of three, seasons. Research also showed that the use of one single season sample lead to inadequately precise representation of the overall biological condition of a site for a year. These conclusions led to the recommended spring and autumn sampling scheme for the 1995 GQA biological survey.

Relationships between the biological condition, environmental characteristics and sources of potential environmental stress of GQA sites were based on the 6016 GQA sites for which there were suitably validated spring and autumn macro-invertebrate samples and RIVPACS environmental variables data for 1995.

Analyses of change in biological condition were all based on 3018 "matched" sites for which there were suitable, validated data available for both years taken from the same or adequately close sampling locations, with macro-invertebrate samples for all three seasons in 1990 and for spring and autumn in 1995 (the sampling targets in each year).

Estimates of biological condition were based on RIVPACS III+ bias-corrected estimates of EQI and biological grade, obtained using the best available Region and year specific estimates of the mean net under-estimation of the number of taxa derived from the IFE audit database.

Most analyses of biological grade were based on the overall grade, defined to be the lower of the two grades based on $EQI_{TAXA}$ and $EQI_{ASPT}$, and usually referred to as biological GQA grade within the Environment Agency.

# 3 RELATIONSHIPS BETWEEN BIOLOGICAL CONDITION OF SITES IN 1995 AND THEIR ENVIRONMENTAL CHARACTERISTICS

There were 6016 sites in the 1995 GQA survey database, developed by IFE within this project, for which spring and autumn biological samples were available together with three seasons RIVPACS environmental data (see section 2). The analyses in this section, which relate biological condition to environmental characteristics, were restricted to this very large sub-set of the total GQA survey sites, so that all sites involved in comparisons were based on the same intensity of sampling.

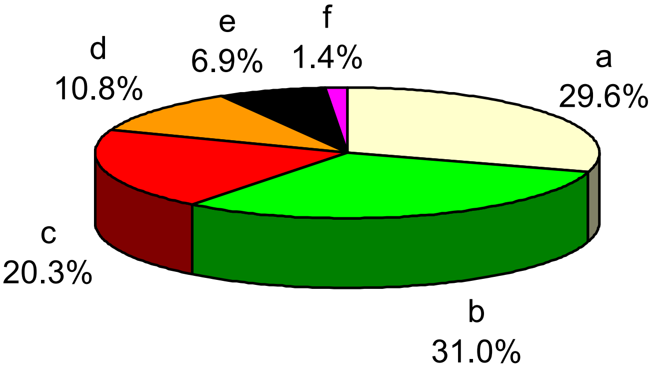
The overall GQA grade of biological condition of a site was defined as the lower of its grades based on using RIVPACS observed to expected ratios (O/E) for each of ASPT and number of taxa. There are six grades (a-f) (see section 1 and Table 1.1). Unless explicitly stated otherwise, the grades reported in this section are corrected for biases due to sample processing errors.

## 3.1 Summary of biological condition in 1995

### 3.1.1 Biological condition across England and Wales

In 1995, 61% of all sites in England and Wales were graded as “very good” or “good” (grades a or b), 31% as “fairly good” or “fair” (grades c or d), 7% or “poor” (grade e) and only just over 1% as “bad” (grade f) (Figure 3.1). These percentages agree within ±2% with those derived independently by Tony Warn of the Environment Agency using an earlier version of the biological database for all sites sampled during the 1995 GQA survey (unpublished report dated November 1996).

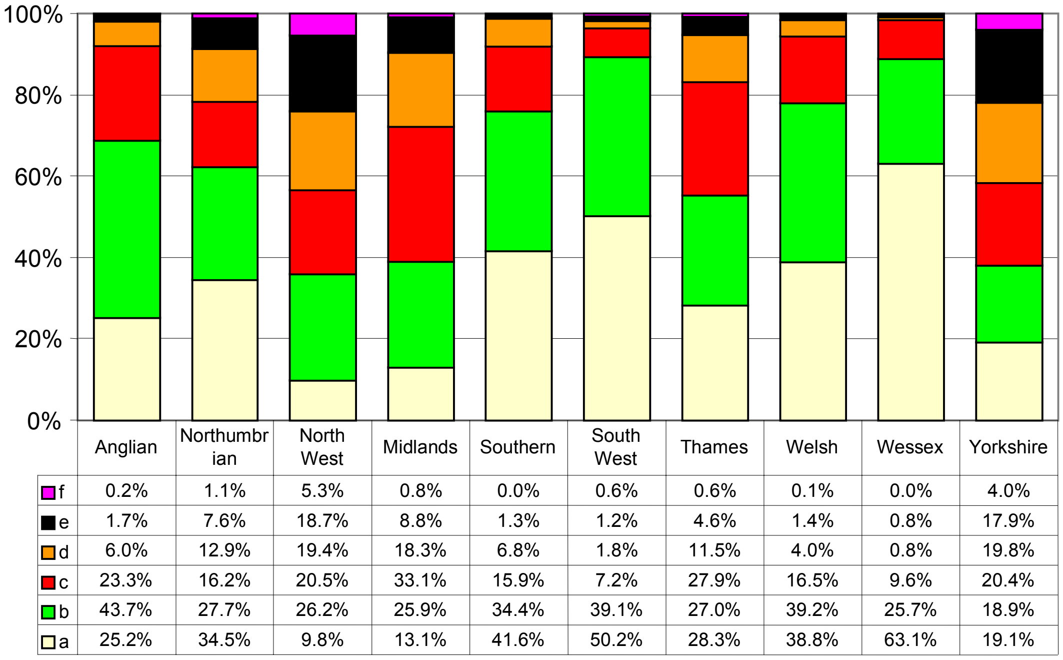
**Figure 3.1 Percentage of sites in England and Wales in each (bias-corrected) biological grade in 1995**



### 3.1.2 Biological condition within each Region

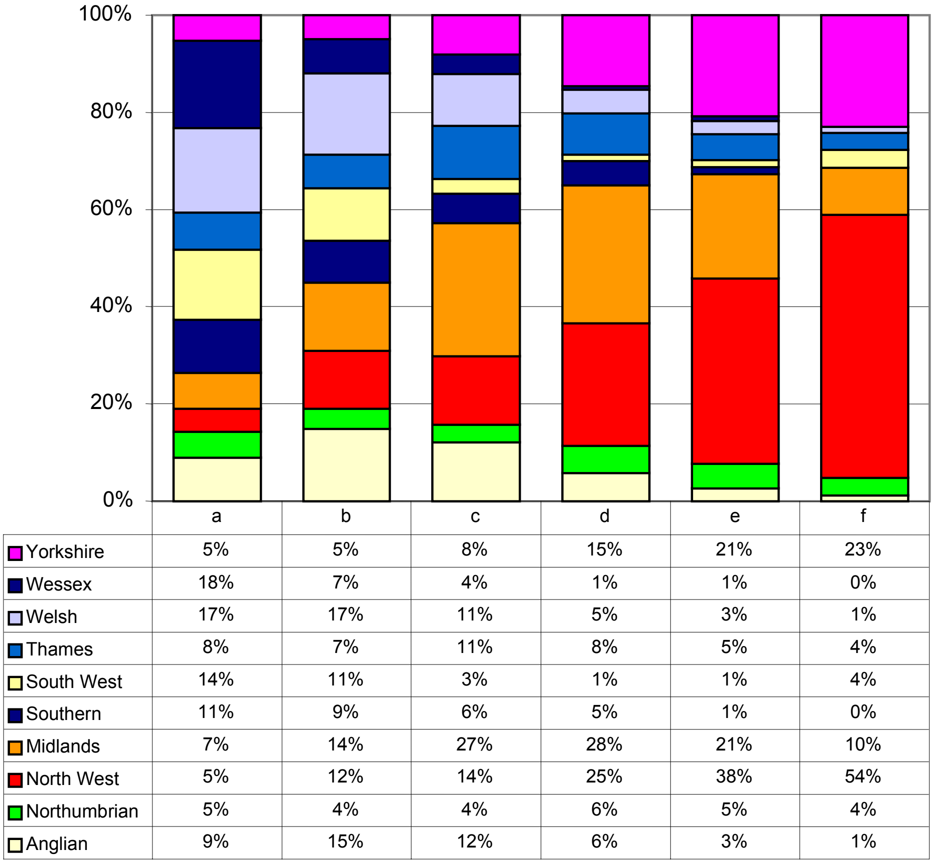
Figure 3.2 shows the percentage of sites in each biological grade in 1995 for each of the ten original NRA Regions. At this stage, only a few simple observations are made.

Figure 3.2 Percentage of sites in each (bias-corrected) biological grade in 1995 within each of the NRA/Agency Regions.



| | Anglian | Northumbrian | North West | Midlands | Southern | South West | Thames | Welsh | Wessex | Yorkshire |
|---|---|---|---|---|---|---|---|---|---|---|
| 🟪 f | 0.2% | 1.1% | 5.3% | 0.8% | 0.0% | 0.6% | 0.6% | 0.1% | 0.0% | 4.0% |
| ⬛ e | 1.7% | 7.6% | 18.7% | 8.8% | 1.3% | 1.2% | 4.6% | 1.4% | 0.8% | 17.9% |
| 🟧 d | 6.0% | 12.9% | 19.4% | 18.3% | 6.8% | 1.8% | 11.5% | 4.0% | 0.8% | 19.8% |
| 🟥 c | 23.3% | 16.2% | 20.5% | 33.1% | 15.9% | 7.2% | 27.9% | 16.5% | 9.6% | 20.4% |
| 🟩 b | 43.7% | 27.7% | 26.2% | 25.9% | 34.4% | 39.1% | 27.0% | 39.2% | 25.7% | 18.9% |
| ⬜ a | 25.2% | 34.5% | 9.8% | 13.1% | 41.6% | 50.2% | 28.3% | 38.8% | 63.1% | 19.1% |

Figure 3.3 Regional distribution of sites for each (bias-corrected) biological grade in 1995.



| | a | b | c | d | e | f |
|---|---|---|---|---|---|---|
| 🟪 Yorkshire | 5% | 5% | 8% | 15% | 21% | 23% |
| 🟦 Wessex | 18% | 7% | 4% | 1% | 1% | 0% |
| ⬜ Welsh | 17% | 17% | 11% | 5% | 3% | 1% |
| 🟦 Thames | 8% | 7% | 11% | 8% | 5% | 4% |
| 🟨 South West | 14% | 11% | 3% | 1% | 1% | 4% |
| 🟦 Southern | 11% | 9% | 6% | 5% | 1% | 0% |
| 🟧 Midlands | 7% | 14% | 27% | 28% | 21% | 10% |
| 🟥 North West | 5% | 12% | 14% | 25% | 38% | 54% |
| 🟩 Northumbrian | 5% | 4% | 4% | 6% | 5% | 4% |
| ⬜ Anglian | 9% | 15% | 12% | 6% | 3% | 1% |

The North-East and North-West Regions had the highest proportions of "poor" and "bad" condition sites (i.e. grades e and f). Moreover, over half (54%) of all the worst grade, f, sites were in the North West Region and a further quarter (23%) in the old Yorkshire Region (Figure 3.3). In contrast, less than 1.5% of all sites in each of Southern, South-West and Welsh Region were grades e or f. The percentage of grade "a" sites was highest in the old South-West (50%) and Wessex (63%) Regions (Figure 3.2).

### 3.1.3 Differences between biological grade based on $EQI_{TAXA}$ and $EQI_{ASPT}$

The lower limit for grade "a", based on EQI for ASPT was set at 1.0 by the Agency in 1995 (Table 1.1). This means that roughly half of the RIVPACS reference sites used to derive the expected fauna for all sites would be graded "a" and the other half would be graded b (or even c) using just $EQI_{ASPT}$. In contrast the lower limit of grade "a" when based on EQI for number of taxa was set at 0.85, so that over 75% of the reference sites would be graded "a" when based on $EQI_{TAXA}$. This inconsistency does not seem logical.

The overall grade for a site is then taken as the poorer of its two grades based these two EQI values. This suggests that for higher quality sites the overall grade is more likely to equal the grade based on $EQI_{ASPT}$ than that based on $EQI_{TAXA}$; in other words, ASPT has more influence on determining the overall grade than number of taxa. We understand (Bob Dines (pers. comm.) that this was done mostly to ensure that sites in Wales with high ASPT but fewer than expected taxa (e.g. mostly stoneflies) were still classified as grade "a". Surely such sites do have some moderate, probably non-organic, stress operating upon them? It is instructive to compare the grades for all suitable GQA sites based on these different indices.

Table 3.1(a) shows that nearly twice as many sites (61% versus 32%) were classified as grade "a" using $EQI_{TAXA}$ compared to using $EQI_{ASPT}$. Half of all the sites that would have been classified as grade "a" based on their number of taxa would be graded b or worse if based on their ASPT, whereas, in contrast, of the 32% of all sites assigned the top grade on the basis of their ASPT, only a small proportion (6% = 1.9/32.3) would be given a lower grade based on their number of taxa (Table 3.1(b)).

As stated previously, the overall grade assigned to a site is the lower of its two grades based on number of taxa and ASPT. Therefore, clearly any site given an overall grade "a" must have been graded "a" on the basis of both its number of taxa and ASPT. However, of all the sites given an overall grade b in 1995, 81% graded "a" on their number of taxa, but only 7% were graded "a" by their ASPT value (Table 3.1(c)-(d)). Thus, at the higher range of qualities, the overall grade for a site is usually determined by its grade based on its ASPT value.

At the poorest quality end of the spectrum, of the 6.9% of all sites given an overall grade f, only 11% were also graded f on the basis of their ASPT, although over two-thirds of such sites were graded e using $EQI_{ASPT}$. The RIVPACS expected values for ASPT range from 4.69 to 6.78. In order to be graded f, a site's value of $EQI_{ASPT}$ must be less than 0.50 (Table 1.1); equating to an observed sample ASPT value of no more than 2.35 to 3.39. Amongst the eight sites graded f in 1995 by their $EQI_{ASPT}$, all had observed ASPT values of less than 2.8 and only one had any taxa with a BMWP score above 3.

In contrast, to be graded f by $EQI_{TAXA}$ requires only that less than 30% of the expected number of taxa are observed. From our spring and autumn combined sample database for the 1995 GQA survey, 78 sites were graded f on $EQI_{TAXA}$, with on average five taxa recorded (range 1-8). Thus, with the present grading system, sites are more likely to be graded f because of their low observed number of taxa than because of their low value of ASPT.

**Table 3.1 (a)-(b) Comparisons of percentage of all (n=6016) sites in England and Wales in 1995 in each (bias-corrected) biological grade based on either ASPT, number of taxa or both (i.e. overall grade); (c)-(d) percentage of sites in each grade based on either (c) $EQI_{TAXA}$ or (d) $EQI_{ASPT}$ separately for sites in each overall GQA grade.**

| (a) | Based on | | Overall grade |
|---|---|---|---|
| Grade | $EQI_{TAXA}$ | $EQI_{ASPT}$ | |
| a | 60.6 | 32.3 | 29.6 |
| b | 15.3 | 30.8 | 31.0 |
| c | 12.1 | 20.3 | 20.3 |
| d | 5.8 | 11.4 | 10.8 |
| e | 4.9 | 5.1 | 6.9 |
| f | 1.3 | 0.1 | 1.4 |
| Total | 100.0 | 100.0 | 100.0 |

| Grade based on $EQI_{TAXA}$ | Grade based on $EQI_{ASPT}$ | | | | | | (b) |
|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | Total |
| a | 30.4 | 24.2 | 5.7 | 0.3 | | | 60.6 |
| b | 1.5 | 5.2 | 7.2 | 1.3 | | | 15.3 |
| c | 0.4 | 1.1 | 5.9 | 4.4 | 0.4 | | 12.1 |
| d | | 0.2 | 1.0 | 3.4 | 1.2 | | 5.8 |
| e | | 0.1 | 0.4 | 1.9 | 2.6 | | 4.9 |
| f | | | 0.1 | 0.2 | 0.9 | 0.1 | 1.3 |
| Total | 32.3 | 30.8 | 20.3 | 11.4 | 5.1 | 0.1 | 100.0 |

| (c) Overall grade | Grade based on $EQI_{TAXA}$ | | | | | | Grade based on $EQI_{ASPT}$ | | | | | | (d) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | a | b | c | d | e | f | Total |
| a | 100 | | | | | | 100 | | | | | | 100 |
| b | 81 | 19 | | | | | 7 | 93 | | | | | 100 |
| c | 28 | 39 | 33 | | | | 2 | 9 | 89 | | | | 100 |
| d | 3 | 12 | 47 | 38 | | | | 2 | 16 | 82 | | | 100 |
| e | | 1 | 5 | 24 | 70 | | 0 | 1 | 6 | 33 | 60 | | 100 |
| f | | | | | 6 | 94 | 1 | | 5 | 12 | 71 | 11 | 100 |

## 3.2 Distribution of Grades in Relation to Environmental Variables

This sub-section assesses the relationships between biological grades for sites and their environmental characteristics. The environmental characteristics of a site, as measured as RIVPACS predictor variables, can be classified into four groups (Table 3.2). Discharge, stream width and depth all generally increase with distance from source and are direct or indirect indicators of the "size" of the river at a site. In particular, values of distance from source, discharge class and stream width have positive correlations of at least 0.79 with each other (Table 3.3).

Although the percentage of the river bed covered by each of boulders/cobbles, pebbles/gravel, sand and silt/clay is measured for each site, the RIVPACS predictions for the target fauna are based on a derived variable called "mean substratum", measured in phi units, and defined as:

$$\text{mean substratum} = \frac{-7.75\%\text{boulders/cobbles} - 3.25\%\text{pebbles/gravel} + 2\%\text{sand} + 8\%\text{silt/clay}}{\%\text{boulders/cobbles} + \%\text{pebbles/gravel} + \%\text{sand} + \%\text{silt/clay}}$$

The relationships between biological condition and environmental characteristics of sites will be summarised within the framework of this four group classification, where appropriate.

Initial correlations and regression analyses relating EQI values (rather than overall grades) to the environmental variables gave many statistically significant relationships because of the large number of sites involved (Table 3.4). For example, biological condition, as measured by either EQI$_{TAXA}$ or EQI$_{ASPT}$, shows weak but statistically highly significant (all $p<0.001$) positive correlations with stream size as measured by any of discharge class, distance from source, stream width or depth. However, the resulting predictive equations (not given) only describe the relatively small changes in the mean EQI values for different values of the environmental variables.

**Table 3.2 Classification of RIVPACS environmental variables for a site**

| SIZE | GEOLOGY | LANDSCAPE | SUBSTRATUM |
|---|---|---|---|
| Distance from source (km)<br>Discharge class<br>Stream width (m)<br>Stream depth (cm) | Alkalinity (mg $l^{-1}$ $CaCO_3$) | Altitude (m)<br>Slope (m $km^{-1}$) | Mean substratum (phi units)<br>%Boulders/cobbles<br>%Pebbles/gravel<br>%Sand<br>%Silt/clay |

**Table 3.3 Spearman rank correlations between the RIVPACS environmental variables for the GQA sites (n=6016).**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Discharge class | 0.79 | | | | | | |
| Log width | 0.79 | 0.83 | | | | | |
| Log depth | 0.58 | 0.53 | 0.57 | | | | |
| Alkalinity | -0.02 | -0.18 | -0.18 | 0.15 | | | |
| Log altitude | -0.23 | -0.14 | -0.14 | -0.39 | -0.21 | | |
| Log slope | -0.50 | -0.37 | -0.37 | -0.59 | -0.35 | 0.57 | |
| Mean substratum | -0.04 | -0.13 | -0.15 | 0.46 | 0.42 | -0.45 | -0.50 |
| | Log distance | Discharge class | Log width | Log depth | Alkalinity | Log altitude | Log slope |

**Table 3.4 Overall Spearman correlations between EQI$_{TAXA}$, EQI$_{ASPT}$ and the RIVPACS environmental variables for the GQA sites in 1995 (n=6016). *,**,*** denote correlations significant at the $p < 0.05$, 0.01 and 0.001 probability level respectively.**

| | EQI$_{TAXA}$ | EQI$_{ASPT}$ |
|---|---|---|
| Discharge class | $0.188^{***}$ | $0.193^{***}$ |
| Log distance | $0.240^{***}$ | $0.255^{***}$ |
| Log width | $0.214^{***}$ | $0.247^{***}$ |
| Log depth | $0.074^{***}$ | $0.136^{***}$ |
| Alkalinity | $-0.085^{***}$ | $-0.038^{**}$ |
| Log alkalinity | $-0.104^{***}$ | $-0.107^{***}$ |
| Log altitude | $0.031^{*}$ | -0.002 |
| Log slope | -0.004 | $-0.056^{***}$ |
| Mean substratum | $-0.161^{***}$ | $-0.086^{***}$ |
| % Cover of boulders/cobbles | $0.050^{***}$ | 0.009 |
| % Cover of pebbles/gravel | $0.225^{***}$ | $0.168^{***}$ |
| % Cover of sand | $-0.115^{***}$ | $-0.122^{***}$ |
| % Cover of silt/clay | $-0.163^{***}$ | $-0.080^{***}$ |

In the remainder of this section, relationships between environmental characteristics and the biological condition of sites are assessed in terms of their overall GQA grade.

### 3.2.1 Overall grade in relation to single RIVPACS environmental variables

Obviously, the site characteristics, as represented by the RIVPACS environmental variables have already been used within RIVPACS to set the expected macro-invertebrate fauna for each site. Allowing for the fact that the environmental characteristics will influence the type of fauna to be expected in the absence of stress or pollution, we examine whether certain environmental types of site tend to be of poorer quality or better quality than others.

Table 3.5 gives the median value of each of the environmental variables for sites in each of the overall biological grades. Although there are trends in the median values for several environmental variables across the grades, the differences in the median values tend to be very small in relation to the full range of values obtained (as indicated by the maximum value given in Table 3.5)

**Table 3.5 Median value of each of the RIVPACS environmental variables for sites in each overall (bias-corrected) biological grade in 1995 (total n = 6016). The maximum value for all sites is included for reference.**

| | Max | Overall grade (bias-corrected) | | | | | |
|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e | f |
| Distance from source (km) | 287 | 13.2 | 11.1 | 7.9 | 6.4 | 6.9 | 7.8 |
| Discharge class | 10 | 3 | 2 | 1 | 1 | 1 | 1 |
| Stream width (m) | 86 | 5.6 | 5 | 3.2 | 2.7 | 3.3 | 4.4 |
| Stream depth (cm) | 1000 | 21.8 | 20.3 | 18.3 | 16.4 | 18.2 | 23.3 |
| Alkalinity (mg $l^{-1}$ CaCO3) | 592 | 142 | 136 | 180 | 157 | 141 | 137 |
| Altitude(m) | 410 | 46 | 50 | 50 | 51 | 54 | 27 |
| Slope (m $km^{-1}$) | 200 | 2.8 | 3.3 | 2.9 | 3.8 | 3.7 | 2.0 |
| Mean substrate (phi units) | 8 | -2.9 | -2.7 | -1.4 | -1.6 | -2.3 | -0.7 |
| % Boulders/cobbles | 98 | 22 | 24 | 16 | 20 | 25 | 23 |
| %Pebbles/gravel | 97 | 44 | 39 | 35 | 34 | 33 | 20 |
| %Sand | 91 | 7 | 8 | 11 | 13 | 11 | 11 |
| %Silt/clay | 100 | 6 | 7 | 15 | 13 | 10 | 16 |

To aid easy identification of general relationships with grades, each of the variables (except discharge class) was individually divided into six ordered categories so that 20% of all the sites were in each of the first four categories and the remaining 20% were in the last two categories, sub-divided so that the last category held the 3% of all sites with the highest (and most extreme) values for the variable.

In Figures 3.4-3.9, the left-hand-side two-way tables and charts ((a) and (c)) show the percentage of sites in each grade separately, for sites in each category of the environmental variable. Grades e and f have been combined here as “e/f” because grade f is not sufficiently common to analyse separately. If there is no relationship between grade and the variable, then within each category, the percentage of sites in each grade should be roughly that in the dataset as a whole, namely 30%, 31%, 20%, 11% and 8% in grades a, b, c, d and e/f respectively (Figure 3.1). The right-hand-side tables and charts ((b) and (d)) show the percentage of sites in each class of the environmental variable separately for sites in each grade; if there is no relationship between grade and the variable, then, within each grade of site, the percentage of sites in each category of the variable should be roughly 20%, 20%,20%, 20%, 17% and 3%.

In nearly all cases, the associations between grade and environmental characteristics of sites which are described and discussed below are all highly statistically significant when tested by a chi-square contingency table association test because of the very large number of sites involved. However, where considered necessary, such as for some associations with grade amongst the 3% of sites with the highest values for a variable, the chi-square test value ($\chi^2$), its degrees of freedom (df) and its test probability value (p) are given as backup support for the statement.

For the vast majority of sites there appears to be no consistent relationship between biological grade and either site altitude or slope (Figure 3.4). However, amongst the 3% of "upland" sites (i.e. >200m) relatively few are of the poorest qualities e and f and relatively more are of grade b ($\chi^2_{4df} = 21.55$; $p<0.001$).

Sites close to their source (defined here as within 5km) are much more likely to be grade d or grades e/f than sites further downstream. For example 15.9% of such "near-source" stream sites are grade e/f compared to only 5.0-9.6% for sites further downstream (Figure 3.5(a)). Although 20% of all sites were within 5 km of their source, these sites formed only 10% of all those graded "a", but 39% of all those graded e/f (Figure 3.5(b)). The percentage of sites in the highest grade increased dramatically with distance from source, ranging from only 15% for sites within 5km of their source to 43% for sites 24-84km from source (Figure 3.5(a)). The apparent impression that grades are slightly poorer for the 3% of sites over 84 km from their source is not statistically significant ($\chi^2_{4df} = 7.09$; $p=0.13$).

Discharge was also related to biological grade. Although 46.5% of all sites sampled in 1995 were discharge class 1 (i.e. small volume streams), they formed only 31% of all grade "a" sites, compared to 58% of all sites graded e/f (Figure 3.5(d)). However, these low discharge streams pre-dominated in grades c and d, where they represented about two-thirds of all such intermediate condition sites (Figure 3.5(d)). Only 20% of the lowest discharge class sites were of grade "a" (Figure 3.5(c)).

Although a high proportion (38%) of the river sites with the highest flows (discharge classes 9-10) were in "very good" condition (i.e. grade a), a higher proportion were also found to be in "poor" or "bad" condition (grade e/f) than sites with lower flows (discharge classes 2-7, Figure 3.5(c)).

In summary, a smaller proportion of low flow sites (discharge class 1) are grade "a", whilst a higher proportion of both the lowest and highest flow sites are more likely to of grade e/f than sites with intermediate discharge levels.

Stream width is related to biological grade in that the percentage of highest condition sites increases with stream width (Figure 3.6(a)). Only a small percentage (13%) of narrow streams (<2.3m) were graded "a", whilst this rose to over 38% for the wide rivers (i.e. >9.5m). As found with discharge, the poorest condition sites are more likely to be either narrow streams or wide rivers than sites of intermediate width (i.e. 2-3.9.5m) (Figure 3.6(a)).

The relationship of biological condition with stream depth has similar features to that with stream width, but it is weaker and is not discussed further (Figure 3.6(c) and (d)).

Biological condition varies with alkalinity. Sites of either intermediate alkalinity ( i.e. 61-182 mg/l $CaCO_3$) or very high alkalinity (i.e. >284 mg/l $CaCO_3$) are 2-3 times more likely to be graded e/f than sites with either very low or moderately high alkalinity (Figure 3.7(a)). Two-thirds of the poorest condition sites (grades e/f) have these intermediate alkalinity values, which is far more than that expected by chance (i.e. 40%) (Figure 3.7(b)). It should be remembered that discharges from sewage treatment works (STW) can affect river alkalinity.

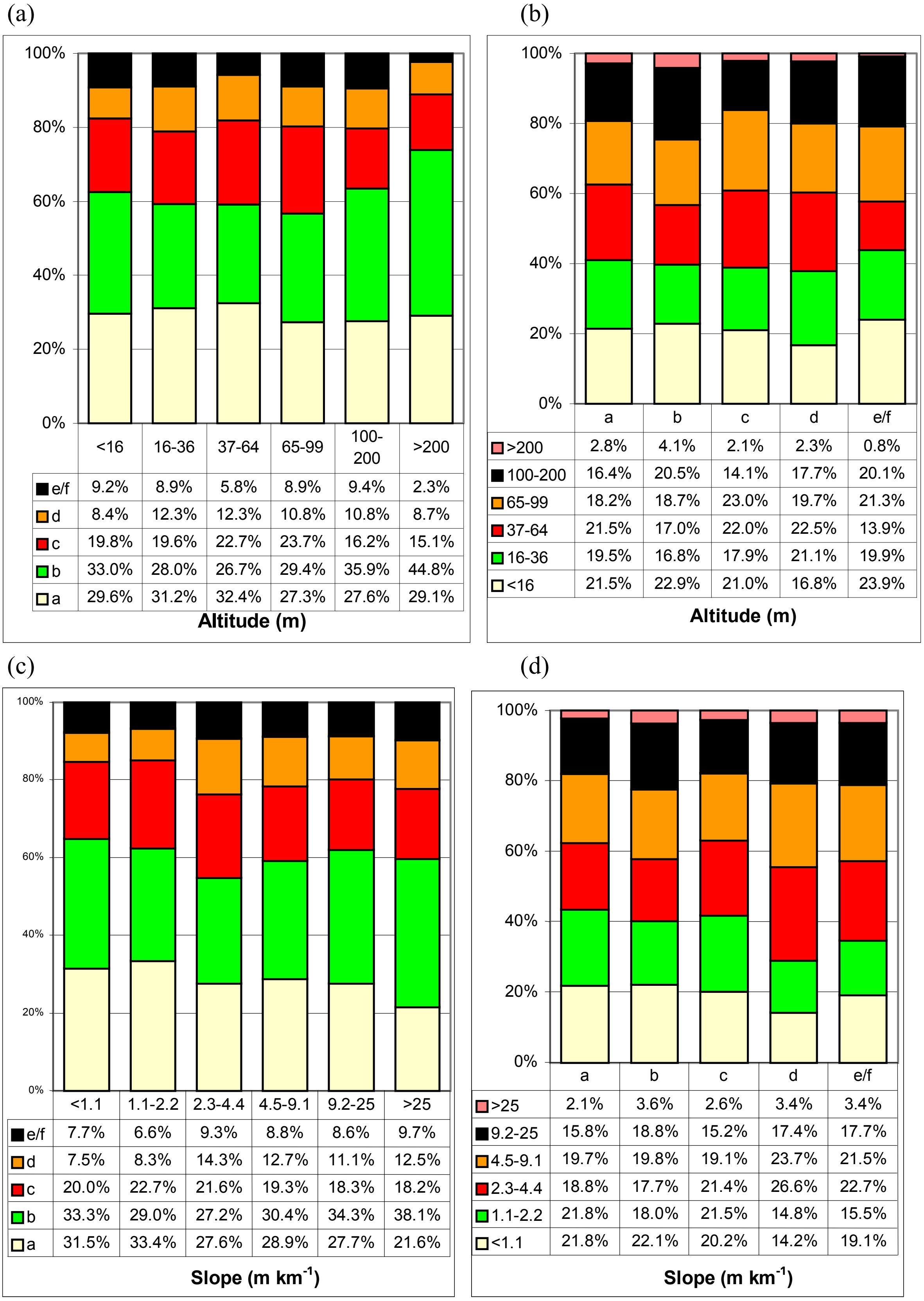
Associations between a site's biological grade and its substratum composition have been assessed both in terms of its mean substratum particle size, measured in phi units, and its percentage cover of each of the four RIVPACS substratum classes. There is an overall tendency for the proportion of grade "a" sites to decline as mean substratum particle size decreases (Figure 3.7(c)).

More detailed examination shows that the proportion of grade "a" sites is most strongly related to the cover of pebbles and/or gravel; sites dominated by pebbles/gravel are twice as likely to be grade "a" as those with under 20% cover by pebbles/gravel (Figure 3.8(c)). There is a weak negative relationship between site grade and its percentage cover of both sand and silt/clay. Sites with a relatively high percentage cover of sand (i.e. >20%) or silt/clay (i.e. >35%) are twice as likely to be in "poor" or "bad" biological condition (grades e and f) as sites with very little or none (Figure 3.9).

All the analyses above are based on relationships with the overall biological grade which, for each site, is the lower of its two grades based on $EQI_{ASPT}$ and $EQI_{TAXA}$. It may be that some of the relationships (Figures 3.4-3.9) between grade and site characteristics do not hold when based on only ASPT or number of taxa. For example, Figure 3.5 shows that relatively more sites near their source are of poorer quality compared to sites further downstream. Poor condition "near-source" sites might be greatly reduced in taxonomic richness from that expected but still have ASPT values not much below the RIVPACS expectation for that type of site. This was investigated.

Figure 3.10 gives the equivalent relationships between grade and distance from source shown in Figure 3.5, but based on just using either $EQI_{ASPT}$ or $EQI_{TAXA}$. Even though the current grading system (Table 1.1) places 61% of all sites in grade "a" when based on $EQI_{TAXA}$ but only 32% using $EQI_{ASPT}$, the pattern of grades based on each EQI is the same with the proportion of sites graded "a" increasing with distance from source. Of all the sites graded e/f using either $EQI_{ASPT}$ or $EQI_{TAXA}$, around 40% are near their source (i.e. <5km), even though such sites only represent 20% of all the sites surveyed (Figure 3.10).

**Figure 3.4 Relationship between (bias-corrected) biological grades (a-d, e/f) in 1995 and six categories of either site altitude ((a)-(b)) or site slope ((c)-(d)). Figures (a) and (c) show the percentage of sites in each grade, separately for each category; figures (b) and (d) show the percentage of sites in each category, separately for each grade. (n = 6016 sites).**



(a)

| | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
|---|---|---|---|---|---|---|
| ■ e/f | 9.2% | 8.9% | 5.8% | 8.9% | 9.4% | 2.3% |
| 🟧 d | 8.4% | 12.3% | 12.3% | 10.8% | 10.8% | 8.7% |
| 🟥 c | 19.8% | 19.6% | 22.7% | 23.7% | 16.2% | 15.1% |
| 🟩 b | 33.0% | 28.0% | 26.7% | 29.4% | 35.9% | 44.8% |
| □ a | 29.6% | 31.2% | 32.4% | 27.3% | 27.6% | 29.1% |

Altitude (m)

(b)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ >200 | 2.8% | 4.1% | 2.1% | 2.3% | 0.8% |
| ■ 100-200 | 16.4% | 20.5% | 14.1% | 17.7% | 20.1% |
| 🟧 65-99 | 18.2% | 18.7% | 23.0% | 19.7% | 21.3% |
| 🟥 37-64 | 21.5% | 17.0% | 22.0% | 22.5% | 13.9% |
| 🟩 16-36 | 19.5% | 16.8% | 17.9% | 21.1% | 19.9% |
| □ <16 | 21.5% | 22.9% | 21.0% | 16.8% | 23.9% |

Altitude (m)

(c)

| | <1.1 | 1.1-2.2 | 2.3-4.4 | 4.5-9.1 | 9.2-25 | >25 |
|---|---|---|---|---|---|---|
| ■ e/f | 7.7% | 6.6% | 9.3% | 8.8% | 8.6% | 9.7% |
| 🟧 d | 7.5% | 8.3% | 14.3% | 12.7% | 11.1% | 12.5% |
| 🟥 c | 20.0% | 22.7% | 21.6% | 19.3% | 18.3% | 18.2% |
| 🟩 b | 33.3% | 29.0% | 27.2% | 30.4% | 34.3% | 38.1% |
| □ a | 31.5% | 33.4% | 27.6% | 28.9% | 27.7% | 21.6% |

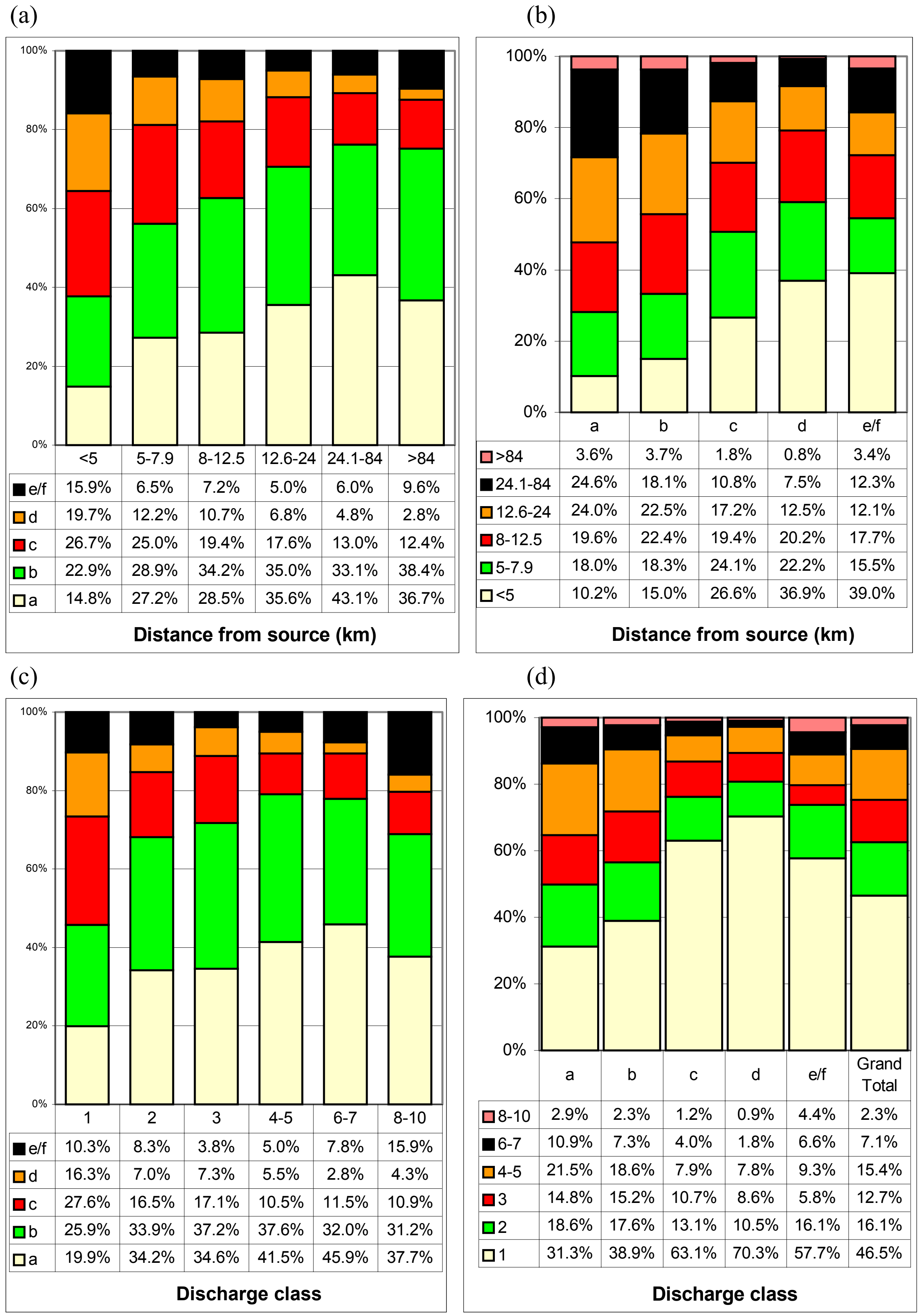
Slope (m km$^{-1}$)

(d)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ >25 | 2.1% | 3.6% | 2.6% | 3.4% | 3.4% |
| ■ 9.2-25 | 15.8% | 18.8% | 15.2% | 17.4% | 17.7% |
| 🟧 4.5-9.1 | 19.7% | 19.8% | 19.1% | 23.7% | 21.5% |
| 🟥 2.3-4.4 | 18.8% | 17.7% | 21.4% | 26.6% | 22.7% |
| 🟩 1.1-2.2 | 21.8% | 18.0% | 21.5% | 14.8% | 15.5% |
| □ <1.1 | 21.8% | 22.1% | 20.2% | 14.2% | 19.1% |

Slope (m km$^{-1}$)

**Figure 3.5 Relationship between (bias-corrected) biological grades (a-d, e/f) in 1995 and six categories of either site distance from source ((a)-(b)) or site discharge category ((c)-(d)). Figures (a) and (c) show the percentage of sites in each grade, separately for each category; figures (b) and (d) show the percentage of sites in each category, separately for each grade. (n = 6016 sites).**



(a)

| | <5 | 5-7.9 | 8-12.5 | 12.6-24 | 24.1-84 | >84 |
|---|---|---|---|---|---|---|
| ■ e/f | 15.9% | 6.5% | 7.2% | 5.0% | 6.0% | 9.6% |
| 🟧 d | 19.7% | 12.2% | 10.7% | 6.8% | 4.8% | 2.8% |
| 🟥 c | 26.7% | 25.0% | 19.4% | 17.6% | 13.0% | 12.4% |
| 🟩 b | 22.9% | 28.9% | 34.2% | 35.0% | 33.1% | 38.4% |
| □ a | 14.8% | 27.2% | 28.5% | 35.6% | 43.1% | 36.7% |

Distance from source (km)

(b)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ >84 | 3.6% | 3.7% | 1.8% | 0.8% | 3.4% |
| ■ 24.1-84 | 24.6% | 18.1% | 10.8% | 7.5% | 12.3% |
| 🟧 12.6-24 | 24.0% | 22.5% | 17.2% | 12.5% | 12.1% |
| 🟥 8-12.5 | 19.6% | 22.4% | 19.4% | 20.2% | 17.7% |
| 🟩 5-7.9 | 18.0% | 18.3% | 24.1% | 22.2% | 15.5% |
| □ <5 | 10.2% | 15.0% | 26.6% | 36.9% | 39.0% |

Distance from source (km)

(c)

| | 1 | 2 | 3 | 4-5 | 6-7 | 8-10 |
|---|---|---|---|---|---|---|
| ■ e/f | 10.3% | 8.3% | 3.8% | 5.0% | 7.8% | 15.9% |
| 🟧 d | 16.3% | 7.0% | 7.3% | 5.5% | 2.8% | 4.3% |
| 🟥 c | 27.6% | 16.5% | 17.1% | 10.5% | 11.5% | 10.9% |
| 🟩 b | 25.9% | 33.9% | 37.2% | 37.6% | 32.0% | 31.2% |
| □ a | 19.9% | 34.2% | 34.6% | 41.5% | 45.9% | 37.7% |

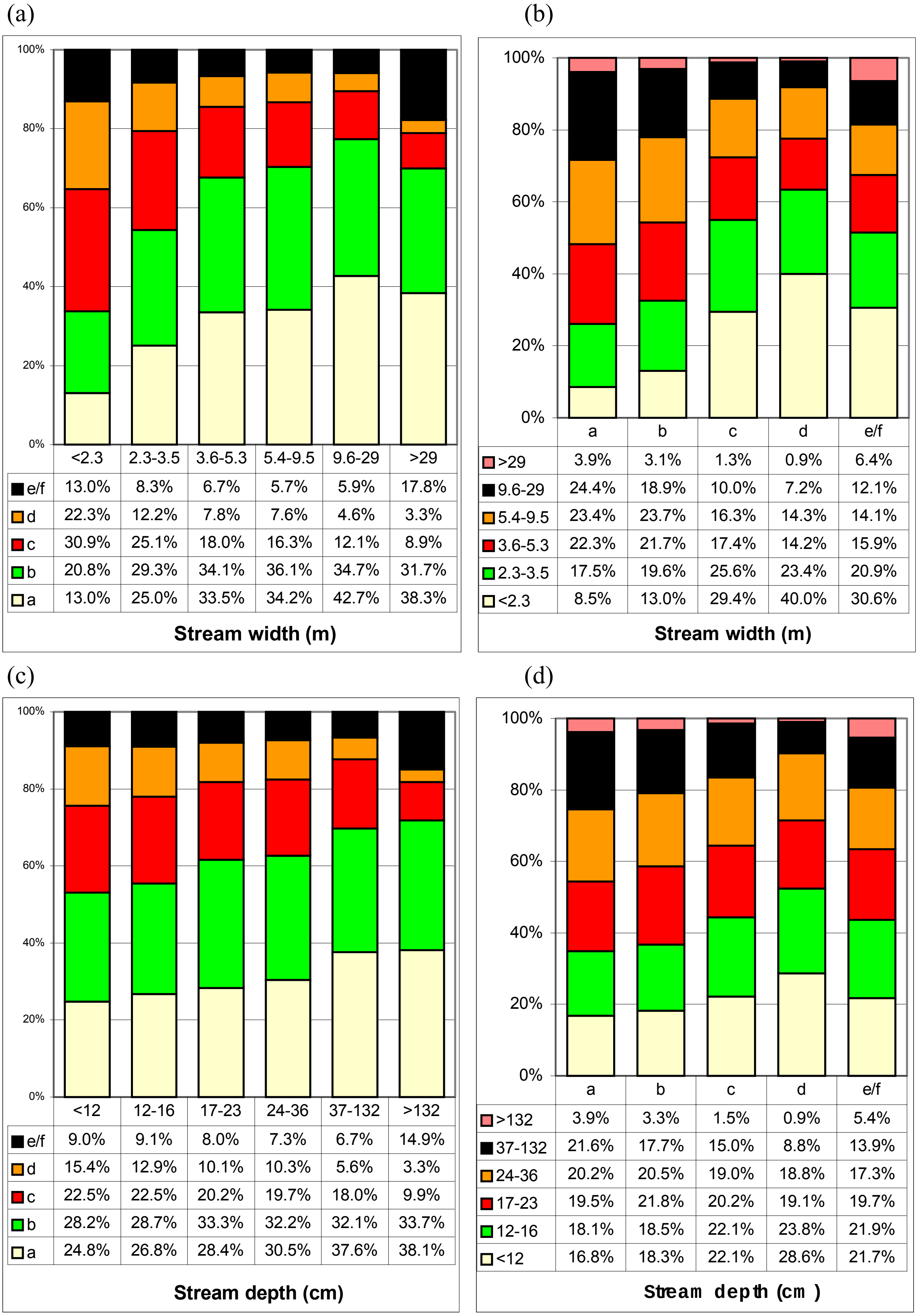
Discharge class

(d)

| | a | b | c | d | e/f | Grand Total |
|---|---|---|---|---|---|---|
| ▨ 8-10 | 2.9% | 2.3% | 1.2% | 0.9% | 4.4% | 2.3% |
| ■ 6-7 | 10.9% | 7.3% | 4.0% | 1.8% | 6.6% | 7.1% |
| 🟧 4-5 | 21.5% | 18.6% | 7.9% | 7.8% | 9.3% | 15.4% |
| 🟥 3 | 14.8% | 15.2% | 10.7% | 8.6% | 5.8% | 12.7% |
| 🟩 2 | 18.6% | 17.6% | 13.1% | 10.5% | 16.1% | 16.1% |
| □ 1 | 31.3% | 38.9% | 63.1% | 70.3% | 57.7% | 46.5% |

Discharge class

**Figure 3.6 Relationship between (bias-corrected) biological grades (a-d, e/f) in 1995 and six categories of either stream width ((a)-(b)) or stream depth ((c)-(d)). Figures (a) and (c) show the percentage of sites in each grade, separately for each category; figures (b) and (d) show the percentage of sites in each category, separately for each grade. (n = 6016 sites).**



(a)

| | <2.3 | 2.3-3.5 | 3.6-5.3 | 5.4-9.5 | 9.6-29 | >29 |
|---|---|---|---|---|---|---|
| ■ e/f | 13.0% | 8.3% | 6.7% | 5.7% | 5.9% | 17.8% |
| 🟧 d | 22.3% | 12.2% | 7.8% | 7.6% | 4.6% | 3.3% |
| 🟥 c | 30.9% | 25.1% | 18.0% | 16.3% | 12.1% | 8.9% |
| 🟩 b | 20.8% | 29.3% | 34.1% | 36.1% | 34.7% | 31.7% |
| □ a | 13.0% | 25.0% | 33.5% | 34.2% | 42.7% | 38.3% |

Stream width (m)

(b)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ >29 | 3.9% | 3.1% | 1.3% | 0.9% | 6.4% |
| ■ 9.6-29 | 24.4% | 18.9% | 10.0% | 7.2% | 12.1% |
| 🟧 5.4-9.5 | 23.4% | 23.7% | 16.3% | 14.3% | 14.1% |
| 🟥 3.6-5.3 | 22.3% | 21.7% | 17.4% | 14.2% | 15.9% |
| 🟩 2.3-3.5 | 17.5% | 19.6% | 25.6% | 23.4% | 20.9% |
| □ <2.3 | 8.5% | 13.0% | 29.4% | 40.0% | 30.6% |

Stream width (m)

(c)

| | <12 | 12-16 | 17-23 | 24-36 | 37-132 | >132 |
|---|---|---|---|---|---|---|
| ■ e/f | 9.0% | 9.1% | 8.0% | 7.3% | 6.7% | 14.9% |
| 🟧 d | 15.4% | 12.9% | 10.1% | 10.3% | 5.6% | 3.3% |
| 🟥 c | 22.5% | 22.5% | 20.2% | 19.7% | 18.0% | 9.9% |
| 🟩 b | 28.2% | 28.7% | 33.3% | 32.2% | 32.1% | 33.7% |
| □ a | 24.8% | 26.8% | 28.4% | 30.5% | 37.6% | 38.1% |

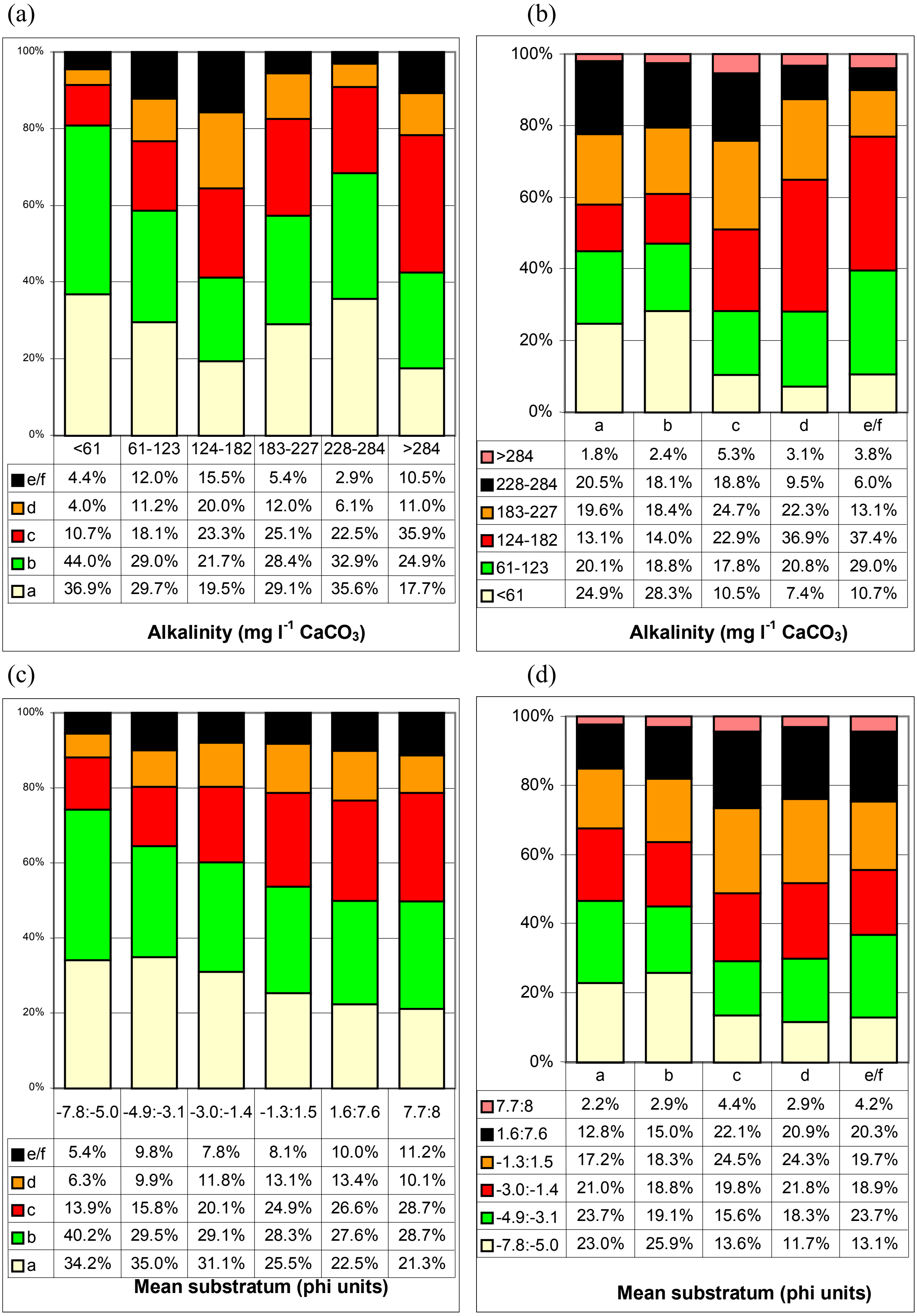
Stream depth (cm)

(d)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ >132 | 3.9% | 3.3% | 1.5% | 0.9% | 5.4% |
| ■ 37-132 | 21.6% | 17.7% | 15.0% | 8.8% | 13.9% |
| 🟧 24-36 | 20.2% | 20.5% | 19.0% | 18.8% | 17.3% |
| 🟥 17-23 | 19.5% | 21.8% | 20.2% | 19.1% | 19.7% |
| 🟩 12-16 | 18.1% | 18.5% | 22.1% | 23.8% | 21.9% |
| □ <12 | 16.8% | 18.3% | 22.1% | 28.6% | 21.7% |

Stream depth (cm )

**Figure 3.7 Relationship between (bias-corrected) biological grades (a-d, e/f) in 1995 and six categories of either stream alkalinity ((a)-(b)) or stream mean substratum ((c)-(d)). Figures (a) and (c) show the percentage of sites in each grade, separately for each category; figures (b) and (d) show the percentage of sites in each category, separately for each grade. (n = 6016 sites).**



(a)

| | <61 | 61-123 | 124-182 | 183-227 | 228-284 | >284 |
|---|---|---|---|---|---|---|
| ■ e/f | 4.4% | 12.0% | 15.5% | 5.4% | 2.9% | 10.5% |
| 🟧 d | 4.0% | 11.2% | 20.0% | 12.0% | 6.1% | 11.0% |
| 🟥 c | 10.7% | 18.1% | 23.3% | 25.1% | 22.5% | 35.9% |
| 🟩 b | 44.0% | 29.0% | 21.7% | 28.4% | 32.9% | 24.9% |
| □ a | 36.9% | 29.7% | 19.5% | 29.1% | 35.6% | 17.7% |

Alkalinity (mg l$^{-1}$ CaCO$_3$)

(b)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ >284 | 1.8% | 2.4% | 5.3% | 3.1% | 3.8% |
| ■ 228-284 | 20.5% | 18.1% | 18.8% | 9.5% | 6.0% |
| 🟧 183-227 | 19.6% | 18.4% | 24.7% | 22.3% | 13.1% |
| 🟥 124-182 | 13.1% | 14.0% | 22.9% | 36.9% | 37.4% |
| 🟩 61-123 | 20.1% | 18.8% | 17.8% | 20.8% | 29.0% |
| □ <61 | 24.9% | 28.3% | 10.5% | 7.4% | 10.7% |

Alkalinity (mg l$^{-1}$ CaCO$_3$)

(c)

| | -7.8:-5.0 | -4.9:-3.1 | -3.0:-1.4 | -1.3:1.5 | 1.6:7.6 | 7.7:8 |
|---|---|---|---|---|---|---|
| ■ e/f | 5.4% | 9.8% | 7.8% | 8.1% | 10.0% | 11.2% |
| 🟧 d | 6.3% | 9.9% | 11.8% | 13.1% | 13.4% | 10.1% |
| 🟥 c | 13.9% | 15.8% | 20.1% | 24.9% | 26.6% | 28.7% |
| 🟩 b | 40.2% | 29.5% | 29.1% | 28.3% | 27.6% | 28.7% |
| □ a | 34.2% | 35.0% | 31.1% | 25.5% | 22.5% | 21.3% |

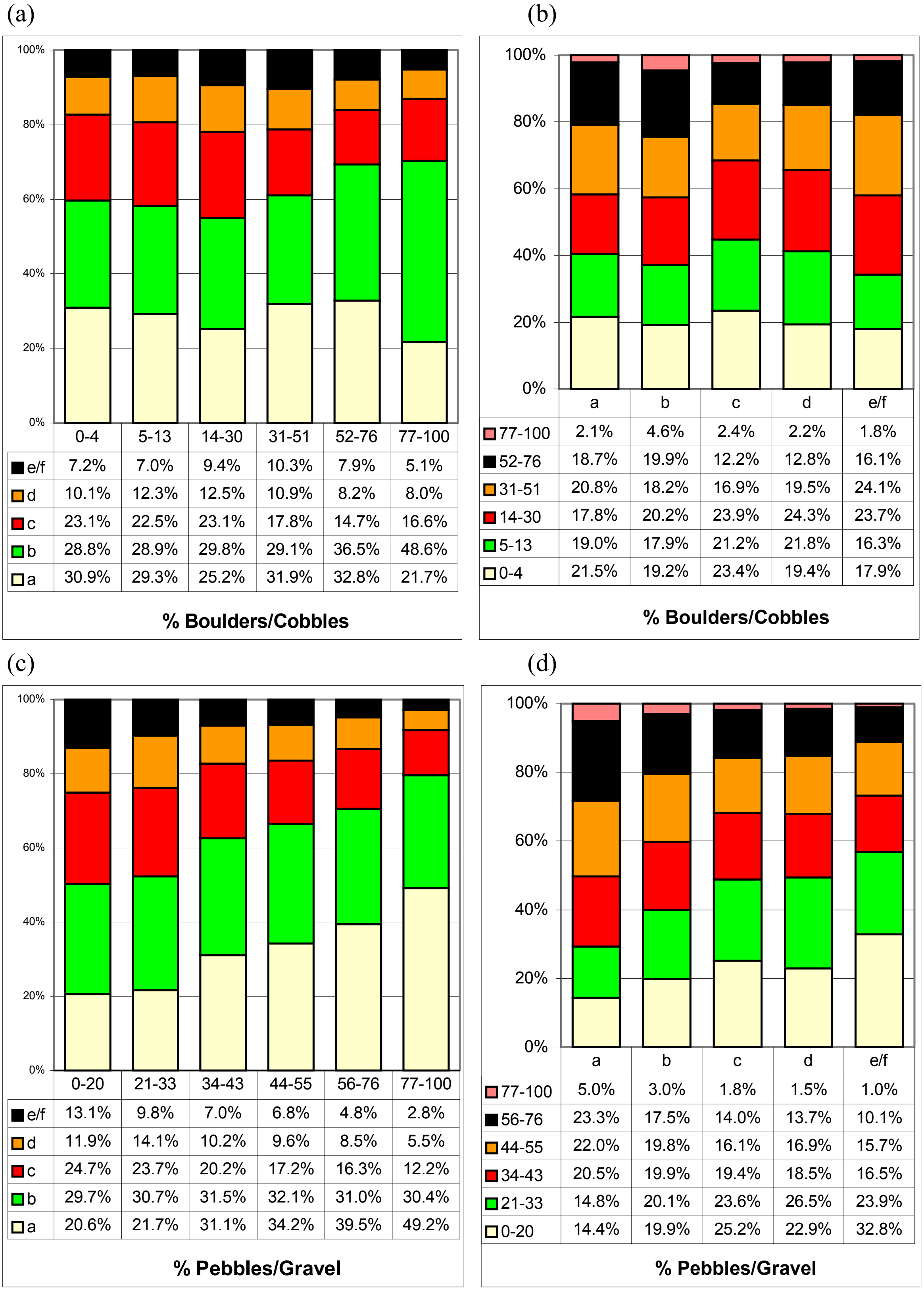
Mean substratum (phi units)

(d)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ 7.7:8 | 2.2% | 2.9% | 4.4% | 2.9% | 4.2% |
| ■ 1.6:7.6 | 12.8% | 15.0% | 22.1% | 20.9% | 20.3% |
| 🟧 -1.3:1.5 | 17.2% | 18.3% | 24.5% | 24.3% | 19.7% |
| 🟥 -3.0:-1.4 | 21.0% | 18.8% | 19.8% | 21.8% | 18.9% |
| 🟩 -4.9:-3.1 | 23.7% | 19.1% | 15.6% | 18.3% | 23.7% |
| □ -7.8:-5.0 | 23.0% | 25.9% | 13.6% | 11.7% | 13.1% |

Mean substratum (phi units)

**Figure 3.8 Relationship between (bias-corrected) biological grades (a-d, e/f) in 1995 and six categories of the percentage substratum cover by either boulders/cobbles ((a)-(b)) or pebbles/gravel ((c)-(d)). Figures (a) and (c) show the percentage of sites in each grade, separately for each category; figures (b) and (d) show the percentage of sites in each category, separately for each grade. (n = 6016 sites).**



(a)

| | 0-4 | 5-13 | 14-30 | 31-51 | 52-76 | 77-100 |
|---|---|---|---|---|---|---|
| ■ e/f | 7.2% | 7.0% | 9.4% | 10.3% | 7.9% | 5.1% |
| 🟧 d | 10.1% | 12.3% | 12.5% | 10.9% | 8.2% | 8.0% |
| 🟥 c | 23.1% | 22.5% | 23.1% | 17.8% | 14.7% | 16.6% |
| 🟩 b | 28.8% | 28.9% | 29.8% | 29.1% | 36.5% | 48.6% |
| □ a | 30.9% | 29.3% | 25.2% | 31.9% | 32.8% | 21.7% |

% Boulders/Cobbles

(b)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ 77-100 | 2.1% | 4.6% | 2.4% | 2.2% | 1.8% |
| ■ 52-76 | 18.7% | 19.9% | 12.2% | 12.8% | 16.1% |
| 🟧 31-51 | 20.8% | 18.2% | 16.9% | 19.5% | 24.1% |
| 🟥 14-30 | 17.8% | 20.2% | 23.9% | 24.3% | 23.7% |
| 🟩 5-13 | 19.0% | 17.9% | 21.2% | 21.8% | 16.3% |
| □ 0-4 | 21.5% | 19.2% | 23.4% | 19.4% | 17.9% |

% Boulders/Cobbles

(c)

| | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
|---|---|---|---|---|---|---|
| ■ e/f | 13.1% | 9.8% | 7.0% | 6.8% | 4.8% | 2.8% |
| 🟧 d | 11.9% | 14.1% | 10.2% | 9.6% | 8.5% | 5.5% |
| 🟥 c | 24.7% | 23.7% | 20.2% | 17.2% | 16.3% | 12.2% |
| 🟩 b | 29.7% | 30.7% | 31.5% | 32.1% | 31.0% | 30.4% |
| □ a | 20.6% | 21.7% | 31.1% | 34.2% | 39.5% | 49.2% |

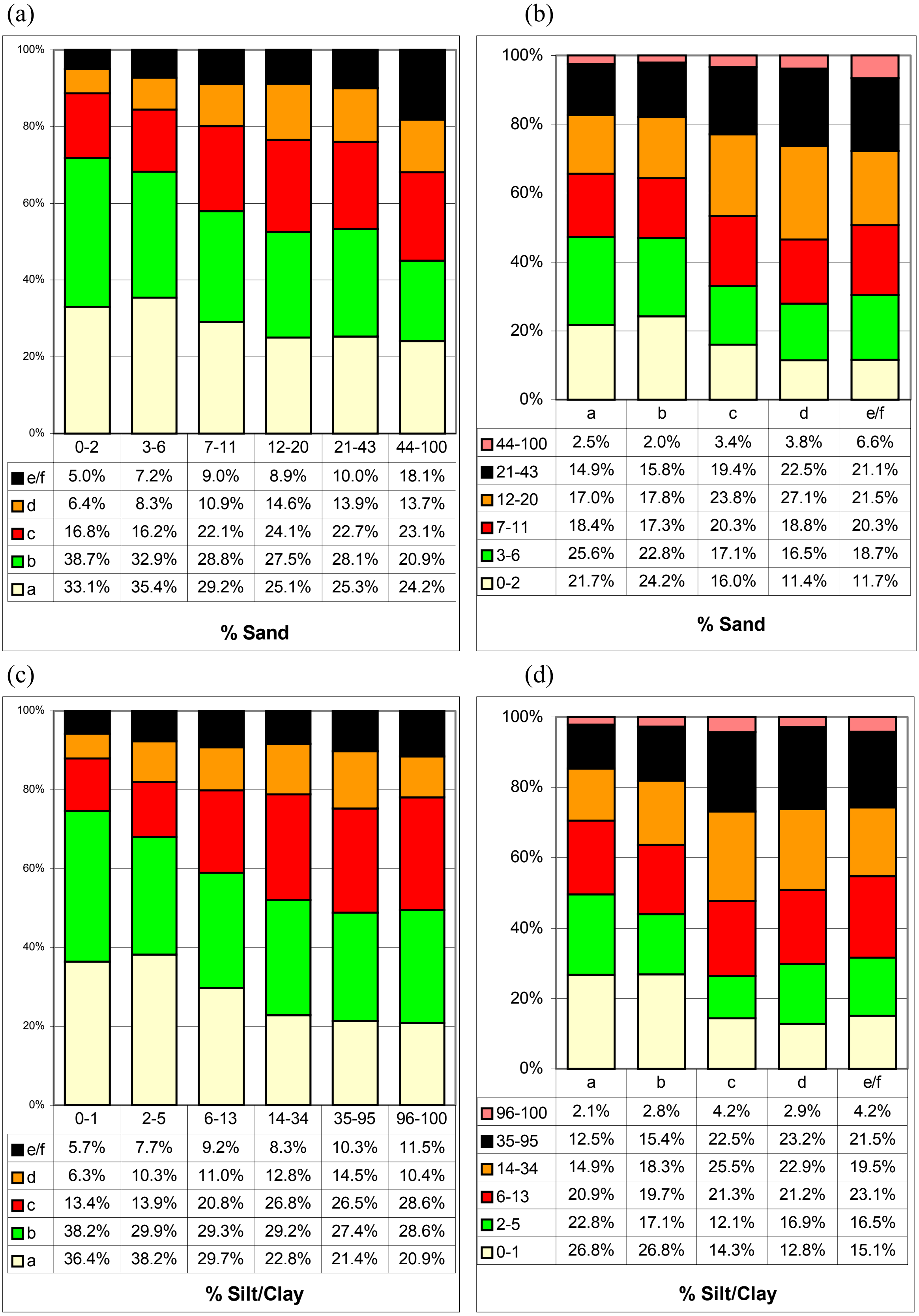
% Pebbles/Gravel

(d)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ▨ 77-100 | 5.0% | 3.0% | 1.8% | 1.5% | 1.0% |
| ■ 56-76 | 23.3% | 17.5% | 14.0% | 13.7% | 10.1% |
| 🟧 44-55 | 22.0% | 19.8% | 16.1% | 16.9% | 15.7% |
| 🟥 34-43 | 20.5% | 19.9% | 19.4% | 18.5% | 16.5% |
| 🟩 21-33 | 14.8% | 20.1% | 23.6% | 26.5% | 23.9% |
| □ 0-20 | 14.4% | 19.9% | 25.2% | 22.9% | 32.8% |

% Pebbles/Gravel

**Figure 3.9 Relationship between (bias-corrected) biological grades (a-d, e/f) in 1995 and six categories of the percentage substratum cover by either sand ((a)-(b)) or silt/clay ((c)-(d)). Figures (a) and (c) show the percentage of sites in each grade, separately for each category; figures (b) and (d) show the percentage of sites in each category, separately for each grade. (n = 6016 sites).**



(a)

| | 0-2 | 3-6 | 7-11 | 12-20 | 21-43 | 44-100 |
|---|---|---|---|---|---|---|
| ■ e/f | 5.0% | 7.2% | 9.0% | 8.9% | 10.0% | 18.1% |
| 🟧 d | 6.4% | 8.3% | 10.9% | 14.6% | 13.9% | 13.7% |
| 🟥 c | 16.8% | 16.2% | 22.1% | 24.1% | 22.7% | 23.1% |
| 🟩 b | 38.7% | 32.9% | 28.8% | 27.5% | 28.1% | 20.9% |
| ☐ a | 33.1% | 35.4% | 29.2% | 25.1% | 25.3% | 24.2% |

% Sand

(b)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| 🟥 44-100 | 2.5% | 2.0% | 3.4% | 3.8% | 6.6% |
| ■ 21-43 | 14.9% | 15.8% | 19.4% | 22.5% | 21.1% |
| 🟧 12-20 | 17.0% | 17.8% | 23.8% | 27.1% | 21.5% |
| 🟥 7-11 | 18.4% | 17.3% | 20.3% | 18.8% | 20.3% |
| 🟩 3-6 | 25.6% | 22.8% | 17.1% | 16.5% | 18.7% |
| ☐ 0-2 | 21.7% | 24.2% | 16.0% | 11.4% | 11.7% |

% Sand

(c)

| | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
|---|---|---|---|---|---|---|
| ■ e/f | 5.7% | 7.7% | 9.2% | 8.3% | 10.3% | 11.5% |
| 🟧 d | 6.3% | 10.3% | 11.0% | 12.8% | 14.5% | 10.4% |
| 🟥 c | 13.4% | 13.9% | 20.8% | 26.8% | 26.5% | 28.6% |
| 🟩 b | 38.2% | 29.9% | 29.3% | 29.2% | 27.4% | 28.6% |
| ☐ a | 36.4% | 38.2% | 29.7% | 22.8% | 21.4% | 20.9% |

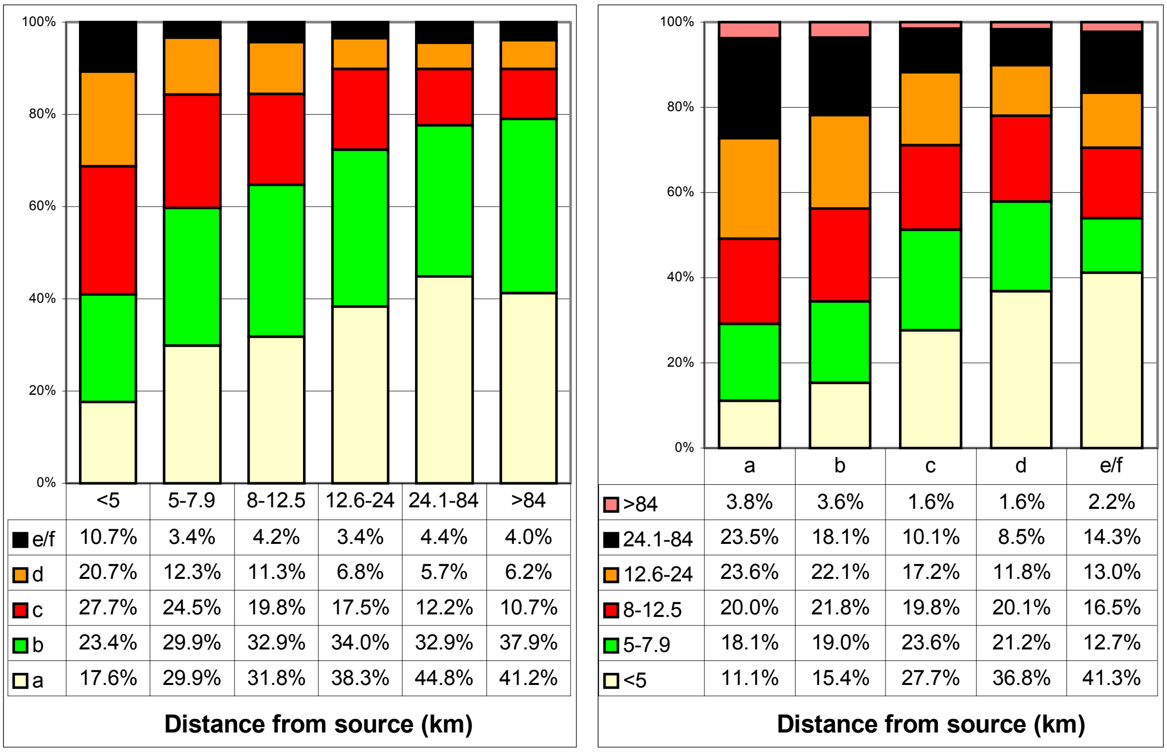
% Silt/Clay

(d)

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| 🟥 96-100 | 2.1% | 2.8% | 4.2% | 2.9% | 4.2% |
| ■ 35-95 | 12.5% | 15.4% | 22.5% | 23.2% | 21.5% |
| 🟧 14-34 | 14.9% | 18.3% | 25.5% | 22.9% | 19.5% |
| 🟥 6-13 | 20.9% | 19.7% | 21.3% | 21.2% | 23.1% |
| 🟩 2-5 | 22.8% | 17.1% | 12.1% | 16.9% | 16.5% |
| ☐ 0-1 | 26.8% | 26.8% | 14.3% | 12.8% | 15.1% |

% Silt/Clay

**Figure 3.10 Relationship between (bias-corrected) biological grade (a-d, e/f) in 1995 and six categories of the distance from source (km) based on either $\mathrm{EQI}_{\mathrm{ASPT}}$ ((a)-(b)) or $\mathrm{EQI}_{\mathrm{TAXA}}$ ((c)-(d)). Figures (a) and (c) show the percentage of sites in each grade, separately for each category; figures (b) and (d) show the percentage of sites in each category, separately for each grade. (n = 6016 sites).**

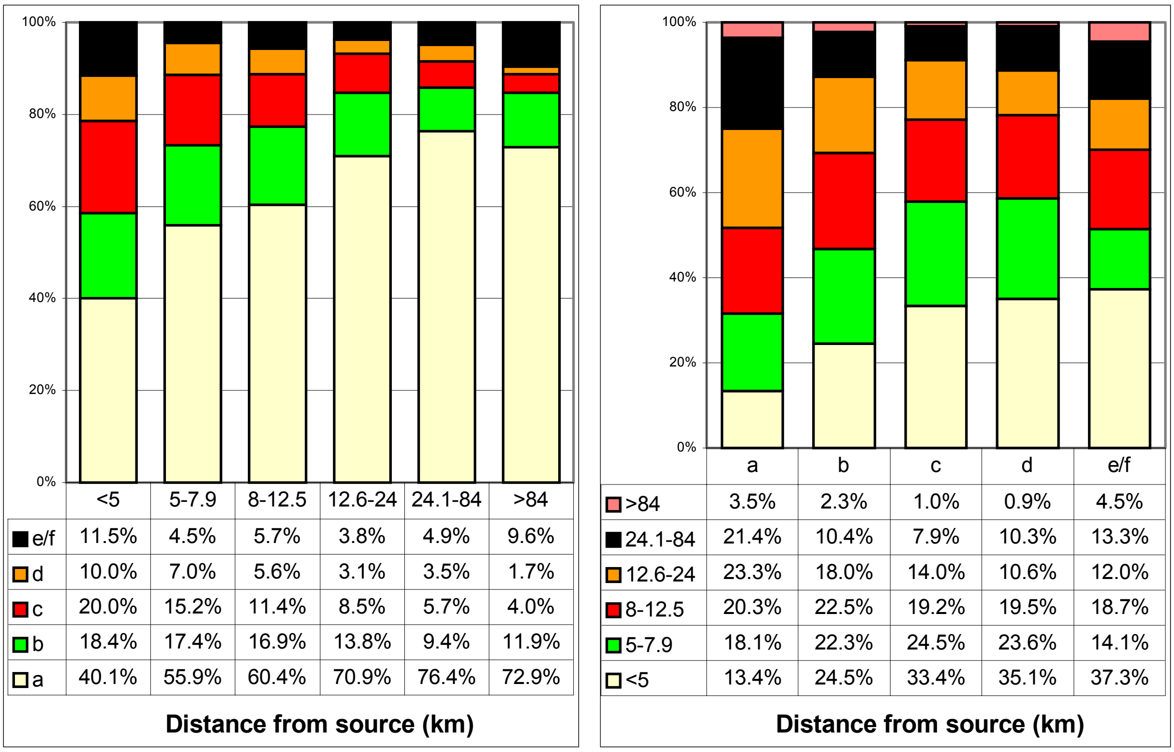


(a) grade based on $\mathrm{EQI}_{\mathrm{ASPT}}$

(b) grade based on $\mathrm{EQI}_{\mathrm{ASPT}}$

| | <5 | 5-7.9 | 8-12.5 | 12.6-24 | 24.1-84 | >84 |
|---|---|---|---|---|---|---|
| ■ e/f | 10.7% | 3.4% | 4.2% | 3.4% | 4.4% | 4.0% |
| 🟧 d | 20.7% | 12.3% | 11.3% | 6.8% | 5.7% | 6.2% |
| 🟥 c | 27.7% | 24.5% | 19.8% | 17.5% | 12.2% | 10.7% |
| 🟩 b | 23.4% | 29.9% | 32.9% | 34.0% | 32.9% | 37.9% |
| □ a | 17.6% | 29.9% | 31.8% | 38.3% | 44.8% | 41.2% |

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ■ >84 | 3.8% | 3.6% | 1.6% | 1.6% | 2.2% |
| ■ 24.1-84 | 23.5% | 18.1% | 10.1% | 8.5% | 14.3% |
| 🟧 12.6-24 | 23.6% | 22.1% | 17.2% | 11.8% | 13.0% |
| 🟥 8-12.5 | 20.0% | 21.8% | 19.8% | 20.1% | 16.5% |
| 🟩 5-7.9 | 18.1% | 19.0% | 23.6% | 21.2% | 12.7% |
| □ <5 | 11.1% | 15.4% | 27.7% | 36.8% | 41.3% |



(c) grade based on $\mathrm{EQI}_{\mathrm{TAXA}}$

(d) grade based on $\mathrm{EQI}_{\mathrm{TAXA}}$

| | <5 | 5-7.9 | 8-12.5 | 12.6-24 | 24.1-84 | >84 |
|---|---|---|---|---|---|---|
| ■ e/f | 11.5% | 4.5% | 5.7% | 3.8% | 4.9% | 9.6% |
| 🟧 d | 10.0% | 7.0% | 5.6% | 3.1% | 3.5% | 1.7% |
| 🟥 c | 20.0% | 15.2% | 11.4% | 8.5% | 5.7% | 4.0% |
| 🟩 b | 18.4% | 17.4% | 16.9% | 13.8% | 9.4% | 11.9% |
| □ a | 40.1% | 55.9% | 60.4% | 70.9% | 76.4% | 72.9% |

| | a | b | c | d | e/f |
|---|---|---|---|---|---|
| ■ >84 | 3.5% | 2.3% | 1.0% | 0.9% | 4.5% |
| ■ 24.1-84 | 21.4% | 10.4% | 7.9% | 10.3% | 13.3% |
| 🟧 12.6-24 | 23.3% | 18.0% | 14.0% | 10.6% | 12.0% |
| 🟥 8-12.5 | 20.3% | 22.5% | 19.2% | 19.5% | 18.7% |
| 🟩 5-7.9 | 18.1% | 22.3% | 24.5% | 23.6% | 14.1% |
| □ <5 | 13.4% | 24.5% | 33.4% | 35.1% | 37.3% |

### 3.2.2 Biological condition in relation to combinations of RIVPACS environmental variables

It is more complicated to analyse and represent the relationships between biological condition and combinations of site environmental attributes. Initial correlation and multiple regression analyses relating EQI values to variables gave many statistically significant relationships because of the large number of sites involved, but the resulting predictive equations only described the relative small changes in the mean EQI values for different values of the environmental variables.

The true relationships between biological condition and environmental attributes may also be non-linear and complex. Therefore, it was considered more informative and accurate to present relationships between quality and site type through a series of two-way tables showing patterns in the proportion of sites in a particular grade for each combination of the categories of each of two RIVPACS environmental variables (Tables 3.6-3.14).

The patterns of relationship with site grade are shown for representative pairs of variables from two of the four classes of variable given in Table 3.2. For example, in Table 3.6, river size is represented by distance from source and landscape type by the altitude of the site.

Tables 3.6-3.9 show, as in section 3.2.1, that small river sites near their source (<5 km) were less likely than larger sites further downstream to be of the highest quality (grade a) and more likely to be of the poorest quality (e/f). However, sites near their source are more likely to be high quality if they are not at very low altitudes (<16m) (Table 3.6).

In section 3.2.1, sites close to the source and sites of intermediate alkalinity were both found to be less likely to be of top quality and more likely to be of grade e/f. Table 3.7 shows that these two patterns are largely independent of each other in that the tendency for sites with intermediate alkalinity to be of relatively poorer quality is observed throughout the range of categories of distances from source.

Within each category of distance from source, the lowest percentage of grade “a” sites and the highest percentage of grade e/f sites occurred amongst sites with fine substrata, namely low cover (i.e. <34%) with pebbles/gravel (Table 3.8)) and high cover (i.e. >34%) with silt/clay (Table 3.9). In particular, amongst large river sites (i.e. >84km from source), if they have little or no silt/clay they are the most likely to be grade “a”, whereas if they are dominated by a fine substratum and/or with few if any pebbles/gravel, they are the most likely to be of very poor quality.

Sites of intermediate or very high alkalinity show a tendency to be in poorer condition irrespective of the altitude of the site (Table 3.10). Amongst the sites with low alkalinity (<61 mg $l^{-1}$ $CaCO_3$), those at high altitude (i.e. >100m) are less likely to be of in the best biological condition, grade “a”.

Within each category of alkalinity, the sites with low (<34%) cover of pebbles/gravel and/or high cover of silt/clay are least likely to be grade “a” (Tables 3.11-3.12). Sites with low cover of pebbles/gravel and intermediate (124-182 mg $l^{-1}$ $CaCO_3$) or very high (>284 mg $l^{-1}$ $CaCO_3$) alkalinity are the most likely to be in poorer condition (c, d or e/f). Three of the five sites with very high alkalinity and covered with a silt/clay fine substratum were in very poor condition (grade e/f, Table 3.12); a much higher than expected proportion.

The likelihood of being high quality increases with the coarseness of the substratum, irrespective of the site altitude (Tables 3.13-3.14).

**Table 3.6 Percentage of sites in each overall (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of distance from source (km) and altitude (m). Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| Distance | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <5 | 6 | 12 | 19 | 17 | 17 | 21 |
| 5-7.9 | 27 | 32 | 27 | 27 | 24 | 30 |
| 8-12.5 | 22 | 29 | 34 | 25 | 35 | 24 |
| 12.6-24 | 34 | 38 | 37 | 35 | 33 | 44 |
| 24.1-84 | 49 | 39 | 40 | 38 | 50 | 67 |
| >84 | 29 | 47 | 45 | 75 | --- | --- |

%grade b

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <5 | 23 | 21 | 21 | 20 | 26 | 38 |
| 5-7.9 | 22 | 22 | 24 | 29 | 40 | 42 |
| 8-12.5 | 36 | 33 | 25 | 32 | 40 | 54 |
| 12.6-24 | 40 | 30 | 26 | 39 | 41 | 44 |
| 24.1-84 | 34 | 31 | 35 | 29 | 39 | 33 |
| >84 | 40 | 37 | 35 | 25 | --- | --- |

%grade c

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| Distance | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <5 | 32 | 26 | 29 | 28 | 21 | 23 |
| 5-7.9 | 29 | 24 | 31 | 25 | 20 | 19 |
| 8-12.5 | 21 | 16 | 24 | 25 | 11 | 11 |
| 12.6-24 | 18 | 20 | 18 | 19 | 13 | 4 |
| 24.1-84 | 10 | 14 | 15 | 18 | 5 | 0 |
| >84 | 12 | 16 | 13 | 0 | --- | --- |

%grade d

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <5 | 18 | 24 | 23 | 18 | 19 | 10 |
| 5-7.9 | 14 | 14 | 13 | 13 | 10 | 9 |
| 8-12.5 | 12 | 14 | 11 | 10 | 6 | 11 |
| 12.6-24 | 4 | 6 | 12 | 4 | 8 | 4 |
| 24.1-84 | 3 | 7 | 5 | 7 | 1 | 0 |
| >84 | 3 | 0 | 6 | 0 | --- | --- |

%grade e/f

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| Distance | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <5 | 21 | 17 | 8 | 17 | 17 | 8 |
| 5-7.9 | 8 | 9 | 5 | 7 | 6 | 0 |
| 8-12.5 | 9 | 7 | 6 | 8 | 7 | 0 |
| 12.6-24 | 4 | 6 | 6 | 3 | 6 | 4 |
| 24.1-84 | 5 | 8 | 5 | 7 | 5 | 0 |
| >84 | 16 | 0 | 0 | 0 | --- | --- |

number of sites

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <5 | 184 | 197 | 198 | 281 | 321 | 39 |
| 5-7.9 | 184 | 195 | 228 | 249 | 265 | 57 |
| 8-12.5 | 252 | 222 | 224 | 267 | 213 | 46 |
| 12.6-24 | 271 | 226 | 271 | 224 | 180 | 27 |
| 24.1-84 | 300 | 238 | 232 | 163 | 82 | 3 |
| >84 | 104 | 38 | 31 | 4 | 0 | 0 |

**Table 3.7 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of distance from source (km) and alkalinity (mg $l^{-1}$ $CaCO_3$). Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | Alkalinity | | | | | |
|---|---|---|---|---|---|---|
| Distance | <61 | 61-123 | 124-182 | 183-227 | 228-284 | >284 |
| <5 | 23 | 13 | 10 | 14 | 20 | 8 |
| 5-7.9 | 33 | 30 | 18 | 27 | 28 | 22 |
| 8-12.5 | 34 | 27 | 21 | 29 | 34 | 9 |
| 12.6-24 | 40 | 39 | 24 | 33 | 42 | 28 |
| 24.1-84 | 55 | 39 | 30 | 39 | 56 | 36 |
| >84 | 56 | 48 | 19 | 39 | 40 | --- |

%grade b

| Alkalinity | | | | | |
|---|---|---|---|---|---|
| <61 | 61-123 | 124-182 | 183-227 | 228-284 | >284 |
| 42 | 21 | 15 | 20 | 25 | 10 |
| 46 | 26 | 17 | 24 | 31 | 14 |
| 49 | 36 | 23 | 25 | 34 | 30 |
| 46 | 31 | 27 | 32 | 36 | 46 |
| 33 | 31 | 26 | 37 | 37 | 29 |
| 38 | 33 | 37 | 43 | 47 | --- |

%grade c

| | Alkalinity | | | | | |
|---|---|---|---|---|---|---|
| Distance | <61 | 61-123 | 124-182 | 183-227 | 228-284 | >284 |
| <5 | 18 | 23 | 23 | 31 | 35 | 42 |
| 5-7.9 | 13 | 25 | 26 | 31 | 30 | 50 |
| 8-12.5 | 10 | 15 | 23 | 26 | 23 | 34 |
| 12.6-24 | 8 | 15 | 21 | 24 | 19 | 23 |
| 24.1-84 | 5 | 13 | 22 | 17 | 6 | 21 |
| >84 | 0 | 10 | 21 | 9 | 13 | --- |

%grade d

| Alkalinity | | | | | |
|---|---|---|---|---|---|
| <61 | 61-123 | 124-182 | 183-227 | 228-284 | >284 |
| 9 | 21 | 25 | 26 | 13 | 19 |
| 4 | 11 | 27 | 12 | 9 | 6 |
| 3 | 12 | 19 | 14 | 6 | 16 |
| 2 | 7 | 16 | 9 | 2 | 0 |
| 2 | 5 | 12 | 4 | 1 | 14 |
| 6 | 0 | 8 | 0 | 0 | --- |

%grade e/f

| | Alkalinity | | | | | |
|---|---|---|---|---|---|---|
| Distance | <61 | 61-123 | 124-182 | 183-227 | 228-284 | >284 |
| <5 | 7 | 22 | 27 | 9 | 8 | 21 |
| 5-7.9 | 4 | 8 | 12 | 6 | 3 | 8 |
| 8-12.5 | 3 | 9 | 13 | 6 | 2 | 11 |
| 12.6-24 | 4 | 7 | 11 | 2 | 1 | 3 |
| 24.1-84 | 5 | 12 | 10 | 2 | 1 | 0 |
| >84 | 0 | 10 | 15 | 9 | 0 | --- |

number of sites

| Alkalinity | | | | | |
|---|---|---|---|---|---|
| <61 | 61-123 | 124-182 | 183-227 | 228-284 | >284 |
| 188 | 253 | 283 | 235 | 213 | 48 |
| 282 | 221 | 231 | 219 | 189 | 36 |
| 293 | 235 | 253 | 198 | 201 | 44 |
| 246 | 236 | 205 | 246 | 227 | 39 |
| 176 | 220 | 177 | 252 | 179 | 14 |
| 16 | 40 | 52 | 54 | 15 | 0 |

**Table 3.8 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of distance from source (km) and percentage cover of pebbles/gravel. Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Distance | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <5 | 6 | 11 | 13 | 20 | 24 | 32 |
| 5-7.9 | 14 | 21 | 31 | 30 | 36 | 64 |
| 8-12.5 | 21 | 19 | 31 | 34 | 38 | 36 |
| 12.6-24 | 31 | 24 | 34 | 41 | 48 | 58 |
| 24.1-84 | 35 | 35 | 46 | 47 | 50 | 60 |
| >84 | 17 | 25 | 52 | 52 | 60 | 43 |

%grade b

| %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|
| 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| 19 | 20 | 26 | 24 | 25 | 23 |
| 30 | 25 | 27 | 33 | 34 | 12 |
| 26 | 36 | 35 | 36 | 38 | 38 |
| 33 | 41 | 36 | 33 | 30 | 42 |
| 40 | 29 | 32 | 35 | 29 | 28 |
| 40 | 54 | 36 | 24 | 27 | 57 |

%grade c

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Distance | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <5 | 32 | 25 | 26 | 24 | 27 | 16 |
| 5-7.9 | 33 | 29 | 25 | 22 | 16 | 21 |
| 8-12.5 | 23 | 26 | 19 | 16 | 13 | 18 |
| 12.6-24 | 22 | 20 | 19 | 15 | 13 | 0 |
| 24.1-84 | 14 | 18 | 12 | 10 | 12 | 8 |
| >84 | 16 | 17 | 8 | 14 | 10 | 0 |

%grade d

| %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|
| 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| 21 | 26 | 19 | 19 | 13 | 16 |
| 13 | 18 | 11 | 8 | 10 | 3 |
| 15 | 12 | 10 | 10 | 7 | 8 |
| 6 | 8 | 6 | 7 | 7 | 0 |
| 4 | 8 | 4 | 3 | 5 | 3 |
| 5 | 0 | 0 | 5 | 3 | 0 |

%grade e/f

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Distance | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <5 | 21 | 18 | 16 | 13 | 11 | 13 |
| 5-7.9 | 10 | 7 | 6 | 7 | 4 | 0 |
| 8-12.5 | 15 | 7 | 5 | 5 | 5 | 0 |
| 12.6-24 | 8 | 7 | 4 | 4 | 1 | 0 |
| 24.1-84 | 7 | 10 | 5 | 5 | 3 | 3 |
| >84 | 22 | 4 | 4 | 5 | 0 | 0 |

number of sites

| %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|
| 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| 278 | 235 | 232 | 219 | 225 | 31 |
| 224 | 272 | 232 | 213 | 204 | 33 |
| 233 | 237 | 247 | 276 | 192 | 39 |
| 229 | 254 | 253 | 229 | 210 | 24 |
| 220 | 196 | 185 | 187 | 190 | 40 |
| 63 | 24 | 25 | 21 | 30 | 14 |

**Table 3.9 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of distance from source (km) and percentage cover of silt/clay. Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Distance | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <5 | 23 | 23 | 16 | 14 | 7 | 4 |
| 5-7.9 | 33 | 42 | 29 | 18 | 17 | 6 |
| 8-12.5 | 32 | 36 | 30 | 22 | 20 | 29 |
| 12.6-24 | 37 | 42 | 36 | 28 | 31 | 46 |
| 24.1-84 | 48 | 44 | 43 | 37 | 41 | 30 |
| >84 | 63 | 50 | 21 | 41 | 16 | 29 |

%grade b

| %cover of silt/clay | | | | | |
|---|---|---|---|---|---|
| 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| 30 | 25 | 25 | 20 | 19 | 17 |
| 40 | 27 | 29 | 25 | 22 | 27 |
| 47 | 31 | 33 | 31 | 26 | 24 |
| 42 | 32 | 30 | 36 | 32 | 35 |
| 30 | 32 | 29 | 40 | 35 | 56 |
| 28 | 34 | 43 | 35 | 53 | 21 |

%grade c

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Distance | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <5 | 18 | 18 | 25 | 31 | 32 | 40 |
| 5-7.9 | 16 | 17 | 23 | 34 | 34 | 45 |
| 8-12.5 | 9 | 15 | 20 | 27 | 30 | 26 |
| 12.6-24 | 12 | 12 | 19 | 25 | 26 | 12 |
| 24.1-84 | 15 | 9 | 16 | 13 | 12 | 11 |
| >84 | 6 | 9 | 21 | 12 | 14 | 21 |

%grade d

| %cover of silt/clay | | | | | |
|---|---|---|---|---|---|
| 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| 13 | 16 | 16 | 23 | 26 | 17 |
| 6 | 9 | 12 | 14 | 21 | 15 |
| 6 | 12 | 10 | 13 | 13 | 12 |
| 5 | 9 | 9 | 6 | 4 | 8 |
| 4 | 7 | 7 | 3 | 4 | 0 |
| 0 | 6 | 7 | 3 | 2 | 0 |

%grade e/f

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Distance | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <5 | 16 | 17 | 18 | 12 | 15 | 23 |
| 5-7.9 | 5 | 5 | 7 | 9 | 6 | 6 |
| 8-12.5 | 5 | 6 | 8 | 7 | 11 | 9 |
| 12.6-24 | 4 | 5 | 6 | 5 | 6 | 0 |
| 24.1-84 | 3 | 9 | 5 | 7 | 7 | 4 |
| >84 | 3 | 0 | 7 | 9 | 16 | 29 |

number of sites

| %cover of silt/clay | | | | | |
|---|---|---|---|---|---|
| 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| 164 | 173 | 267 | 290 | 278 | 48 |
| 250 | 214 | 249 | 247 | 185 | 33 |
| 280 | 226 | 283 | 226 | 175 | 34 |
| 305 | 221 | 258 | 216 | 173 | 26 |
| 279 | 199 | 182 | 150 | 181 | 27 |
| 32 | 32 | 14 | 34 | 51 | 14 |

**Table 3.10 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of alkalinity (mg $l^{-1}$ $CaCO_3$) and altitude (m). Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <61 | 39 | 42 | 51 | 40 | 30 | 30 |
| 61-123 | 37 | 32 | 31 | 23 | 24 | 34 |
| 124-182 | 19 | 20 | 18 | 17 | 27 | 0 |
| 183-227 | 24 | 35 | 30 | 28 | 26 | --- |
| 228-284 | 34 | 34 | 42 | 31 | 39 | --- |
| >284 | 14 | 20 | 19 | 25 | 10 | --- |

%grade b

| Altitude | | | | | |
|---|---|---|---|---|---|
| <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| 43 | 44 | 36 | 40 | 48 | 48 |
| 26 | 27 | 25 | 32 | 33 | 39 |
| 29 | 16 | 23 | 19 | 20 | 30 |
| 35 | 24 | 26 | 27 | 32 | --- |
| 36 | 37 | 26 | 33 | 31 | --- |
| 33 | 29 | 24 | 21 | 5 | --- |

%grade c

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <61 | 13 | 8 | 6 | 12 | 10 | 16 |
| 61-123 | 19 | 13 | 20 | 20 | 20 | 17 |
| 124-182 | 18 | 23 | 26 | 27 | 24 | 0 |
| 183-227 | 24 | 23 | 26 | 30 | 16 | --- |
| 228-284 | 21 | 23 | 25 | 24 | 14 | --- |
| >284 | 33 | 32 | 43 | 46 | 29 | --- |

%grade d

| Altitude | | | | | |
|---|---|---|---|---|---|
| <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| 4 | 2 | 3 | 4 | 5 | 5 |
| 8 | 12 | 12 | 11 | 15 | 7 |
| 15 | 22 | 22 | 22 | 17 | 60 |
| 9 | 15 | 15 | 9 | 13 | --- |
| 5 | 6 | 5 | 7 | 9 | --- |
| 5 | 16 | 8 | 4 | 24 | --- |

%grade e/f

| | Altitude | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| <61 | 2 | 5 | 3 | 5 | 7 | 2 |
| 61-123 | 10 | 17 | 12 | 15 | 9 | 2 |
| 124-182 | 19 | 19 | 11 | 15 | 13 | 10 |
| 183-227 | 7 | 3 | 3 | 6 | 12 | --- |
| 228-284 | 4 | 0 | 2 | 4 | 7 | --- |
| >284 | 16 | 4 | 5 | 4 | 33 | --- |

number sites

| Altitude | | | | | |
|---|---|---|---|---|---|
| <16 | 16-36 | 37-64 | 65-99 | 100-200 | >200 |
| 183 | 130 | 155 | 196 | 416 | 121 |
| 270 | 242 | 179 | 206 | 267 | 41 |
| 269 | 225 | 254 | 262 | 181 | 10 |
| 274 | 253 | 298 | 273 | 106 | 0 |
| 256 | 210 | 261 | 227 | 70 | 0 |
| 43 | 56 | 37 | 24 | 21 | 0 |

**Table 3.11 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of alkalinity (mg $l^{-1}$ $CaCO_3$) and percentage cover of pebbles/gravel. Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <61 | 25 | 28 | 46 | 39 | 44 | 26 |
| 61-123 | 24 | 23 | 32 | 35 | 36 | 41 |
| 124-182 | 16 | 11 | 21 | 24 | 28 | 33 |
| 183-227 | 18 | 19 | 22 | 34 | 42 | 69 |
| 228-284 | 26 | 32 | 31 | 40 | 47 | 63 |
| >284 | 10 | 12 | 11 | 23 | 48 | 20 |

%grade b

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <61 | 47 | 49 | 38 | 41 | 45 | 61 |
| 61-123 | 28 | 28 | 27 | 30 | 31 | 36 |
| 124-182 | 19 | 19 | 21 | 23 | 28 | 19 |
| 183-227 | 33 | 28 | 32 | 28 | 23 | 18 |
| 228-284 | 31 | 28 | 36 | 38 | 33 | 21 |
| >284 | 19 | 27 | 35 | 23 | 14 | 40 |

%grade c

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <61 | 14 | 14 | 10 | 10 | 6 | 11 |
| 61-123 | 21 | 20 | 18 | 15 | 15 | 14 |
| 124-182 | 24 | 28 | 22 | 21 | 21 | 19 |
| 183-227 | 26 | 27 | 32 | 23 | 22 | 9 |
| 228-284 | 31 | 29 | 24 | 15 | 13 | 13 |
| >284 | 40 | 44 | 27 | 34 | 33 | 20 |

%grade d

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <61 | 9 | 4 | 2 | 4 | 5 | 3 |
| 61-123 | 9 | 15 | 12 | 12 | 8 | 5 |
| 124-182 | 19 | 27 | 19 | 20 | 15 | 22 |
| 183-227 | 12 | 19 | 12 | 10 | 10 | 3 |
| 228-284 | 8 | 6 | 8 | 4 | 5 | 0 |
| >284 | 14 | 5 | 22 | 9 | 5 | 0 |

%grade e/f

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <61 | 5 | 6 | 4 | 6 | 2 | 0 |
| 61-123 | 18 | 14 | 11 | 7 | 9 | 5 |
| 124-182 | 23 | 15 | 17 | 13 | 8 | 7 |
| 183-227 | 10 | 6 | 3 | 5 | 3 | 0 |
| 228-284 | 3 | 5 | 2 | 3 | 2 | 4 |
| >284 | 17 | 12 | 5 | 11 | 0 | 20 |

number of sites

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <61 | 148 | 265 | 314 | 259 | 177 | 38 |
| 61-123 | 246 | 270 | 226 | 233 | 208 | 22 |
| 124-182 | 301 | 252 | 208 | 215 | 198 | 27 |
| 183-227 | 267 | 219 | 206 | 209 | 238 | 65 |
| 228-284 | 243 | 171 | 183 | 194 | 209 | 24 |
| >284 | 42 | 41 | 37 | 35 | 21 | 5 |

**Table 3.12 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of alkalinity (mg $l^{-1}$ $CaCO_3$) and percentage cover of silt/clay. Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <61 | 38 | 42 | 34 | 29 | 28 | 25 |
| 61-123 | 36 | 29 | 24 | 22 | 28 | 39 |
| 124-182 | 26 | 29 | 19 | 11 | 16 | 10 |
| 183-227 | 43 | 48 | 31 | 23 | 18 | 21 |
| 228-284 | 57 | 50 | 41 | 32 | 26 | 22 |
| >284 | 0 | 31 | 28 | 16 | 9 | 0 |

%grade b

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <61 | 49 | 38 | 42 | 42 | 35 | 25 |
| 61-123 | 37 | 32 | 24 | 27 | 17 | 18 |
| 124-182 | 24 | 22 | 20 | 20 | 22 | 29 |
| 183-227 | 22 | 25 | 27 | 27 | 33 | 40 |
| 228-284 | 13 | 30 | 35 | 36 | 32 | 29 |
| >284 | 14 | 15 | 28 | 27 | 26 | 0 |

%grade c

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <61 | 9 | 11 | 12 | 13 | 18 | 50 |
| 61-123 | 15 | 13 | 21 | 21 | 25 | 21 |
| 124-182 | 22 | 16 | 24 | 30 | 21 | 29 |
| 183-227 | 16 | 16 | 27 | 31 | 27 | 23 |
| 228-284 | 9 | 13 | 15 | 24 | 31 | 38 |
| >284 | 14 | 31 | 30 | 43 | 40 | 20 |

%grade d

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <61 | 2 | 5 | 4 | 10 | 13 | 0 |
| 61-123 | 7 | 14 | 14 | 16 | 10 | 12 |
| 124-182 | 15 | 19 | 22 | 20 | 25 | 12 |
| 183-227 | 10 | 8 | 10 | 15 | 15 | 12 |
| 228-284 | 13 | 3 | 5 | 5 | 8 | 7 |
| >284 | 43 | 8 | 8 | 6 | 16 | 20 |

%grade e/f

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <61 | 3 | 4 | 8 | 6 | 8 | 0 |
| 61-123 | 5 | 12 | 17 | 13 | 20 | 9 |
| 124-182 | 12 | 13 | 15 | 19 | 16 | 21 |
| 183-227 | 8 | 3 | 5 | 4 | 8 | 5 |
| 228-284 | 9 | 4 | 3 | 2 | 3 | 4 |
| >284 | 29 | 15 | 6 | 8 | 9 | 60 |

number of sites

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Alkalinity | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <61 | 567 | 296 | 196 | 98 | 40 | 4 |
| 61-123 | 394 | 232 | 216 | 158 | 172 | 33 |
| 124-182 | 197 | 225 | 245 | 248 | 234 | 52 |
| 183-227 | 99 | 186 | 286 | 301 | 289 | 43 |
| 228-284 | 46 | 113 | 260 | 295 | 265 | 45 |
| >284 | 7 | 13 | 50 | 63 | 43 | 5 |

**Table 3.13 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of altitude (m) and percentage cover of pebbles/gravel. Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Altitude | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <16 | 23 | 25 | 34 | 37 | 41 | 40 |
| 16-36 | 23 | 20 | 28 | 30 | 44 | 71 |
| 37-64 | 17 | 21 | 31 | 37 | 47 | 50 |
| 65-99 | 16 | 18 | 27 | 37 | 33 | 47 |
| 100-200 | 22 | 24 | 33 | 30 | 28 | 23 |
| >200 | 18 | 23 | 45 | 24 | 50 | 50 |

%grade b

| %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|
| 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| 30 | 34 | 33 | 37 | 34 | 47 |
| 23 | 30 | 27 | 31 | 30 | 20 |
| 28 | 21 | 27 | 27 | 29 | 30 |
| 31 | 25 | 34 | 30 | 28 | 25 |
| 38 | 39 | 33 | 34 | 37 | 35 |
| 33 | 43 | 50 | 60 | 42 | 50 |

%grade c

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Altitude | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <16 | 24 | 23 | 18 | 14 | 14 | 7 |
| 16-36 | 21 | 20 | 23 | 22 | 15 | 4 |
| 37-64 | 31 | 32 | 24 | 18 | 13 | 13 |
| 65-99 | 30 | 27 | 23 | 17 | 23 | 19 |
| 100-200 | 16 | 18 | 15 | 14 | 17 | 23 |
| >200 | 28 | 18 | 3 | 16 | 0 | 0 |

%grade d

| %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|
| 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| 9 | 10 | 7 | 8 | 8 | 3 |
| 14 | 21 | 13 | 9 | 8 | 4 |
| 16 | 17 | 12 | 12 | 7 | 7 |
| 12 | 15 | 9 | 9 | 9 | 6 |
| 15 | 10 | 10 | 10 | 11 | 8 |
| 13 | 14 | 3 | 0 | 8 | 0 |

%grade e/f

| | %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|---|
| Altitude | 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| <16 | 15 | 8 | 8 | 3 | 4 | 3 |
| 16-36 | 19 | 9 | 8 | 8 | 3 | 0 |
| 37-64 | 9 | 8 | 5 | 6 | 4 | 0 |
| 65-99 | 11 | 15 | 7 | 6 | 6 | 3 |
| 100-200 | 9 | 10 | 8 | 12 | 8 | 12 |
| >200 | 8 | 2 | 0 | 0 | 0 | 0 |

number of sites

| %cover of pebbles/gravel | | | | | |
|---|---|---|---|---|---|
| 0-20 | 21-33 | 34-43 | 44-55 | 56-76 | 77-100 |
| 497 | 222 | 180 | 202 | 164 | 30 |
| 195 | 198 | 216 | 239 | 223 | 45 |
| 174 | 225 | 241 | 251 | 247 | 46 |
| 189 | 259 | 239 | 233 | 236 | 32 |
| 153 | 258 | 260 | 195 | 169 | 26 |
| 39 | 56 | 38 | 25 | 12 | 2 |

**Table 3.14 Percentage of sites in each (bias-corrected) biological grade (a-d, e/f) and total number of all 1995 sites for each combination of categories of altitude (m) and percentage cover of silt/clay. Cells are shaded in deciles of percentages to aid interpretation of patterns. (n = 6016 sites).**

%grade a

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Altitude | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <16 | 38 | 42 | 34 | 29 | 28 | 25 |
| 16-36 | 36 | 29 | 24 | 22 | 28 | 39 |
| 37-64 | 26 | 29 | 19 | 11 | 16 | 10 |
| 65-99 | 43 | 48 | 31 | 23 | 18 | 21 |
| 100-200 | 57 | 50 | 41 | 32 | 26 | 22 |
| >200 | 0 | 31 | 28 | 16 | 9 | 0 |

%grade b

| %cover of silt/clay | | | | | |
|---|---|---|---|---|---|
| 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| 49 | 38 | 42 | 42 | 35 | 25 |
| 37 | 32 | 24 | 27 | 17 | 18 |
| 24 | 22 | 20 | 20 | 22 | 29 |
| 22 | 25 | 27 | 27 | 33 | 40 |
| 13 | 30 | 35 | 36 | 32 | 29 |
| 14 | 15 | 28 | 27 | 26 | 0 |

%grade c

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Altitude | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <16 | 9 | 11 | 12 | 13 | 18 | 50 |
| 16-36 | 15 | 13 | 21 | 21 | 25 | 21 |
| 37-64 | 22 | 16 | 24 | 30 | 21 | 29 |
| 65-99 | 16 | 16 | 27 | 31 | 27 | 23 |
| 100-200 | 9 | 13 | 15 | 24 | 31 | 38 |
| >200 | 14 | 31 | 30 | 43 | 40 | 20 |

%grade d

| %cover of silt/clay | | | | | |
|---|---|---|---|---|---|
| 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| 2 | 5 | 4 | 10 | 13 | 0 |
| 7 | 14 | 14 | 16 | 10 | 12 |
| 15 | 19 | 22 | 20 | 25 | 12 |
| 10 | 8 | 10 | 15 | 15 | 12 |
| 13 | 3 | 5 | 5 | 8 | 7 |
| 43 | 8 | 8 | 6 | 16 | 20 |

%grade e/f

| | %cover of silt/clay | | | | | |
|---|---|---|---|---|---|---|
| Altitude | 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| <16 | 3 | 4 | 8 | 6 | 8 | 0 |
| 16-36 | 5 | 12 | 17 | 13 | 20 | 9 |
| 37-64 | 12 | 13 | 15 | 19 | 16 | 21 |
| 65-99 | 8 | 3 | 5 | 4 | 8 | 5 |
| 100-200 | 9 | 4 | 3 | 2 | 3 | 4 |
| >200 | 29 | 15 | 6 | 8 | 9 | 60 |

number of sites

| %cover of silt/clay | | | | | |
|---|---|---|---|---|---|
| 0-1 | 2-5 | 6-13 | 14-34 | 35-95 | 96-100 |
| 567 | 296 | 196 | 98 | 40 | 4 |
| 394 | 232 | 216 | 158 | 172 | 33 |
| 197 | 225 | 245 | 248 | 234 | 52 |
| 99 | 186 | 286 | 301 | 289 | 43 |
| 46 | 113 | 260 | 295 | 265 | 45 |
| 7 | 13 | 50 | 63 | 43 | 5 |

The best fitting logistic multiple regression model for predicting the probability $P_a$ of being overall grade "a" (with all variables significant at $p<0.001$) was :

$$\mathrm{Log}(P_a/(1-P_a) = -3.57 + 0.662\ \mathrm{LogDistance} + 0.0202\ \%\mathrm{Pebbles/Gravel} - 0.055\ \mathrm{Mean\ substratum} + 0.82\ \mathrm{LogDepth}$$

re-enforcing the finding that sites further from their source, with non-fine substrata and especially those with considerable covering of pebbles/gravel tend to be the most likely to be of the highest biological grade. After allowing for associations with distance from source and substratum type, the deeper river sites tend to be more likely to be grade "a".

Similarly, the best fitting logistic multiple regression model for predicting the probability $P_{e/f}$ of being in poor condition (overall grade e/f) (with all variables significant at $p<0.001$) was :

$$\mathrm{Log}(P_{e/f}/(1-P_{e/f}) = -5.60 - 0.879\ \mathrm{Log\ Distance} - 0.0198\ \%\mathrm{Pebbles/Gravel} - 0.0141\ \mathrm{Alkalinity} + 3.28\ \mathrm{Log\ Alkalinity}$$

This supports the previous conclusions that sites near the source and lacking in coarse substratum are more likely to be in the poorest condition. It also represent the complex relationship with alkalinity described above, where sites with intermediate alkalinity especially are more likely to be of the poorest grades.

## 3.3 Summary

In 1995, 61% of all sites in England and Wales were graded as "very good" or "good" (grades a or b), 31% as "fairly good" or "fair" (grades c or d), 7% as "poor" (grade e) and only 1.4% as "bad" (grade f). These percentages agree closely with those derived independently by the Environment Agency using their version of the GQA database.

The current settings of GQA grade limits for $\mathrm{EQI_{TAXA}}$ and $\mathrm{EQI_{ASPT}}$ have implications for the overall grade given to sites. The lower EQI limit for grade "a" is 1.00 for $\mathrm{EQI_{ASPT}}$ but only 0.85 for $\mathrm{EQI_{TAXA}}$. We understand that this was done mostly to ensure that sites in Wales considered to be of high quality, with high ASPT but fewer than expected taxa, were still classified as grade "a". This major difference in grade "a" limits is largely responsible for 61% of all sites being graded "a" based on their number of taxa, but only 32% using their ASPT. The ASPT value for a site, therefore, in practice usually determines whether or not it is classed as overall grade "a".

With the present grading system, sites are far more likely to be given overall GQA grade f because of their lack of taxa (i.e. <30% expected number) than because of their low ASPT (which, in practice usually requires no taxa with BMWP score above 3).

These apparent effects of the current GQA grade limits may or may not be desirable. One possible interpretation is that most mild stress is from organic pollution, whereas relatively more severe stress is from toxic pollution. It is accepted that, for reasons of continuity and consistency in presentation of results for the 2000 GQA, the current grade ranges should be retained for that year, but it is recommended that they should be re-considered for future surveys.

North West Region had by far the highest percentage (5.3%) of grade f sites, which may influence apparent overall associations between poor biological condition and site characteristics and stress types across England and Wales.

To aid assessment of associations between biological grade and environmental variables, each variable was divided into ordered classes with 20% of sites in each, but the highest class sub-divided so as to separate the 3% of all sites with the highest values.

No strong relationships existed between grade and either altitude or slope, although the 3% of sites above 200m were relatively unlikely to be grades e/f and most likely to be grade b.

16% of sites close to their source (i.e. within 5km) were grade e/f compared to only 5-10% of sites further downstream. The percentage of sites in the highest grade increased dramatically with distance from source, from only 15% for sites within 5km of their source to over 40% for sites over 24km from source. Sites near their source are more likely to be in good condition if they are not at very low altitudes (<16m).

Discharge was also related to biological grade. Although 47% of all sites sampled in 1995 were discharge class 1, they formed only 31% of all grade “a” sites, but 58% of all sites graded e/f. However, these low discharge streams were most dominant in grades c and d where they represented about two-thirds of all such intermediate condition sites.

Sites graded e/f were relatively more likely to be either narrow (<2m), discharge class 1 sites within 5km of their sources or very wide sites (>10m) with high discharge (classes 9-10). However, a large percentage (38%) of the river sites with the highest discharge classes (9-10) were also of the highest grade.

Although the GQA grading system places more sites in grade “a” using $EQI_{TAXA}$ than using $EQI_{ASPT}$, the tendency for small streams near their source to be in poorer condition is similar when based on either EQI. Thus poor condition “near-source” sites are often reduced in both number and average BMWP score of taxa.

Sites of either intermediate alkalinity ( i.e. 61-182 mg $l^{-1}$ $CaCO_3$) or very high alkalinity (i.e. >284 mg $l^{-1}$ $CaCO_3$) are 2-3 times more likely to be graded e/f than sites with either very low or moderately high alkalinity. This complex pattern merits further investigation.

Sites with substrata dominated by pebbles/gravel are twice as likely to be grade “a” as those with less than 20%. Fine sediment sites with a relatively high percentage cover of sand (i.e. >20%) or silt/clay (i.e. >35%) are twice as likely to be of “poor” or “bad” biological condition (grades e and f) as sites with very little or none, irrespective of the stream size or distance from source. Fine sediment sites are likely to provide a lower diversity of habitats.

# 4 CHANGES IN BIOLOGICAL CONDITION BETWEEN 1990 AND 1995

## 4.1 Introduction and Methods

The aim of this section is to provide an assessment of the pattern of changes in the biological condition of river sites that has occurred between the 1990 River Quality Survey (RQS) and the 1995 General Quality Assessment (GQA)

### 4.1.1 Selection of suitable matched sites and data

All analyses of change were based on the 3018 matched sites, selected as described in section 2.1.2. Estimates of the environmental variables for each site were based on the average of the values for 1990 and 1995, as explained in section 2.1.3 All changes in EQI values and biological grade were based on bias-corrected values as detailed in section 2.1.4.

### 4.1.2 Methods of estimating probability of change in biological condition and classes of change

Estimates of the magnitude of change in quality at a site and assessments of the likelihood (i.e. probability) that a real change has occurred were assessed using the RIVPACS III+ software package (Clarke *et al.* 1997).

First, the RIVPACS 'Prediction' procedure was used on the biological and environmental data for the matched sites in each of 1990 and 1995 and the observed (O), expected (E) and O/E ratios (i.e. Ecological Quality Indices (EQI)) for number of taxa and ASPT were output to 'RIVPACS O-E type 1 files' (see section 6.11.1 of Clarke *et al.* 1997). These two files were then amended to include the year and region specific sample biases of Table 2.2. The two files were then used as input files to the 'Compare' procedure in RIVPACS III+ to derive assessments of biological condition in each year and changes in condition for each of the matched sites, both uncorrected and corrected for sample processing biases. RIVPACS III+ was also used to provide assessments and confidence limits for the change in EQI values at a site and hence a statistical test of whether the observed change in EQI was likely to be real. In addition it was used to estimate the probability that the site was in each biological grade in each year and hence the probability that the site had improved or deteriorated in grade. The actual EQI value observed for a site, uncorrected for bias, is called the "face EQI value uncorrected for bias" and the grade of the site based on these "face" EQI values is called the "face band uncorrected for bias" (see Clarke *et al.* 1997, section 7). The estimated EQI and consequent biological grade after correcting for bias are called the "face EQI corrected for bias" and "face grade corrected for bias".

RIVPACS III+ uses computer simulations to estimate the probability of change in EQI and biological grade at a site. From the simulations RIVPACS III+ is used to estimate the frequency distribution for the true change in biological condition. This, in turn, enables a statistical test to be used to derive the probability of getting the observed difference in EQI, under the null hypothesis that there had been no real underlying change.

This frequency distribution can also be used to estimate the probability that the site was in one grade in one year (1990) and another particular (perhaps the same) grade in a second year (1995). Summing up the probabilities across all the simulation cases where the site had been downgraded (e.g. from grade b to c) gives an estimate of the probability ($P_{down}$) that the site has really deteriorated in biological grade. Similarly, by summing up the probabilities across all the cases where the site had been upgraded (e.g. from grade b to a) gives an estimate of the probability ($P_{up}$) that the site has really improved in biological grade.

Sites were assigned to classes of change by each of two methods, both of which are based on bias-corrected values:

Method 1: change classes called "Likelihood of a change in grade" :
In this method, all sites were classified into one of seven classes based solely on the values of $P_{down}$ and $P_{up}$, as follows:
If $P_{down} \leq 0.50$ and $P_{up} \leq 0.50$ then the site is most likely to have stayed the "same grade" and is classified as having stayed in its face grade corrected for bias for 1995.
If $P_{down} > 0.50$ then the site is most likely to have become a poorer grade and is classed as "downgraded with p>95%, p>75% or p>50%" according to whether $P_{down}$ is >0.95, >0.75 or >0.50 respectively. Similarly if $P_{up} > 0.50$ then the site is most likely to have become a better grade and is classed as "upgraded with p>95%, p>75% or p>50%" according to whether $P_{up}$ is >0.95, >0.75 or >0.50 respectively.

Method 2: change classes called "Most probable change in grade"
In this method, all sites were classified into one of 21 classes as follows:
If $P_{down} \leq 0.50$ and $P_{up} \leq 0.50$ then the site is most likely to have stayed the "same grade" as per method 1. Otherwise (i.e. if $P_{down} > 0.50$ or $P_{up} > 0.50$) then the change from the "face" grade in 1990 to the "face" grade in 1995 is taken as the most probable change in grade class. Thus, for example, a "most probable change in grade" of "c to a" means the overall face grade corrected for bias was c in 1990 and "a" in 1995 and the probability $P_{up}$ of an improvement in grade was over 50%.

Analyses of change in relation to environmental and other factors are reported in terms of one or other of these two definitions of statistically significant change.

## 4.2 Summary of Changes in Biological Condition Between 1990 and 1995

Section 4.2.1 summarises the changes in the "face" grades for the matched sites based on their "face" EQI values, regardless of the statistical significance of the change. Section 4.2.2 summarises the probabilities of real changes in biological condition at matched sites in terms of changes in their EQI values and grades, corrected for bias.

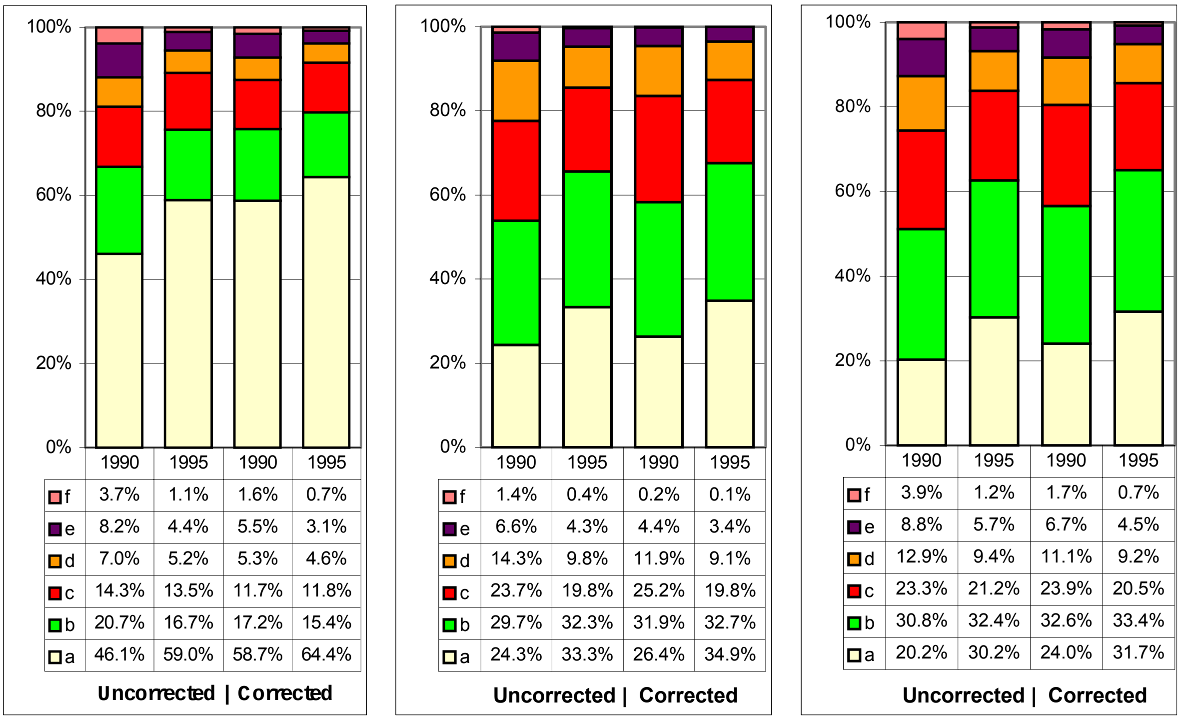
### 4.2.1 Observed changes in grade, regardless of statistical significance

Figure 4.1 shows the overall percentage of the matched sites in England and Wales assigned to each grade in 1990 and 1995.

When uncorrected for biases, there appears to be a dramatic increase in the overall biological condition of sites between 1990 and 1995 based on EQI for number of taxa (Figure 4.1(a)). Only 46.1% of sites were graded "a" in 1990 compared to 59.0% in 1995; whilst 3.7% of matched sites were graded f in 1990, this fell to only 1.1% in 1995.

Correcting for biases always increases the estimated EQI based on number of taxa. However, because sample processing biases were generally greater in 1990 than 1995 (Table 2.2), the effect of correcting for biases is to increase the estimated $EQI_{TAXA}$ values for 1990 more than the values for 1995, so the size of the estimated inter-year differences are reduced. For example, once corrected for bias in $EQI_{TAXA}$, 58.7% of sites were assigned grade "a" in 1990 compared to 64.4% in 1995, an improvement of 5.7% between the two surveys, compared to a corresponding estimated improvement of 12.9% if biases are ignored. Even after correcting for bias, there were less than half as many (0.7% versus 1.6%) sites graded f in 1995 compared to 1990 (Figure 4.1(a)).

**Figure 4.1 Percentage of all 3018 matched sites in England and Wales in each grade (a-f) in 1990 and 1995, uncorrected (left) and corrected (right) for sample processing biases. Grades based on (a) $EQI_{TAXA}$ (b) $EQI_{ASPT}$ and (c) the overall grade.**



(a) grade using $EQI_{TAXA}$

| | 1990 | 1995 | 1990 | 1995 |
|---|---|---|---|---|
| f | 3.7% | 1.1% | 1.6% | 0.7% |
| e | 8.2% | 4.4% | 5.5% | 3.1% |
| d | 7.0% | 5.2% | 5.3% | 4.6% |
| c | 14.3% | 13.5% | 11.7% | 11.8% |
| b | 20.7% | 16.7% | 17.2% | 15.4% |
| a | 46.1% | 59.0% | 58.7% | 64.4% |

Uncorrected | Corrected

(b) grade using $EQI_{ASPT}$

| | 1990 | 1995 | 1990 | 1995 |
|---|---|---|---|---|
| f | 1.4% | 0.4% | 0.2% | 0.1% |
| e | 6.6% | 4.3% | 4.4% | 3.4% |
| d | 14.3% | 9.8% | 11.9% | 9.1% |
| c | 23.7% | 19.8% | 25.2% | 19.8% |
| b | 29.7% | 32.3% | 31.9% | 32.7% |
| a | 24.3% | 33.3% | 26.4% | 34.9% |

Uncorrected | Corrected

(c) overall grade

| | 1990 | 1995 | 1990 | 1995 |
|---|---|---|---|---|
| f | 3.9% | 1.2% | 1.7% | 0.7% |
| e | 8.8% | 5.7% | 6.7% | 4.5% |
| d | 12.9% | 9.4% | 11.1% | 9.2% |
| c | 23.3% | 21.2% | 23.9% | 20.5% |
| b | 30.8% | 32.4% | 32.6% | 33.4% |
| a | 20.2% | 30.2% | 24.0% | 31.7% |

Uncorrected | Corrected

There also appears to be a considerable improvement in the overall biological condition of matched sites when assessed using $EQI_{ASPT}$ (Figure 4.1(b)). However, as discussed in section 3.1.3, because of the way the GQA grade limits were set (Table 1.1), roughly twice as many sites were classed as grade "a" when based on their $EQI_{TAXA}$ as when based on their $EQI_{ASPT}$. The effect of correcting for bias due to sample processing errors is much less for $EQI_{ASPT}$ than for $EQI_{TAXA}$, especially for 1995. There was still, however, a general tendency for estimated site condition, based on $EQI_{ASPT}$, to increase slightly when corrected for bias. In particular, the percentage of matched sites graded f on $EQI_{ASPT}$ in 1990 decreased from 1.4% to only 0.2% when corrected for bias (Figure 4.1(b)).

When assessed by their overall GQA grade (i.e. the lower of their grades based on $EQI_{TAXA}$ and $EQI_{ASPT}$), there was a marked increase between 1990 and 1995 in the percentage of all matched sites graded "a" and a decrease in sites graded e or f (Figure 4.1(c)). After correcting for bias, 31.7% of matched sites were classified as grade "a" in 1995 compared to only 24.0% in 1990, whilst the percentage of sites graded e or worse fell from 8.4% in 1990 to 5.2% in 1995. This suggests some improvement to an appreciable proportion of the poorest condition sites. The statistical probability of a real improvement is assessed in the next sub-section.

Table 4.1 summarises the change in “face” grade of all matched sites according to their grade in 1990, after correcting both years grades for sample processing biases. When grading is based only on $\text{EQI}_{\text{TAXA}}$, an improvement in “face” grade was recorded for at least 50% of sites with the potential (i.e. sites in grades b-f in 1990), irrespective of their grade in 1990 (see right-hand side of Table 4.1(a)).

**Table 4.1 Percentage of matched sites in each grade in 1995 (columns), shown separately for sites in each (bias-corrected) grade in 1990 (rows), based on (a) $\text{EQI}_{\text{TAXA}}$, (b) $\text{EQI}_{\text{ASPT}}$ and (c) overall GQA grade. Shaded cells show the percentage of sites in each grade in 1990 remaining the same grade in 1995. Right-hand-side columns show the percentages of sites upgraded and downgraded. (n = 3018 sites).**

| (a) $\text{EQI}_{\text{TAXA}}$ | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 59.0 | 16.7 | 13.5 | 5.2 | 4.4 | 1.1 | 100.0 | | |
| % of sites in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 46.1 | a | 90 | 8 | 2 | 0 | 0 | 0 | 100 | --- | 10 |
| 20.7 | b | 53 | 31 | 14 | 2 | 0 | 0 | 100 | 52 | 16 |
| 14.3 | c | 21 | 34 | 33 | 10 | 2 | 0 | 100 | 55 | 12 |
| 7.0 | d | 8 | 16 | 44 | 20 | 11 | 1 | 100 | 68 | 12 |
| 8.2 | e | 2 | 7 | 29 | 28 | 30 | 4 | 100 | 66 | 4 |
| 3.7 | f | 0 | 4 | 17 | 17 | 31 | 31 | 100 | 69 | --- |
| 100.0 | Total | | | | | | | | 24 | 11 |

| (b) $\text{EQI}_{\text{ASPT}}$ | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 34.9 | 32.7 | 19.8 | 9.1 | 3.4 | 0.1 | 100.0 | | |
| % of sites in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 26.4 | a | 79 | 20 | 1 | 0 | 0 | 0 | 100 | --- | 21 |
| 31.9 | b | 39 | 53 | 8 | 0 | 0 | 0 | 100 | 39 | 8 |
| 25.2 | c | 7 | 38 | 46 | 8 | 1 | 0 | 100 | 45 | 9 |
| 11.9 | d | 0 | 7 | 40 | 45 | 7 | 1 | 100 | 47 | 8 |
| 4.4 | e | 0 | 1 | 12 | 36 | 51 | 0 | 100 | 49 | 0 |
| 0.2 | f | 0 | 0 | 17 | 33 | 50 | 0 | 100 | 100 | --- |
| 100.0 | Total | | | | | | | | 38 | 10 |

| (c) overall GQA grade | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 31.7 | 33.4 | 20.5 | 9.2 | 4.5 | 0.7 | 100.0 | | |
| % of sites in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 24.0 | a | 75 | 23 | 2 | | | | 100 | --- | 25 |
| 32.6 | b | 37 | 54 | 9 | | | | 100 | 37 | 9 |
| 23.9 | c | 7 | 39 | 46 | 8 | 1 | | 100 | 46 | 9 |
| 11.1 | d | 1 | 7 | 44 | 40 | 7 | | 100 | 52 | 7 |
| 6.7 | e | | 1 | 16 | 37 | 42 | 3 | 100 | 54 | 3 |
| 1.7 | f | | | 12 | 19 | 40 | 29 | 100 | 71 | --- |
| 100.0 | Total | | | | | | | | 34 | 12 |

However, because nearly half (46.1%) of all matched sites were graded “a” in 1990 on the basis of their $\text{EQI}_{\text{TAXA}}$ values (and hence cannot possible improve in grade), the overall percentage of all sites showing an improvement in “face” grade based on $\text{EQI}_{\text{TAXA}}$ is 24%. Between 10-16% of sites assigned “face” band a-d in 1990 based on $\text{EQI}_{\text{TAXA}}$ were downgraded in 1995. Amongst all matched sites, 11% were downgraded in their “face” grade based on their $\text{EQI}_{\text{TAXA}}$ values corrected for bias (Table 4.1(a)).

When graded solely on their $EQI_{ASPT}$ values (corrected for bias) 39-49% of all sites graded b-e in 1990 were upgraded as were all six matched sites graded f by their $EQI_{ASPT}$ value in 1990 (Table 4.1(b)). A relatively high percentage (20%) of sites graded “a” in 1990 were downgraded to b in 1995, whilst only 8-9% of sites graded b-d in 1990 were assigned a poorer “face” grade based on their $EQI_{ASPT}$ in 1995.

Overall, based on their $EQI_{ASPT}$ (corrected for bias), 38% of all sites showed an improvement in “face” grade and only 10% a deterioration.

When the grades based on $EQI_{TAXA}$ and $EQI_{ASPT}$ are combined to give an overall “face” grade corrected for bias for each site, 34% of all matched sites were upgraded in 1995 and only 12% were downgraded (Table 4.1(c)). Three quarters of all sites given “face” grade “a” in 1990 were also graded “a” in 1995. Meanwhile, of the 1.7% of all matched sites given overall grade f in 1990 only 29% were still graded f in 1995, 40% were graded one grade higher, 19% two grades and 12% three grades higher (i.e. grade c) (Table 4.1(c)). In terms of grade based on $EQI_{ASPT}$ or the overall grade, around or just under 50% of sites assigned to each of the grades b-e in 1990 were classed as the same grade in 1995 (diagonal in Table 4.1(b),(c)).

On the basis of their overall grade (corrected for bias) 34% of sites were assigned a higher grade in 1995 than 1990, 12% were downgraded and hence 54% were given the same grade (Table 4.1(c)).

Table 4.2 shows the percentage of sites in each of the ten NRA Regions in 1990 which were upgraded or downgraded in 1995 on the basis of their “face” overall grade corrected for bias. The percentage of sites with a higher “face” grade varied from 22% in South-West Region to 40% in Yorkshire and 44% in Wessex (although only 34 sites in Wessex could be matched in the 1990 RQS and 1995 GQA surveys).

**Table 4.2 Percentage of matched sites in each Region which were upgraded, stayed the same grade, or were downgraded between the 1990 RQS and 1995 GQA surveys based on their overall “face” grade corrected for bias**.

| Region in 1990 | Matched sites | upgraded | same grade | downgraded |
|---|---|---|---|---|
| Anglian | 428 | 38 | 51 | 12 |
| Northumbrian | 223 | 36 | 55 | 9 |
| North-West | 273 | 38 | 49 | 12 |
| Midlands | 576 | 32 | 54 | 14 |
| Southern | 280 | 36 | 54 | 10 |
| South-West | 279 | 22 | 65 | 13 |
| Thames | 221 | 36 | 56 | 8 |
| Welsh | 525 | 31 | 55 | 14 |
| Wessex | 34 | 44 | 47 | 9 |
| Yorkshire | 179 | 40 | 48 | 12 |
| England and Wales | 3018 | 34 | 54 | 12 |

Tables 4.3(a)-(i) summarise the changes between 1990 and 1995 in overall “face” grade corrected for bias, for each of the NRA regions in 1990 (except Wessex for which there were too few matched sites).

**Table 4.3 Percentage of matched sites from each NRA Region in each overall (bias-corrected) grade in 1995 (columns), shown separately for sites in each grade in 1990 (rows). Shaded cells show the percentage of sites in each grade in 1990 remaining the same grade in 1995. Right-hand side columns show the percentages of sites upgraded and downgraded. Insufficient matched sites for analysis of Wessex NRA Region.**

| (a) Anglian Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 27 | 44 | 22 | 5 | 1 | 0 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 18 | a | 61 | 37 | 3 | 0 | 0 | 0 | 100 | --- | 39 |
| 39 | b | 36 | 56 | 8 | 0 | 0 | 0 | 100 | 36 | 8 |
| 32 | c | 6 | 47 | 42 | 4 | 0 | 0 | 100 | 53 | 4 |
| 7 | d | 6 | 3 | 45 | 42 | 3 | 0 | 100 | 55 | 3 |
| 2 | e | 0 | 0 | 30 | 40 | 30 | 0 | 100 | 70 | 0 |
| 1 | f | 0 | 0 | 67 | 0 | 0 | 33 | 100 | 67 | --- |
| 100 | Total | | | | | | | | 38 | 12 |

| (b) Northumbrian Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 41 | 28 | 13 | 11 | 6 | 1 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 26 | a | 84 | 16 | 0 | 0 | 0 | 0 | 100 | --- | 16 |
| 38 | b | 47 | 48 | 5 | 0 | 0 | 0 | 100 | 47 | 5 |
| 13 | c | 11 | 36 | 39 | 14 | 0 | 0 | 100 | 46 | 14 |
| 12 | d | 0 | 8 | 38 | 42 | 12 | 0 | 100 | 46 | 12 |
| 9 | e | 0 | 0 | 14 | 38 | 48 | 0 | 100 | 52 | 0 |
| 5 | f | 0 | 0 | 17 | 33 | 17 | 33 | 100 | 67 | --- |
| 100 | Total | | | | | | | | 36 | 9 |

| (c) North West Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 18 | 35 | 19 | 12 | 12 | 3 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 14 | a | 69 | 31 | 0 | 0 | 0 | 0 | 100 | --- | 31 |
| 36 | b | 27 | 52 | 20 | 1 | 0 | 0 | 100 | 27 | 21 |
| 13 | c | 5 | 27 | 55 | 11 | 1 | 0 | 100 | 32 | 13 |
| 12 | d | 0 | 3 | 41 | 50 | 7 | 0 | 100 | 44 | 7 |
| 19 | e | 2 | 0 | 13 | 33 | 46 | 6 | 100 | 48 | 6 |
| 6 | f | 0 | 0 | 0 | 20 | 60 | 20 | 100 | 80 | --- |
| 100 | Total | | | | | | | | 32 | 14 |

| (d) Midlands Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 24 | 35 | 18 | 7 | 1 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 11 | a | 69 | 31 | 0 | 0 | 0 | 0 | 100 | --- | 31 |
| 20 | b | 27 | 52 | 20 | 1 | 0 | 0 | 100 | 27 | 21 |
| 38 | c | 5 | 27 | 55 | 11 | 1 | 0 | 100 | 32 | 13 |
| 21 | d | 0 | 3 | 41 | 50 | 7 | 0 | 100 | 44 | 7 |
| 9 | e | 2 | 0 | 13 | 33 | 46 | 6 | 100 | 48 | 6 |
| 1 | f | 0 | 0 | 0 | 20 | 60 | 20 | 100 | 80 | --- |
| 100 | Total | | | | | | | | 32 | 14 |

## Table 4.3 (continued)

| (e) Southern Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 44 | 36 | 14 | 5 | 1 | 0 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 29 | a | 84 | 14 | 2 | 0 | 0 | 0 | 100 | --- | 16 |
| 36 | b | 45 | 50 | 5 | 0 | 0 | 0 | 100 | 45 | 5 |
| 28 | c | 12 | 48 | 31 | 8 | 1 | 0 | 100 | 60 | 9 |
| 7 | d | 0 | 15 | 30 | 45 | 10 | 0 | 100 | 45 | 10 |
| 1 | e | 0 | 0 | 50 | 0 | 50 | 0 | 100 | 50 | 0 |
| 0 | f | | | | | | | | --- | --- |
| 100 | Total | | | | | | | | 36 | 10 |

| (f) South West Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 58 | 37 | 5 | 1 | 0 | 0 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 52 | a | 78 | 22 | 0 | 0 | 0 | 0 | 100 | --- | 22 |
| 39 | b | 39 | 56 | 5 | 0 | 0 | 0 | 100 | 39 | 5 |
| 7 | c | 26 | 42 | 32 | 0 | 0 | 0 | 100 | 68 | 0 |
| 2 | d | 0 | 20 | 40 | 40 | 0 | 0 | 100 | 60 | 0 |
| 1 | e | 0 | 0 | 0 | 100 | 0 | 0 | 100 | 100 | 0 |
| 0 | f | | | | | | | 100 | | --- |
| 100 | Total | | | | | | | | 22 | 13 |

| (g) Thames Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 32 | 27 | 27 | 10 | 4 | 0 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 21 | a | 85 | 13 | 2 | 0 | 0 | 0 | 100 | --- | 15 |
| 31 | b | 40 | 51 | 9 | 0 | 0 | 0 | 100 | 40 | 9 |
| 25 | c | 7 | 29 | 56 | 7 | 0 | 0 | 100 | 36 | 7 |
| 13 | d | 0 | 10 | 59 | 31 | 0 | 0 | 100 | 69 | 0 |
| 10 | e | 0 | 0 | 24 | 29 | 43 | 5 | 100 | 52 | 5 |
| 1 | f | 0 | 0 | 0 | 100 | 0 | 0 | 100 | 100 | --- |
| 100 | Total | | | | | | | | 36 | 8 |

| (h) Welsh Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 35 | 40 | 19 | 5 | 2 | 0 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 30 | a | 72 | 25 | 3 | 0 | 0 | 0 | 100 | --- | 28 |
| 36 | b | 35 | 55 | 9 | 1 | 1 | 0 | 100 | 35 | 10 |
| 23 | c | 4 | 44 | 46 | 6 | 0 | 0 | 100 | 48 | 6 |
| 8 | d | 0 | 24 | 40 | 29 | 5 | 2 | 100 | 64 | 7 |
| 3 | e | 0 | 7 | 27 | 33 | 33 | 0 | 100 | 67 | 0 |
| 0 | f | 0 | 0 | 100 | 0 | 0 | 0 | 100 | 100 | --- |
| 100 | Total | | | | | | | | 31 | 14 |

| (i) Yorkshire Region | | % of sites in grade in 1995 | | | | | | | % of sites upgraded in 1995 | % of sites downgraded in 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 27 | 22 | 18 | 16 | 13 | 3 | 100 | | |
| % in grade in 1990 | | a | b | c | d | e | f | Total | | |
| 25 | a | 75 | 18 | 7 | 0 | 0 | 0 | 100 | --- | 25 |
| 20 | b | 44 | 47 | 8 | 0 | 0 | 0 | 100 | 44 | 8 |
| 15 | c | 0 | 46 | 46 | 8 | 0 | 0 | 100 | 46 | 8 |
| 17 | d | 0 | 7 | 40 | 40 | 13 | 0 | 100 | 47 | 13 |
| 13 | e | 0 | 4 | 4 | 46 | 38 | 8 | 100 | 54 | 8 |
| 11 | f | 0 | 0 | 11 | 16 | 58 | 16 | 100 | 84 | --- |
| 100 | Total | | | | | | | | 40 | 12 |

### 4.2.2 Statistical significance of changes in grade

This sub-section summarises analyses of the statistical significance of the changes in the overall biological grade of individual matched sites between the 1990 RQS and 1995 GQA surveys, as assessed by RIVPACS III+ (Clarke *et al.* 1997) using the methods of section 4.1.2.

Two methods are used to classify the statistically significant changes in the overall grade, either the classes of "likelihood of a change in grade" or the "most probable change in grade", as defined in section 4.1.2.

Table 4.4 shows the percentages of matched sites in each grade in 1990 which, by 1995, had shown either an improvement (upgraded) or deterioration (downgraded) at each of the three levels of likelihood of change in grade. Overall 31.2% of all matched sites were more likely than not to have improved in grade (i.e $P_{up}>0.50$), whereas just under 10% were more likely than not to have deteriorated in grade. If, rather than the 50% statistical significance level, the more usual research convention of P>0.95 for statistical tests is used to determine real change, then far fewer sites would be classed as having changed grade, with only 4.2% showing a definite upgrade and a mere 0.7% almost definitely being a poorer grade in 1995 compared to 1990.

**Table 4.4 Percentage of sites in each overall grade in 1990 classified by "likelihood of a change in grade" by 1995 (i.e. downgraded or upgraded with >50%, >75% or >95% probability).**

| % of sites in each grade in 1990 | | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|---|
| | | >95% | >75% | >50% | | >50% | >75% | >95% |
| a | 24 | 1.2 | 5.6 | 18.1 | 81.9 | --- | --- | --- |
| b | 33 | 0.6 | 2.8 | 7.2 | 59.1 | 33.0 | 11.5 | 1.1 |
| c | 24 | 0.7 | 3.1 | 7.7 | 49.4 | 42.9 | 23.0 | 6.0 |
| d | 11 | 0.0 | 2.4 | 7.8 | 43.6 | 48.7 | 27.2 | 7.8 |
| e | 7 | 0.0 | 0.5 | 3.0 | 42.8 | 54.2 | 33.8 | 15.4 |
| f | 2 | --- | --- | --- | 30.8 | 69.2 | 55.7 | 28.8 |
| England and Wales | 100 | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

Table 4.5 shows the likelihood of a change in grade in relation to the number of "face" grades a site had either improved or deteriorated. Amongst those sites whose face grade did not change, the RIVPACS III+ likelihood of a change in grade was nearly always (i.e. 94.4%) less than 50% and they would be classified probabilistically as the "same grade". Of those sites which showed a change of one grade in their face grade, 84% of those showing an improvement and 72% of those showing a downgrade, did so with statistical test probabilities >50%.

This is very important in that it implies that when the face grade changed, even by only one grade, it more likely than not indicated that there had been a real change in GQA grade (as presently defined). Thus the errors and uncertainty in the whole RIVPACS approach as incorporated into the RIVPACS III+ "Compare" procedure are not so great as to prevent most observed changes in GQA grade being merely due to chance and errors in the whole system.

Obviously all changes of one grade are not the same, in that sites whose changes in EQI values are very small, but which just move them across the boundary between two grades are quite likely to not have really changed grade. However, Table 4.5, indicates that if we only knew a site had changed quality by one grade (and did not know its changes in EQI values) then, at least for the size of changes which occurred between the 1990 RQS and the 1995 GQA surveys, the change in grade is more likely than not to be real.

**Table 4.5 Percentage of sites which were either a poorer grade (downgraded) or a better grade (upgraded) in 1995 with >50%, >75% or >95% probability, in relation to the "face" change in overall (bias-corrected) grade.**

| "face" change in overall grade | Matched sites | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|---|
| | | >95% | >75% | >50% | | >50% | >75% | >95% |
| Down 3 grades | 1 | 100.0 | | | | | | |
| Down 2 grades | 23 | 56.5 | 100.0 | | | | | |
| Down 1 grade | 342 | 1.8 | 22.3 | 72.5 | 27.5 | | | |
| same grade | 1635 | | | 1.4 | 94.4 | 4.2 | | |
| Up 1 grade | 888 | | | | 16.1 | 83.9 | 38.0 | 5.5 |
| Up 2 grades | 117 | | | | | | 100.0 | 55.6 |
| Up 3 grades | 11 | | | | | | | 100.0 |
| Up 4 grades | 1 | | | | | | | 100.0 |
| England and Wales | 3018 | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

As a caveat to this optimistic conclusion, Table 4.5 does also indicate that if change in grade is only accepted as real when the "likelihood of a change in grade" ($P_{up}$ or $P_{down}$) is >95%, then only 5.5% of sites with an upgrade of one face grade and 1.8% of sites downgraded by one grade would be accepted as definite changes. Thus a change of one grade is more likely than not to indicate a real change in overall GQA grade, but can rarely be determined as having almost definitely changed (where "definite" here means with > 95% probability).

Slightly more than half of all sites either upgraded or downgraded by two grades would be treated as real changes in grade (albeit perhaps by only one grade) using this 95% test probability level. If the "face" grade for a site showed a change of at least three grades between the two surveys, then RIVPACS III+ estimates that such "face" changes always indicate a very likely (i.e. P>0.95) real change of grade (although not necessarily by as much as the "face" change). Thus a "face" change of two of more grades is almost certainly (i.e. P>0.95) a real change in grade for the majority (i.e. over half) of such sites.

### 4.2.3 Statistical changes in biological grade in relation to Region and Landscape type

Table 4.6 shows the variation between the ten NRA Regions, as they existed at the time of the 1990 RQS survey, in terms of the percentages of sites which showed each class of "likelihood of change in grade" by 1995.

**Table 4.6 Percentage of sites in each NRA Region in 1990 which by 1995 were either downgraded or upgraded with >50%, >75% or >95% probability.**

| Region in 1990 | Matched sites | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|---|
| | | >95% | >75% | >50% | | >50% | >75% | >95% |
| Anglian | 428 | 0.2 | 1.8 | 9.5 | 55.4 | 35.0 | 14.9 | 4.2 |
| Northumbrian | 223 | 0.0 | 2.7 | 8.1 | 57.4 | 34.5 | 17.9 | 4.9 |
| North-West | 273 | 1.1 | 4.0 | 10.6 | 54.6 | 34.8 | 21.6 | 5.5 |
| Midlands | 576 | 0.9 | 4.2 | 12.2 | 57.8 | 30.0 | 12.5 | 2.8 |
| Southern | 280 | 0.4 | 3.3 | 7.6 | 57.9 | 34.6 | 17.5 | 3.9 |
| South-West | 279 | 0.7 | 2.5 | 9.7 | 72.8 | 17.5 | 7.1 | 1.4 |
| Thames | 221 | 0.5 | 1.9 | 5.1 | 59.3 | 35.7 | 18.1 | 5.9 |
| Welsh | 525 | 1.0 | 4.6 | 11.3 | 60.8 | 28.0 | 15.4 | 4.4 |
| Wessex | 34 | 0.0 | 0.0 | 2.9 | 55.9 | 41.1 | 20.5 | 2.9 |
| Yorkshire | 179 | 1.1 | 3.9 | 10.0 | 55.3 | 34.6 | 19.5 | 7.8 |
| England and Wales | 3018 | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

The Institute of Terrestrial Ecology (ITE) have produced an environmental classification into 32 Land Classes of all 1km National Grid squares in Great Britain (Bunce *et al.* 1996a, 1996b). This is widely used as a stratification basis from national sampling and surveys of the countryside in GB. ITE then amalgamated these 32 Land Classes into four Landscape types which they called “Arable”, Pastoral”, “Marginal” and “Upland” (Barr *et al.* 1993). These ITE Landscape types have been used here as a readily available indicator of the type of land in the immediate catchment of the river sites. In particular, sites were classified according to the ITE Landscape type of the 1km square within which the site lay. Amongst the 3018 matched GQA sites analysed in this report, only 17 were from what the ITE classification termed “Upland” landscapes. Therefore, for analysis, QGA sites in “Marginal” and “Upland” landscapes are treated as one type.

Table 4.7(a) shows the distribution of ITE Landscape types within each 1990 NRA Region, while Tables 4.7(b-c) show the percentage of sites in each biological grade in 1990 and the likelihood of a change in grade by 1995, separately for each sites in each Landscape type. When classified by ITE Landscape type, 33% of all sites in “marginal/upland” landscapes were grade “a” in 1990 compared to only 21% in arable landscapes. However, by 1995 one-third (33%) of all “arable” landscape river sites had more likely than not improved in grade, compared to only 22% of those in the “marginal/upland” landscapes.

Table 4.8 shows variation in “most probable change in grade” for sites in each 1990 NRA region and in each ITE Landscape type.

The ITE Land Classification of all 1km squares in GB was based on the use of environmental attributes of squares derived from published Ordnance Survey, geological and climatic maps. As such it was intended to be a fixed classification, primarily for use an efficient stratification of all land in GB. It does not measure actual change in landscape features, nor in particular, land use over time. This means that it cannot be used to correlate changes in biological condition in rivers to changes in land use within the catchment. To do this requires something like the ITE Land Cover Map (ITELCM) information derived by satellite images covering all of GB. The first ITELCM was produced for land cover of GB around 1990 and classifies each 25m square “pixel” into one of 17 or 25 land cover types (Fuller *et al.* 1994). The ITELCM is currently being revised for land cover around 1998/99 as part of the Countryside Survey 2000 project being undertaken by the Centre of Ecology and Hydrology.

Table 4.9 shows the likelihood of an upgrade and downgrade in relation to the average environmental characteristics of sites in 1990 and 1995. The are few, if any, obvious relationships.

**Table 4.7 Analyses of river sites by the ITE Landscape type ("Arable", "Pastoral", "Marginal/Upland") of the National Grid 1km square within which the site lies, in relation to Region, grade and change in grade.**

**(a) Percentage of sites in each ITE Landscape type, separately for each NRA Region.**

| Region in 1990 | Matched sites | ITE Landscape type | | |
|---|---|---|---|---|
| | | Arable | Pastoral | Marginal/ Upland |
| Anglian | 428 | 94.9 | 5.1 | 0.0 |
| Northumbrian | 223 | 33.2 | 43.1 | 23.7 |
| North West | 273 | 9.9 | 67.8 | 22.3 |
| Midlands | 576 | 45.8 | 50.0 | 4.2 |
| Southern | 280 | 82.9 | 17.1 | 0.0 |
| South West | 279 | 3.2 | 90.3 | 6.5 |
| Thames | 221 | 64.3 | 35.8 | 0.0 |
| Welsh | 525 | 5.0 | 68.8 | 26.3 |
| Wessex | 34 | 76.5 | 23.5 | 0.0 |
| Yorkshire | 179 | 28.5 | 62.0 | 9.5 |
| England and Wales | 3018 | 41.7 | 48.0 | 10.3 |

**(b) Percentage of sites in each ITE Landscape type that were each overall grade in 1990 (This shows the potential for improvement in grade by 1995 in each Landscape type).**

| ITE Landscape type | Matched sites | Overall grade in 1990 | | | | | |
|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e | F |
| Arable | 1257 | 20.6 | 32.8 | 28.9 | 11.4 | 4.9 | 1.4 |
| Pastoral | 1450 | 25.0 | 30.3 | 21.6 | 12.1 | 8.8 | 2.3 |
| Marginal/Upland | 311 | 33.1 | 42.8 | 15.1 | 5.1 | 3.9 | 0.0 |
| England and Wales | 3018 | 24.0 | 32.6 | 23.9 | 11.1 | 6.7 | 1.7 |

**(c) Percentage of sites in each ITE Landscape type which by 1995 were either a poorer grade (downgraded) or a better grade (upgraded) with >50%, >75% or >95% probability.**

| ITE Landscape type | Matched sites | downgraded | | | same grade | Upgraded | | |
|---|---|---|---|---|---|---|---|---|
| | | >95% | >75% | >50% | | >50% | >75% | >95% |
| Arable | 1257 | 0.3 | 2.3 | 9.4 | 57.6 | 33.0 | 14.8 | 4.5 |
| Pastoral | 1450 | 1.0 | 3.9 | 9.8 | 58.7 | 31.5 | 17.4 | 4.6 |
| Marginal/Upland | 311 | 0.6 | 4.8 | 11.5 | 65.9 | 22.5 | 10.0 | 1.3 |
| England and Wales | 3018 | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

## Table 4.8 Percentage of sites in each class of “most probable change in grade” between 1990 and 1995, separately for sites in (a) each NRA Region in 1990 and (b) each ITE Landscape type.

| (a) Region in 1990 | sites | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | E | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anglian | 428 | 11 | 2 | 13 | 1 | 3 | 1 | 1 | 0 | 0 | 12 | 26 | 17 | 4 | 1 | 0 | 5 | 0 | 3 | 1 | 0 | 0 |
| Northumbrian | 223 | 15 | 1 | 4 | 1 | 4 | 1 | 4 | 1 | 0 | 23 | 21 | 6 | 5 | 4 | 1 | 3 | 0 | 2 | 1 | 1 | 0 |
| North-West | 273 | 6 | 1 | 5 | 0 | 8 | 4 | 7 | 1 | 2 | 9 | 28 | 5 | 3 | 9 | 3 | 4 | 1 | 2 | 1 | 1 | 0 |
| Midlands | 576 | 5 | 2 | 10 | 1 | 7 | 1 | 3 | 0 | 1 | 9 | 12 | 23 | 13 | 5 | 0 | 3 | 0 | 3 | 4 | 1 | 1 |
| Southern | 280 | 13 | 3 | 13 | 1 | 2 | 0 | 0 | 0 | 0 | 26 | 22 | 9 | 4 | 0 | 0 | 2 | 1 | 1 | 3 | 1 | 0 |
| South-West | 279 | 12 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 44 | 25 | 3 | 1 | 0 | 0 | 8 | 0 | 1 | 0 | 0 | 0 |
| Thames | 221 | 11 | 2 | 6 | 1 | 7 | 2 | 2 | 1 | 0 | 18 | 18 | 16 | 5 | 5 | 0 | 2 | 0 | 2 | 1 | 0 | 0 |
| Welsh | 525 | 10 | 1 | 9 | 2 | 3 | 1 | 1 | 0 | 0 | 24 | 22 | 12 | 2 | 1 | 0 | 5 | 1 | 3 | 1 | 0 | 0 |
| Wessex | 34 | 32 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 9 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| Yorkshire | 179 | 6 | 0 | 5 | 1 | 6 | 1 | 6 | 3 | 6 | 21 | 12 | 9 | 8 | 6 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| England and Wales | 3018 | 10 | 2 | 8 | 1 | 4 | 1 | 2 | 1 | 1 | 20 | 21 | 12 | 5 | 3 | 1 | 4 | 0 | 2 | 2 | 1 | 0 |

| (b) ITE Landscape type | sites | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | E | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arable | 1257 | 10 | 2 | 10 | 1 | 4 | 1 | 1 | 1 | 0 | 17 | 20 | 15 | 6 | 2 | 0 | 3 | 0 | 2 | 2 | 0 | 0 |
| Pastoral | 1450 | 11 | 0 | 6 | 1 | 2 | 1 | 2 | 0 | 0 | 26 | 29 | 8 | 2 | 2 | 0 | 6 | 1 | 3 | 1 | 1 | 0 |
| Marginal/Upland | 311 | 9 | 2 | 7 | 1 | 6 | 2 | 3 | 1 | 1 | 21 | 19 | 11 | 5 | 4 | 1 | 4 | 0 | 2 | 1 | 1 | 0 |
| England and Wales | 3018 | 10 | 2 | 8 | 1 | 4 | 1 | 2 | 1 | 1 | 20 | 21 | 12 | 5 | 3 | 1 | 4 | 0 | 2 | 2 | 1 | 0 |

**Table 4.9 (a)-(d) Percentage of sites in each class of "likelihood of a change in grade" between 1990 and 1995, shown separately for sites in each category of (a) altitude (m), (b) slope (m $km^{-1}$), (c) distance from source (km) or (d) discharge class.**

| (a) Altitude (m) | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| <16 | 0.4 | 3.2 | 8.4 | 56.4 | 35.2 | 17.1 | 4.7 |
| 16-36 | 0.7 | 2.4 | 9.1 | 55.6 | 35.3 | 18.4 | 5.4 |
| 37-64 | 0.7 | 2.8 | 8.1 | 58.7 | 33.2 | 17.1 | 4.8 |
| 65-99 | 1.1 | 4.0 | 11.9 | 59.7 | 28.3 | 15.0 | 4.5 |
| 100-200 | 0.6 | 3.9 | 12.4 | 63.1 | 24.4 | 10.6 | 1.7 |
| >200 | 0.0 | 5.8 | 8.7 | 73.1 | 18.3 | 4.8 | 1.0 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (b) Slope (m $km^{-1}$) | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| <1.1 | 0.4 | 2.8 | 8.5 | 54.6 | 37.0 | 17.6 | 5.4 |
| 1.1-2.2 | 0.7 | 2.9 | 7.8 | 59.1 | 33.1 | 18.7 | 5.7 |
| 2.3-4.4 | 0.8 | 2.1 | 8.0 | 59.9 | 32.1 | 14.3 | 3.3 |
| 4.5-9.1 | 1.2 | 4.7 | 12.5 | 58.7 | 28.8 | 15.5 | 4.0 |
| 9.2-25 | 0.2 | 5.0 | 13.2 | 63.5 | 23.3 | 11.6 | 1.9 |
| >25 | 0.0 | 6.3 | 11.1 | 66.7 | 22.2 | 7.9 | 1.6 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (c) Distance from source (km) | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| <5.0 | 1.3 | 4.3 | 11.1 | 59.4 | 29.5 | 16.8 | 4.0 |
| 5.0-7.9 | 0.6 | 5.5 | 13.4 | 56.9 | 29.7 | 15.4 | 4.2 |
| 8.0-12.5 | 0.3 | 3.1 | 8.8 | 56.7 | 34.5 | 15.6 | 4.9 |
| 12.6-24 | 0.7 | 1.8 | 7.8 | 59.6 | 32.6 | 14.8 | 2.6 |
| 24.1-84 | 0.6 | 2.9 | 8.4 | 61.8 | 29.8 | 15.3 | 5.3 |
| >84 | 1.0 | 3.0 | 14.3 | 61.2 | 24.5 | 15.3 | 4.1 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (d) Discharge class | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| 1 | 0.8 | 3.9 | 11.0 | 56.1 | 32.9 | 16.3 | 4.3 |
| 2 | 0.2 | 3.1 | 9.2 | 58.8 | 32.0 | 16.9 | 4.9 |
| 3 | 0.7 | 3.2 | 9.6 | 59.4 | 31.0 | 12.4 | 3.1 |
| 4-5 | 0.6 | 2.6 | 7.6 | 60.0 | 32.3 | 16.0 | 4.1 |
| 6-7 | 0.8 | 2.4 | 10.5 | 67.7 | 21.8 | 13.3 | 4.0 |
| 8-10 | 1.2 | 3.5 | 8.1 | 66.3 | 25.6 | 13.0 | 4.7 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

**Table 4.9 (e)-(h) Percentage of sites in each class of "likelihood of a change in grade" between 1990 and 1995, shown separately for sites in each category of (e) stream width (m), (f) stream depth (cm), (g) alkalinity (mg $l^{-1}$ $CaCO_3$) or (h) mean substratum (phi units).**

| (e) Stream width (m) | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| <2.3 | 1.4 | 4.0 | 12.6 | 53.3 | 34.1 | 11.4 | 5.5 |
| 2.3-3.5 | 0.5 | 2.5 | 8.8 | 58.9 | 32.2 | 13.5 | 3.5 |
| 3.6-5.3 | 0.7 | 2.7 | 10.2 | 57.3 | 32.5 | 11.5 | 3.1 |
| 5.4-9.5 | 0.4 | 2.6 | 9.7 | 59.8 | 30.5 | 10.4 | 4.3 |
| 9.6-29 | 0.3 | 1.9 | 8.4 | 62.6 | 29.0 | 10.0 | 4.9 |
| >29 | 1.7 | 2.5 | 10.1 | 63.9 | 26.1 | 11.8 | 4.2 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (f) Stream depth (cm) | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| <12 | 0.9 | 4.0 | 11.2 | 61.3 | 27.5 | 12.1 | 1.6 |
| 12-16 | 1.0 | 5.0 | 13.1 | 56.8 | 30.1 | 15.5 | 5.2 |
| 17-23 | 0.3 | 3.0 | 8.1 | 60.4 | 31.5 | 15.6 | 3.6 |
| 24-36 | 0.7 | 2.2 | 9.5 | 60.1 | 30.4 | 14.4 | 3.7 |
| 37-132 | 0.6 | 2.7 | 6.8 | 57.1 | 36.1 | 17.8 | 5.2 |
| >132 | 0.0 | 2.6 | 12.8 | 52.6 | 34.6 | 28.2 | 14.1 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (g) Alkalinity (mg $l^{-1}$ $CaCO_3$) | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| <61 | 0.8 | 3.2 | 11.7 | 69.7 | 18.6 | 8.3 | 1.6 |
| 61-123 | 0.5 | 3.7 | 8.0 | 58.9 | 33.1 | 16.7 | 4.2 |
| 124-182 | 0.5 | 3.5 | 10.1 | 54.2 | 35.7 | 20.3 | 6.0 |
| 183-227 | 0.8 | 2.8 | 10.6 | 55.9 | 33.5 | 15.9 | 3.9 |
| 228-284 | 0.7 | 3.1 | 8.1 | 56.9 | 35.0 | 16.2 | 5.0 |
| >284 | 1.0 | 4.1 | 10.3 | 48.5 | 41.2 | 18.3 | 7.2 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (h) Mean substratum (phi units) | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| -7.8:-5.0 | 0.8 | 3.1 | 10.8 | 65.5 | 23.6 | 9.6 | 2.0 |
| -4.9:-3.1 | 0.3 | 2.7 | 10.1 | 62.2 | 27.7 | 9.3 | 4.1 |
| -3.0:-1.4 | 0.4 | 2.1 | 8.5 | 58.6 | 32.9 | 11.5 | 4.8 |
| -1.3:1.5 | 0.8 | 2.6 | 10.2 | 53.8 | 36.0 | 12.9 | 3.8 |
| 1.6:7.6 | 0.9 | 2.0 | 8.1 | 52.6 | 39.3 | 14.5 | 7.5 |
| 7.7:8 | 1.3 | 6.5 | 13.0 | 54.5 | 32.5 | 10.4 | 3.9 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

**Table 4.9 (i)-(l) Percentage of sites in each class of "likelihood of a change in grade" between 1990 and 1995, shown separately for sites in each category of % cover of (i) boulders/cobbles, (j) pebbles/gravel, (k) sand or (l) silt/clay.**

| (i)<br>% Boulders/Cobbles | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| 0-4 | 0.6 | 2.7 | 7.5 | 54.8 | 37.7 | 18.5 | 5.7 |
| 5-13 | 0.7 | 2.9 | 8.6 | 57.2 | 34.2 | 16.8 | 4.8 |
| 14-30 | 0.9 | 3.4 | 10.1 | 56.4 | 33.5 | 15.9 | 3.5 |
| 31-51 | 0.2 | 3.3 | 11.4 | 62.3 | 26.4 | 13.3 | 4.1 |
| 52-76 | 0.7 | 3.7 | 9.3 | 63.6 | 27.1 | 14.4 | 3.0 |
| 77-100 | 1.9 | 6.5 | 18.5 | 61.1 | 20.4 | 8.3 | 3.7 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (j)<br>% Pebbles/Gravel | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| 0-20 | 1.1 | 3.4 | 9.9 | 55.1 | 34.9 | 12.6 | 7.3 |
| 21-33 | 0.5 | 3.0 | 11.5 | 59.8 | 28.7 | 10.4 | 4.0 |
| 34-43 | 0.5 | 3.1 | 10.0 | 57.7 | 32.3 | 13.5 | 2.6 |
| 44-55 | 0.5 | 2.6 | 9.1 | 62.1 | 28.8 | 9.4 | 3.2 |
| 56-76 | 1.0 | 0.8 | 7.5 | 59.1 | 33.4 | 11.1 | 4.3 |
| 77-100 | 0.0 | 3.4 | 13.8 | 67.2 | 19.0 | 5.2 | 3.4 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (k)<br>% sand | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| 0-2 | 0.7 | 3.5 | 11.6 | 61.6 | 26.9 | 10.0 | 3.2 |
| 3-6 | 0.8 | 2.7 | 9.0 | 63.1 | 27.9 | 10.6 | 3.8 |
| 7-11 | 0.4 | 1.8 | 8.8 | 61.2 | 30.1 | 9.8 | 4.5 |
| 12-20 | 0.3 | 2.4 | 10.3 | 53.6 | 36.2 | 13.7 | 5.6 |
| 21-43 | 1.0 | 2.6 | 8.8 | 55.2 | 35.9 | 11.6 | 4.0 |
| 44-100 | 1.7 | 3.3 | 10.0 | 48.3 | 41.7 | 21.7 | 5.0 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

| (l)<br>%silt/clay | downgraded | | | same grade | upgraded | | |
|---|---|---|---|---|---|---|---|
| | >95% | >75% | >50% | | >50% | >75% | >95% |
| 0-1 | 0.5 | 3.0 | 10.9 | 64.3 | 24.8 | 9.6 | 2.2 |
| 2-5 | 0.6 | 2.5 | 9.5 | 63.0 | 27.5 | 9.7 | 3.2 |
| 6-13 | 0.9 | 2.2 | 8.1 | 60.4 | 31.5 | 10.7 | 5.2 |
| 14-34 | 0.7 | 2.6 | 11.1 | 53.7 | 35.2 | 12.9 | 3.6 |
| 35-95 | 0.6 | 2.2 | 8.1 | 51.6 | 40.3 | 14.6 | 7.7 |
| 96-100 | 1.4 | 6.8 | 13.7 | 56.2 | 30.1 | 9.6 | 4.1 |
| Total | 0.7 | 3.4 | 9.8 | 59.0 | 31.2 | 15.5 | 4.2 |

## 4.3 Summary

As a consequence of the general level of sample bias resulting from under-estimation of number of taxa being greater in 1990 than 1995, it is important to correct for sample bias in estimating change in biological condition. This is especially important for Regions which had improved their analytical performance since 1990. Uncorrected for bias the percentage of sites graded "a", based on their $EQI_{TAXA}$, appeared to increase from 46% in 1990 to 59% in 1995. Once corrected for bias, the corresponding figures were 59% to 64%, a much smaller improvement.

Once corrected for bias, 24% of all sites were upgraded and only 11% downgraded, between 1990 and 1995, on their "face" grade based on $EQI_{TAXA}$. The general improvement in "face" grades was greater when based on $EQI_{ASPT}$ (38% upgraded, 10% downgraded), leading to 34% of sites being given a higher overall GQA grade in 1995 than 1990 and only 12% downgraded.

These bias-corrected improvements occurred in all Regions, although they were least in South West Region, probably because such a high proportion (52%) of its sites were already grade "a" in 1990.

RIVPACS III+ was used to assess the statistical significance of change. Overall, 31% of sites were more likely than not (i.e. probability >50%) to have improved in grade, whilst just under 10% were more likely than not to have deteriorated in grade. If the more conventional 95% statistical significance level is used to denote a "definite" real change, then far fewer sites would be classed as having changed, with only 4.2% showing a definite upgrade and a mere 0.7% definitely downgraded. The corresponding percentages of "definite" changes in grade for the chemistry GQA were 10.02% upgraded and 0.66% downgraded.

Amongst sites whose "face" GQA grade did not change, the RIVPACS III+ estimated likelihood of a change in grade was less than 50% in nearly all cases, which is comforting. Moreover, of those sites which showed a change of one grade, 84% of those showing an improvement and 72% of those showing a downgrade, did so with statistical test probabilities >50%. The observed changes in EQI values between 1990 and 1995 resulting in a change of one grade were therefore more likely than not to indicate a real change in overall GQA grade, but could rarely be determined as having definitely (i.e. >95%) changed.

A "face" change of two of more grades is "definitely" (i.e. $P>0.95$) a real change in grade for the majority of such sites.

This implies that when the "face" grade changed, even by only one grade, it more likely than not indicated that there had been a real change in GQA grade (as presently defined). Thus the errors and uncertainty in the whole RIVPACS III+ procedure are not so great as to lead to most of the observed changes in GQA "face" grade being merely due to chance and uncertainty in the whole system.

It was therefore relatively easy to identify changes of the size which occurred between 1990 and 1995 as statistical significant at the 50% probability level (i.e. "more likely than not"), but difficult at the 95% level (i.e. to be very confident a change has really occurred).

When classified by ITE Landscape type, 33% of all sites in "marginal/upland" landscapes were grade "a" in 1990 compared to only 21% in "arable" landscapes. However, by 1995 one-third (33%) of all "arable" landscape river sites had more likely than not improved in grade, compared to only 22% of those in the "marginal/upland" landscapes.

Changes in biological grade did not seem to be consistently associated with any particular environmental types of site.

# 5 COMPARISON OF THE BIOLOGICAL CONDITION AND CHANGES IN CONDITION OF SITES WITH SOURCES OF POTENTIAL ENVIRONMENTAL STRESS

## 5.1 Database on Sources of Potential Environmental Stress for GQA Sites

Information on the types of environmental stresses and polluting influences which were thought to be operating at each site at the time of the 1995 GQA survey was obtained through a questionnaire sent out to the biologists within each of the Environment Agency Regions (Appendix 1).

The proportion of GQA sites for which information was provided and the detail of the responses was both impressive and encouraging. Responses were received for a total of 6570 GQA sites. The responses were amalgamated into a EXCEL spreadsheet, checked for inconsistencies, obvious encoding errors corrected, and then built into IFE's Quinqennial Survey Database (QSD) which holds IFE's version of the 1990 RQS and the 1995 GQA biological survey data. This process was very time-consuming, but benefited from the exchange of information with the University of Staffordshire.

The patterns of apparent relationships between the potential environmental stresses and the geographic location, environmental type and biological condition of sites reported below should be interpreted with considerable caution. Some Areas, laboratories and individual biologists will interpret the stresses in their area and/or the requirements of the IFE questionnaire differently. Biologists will have differed in the amount of time they devoted to considering and recording the potential stresses operating on sites in their area. Some will have more detailed knowledge and experience of the problems in each part of each catchment.

The analyses of the 1995 GQA data in the previous sections of this report have been based on 6016 sites for which there was suitably validated spring and autumn macro-invertebrate samples and RIVPACS environmental variables data (Table 2.1). Questionnaire information on environmental stresses was linked to these 6016 sites. There was a total of 168 sites for which either the survey response indicated that no information on environmental stresses was available (37 sites) or the questionnaire database site names and site codes could not be linked to the rest of IFE's QSD database. For the purpose of the analyses in this section these sites were all recorded, for convenience, as having stress category "No information (NI)" (The alternative option of eliminating this small proportion of sites from all analyses would have made very little difference to the patterns of association and conclusions).

The questionnaire produced responses on the presence and character of a very wide range of types of potential environmental stress. These were represented by about 150 individual stress categories, which were grouped into classes, which shall hereafter be referred to as major environmental stress types. Each individual stress was assigned a two-letter code in the questionnaire and this was used by the respondants to record the type of stress thought to be impacting each site.

For each type of stress, the respondants were asked to provide further information, where known, about the character of the stress, coded in terms of up to three stress qualifiers, namely its severity (V), its temporal character (T) and its spatial character (S) (Table 5.1).

**Table 5.1 Qualifiers of environmental stress types**

| Severity (V) | Temporal (T) | Spatial (S) |
|---|---|---|
| 1 = severe | 1 = acute (recorded as "a") | 1 = point source (recorded as "p") |
| 2 = moderate | 2 = seasonal ("s") | 2 = diffuse ("d") |
| 3 = light | 3 = chronic ("c") | |
| 4 = no qualifier | | |
| 5 = suspected/possible/unconfirmed | | |

The qualifiers for a particular stress at a site were encoded by IFE, for compactness, into the IFE QSD database as a single three digit code Q, calculated as: $Q = 100\,V + 10\,T + S$.

For example, a light, seasonal stress from a point source would have Q=321.

The grouping of individual stress types to major environmental stress types used in the questionnaire (Davy-Bowker *et al.* 2000) was revised slightly to give the groupings shown in Table 5.2.

## 5.2 Overall Occurrence of Environmental Stress Types and their Qualifiers

Table 5.2 shows the frequency of occurrence of each of the individual stress types amongst all the GQA sites. The frequency of each level of severity of each stress is also given. In this and other initial tables of results (Table 5.2-5.7), the stresses are listed in roughly the same order as they were in the questionnaire design, but in later tables, which show results for each Environment Agency Region or Area (Tables 5.8-5.13), they are given in order of decreasing frequency of occurrence to highlight regionally important stresses.

### 5.2.1 Overall occurrence of qualifiers for individual and major stress types

The most frequently occurring types of individual stress across the whole of England and Wales are recorded as general, non-specific farming (16.1% of all sites), the effect of fertilisers (11.0%), treated sewage treatment works (STW) effluent (24.6%), combined sewer overflow (9.8%) and urban run-off (14.9%). Sediment siltation problems were recorded at nearly 8% of all sites, which may be relevant to macro-invertebrate habitats. There was "no perceived problem" from any environmental stress at 11.2% of all sites (Table 5.2).

Where present, the impact of treated STW effluent was thought to be severe at nearly 23% (339/1477) of all such sites, but it was most often thought to have only a 'light' impact (39%). Although the impacts of heavy industry were only thought to cause stress at 1.7% of sites, in nearly all of those sites, the impact was considered to be severe.

Environmental stress due to effects of farming in general was very common, but the specific effect of 'intensive arablisation' of land use was recorded as likely to be impacting on 6.6% of all sites, mostly at severe or moderate levels.

Table 5.3 shows the frequency of occurrence of each type of environmental stress in terms of its spatial origin (i.e. whether from a point source or diffuse inputs from a wide area) and temporal nature (i.e. whether acute (as from a sudden discharge), seasonal, or chronic (i.e. persistent/long-term)).

**Table 5.2 Overall frequency of occurrence of individual environmental stress types amongst the GQA sites in 1995 (n=6016), together with frequency of each severity code (1 = severe, 2 = moderate, 3 = light, 4 = severity not given, 5 = stress only suspected).**

| *Table 5.2* | Individual stresses | | Overall occurrences | | Severity code | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | No. of sites | % of sites | 1 | 2 | 3 | 4 | 5 |
| Farming | FA | Farming | 967 | 16.1 | 91 | 449 | 318 | 1 | 108 |
| Farming | EU | Eutrophication | 9 | 0.2 | 6 | 0 | 3 | 0 | 0 |
| Farming | FE | Fertilisers | 660 | 11.0 | 15 | 244 | 205 | 0 | 196 |
| Farming | WC | Water cress beds | 10 | 0.2 | 1 | 3 | 6 | 0 | 0 |
| Farming | FF | Fish farm | 81 | 1.4 | 5 | 27 | 45 | 0 | 4 |
| Pesticides | PE | Pesticides | 161 | 2.7 | 9 | 12 | 120 | 0 | 20 |
| Pesticides | HE | Herbicides | 177 | 3.0 | 3 | 7 | 150 | 0 | 17 |
| Pesticides | IN | Insecticides | 197 | 3.3 | 12 | 17 | 152 | 0 | 16 |
| Pesticides | SD | Sheep-dip | 34 | 0.6 | 1 | 6 | 8 | 0 | 19 |
| Waste | WA | Waste | 5 | 0.1 | 0 | 2 | 1 | 0 | 2 |
| Waste | PI | Piggery waste | 31 | 0.6 | 2 | 15 | 8 | 0 | 6 |
| Waste | PO | Poultry waste | 13 | 0.3 | 3 | 4 | 3 | 0 | 3 |
| Waste | SL | Slurry | 187 | 3.2 | 5 | 14 | 36 | 1 | 131 |
| Waste | SI | Silage | 14 | 0.3 | 1 | 3 | 6 | 0 | 4 |
| Waste | SR | Sludge applied to land | 5 | 0.1 | 0 | 1 | 4 | 0 | 0 |
| Agri-industry | AI | Agri-industry | 24 | 0.4 | 4 | 6 | 10 | 1 | 3 |
| Agri-industry | AB | Abattoir | 21 | 0.4 | 5 | 5 | 6 | 0 | 5 |
| Agri-industry | DA | Dairy | 173 | 2.9 | 12 | 73 | 79 | 0 | 9 |
| Agri-industry | VE | Vegetable processing | 21 | 0.4 | 6 | 8 | 3 | 0 | 4 |
| Agri-industry | TA | Tanning/leather | 5 | 0.1 | 0 | 0 | 2 | 0 | 3 |
| Agri-industry | WO | Wool | 1 | 0.1 | 0 | 0 | 1 | 0 | 0 |
| Agri-industry | FL | Flour mill | 2 | 0.1 | 1 | 1 | 0 | 0 | 0 |
| Agri-industry | BR | Brewery | 17 | 0.3 | 0 | 7 | 8 | 0 | 2 |
| Agri-industry | SU | Sugar refinery | 6 | 0.1 | 1 | 4 | 0 | 0 | 1 |
| Industrial discharge | ID | Industrial discharge | 81 | 1.4 | 16 | 30 | 27 | 0 | 8 |
| Industrial discharge | HI | Heavy industry | 98 | 1.7 | 45 | 18 | 11 | 0 | 24 |
| Industrial discharge | PL | Plating industry | 4 | 0.1 | 1 | 2 | 1 | 0 | 0 |
| Industrial discharge | LI | Light industry/commercial | 152 | 2.6 | 26 | 46 | 53 | 1 | 26 |
| Industrial discharge | DE | Detergent | 4 | 0.1 | 0 | 2 | 2 | 0 | 0 |
| Industrial discharge | PM | Paper mill | 26 | 0.5 | 4 | 8 | 12 | 0 | 2 |
| Industrial discharge | BW | Brick works | 2 | 0.1 | 0 | 1 | 0 | 0 | 1 |
| Industrial discharge | CE | Cement works | 8 | 0.2 | 3 | 1 | 4 | 0 | 0 |
| Industrial discharge | CW | Cooling water (warm) | 22 | 0.4 | 2 | 11 | 5 | 0 | 4 |
| Industrial discharge | DY | Colouration (dye) | 31 | 0.6 | 6 | 18 | 6 | 0 | 1 |
| Sediment at the site | SX | Sediment at the site | 36 | 0.6 | 6 | 20 | 10 | 0 | 0 |
| Sediment at the site | TX | Contaminated sediment | 197 | 3.3 | 26 | 25 | 14 | 0 | 132 |
| Sediment at the site | IS | Inert siltation | 475 | 7.9 | 59 | 248 | 159 | 0 | 9 |
| Sediment at the site | GS | Eroded gravel/boulders in channel | 25 | 0.5 | 6 | 6 | 13 | 0 | 0 |
| Oils, petrochemicals | OI | Oils, petrochemicals | 52 | 0.9 | 10 | 20 | 17 | 0 | 5 |
| Oils, petrochemicals | CO | Crude oil | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | TO | Tar/bitumen | 1 | 0.1 | 1 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | VO | Vegetable oil | 4 | 0.1 | 1 | 0 | 3 | 0 | 0 |
| Oils, petrochemicals | LO | Lubricating oil | 1 | 0.1 | 1 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | FO | Fuel (diesel/petrol) | 37 | 0.7 | 4 | 7 | 18 | 0 | 8 |
| Construction | CT | Construction | 2 | 0.1 | 1 | 0 | 1 | 0 | 0 |
| Construction | BU | Building and road site | 20 | 0.4 | 2 | 14 | 3 | 0 | 1 |
| Leachate | LE | Leachate | 17 | 0.3 | 1 | 6 | 6 | 0 | 4 |
| Leachate | SY | Scrap yard | 3 | 0.1 | 0 | 1 | 1 | 0 | 1 |
| Leachate | SH | Slag heap | 21 | 0.4 | 3 | 4 | 11 | 0 | 3 |
| Leachate | DL | Domestic landfill | 58 | 1.0 | 11 | 14 | 17 | 0 | 16 |
| Leachate | TI | Toxic/industrial landfill | 63 | 1.1 | 15 | 15 | 8 | 0 | 25 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 279 | 4.7 | 85 | 121 | 66 | 0 | 7 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 1477 | 24.6 | 339 | 518 | 573 | 2 | 45 |
| Sewage Treatment Works (STW) | SE | Septic tank | 207 | 3.5 | 11 | 33 | 140 | 1 | 22 |

| *Table 5.2* | Individual stresses | | Overall occurrences | | Severity code | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | No. of sites | % of sites | 1 | 2 | 3 | 4 | 5 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 221 | 3.7 | 64 | 82 | 54 | 1 | 20 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 586 | 9.8 | 79 | 259 | 194 | 2 | 52 |
| Water Treatment Works (WTW) | WT | Water Treatment Works (WTW) | 33 | 0.6 | 4 | 7 | 12 | 0 | 10 |
| Water Treatment Works (WTW) | FS | Iron sulphate from WTW | 2 | 0.1 | 1 | 0 | 1 | 0 | 0 |
| Water Treatment Works (WTW) | AS | Aluminium sulphate from WTW | 6 | 0.1 | 0 | 3 | 2 | 0 | 1 |
| Water Treatment Works (WTW) | SW | Swimming pool | 3 | 0.1 | 0 | 0 | 0 | 0 | 3 |
| Run-off | RO | Run-off | 108 | 1.8 | 1 | 2 | 16 | 1 | 88 |
| Run-off | UR | Urban run-off | 892 | 14.9 | 220 | 370 | 235 | 2 | 65 |
| Run-off | HY | Highway run-off (including salt) | 299 | 5.0 | 19 | 77 | 103 | 1 | 99 |
| Run-off | RR | Railway run-off | 40 | 0.7 | 2 | 2 | 14 | 0 | 22 |
| Run-off | HR | Heavy industry run-off | 60 | 1.0 | 15 | 22 | 8 | 0 | 15 |
| Run-off | LR | Light industry/commercial run-off | 214 | 3.6 | 46 | 87 | 61 | 0 | 20 |
| Acid deposition | AD | Acid deposition | 80 | 1.4 | 17 | 23 | 20 | 0 | 20 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 61 | 1.1 | 10 | 18 | 22 | 1 | 10 |
| Mining, quarries and extraction | MM | Metal mine drainage | 105 | 1.8 | 12 | 31 | 54 | 0 | 8 |
| Mining, quarries and extraction | CM | Coal mine drainage | 122 | 2.1 | 19 | 49 | 46 | 0 | 8 |
| Mining, quarries and extraction | CC | China clay extraction | 25 | 0.5 | 9 | 9 | 7 | 0 | 0 |
| Mining, quarries and extraction | QA | Quarry (acid rock) | 9 | 0.2 | 1 | 2 | 4 | 0 | 2 |
| Mining, quarries and extraction | QB | Quarry (limestone/chalk) | 13 | 0.3 | 2 | 4 | 4 | 0 | 3 |
| Mining, quarries and extraction | SG | Sand and gravel extraction | 23 | 0.4 | 1 | 9 | 12 | 0 | 1 |
| Channel at the site | AN | Channel at the site | 11 | 0.2 | 2 | 4 | 5 | 0 | 0 |
| Channel at the site | CA | Channelisation | 441 | 7.4 | 108 | 224 | 102 | 1 | 6 |
| Channel at the site | CU | Culvert | 31 | 0.6 | 8 | 14 | 8 | 0 | 1 |
| Channel at the site | CV | Cave | 1 | 0.1 | 0 | 1 | 0 | 0 | 0 |
| Channel at the site | BE | Bedrock | 70 | 1.2 | 14 | 31 | 21 | 0 | 4 |
| Channel at the site | BD | Concrete stream bed | 19 | 0.4 | 10 | 3 | 6 | 0 | 0 |
| Channel at the site | BG | Bridge | 274 | 4.6 | 10 | 60 | 188 | 2 | 14 |
| Man-made watercourse | CN | Canal | 6 | 0.1 | 1 | 4 | 1 | 0 | 0 |
| Man-made watercourse | RN | River navigation (locks etc) | 57 | 1.0 | 17 | 34 | 5 | 1 | 0 |
| Man-made watercourse | DI | Artificial ditch of dyke | 17 | 0.3 | 9 | 6 | 2 | 0 | 0 |
| Channel Management | DN | Dredging | 92 | 1.6 | 13 | 27 | 39 | 1 | 12 |
| Channel Management | WD | Weed cutting | 68 | 1.2 | 7 | 25 | 24 | 3 | 9 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 175 | 3.0 | 37 | 79 | 58 | 0 | 1 |
| Artificial bank at the site | AT | Artificial bank at the site | 29 | 0.5 | 7 | 16 | 4 | 1 | 1 |
| Artificial bank at the site | UC | Unconsolidated (Rip-rap/boulder) | 47 | 0.8 | 7 | 27 | 11 | 0 | 2 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 179 | 3.0 | 40 | 60 | 70 | 3 | 6 |
| Artificial bank at the site | SP | Sheet piling | 22 | 0.4 | 7 | 7 | 8 | 0 | 0 |
| Bank practices at the site | BP | Bank practices at the site | 3 | 0.1 | 0 | 1 | 2 | 0 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 217 | 3.7 | 9 | 54 | 102 | 1 | 51 |
| Bank practices at the site | MO | Mown/managed riparian zone | 61 | 1.1 | 9 | 19 | 32 | 0 | 1 |
| Bank practices at the site | OG | Over grazing | 22 | 0.4 | 1 | 6 | 13 | 0 | 2 |
| Impoundments | RF | Regulated flow | 149 | 2.5 | 26 | 48 | 69 | 3 | 3 |
| Impoundments | WE | Weirs | 154 | 2.6 | 18 | 55 | 71 | 4 | 6 |
| Impoundments | RE | Reservoir u/s catchment | 135 | 2.3 | 25 | 44 | 57 | 2 | 7 |
| Impoundments | PF | Ponded flow (lake or reservoir d/s) | 56 | 1.0 | 16 | 26 | 13 | 0 | 1 |
| Impoundments | LP | Lake or pond close u/s | 164 | 2.8 | 32 | 67 | 54 | 4 | 7 |
| Impoundments | HW | Hypolimnic water | 8 | 0.2 | 2 | 3 | 2 | 0 | 1 |
| Impoundments | RT | River transfer | 33 | 0.6 | 14 | 10 | 9 | 0 | 0 |
| Impoundments | FT | Freshwater but tidal | 61 | 1.1 | 14 | 29 | 14 | 0 | 4 |
| Low flow | LF | Low flow | 220 | 3.7 | 39 | 90 | 71 | 4 | 16 |
| Low flow | AP | Abstraction for public supply | 33 | 0.6 | 5 | 13 | 13 | 0 | 2 |
| Low flow | AG | Abstraction from groundwater | 62 | 1.1 | 10 | 16 | 28 | 2 | 6 |
| Low flow | AR | Abstraction from river | 36 | 0.6 | 8 | 13 | 13 | 0 | 2 |
| Low flow | IR | Abstraction for irrigation | 56 | 1.0 | 12 | 21 | 21 | 1 | 1 |
| Low flow | CD | Cessation of STW discharge | 3 | 0.1 | 1 | 2 | 0 | 0 | 0 |
| Low flow | DT | Drought | 132 | 2.2 | 7 | 52 | 58 | 0 | 15 |
| No flow | NF | No flow | 8 | 0.2 | 4 | 4 | 0 | 0 | 0 |
| No flow | WI | Winterbourne (natural) | 11 | 0.2 | 4 | 2 | 3 | 2 | 0 |
| No flow | DC | Dry channel (caused by man) | 3 | 0.1 | 1 | 0 | 1 | 0 | 1 |

| Table 5.2 | Individual stresses | | Overall occurrences | | Severity code | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | No. of sites | % of sites | 1 | 2 | 3 | 4 | 5 |
| Saline | SA | Saline | 13 | 0.3 | 2 | 5 | 3 | 0 | 3 |
| Saline | MA | Marine origin | 22 | 0.4 | 4 | 7 | 7 | 0 | 4 |
| Saline | IG | Inland geological | 3 | 0.1 | 1 | 0 | 1 | 0 | 1 |
| Saline | IL | Industrial discharge | 5 | 0.1 | 1 | 2 | 2 | 0 | 0 |
| Land use | LU | Land use | 5 | 0.1 | 0 | 3 | 2 | 0 | 0 |
| Land use | CF | Afforestation (conifer) | 96 | 1.6 | 13 | 26 | 28 | 1 | 28 |
| Land use | IA | Intensive arablisation | 397 | 6.6 | 121 | 205 | 44 | 12 | 15 |
| Land use | US | Urban/suburban | 344 | 5.8 | 64 | 166 | 111 | 1 | 2 |
| Land use | MD | Moorland drainage | 101 | 1.7 | 5 | 41 | 39 | 0 | 16 |
| Land use | UO | Upland overgrazing | 5 | 0.1 | 1 | 3 | 0 | 0 | 1 |
| Land use | RB | Reedbed at the site | 6 | 0.1 | 1 | 1 | 4 | 0 | 0 |
| Reclaimed land | RL | Reclaimed land | 4 | 0.1 | 1 | 2 | 1 | 0 | 0 |
| Reclaimed land | RI | Industrial reclaimed land | 17 | 0.3 | 2 | 5 | 9 | 0 | 1 |
| Reclaimed land | OC | Open/cast reclaimed land | 7 | 0.2 | 0 | 2 | 2 | 0 | 3 |
| Bank erosion | EC | Clay bank erosion | 42 | 0.7 | 0 | 15 | 14 | 0 | 13 |
| Bank erosion | ES | Sand bank erosion | 44 | 0.8 | 5 | 14 | 13 | 0 | 12 |
| Bank erosion | EG | Gravel, boulder bank erosion | 18 | 0.3 | 3 | 11 | 4 | 0 | 0 |
| Sorting problem | PR | Poorly preserved sample | 8 | 0.2 | 0 | 0 | 5 | 3 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 193 | 3.3 | 0 | 0 | 0 | 187 | 6 |
| Sampling difficulty | AL | Air-lift used to sample | 16 | 0.3 | 0 | 0 | 0 | 16 | 0 |
| Sampling difficulty | AC | Access to one bank only | 168 | 2.8 | 0 | 0 | 0 | 168 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 141 | 2.4 | 32 | 58 | 51 | 0 | 0 |
| No perceived problem | NP | No perceived problem | 669 | 11.2 | 1 | 0 | 1 | 667 | 0 |
| No information | NI | No information | 168 | 2.8 | 0 | 0 | 0 | 168 | 0 |
| Other | BM | Boat mooring | 1 | 0.1 | 0 | 1 | 0 | 0 | 0 |
| Other | SF | Sewage fungus | 92 | 1.6 | 5 | 17 | 58 | 2 | 10 |
| Other | OH | Ochre | 125 | 2.1 | 34 | 41 | 42 | 3 | 5 |
| Other | CL | Cladophora | 431 | 7.2 | 58 | 254 | 109 | 8 | 2 |
| Other | MY | Stress is a mystery | 80 | 1.4 | 4 | 30 | 17 | 25 | 4 |
| Other | AF | Unknown | 2 | 0.1 | 0 | 0 | 2 | 0 | 0 |
| Other | BL | Unknown | 2 | 0.1 | 0 | 1 | 1 | 0 | 0 |
| Other | CR | Unknown | 1 | 0.1 | 0 | 1 | 0 | 0 | 0 |
| Other | EI | Unknown | 1 | 0.1 | 0 | 0 | 1 | 0 | 0 |
| Other | JT | Unknown | 1 | 0.1 | 1 | 0 | 0 | 0 | 0 |
| Other | LM | Unknown | 1 | 0.1 | 0 | 0 | 0 | 0 | 1 |
| Other | MR | Unknown | 1 | 0.1 | 0 | 0 | 0 | 0 | 1 |
| Other | PG | Unknown | 1 | 0.1 | 0 | 0 | 0 | 0 | 1 |
| Other | SO | Unknown | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| Other | UK | Unknown | 1 | 0.1 | 0 | 0 | 1 | 0 | 0 |
| Other | VR | Unknown | 9 | 0.2 | 1 | 8 | 0 | 0 | 0 |
| Other | VS | Unknown | 10 | 0.2 | 0 | 9 | 1 | 0 | 0 |
| | | Total | 15543 | | 2304 | 5278 | 4995 | 1311 | 1655 |

The frequency of these qualifiers should be interpreted with caution, as for most stress types, they were not recorded for the vast majority of cases (often <20%). Most of the qualifiers are as one might expect. For example fertilisers, herbicides and insecticides from farming are considered to be diffuse impacts (i.e. from across whole fields) and to generally have chronic long-term impacts.

In contrast, treated STW effluent or oils from the petrochemical industry are from point sources, but also usually considered to be chronic. Problems of drought were all recorded as seasonal as one might expect, although one site's drought problem was recorded as chronic (i.e. all year round).

**Table 5.3 Frequency of occurrence of individual environmental stress types amongst the GQA sites in 1995 (n=6016), classified according to the spatial (p=point, d=diffuse) and temporal (a=acute, s=seasonal, c=chronic) occurrence of the stress. Total = total number of sites identified as having the stress.**

| *Table 5.3* | Individual stresses | | Total | spatial | | temporal | | | point (p) | | | diffuse (d) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | | p | d | a | s | c | a | s | c | a | s | c |
| Farming | FA | Farming | 967 | 5 | 141 | 1 | 6 | 30 | 0 | 0 | 0 | 0 | 0 | 17 |
| Farming | EU | Eutrophication | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Farming | FE | Fertilisers | 660 | 3 | 397 | 0 | 111 | 167 | 0 | 0 | 0 | 0 | 110 | 158 |
| Farming | WC | Water cress beds | 10 | 5 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 | 0 |
| Farming | FF | Fish farm | 81 | 28 | 2 | 1 | 0 | 21 | 1 | 0 | 19 | 0 | 0 | 0 |
| Pesticides | PE | Pesticides | 161 | 1 | 113 | 0 | 110 | 8 | 0 | 1 | 0 | 0 | 109 | 0 |
| Pesticides | HE | Herbicides | 177 | 2 | 152 | 0 | 5 | 154 | 0 | 0 | 2 | 0 | 0 | 151 |
| Pesticides | IN | Insecticides | 197 | 16 | 152 | 5 | 5 | 154 | 5 | 0 | 6 | 0 | 2 | 145 |
| Pesticides | SD | Sheep-dip | 34 | 2 | 0 | 2 | 1 | 2 | 0 | 0 | 2 | 0 | 0 | 0 |
| Waste | WA | Waste | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Waste | PI | Piggery waste | 31 | 3 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Waste | PO | Poultry waste | 13 | 2 | 4 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Waste | SL | Slurry | 187 | 15 | 134 | 8 | 13 | 3 | 6 | 0 | 1 | 0 | 4 | 0 |
| Waste | SI | Silage | 14 | 0 | 0 | 1 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Waste | SR | Sludge applied to land | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agri-industry | AI | Agri-industry | 24 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agri-industry | AB | Abattoir | 21 | 7 | 3 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| Agri-industry | DA | Dairy | 173 | 7 | 21 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agri-industry | VE | Vegetable processing | 21 | 8 | 0 | 1 | 3 | 5 | 1 | 0 | 3 | 0 | 0 | 0 |
| Agri-industry | TA | Tanning/leather | 5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Agri-industry | WO | Wool | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agri-industry | FL | Flour mill | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 |
| Agri-industry | BR | Brewery | 17 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agri-industry | SU | Sugar refinery | 6 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Industrial discharge | ID | Industrial discharge | 81 | 9 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industrial discharge | HI | Heavy industry | 98 | 18 | 0 | 3 | 1 | 50 | 1 | 1 | 18 | 0 | 0 | 0 |
| Industrial discharge | PL | Plating industry | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industrial discharge | LI | Light industry/commercial | 152 | 34 | 4 | 3 | 2 | 29 | 3 | 0 | 19 | 0 | 0 | 0 |
| Industrial discharge | DE | Detergent | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industrial discharge | PM | Paper mill | 26 | 6 | 0 | 2 | 0 | 8 | 0 | 0 | 3 | 0 | 0 | 0 |
| Industrial discharge | BW | Brick works | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industrial discharge | CE | Cement works | 8 | 2 | 1 | 0 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 |
| Industrial discharge | CW | Cooling water (warm) | 22 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Industrial discharge | DY | Colouration (dye) | 31 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sediment at the site | SX | Sediment at the site | 36 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sediment at the site | TX | Contaminated sediment | 197 | 35 | 119 | 1 | 0 | 156 | 0 | 0 | 35 | 0 | 0 | 117 |
| Sediment at the site | IS | Inert siltation | 475 | 5 | 7 | 1 | 2 | 46 | 0 | 1 | 4 | 0 | 0 | 2 |

| ***Table 5.3*** | Individual stresses | | Total | spatial | | temporal | | | point (p) | | | diffuse (d) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | | p | d | a | s | c | a | s | c | a | s | c |
| Sediment at the site | GS | Eroded gravel/boulders in channel | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | OI | Oils, petrochemicals | 52 | 21 | 0 | 2 | 1 | 26 | 1 | 1 | 16 | 0 | 0 | 0 |
| Oils, petrochemicals | CO | Crude oil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | TO | Tar/bitumen | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | VO | Vegetable oil | 4 | 3 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | LO | Lubricating oil | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oils, petrochemicals | FO | Fuel (diesel/petrol) | 37 | 4 | 6 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Construction | CT | Construction | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction | BU | Building and road site | 20 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Leachate | LE | Leachate | 17 | 3 | 2 | 0 | 0 | 5 | 0 | 0 | 2 | 0 | 0 | 1 |
| Leachate | SY | Scrap yard | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Leachate | SH | Slag heap | 21 | 2 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Leachate | DL | Domestic landfill | 58 | 7 | 3 | 0 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 0 |
| Leachate | TI | Toxic/industrial landfill | 63 | 3 | 8 | 3 | 0 | 11 | 0 | 0 | 0 | 1 | 0 | 3 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 279 | 22 | 0 | 0 | 1 | 25 | 0 | 0 | 22 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 1477 | 675 | 4 | 3 | 4 | 157 | 3 | 3 | 80 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 207 | 38 | 42 | 0 | 1 | 11 | 0 | 1 | 6 | 0 | 1 | 1 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 221 | 39 | 0 | 27 | 6 | 21 | 26 | 0 | 4 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 586 | 50 | 10 | 2 | 21 | 21 | 0 | 0 | 1 | 0 | 0 | 0 |
| Water Treatment Works (WTW) | WT | Water Treatment Works (WTW) | 33 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 |
| Water Treatment Works (WTW) | FS | Iron sulphate from WTW | 2 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| Water Treatment Works (WTW) | AS | Aluminium sulphate from WTW | 6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water Treatment Works (WTW) | SW | Swimming pool | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Run-off | RO | Run-off | 108 | 3 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Run-off | UR | Urban run-off | 892 | 48 | 127 | 2 | 27 | 79 | 1 | 0 | 28 | 0 | 0 | 0 |
| Run-off | HY | Highway run-off (including salt) | 299 | 16 | 9 | 1 | 19 | 17 | 1 | 0 | 10 | 0 | 0 | 0 |
| Run-off | RR | Railway run-off | 40 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Run-off | HR | Heavy industry run-off | 60 | 18 | 0 | 1 | 3 | 15 | 0 | 0 | 13 | 0 | 0 | 0 |
| Run-off | LR | Light industry/commercial run-off | 214 | 34 | 20 | 3 | 0 | 27 | 2 | 0 | 21 | 0 | 0 | 1 |
| Acid deposition | AD | Acid deposition | 80 | 0 | 8 | 1 | 13 | 2 | 0 | 0 | 0 | 1 | 6 | 0 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 61 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mining, quarries and extraction | MM | Metal mine drainage | 105 | 3 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mining, quarries and extraction | CM | Coal mine drainage | 122 | 15 | 2 | 1 | 1 | 10 | 0 | 1 | 3 | 0 | 0 | 0 |
| Mining, quarries and extraction | CC | China clay extraction | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mining, quarries and extraction | QA | Quarry (acid rock) | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mining, quarries and extraction | QB | Quarry (limestone/chalk) | 13 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Mining, quarries and extraction | SG | Sand and gravel extraction | 23 | 3 | 1 | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 |
| Channel at the site | AN | Channel at the site | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel at the site | CA | Channelisation | 441 | 0 | 1 | 0 | 0 | 68 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel at the site | CU | Culvert | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel at the site | CV | Cave | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel at the site | BE | Bedrock | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| ***Table 5.3*** | Individual stresses | | Total | spatial | | temporal | | | point (p) | | | diffuse (d) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | | p | d | a | s | c | a | s | c | a | s | c |
| Channel at the site | BD | Concrete stream bed | 19 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel at the site | BG | Bridge | 274 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Man-made watercourse | CN | Canal | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Man-made watercourse | RN | River navigation (locks etc) | 57 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 |
| Man-made watercourse | DI | Artificial ditch of dyke | 17 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel Management | DN | Dredging | 92 | 0 | 0 | 7 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel Management | WD | Weed cutting | 68 | 0 | 1 | 10 | 16 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 175 | 0 | 0 | 0 | 32 | 24 | 0 | 0 | 0 | 0 | 0 | 0 |
| Artificial bank at the site | AT | Artificial bank at the site | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Artificial bank at the site | UC | Unconsolidated (Rip-rap/boulder) | 47 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 179 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| Artificial bank at the site | SP | Sheet piling | 22 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank practices at the site | BP | Bank practices at the site | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 217 | 2 | 0 | 0 | 1 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank practices at the site | MO | Mown/managed riparian zone | 61 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank practices at the site | OG | Over grazing | 22 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Impoundments | RF | Regulated flow | 149 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 |
| Impoundments | WE | Weirs | 154 | 1 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 135 | 8 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Impoundments | PF | Ponded flow (lake or reservoir d/s) | 56 | 2 | 0 | 0 | 3 | 4 | 0 | 0 | 1 | 0 | 0 | 0 |
| Impoundments | LP | Lake or pond close u/s | 164 | 7 | 1 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Impoundments | HW | Hypolimnic water | 8 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| Impoundments | RT | River transfer | 33 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Impoundments | FT | Freshwater but tidal | 61 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low flow | LF | Low flow | 220 | 0 | 0 | 0 | 49 | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low flow | AP | Abstraction for public supply | 33 | 11 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low flow | AG | Abstraction from groundwater | 62 | 1 | 1 | 0 | 1 | 6 | 0 | 1 | 0 | 0 | 0 | 0 |
| Low flow | AR | Abstraction from river | 36 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low flow | IR | Abstraction for irrigation | 56 | 2 | 11 | 0 | 13 | 0 | 0 | 2 | 0 | 0 | 11 | 0 |
| Low flow | CD | Cessation of STW discharge | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low flow | DT | Drought | 132 | 0 | 0 | 0 | 27 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| No flow | NF | No flow | 8 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No flow | WI | Winterbourne (natural) | 11 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No flow | DC | Dry channel (caused by man) | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Saline | SA | Saline | 13 | 0 | 5 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| Saline | MA | Marine origin | 22 | 0 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Saline | IG | Inland geological | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Saline | IL | Industrial discharge | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Land use | LU | Land use | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Land use | CF | Afforestation (conifer) | 96 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Land use | IA | Intensive arablisation | 397 | 0 | 12 | 0 | 0 | 111 | 0 | 0 | 0 | 0 | 0 | 0 |
| Land use | US | Urban/suburban | 344 | 2 | 0 | 0 | 0 | 46 | 0 | 0 | 2 | 0 | 0 | 0 |

| ***Table 5.3*** | Individual stresses | | Total | spatial | | temporal | | | point (p) | | | diffuse (d) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | | p | d | a | s | c | a | s | c | a | s | c |
| Land use | MD | Moorland drainage | 101 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Land use | UO | Upland overgrazing | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Land use | RB | Reedbed at the site | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Reclaimed land | RL | Reclaimed land | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Reclaimed land | RI | Industrial reclaimed land | 17 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Reclaimed land | OC | Open/cast reclaimed land | 7 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank erosion | EC | Clay bank erosion | 42 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank erosion | ES | Sand bank erosion | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank erosion | EG | Gravel, boulder bank erosion | 18 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sorting problem | PR | Poorly preserved sample | 8 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 193 | 0 | 0 | 0 | 1 | 21 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sampling difficulty | AL | Air-lift used to sample | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sampling difficulty | AC | Access to one bank only | 168 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 141 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| No perceived problem | NP | No perceived problem | 669 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No information | NI | No information | 168 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | BM | Boat mooring | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | SF | Sewage fungus | 92 | 1 | 0 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Other | OH | Ochre | 125 | 3 | 5 | 0 | 1 | 16 | 0 | 0 | 1 | 0 | 0 | 2 |
| Other | CL | Cladophora | 431 | 0 | 1 | 0 | 54 | 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | MY | Stress is a mystery | 80 | 0 | 0 | 1 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | AF | Unknown | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | BL | Unknown | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | CR | Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | EI | Unknown | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | JT | Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | LM | Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | MR | Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | PG | Unknown | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | SO | Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | UK | Unknown | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Other | VR | Unknown | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | VS | Unknown | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Total | 14239 | 1291 | 1584 | 113 | 604 | 1750 | 55 | 13 | 342 | 2 | 245 | 599 |

Tables 5.4 and 5.5 are the equivalent of Tables 5.2 and 5.3 for the major environmental stress type. A major stress type was assumed to be present at a site if any one of its component individual stresses was present. The severity level of a major stress was taken as the highest severity recorded for any of the component individual stresses at the site.

At this recording level, the most common sources of environmental stress were sewage treatment works (STW) (40.6%) and farming (27.5% of all sites) (Table 5.4). Other common stresses were sediment problems at the site (mostly siltation (Table 5.2)), problems with run-off (mostly from urban areas and highways (Table 5.2)), impacts on the channel of sites due to channelisation and bridge works (13.4%), various types of impoundment (10.9%) and land use problems (15.1%), especially from arable intensification and urban/suburban impacts.

**Table 5.4 Overall frequency of occurrence of each major environmental stress type amongst the GQA sites in 1995 (n=6016), together with frequency of each severity code (1 = severe, 2 = moderate, 3 = light, 4 = severity not given, 5 = stress only suspected).**

| **Major stress name** | Overall occurrences | | Severity code | | | | |
|---|---|---|---|---|---|---|---|
| | No. of sites | % of sites | 1 | 2 | 3 | 4 | 5 |
| Farming | 1653 | 27.5 | 118 | 702 | 552 | 1 | 280 |
| Pesticides | 397 | 6.6 | 23 | 35 | 282 | 0 | 57 |
| Waste | 243 | 4 | 10 | 36 | 54 | 1 | 142 |
| Agri-industry | 266 | 4.4 | 29 | 103 | 108 | 1 | 25 |
| Industrial discharge | 397 | 6.6 | 97 | 130 | 111 | 1 | 58 |
| Sediment at the site | 699 | 11.6 | 95 | 297 | 192 | 0 | 115 |
| Oils, petrochemicals | 95 | 1.6 | 17 | 27 | 38 | 0 | 13 |
| Construction | 22 | 0.4 | 3 | 14 | 4 | 0 | 1 |
| Leachate | 151 | 2.5 | 29 | 39 | 36 | 0 | 47 |
| Sewage Treatment Works (STW) | 2442 | 40.6 | 537 | 905 | 881 | 3 | 116 |
| Water Treatment Works (WTW) | 44 | 0.7 | 5 | 10 | 15 | 0 | 14 |
| Run-off | 1334 | 22.2 | 259 | 446 | 362 | 4 | 263 |
| Acid deposition | 80 | 1.3 | 17 | 23 | 20 | 0 | 20 |
| Mining, quarries and extraction | 347 | 5.8 | 54 | 122 | 139 | 1 | 31 |
| Channel at the site | 805 | 13.4 | 147 | 325 | 306 | 3 | 24 |
| Man-made watercourse | 80 | 1.3 | 27 | 44 | 8 | 1 | 0 |
| Channel Management | 148 | 2.5 | 18 | 47 | 59 | 3 | 21 |
| Choked channel (>33% plant) | 175 | 2.9 | 37 | 79 | 58 | 0 | 1 |
| Artificial bank at the site | 272 | 4.5 | 61 | 108 | 90 | 4 | 9 |
| Bank practices at the site | 290 | 4.8 | 19 | 78 | 138 | 1 | 54 |
| Impoundments | 654 | 10.9 | 134 | 248 | 238 | 9 | 25 |
| Low flow | 491 | 8.2 | 81 | 197 | 175 | 6 | 32 |
| No flow | 22 | 0.4 | 9 | 6 | 4 | 2 | 1 |
| Saline | 42 | 0.7 | 8 | 14 | 12 | 0 | 8 |
| Land use | 907 | 15.1 | 203 | 429 | 204 | 12 | 59 |
| Reclaimed land | 28 | 0.5 | 3 | 9 | 12 | 0 | 4 |
| Bank erosion | 103 | 1.7 | 8 | 39 | 31 | 0 | 25 |
| Sorting problem | 8 | 0.1 | 0 | 0 | 5 | 3 | 0 |
| Sampling difficulty | 475 | 7.9 | 32 | 58 | 51 | 329 | 5 |
| No perceived problem | 669 | 11.1 | 0 | 0 | 1 | 668 | 0 |
| No information | 168 | 2.8 | 0 | 0 | 0 | 168 | 0 |
| Other | 732 | 12.2 | 103 | 348 | 221 | 38 | 22 |
| Total | 14239 | | 2183 | 4918 | 4407 | 1259 | 1472 |

**Table 5.5 Frequency of occurrence of each major environmental stress type amongst the GQA sites in 1995 (n=6016), classified according to the spatial (p=point, d=diffuse) and temporal (a=acute, s=seasonal, c=chronic) character of the stress.**

| Major stress name | Total | spatial | | temporal | | | point (p) | | | diffuse (d) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | p | d | a | s | c | a | s | c | a | s | C |
| Farming | 1653 | 41 | 540 | 2 | 117 | 222 | 1 | 0 | 23 | 0 | 110 | 175 |
| Pesticides | 397 | 21 | 417 | 7 | 121 | 318 | 5 | 1 | 10 | 0 | 111 | 296 |
| Waste | 243 | 20 | 155 | 9 | 18 | 5 | 6 | 0 | 2 | 0 | 4 | 0 |
| Agri-industry | 266 | 36 | 25 | 4 | 8 | 13 | 1 | 1 | 7 | 0 | 0 | 0 |
| Industrial discharge | 397 | 72 | 7 | 11 | 3 | 92 | 4 | 1 | 42 | 0 | 0 | 0 |
| Sediment at the site | 699 | 41 | 126 | 2 | 2 | 203 | 0 | 1 | 39 | 0 | 0 | 119 |
| Oils, petrochemicals | 95 | 28 | 6 | 7 | 1 | 28 | 3 | 1 | 17 | 0 | 0 | 0 |
| Construction | 22 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Leachate | 151 | 15 | 21 | 3 | 0 | 26 | 0 | 0 | 3 | 1 | 0 | 4 |
| Sewage Treatment Works (STW) | 2442 | 824 | 56 | 32 | 33 | 235 | 29 | 4 | 113 | 0 | 1 | 1 |
| Water Treatment Works (WTW) | 44 | 5 | 0 | 0 | 0 | 6 | 0 | 0 | 4 | 0 | 0 | 0 |
| Run-off | 1334 | 119 | 159 | 8 | 51 | 140 | 4 | 0 | 72 | 0 | 0 | 1 |
| Acid deposition | 80 | 0 | 8 | 1 | 13 | 2 | 0 | 0 | 0 | 1 | 6 | 0 |
| Mining, quarries and extraction | 347 | 25 | 9 | 3 | 1 | 15 | 1 | 1 | 5 | 0 | 0 | 0 |
| Channel at the site | 805 | 2 | 1 | 0 | 0 | 71 | 0 | 0 | 0 | 0 | 0 | 0 |
| Man-made watercourse | 80 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| Channel Management | 148 | 0 | 1 | 17 | 19 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Choked channel (>33% plant) | 175 | 0 | 0 | 0 | 32 | 24 | 0 | 0 | 0 | 0 | 0 | 0 |
| Artificial bank at the site | 272 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank practices at the site | 290 | 3 | 0 | 1 | 2 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Impoundments | 654 | 19 | 3 | 0 | 6 | 45 | 0 | 0 | 2 | 0 | 0 | 0 |
| Low flow | 491 | 14 | 15 | 0 | 91 | 28 | 0 | 3 | 0 | 0 | 11 | 0 |
| No flow | 22 | 0 | 0 | 2 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Saline | 42 | 0 | 5 | 1 | 3 | 5 | 0 | 0 | 0 | 0 | 1 | 1 |
| Land use | 907 | 2 | 22 | 0 | 0 | 159 | 0 | 0 | 2 | 0 | 0 | 0 |
| Reclaimed land | 28 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank erosion | 103 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sorting problem | 8 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sampling difficulty | 475 | 0 | 0 | 0 | 2 | 23 | 0 | 0 | 0 | 0 | 0 | 0 |
| No perceived problem | 669 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No information | 168 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 732 | 4 | 7 | 3 | 62 | 41 | 1 | 0 | 1 | 0 | 1 | 2 |
| Total | 14239 | 1291 | 1584 | 113 | 604 | 1750 | 55 | 13 | 342 | 2 | 245 | 599 |

## 5.2.2 Comparison between Regions in frequency of stress types

Table 5.6 shows the percentage of sites in each of the ten former NRA Regions considered, potentially, to be impacted by each individual type of environmental stress. Table 5.7 gives the same information for the major environmental stress types.

Impacts from fertilisers used in farming were thought to be a potential problem at nearly 60% of river sites in Anglian region, a far higher percentage than for any other Region (the South West Region with 24.6% of sites was next). Fertiliser problems were recorded in only a small proportion of sites in Wales and, rather surprisingly, in Thames Region. Pesticide, herbicide and insecticide impacts were also only considered important and widespread in Anglian Region (Table 5.6).

**Table 5.6 Percentage frequency of occurrence of each individual environmental stress type amongst the GQA sites in each NRA/Agency region in 1995. (Ang=Anglian, Nor=Northumbrian, NW=North West, Mid=Midlands, South=Southern, SW=South West, Tha=Thames, Wes=Wessex, York=Yorkshire).**

| *Table 5.6* | Individual stresses | | Overall | NRA Region (total no. of sites) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Major stress name | Code | Full name | | 1 Ang | 2 Nor | 3 NW | 4 Mid | 5 South | 6 SW | 7 Tha | 8 Welsh | 9 Wes | 10 York |
| | | | | (636) | (278) | (844) | (1011) | (471) | (512) | (477) | (796) | (510) | (481) |
| Farming | FA | Farming | 16.1 | | 2.5 | 30.9 | 23.9 | 4.5 | 7.4 | 34.2 | 4.4 | 35.5 | 4.0 |
| Farming | EU | Eutrophication | 0.2 | | | | | | 1.8 | | | | |
| Farming | FE | Fertilisers | 11.0 | 58.8 | 8.6 | 3.6 | 3.4 | 3.8 | 24.6 | 0.2 | 0.6 | 2.0 | 7.9 |
| Farming | WC | Water cress beds | 0.2 | | | | | 1.1 | | 0.2 | | 0.8 | |
| Farming | FF | Fish farm | 1.4 | 1.1 | 0.4 | 0.6 | 0.1 | 2.5 | 1.8 | 1.7 | 0.4 | 4.9 | 2.1 |
| Pesticides | PE | Pesticides | 2.7 | 17.9 | 0.7 | 0.8 | 1.4 | 3.2 | 0.4 | | 0.5 | 0.2 | 0.4 |
| Pesticides | HE | Herbicides | 3.0 | 24.1 | 2.2 | 0.7 | 0.1 | 0.6 | | 1.0 | 0.1 | | 0.4 |
| Pesticides | IN | Insecticides | 3.3 | 24.2 | 2.2 | 1.4 | 1.2 | 0.2 | 0.8 | | | 0.4 | 1.2 |
| Pesticides | SD | Sheep-dip | 0.6 | 0.6 | 1.8 | 1.7 | 0.1 | | | 0.2 | 0.3 | | 1.5 |
| Waste | WA | Waste | 0.1 | 0.2 | | 0.1 | 0.2 | | | | | 0.2 | |
| Waste | PI | Piggery waste | 0.6 | 3.5 | | 0.4 | 0.1 | 0.8 | | | | | 0.2 |
| Waste | PO | Poultry waste | 0.3 | 0.3 | 0.4 | 0.6 | 0.2 | 0.4 | | | | 0.2 | |
| Waste | SL | Slurry | 3.2 | 2.4 | 0.4 | 2.6 | 0.1 | 18.0 | 0.4 | 1.0 | 2.3 | 0.6 | 7.3 |
| Waste | SI | Silage | 0.3 | | 0.4 | 0.9 | | 0.4 | | | | 0.6 | |
| Waste | SR | Sludge applied to land | 0.1 | | | | | | 1.0 | | | | |
| Agri-industry | AI | Agri-industry | 0.4 | 0.8 | 1.1 | 0.2 | 0.8 | 0.2 | 0.2 | 0.2 | | 0.6 | |
| Agri-industry | AB | Abattoir | 0.4 | 1.6 | | 0.2 | 0.2 | | 1.2 | 0.2 | | | |
| Agri-industry | DA | Dairy | 2.9 | | 1.4 | 10.9 | 1.0 | 3.0 | 8.0 | 0.6 | 0.4 | 1.0 | 0.2 |
| Agri-industry | VE | Vegetable processing | 0.4 | 0.8 | 0.7 | 0.9 | 0.4 | 0.2 | | | | | 0.2 |
| Agri-industry | TA | Tanning/leather | 0.1 | | 0.4 | | | | 0.6 | | | 0.2 | |
| Agri-industry | WO | Wool | 0.1 | | | | | | | | | | 0.2 |
| Agri-industry | FL | Flour mill | 0.1 | 0.3 | | | | | | | | | |
| Agri-industry | BR | Brewery | 0.3 | 1.3 | | | 0.6 | | 0.2 | | | 0.4 | |
| Agri-industry | SU | Sugar refinery | 0.1 | 0.3 | | 0.4 | | | | | | | 0.2 |
| Industrial discharge | ID | Industrial discharge | 1.4 | 0.5 | 0.7 | 4.1 | 1.2 | 0.2 | 0.6 | | 1.1 | 2.0 | 1.2 |
| Industrial discharge | HI | Heavy industry | 1.7 | 3.0 | 0.4 | 1.1 | 0.8 | 0.2 | 0.2 | | 0.9 | | 10.8 |
| Industrial discharge | PL | Plating industry | 0.1 | | | 0.2 | 0.1 | | | | | 0.2 | |
| Industrial discharge | LI | Light industry/commercial | 2.6 | 4.2 | 1.8 | 4.5 | 2.5 | 1.9 | 1.0 | 1.3 | 3.1 | 2.4 | |
| Industrial discharge | DE | Detergent | 0.1 | | 1.1 | | | | | | | 0.2 | |
| Industrial discharge | PM | Paper mill | 0.5 | | 0.7 | 1.2 | 0.1 | 1.1 | 1.0 | | 0.1 | 0.4 | |
| Industrial discharge | BW | Brick works | 0.1 | | | | | 0.4 | | | | | |
| Industrial discharge | CE | Cement works | 0.2 | 0.3 | 1.1 | 0.2 | 0.1 | | | | | | |
| Industrial discharge | CW | Cooling water (warm) | 0.4 | 0.5 | 0.4 | 0.2 | 1.1 | | | 0.8 | 0.1 | | |
| Industrial discharge | DY | Colouration (dye) | 0.6 | | | 0.5 | 2.5 | | | 0.2 | | | 0.2 |

| **Table 5.6**<br>Major stress name | Individual stresses | | Overall | NRA Region (total no. of sites) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Code | Full name | | 1 Ang (636) | 2 Nor (278) | 3 NW (844) | 4 Mid (1011) | 5 South (471) | 6 SW (512) | 7 Tha (477) | 8 Welsh (796) | 9 Wes (510) | 10 York (481) |
| Sediment at the site | SX | Sediment at the site | 0.6 | 0.2 | | 3.4 | 0.1 | | 0.6 | | | | 0.4 |
| Sediment at the site | TX | Contaminated sediment | 3.3 | 24.2 | 2.2 | 0.8 | 0.9 | | 1.2 | 0.4 | 0.1 | | 2.5 |
| Sediment at the site | IS | Inert siltation | 7.9 | 5.8 | 2.5 | 8.4 | 11.7 | 8.9 | 0.4 | 9.0 | 6.0 | 16.1 | 5.2 |
| Sediment at the site | GS | Eroded gravel/boulders in channel | 0.5 | | 0.4 | 1.5 | | | | 0.2 | 1.3 | | |
| Oils, petrochemicals | OI | Oils, petrochemicals | 0.9 | 4.6 | 0.4 | 0.5 | 0.3 | 0.6 | | 1.3 | 0.8 | | |
| Oils, petrochemicals | CO | Crude oil | 0.0 | | | | | | | | | | |
| Oils, petrochemicals | TO | Tar/bitumen | 0.1 | | | | | | | | | | 0.2 |
| Oils, petrochemicals | VO | Vegetable oil | 0.1 | 0.2 | 0.7 | 0.1 | | | | | | | |
| Oils, petrochemicals | LO | Lubricating oil | 0.1 | | | | | 0.2 | | | | | |
| Oils, petrochemicals | FO | Fuel (diesel/petrol) | 0.7 | 1.4 | 1.1 | 0.4 | 0.1 | 3.0 | 0.2 | 0.2 | 0.3 | 0.6 | |
| Construction | CT | Construction | 0.1 | | | 0.1 | | | 0.2 | | | | |
| Construction | BU | Building and road site | 0.4 | 0.8 | | 0.2 | 0.3 | | 0.2 | 1.7 | | | 0.2 |
| Leachate | LE | Leachate | 0.3 | 0.8 | | 0.8 | 0.2 | | 0.2 | | 0.1 | 0.2 | |
| Leachate | SY | Scrap yard | 0.1 | | 0.4 | 0.1 | | 0.2 | | | | | |
| Leachate | SH | Slag heap | 0.4 | | 2.5 | 0.8 | 0.5 | | | | | | 0.4 |
| Leachate | DL | Domestic landfill | 1.0 | 1.1 | 1.8 | 1.4 | 0.5 | 1.5 | 1.0 | 1.0 | 0.6 | 0.4 | 1.0 |
| Leachate | TI | Toxic/industrial landfill | 1.1 | 1.4 | 2.9 | 2.1 | 1.1 | | 0.2 | | 0.3 | | 2.9 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 4.7 | 2.7 | 1.4 | 0.8 | 20.1 | 1.7 | 1.0 | | 0.1 | 6.5 | 0.2 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 24.6 | 42.0 | 30.6 | 21.0 | 26.5 | 28.2 | 12.9 | 44.4 | 7.8 | 15.1 | 27.0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 3.5 | 6.4 | 4.7 | 14.1 | 0.9 | 0.4 | 1.6 | | 0.5 | 1.2 | 1.0 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 3.7 | 6.0 | 1.4 | 7.5 | 8.0 | 1.9 | 0.8 | 2.5 | 0.8 | 0.6 | 0.2 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 9.8 | 2.0 | 18.7 | 21.0 | 5.8 | 0.8 | | 0.4 | 19.3 | 0.4 | 25.6 |
| Water Treatment Works (WTW) | WT | Water Treatment Works (WTW) | 0.6 | 0.3 | | 0.4 | 0.4 | 0.4 | 1.0 | 1.3 | 1.0 | 0.2 | 0.4 |
| Water Treatment Works (WTW) | FS | Iron sulphate from WTW | 0.1 | 0.3 | | | | | | | | | |
| Water Treatment Works (WTW) | AS | Aluminium sulphate from WTW | 0.1 | | 2.2 | | | | | | | | |
| Water Treatment Works (WTW) | SW | Swimming pool | 0.1 | 0.2 | | | | 0.2 | | | | | 0.2 |
| Run-off | RO | Run-off | 1.8 | 0.2 | | 1.4 | | 0.2 | 0.2 | | 11.1 | 0.8 | 0.2 |
| Run-off | UR | Urban run-off | 14.9 | 14.6 | 7.2 | 25.4 | 27.5 | 7.9 | 6.8 | 19.1 | 0.5 | 1.8 | 23.1 |
| Run-off | HY | Highway run-off (including salt) | 5.0 | 3.0 | 2.2 | 11.8 | 3.6 | 2.8 | 13.1 | 5.9 | 0.6 | 2.4 | 2.7 |
| Run-off | RR | Railway run-off | 0.7 | 0.3 | 1.4 | 0.6 | 0.5 | 0.8 | 2.7 | 1.0 | | 0.2 | |
| Run-off | HR | Heavy industry run-off | 1.0 | 2.2 | 0.7 | 0.9 | 0.9 | 3.8 | | | 0.3 | | 1.5 |
| Run-off | LR | Light industry/commercial run-off | 3.6 | 7.5 | 3.6 | 7.7 | 5.0 | 2.3 | 0.8 | 3.4 | 0.6 | 0.2 | 0.6 |
| Acid deposition | AD | Acid deposition | 1.4 | | 0.4 | 2.7 | 0.5 | | | | 6.4 | | |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 1.1 | | 4.0 | 0.8 | 2.5 | 0.4 | 2.5 | | 0.4 | | |
| Mining, quarries and extraction | MM | Metal mine drainage | 1.8 | 0.2 | 9.0 | 0.4 | 0.6 | | 8.8 | | 3.0 | | 0.2 |
| Mining, quarries and extraction | CM | Coal mine drainage | 2.1 | | 7.6 | 2.5 | 2.8 | | | | 3.0 | | 5.8 |
| Mining, quarries and extraction | CC | China clay extraction | 0.5 | | | | | | 4.9 | | | | |
| Mining, quarries and extraction | QA | Quarry (acid rock) | 0.2 | | 0.7 | 0.4 | 0.1 | | 0.4 | | 0.1 | | |
| Mining, quarries and extraction | QB | Quarry (limestone/chalk) | 0.3 | | | | 0.3 | | 0.4 | | 0.1 | 1.2 | 0.2 |
| Mining, quarries and extraction | SG | Sand and gravel extraction | 0.4 | 0.3 | 0.4 | 0.8 | 0.4 | | | 1.5 | 0.1 | 0.2 | |

| ***Table 5.6***<br>Major stress name | Individual stresses |  | Overall | NRA Region (total no. of sites) |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Code | Full name |  | 1 Ang (636) | 2 Nor (278) | 3 NW (844) | 4 Mid (1011) | 5 South (471) | 6 SW (512) | 7 Tha (477) | 8 Welsh (796) | 9 Wes (510) | 10 York (481) |
| Channel at the site | AN | Channel at the site | 0.2 |  | 1.1 |  | 0.1 |  |  |  |  | 1.4 |  |
| Channel at the site | CA | Channelisation | 7.4 | 23.9 | 2.2 | 8.8 | 3.4 | 1.7 | 1.6 | 14.0 | 2.5 | 12.9 | 1.2 |
| Channel at the site | CU | Culvert | 0.6 |  | 0.4 | 1.8 | 0.4 | 0.4 |  | 0.6 | 0.5 | 0.4 |  |
| Channel at the site | CV | Cave | 0.1 |  |  |  |  |  |  |  |  | 0.2 |  |
| Channel at the site | BE | Bedrock | 1.2 |  | 1.8 | 1.5 | 0.3 |  | 5.9 |  | 2.1 | 0.4 |  |
| Channel at the site | BD | Concrete stream bed | 0.4 | 0.5 |  | 0.2 | 0.5 | 0.6 | 0.2 | 0.8 | 0.1 |  |  |
| Channel at the site | BG | Bridge | 4.6 | 31.4 | 6.5 | 1.3 | 1.2 | 3.4 | 0.4 | 0.4 | 1.1 | 0.8 |  |
| Man-made watercourse | CN | Canal | 0.1 |  |  | 0.2 |  |  |  | 0.6 |  | 0.2 |  |
| Man-made watercourse | RN | River navigation (locks etc) | 1.0 | 2.7 |  | 0.6 | 1.0 |  |  | 5.0 |  | 0.2 |  |
| Man-made watercourse | DI | Artificial ditch of dyke | 0.3 | 0.3 |  | 1.4 | 0.1 |  |  |  |  | 0.4 |  |
| Channel Management | DN | Dredging | 1.6 | 1.4 | 0.4 | 1.9 | 0.6 | 0.6 | 1.2 | 0.6 | 0.8 | 7.5 | 0.8 |
| Channel Management | WD | Weed cutting | 1.2 | 2.2 | 0.4 | 2.1 | 0.1 | 4.0 |  | 0.2 | 0.3 | 0.6 | 1.9 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 3.0 | 7.4 | 0.4 | 1.2 | 1.7 | 5.3 | 1.6 | 7.5 | 1.0 | 2.9 | 1.7 |
| Artificial bank at the site | AT | Artificial bank at the site | 0.5 | 1.7 |  | 0.6 | 0.4 | 0.2 | 0.4 | 0.6 | 0.1 | 0.4 |  |
| Artificial bank at the site | UC | Unconsolidated (Rip-rap/boulder) | 0.8 | 0.3 |  | 1.1 | 0.6 |  | 1.4 | 0.4 | 2.5 | 0.2 |  |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 3.0 | 3.0 | 0.4 | 2.8 | 0.8 | 0.6 | 5.3 | 7.8 | 4.5 | 4.7 |  |
| Artificial bank at the site | SP | Sheet piling | 0.4 | 1.3 |  | 0.1 | 0.1 | 0.4 |  | 1.7 |  | 0.4 |  |
| Bank practices at the site | BP | Bank practices at the site | 0.1 |  |  |  |  |  |  | 0.2 |  | 0.4 |  |
| Bank practices at the site | LV | Livestock poaching, trampling | 3.7 | 1.3 | 4.0 | 3.4 | 0.9 | 3.0 | 12.1 | 1.5 | 5.8 | 5.9 | 0.2 |
| Bank practices at the site | MO | Mown/managed riparian zone | 1.1 | 0.3 |  | 0.8 | 0.3 | 4.2 | 1.4 | 2.1 | 0.4 | 1.8 |  |
| Bank practices at the site | OG | Over grazing | 0.4 | 0.2 | 1.1 | 0.7 |  | 0.2 |  |  | 0.5 | 1.4 |  |
| Impoundments | RF | Regulated flow | 2.5 | 2.5 | 2.2 | 2.1 | 0.9 | 4.0 | 2.0 | 0.4 | 2.0 | 8.4 | 2.1 |
| Impoundments | WE | Weirs | 2.6 | 4.6 | 0.7 | 0.8 | 0.8 | 4.0 | 2.1 | 6.3 | 2.4 | 4.3 | 1.5 |
| Impoundments | RE | Reservoir u/s catchment | 2.3 | 0.3 | 5.8 | 2.6 | 1.9 | 1.9 | 5.9 | 0.2 | 2.3 | 2.5 | 1.0 |
| Impoundments | PF | Ponded flow (lake or reservoir d/s) | 1.0 | 4.9 |  | 0.1 | 0.4 | 0.6 | 0.8 | 1.5 | 0.1 | 1.0 |  |
| Impoundments | LP | Lake or pond close u/s | 2.8 | 9.0 | 0.7 | 1.9 | 3.1 | 3.8 | 1.0 | 4.2 | 0.4 | 1.6 | 0.8 |
| Impoundments | HW | Hypolimnic water | 0.2 | 0.3 |  |  | 0.1 |  |  |  | 0.5 | 0.2 |  |
| Impoundments | RT | River transfer | 0.6 | 5.0 |  |  |  | 0.2 |  |  |  |  |  |
| Impoundments | FT | Freshwater but tidal | 1.1 | 2.0 | 1.4 | 2.3 |  | 0.6 | 1.0 |  | 1.4 | 0.2 | 1.0 |
| Low flow | LF | Low flow | 3.7 | 2.7 | 3.6 | 3.7 | 4.6 | 12.1 | 1.6 |  | 0.3 | 7.6 | 1.9 |
| Low flow | AP | Abstraction for public supply | 0.6 | 0.6 | 0.7 | 0.2 |  | 0.8 | 1.2 | 0.4 |  | 0.4 | 2.3 |
| Low flow | AG | Abstraction from groundwater | 1.1 | 2.4 |  |  | 0.7 | 1.1 |  | 2.7 |  | 4.3 |  |
| Low flow | AR | Abstraction from river | 0.6 | 0.8 |  | 0.5 | 0.7 | 1.7 | 1.2 | 0.6 | 0.4 |  |  |
| Low flow | IR | Abstraction for irrigation | 1.0 | 5.5 |  | 0.7 | 0.9 | 1.3 |  |  |  |  |  |
| Low flow | CD | Cessation of STW discharge | 0.1 | 0.3 |  | 0.1 |  |  |  |  |  |  |  |
| Low flow | DT | Drought | 2.2 |  |  | 6.6 |  | 0.6 |  | 7.1 | 0.4 | 5.3 | 1.9 |
| No flow | NF | No flow | 0.2 | 0.5 |  | 0.4 |  | 0.4 |  |  |  |  |  |
| No flow | WI | Winterbourne (natural) | 0.2 | 0.6 |  | 0.2 | 0.2 | 0.2 |  | 0.2 |  | 0.2 |  |
| No flow | DC | Dry channel (caused by man) | 0.1 | 0.2 |  |  |  | 0.2 | 0.2 |  |  |  |  |
| Saline | SA | Saline | 0.3 |  |  | 0.1 | 0.4 | 0.2 | 0.4 |  | 0.1 | 0.8 |  |

| ***Table 5.6***<br>Major stress name | Individual stresses | | Overall | NRA Region (total no. of sites) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Code | Full name | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | Ang | Nor | NW | Mid | South | SW | Tha | Welsh | Wes | York |
| | | | | (636) | (278) | (844) | (1011) | (471) | (512) | (477) | (796) | (510) | (481) |
| Saline | MA | Marine origin | 0.4 | 1.3 | | 0.2 | 0.2 | 1.1 | | | 0.1 | 0.6 | 0.2 |
| Saline | IG | Inland geological | 0.1 | | | 0.2 | 0.1 | | | | | | |
| Saline | IL | Industrial discharge | 0.1 | | | 0.4 | | 0.4 | | | | | |
| Land use | LU | Land use | 0.1 | | | 0.1 | | 0.2 | | | | 0.6 | |
| Land use | CF | Afforestation (conifer) | 1.6 | 0.6 | 1.8 | 1.2 | 0.5 | 1.1 | 6.3 | | 4.0 | 0.6 | |
| Land use | IA | Intensive arablisation | 6.6 | 41.7 | 1.8 | 2.0 | 6.0 | 6.4 | | 0.6 | 0.9 | 1.8 | |
| Land use | US | Urban/suburban | 5.8 | 12.3 | 0.4 | 7.8 | 6.9 | 3.8 | 3.1 | 8.8 | 0.4 | 9.6 | 0.2 |
| Land use | MD | Moorland drainage | 1.7 | | 3.2 | 3.4 | 0.1 | | 8.2 | | 1.9 | | 1.0 |
| Land use | UO | Upland overgrazing | 0.1 | | | 0.4 | | | | | 0.1 | | 0.2 |
| Land use | RB | Reedbed at the site | 0.1 | 0.2 | | | | | 1.0 | | | | |
| Reclaimed land | RL | Reclaimed land | 0.1 | | | 0.4 | | | | | 0.1 | | |
| Reclaimed land | RI | Industrial reclaimed land | 0.3 | 0.2 | 1.4 | 0.4 | | 0.2 | | | 0.5 | | 0.8 |
| Reclaimed land | OC | Open/cast reclaimed land | 0.2 | 0.3 | | | | | | | 0.5 | | 0.2 |
| Bank erosion | EC | Clay bank erosion | 0.7 | | 0.4 | 0.4 | 0.2 | | 4.5 | 2.5 | | 0.2 | |
| Bank erosion | ES | Sand bank erosion | 0.8 | 0.2 | | 1.1 | | | 3.5 | | 1.8 | 0.4 | |
| Bank erosion | EG | Gravel, boulder bank erosion | 0.3 | | 0.4 | 1.5 | | | | | 0.4 | 0.2 | |
| Sorting problem | PR | Poorly preserved sample | 0.2 | | | | | | | | 0.6 | 0.6 | |
| Sampling difficulty | DR | Dredge used to sample | 3.3 | 6.8 | 0.7 | 0.1 | 1.5 | 10.4 | 2.9 | 0.4 | 0.8 | 11.2 | 0.6 |
| Sampling difficulty | AL | Air-lift used to sample | 0.3 | | | | | | | | | | 3.3 |
| Sampling difficulty | AC | Access to one bank only | 2.8 | 3.1 | 1.8 | 2.6 | 0.5 | 0.8 | 0.2 | 10.5 | 3.3 | 6.5 | 0.4 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 2.4 | 0.3 | 4.0 | 2.3 | 0.4 | 0.2 | 12.1 | | 4.6 | 0.4 | 0.6 |
| No perceived problem | NP | No perceived problem | 11.2 | 10.2 | 10.8 | 3.8 | 9.8 | 12.3 | 5.7 | 5.2 | 28.1 | 12.2 | 9.4 |
| No information | NI | No information | 2.8 | 0.2 | 11.2 | 6.5 | 1.7 | 2.5 | 2.3 | 1.0 | | 1.2 | 6.0 |
| Other | BM | Boat mooring | 0.1 | | | | | 0.2 | | | | | |
| Other | SF | Sewage fungus | 1.6 | 0.2 | 0.7 | 2.1 | | | 8.4 | 0.2 | 2.5 | 1.4 | |
| Other | OH | Ochre | 2.1 | 0.3 | 2.9 | 4.3 | 0.4 | 2.8 | 4.9 | 0.2 | 3.1 | 0.6 | 1.7 |
| Other | CL | Cladophora | 7.2 | 14.5 | 7.9 | 4.4 | 13.6 | 0.2 | 1.6 | 14.5 | 4.9 | 4.9 | |
| Other | MY | Stress is a mystery | 1.4 | 0.8 | 0.7 | 0.6 | 0.5 | 3.8 | 1.4 | | 2.6 | 0.4 | 3.1 |
| Other | AF | Unknown | 0.1 | | | 0.1 | | | | | | 0.2 | |
| Other | BL | Unknown | 0.1 | | | 0.2 | | | | | | | |
| Other | CR | Unknown | 0.1 | 0.2 | | | | | | | | | |
| Other | EI | Unknown | 0.1 | 0.2 | | | | | | | | | |
| Other | JT | Unknown | 0.1 | | | | 0.1 | | | | | | |
| Other | LM | Unknown | 0.1 | | | 0.1 | | | | | | | |
| Other | MR | Unknown | 0.1 | | | 0.1 | | | | | | | |
| Other | PG | Unknown | 0.1 | | | | | 0.2 | | | | | |
| Other | SO | Unknown | 0.0 | | | | | | | | | | |
| Other | UK | Unknown | 0.1 | 0.2 | | | | | | | | | |
| Other | VR | Unknown | 0.2 | | | | 0.9 | | | | | | |
| Other | VS | Unknown | 0.2 | | | | 0.9 | | | | | 0.2 | |

**Table 5.7 Percentage frequency of occurrence of each major environmental stress type amongst the GQA sites in each NRA/Agency region in 1995. (Ang=Anglian, Nor=Northumbrian, NW=North West, Mid=Midlands, South=Southern, SW=South West, Tha=Thames, Wes=Wessex, York=Yorkshire)**

| Major environmental stress type | Overall | NRA Region (total no. of sites) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | Ang (636) | Nor (278) | NW (844) | Mid (1011) | South (471) | SW (512) | Tha (477) | Welsh (796) | Wes (510) | York (481) |
| Farming | 27.5 | 59.0 | 11.6 | 34.4 | 25.7 | 11.5 | 30.1 | 35.3 | 5.5 | 41.6 | 13.8 |
| Pesticides | 6.6 | 42.2 | 5.1 | 4.0 | 2.7 | 3.9 | 1.2 | 1.3 | 0.9 | 0.6 | 3.2 |
| Waste | 4 | 6.2 | 1.1 | 3.6 | 0.6 | 19.4 | 1.4 | 1.1 | 2.3 | 1.6 | 7.5 |
| Agri-industry | 4.4 | 4.9 | 3.6 | 12.6 | 3.0 | 3.4 | 9.8 | 1.1 | 0.4 | 2.2 | 0.9 |
| Industrial discharge | 6.6 | 6.5 | 5.1 | 10.8 | 8.0 | 3.9 | 2.8 | 2.4 | 5.5 | 5.1 | 12.3 |
| Sediment at the site | 11.6 | 25.5 | 5.1 | 14.1 | 12.5 | 9.0 | 2.2 | 9.7 | 7.5 | 16.1 | 8.0 |
| Oils, petrochemicals | 1.6 | 6.2 | 2.2 | 1.0 | 0.4 | 3.9 | 0.2 | 1.5 | 1.1 | 0.6 | 0.3 |
| Construction | 0.4 | 0.8 | 0.0 | 0.4 | 0.3 | 0.0 | 0.4 | 1.7 | 0.0 | 0.0 | 0.3 |
| Leachate | 2.5 | 3.4 | 5.4 | 5.0 | 2.3 | 1.7 | 1.4 | 1.1 | 1.1 | 0.6 | 4.0 |
| Sewage Treatment Works (STW) | 40.6 | 53.0 | 44.7 | 49.9 | 54.6 | 31.3 | 15.9 | 46.0 | 26.2 | 23.2 | 49.1 |
| Water Treatment Works (WTW) | 0.7 | 0.8 | 2.2 | 0.4 | 0.4 | 0.7 | 1.0 | 1.3 | 1.1 | 0.2 | 0.7 |
| Run-off | 22.2 | 18.6 | 11.2 | 36.7 | 31.3 | 15.1 | 19.6 | 27.7 | 13.0 | 5.3 | 26.5 |
| Acid deposition | 1.3 | 0.0 | 0.4 | 2.8 | 0.5 | 0.0 | 0.0 | 0.0 | 6.5 | 0.0 | 0.0 |
| Mining, quarries and extraction | 5.8 | 0.5 | 21.3 | 4.8 | 6.7 | 0.5 | 15.5 | 1.5 | 6.7 | 1.4 | 6.3 |
| Channel at the site | 13.4 | 52.3 | 11.6 | 12.6 | 5.6 | 5.8 | 7.9 | 15.4 | 6.5 | 16.1 | 1.3 |
| Man-made watercourse | 1.3 | 3.0 | 0.0 | 2.3 | 1.1 | 0.0 | 0.0 | 5.7 | 0.0 | 0.8 | 0.0 |
| Channel Management | 2.5 | 2.4 | 0.8 | 3.8 | 0.7 | 4.7 | 1.2 | 0.9 | 1.1 | 7.9 | 2.5 |
| Choked channel (>33% plant) | 2.9 | 7.4 | 0.4 | 1.2 | 1.7 | 5.4 | 1.6 | 7.6 | 1.1 | 3.0 | 1.7 |
| Artificial bank at the site | 4.5 | 6.0 | 0.4 | 4.6 | 1.9 | 1.3 | 7.1 | 10.5 | 7.0 | 5.7 | 0.0 |
| Bank practices at the site | 4.8 | 1.6 | 4.7 | 4.4 | 1.2 | 7.3 | 13.5 | 3.8 | 6.2 | 9.3 | 0.3 |
| Impoundments | 10.9 | 22.7 | 8.3 | 8.6 | 6.1 | 15.1 | 10.6 | 12.0 | 7.0 | 17.3 | 6.1 |
| Low flow | 8.2 | 11.2 | 4.4 | 11.0 | 6.5 | 17.7 | 4.0 | 9.9 | 1.1 | 13.6 | 5.0 |
| No flow | 0.4 | 1.3 | 0.0 | 0.6 | 0.2 | 0.9 | 0.2 | 0.3 | 0.0 | 0.2 | 0.0 |
| Saline | 0.7 | 1.3 | 0.0 | 0.9 | 0.7 | 1.7 | 0.4 | 0.0 | 0.3 | 1.4 | 0.3 |
| Land use | 15.1 | 51.0 | 7.2 | 13.9 | 13.4 | 11.5 | 17.6 | 9.5 | 6.7 | 12.2 | 1.5 |
| Reclaimed land | 0.5 | 0.5 | 1.5 | 0.8 | 0.0 | 0.3 | 0.0 | 0.0 | 1.2 | 0.0 | 1.1 |
| Bank erosion | 1.7 | 0.2 | 0.8 | 2.9 | 0.2 | 0.0 | 8.1 | 2.6 | 2.2 | 0.8 | 0.0 |
| Sorting problem | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.6 | 0.0 |
| Sampling difficulty | 7.9 | 9.8 | 5.4 | 5.0 | 2.4 | 11.1 | 15.3 | 11.0 | 8.2 | 12.0 | 5.0 |
| No perceived problem | 11.1 | 10.3 | 10.8 | 3.8 | 9.8 | 12.4 | 5.7 | 5.3 | 28.2 | 12.2 | 9.4 |
| No information | 2.8 | 0.2 | 11.2 | 6.6 | 1.7 | 2.6 | 2.4 | 1.1 | 0.0 | 1.2 | 6.1 |
| Other | 12.2 | 16.2 | 11.9 | 11.0 | 15.7 | 7.3 | 16.1 | 14.9 | 12.4 | 7.5 | 4.8 |

However, when viewed at the major stress level, environmental stresses from farming in general were considered to be widespread and affecting more than 25% of all sites in Anglian, North West, Midlands, South West, Thames and Wessex Regions (Table 5.7). Impacts from sewage treatment works (STW) were the most commonly recorded major stress type in every region except Anglian, South West and Wessex Region where stresses from general farming were even more common.

Over 50% of the sites in Anglian region had some form of channel influence, reflecting the high degree of river channelisation in East Anglian lowland rivers. This was more than three times the equivalent percentage for any other Region.

## 5.3 Environmental Stresses in Relation to Biological Grade in 1995

### 5.3.1 England and Wales

The tendency for the perceived occurrence of particular types of environmental stress to be associated with sites of either high, moderate or poor biological grades (a-f) was assessed. Biological grade for a site was taken to be its overall GQA grade corrected for bias. Tables 5.8 and 5.9 show the percentage occurrence amongst sites of each grade for each individual and major stress type respectively. In each table the stresses are arranged in decreasing order of overall frequency to aid interpretation.

The patterns are very interesting, although not always unexpected.

At least two-thirds of sites graded d, e or f were recorded as likely to affected by the impacts of sewage treatment works (STW) (Table 5.9). This STW effect is most commonly from treated effluent and combined or storm sewer overflow problems (Table 5.8). Surprisingly, 22% of the highest grade sites were also considered to be prone to stress from STW.

Stresses from farming in general were common in all except the very poorest grade of site. In contrast, stress from industrial discharge and run-off problems, especially in urban areas, are rare in high grade sites, but become increasingly common in very poor grade sites. Roughly half of all sites graded d-f in 1995 were considered to be affected by run-off problems, especially from urban areas. Also, over 10% of all such poor quality sites were recorded as being subject to other general problems resulting from being in or near urban/suburban areas of land use (Table 5.8).

Sediment related stresses, including siltation and contamination, were slightly less common at high quality sites.

Most of the sites where there was “no perceived problem” were grade “a” and none was worse than grade c (Table 5.9), suggesting that the local Environment Agency ecologists have an understanding of what is causing the stress in nearly all sites which are not of the highest grade.

The average number of types of stress thought to be operating at a site tends to be greater for poorer quality sites, as one might expect. (Table 5.10). However, for sites in any of grades c-f the most typical (i.e. statistical mode) and the median number of stresses is three. Up to 19 different individual types of stress were recorded for any one site.

### 5.3.2 Environmental stress in relation to biological grade in each Environment Agency Region or Area within Region

Tables 5.11(a)-(j) give the percentage occurrence of each individual and major environmental stress type for sites in each biological grade (a-f), separately for each NRA/Environment Agency Region. The patterns of tendencies for the frequency of particular stresses to be higher in poorer quality sites that was identified in the analyses of all sites in England and Wales together, is usually repeated within individual Regions where the particular stress is common. No further explanation of the regional results is therefore considered necessary.

Tables 5.12(a)-(x) give the percentage occurrence of each individual and major environmental stress type for sites in each biological grade (a-f), separately for each Environment Agency Area within each Region. There is no table for the Tees Area, (g), of Northumbrian Region as there were insufficient sites matched to this area. There are also no Tables 5.12 (k), (q) and (u) as these "Areas" represent the whole of the Midlands, Thames and Wessex Regions respectively, whose results are given in Tables 5.11 (d), (g) and (i). The main extra value of Table 5.12 over 5.11 is that it highlights differences between Areas within a Region.

**Table 5.8 Percentage frequency of occurrence of each individual environmental stress type amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995. Stress types ordered by decreasing overall frequency of occurrence (down to 3%).**

| Major stress name | Individual stresses | | | Grade | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Code | Full name | Overall | a (1782) | b (1863) | c (1224) | d (650) | e (414) | f (83) |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 25 | 17 | 24 | 30 | 31 | 37 | 37 |
| Farming | FA | Farming | 17 | 14 | 19 | 22 | 12 | 10 | 8 |
| Run-off | UR | Urban run-off | 15 | 3 | 8 | 20 | 36 | 51 | 45 |
| No perceived problem | NP | No perceived problem | 12 | 27 | 10 | 2 | 0 | 0 | 0 |
| Farming | FE | Fertilisers | 11 | 11 | 15 | 11 | 7 | 4 | 4 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 10 | 2 | 6 | 12 | 23 | 36 | 31 |
| Sediment at the site | IS | Inert siltation | 8 | 7 | 8 | 11 | 10 | 9 | 11 |
| Channel at the site | CA | Channelisation | 8 | 5 | 9 | 9 | 8 | 9 | 11 |
| Other | CL | Cladophora | 8 | 4 | 9 | 11 | 11 | 7 | 0 |
| Land use | IA | Intensive arablisation | 7 | 5 | 9 | 9 | 6 | 2 | 3 |
| Land use | US | Urban/suburban | 6 | 4 | 5 | 7 | 12 | 11 | 15 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 5 | 3 | 4 | 8 | 9 | 4 | 2 |
| Run-off | HY | Highway run-off (including salt) | 5 | 4 | 5 | 5 | 9 | 10 | 10 |
| Channel at the site | BG | Bridge | 5 | 4 | 7 | 5 | 4 | 2 | 2 |
| Pesticides | IN | Insecticides | 4 | 3 | 5 | 4 | 4 | 4 | 3 |
| Waste | SL | Slurry | 4 | 5 | 4 | 3 | 3 | 2 | 0 |
| Sediment at the site | TX | Contaminated sediment | 4 | 2 | 4 | 4 | 3 | 7 | 11 |
| Sewage Treatment Works (STW) | SE | Septic tank | 4 | 2 | 3 | 6 | 7 | 5 | 3 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 4 | 1 | 2 | 5 | 9 | 14 | 16 |
| Run-off | LR | Light industry/commercial run-off | 4 | 1 | 2 | 5 | 9 | 11 | 10 |
| Bank practices at the site | LV | Livestock poaching, trampling | 4 | 6 | 5 | 3 | 2 | 1 | 0 |
| Low flow | LF | Low flow | 4 | 3 | 4 | 5 | 5 | 3 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 4 | 5 | 4 | 3 | 2 | 2 | 2 |
| Pesticides | PE | Pesticides | 3 | 2 | 4 | 3 | 3 | 2 | 3 |
| Pesticides | HE | Herbicides | 3 | 3 | 4 | 4 | 4 | 2 | 2 |
| Agri-industry | DA | Dairy | 3 | 3 | 2 | 4 | 7 | 4 | 5 |
| Industrial discharge | LI | Light industry/commercial | 3 | 2 | 2 | 4 | 6 | 6 | 9 |
| Mining, quarries and extraction | CM | Coal mine drainage | 3 | 1 | 2 | 3 | 6 | 5 | 9 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 3 | 2 | 4 | 5 | 3 | 1 | 2 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 3 | 3 | 3 | 4 | 3 | 5 | 3 |
| Impoundments | RF | Regulated flow | 3 | 4 | 4 | 2 | 1 | 2 | 3 |
| Impoundments | WE | Weirs | 3 | 3 | 4 | 2 | 2 | 1 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 3 | 2 | 4 | 3 | 2 | 2 | 0 |
| Impoundments | LP | Lake or pond close u/s | 3 | 3 | 4 | 3 | 3 | 2 | 0 |
| Low flow | DT | Drought | 3 | 3 | 3 | 2 | 3 | 1 | 0 |
| Sampling difficulty | AC | Access to one bank only | 3 | 4 | 3 | 3 | 2 | 2 | 4 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 3 | 3 | 4 | 2 | 1 | 1 | 2 |
| No information | NI | No information | 3 | 3 | 3 | 4 | 2 | 4 | 7 |
| Other | OH | Ochre | 3 | 1 | 2 | 3 | 3 | 5 | 9 |

One strange observation on Table 5.12 is that at least 80% of all sites in the Eastern and Northern Areas, (a) and (c), of Anglian Region are reported as subject to various potential stresses from farming, whereas in the Central Area (b), farming stresses were not reported. This could simply be because the questionnaire respondant considered farming effects to be all pervasive, so that they did not report them for each site in turn.

**Table 5.9 Percentage frequency of occurrence of each of the major environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995. Stress types ordered by decreasing overall frequency of occurrence (down to 3%).**

| Major stress name | Overall | Grade | | | | | |
|---|---|---|---|---|---|---|---|
| | | a (1782) | b (1863) | c (1224) | d (650) | e (414) | f (83) |
| Sewage Treatment Works (STW) | 41 | 22 | 35 | 52 | 65 | 76 | 66 |
| Farming | 28 | 27 | 34 | 32 | 19 | 13 | 9 |
| Run-off | 23 | 8 | 14 | 30 | 46 | 61 | 49 |
| Land use | 16 | 12 | 17 | 17 | 18 | 13 | 17 |
| Channel at the site | 14 | 11 | 16 | 16 | 13 | 13 | 13 |
| Other | 13 | 7 | 14 | 17 | 17 | 15 | 11 |
| Sediment at the site | 12 | 9 | 12 | 15 | 14 | 15 | 21 |
| No perceived problem | 12 | 27 | 10 | 2 | 0 | 0 | 0 |
| Impoundments | 11 | 12 | 14 | 9 | 8 | 5 | 10 |
| Low flow | 9 | 8 | 11 | 9 | 8 | 4 | 0 |
| Sampling difficulty | 8 | 10 | 10 | 7 | 4 | 5 | 9 |
| Pesticides | 7 | 5 | 9 | 8 | 6 | 6 | 5 |
| Industrial discharge | 7 | 3 | 4 | 8 | 12 | 23 | 34 |
| Mining, quarries and extraction | 6 | 4 | 6 | 8 | 9 | 8 | 14 |
| Waste | 5 | 5 | 5 | 4 | 4 | 3 | 0 |
| Agri-industry | 5 | 3 | 4 | 6 | 8 | 8 | 5 |
| Artificial bank at the site | 5 | 4 | 5 | 6 | 5 | 7 | 3 |
| Bank practices at the site | 5 | 8 | 6 | 4 | 4 | 1 | 0 |
| Leachate | 3 | 1 | 1 | 3 | 6 | 10 | 15 |
| Channel Management | 3 | 3 | 3 | 2 | 4 | 3 | 5 |
| Choked channel (>33% plant) | 3 | 2 | 4 | 5 | 3 | 1 | 2 |
| No information | 3 | 3 | 3 | 4 | 2 | 4 | 7 |

**Table 5.10 Number of individual environmental stress types present per GQA site in relation to its overall grade (a-f, bias-corrected) in 1995. (Stress types NP=No perceived stress and NI=No information were excluded)**

| | Overall | Grade | | | | | |
|---|---|---|---|---|---|---|---|
| | | a (1782) | b (1863) | c (1224) | d (650) | e (414) | f (83) |
| % sites with no stresses | 13.9 | 29.0 | 12.5 | 4.7 | 1.9 | 3.4 | 6.0 |
| % sites with 1 stress | 20.8 | 24.6 | 24.1 | 18.1 | 15.7 | 6.3 | 13.3 |
| % sites with 2 stresses | 23.5 | 20.0 | 25.0 | 27.0 | 23.7 | 22.5 | 16.9 |
| % sites with 3 stresses | 19.7 | 13.8 | 18.4 | 24.3 | 24.9 | 28.0 | 25.3 |
| % sites with 4-5 stresses | 15.6 | 8.3 | 12.4 | 19.1 | 27.2 | 31.6 | 21.7 |
| % sites with 6-10 stresses | 6.0 | 4.2 | 7.1 | 5.9 | 5.9 | 7.0 | 16.9 |
| % sites with >10 stresses | 0.6 | 0.2 | 0.6 | 0.8 | 0.8 | 1.2 | 0.0 |
| mean no. of stresses | 2.4 | 1.7 | 2.4 | 2.8 | 3.1 | 3.4 | 2.4 |
| median no. of stresses | 2 | 1 | 2 | 3 | 3 | 3 | 3 |
| maximum no. of stresses | 19 | 14 | 19 | 15 | 14 | 13 | 10 |

**Table 5.11 (a) Anglian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-d, e/f; bias-corrected) in 1995. Major, then individual stress types ordered by decreasing overall frequency of occurrence (down to approx. 3%). (Total number of sites in each grade given in brackets)**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (636) | (160) | (278) | (148) | (38) | (12) |
| Farming | . | . | 59 | 60 | 61 | 55 | 58 | 75 |
| Sewage Treatment Works (STW) | . | . | 53 | 44 | 52 | 63 | 69 | 59 |
| Channel at the site | . | . | 53 | 50 | 60 | 46 | 40 | 50 |
| Land use | . | . | 51 | 52 | 50 | 50 | 56 | 59 |
| Pesticides | . | . | 43 | 39 | 45 | 39 | 45 | 67 |
| Sediment at the site | . | . | 26 | 23 | 26 | 24 | 32 | 67 |
| Impoundments | . | . | 23 | 33 | 25 | 14 | 14 | 0 |
| Run-off | . | . | 19 | 9 | 16 | 25 | 48 | 59 |
| Other | . | . | 17 | 10 | 21 | 19 | 6 | 9 |
| Low flow | . | . | 12 | 14 | 13 | 10 | 6 | 0 |
| No perceived problem | . | . | 11 | 23 | 9 | 5 | 0 | 0 |
| Sampling difficulty | . | . | 10 | 13 | 9 | 11 | 6 | 9 |
| Choked channel (>33% plant) | . | . | 8 | 5 | 7 | 12 | 11 | 0 |
| Waste | . | . | 7 | 2 | 8 | 8 | 6 | 9 |
| Industrial discharge | . | . | 7 | 4 | 6 | 8 | 16 | 34 |
| Oils, petrochemicals | . | . | 7 | 5 | 4 | 8 | 22 | 34 |
| Artificial bank at the site | . | . | 6 | 5 | 7 | 3 | 14 | 25 |
| Agri-industry | . | . | 5 | 4 | 6 | 6 | 6 | 9 |
| Leachate | . | . | 4 | 3 | 3 | 6 | 3 | 0 |
| | | | | | | | | |
| Farming | FE | Fertilisers | 59 | 60 | 61 | 55 | 58 | 75 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 42 | 37 | 42 | 50 | 45 | 17 |
| Land use | IA | Intensive arablisation | 42 | 48 | 45 | 39 | 22 | 9 |
| Channel at the site | BG | Bridge | 32 | 30 | 33 | 32 | 35 | 17 |
| Pesticides | HE | Herbicides | 25 | 22 | 25 | 22 | 32 | 59 |
| Pesticides | IN | Insecticides | 25 | 22 | 25 | 22 | 35 | 59 |
| Sediment at the site | TX | Contaminated sediment | 25 | 22 | 25 | 23 | 32 | 59 |
| Channel at the site | CA | Channelisation | 24 | 24 | 32 | 15 | 8 | 34 |
| Pesticides | PE | Pesticides | 18 | 17 | 21 | 17 | 11 | 9 |
| Run-off | UR | Urban run-off | 15 | 7 | 12 | 19 | 48 | 50 |
| Other | CL | Cladophora | 15 | 10 | 20 | 15 | 6 | 0 |
| Land use | US | Urban/suburban | 13 | 6 | 10 | 15 | 37 | 50 |
| No perceived problem | NP | No perceived problem | 11 | 23 | 9 | 5 | 0 | 0 |
| Impoundments | LP | Lake or pond close u/s | 9 | 14 | 9 | 7 | 6 | 0 |
| Run-off | LR | Light industry/commercial run-off | 8 | 2 | 7 | 10 | 29 | 25 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 8 | 5 | 7 | 12 | 11 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 7 | 4 | 7 | 9 | 8 | 25 |
| Sampling difficulty | DR | Dredge used to sample | 7 | 10 | 6 | 8 | 6 | 9 |
| Sediment at the site | IS | Inert siltation | 6 | 7 | 7 | 5 | 0 | 25 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 6 | 5 | 5 | 7 | 16 | 34 |
| Impoundments | RT | River transfer | 6 | 9 | 7 | 0 | 0 | 0 |
| Low flow | IR | Abstraction for irrigation | 6 | 9 | 7 | 4 | 0 | 0 |
| Industrial discharge | LI | Light industry/commercial | 5 | 3 | 3 | 5 | 11 | 34 |
| Oils, petrochemicals | OI | Oils, petrochemicals | 5 | 0 | 3 | 7 | 22 | 34 |
| Impoundments | WE | Weirs | 5 | 4 | 7 | 3 | 3 | 0 |
| Impoundments | PF | Ponded flow (lake or reservoir d/s) | 5 | 5 | 5 | 7 | 3 | 0 |
| Waste | PI | Piggery waste | 4 | 2 | 5 | 4 | 6 | 9 |
| Sampling difficulty | AC | Access to one bank only | 4 | 4 | 4 | 3 | 0 | 0 |

## Table 5.11(b) Northumbrian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.9(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (278) | (96) | (77) | (45) | (36) | (24) |
| Sewage Treatment Works (STW) | . | . | 45 | 23 | 41 | 49 | 75 | 92 |
| Mining, quarries and extraction | . | . | 22 | 22 | 24 | 18 | 17 | 25 |
| Farming | . | . | 12 | 9 | 13 | 18 | 9 | 13 |
| Run-off | . | . | 12 | 4 | 8 | 5 | 28 | 42 |
| Channel at the site | . | . | 12 | 9 | 13 | 16 | 12 | 13 |
| No information | . | . | 12 | 14 | 8 | 18 | 9 | 5 |
| Other | . | . | 12 | 7 | 15 | 9 | 20 | 21 |
| No perceived problem | . | . | 11 | 27 | 7 | 0 | 0 | 0 |
| Impoundments | . | . | 9 | 11 | 12 | 5 | 3 | 5 |
| Land use | . | . | 8 | 10 | 8 | 5 | 9 | 0 |
| Pesticides | . | . | 6 | 7 | 8 | 0 | 6 | 0 |
| Industrial discharge | . | . | 6 | 3 | 3 | 7 | 12 | 13 |
| Sediment at the site | . | . | 6 | 4 | 7 | 3 | 3 | 17 |
| Leachate | . | . | 6 | 2 | 2 | 7 | 12 | 25 |
| Sampling difficulty | . | . | 6 | 8 | 8 | 3 | 0 | 5 |
| Bank practices at the site | . | . | 5 | 5 | 6 | 5 | 9 | 0 |
| Low flow | . | . | 5 | 0 | 2 | 12 | 14 | 5 |
| Agri-industry | . | . | 4 | 2 | 6 | 3 | 6 | 9 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 31 | 15 | 28 | 36 | 59 | 55 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 19 | 11 | 12 | 14 | 42 | 50 |
| No information | NI | No information | 12 | 14 | 8 | 18 | 9 | 5 |
| No perceived problem | NP | No perceived problem | 11 | 27 | 7 | 0 | 0 | 0 |
| Farming | FE | Fertilisers | 9 | 6 | 10 | 18 | 9 | 5 |
| Mining, quarries and extraction | MM | Metal mine drainage | 9 | 14 | 15 | 0 | 0 | 5 |
| Run-off | UR | Urban run-off | 8 | 4 | 3 | 5 | 17 | 30 |
| Mining, quarries and extraction | CM | Coal mine drainage | 8 | 5 | 8 | 7 | 12 | 17 |
| Other | CL | Cladophora | 8 | 6 | 10 | 5 | 17 | 9 |
| Channel at the site | BG | Bridge | 7 | 5 | 11 | 5 | 3 | 13 |
| Impoundments | RE | Reservoir u/s catchment | 6 | 10 | 10 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 5 | 5 | 6 | 7 | 3 | 5 |
| Run-off | LR | Light industry/commercial run-off | 4 | 0 | 3 | 0 | 14 | 13 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 4 | 3 | 3 | 12 | 3 | 5 |
| Bank practices at the site | LV | Livestock poaching, trampling | 4 | 4 | 4 | 5 | 9 | 0 |
| Low flow | LF | Low flow | 4 | 0 | 0 | 9 | 14 | 5 |
| Land use | MD | Moorland drainage | 4 | 6 | 6 | 0 | 0 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 4 | 7 | 7 | 0 | 0 | 0 |
| Farming | FA | Farming | 3 | 3 | 4 | 0 | 0 | 9 |
| Pesticides | HE | Herbicides | 3 | 4 | 2 | 0 | 6 | 0 |
| Pesticides | IN | Insecticides | 3 | 3 | 3 | 0 | 6 | 0 |
| Sediment at the site | TX | Contaminated sediment | 3 | 0 | 3 | 0 | 0 | 17 |
| Sediment at the site | IS | Inert siltation | 3 | 4 | 3 | 3 | 3 | 0 |
| Leachate | SH | Slag heap | 3 | 0 | 2 | 5 | 6 | 9 |
| Leachate | TI | Toxic/industrial landfill | 3 | 2 | 0 | 0 | 6 | 21 |

**Table 5.11(c) North-West (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (844) | (83) | (221) | (173) | (164) | (203) |
| Sewage Treatment Works (STW) | . | . | 50 | 10 | 25 | 53 | 72 | 75 |
| Run-off | . | . | 37 | 11 | 12 | 37 | 52 | 63 |
| Farming | . | . | 35 | 43 | 51 | 38 | 27 | 17 |
| Sediment at the site | . | . | 15 | 15 | 18 | 17 | 13 | 10 |
| Land use | . | . | 14 | 10 | 13 | 10 | 14 | 22 |
| Agri-industry | . | . | 13 | 0 | 4 | 20 | 25 | 12 |
| Channel at the site | . | . | 13 | 4 | 8 | 15 | 16 | 19 |
| Industrial discharge | . | . | 11 | 3 | 3 | 10 | 16 | 22 |
| Low flow | . | . | 11 | 7 | 21 | 11 | 11 | 3 |
| Other | . | . | 11 | 11 | 12 | 13 | 11 | 10 |
| Impoundments | . | . | 9 | 5 | 12 | 11 | 8 | 6 |
| No information | . | . | 7 | 11 | 9 | 6 | 4 | 7 |
| Leachate | . | . | 5 | 0 | 1 | 5 | 8 | 11 |
| Mining, quarries and extraction | . | . | 5 | 2 | 4 | 5 | 9 | 6 |
| Artificial bank at the site | . | . | 5 | 4 | 5 | 5 | 4 | 6 |
| Bank practices at the site | . | . | 5 | 5 | 6 | 6 | 5 | 2 |
| Sampling difficulty | . | . | 5 | 7 | 7 | 5 | 5 | 4 |
| Pesticides | . | . | 4 | 3 | 4 | 5 | 3 | 6 |
| Waste | . | . | 4 | 2 | 1 | 5 | 8 | 4 |
| Channel Management | . | . | 4 | 2 | 3 | 5 | 7 | 4 |
| No perceived problem | . | . | 4 | 20 | 8 | 0 | 0 | 0 |
| Acid deposition | . | . | 3 | 5 | 6 | 3 | 0 | 1 |
| Man-made watercourse | . | . | 3 | 0 | 0 | 3 | 4 | 5 |
| Bank erosion | . | . | 3 | 5 | 6 | 3 | 2 | 1 |
| | | | | | | | | |
| Farming | FA | Farming | 31 | 41 | 48 | 33 | 22 | 16 |
| Run-off | UR | Urban run-off | 26 | 3 | 5 | 27 | 36 | 49 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 21 | 7 | 12 | 24 | 28 | 30 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 21 | 0 | 2 | 15 | 32 | 48 |
| Sewage Treatment Works (STW) | SE | Septic tank | 15 | 4 | 9 | 26 | 23 | 8 |
| Run-off | HY | Highway run-off (including salt) | 12 | 7 | 6 | 10 | 19 | 18 |
| Agri-industry | DA | Dairy | 11 | 0 | 3 | 18 | 22 | 10 |
| Sediment at the site | IS | Inert siltation | 9 | 5 | 9 | 10 | 11 | 8 |
| Channel at the site | CA | Channelisation | 9 | 3 | 5 | 11 | 10 | 15 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 8 | 2 | 2 | 7 | 11 | 15 |
| Run-off | LR | Light industry/commercial run-off | 8 | 0 | 1 | 5 | 13 | 18 |
| Land use | US | Urban/suburban | 8 | 5 | 4 | 4 | 8 | 18 |
| Low flow | DT | Drought | 7 | 5 | 13 | 6 | 7 | 2 |
| No information | NI | No information | 7 | 11 | 9 | 6 | 4 | 7 |
| Industrial discharge | ID | Industrial discharge | 5 | 3 | 1 | 5 | 5 | 9 |
| Industrial discharge | LI | Light industry/commercial | 5 | 0 | 1 | 5 | 7 | 9 |
| Other | OH | Ochre | 5 | 4 | 4 | 6 | 5 | 5 |
| Other | CL | Cladophora | 5 | 7 | 7 | 6 | 4 | 1 |
| Farming | FE | Fertilisers | 4 | 2 | 2 | 6 | 6 | 4 |
| Sediment at the site | SX | Sediment at the site | 4 | 5 | 6 | 5 | 2 | 1 |
| Bank practices at the site | LV | Livestock poaching, trampling | 4 | 5 | 5 | 5 | 5 | 1 |
| Low flow | LF | Low flow | 4 | 3 | 8 | 5 | 4 | 1 |
| Land use | MD | Moorland drainage | 4 | 3 | 8 | 5 | 2 | 1 |
| Waste | SL | Slurry | 3 | 2 | 1 | 5 | 5 | 2 |
| Leachate | TI | Toxic/industrial landfill | 3 | 0 | 0 | 2 | 4 | 5 |

## Table 5.11(d) Midlands (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (1011) | (132) | (262) | () | () | () |
| Sewage Treatment Works (STW) | . | . | 55 | 30 | 44 | 59 | 70 | 77 |
| Run-off | . | . | 32 | 7 | 18 | 35 | 48 | 63 |
| Farming | . | . | 26 | 20 | 32 | 36 | 15 | 7 |
| Other | . | . | 16 | 7 | 17 | 18 | 18 | 17 |
| Land use | . | . | 14 | 5 | 13 | 14 | 23 | 12 |
| Sediment at the site | . | . | 13 | 4 | 12 | 15 | 15 | 16 |
| No perceived problem | . | . | 10 | 44 | 15 | 2 | 0 | 0 |
| Industrial discharge | . | . | 8 | 2 | 3 | 9 | 13 | 21 |
| Mining, quarries and extraction | . | . | 7 | 1 | 5 | 10 | 9 | 9 |
| Impoundments | . | . | 7 | 6 | 8 | 6 | 7 | 5 |
| Low flow | . | . | 7 | 7 | 9 | 7 | 6 | 4 |
| Channel at the site | . | . | 6 | 3 | 6 | 8 | 6 | 4 |
| Pesticides | . | . | 3 | 2 | 4 | 4 | 3 | 2 |
| Agri-industry | . | . | 3 | 0 | 4 | 4 | 3 | 6 |
| Leachate | . | . | 3 | 0 | 1 | 1 | 5 | 13 |
| Sampling difficulty | . | . | 3 | 2 | 4 | 3 | 2 | 2 |
| | | | | | | | | |
| Run-off | UR | Urban run-off | 28 | 4 | 15 | 29 | 45 | 61 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 27 | 22 | 23 | 26 | 29 | 41 |
| Farming | FA | Farming | 24 | 19 | 30 | 34 | 13 | 6 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 21 | 5 | 18 | 26 | 28 | 16 |
| Other | CL | Cladophora | 14 | 5 | 15 | 17 | 15 | 13 |
| Sediment at the site | IS | Inert siltation | 12 | 4 | 12 | 15 | 13 | 12 |
| No perceived problem | NP | No perceived problem | 10 | 44 | 15 | 2 | 0 | 0 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 9 | 3 | 3 | 6 | 14 | 31 |
| Land use | IA | Intensive arablisation | 7 | 1 | 9 | 8 | 8 | 2 |
| Land use | US | Urban/suburban | 7 | 2 | 4 | 7 | 15 | 11 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 6 | 2 | 3 | 6 | 11 | 11 |
| Run-off | LR | Light industry/commercial run-off | 6 | 2 | 2 | 7 | 8 | 8 |
| Low flow | LF | Low flow | 5 | 6 | 5 | 5 | 5 | 3 |
| Farming | FE | Fertilisers | 4 | 2 | 7 | 3 | 3 | 2 |
| Run-off | HY | Highway run-off (including salt) | 4 | 2 | 3 | 4 | 5 | 8 |
| Channel at the site | CA | Channelisation | 4 | 0 | 4 | 5 | 5 | 4 |
| Impoundments | LP | Lake or pond close u/s | 4 | 1 | 5 | 3 | 5 | 3 |
| Industrial discharge | LI | Light industry/commercial | 3 | 1 | 0 | 3 | 5 | 7 |
| Industrial discharge | DY | Colouration (dye) | 3 | 0 | 1 | 3 | 5 | 6 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 3 | 0 | 1 | 6 | 3 | 2 |
| Mining, quarries and extraction | CM | Coal mine drainage | 3 | 0 | 2 | 3 | 5 | 7 |

**Table 5.11(e) Southern (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (471) | (196) | (162) | (75) | (32) | (6) |
| Sewage Treatment Works (STW) | . | . | 32 | 28 | 33 | 35 | 38 | 50 |
| Waste | . | . | 20 | 28 | 19 | 6 | 7 | 17 |
| Low flow | . | . | 18 | 16 | 18 | 26 | 19 | 0 |
| Run-off | . | . | 16 | 9 | 15 | 27 | 29 | 34 |
| Impoundments | . | . | 16 | 15 | 17 | 15 | 13 | 17 |
| No perceived problem | . | . | 13 | 21 | 9 | 4 | 0 | 0 |
| Farming | . | . | 12 | 16 | 12 | 6 | 4 | 0 |
| Land use | . | . | 12 | 5 | 12 | 19 | 38 | 34 |
| Sampling difficulty | . | . | 12 | 11 | 16 | 6 | 7 | 0 |
| Sediment at the site | . | . | 9 | 9 | 8 | 12 | 13 | 17 |
| Bank practices at the site | . | . | 8 | 10 | 4 | 8 | 13 | 0 |
| Other | . | . | 8 | 2 | 12 | 12 | 10 | 17 |
| Channel at the site | . | . | 6 | 5 | 6 | 10 | 10 | 0 |
| Choked channel (>33% plant) | . | . | 6 | 4 | 8 | 6 | 4 | 17 |
| Channel Management | . | . | 5 | 8 | 2 | 3 | 10 | 0 |
| Pesticides | . | . | 4 | 4 | 2 | 7 | 10 | 17 |
| Agri-industry | . | . | 4 | 6 | 2 | 0 | 4 | 17 |
| Industrial discharge | . | . | 4 | 2 | 2 | 7 | 16 | 34 |
| Oils, petrochemicals | . | . | 4 | 2 | 2 | 11 | 16 | 17 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 29 | 26 | 31 | 31 | 29 | 17 |
| Waste | SL | Slurry | 19 | 28 | 17 | 4 | 7 | 17 |
| Low flow | LF | Low flow | 13 | 7 | 15 | 22 | 16 | 0 |
| No perceived problem | NP | No perceived problem | 13 | 21 | 9 | 4 | 0 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 11 | 10 | 15 | 6 | 7 | 0 |
| Sediment at the site | IS | Inert siltation | 9 | 9 | 8 | 12 | 13 | 17 |
| Run-off | UR | Urban run-off | 8 | 5 | 7 | 19 | 13 | 17 |
| Land use | IA | Intensive arablisation | 7 | 3 | 7 | 12 | 16 | 17 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 6 | 4 | 8 | 6 | 4 | 17 |
| Farming | FA | Farming | 5 | 5 | 7 | 3 | 0 | 0 |
| Channel Management | WD | Weed cutting | 5 | 8 | 2 | 2 | 4 | 0 |
| Bank practices at the site | MO | Mown/managed riparian zone | 5 | 7 | 1 | 4 | 13 | 0 |
| Impoundments | RF | Regulated flow | 5 | 5 | 5 | 2 | 4 | 0 |
| Impoundments | WE | Weirs | 5 | 7 | 3 | 2 | 7 | 0 |
| Farming | FE | Fertilisers | 4 | 4 | 5 | 3 | 4 | 0 |
| Pesticides | PE | Pesticides | 4 | 3 | 2 | 4 | 10 | 17 |
| Run-off | HR | Heavy industry run-off | 4 | 3 | 5 | 6 | 4 | 17 |
| Channel at the site | BG | Bridge | 4 | 4 | 4 | 3 | 7 | 0 |
| Impoundments | LP | Lake or pond close u/s | 4 | 3 | 5 | 6 | 4 | 17 |
| Land use | US | Urban/suburban | 4 | 1 | 3 | 7 | 22 | 17 |
| Other | MY | Stress could not be identified (mystery) | 4 | 1 | 7 | 7 | 7 | 0 |
| Farming | FF | Fish farm | 3 | 7 | 0 | 0 | 0 | 0 |
| Agri-industry | DA | Dairy | 3 | 6 | 2 | 0 | 4 | 0 |
| Oils, petrochemicals | FO | Fuel (diesel/petrol) | 3 | 2 | 2 | 7 | 13 | 17 |
| Run-off | HY | Highway run-off (including salt) | 3 | 2 | 2 | 6 | 13 | 0 |
| Run-off | LR | Light industry/commercial run-off | 3 | 1 | 4 | 4 | 4 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 3 | 4 | 4 | 4 | 0 | 0 |

## Table 5.11(f) South-West (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (512) | (257) | (200) | (37) | (9) | (9) |
| Farming | . | . | 31 | 35 | 29 | 22 | 12 | 0 |
| Run-off | . | . | 20 | 20 | 22 | 14 | 12 | 0 |
| Land use | . | . | 18 | 18 | 19 | 17 | 12 | 12 |
| Other | . | . | 17 | 13 | 14 | 33 | 34 | 89 |
| Sewage Treatment Works (STW) | . | . | 16 | 12 | 20 | 25 | 23 | 0 |
| Mining, quarries and extraction | . | . | 16 | 10 | 14 | 36 | 56 | 100 |
| Sampling difficulty | . | . | 16 | 11 | 21 | 25 | 12 | 0 |
| Bank practices at the site | . | . | 14 | 18 | 11 | 6 | 0 | 0 |
| Impoundments | . | . | 11 | 10 | 11 | 22 | 0 | 0 |
| Agri-industry | . | . | 10 | 11 | 9 | 11 | 0 | 0 |
| Bank erosion | . | . | 9 | 11 | 7 | 0 | 12 | 0 |
| Channel at the site | . | . | 8 | 9 | 7 | 9 | 23 | 0 |
| Artificial bank at the site | . | . | 8 | 6 | 9 | 17 | 0 | 0 |
| No perceived problem | . | . | 6 | 9 | 4 | 0 | 0 | 0 |
| Low flow | . | . | 4 | 2 | 7 | 6 | 0 | 0 |
| Industrial discharge | . | . | 3 | 3 | 3 | 6 | 0 | 12 |
| Sediment at the site | . | . | 3 | 0 | 1 | 3 | 12 | 78 |
| No information | . | . | 3 | 2 | 4 | 0 | 0 | 0 |
| | | | | | | | | |
| Farming | FE | Fertilisers | 25 | 29 | 24 | 11 | 12 | 0 |
| Run-off | HY | Highway run-off (including salt) | 14 | 14 | 15 | 9 | 12 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 13 | 11 | 17 | 14 | 12 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 13 | 16 | 11 | 0 | 0 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 13 | 10 | 17 | 11 | 0 | 0 |
| Agri-industry | DA | Dairy | 9 | 11 | 7 | 6 | 0 | 0 |
| Mining, quarries and extraction | MM | Metal mine drainage | 9 | 3 | 9 | 30 | 45 | 56 |
| Land use | MD | Moorland drainage | 9 | 7 | 11 | 9 | 0 | 0 |
| Other | SF | Sewage fungus | 9 | 9 | 9 | 14 | 0 | 0 |
| Farming | FA | Farming | 8 | 11 | 5 | 9 | 0 | 0 |
| Run-off | UR | Urban run-off | 7 | 7 | 9 | 3 | 0 | 0 |
| Land use | CF | Afforestation (conifer) | 7 | 9 | 5 | 0 | 0 | 0 |
| Channel at the site | BE | Bedrock | 6 | 8 | 5 | 6 | 0 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 6 | 3 | 7 | 17 | 0 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 6 | 6 | 7 | 11 | 0 | 0 |
| No perceived problem | NP | No perceived problem | 6 | 9 | 4 | 0 | 0 | 0 |
| Mining, quarries and extraction | CC | China clay extraction | 5 | 2 | 4 | 17 | 23 | 45 |
| Bank erosion | EC | Clay bank erosion | 5 | 7 | 4 | 0 | 0 | 0 |
| Other | OH | Ochre | 5 | 2 | 3 | 19 | 23 | 89 |
| Land use | US | Urban/suburban | 4 | 3 | 3 | 9 | 12 | 0 |
| Bank erosion | ES | Sand bank erosion | 4 | 4 | 4 | 0 | 12 | 0 |
| Run-off | RR | Railway run-off | 3 | 4 | 2 | 6 | 0 | 0 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 3 | 5 | 1 | 0 | 0 | 0 |
| Impoundments | WE | Weirs | 3 | 2 | 3 | 9 | 0 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 3 | 1 | 4 | 14 | 12 | 0 |
| No information | NI | No information | 3 | 2 | 4 | 0 | 0 | 0 |

## Table 5.11(g) Thames (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (477) | (135) | (129) | (133) | (55) | (25) |
| Sewage Treatment Works (STW) | . | . | 46 | 43 | 43 | 52 | 40 | 64 |
| Farming | . | . | 36 | 35 | 43 | 40 | 24 | 4 |
| Run-off | . | . | 28 | 9 | 18 | 34 | 62 | 80 |
| Channel at the site | . | . | 16 | 5 | 14 | 15 | 37 | 40 |
| Other | . | . | 15 | 5 | 12 | 14 | 39 | 44 |
| Impoundments | . | . | 12 | 12 | 25 | 5 | 8 | 4 |
| Artificial bank at the site | . | . | 11 | 5 | 8 | 14 | 17 | 28 |
| Sampling difficulty | . | . | 11 | 14 | 14 | 9 | 4 | 12 |
| Sediment at the site | . | . | 10 | 3 | 7 | 17 | 15 | 12 |
| Low flow | . | . | 10 | 11 | 14 | 9 | 6 | 4 |
| Land use | . | . | 10 | 6 | 7 | 13 | 17 | 8 |
| Choked channel (>33% plant) | . | . | 8 | 3 | 7 | 13 | 11 | 4 |
| Man-made watercourse | . | . | 6 | 8 | 10 | 4 | 0 | 4 |
| No perceived problem | . | . | 6 | 18 | 1 | 1 | 0 | 0 |
| Bank practices at the site | . | . | 4 | 3 | 5 | 3 | 8 | 4 |
| Industrial discharge | . | . | 3 | 2 | 2 | 4 | 2 | 4 |
| Bank erosion | . | . | 3 | 0 | 0 | 4 | 10 | 12 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 45 | 42 | 43 | 51 | 39 | 52 |
| Farming | FA | Farming | 35 | 32 | 42 | 40 | 24 | 4 |
| Run-off | UR | Urban run-off | 20 | 2 | 8 | 25 | 53 | 72 |
| Channel at the site | CA | Channelisation | 15 | 5 | 13 | 14 | 35 | 32 |
| Other | CL | Cladophora | 15 | 5 | 11 | 14 | 39 | 40 |
| Sampling difficulty | AC | Access to one bank only | 11 | 14 | 14 | 9 | 4 | 4 |
| Sediment at the site | IS | Inert siltation | 10 | 3 | 7 | 16 | 13 | 8 |
| Land use | US | Urban/suburban | 9 | 6 | 7 | 12 | 17 | 8 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 8 | 3 | 7 | 13 | 11 | 4 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 8 | 4 | 6 | 10 | 15 | 16 |
| Low flow | DT | Drought | 8 | 7 | 9 | 8 | 6 | 4 |
| Impoundments | WE | Weirs | 7 | 7 | 11 | 4 | 4 | 0 |
| Run-off | HY | Highway run-off (including salt) | 6 | 7 | 7 | 5 | 8 | 4 |
| Man-made watercourse | RN | River navigation (locks etc) | 6 | 8 | 9 | 3 | 0 | 0 |
| No perceived problem | NP | No perceived problem | 6 | 18 | 1 | 1 | 0 | 0 |
| Impoundments | LP | Lake or pond close u/s | 5 | 3 | 10 | 2 | 4 | 0 |
| Run-off | LR | Light industry/commercial run-off | 4 | 1 | 4 | 6 | 4 | 8 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 3 | 2 | 0 | 4 | 4 | 16 |
| Bank practices at the site | MO | Mown/managed riparian zone | 3 | 1 | 2 | 3 | 6 | 4 |
| Low flow | AG | Abstraction from groundwater | 3 | 4 | 6 | 1 | 0 | 0 |
| Bank erosion | EC | Clay bank erosion | 3 | 0 | 0 | 4 | 10 | 12 |

## Table 5.11(h) Welsh (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (796) | (309) | (312) | (131) | (32) | (12) |
| No perceived problem | . | . | 29 | 50 | 22 | 4 | 0 | 0 |
| Sewage Treatment Works (STW) | . | . | 27 | 11 | 26 | 49 | 75 | 67 |
| Run-off | . | . | 13 | 1 | 11 | 36 | 50 | 50 |
| Other | . | . | 13 | 6 | 11 | 23 | 41 | 42 |
| Sampling difficulty | . | . | 9 | 8 | 8 | 11 | 10 | 17 |
| Sediment at the site | . | . | 8 | 8 | 7 | 10 | 7 | 0 |
| Acid deposition | . | . | 7 | 2 | 12 | 7 | 7 | 17 |
| Mining, quarries and extraction | . | . | 7 | 2 | 8 | 13 | 13 | 25 |
| Channel at the site | . | . | 7 | 5 | 7 | 11 | 7 | 9 |
| Artificial bank at the site | . | . | 7 | 6 | 5 | 13 | 10 | 34 |
| Bank practices at the site | . | . | 7 | 8 | 7 | 4 | 0 | 0 |
| Impoundments | . | . | 7 | 3 | 9 | 12 | 13 | 17 |
| Land use | . | . | 7 | 3 | 9 | 11 | 13 | 0 |
| Farming | . | . | 6 | 4 | 6 | 10 | 4 | 0 |
| Industrial discharge | . | . | 6 | 3 | 5 | 12 | 13 | 17 |
| Waste | . | . | 3 | 4 | 3 | 0 | 0 | 0 |
| Bank erosion | . | . | 3 | 2 | 2 | 5 | 4 | 9 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 20 | 4 | 18 | 46 | 66 | 59 |
| Run-off | RO | Run-off | 12 | 0 | 8 | 33 | 47 | 50 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 8 | 7 | 11 | 6 | 10 | 0 |
| Sediment at the site | IS | Inert siltation | 7 | 7 | 6 | 7 | 7 | 0 |
| Acid deposition | AD | Acid deposition | 7 | 2 | 12 | 7 | 7 | 17 |
| Bank practices at the site | LV | Livestock poaching, trampling | 6 | 8 | 6 | 4 | 0 | 0 |
| Farming | FA | Farming | 5 | 4 | 5 | 9 | 0 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 5 | 4 | 4 | 7 | 0 | 34 |
| Land use | CF | Afforestation (conifer) | 5 | 2 | 6 | 7 | 7 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 5 | 4 | 6 | 5 | 7 | 9 |
| Other | CL | Cladophora | 5 | 2 | 5 | 11 | 19 | 9 |
| Industrial discharge | LI | Light industry/commercial | 4 | 2 | 3 | 7 | 7 | 17 |
| Mining, quarries and extraction | MM | Metal mine drainage | 4 | 2 | 5 | 4 | 4 | 0 |
| Mining, quarries and extraction | CM | Coal mine drainage | 4 | 1 | 3 | 7 | 10 | 25 |
| Sampling difficulty | AC | Access to one bank only | 4 | 4 | 2 | 6 | 4 | 9 |
| Other | OH | Ochre | 4 | 1 | 2 | 7 | 13 | 25 |
| Waste | SL | Slurry | 3 | 4 | 3 | 0 | 0 | 0 |
| Channel at the site | CA | Channelisation | 3 | 1 | 3 | 8 | 0 | 0 |
| Channel at the site | BE | Bedrock | 3 | 3 | 3 | 2 | 0 | 0 |
| Artificial bank at the site | UC | Unconsolidated (Rip-rap/boulder) | 3 | 2 | 2 | 7 | 10 | 0 |
| Impoundments | RF | Regulated flow | 3 | 1 | 3 | 1 | 7 | 9 |
| Impoundments | WE | Weirs | 3 | 2 | 3 | 5 | 4 | 9 |
| Impoundments | RE | Reservoir u/s catchment | 3 | 1 | 4 | 2 | 10 | 9 |
| Other | SF | Sewage fungus | 3 | 1 | 3 | 4 | 10 | 9 |
| Other | MY | Stress could not be identified(mystery) | 3 | 2 | 3 | 5 | 4 | 9 |

**Table 5.11(i) Wessex (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (510) | (322) | (131) | (49) | (4) | (4) |
| Farming | . | . | 42 | 36 | 55 | 54 | 25 | 25 |
| Sewage Treatment Works (STW) | . | . | 24 | 19 | 28 | 35 | 25 | 75 |
| Impoundments | . | . | 18 | 17 | 22 | 13 | 0 | 0 |
| Sediment at the site | . | . | 17 | 16 | 18 | 15 | 25 | 50 |
| Channel at the site | . | . | 17 | 13 | 17 | 39 | 25 | 25 |
| Low flow | . | . | 14 | 12 | 13 | 23 | 25 | 100 |
| Land use | . | . | 13 | 12 | 12 | 23 | 0 | 0 |
| No perceived problem | . | . | 13 | 19 | 3 | 0 | 0 | 0 |
| Sampling difficulty | . | . | 12 | 14 | 10 | 9 | 0 | 0 |
| Bank practices at the site | . | . | 10 | 7 | 14 | 15 | 0 | 0 |
| Channel Management | . | . | 8 | 8 | 10 | 7 | 0 | 0 |
| Other | . | . | 8 | 5 | 13 | 9 | 25 | 25 |
| Industrial discharge | . | . | 6 | 5 | 7 | 9 | 25 | 0 |
| Run-off | . | . | 6 | 5 | 7 | 7 | 25 | 25 |
| Artificial bank at the site | . | . | 6 | 6 | 6 | 9 | 0 | 0 |
| Agri-industry | . | . | 3 | 1 | 4 | 7 | 0 | 0 |
| Choked channel (>33% plant) | . | . | 3 | 4 | 2 | 7 | 0 | 0 |
| | | | | | | | | |
| Farming | FA | Farming | 36 | 29 | 49 | 45 | 25 | 25 |
| Sediment at the site | IS | Inert siltation | 17 | 16 | 18 | 15 | 25 | 50 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 16 | 10 | 23 | 29 | 25 | 75 |
| Channel at the site | CA | Channelisation | 13 | 11 | 12 | 35 | 0 | 25 |
| No perceived problem | NP | No perceived problem | 13 | 19 | 3 | 0 | 0 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 12 | 13 | 10 | 9 | 0 | 0 |
| Land use | US | Urban/suburban | 10 | 10 | 10 | 13 | 0 | 0 |
| Impoundments | RF | Regulated flow | 9 | 9 | 10 | 7 | 0 | 0 |
| Channel Management | DN | Dredging | 8 | 8 | 9 | 7 | 0 | 0 |
| Low flow | LF | Low flow | 8 | 5 | 7 | 21 | 25 | 100 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 7 | 9 | 5 | 3 | 0 | 0 |
| Sampling difficulty | AC | Access to one bank only | 7 | 8 | 4 | 7 | 0 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 6 | 5 | 10 | 9 | 0 | 0 |
| Low flow | DT | Drought | 6 | 6 | 7 | 3 | 0 | 0 |
| Farming | FF | Fish farm | 5 | 6 | 5 | 3 | 0 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 5 | 5 | 4 | 7 | 0 | 0 |
| Impoundments | WE | Weirs | 5 | 5 | 7 | 0 | 0 | 0 |
| Low flow | AG | Abstraction from groundwater | 5 | 6 | 4 | 3 | 0 | 0 |
| Other | CL | Cladophora | 5 | 5 | 7 | 5 | 25 | 0 |
| Industrial discharge | LI | Light industry/commercial | 3 | 3 | 3 | 5 | 0 | 0 |
| Run-off | HY | Highway run-off (including salt) | 3 | 2 | 4 | 3 | 0 | 0 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 3 | 4 | 2 | 7 | 0 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 3 | 2 | 6 | 5 | 0 | 0 |

## Table 5.11(j) Yorkshire (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.11(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (481) | (92) | (91) | (98) | (95) | (105) |
| Sewage Treatment Works (STW) | . | . | 50 | 15 | 36 | 49 | 64 | 80 |
| Run-off | . | . | 27 | 3 | 10 | 23 | 39 | 55 |
| Farming | . | . | 14 | 17 | 27 | 15 | 9 | 5 |
| Industrial discharge | . | . | 13 | 2 | 2 | 6 | 9 | 42 |
| No perceived problem | . | . | 10 | 36 | 13 | 2 | 0 | 0 |
| Waste | . | . | 8 | 9 | 16 | 11 | 4 | 1 |
| Sediment at the site | . | . | 8 | 2 | 3 | 10 | 12 | 15 |
| Mining, quarries and extraction | . | . | 7 | 2 | 8 | 7 | 13 | 4 |
| Impoundments | . | . | 7 | 9 | 7 | 7 | 5 | 5 |
| No information | . | . | 7 | 16 | 4 | 8 | 2 | 4 |
| Low flow | . | . | 5 | 7 | 10 | 4 | 6 | 1 |
| Sampling difficulty | . | . | 5 | 10 | 5 | 3 | 0 | 9 |
| Other | . | . | 5 | 4 | 5 | 12 | 5 | 1 |
| Pesticides | . | . | 4 | 2 | 5 | 5 | 5 | 2 |
| Leachate | . | . | 4 | 0 | 0 | 2 | 10 | 9 |
| Channel Management | . | . | 3 | 3 | 4 | 5 | 3 | 1 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 28 | 8 | 20 | 28 | 31 | 47 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 26 | 4 | 16 | 25 | 43 | 40 |
| Run-off | UR | Urban run-off | 24 | 2 | 9 | 18 | 32 | 53 |
| Industrial discharge | HI | Heavy industry | 11 | 0 | 2 | 6 | 7 | 39 |
| No perceived problem | NP | No perceived problem | 10 | 36 | 13 | 2 | 0 | 0 |
| Farming | FE | Fertilisers | 8 | 9 | 17 | 11 | 5 | 1 |
| Waste | SL | Slurry | 8 | 9 | 15 | 11 | 4 | 1 |
| No information | NI | No information | 7 | 16 | 4 | 8 | 2 | 4 |
| Sediment at the site | IS | Inert siltation | 6 | 0 | 3 | 7 | 10 | 8 |
| Mining, quarries and extraction | CM | Coal mine drainage | 6 | 0 | 7 | 7 | 13 | 4 |
| Farming | FA | Farming | 4 | 4 | 5 | 5 | 5 | 4 |
| Sampling difficulty | AL | Air-lift used to sample | 4 | 7 | 5 | 0 | 0 | 6 |
| Other | MY | Stress could not be identified mystery) | 4 | 4 | 4 | 8 | 3 | 0 |
| Farming | FF | Fish farm | 3 | 6 | 6 | 0 | 0 | 0 |
| Sediment at the site | TX | Contaminated sediment | 3 | 0 | 0 | 4 | 3 | 7 |
| Leachate | TI | Toxic/industrial landfill | 3 | 0 | 0 | 2 | 6 | 8 |
| Run-off | HY | Highway run-off (including salt) | 3 | 0 | 2 | 5 | 8 | 1 |
| Impoundments | RF | Regulated flow | 3 | 4 | 0 | 6 | 2 | 1 |
| Low flow | AP | Abstraction for public supply | 3 | 6 | 6 | 2 | 0 | 0 |

**Table 5.12 (a) Area (a) 'Eastern' within Anglian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-d, e/f; bias-corrected) in 1995. Major, then individual stress types ordered by decreasing overall frequency of occurrence (down to approx. 3%). (Total number of sites in each grade given in brackets)**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (277) | (76) | (124) | (61) | (14) | (2) |
| Farming | . | . | 80 | 78 | 82 | 78 | 72 | 100 |
| Channel at the site | . | . | 79 | 78 | 78 | 78 | 93 | 100 |
| Land use | . | . | 67 | 69 | 63 | 73 | 65 | 50 |
| Sewage Treatment Works (STW) | . | . | 63 | 57 | 65 | 64 | 72 | 100 |
| Pesticides | . | . | 42 | 35 | 47 | 41 | 36 | 50 |
| Impoundments | . | . | 40 | 52 | 43 | 25 | 15 | 0 |
| Other | . | . | 25 | 16 | 32 | 25 | 8 | 50 |
| Run-off | . | . | 19 | 14 | 18 | 22 | 43 | 50 |
| Low flow | . | . | 16 | 19 | 17 | 10 | 8 | 0 |
| Waste | . | . | 12 | 3 | 16 | 15 | 15 | 50 |
| Sampling difficulty | . | . | 11 | 19 | 11 | 5 | 0 | 0 |
| Agri-industry | . | . | 7 | 6 | 7 | 9 | 15 | 0 |
| Choked channel (>33% plant) | . | . | 7 | 3 | 7 | 12 | 15 | 0 |
| Artificial bank at the site | . | . | 6 | 6 | 8 | 0 | 15 | 50 |
| Industrial discharge | . | . | 4 | 3 | 5 | 2 | 0 | 0 |
| Oils, petrochemicals | . | . | 4 | 10 | 2 | 4 | 0 | 0 |
| Leachate | . | . | 4 | 4 | 5 | 4 | 0 | 0 |
| No flow | . | . | 3 | 0 | 3 | 7 | 8 | 0 |
| | | | | | | | | |
| Farming | FE | Fertilisers | 79 | 78 | 81 | 78 | 72 | 100 |
| Channel at the site | BG | Bridge | 72 | 64 | 72 | 78 | 93 | 100 |
| Land use | IA | Intensive arablisation | 57 | 62 | 55 | 60 | 36 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 54 | 50 | 56 | 55 | 58 | 50 |
| Pesticides | PE | Pesticides | 42 | 35 | 47 | 41 | 29 | 50 |
| Other | CL | Cladophora | 24 | 16 | 31 | 23 | 8 | 0 |
| Impoundments | LP | Lake or pond close u/s | 18 | 25 | 17 | 14 | 8 | 0 |
| Run-off | UR | Urban run-off | 15 | 8 | 14 | 20 | 43 | 0 |
| Channel at the site | CA | Channelisation | 14 | 23 | 15 | 2 | 8 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 13 | 6 | 14 | 19 | 15 | 100 |
| Low flow | IR | Abstraction for irrigation | 13 | 18 | 14 | 9 | 0 | 0 |
| Land use | US | Urban/suburban | 13 | 8 | 13 | 15 | 36 | 50 |
| Impoundments | PF | Ponded flow (lake or reservoir d/s) | 10 | 10 | 11 | 12 | 0 | 0 |
| Impoundments | RT | River transfer | 9 | 11 | 13 | 0 | 0 | 0 |
| Waste | PI | Piggery waste | 8 | 3 | 10 | 9 | 15 | 50 |
| Run-off | LR | Light industry/commercial run-off | 8 | 3 | 8 | 9 | 36 | 0 |
| Sampling difficulty | AC | Access to one bank only | 8 | 8 | 9 | 5 | 0 | 0 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 7 | 3 | 7 | 12 | 15 | 0 |
| Impoundments | WE | Weirs | 6 | 3 | 9 | 2 | 0 | 0 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 5 | 3 | 5 | 9 | 0 | 0 |
| Impoundments | FT | Freshwater but tidal | 5 | 12 | 3 | 0 | 8 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 5 | 14 | 3 | 0 | 0 | 0 |
| Waste | SL | Slurry | 4 | 0 | 5 | 7 | 0 | 0 |
| Agri-industry | AB | Abattoir | 4 | 3 | 4 | 5 | 0 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 4 | 2 | 5 | 0 | 15 | 50 |
| Low flow | AG | Abstraction from groundwater | 4 | 4 | 5 | 0 | 0 | 0 |
| Agri-industry | BR | Brewery | 3 | 3 | 4 | 0 | 15 | 0 |

**Table 5.12(b) Area (b) 'Central' in Anglian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (204) | (48) | (87) | (54) | (12) | (3) |
| Sewage Treatment Works (STW) | . | . | 38 | 13 | 36 | 62 | 59 | 0 |
| No perceived problem | . | . | 32 | 75 | 27 | 12 | 0 | 0 |
| Channel at the site | . | . | 24 | 13 | 32 | 23 | 0 | 67 |
| Run-off | . | . | 7 | 0 | 5 | 12 | 17 | 34 |
| Sampling difficulty | . | . | 5 | 0 | 6 | 4 | 17 | 0 |
| Sediment at the site | . | . | 4 | 3 | 5 | 4 | 0 | 34 |
| Artificial bank at the site | . | . | 4 | 3 | 6 | 2 | 0 | 0 |
| Other | . | . | 4 | 0 | 3 | 10 | 0 | 0 |
| Agri-industry | . | . | 3 | 0 | 4 | 4 | 0 | 0 |
| | | | | | | | | |
| No perceived problem | NP | No perceived problem | 32 | 75 | 27 | 12 | 0 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 30 | 11 | 29 | 47 | 42 | 0 |
| Channel at the site | CA | Channelisation | 24 | 13 | 32 | 23 | 0 | 67 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 8 | 3 | 7 | 13 | 17 | 0 |
| Run-off | UR | Urban run-off | 5 | 0 | 4 | 8 | 17 | 34 |
| Sampling difficulty | DR | Dredge used to sample | 5 | 0 | 6 | 4 | 17 | 0 |
| Sediment at the site | IS | Inert siltation | 4 | 3 | 5 | 4 | 0 | 34 |
| Artificial bank at the site | AT | Artificial bank at the site | 3 | 3 | 4 | 2 | 0 | 0 |
| Other | MY | Stress could not be identified(mystery) | 3 | 0 | 3 | 6 | 0 | 0 |

### Table 5.12(c) Area (c) 'Northern' in Anglian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (155) | (36) | (67) | (33) | (12) | (7) |
| Farming | . | . | 100 | 100 | 100 | 97 | 100 | 100 |
| Sediment at the site | . | . | 100 | 98 | 100 | 100 | 100 | 100 |
| Pesticides | . | . | 99 | 98 | 100 | 97 | 100 | 100 |
| Land use | . | . | 90 | 87 | 92 | 91 | 92 | 86 |
| Sewage Treatment Works (STW) | . | . | 56 | 56 | 47 | 64 | 75 | 72 |
| Channel at the site | . | . | 44 | 39 | 63 | 25 | 17 | 29 |
| Run-off | . | . | 35 | 12 | 26 | 52 | 84 | 72 |
| Impoundments | . | . | 22 | 37 | 21 | 10 | 25 | 0 |
| Industrial discharge | . | . | 20 | 12 | 12 | 31 | 42 | 58 |
| Oils, petrochemicals | . | . | 19 | 0 | 11 | 28 | 67 | 58 |
| Low flow | . | . | 19 | 20 | 20 | 22 | 9 | 0 |
| Other | . | . | 19 | 12 | 23 | 25 | 9 | 0 |
| Choked channel (>33% plant) | . | . | 18 | 14 | 17 | 28 | 17 | 0 |
| Sampling difficulty | . | . | 15 | 17 | 9 | 31 | 0 | 15 |
| Man-made watercourse | . | . | 10 | 6 | 18 | 4 | 0 | 0 |
| Channel Management | . | . | 10 | 12 | 15 | 4 | 0 | 0 |
| Artificial bank at the site | . | . | 10 | 6 | 8 | 10 | 25 | 29 |
| Leachate | . | . | 6 | 3 | 5 | 13 | 9 | 0 |
| Agri-industry | . | . | 5 | 6 | 5 | 4 | 0 | 15 |
| | | | | | | | | |
| Farming | FE | Fertilisers | 100 | 100 | 100 | 97 | 100 | 100 |
| Sediment at the site | TX | Contaminated sediment | 100 | 98 | 100 | 100 | 100 | 100 |
| Pesticides | HE | Herbicides | 99 | 98 | 100 | 97 | 100 | 100 |
| Pesticides | IN | Insecticides | 99 | 98 | 100 | 97 | 100 | 100 |
| Land use | IA | Intensive arablisation | 71 | 81 | 83 | 64 | 25 | 15 |
| Channel at the site | CA | Channelisation | 44 | 39 | 63 | 25 | 17 | 29 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 38 | 42 | 33 | 49 | 34 | 15 |
| Run-off | UR | Urban run-off | 28 | 12 | 18 | 34 | 84 | 72 |
| Land use | US | Urban/suburban | 27 | 9 | 18 | 40 | 67 | 72 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 22 | 14 | 18 | 22 | 42 | 58 |
| Sediment at the site | IS | Inert siltation | 19 | 25 | 20 | 16 | 0 | 29 |
| Oils, petrochemicals | OI | Oils, petrochemicals | 18 | 0 | 9 | 28 | 67 | 58 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 18 | 14 | 17 | 28 | 17 | 0 |
| Other | CL | Cladophora | 18 | 12 | 23 | 22 | 9 | 0 |
| Run-off | LR | Light industry/commercial run-off | 17 | 3 | 9 | 28 | 50 | 43 |
| Industrial discharge | LI | Light industry/commercial | 15 | 6 | 9 | 22 | 25 | 58 |
| Sampling difficulty | DR | Dredge used to sample | 14 | 14 | 9 | 28 | 0 | 15 |
| Industrial discharge | HI | Heavy industry | 13 | 3 | 5 | 19 | 42 | 58 |
| Low flow | LF | Low flow | 11 | 12 | 12 | 10 | 9 | 0 |
| Run-off | HR | Heavy industry run-off | 10 | 3 | 5 | 13 | 34 | 29 |
| Man-made watercourse | RN | River navigation (locks etc) | 10 | 6 | 18 | 0 | 0 | 0 |
| Channel Management | WD | Weed cutting | 10 | 9 | 15 | 4 | 0 | 0 |
| Run-off | HY | Highway run-off (including salt) | 9 | 0 | 8 | 22 | 0 | 15 |
| Impoundments | WE | Weirs | 9 | 12 | 12 | 0 | 9 | 0 |
| Channel Management | DN | Dredging | 6 | 12 | 6 | 4 | 0 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 6 | 0 | 3 | 7 | 25 | 29 |
| Impoundments | RF | Regulated flow | 6 | 12 | 8 | 0 | 0 | 0 |
| Impoundments | RT | River transfer | 6 | 14 | 6 | 0 | 0 | 0 |

**Table 5.12(d) Area (d) ‘Wear’ in Northumbrian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (66) | (15) | (20) | (10) | (10) | (11) |
| Sewage Treatment Works (STW) | . | . | 72 | 54 | 50 | 90 | 90 | 100 |
| Mining, quarries and extraction | . | . | 31 | 20 | 30 | 30 | 30 | 46 |
| Other | . | . | 29 | 20 | 30 | 20 | 40 | 37 |
| Run-off | . | . | 26 | 14 | 10 | 10 | 50 | 64 |
| Channel at the site | . | . | 22 | 14 | 35 | 20 | 10 | 19 |
| No perceived problem | . | . | 13 | 27 | 20 | 0 | 0 | 0 |
| Sediment at the site | . | . | 8 | 7 | 10 | 0 | 0 | 19 |
| Pesticides | . | . | 7 | 20 | 5 | 0 | 0 | 0 |
| Industrial discharge | . | . | 5 | 0 | 5 | 10 | 0 | 10 |
| Low flow | . | . | 5 | 0 | 0 | 20 | 0 | 10 |
| Oils, petrochemicals | . | . | 4 | 0 | 5 | 0 | 0 | 10 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 54 | 27 | 40 | 60 | 90 | 73 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 44 | 34 | 25 | 40 | 70 | 73 |
| Mining, quarries and extraction | CM | Coal mine drainage | 23 | 14 | 15 | 30 | 30 | 37 |
| Channel at the site | BG | Bridge | 22 | 14 | 35 | 20 | 10 | 19 |
| Other | CL | Cladophora | 22 | 14 | 25 | 20 | 40 | 10 |
| Run-off | UR | Urban run-off | 17 | 14 | 0 | 10 | 30 | 46 |
| Run-off | LR | Light industry/commercial run-off | 16 | 0 | 10 | 0 | 50 | 28 |
| No perceived problem | NP | No perceived problem | 13 | 27 | 20 | 0 | 0 | 0 |
| Pesticides | SD | Sheep-dip | 7 | 20 | 5 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 7 | 7 | 5 | 10 | 0 | 10 |
| Sediment at the site | TX | Contaminated sediment | 5 | 0 | 5 | 0 | 0 | 19 |
| Mining, quarries and extraction | MM | Metal mine drainage | 5 | 7 | 10 | 0 | 0 | 0 |
| Other | OH | Ochre | 5 | 0 | 5 | 0 | 10 | 10 |
| Industrial discharge | ID | Industrial discharge | 4 | 0 | 0 | 10 | 0 | 10 |
| Sediment at the site | IS | Inert siltation | 4 | 7 | 5 | 0 | 0 | 0 |
| Run-off | RR | Railway run-off | 4 | 0 | 0 | 0 | 10 | 10 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 4 | 0 | 5 | 0 | 0 | 10 |
| Low flow | LF | Low flow | 4 | 0 | 0 | 10 | 0 | 10 |
| Other | SF | Sewage fungus | 4 | 0 | 0 | 0 | 0 | 19 |

## Table 5.12(e) Area (e) 'Tyne' in Northumbrian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (76) | (36) | (24) | (2) | (6) | (8) |
| Mining, quarries and extraction | . | . | 37 | 42 | 46 | 0 | 34 | 0 |
| Sewage Treatment Works (STW) | . | . | 32 | 14 | 34 | 50 | 50 | 88 |
| Land use | . | . | 23 | 25 | 25 | 0 | 34 | 0 |
| Impoundments | . | . | 22 | 25 | 30 | 0 | 0 | 0 |
| Sampling difficulty | . | . | 15 | 20 | 17 | 0 | 0 | 0 |
| Pesticides | . | . | 12 | 9 | 17 | 0 | 34 | 0 |
| Industrial discharge | . | . | 11 | 6 | 5 | 50 | 34 | 25 |
| Sediment at the site | . | . | 11 | 6 | 9 | 50 | 17 | 25 |
| Leachate | . | . | 11 | 3 | 0 | 0 | 34 | 63 |
| No perceived problem | . | . | 11 | 20 | 5 | 0 | 0 | 0 |
| Run-off | . | . | 10 | 0 | 9 | 0 | 34 | 38 |
| Channel at the site | . | . | 10 | 12 | 5 | 0 | 17 | 13 |
| Water Treatment Works (WTW) | . | . | 8 | 6 | 13 | 50 | 0 | 0 |
| Farming | . | . | 7 | 6 | 9 | 0 | 17 | 0 |
| Bank practices at the site | . | . | 7 | 9 | 9 | 0 | 0 | 0 |
| Oils, petrochemicals | . | . | 6 | 0 | 9 | 0 | 0 | 25 |
| Other | . | . | 6 | 0 | 9 | 0 | 17 | 13 |
| Agri-industry | . | . | 4 | 3 | 0 | 0 | 0 | 25 |
| Reclaimed land | . | . | 4 | 3 | 0 | 0 | 17 | 13 |
| | | | | | | | | |
| Mining, quarries and extraction | MM | Metal mine drainage | 28 | 34 | 38 | 0 | 0 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 22 | 25 | 30 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 19 | 12 | 21 | 50 | 17 | 38 |
| Land use | MD | Moorland drainage | 12 | 14 | 17 | 0 | 0 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 12 | 17 | 13 | 0 | 0 | 0 |
| No perceived problem | NP | No perceived problem | 11 | 20 | 5 | 0 | 0 | 0 |
| Leachate | TI | Toxic/industrial landfill | 10 | 3 | 0 | 0 | 34 | 50 |
| Pesticides | HE | Herbicides | 8 | 9 | 5 | 0 | 34 | 0 |
| Pesticides | IN | Insecticides | 8 | 6 | 9 | 0 | 34 | 0 |
| Water Treatment Works (WTW) | AS | Aluminium sulphate from WTW | 8 | 6 | 13 | 50 | 0 | 0 |
| Mining, quarries and extraction | CM | Coal mine drainage | 8 | 6 | 13 | 0 | 17 | 0 |
| Impoundments | RF | Regulated flow | 8 | 6 | 17 | 0 | 0 | 0 |
| Sediment at the site | IS | Inert siltation | 7 | 6 | 5 | 50 | 17 | 0 |
| Sampling difficulty | AC | Access to one bank only | 7 | 9 | 9 | 0 | 0 | 0 |
| Farming | FE | Fertilisers | 6 | 3 | 9 | 0 | 17 | 0 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 6 | 3 | 13 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 6 | 0 | 0 | 0 | 34 | 25 |
| Run-off | UR | Urban run-off | 6 | 0 | 5 | 0 | 17 | 25 |
| Run-off | HY | Highway run-off (including salt) | 6 | 0 | 0 | 0 | 34 | 25 |
| Channel at the site | BE | Bedrock | 6 | 9 | 5 | 0 | 0 | 0 |
| Land use | CF | Afforestation (conifer) | 6 | 6 | 9 | 0 | 0 | 0 |
| Land use | IA | Intensive arablisation | 6 | 6 | 0 | 0 | 34 | 0 |
| Industrial discharge | DE | Detergent | 4 | 0 | 0 | 50 | 17 | 13 |
| Sediment at the site | TX | Contaminated sediment | 4 | 0 | 5 | 0 | 0 | 25 |
| Leachate | DL | Domestic landfill | 4 | 0 | 0 | 0 | 17 | 25 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 4 | 0 | 0 | 0 | 17 | 25 |

**Table 5.12(f) Area (f) ‘Tweed’ in Northumbrian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (91) | (27) | (26) | (22) | (13) | (3) |
| Sewage Treatment Works (STW) | . | . | 50 | 30 | 50 | 46 | 85 | 100 |
| Farming | . | . | 22 | 15 | 31 | 28 | 0 | 67 |
| Mining, quarries and extraction | . | . | 13 | 12 | 4 | 23 | 8 | 34 |
| Channel at the site | . | . | 13 | 8 | 8 | 23 | 16 | 0 |
| No perceived problem | . | . | 11 | 38 | 0 | 0 | 0 | 0 |
| Bank practices at the site | . | . | 9 | 4 | 8 | 10 | 24 | 0 |
| Low flow | . | . | 9 | 0 | 0 | 14 | 39 | 0 |
| Other | . | . | 9 | 12 | 8 | 5 | 16 | 0 |
| Agri-industry | . | . | 7 | 0 | 16 | 5 | 8 | 0 |
| Impoundments | . | . | 7 | 4 | 4 | 10 | 8 | 34 |
| Leachate | . | . | 6 | 0 | 4 | 10 | 16 | 0 |
| Run-off | . | . | 6 | 4 | 8 | 0 | 16 | 0 |
| Sampling difficulty | . | . | 4 | 0 | 8 | 5 | 0 | 0 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 32 | 19 | 31 | 32 | 62 | 34 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 19 | 19 | 16 | 10 | 31 | 67 |
| Farming | FE | Fertilisers | 16 | 12 | 20 | 28 | 0 | 0 |
| No perceived problem | NP | No perceived problem | 11 | 38 | 0 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 10 | 12 | 12 | 10 | 8 | 0 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 10 | 8 | 4 | 23 | 8 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 9 | 4 | 8 | 10 | 24 | 0 |
| Low flow | LF | Low flow | 9 | 0 | 0 | 14 | 39 | 0 |
| Farming | FA | Farming | 7 | 4 | 12 | 0 | 0 | 67 |
| Other | CL | Cladophora | 7 | 12 | 4 | 0 | 16 | 0 |
| Channel at the site | CA | Channelisation | 6 | 4 | 4 | 10 | 8 | 0 |
| Leachate | SH | Slag heap | 5 | 0 | 4 | 5 | 16 | 0 |
| Impoundments | FT | Freshwater but tidal | 5 | 0 | 4 | 10 | 0 | 34 |
| Agri-industry | AI | Agri-industry | 4 | 0 | 12 | 0 | 0 | 0 |
| Run-off | UR | Urban run-off | 4 | 4 | 4 | 0 | 8 | 0 |
| Channel at the site | AN | Channel at the site | 4 | 0 | 0 | 14 | 0 | 0 |
| Agri-industry | DA | Dairy | 3 | 0 | 4 | 0 | 8 | 0 |
| Leachate | DL | Domestic landfill | 3 | 0 | 0 | 5 | 8 | 0 |

**Table 5.12(g) Area (g) ‘Tees’ in Northumbrian (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

**This table is not given as insufficient sites in this catchment area were identified within the analysis.**

**Table 5.12(h) Area (h) 'Northern' in North West (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (232) | (58) | (113) | (41) | (15) | (5) |
| Farming | . | . | 68 | 54 | 69 | 81 | 80 | 60 |
| Sediment at the site | . | . | 23 | 13 | 19 | 37 | 47 | 40 |
| Sewage Treatment Works (STW) | . | . | 23 | 9 | 19 | 40 | 54 | 40 |
| Low flow | . | . | 22 | 7 | 25 | 25 | 54 | 0 |
| Other | . | . | 17 | 14 | 16 | 20 | 40 | 0 |
| Land use | . | . | 14 | 13 | 19 | 8 | 0 | 0 |
| Run-off | . | . | 13 | 14 | 9 | 15 | 14 | 40 |
| Impoundments | . | . | 12 | 7 | 11 | 15 | 20 | 20 |
| No perceived problem | . | . | 9 | 23 | 7 | 0 | 0 | 0 |
| Acid deposition | . | . | 8 | 7 | 9 | 5 | 0 | 20 |
| Channel at the site | . | . | 7 | 4 | 7 | 13 | 0 | 0 |
| Channel Management | . | . | 6 | 2 | 5 | 10 | 14 | 0 |
| Pesticides | . | . | 5 | 4 | 6 | 5 | 0 | 0 |
| Bank practices at the site | . | . | 5 | 2 | 6 | 3 | 14 | 20 |
| Bank erosion | . | . | 5 | 6 | 4 | 10 | 0 | 0 |
| Sampling difficulty | . | . | 5 | 4 | 6 | 5 | 0 | 20 |
| Choked channel (>33% plant) | . | . | 4 | 0 | 3 | 5 | 14 | 20 |
| | | | | | | | | |
| Farming | FA | Farming | 66 | 52 | 68 | 79 | 80 | 60 |
| Sediment at the site | SX | Sediment at the site | 13 | 7 | 12 | 20 | 14 | 20 |
| Low flow | DT | Drought | 13 | 6 | 15 | 13 | 34 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 12 | 6 | 9 | 13 | 47 | 40 |
| Low flow | LF | Low flow | 12 | 4 | 14 | 13 | 27 | 0 |
| Other | CL | Cladophora | 11 | 9 | 11 | 10 | 27 | 0 |
| Sediment at the site | IS | Inert siltation | 10 | 4 | 8 | 18 | 34 | 20 |
| Run-off | HY | Highway run-off (including salt) | 9 | 9 | 8 | 8 | 14 | 40 |
| No perceived problem | NP | No perceived problem | 9 | 23 | 7 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 8 | 4 | 5 | 25 | 7 | 0 |
| Acid deposition | AD | Acid deposition | 8 | 7 | 9 | 5 | 0 | 20 |
| Impoundments | FT | Freshwater but tidal | 7 | 6 | 7 | 8 | 20 | 0 |
| Land use | MD | Moorland drainage | 7 | 4 | 9 | 5 | 0 | 0 |
| Channel at the site | CA | Channelisation | 6 | 4 | 5 | 13 | 0 | 0 |
| Channel Management | WD | Weed cutting | 6 | 2 | 5 | 10 | 14 | 0 |
| Land use | US | Urban/suburban | 6 | 7 | 7 | 3 | 0 | 0 |
| Pesticides | SD | Sheep-dip | 5 | 4 | 6 | 5 | 0 | 0 |
| Run-off | UR | Urban run-off | 4 | 4 | 2 | 8 | 0 | 0 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 4 | 0 | 3 | 5 | 14 | 20 |
| Bank practices at the site | LV | Livestock poaching, trampling | 4 | 2 | 4 | 0 | 14 | 20 |
| Impoundments | LP | Lake or pond close u/s | 4 | 0 | 3 | 8 | 0 | 20 |
| Land use | CF | Afforestation (conifer) | 4 | 4 | 5 | 0 | 0 | 0 |
| Other | OH | Ochre | 4 | 4 | 3 | 8 | 7 | 0 |

### Table 5.12(i) Area (i) ‘Central’ in North West (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (228) | (13) | (67) | (51) | (46) | (51) |
| Sewage Treatment Works (STW) | . | . | 50 | 24 | 29 | 55 | 61 | 69 |
| Farming | . | . | 41 | 24 | 42 | 55 | 46 | 26 |
| Run-off | . | . | 30 | 0 | 8 | 30 | 46 | 53 |
| Channel at the site | . | . | 28 | 8 | 14 | 28 | 33 | 46 |
| Sediment at the site | . | . | 25 | 39 | 26 | 22 | 24 | 24 |
| Land use | . | . | 17 | 8 | 8 | 12 | 22 | 30 |
| Low flow | . | . | 15 | 8 | 23 | 14 | 16 | 6 |
| Artificial bank at the site | . | . | 14 | 24 | 11 | 10 | 14 | 18 |
| Other | . | . | 14 | 0 | 11 | 20 | 11 | 18 |
| Sampling difficulty | . | . | 13 | 24 | 12 | 10 | 14 | 14 |
| Channel Management | . | . | 9 | 0 | 0 | 6 | 20 | 16 |
| Impoundments | . | . | 9 | 0 | 14 | 2 | 9 | 10 |
| Industrial discharge | . | . | 8 | 0 | 2 | 6 | 7 | 18 |
| Bank practices at the site | . | . | 8 | 24 | 11 | 14 | 3 | 0 |
| Pesticides | . | . | 7 | 0 | 3 | 6 | 9 | 10 |
| Agri-industry | . | . | 6 | 0 | 2 | 8 | 11 | 4 |
| Mining, quarries and extraction | . | . | 6 | 0 | 5 | 8 | 7 | 4 |
| Man-made watercourse | . | . | 5 | 0 | 0 | 6 | 9 | 8 |
| No perceived problem | . | . | 5 | 24 | 11 | 0 | 0 | 0 |
| Leachate | . | . | 4 | 0 | 2 | 4 | 11 | 2 |
| | | | | | | | | |
| Farming | FA | Farming | 31 | 24 | 35 | 40 | 27 | 24 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 23 | 16 | 17 | 30 | 20 | 30 |
| Run-off | UR | Urban run-off | 22 | 0 | 5 | 26 | 31 | 40 |
| Channel at the site | CA | Channelisation | 20 | 0 | 6 | 20 | 29 | 36 |
| Sediment at the site | IS | Inert siltation | 19 | 16 | 15 | 20 | 24 | 20 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 15 | 0 | 5 | 22 | 24 | 14 |
| Low flow | DT | Drought | 12 | 8 | 18 | 10 | 14 | 6 |
| Farming | FE | Fertilisers | 11 | 0 | 5 | 14 | 20 | 8 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 11 | 0 | 0 | 2 | 18 | 32 |
| Run-off | HY | Highway run-off (including salt) | 9 | 0 | 3 | 4 | 14 | 18 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 9 | 8 | 8 | 10 | 7 | 10 |
| Land use | US | Urban/suburban | 9 | 0 | 0 | 4 | 11 | 24 |
| Sewage Treatment Works (STW) | SE | Septic tank | 8 | 8 | 8 | 12 | 11 | 2 |
| Channel Management | DN | Dredging | 8 | 0 | 0 | 4 | 14 | 16 |
| Other | OH | Ochre | 8 | 0 | 5 | 8 | 11 | 10 |
| Bank practices at the site | LV | Livestock poaching, trampling | 7 | 24 | 8 | 12 | 3 | 0 |
| Sampling difficulty | AC | Access to one bank only | 7 | 0 | 2 | 6 | 11 | 12 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 7 | 24 | 11 | 4 | 3 | 2 |
| Land use | IA | Intensive arablisation | 6 | 0 | 0 | 6 | 11 | 10 |
| Industrial discharge | LI | Light industry/commercial | 5 | 0 | 2 | 4 | 3 | 14 |
| Sediment at the site | GS | Eroded gravel/boulders in channel | 5 | 24 | 11 | 2 | 0 | 0 |
| Channel at the site | BE | Bedrock | 5 | 8 | 6 | 8 | 3 | 0 |
| Man-made watercourse | DI | Artificial ditch of dyke | 5 | 0 | 0 | 6 | 9 | 8 |
| No perceived problem | NP | No perceived problem | 5 | 24 | 11 | 0 | 0 | 0 |
| Run-off | LR | Light industry/commercial run-off | 4 | 0 | 0 | 2 | 7 | 6 |
| Mining, quarries and extraction | CM | Coal mine drainage | 4 | 0 | 3 | 4 | 7 | 4 |
| Channel at the site | CU | Culvert | 4 | 0 | 2 | 0 | 5 | 10 |

## Table 5.12(j) Area (j) 'Southern' in North West (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (329) | (3) | (23) | (71) | (98) | (134) |
| Sewage Treatment Works (STW) | . | . | 78 | 0 | 61 | 67 | 83 | 86 |
| Run-off | . | . | 65 | 34 | 44 | 61 | 64 | 73 |
| Agri-industry | . | . | 29 | 0 | 27 | 43 | 37 | 17 |
| Industrial discharge | . | . | 21 | 67 | 9 | 16 | 22 | 25 |
| Land use | . | . | 15 | 0 | 9 | 10 | 13 | 21 |
| Farming | . | . | 13 | 34 | 31 | 6 | 12 | 14 |
| Leachate | . | . | 10 | 0 | 0 | 6 | 9 | 15 |
| Channel at the site | . | . | 10 | 0 | 0 | 9 | 11 | 11 |
| Impoundments | . | . | 9 | 0 | 22 | 16 | 6 | 5 |
| Mining, quarries and extraction | . | . | 8 | 0 | 9 | 5 | 12 | 7 |
| Other | . | . | 7 | 34 | 5 | 5 | 8 | 8 |
| Waste | . | . | 6 | 0 | 0 | 6 | 10 | 4 |
| Sediment at the site | . | . | 4 | 0 | 0 | 5 | 3 | 5 |
| Pesticides | . | . | 3 | 0 | 0 | 3 | 0 | 6 |
| | | | | | | | | |
| Run-off | UR | Urban run-off | 48 | 0 | 22 | 41 | 46 | 59 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 45 | 0 | 5 | 20 | 42 | 67 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 30 | 0 | 22 | 30 | 30 | 33 |
| Agri-industry | DA | Dairy | 27 | 0 | 27 | 41 | 35 | 15 |
| Sewage Treatment Works (STW) | SE | Septic tank | 26 | 0 | 40 | 40 | 32 | 12 |
| Run-off | HY | Highway run-off (including salt) | 19 | 0 | 14 | 16 | 23 | 19 |
| Run-off | LR | Light industry/commercial run-off | 18 | 0 | 5 | 10 | 19 | 24 |
| Farming | FA | Farming | 12 | 34 | 27 | 6 | 12 | 12 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 11 | 0 | 5 | 15 | 10 | 10 |
| Land use | US | Urban/suburban | 11 | 0 | 0 | 5 | 9 | 18 |
| Industrial discharge | ID | Industrial discharge | 10 | 67 | 5 | 9 | 9 | 12 |
| Industrial discharge | LI | Light industry/commercial | 8 | 0 | 0 | 9 | 10 | 9 |
| Channel at the site | CA | Channelisation | 6 | 0 | 0 | 5 | 4 | 9 |
| Leachate | TI | Toxic/industrial landfill | 5 | 0 | 0 | 3 | 3 | 8 |
| Impoundments | RE | Reservoir u/s catchment | 5 | 0 | 9 | 10 | 4 | 3 |
| Waste | SL | Slurry | 4 | 0 | 0 | 6 | 7 | 3 |
| Run-off | RO | Run-off | 4 | 34 | 14 | 2 | 2 | 3 |
| Mining, quarries and extraction | CM | Coal mine drainage | 4 | 0 | 0 | 2 | 6 | 5 |
| Impoundments | RF | Regulated flow | 4 | 0 | 18 | 8 | 2 | 2 |
| Land use | MD | Moorland drainage | 4 | 0 | 9 | 8 | 3 | 1 |
| Other | SF | Sewage fungus | 4 | 0 | 0 | 0 | 8 | 5 |
| Other | OH | Ochre | 4 | 34 | 5 | 3 | 2 | 4 |
| Industrial discharge | HI | Heavy industry | 3 | 0 | 0 | 0 | 5 | 3 |
| Leachate | SH | Slag heap | 3 | 0 | 0 | 2 | 2 | 4 |
| Leachate | DL | Domestic landfill | 3 | 0 | 0 | 2 | 3 | 4 |
| Channel at the site | CU | Culvert | 3 | 0 | 0 | 2 | 3 | 3 |
| Channel at the site | BG | Bridge | 3 | 0 | 0 | 3 | 6 | 0 |

## Table 5.12(l) Area (l) ‘Kent’ in Southern (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (206) | (66) | (79) | (42) | (15) | (4) |
| Sewage Treatment Works (STW) | . | . | 34 | 14 | 40 | 46 | 54 | 50 |
| No perceived problem | . | . | 24 | 50 | 16 | 8 | 0 | 0 |
| Sampling difficulty | . | . | 15 | 10 | 25 | 5 | 14 | 0 |
| Low flow | . | . | 14 | 13 | 12 | 22 | 7 | 0 |
| Run-off | . | . | 13 | 5 | 14 | 17 | 20 | 50 |
| Impoundments | . | . | 13 | 8 | 17 | 15 | 14 | 0 |
| Channel at the site | . | . | 12 | 13 | 12 | 15 | 7 | 0 |
| Other | . | . | 11 | 2 | 16 | 15 | 20 | 0 |
| Farming | . | . | 9 | 13 | 11 | 5 | 0 | 0 |
| Land use | . | . | 8 | 2 | 11 | 10 | 14 | 0 |
| Pesticides | . | . | 7 | 8 | 4 | 10 | 7 | 25 |
| Sediment at the site | . | . | 6 | 0 | 6 | 17 | 7 | 0 |
| Industrial discharge | . | . | 3 | 0 | 2 | 5 | 7 | 50 |
| Saline | . | . | 3 | 0 | 6 | 3 | 0 | 0 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 32 | 14 | 37 | 43 | 47 | 25 |
| No perceived problem | NP | No perceived problem | 24 | 50 | 16 | 8 | 0 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 14 | 10 | 23 | 5 | 14 | 0 |
| Run-off | UR | Urban run-off | 9 | 4 | 8 | 15 | 14 | 25 |
| Low flow | LF | Low flow | 9 | 5 | 9 | 17 | 7 | 0 |
| Channel at the site | BG | Bridge | 8 | 10 | 8 | 5 | 7 | 0 |
| Pesticides | PE | Pesticides | 7 | 8 | 4 | 8 | 7 | 25 |
| Other | MY | Stress could not be identified(mystery) | 7 | 0 | 8 | 12 | 14 | 0 |
| Farming | FA | Farming | 6 | 8 | 8 | 0 | 0 | 0 |
| Sediment at the site | IS | Inert siltation | 6 | 0 | 6 | 17 | 7 | 0 |
| Land use | IA | Intensive arablisation | 6 | 0 | 7 | 10 | 14 | 0 |
| Channel at the site | CA | Channelisation | 4 | 4 | 4 | 5 | 7 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 4 | 0 | 7 | 8 | 0 | 0 |
| Impoundments | LP | Lake or pond close u/s | 4 | 4 | 4 | 5 | 0 | 0 |
| Other | OH | Ochre | 4 | 2 | 7 | 3 | 0 | 0 |
| Farming | FE | Fertilisers | 3 | 4 | 3 | 5 | 0 | 0 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 3 | 0 | 6 | 3 | 7 | 0 |
| Run-off | LR | Light industry/commercial run-off | 3 | 2 | 6 | 0 | 7 | 0 |
| Impoundments | WE | Weirs | 3 | 4 | 3 | 0 | 7 | 0 |

**Table 5.12(m) Area (m) ‘Sussex’ in Southern (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (123) | (75) | (40) | (6) | (2) | (0) |
| Waste | . | . | 57 | 66 | 45 | 34 | 50 | |
| Sewage Treatment Works (STW) | . | . | 44 | 42 | 45 | 67 | 0 | |
| Low flow | . | . | 21 | 18 | 20 | 50 | 50 | |
| Impoundments | . | . | 20 | 19 | 23 | 17 | 0 | |
| Sampling difficulty | . | . | 18 | 19 | 15 | 34 | 0 | |
| Run-off | . | . | 17 | 15 | 15 | 50 | 0 | |
| Farming | . | . | 14 | 14 | 15 | 0 | 0 | |
| Choked channel (>33% plant) | . | . | 12 | 8 | 15 | 17 | 50 | |
| Agri-industry | . | . | 11 | 14 | 8 | 0 | 0 | |
| Sediment at the site | . | . | 9 | 10 | 8 | 0 | 0 | |
| Land use | . | . | 9 | 6 | 10 | 17 | 50 | |
| Leachate | . | . | 5 | 2 | 8 | 34 | 0 | |
| Channel Management | . | . | 4 | 0 | 3 | 34 | 50 | |
| Other | . | . | 4 | 2 | 8 | 0 | 0 | |
| Industrial discharge | . | . | 3 | 2 | 3 | 17 | 0 | |
| | | | | | | | | |
| Waste | SL | Slurry | 56 | 66 | 43 | 17 | 50 | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 42 | 40 | 45 | 50 | 0 | |
| Sampling difficulty | DR | Dredge used to sample | 18 | 18 | 15 | 34 | 0 | |
| Low flow | LF | Low flow | 14 | 8 | 18 | 50 | 0 | |
| Impoundments | RF | Regulated flow | 13 | 12 | 15 | 0 | 0 | |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 12 | 8 | 15 | 17 | 50 | |
| Agri-industry | DA | Dairy | 11 | 14 | 8 | 0 | 0 | |
| Farming | FE | Fertilisers | 9 | 7 | 15 | 0 | 0 | |
| Sediment at the site | IS | Inert siltation | 9 | 10 | 8 | 0 | 0 | |
| Run-off | UR | Urban run-off | 9 | 6 | 10 | 50 | 0 | |
| Land use | IA | Intensive arablisation | 9 | 6 | 10 | 17 | 50 | |
| Run-off | HR | Heavy industry run-off | 8 | 7 | 10 | 0 | 0 | |
| Leachate | DL | Domestic landfill | 5 | 0 | 8 | 34 | 0 | |
| Low flow | IR | Abstraction for irrigation | 5 | 6 | 3 | 0 | 50 | |
| Impoundments | LP | Lake or pond close u/s | 4 | 0 | 8 | 17 | 0 | |
| Other | MY | Stress could not be identified(mystery) | 4 | 2 | 8 | 0 | 0 | |
| Farming | FA | Farming | 3 | 4 | 0 | 0 | 0 | |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 3 | 2 | 3 | 17 | 0 | |
| Channel Management | WD | Weed cutting | 3 | 0 | 3 | 17 | 50 | |

**Table 5.12(n) Area (n) 'Hampshire' in Southern (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (140) | (54) | (42) | (27) | (15) | (2) |
| Low flow | . | . | 23 | 17 | 27 | 26 | 27 | 0 |
| Bank practices at the site | . | . | 22 | 30 | 15 | 15 | 27 | 0 |
| Land use | . | . | 21 | 6 | 15 | 34 | 60 | 100 |
| Sewage Treatment Works (STW) | . | . | 18 | 25 | 10 | 12 | 27 | 50 |
| Run-off | . | . | 18 | 6 | 15 | 38 | 40 | 0 |
| Farming | . | . | 15 | 23 | 12 | 8 | 7 | 0 |
| Sediment at the site | . | . | 15 | 17 | 12 | 8 | 20 | 50 |
| Impoundments | . | . | 15 | 19 | 10 | 15 | 14 | 50 |
| Waste | . | . | 14 | 8 | 27 | 8 | 7 | 50 |
| Channel Management | . | . | 13 | 28 | 3 | 0 | 7 | 0 |
| Oils, petrochemicals | . | . | 11 | 2 | 5 | 26 | 27 | 50 |
| Industrial discharge | . | . | 7 | 4 | 3 | 8 | 27 | 0 |
| No perceived problem | . | . | 6 | 12 | 5 | 0 | 0 | 0 |
| Other | . | . | 6 | 2 | 8 | 12 | 0 | 50 |
| Choked channel (>33% plant) | . | . | 5 | 0 | 10 | 8 | 0 | 50 |
| No information | . | . | 5 | 4 | 10 | 4 | 0 | 0 |
| Pesticides | . | . | 3 | 0 | 0 | 4 | 14 | 0 |
| Channel at the site | . | . | 3 | 0 | 0 | 4 | 14 | 0 |
| No flow | . | . | 3 | 0 | 3 | 8 | 0 | 0 |
| | | | | | | | | |
| Low flow | LF | Low flow | 17 | 8 | 22 | 23 | 27 | 0 |
| Sediment at the site | IS | Inert siltation | 15 | 17 | 12 | 8 | 20 | 50 |
| Bank practices at the site | MO | Mown/managed riparian zone | 15 | 23 | 3 | 12 | 27 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 13 | 21 | 8 | 8 | 14 | 0 |
| Land use | US | Urban/suburban | 13 | 2 | 10 | 19 | 47 | 50 |
| Waste | SL | Slurry | 12 | 8 | 20 | 8 | 7 | 50 |
| Channel Management | WD | Weed cutting | 12 | 28 | 3 | 0 | 0 | 0 |
| Oils, petrochemicals | FO | Fuel (diesel/petrol) | 10 | 2 | 5 | 19 | 27 | 50 |
| Farming | FF | Fish farm | 8 | 19 | 0 | 0 | 0 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 8 | 8 | 12 | 4 | 0 | 0 |
| Impoundments | WE | Weirs | 8 | 13 | 5 | 4 | 7 | 0 |
| Run-off | UR | Urban run-off | 7 | 4 | 0 | 19 | 14 | 0 |
| Run-off | HY | Highway run-off (including salt) | 7 | 2 | 5 | 8 | 27 | 0 |
| Land use | IA | Intensive arablisation | 7 | 0 | 5 | 15 | 14 | 50 |
| Run-off | HR | Heavy industry run-off | 6 | 0 | 8 | 15 | 7 | 0 |
| No perceived problem | NP | No perceived problem | 6 | 12 | 5 | 0 | 0 | 0 |
| Farming | FA | Farming | 5 | 2 | 10 | 8 | 0 | 0 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works (STW) | 5 | 4 | 3 | 4 | 14 | 50 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 5 | 0 | 10 | 8 | 0 | 50 |
| Impoundments | LP | Lake or pond close u/s | 5 | 4 | 5 | 4 | 7 | 50 |
| No information | NI | No information | 5 | 4 | 10 | 4 | 0 | 0 |
| Other | OH | Ochre | 5 | 2 | 5 | 8 | 0 | 50 |
| Farming | WC | Water cress beds | 3 | 6 | 3 | 0 | 0 | 0 |
| Waste | PI | Piggery waste | 3 | 0 | 5 | 4 | 0 | 0 |
| Industrial discharge | LI | Light industry/commercial | 3 | 0 | 0 | 4 | 20 | 0 |
| Run-off | LR | Light industry/commercial run-off | 3 | 0 | 3 | 12 | 0 | 0 |
| Low flow | AP | Abstraction for public supply | 3 | 6 | 0 | 0 | 0 | 0 |
| Low flow | AR | Abstraction from river | 3 | 4 | 3 | 4 | 0 | 0 |

### Table 5.12(o) Area (o) ‘Cornwall’ in South West (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (185) | (78) | (75) | (18) | (5) | (9) |
| Mining, quarries and extraction | . | . | 34 | 15 | 32 | 73 | 100 | 100 |
| Agri-industry | . | . | 23 | 35 | 16 | 12 | 0 | 0 |
| Sewage Treatment Works (STW) | . | . | 23 | 16 | 30 | 34 | 20 | 0 |
| Impoundments | . | . | 16 | 16 | 15 | 28 | 0 | 0 |
| Other | . | . | 14 | 6 | 8 | 28 | 40 | 89 |
| Land use | . | . | 12 | 16 | 8 | 12 | 20 | 12 |
| Farming | . | . | 11 | 11 | 14 | 6 | 0 | 0 |
| No perceived problem | . | . | 10 | 16 | 8 | 0 | 0 | 0 |
| Low flow | . | . | 7 | 3 | 14 | 0 | 0 | 0 |
| Sampling difficulty | . | . | 7 | 2 | 14 | 6 | 0 | 0 |
| Sediment at the site | . | . | 6 | 0 | 3 | 6 | 20 | 78 |
| Channel at the site | . | . | 5 | 3 | 4 | 6 | 40 | 0 |
| Waste | . | . | 4 | 4 | 6 | 0 | 0 | 0 |
| Industrial discharge | . | . | 4 | 6 | 2 | 0 | 0 | 12 |
| Leachate | . | . | 3 | 3 | 2 | 6 | 20 | 0 |
| Artificial bank at the site | . | . | 3 | 2 | 3 | 12 | 0 | 0 |
| | | | | | | | | |
| Mining, quarries and extraction | MM | Metal mine drainage | 24 | 8 | 23 | 62 | 80 | 56 |
| Agri-industry | DA | Dairy | 22 | 34 | 16 | 12 | 0 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 18 | 12 | 26 | 17 | 20 | 0 |
| Mining, quarries and extraction | CC | China clay extraction | 14 | 7 | 11 | 34 | 40 | 45 |
| Impoundments | RE | Reservoir u/s catchment | 11 | 9 | 12 | 17 | 0 | 0 |
| No perceived problem | NP | No perceived problem | 10 | 16 | 8 | 0 | 0 | 0 |
| Other | OH | Ochre | 10 | 2 | 3 | 28 | 40 | 89 |
| Impoundments | RF | Regulated flow | 6 | 3 | 11 | 0 | 0 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 6 | 2 | 12 | 0 | 0 | 0 |
| Farming | EU | Eutrophication | 5 | 7 | 4 | 6 | 0 | 0 |
| Land use | CF | Afforestation (conifer) | 5 | 11 | 2 | 0 | 0 | 0 |
| Land use | US | Urban/suburban | 5 | 4 | 4 | 12 | 20 | 0 |
| Farming | FF | Fish farm | 4 | 2 | 7 | 0 | 0 | 0 |
| Sediment at the site | TX | Contaminated sediment | 4 | 0 | 0 | 0 | 20 | 56 |
| Sewage Treatment Works (STW) | SE | Septic tank | 4 | 3 | 4 | 12 | 0 | 0 |
| Channel at the site | CA | Channelisation | 4 | 2 | 4 | 6 | 40 | 0 |
| Low flow | AP | Abstraction for public supply | 4 | 3 | 6 | 0 | 0 | 0 |
| Low flow | AR | Abstraction from river | 4 | 0 | 8 | 0 | 0 | 0 |
| Waste | SR | Sludge applied to land | 3 | 3 | 4 | 0 | 0 | 0 |
| Leachate | DL | Domestic landfill | 3 | 3 | 2 | 6 | 20 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 3 | 2 | 2 | 12 | 0 | 0 |
| Impoundments | FT | Freshwater but tidal | 3 | 4 | 2 | 0 | 0 | 0 |
| Land use | RB | Reedbed at the site | 3 | 3 | 3 | 0 | 0 | 12 |
| Other | MY | Stress could not be identified (mystery) | 3 | 3 | 3 | 0 | 0 | 0 |

## Table 5.12(p) Area (p) 'Devon' in South West (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses |  | Overall % (318) | Grade |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  | a | b | c | d | e/f |
|  | Code | Full name |  | (176) | (119) | (19) | (4) | (0) |
| Farming | . | . | 43 | 46 | 40 | 37 | 25 |  |
| Run-off | . | . | 32 | 29 | 37 | 27 | 25 |  |
| Bank practices at the site | . | . | 22 | 26 | 18 | 6 | 0 |  |
| Land use | . | . | 22 | 19 | 27 | 22 | 0 |  |
| Sampling difficulty | . | . | 21 | 15 | 27 | 43 | 25 |  |
| Other | . | . | 18 | 16 | 19 | 37 | 25 |  |
| Sewage Treatment Works (STW) | . | . | 13 | 11 | 16 | 16 | 25 |  |
| Bank erosion | . | . | 13 | 15 | 12 | 0 | 25 |  |
| Channel at the site | . | . | 11 | 11 | 10 | 11 | 0 |  |
| Artificial bank at the site | . | . | 10 | 7 | 13 | 22 | 0 |  |
| Impoundments | . | . | 9 | 8 | 9 | 16 | 0 |  |
| Mining, quarries and extraction | . | . | 6 | 8 | 4 | 0 | 0 |  |
| No perceived problem | . | . | 4 | 6 | 2 | 0 | 0 |  |
| Agri-industry | . | . | 3 | 1 | 6 | 11 | 0 |  |
| Industrial discharge | . | . | 3 | 2 | 4 | 11 | 0 |  |
| Choked channel (>33% plant) | . | . | 3 | 0 | 5 | 6 | 25 |  |
| Low flow | . | . | 3 | 2 | 4 | 11 | 0 |  |
|  |  |  |  |  |  |  |  |  |
| Farming | FE | Fertilisers | 39 | 41 | 40 | 22 | 25 |  |
| Run-off | HY | Highway run-off (including salt) | 22 | 20 | 25 | 16 | 25 |  |
| Bank practices at the site | LV | Livestock poaching, trampling | 20 | 24 | 17 | 0 | 0 |  |
| Sampling difficulty | BO | Bouldery site sampling difficult | 17 | 14 | 22 | 22 | 0 |  |
| Land use | MD | Moorland drainage | 14 | 10 | 19 | 16 | 0 |  |
| Other | SF | Sewage fungus | 13 | 12 | 13 | 27 | 0 |  |
| Farming | FA | Farming | 12 | 15 | 7 | 16 | 0 |  |
| Run-off | UR | Urban run-off | 12 | 10 | 15 | 6 | 0 |  |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 11 | 10 | 13 | 11 | 0 |  |
| Channel at the site | BE | Bedrock | 10 | 11 | 9 | 11 | 0 |  |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 8 | 4 | 11 | 22 | 0 |  |
| Land use | CF | Afforestation (conifer) | 8 | 9 | 7 | 0 | 0 |  |
| Bank erosion | EC | Clay bank erosion | 8 | 10 | 6 | 0 | 0 |  |
| Bank erosion | ES | Sand bank erosion | 6 | 6 | 6 | 0 | 25 |  |
| Run-off | RR | Railway run-off | 5 | 6 | 3 | 11 | 0 |  |
| Sampling difficulty | DR | Dredge used to sample | 5 | 2 | 6 | 22 | 25 |  |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 4 | 6 | 2 | 0 | 0 |  |
| Impoundments | RE | Reservoir u/s catchment | 4 | 4 | 4 | 6 | 0 |  |
| No perceived problem | NP | No perceived problem | 4 | 6 | 2 | 0 | 0 |  |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 3 | 0 | 5 | 6 | 25 |  |
| Impoundments | WE | Weirs | 3 | 2 | 4 | 6 | 0 |  |
| Low flow | LF | Low flow | 3 | 2 | 4 | 11 | 0 |  |
| Land use | US | Urban/suburban | 3 | 2 | 3 | 6 | 0 |  |
| Other | OH | Ochre | 3 | 2 | 3 | 11 | 0 |  |
| Other | CL | Cladophora | 3 | 3 | 3 | 0 | 0 |  |

**Table 5.12(r) Area (r) 'Northern' in Welsh (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (204) | (67) | (95) | (30) | (9) | (3) |
| Sampling difficulty | . | . | 22 | 18 | 19 | 37 | 23 | 34 |
| No perceived problem | . | . | 21 | 44 | 14 | 0 | 0 | 0 |
| Farming | . | . | 18 | 15 | 16 | 37 | 0 | 0 |
| Sewage Treatment Works (STW) | . | . | 14 | 6 | 16 | 7 | 67 | 34 |
| Land use | . | . | 13 | 6 | 14 | 24 | 23 | 0 |
| Sediment at the site | . | . | 11 | 11 | 9 | 20 | 0 | 0 |
| Industrial discharge | . | . | 9 | 5 | 10 | 14 | 12 | 0 |
| Impoundments | . | . | 9 | 3 | 9 | 17 | 12 | 34 |
| Bank erosion | . | . | 9 | 8 | 5 | 20 | 12 | 34 |
| Channel at the site | . | . | 7 | 5 | 8 | 10 | 12 | 0 |
| Bank practices at the site | . | . | 7 | 6 | 10 | 4 | 0 | 0 |
| Mining, quarries and extraction | . | . | 6 | 5 | 3 | 17 | 12 | 0 |
| Run-off | . | . | 4 | 0 | 8 | 0 | 12 | 0 |
| Acid deposition | . | . | 4 | 2 | 6 | 4 | 12 | 0 |
| | | | | | | | | |
| No perceived problem | NP | No perceived problem | 21 | 44 | 14 | 0 | 0 | 0 |
| Farming | FA | Farming | 18 | 15 | 15 | 37 | 0 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 16 | 15 | 17 | 14 | 12 | 0 |
| Land use | CF | Afforestation (conifer) | 9 | 5 | 8 | 20 | 23 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 7 | 2 | 12 | 4 | 12 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 7 | 6 | 10 | 4 | 0 | 0 |
| Bank erosion | ES | Sand bank erosion | 7 | 6 | 3 | 20 | 12 | 34 |
| Sampling difficulty | AC | Access to one bank only | 7 | 3 | 3 | 24 | 12 | 34 |
| Sediment at the site | IS | Inert siltation | 6 | 3 | 6 | 14 | 0 | 0 |
| Impoundments | FT | Freshwater but tidal | 6 | 2 | 5 | 17 | 0 | 34 |
| Sediment at the site | GS | Eroded gravel/boulders in channel | 5 | 8 | 4 | 7 | 0 | 0 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 5 | 0 | 5 | 4 | 45 | 0 |
| Channel at the site | BG | Bridge | 5 | 5 | 6 | 0 | 12 | 0 |
| Industrial discharge | ID | Industrial discharge | 4 | 0 | 4 | 10 | 12 | 0 |
| Industrial discharge | LI | Light industry/commercial | 4 | 5 | 5 | 4 | 0 | 0 |
| Acid deposition | AD | Acid deposition | 4 | 2 | 6 | 4 | 12 | 0 |
| Mining, quarries and extraction | MM | Metal mine drainage | 4 | 5 | 2 | 10 | 12 | 0 |
| Land use | MD | Moorland drainage | 4 | 2 | 7 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 3 | 3 | 3 | 0 | 12 | 34 |

**Table 5.12(s) Area (s) 'South West' in Welsh (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (273) | (133) | (117) | (20) | (2) | (1) |
| No perceived problem | . | . | 42 | 57 | 33 | 5 | 0 | 0 |
| Sewage Treatment Works (STW) | . | . | 22 | 17 | 24 | 45 | 50 | 0 |
| Acid deposition | . | . | 13 | 2 | 23 | 20 | 0 | 100 |
| Mining, quarries and extraction | . | . | 10 | 3 | 16 | 15 | 0 | 100 |
| Sediment at the site | . | . | 9 | 9 | 7 | 15 | 50 | 0 |
| Waste | . | . | 7 | 8 | 6 | 0 | 0 | 0 |
| Other | . | . | 7 | 6 | 7 | 5 | 50 | 100 |
| Impoundments | . | . | 6 | 3 | 9 | 10 | 50 | 0 |
| Land use | . | . | 6 | 1 | 9 | 15 | 0 | 0 |
| Artificial bank at the site | . | . | 5 | 5 | 5 | 0 | 0 | 0 |
| Industrial discharge | . | . | 4 | 3 | 3 | 20 | 0 | 0 |
| Channel at the site | . | . | 3 | 3 | 3 | 10 | 0 | 0 |
| Reclaimed land | . | . | 3 | 1 | 4 | 10 | 0 | 0 |
| | | | | | | | | |
| No perceived problem | NP | No perceived problem | 42 | 57 | 33 | 5 | 0 | 0 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 14 | 9 | 17 | 40 | 0 | 0 |
| Acid deposition | AD | Acid deposition | 13 | 2 | 23 | 20 | 0 | 100 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 11 | 10 | 13 | 5 | 50 | 0 |
| Sediment at the site | IS | Inert siltation | 9 | 9 | 7 | 10 | 50 | 0 |
| Waste | SL | Slurry | 7 | 8 | 6 | 0 | 0 | 0 |
| Mining, quarries and extraction | MM | Metal mine drainage | 6 | 1 | 12 | 10 | 0 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 6 | 1 | 9 | 10 | 50 | 0 |
| Impoundments | RF | Regulated flow | 5 | 2 | 6 | 5 | 50 | 0 |
| Land use | CF | Afforestation (conifer) | 5 | 1 | 9 | 5 | 0 | 0 |
| Mining, quarries and extraction | CM | Coal mine drainage | 4 | 2 | 5 | 5 | 0 | 100 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 4 | 4 | 4 | 0 | 0 | 0 |
| Channel at the site | CA | Channelisation | 3 | 3 | 3 | 10 | 0 | 0 |
| Other | SF | Sewage fungus | 3 | 2 | 5 | 0 | 50 | 0 |
| Other | OH | Ochre | 3 | 3 | 3 | 5 | 0 | 100 |

## Table 5.12(t) Area (t) 'South East' in Welsh (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (319) | (109) | (100) | (81) | (21) | (8) |
| Sewage Treatment Works (STW) | . | . | 38 | 7 | 36 | 66 | 81 | 88 |
| Run-off | . | . | 29 | 0 | 25 | 56 | 72 | 75 |
| Other | . | . | 25 | 9 | 24 | 36 | 58 | 38 |
| No perceived problem | . | . | 22 | 45 | 17 | 4 | 0 | 0 |
| Artificial bank at the site | . | . | 14 | 10 | 9 | 21 | 15 | 50 |
| Bank practices at the site | . | . | 11 | 19 | 11 | 5 | 0 | 0 |
| Channel at the site | . | . | 10 | 7 | 11 | 12 | 5 | 13 |
| Impoundments | . | . | 7 | 4 | 7 | 10 | 10 | 13 |
| Industrial discharge | . | . | 6 | 1 | 3 | 9 | 15 | 25 |
| Mining, quarries and extraction | . | . | 6 | 0 | 4 | 10 | 15 | 25 |
| Sampling difficulty | . | . | 6 | 10 | 3 | 4 | 5 | 13 |
| Sediment at the site | . | . | 5 | 6 | 5 | 4 | 5 | 0 |
| Land use | . | . | 5 | 2 | 5 | 5 | 10 | 0 |
| Acid deposition | . | . | 4 | 1 | 4 | 4 | 5 | 13 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 34 | 1 | 32 | 62 | 81 | 88 |
| Run-off | RO | Run-off | 28 | 0 | 24 | 54 | 72 | 75 |
| No perceived problem | NP | No perceived problem | 22 | 45 | 17 | 4 | 0 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 11 | 18 | 9 | 5 | 0 | 0 |
| Other | CL | Cladophora | 11 | 3 | 11 | 18 | 29 | 13 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 9 | 7 | 7 | 10 | 0 | 50 |
| Other | MY | Stress could not be identified (mystery) | 7 | 5 | 8 | 8 | 5 | 0 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 6 | 6 | 6 | 7 | 5 | 0 |
| Channel at the site | BE | Bedrock | 6 | 7 | 8 | 3 | 0 | 0 |
| Artificial bank at the site | UC | Unconsolidated (Rip-rap/boulder) | 6 | 3 | 3 | 12 | 15 | 0 |
| Impoundments | WE | Weirs | 6 | 4 | 5 | 8 | 5 | 0 |
| Other | OH | Ochre | 6 | 0 | 3 | 10 | 20 | 25 |
| Industrial discharge | LI | Light industry/commercial | 5 | 1 | 2 | 8 | 10 | 25 |
| Sediment at the site | IS | Inert siltation | 5 | 6 | 5 | 4 | 5 | 0 |
| Mining, quarries and extraction | CM | Coal mine drainage | 5 | 0 | 3 | 9 | 15 | 25 |
| Acid deposition | AD | Acid deposition | 4 | 1 | 4 | 4 | 5 | 13 |
| Sampling difficulty | AC | Access to one bank only | 4 | 8 | 2 | 0 | 0 | 0 |
| Other | SF | Sewage fungus | 4 | 1 | 4 | 5 | 10 | 13 |
| Channel at the site | CA | Channelisation | 3 | 0 | 3 | 7 | 0 | 0 |

**Table 5.12(v) Area (v) 'Ridings – West (including Aire catchment)' in Yorkshire (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (296) | (14) | (40) | (65) | (85) | (92) |
| Sewage Treatment Works (STW) | . | . | 60 | 22 | 35 | 45 | 63 | 84 |
| Run-off | . | . | 42 | 15 | 18 | 33 | 42 | 62 |
| Industrial discharge | . | . | 20 | 0 | 3 | 8 | 10 | 48 |
| Sediment at the site | . | . | 12 | 0 | 5 | 13 | 13 | 16 |
| Mining, quarries and extraction | . | . | 10 | 0 | 18 | 10 | 15 | 5 |
| Leachate | . | . | 7 | 0 | 0 | 2 | 11 | 10 |
| No perceived problem | . | . | 7 | 50 | 28 | 2 | 0 | 0 |
| Farming | . | . | 5 | 0 | 8 | 5 | 5 | 4 |
| Pesticides | . | . | 5 | 8 | 5 | 5 | 5 | 3 |
| Impoundments | . | . | 5 | 0 | 0 | 10 | 5 | 4 |
| Other | . | . | 5 | 0 | 3 | 11 | 4 | 2 |
| Low flow | . | . | 4 | 8 | 5 | 4 | 6 | 2 |
| Sampling difficulty | . | . | 4 | 0 | 0 | 4 | 0 | 9 |
| Channel at the site | . | . | 3 | 0 | 3 | 5 | 2 | 2 |
| Land use | . | . | 3 | 15 | 3 | 5 | 2 | 0 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 39 | 15 | 25 | 33 | 46 | 45 |
| Run-off | UR | Urban run-off | 37 | 8 | 18 | 27 | 35 | 60 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 29 | 8 | 10 | 17 | 28 | 48 |
| Industrial discharge | HI | Heavy industry | 18 | 0 | 3 | 8 | 8 | 44 |
| Mining, quarries and extraction | CM | Coal mine drainage | 10 | 0 | 15 | 10 | 15 | 5 |
| Sediment at the site | IS | Inert siltation | 9 | 0 | 5 | 10 | 11 | 9 |
| No perceived problem | NP | No perceived problem | 7 | 50 | 28 | 2 | 0 | 0 |
| Leachate | TI | Toxic/industrial landfill | 5 | 0 | 0 | 2 | 6 | 9 |
| Run-off | HY | Highway run-off (including salt) | 5 | 0 | 3 | 5 | 9 | 2 |
| Farming | FA | Farming | 4 | 0 | 3 | 5 | 4 | 4 |
| Sediment at the site | TX | Contaminated sediment | 4 | 0 | 0 | 4 | 3 | 8 |
| Low flow | LF | Low flow | 4 | 8 | 5 | 2 | 5 | 2 |
| Pesticides | IN | Insecticides | 3 | 0 | 3 | 2 | 3 | 3 |
| Run-off | HR | Heavy industry run-off | 3 | 0 | 0 | 5 | 2 | 4 |
| Channel at the site | CA | Channelisation | 3 | 0 | 3 | 5 | 2 | 2 |
| Impoundments | RF | Regulated flow | 3 | 0 | 0 | 8 | 2 | 2 |
| Other | MY | Stress could not be identified(mystery) | 3 | 0 | 0 | 10 | 2 | 0 |

**Table 5.12(w) Area (w) 'Dales – (including Derwent catchment)' in Yorkshire (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (146) | (67) | (42) | (21) | (7) | (9) |
| Sewage Treatment Works (STW) | . | . | 38 | 15 | 41 | 77 | 100 | 56 |
| Farming | . | . | 29 | 17 | 41 | 48 | 43 | 12 |
| Waste | . | . | 24 | 12 | 31 | 48 | 43 | 12 |
| No perceived problem | . | . | 18 | 39 | 0 | 0 | 0 | 0 |
| Impoundments | . | . | 11 | 11 | 15 | 0 | 0 | 23 |
| Low flow | . | . | 9 | 8 | 17 | 5 | 0 | 0 |
| No information | . | . | 8 | 12 | 3 | 5 | 0 | 12 |
| Choked channel (>33% plant) | . | . | 6 | 3 | 5 | 15 | 15 | 0 |
| Sampling difficulty | . | . | 6 | 8 | 5 | 0 | 0 | 12 |
| Other | . | . | 6 | 5 | 8 | 10 | 0 | 0 |
| Channel Management | . | . | 5 | 2 | 8 | 5 | 15 | 0 |
| Pesticides | . | . | 3 | 0 | 5 | 5 | 0 | 0 |
| Run-off | . | . | 3 | 0 | 3 | 5 | 15 | 0 |
| | | | | | | | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 30 | 9 | 31 | 67 | 86 | 45 |
| Farming | FE | Fertilisers | 24 | 12 | 31 | 48 | 43 | 12 |
| Waste | SL | Slurry | 24 | 12 | 31 | 48 | 43 | 12 |
| No perceived problem | NP | No perceived problem | 18 | 39 | 0 | 0 | 0 | 0 |
| Low flow | AP | Abstraction for public supply | 8 | 8 | 12 | 5 | 0 | 0 |
| No information | NI | No information | 8 | 12 | 3 | 5 | 0 | 12 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 7 | 2 | 10 | 10 | 15 | 12 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 6 | 3 | 5 | 15 | 15 | 0 |
| Channel Management | WD | Weed cutting | 5 | 2 | 8 | 5 | 15 | 0 |
| Low flow | DT | Drought | 5 | 5 | 8 | 5 | 0 | 0 |
| Sampling difficulty | AL | Air-lift used to sample | 5 | 6 | 5 | 0 | 0 | 12 |
| Other | MY | Stress could not be identified(mystery) | 5 | 5 | 8 | 5 | 0 | 0 |
| Farming | FF | Fish farm | 4 | 5 | 5 | 0 | 0 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 4 | 5 | 5 | 0 | 0 | 0 |
| Farming | FA | Farming | 3 | 2 | 5 | 0 | 0 | 0 |
| Pesticides | SD | Sheep-dip | 3 | 0 | 5 | 5 | 0 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 3 | 5 | 0 | 0 | 0 | 0 |
| Impoundments | RF | Regulated flow | 3 | 5 | 0 | 0 | 0 | 0 |
| Impoundments | WE | Weirs | 3 | 3 | 5 | 0 | 0 | 0 |
| Impoundments | FT | Freshwater but tidal | 3 | 0 | 3 | 0 | 0 | 23 |

**Table 5.12(x) Area (x) ‘Ridings – East (including Hull)’ in Yorkshire (NRA) Region: percentage frequency of occurrence of each of the environmental stress types identified amongst the GQA sites in each overall grade (a-f, bias-corrected) in 1995; details as for Table 5.12(a).**

| Major stress name | Individual stresses | | Overall % | Grade | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | a | b | c | d | e/f |
| | Code | Full name | (20) | (5) | (7) | (8) | (0) | (0) |
| Farming | . | . | 45 | 80 | 58 | 13 | | |
| Sampling difficulty | . | . | 30 | 80 | 29 | 0 | | |
| Sewage Treatment Works (STW) | . | . | 20 | 0 | 15 | 38 | | |
| Channel Management | . | . | 20 | 20 | 0 | 38 | | |
| No information | . | . | 10 | 0 | 0 | 25 | | |
| Other | . | . | 10 | 0 | 0 | 25 | | |
| Waste | . | . | 5 | 0 | 15 | 0 | | |
| Agri-industry | . | . | 5 | 0 | 0 | 13 | | |
| Sediment at the site | . | . | 5 | 0 | 0 | 13 | | |
| Run-off | . | . | 5 | 0 | 15 | 0 | | |
| Impoundments | . | . | 5 | 20 | 0 | 0 | | |
| Saline | . | . | 5 | 0 | 15 | 0 | | |
| | | | | | | | | |
| Farming | FF | Fish farm | 25 | 40 | 43 | 0 | | |
| Farming | FA | Farming | 20 | 40 | 15 | 13 | | |
| Sampling difficulty | AL | Air-lift used to sample | 20 | 40 | 29 | 0 | | |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 15 | 0 | 15 | 25 | | |
| Channel Management | DN | Dredging | 15 | 20 | 0 | 25 | | |
| Channel Management | WD | Weed cutting | 10 | 20 | 0 | 13 | | |
| Sampling difficulty | DR | Dredge used to sample | 10 | 40 | 0 | 0 | | |
| No information | NI | No information | 10 | 0 | 0 | 25 | | |
| Other | OH | Ochre | 10 | 0 | 0 | 25 | | |
| Waste | PI | Piggery waste | 5 | 0 | 15 | 0 | | |
| Agri-industry | DA | Dairy | 5 | 0 | 0 | 13 | | |
| Sediment at the site | TX | Contaminated sediment | 5 | 0 | 0 | 13 | | |
| Sewage Treatment Works (STW) | SE | Septic tank | 5 | 0 | 0 | 13 | | |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 5 | 0 | 0 | 13 | | |
| Run-off | LR | Light industry/commercial run-off | 5 | 0 | 15 | 0 | | |
| Impoundments | WE | Weirs | 5 | 20 | 0 | 0 | | |
| Saline | MA | Marine origin | 5 | 0 | 15 | 0 | | |

## 5.4 Environmental Stresses in Relation to Change in Biological Grade

### 5.4.1 Frequency of environmental stresses in relation to change in biological grade

Ideally, changes in biological condition would be assessed in relation to perceived changes in the type and severity of environmental stress. However, at present, such information is not, to our knowledge, collected in a standardised form on a national basis. It is considered advantageous that such information is collected routinely in the future.

From the responses to the questionnaire devised within this project, we have information on the perceived types of environmental stress thought to operating on each GQA site at the time of the 1995 survey (Appendix 1).

The extent to which the changes in quality between the 1990 RQS and 1995 GQA surveys can be associated with the type and severity of environmental stresses potentially impacting upon each site at the time of the second survey in 1995 was assessed. One aim was to assess whether the biological effects caused by particular types of stress had been alleviated or decreased between the two surveys. These analyses were based on the 3018 matched sites.

Change in biological condition can be defined in several ways, based on change in EQI or change in grade, using either just the simple "face" change in EQI or grade, or involving some probabilistic assessment of change based on RIVPACS III+ (see section 4.1). For these analyses, the change for a site between 1990 and 1995 was based on one of the two probabilistic definitions of change in overall grade (corrected for bias) defined in section 4.1.2, namely 'likelihood of a change in grade' or 'most probable change in grade'.

Table 5.13 shows the percentage frequency of occurrence of individual and major stress types amongst all matched sites in England and Wales, separately for sites in each class of 'likelihood of change in grade'. It should be noted that only 20 of the 3018 matched sites were very likely (i.e. >95%) to have deteriorated in grade.

Although initially surprising, Table 5.13 immediately shows that few, if any, of the environmental stresses had any very strong tendency to be less frequent amongst sites that had probably improved in grade and/or more frequent amongst sites which had probably deteriorated in grade. For example, stresses related to STW occurred in about half (50%) of all sites which had very likely (i.e. >95%) got worse, but also in sites which had very likely improved (54%).

This contrasts very strongly with the previous sub-section which showed numerous very strong trends between frequency of occurrence of particular stresses in 1995 and the biological grade of the site in 1995. A likely explanation is that many of the sites which were subject to a particular stress at the time of the questionnaire in 1995 were also subject to the same stress in 1990. Some of the sites with this stress may have (been) improved, others may had stayed the same in the same condition or even deteriorated.

One exception may be stresses from 'Industrial discharges' which are more frequent amongst the sites which have very likely improved condition. This may be because such industry has declined or ceased or their discharges to rivers have improved in quality. Run-off from urban areas shows a similar association with an improvement in biological grade.

Three of the 20 sites which very likely deteriorated in grade suffered from low flow problems; this is a significantly higher proportion ($p<0.05$) than amongst those sites which had been upgraded. This is not surprising as it is known that low flow problems are increasing. In fact, one might have expected stronger associations of trends in biological condition with cases of stress from low flows.

The strong relationships between frequency of environmental stresses and the biological grade in 1995, rather than with the improvement in grade since 1990, is why the relationships involving stress within each Environment Agency Region or Area within each Region have only been shown in relation to site grade in 1995, rather than change in grade (Tables 5.10 and 5.11).

Table 5.14 shows the percentage frequency of occurrence of individual and major environmental stress types amongst all matched sites in England and Wales, separately for sites in each class of "most probable change in grade". This is very informative and re-enforces the conclusions above. Amongst sites which most likely stayed the same grade between 1990 and 1995, stresses from STW, run-off, channel and sediment problems, industrial discharges and leachates were all more frequent in the poorer grade sites. Sites of a particular grade in 1995 tended, as likely as not, to have a particular stress, irrespective of whether they had improved or deteriorated in grade since 1990.

### 5.4.2 Severity of environmental stresses in relation to change in biological grade

Although there may not be strong relationships between extent and direction of change in biological condition and the occurrence of particular environmental stresses, there may be associations between the estimated severity of the stress (Table 5.1) and the direction of change in biological condition. In the following analyses, where there was no qualifier (i.e. severity code 4, see Table 5.1) for the severity of a particular stress, it was set to "light", all qualifiers of "suspected/possible/unconfirmed" were classed as "suspected".

Figure 5.1 shows the frequency of occurrence of each severity level of environmental stress due to either farming or industrial discharge for sites in each class of likelihood of change in grade. The perceived severity of impacts from farming does not seem to be related to the likelihood and direction of change in quality of sites (Figure 5.1(a)).

The pattern for industrial discharge is interesting (Figure 5.1(b)). There was a higher than average proportion of sites which had been very likely downgraded which had severe industrial discharge problems, but there was also a much higher than average proportion of sites which had industrial discharge problems, both light and severe, amongst those which had been upgraded. Thus some sites subject to severe stress from industrial discharges had become even worse quality, but far more had improved in quality since 1990.

Figure 5.2 shows the percentage of sites with each class of severity of selected environmental stress for sites in each class of 'most probable change in grade'. The over-riding trends in severity are still seen to be with grade in 1995 rather than with the direction of change in quality since 1990. However, a few observations are made.

The general stresses from ‘farming’ were considered to mostly be of light to moderate severity, although severe stresses were more common around intermediate quality sites (grades c-e) (Figure 5.2(a)). There were however, no obvious patterns of severity with direction of change in grade.

There were some suggestions that severe and moderate recorded levels of stress from eewage treatment works were more common amongst sites which had improved from grades e or f to grades d or e, than amongst sites which had deteriorated to grades d or e (Figure 5.2(b)). Severe and moderate stress from STW was also less common amongst sites which had improved from grade b or c to “a” than amongst sites which had been downgraded from “a” to b or c.

Of those sites graded e in 1995, severe levels of stress from industrial discharge were more commonly identified amongst those which had improved since 1990 than amongst those which had either stayed the same or had deteriorated. This may suggest that reductions or improvements had occurred at many known or established major sources of industrial discharge (Figure 5.2(c)).

Moderate and severe stresses from low flow problems were more common amongst sites which declined to grades e or f during the 1990’s than for sites which were already of such poor quality in 1990.

Severe levels of “urban run-off” were more commonly recorded amongst poorer condition sites which had improved than amongst other equivalent-condition sites in 1995 (Figure 5.2(f)).

**Table 5.13 Percentage frequency of occurrence of each environmental stress type amongst the matched GQA sites in relation to their "likelihood of a change in grade" (bias-corrected) between 1990 and 1995. Major, then individual stress types ordered by decreasing overall frequency of occurrence. (Total number of sites in each category given in brackets).**

| Major stress name | Individual stresses | | Overall % | Likelihood of a change in grade | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | downgraded | | | same | upgraded | | |
| | Code | Full name | (3018) | >95% (20) | >75% (80) | >50% (195) | (1780) | >50% (476) | >75% (341) | >95% (126) |
| Sewage Treatment Works | | | 41 | 50 | 50 | 39 | 39 | 44 | 44 | 54 |
| Farming | | | 28 | 25 | 25 | 24 | 27 | 32 | 33 | 24 |
| Run-off | | | 22 | 30 | 20 | 20 | 20 | 24 | 25 | 28 |
| Land use | | | 17 | 15 | 19 | 16 | 17 | 19 | 15 | 11 |
| Channel at the site | | | 15 | 15 | 9 | 12 | 13 | 18 | 17 | 24 |
| Other | | | 14 | 20 | 18 | 12 | 14 | 15 | 13 | 15 |
| Impoundments | | | 12 | 0 | 8 | 9 | 12 | 12 | 12 | 13 |
| No perceived problem | | | 12 | 5 | 5 | 10 | 14 | 11 | 10 | 10 |
| Sediment at the site | | | 11 | 5 | 12 | 7 | 11 | 13 | 12 | 8 |
| Pesticides | | | 9 | 5 | 5 | 11 | 9 | 12 | 9 | 6 |
| Sampling difficulty | | | 9 | 10 | 7 | 10 | 9 | 9 | 8 | 10 |
| Low flow | | | 8 | 15 | 7 | 9 | 8 | 8 | 7 | 5 |
| Industrial discharge | | | 7 | 10 | 8 | 5 | 6 | 7 | 7 | 17 |
| Mining, quarries and extraction | | | 7 | 5 | 17 | 6 | 7 | 6 | 7 | 6 |
| Artificial bank at the site | | | 6 | 10 | 3 | 6 | 6 | 6 | 5 | 4 |
| Waste | | | 5 | 10 | 8 | 5 | 4 | 6 | 6 | 7 |
| Agri-industry | | | 5 | 0 | 3 | 5 | 4 | 7 | 4 | 5 |
| Bank practices at the site | | | 5 | 5 | 9 | 4 | 6 | 5 | 4 | 3 |
| Leachate | | | 3 | 5 | 4 | 3 | 3 | 2 | 2 | 6 |
| Choked channel (>33% plant) | | | 3 | 15 | 0 | 2 | 3 | 5 | 4 | 4 |
| Bank erosion | | | 3 | 5 | 4 | 2 | 3 | 2 | 2 | 4 |
| No information | | | 3 | 0 | 0 | 2 | 3 | 2 | 4 | 3 |
| Oils, petrochemicals | | | 2 | 0 | 2 | 4 | 2 | 2 | 2 | 3 |
| Acid deposition | | | 2 | 0 | 3 | 2 | 2 | 1 | 2 | 1 |
| Channel Management | | | 2 | 5 | 4 | 2 | 2 | 3 | 3 | 1 |
| Construction | | | 1 | 0 | 3 | 2 | 1 | 1 | 1 | 1 |
| Water Treatment Works | | | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 1 |
| Man-made watercourse | | | 1 | 0 | 2 | 2 | 2 | 1 | 2 | 1 |
| No flow | | | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Saline | | | 1 | 0 | 2 | 1 | 1 | 1 | 1 | 0 |
| Reclaimed land | | | 1 | 0 | 2 | 0 | 1 | 1 | 1 | 2 |
| Sorting problem | | | 1 | 0 | 2 | 0 | 1 | 1 | 1 | 0 |
| | | | | | | | | | | |
| Sewage Treatment Works | TS | Treated STW effluent | 25 | 30 | 25 | 18 | 23 | 28 | 29 | 38 |
| Farming | FE | Fertilisers | 15 | 15 | 8 | 14 | 13 | 19 | 17 | 15 |
| Farming | FA | Farming | 14 | 5 | 17 | 10 | 14 | 14 | 17 | 10 |
| Run-off | UR | Urban run-off | 14 | 10 | 12 | 11 | 13 | 15 | 16 | 19 |
| No perceived problem | NP | No perceived problem | 12 | 5 | 5 | 10 | 14 | 11 | 10 | 10 |
| Sewage Treatment Works | CS | Combined sewer overflow | 10 | 5 | 18 | 9 | 9 | 11 | 13 | 14 |
| Land use | IA | Intensive arablisation | 9 | 15 | 10 | 9 | 8 | 12 | 9 | 8 |
| Other | CL | Cladophora | 9 | 10 | 7 | 4 | 9 | 11 | 9 | 9 |
| Channel at the site | CA | Channelisation | 8 | 0 | 4 | 10 | 6 | 10 | 8 | 16 |
| Sediment at the site | IS | Inert siltation | 7 | 5 | 10 | 4 | 7 | 8 | 6 | 4 |
| Sewage Treatment Works | ST | Sewage Treatment Works | 6 | 10 | 7 | 11 | 6 | 6 | 4 | 4 |
| Channel at the site | BG | Bridge | 6 | 10 | 4 | 2 | 6 | 10 | 8 | 7 |
| Land use | US | Urban/suburban | 6 | 0 | 3 | 5 | 6 | 7 | 6 | 4 |
| Pesticides | HE | Herbicides | 5 | 0 | 2 | 5 | 5 | 6 | 5 | 4 |
| Pesticides | IN | Insecticides | 5 | 0 | 2 | 6 | 5 | 6 | 5 | 4 |
| Sediment at the site | TX | Contaminated sediment | 5 | 5 | 0 | 5 | 5 | 6 | 5 | 4 |
| Run-off | HY | Highway run-off (including salt) | 5 | 10 | 3 | 5 | 4 | 7 | 5 | 6 |
| Pesticides | PE | Pesticides | 4 | 0 | 3 | 5 | 4 | 5 | 5 | 2 |
| Waste | SL | Slurry | 4 | 10 | 7 | 5 | 3 | 5 | 4 | 4 |
| Sewage Treatment Works | SS | Storm sewer overflow | 4 | 5 | 4 | 5 | 4 | 4 | 4 | 3 |
| Run-off | LR | Light industry/commercial run-off | 4 | 0 | 3 | 5 | 4 | 4 | 4 | 8 |
| Artificial bank at the site | SB | Consolidated(stone/brick/concrete | 4 | 5 | 3 | 4 | 4 | 4 | 3 | 4 |
| Bank practices at the site | LV | Livestock poaching, trampling | 4 | 0 | 9 | 4 | 5 | 4 | 3 | 3 |

**Table 5.14 Percentage frequency of occurrence of each environmental stress type amongst the 3018 matched GQA sites in relation to their "most probable change in grade" between 1990 and 1995. Major, then individual stress types ordered by decreasing total frequency of occurrence. (M = total number of sites in each category).**

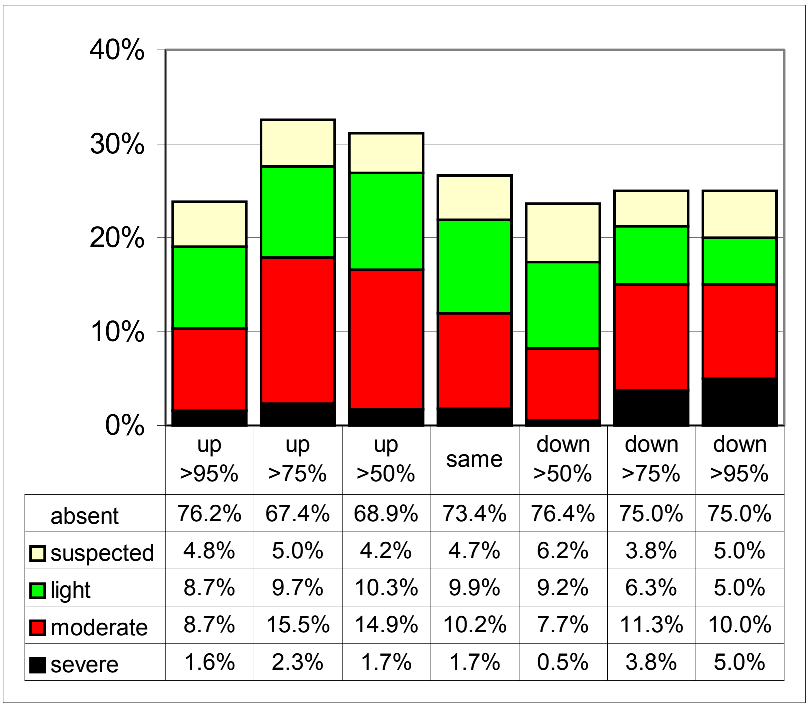
| Table 5.14 | Individual stresses | | Total | upgraded | | | | | | | | | same | | | | | | downgraded | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Major stress name | | | | b to a | c to a | c to b | d to a/b | d to c | e to a/b/c | e to d | f to c/d | f to e | a | b | c | d | e | f | a to b | a to c | b to c/d/e | c to d/e | d to e/f | e to f |
| | Code | Full name M→ | | 294 | 49 | 247 | 27 | 132 | 37 | 66 | 16 | 20 | 591 | 621 | 377 | 157 | 94 | 16 | 118 | 15 | 69 | 49 | 19 | 4 |
| Sewage Treatment Works (STW) | . | . . . . . | 41 | 27 | 41 | 46 | 45 | 54 | 65 | 78 | 63 | 80 | 20 | 31 | 59 | 71 | 82 | 82 | 28 | 27 | 43 | 64 | 69 | 100 |
| Farming | . | . . . . . | 28 | 32 | 31 | 38 | 23 | 32 | 22 | 11 | 32 | 0 | 24 | 32 | 33 | 18 | 14 | 19 | 27 | 20 | 25 | 21 | 22 | 0 |
| Run-off | . | . . . . . | 22 | 9 | 17 | 21 | 30 | 37 | 46 | 61 | 57 | 70 | 7 | 11 | 33 | 46 | 61 | 69 | 9 | 14 | 16 | 35 | 53 | 75 |
| Land use | . | . . . . . | 17 | 16 | 13 | 20 | 12 | 14 | 11 | 10 | 13 | 10 | 12 | 18 | 22 | 21 | 20 | 19 | 16 | 20 | 11 | 29 | 11 | 0 |
| Channel at the site | . | . . . . . | 15 | 15 | 15 | 21 | 19 | 19 | 33 | 22 | 13 | 15 | 9 | 16 | 15 | 9 | 18 | 25 | 14 | 20 | 15 | 5 | 0 | 0 |
| Other | . | . . . . . | 14 | 6 | 11 | 17 | 15 | 22 | 14 | 22 | 19 | 10 | 8 | 15 | 20 | 20 | 20 | 0 | 11 | 34 | 14 | 17 | 22 | 0 |
| Impoundments | . | . . . . . | 12 | 13 | 15 | 16 | 23 | 7 | 9 | 2 | 25 | 5 | 11 | 14 | 11 | 8 | 8 | 13 | 6 | 0 | 12 | 11 | 6 | 0 |
| No perceived problem | . | . . . . . | 12 | 22 | 17 | 6 | 12 | 1 | 3 | 0 | 7 | 0 | 29 | 12 | 2 | 0 | 0 | 0 | 16 | 0 | 8 | 0 | 0 | 0 |
| Sediment at the site | . | . . . . . | 11 | 10 | 13 | 15 | 12 | 13 | 6 | 5 | 7 | 15 | 7 | 11 | 16 | 12 | 14 | 32 | 8 | 7 | 5 | 11 | 11 | 25 |
| Pesticides | . | . . . . . | 9 | 10 | 9 | 14 | 0 | 8 | 3 | 4 | 7 | 10 | 5 | 11 | 13 | 9 | 4 | 13 | 8 | 14 | 6 | 13 | 11 | 0 |
| Sampling difficulty | . | . . . . . | 9 | 13 | 7 | 9 | 15 | 7 | 9 | 4 | 0 | 0 | 9 | 11 | 7 | 4 | 5 | 7 | 9 | 14 | 14 | 7 | 6 | 0 |
| Low flow | . | . . . . . | 8 | 8 | 11 | 9 | 0 | 6 | 3 | 5 | 0 | 0 | 6 | 11 | 9 | 5 | 4 | 0 | 9 | 7 | 6 | 13 | 6 | 0 |
| Industrial discharge | . | . . . . . | 7 | 5 | 9 | 6 | 8 | 7 | 17 | 14 | 19 | 50 | 2 | 3 | 8 | 14 | 23 | 63 | 2 | 0 | 6 | 11 | 11 | 25 |
| Mining, quarries and extraction | . | . . . . . | 7 | 5 | 5 | 7 | 12 | 6 | 6 | 14 | 0 | 5 | 6 | 6 | 8 | 8 | 9 | 7 | 7 | 0 | 12 | 9 | 16 | 25 |
| Artificial bank at the site | . | . . . . . | 6 | 5 | 0 | 5 | 12 | 7 | 6 | 8 | 0 | 0 | 4 | 5 | 8 | 8 | 13 | 0 | 5 | 7 | 5 | 0 | 22 | 0 |
| Waste | . | . . . . . | 5 | 7 | 11 | 6 | 4 | 6 | 3 | 2 | 0 | 0 | 4 | 5 | 3 | 3 | 2 | 0 | 8 | 14 | 3 | 5 | 0 | 0 |
| Agri-industry | . | . . . . . | 5 | 5 | 0 | 6 | 8 | 4 | 9 | 19 | 7 | 5 | 4 | 4 | 4 | 4 | 5 | 13 | 4 | 0 | 3 | 3 | 11 | 0 |
| Bank practices at the site | . | . . . . . | 5 | 6 | 3 | 4 | 8 | 4 | 0 | 7 | 0 | 0 | 9 | 5 | 3 | 2 | 2 | 0 | 10 | 0 | 2 | 7 | 0 | 0 |
| Leachate | . | . . . . . | 3 | 2 | 0 | 2 | 4 | 2 | 6 | 14 | 7 | 5 | 1 | 1 | 3 | 5 | 7 | 25 | 0 | 7 | 2 | 7 | 11 | 25 |
| Choked channel (>33% plant) | . | . . . . . | 3 | 2 | 3 | 9 | 4 | 7 | 0 | 4 | 0 | 0 | 2 | 3 | 5 | 4 | 0 | 0 | 3 | 7 | 0 | 3 | 0 | 0 |
| Bank erosion | . | . . . . . | 3 | 3 | 5 | 2 | 0 | 3 | 0 | 5 | 13 | 0 | 4 | 3 | 2 | 1 | 2 | 0 | 4 | 0 | 3 | 0 | 0 | 0 |
| No information | . | . . . . . | 3 | 3 | 7 | 2 | 4 | 6 | 0 | 2 | 0 | 10 | 4 | 2 | 3 | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 |
| Oils, petrochemicals | . | . . . . . | 2 | 1 | 3 | 3 | 0 | 2 | 3 | 2 | 0 | 5 | 1 | 1 | 3 | 5 | 6 | 0 | 1 | 0 | 3 | 3 | 11 | 0 |
| Acid deposition | . | . . . . . | 2 | 2 | 3 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 0 | 3 | 0 | 2 | 0 | 2 | 0 | 6 | 0 |
| Channel Management | . | . . . . . | 2 | 2 | 3 | 5 | 0 | 4 | 0 | 0 | 0 | 5 | 2 | 2 | 2 | 2 | 3 | 7 | 0 | 7 | 2 | 5 | 6 | 0 |

| Table 5.14<br>Major stress name | Individual stresses | | Total | upgraded | | | | | | | | | same | | | | | | downgraded | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | b to a | c to a | c to b | d to a/b | d to c | e to a/b/c | e to d | f to c/d | f to e | a | b | c | d | e | f | a to b | a to c | b to c/d/e | c to d/e | d to e/f | e to f |
| | Code | Full name M→ | | 294 | 49 | 247 | 27 | 132 | 37 | 66 | 16 | 20 | 591 | 621 | 377 | 157 | 94 | 16 | 118 | 15 | 69 | 49 | 19 | 4 |
| Sewage Treatment Works (STW) | TS | Treated STW effluent | 25 | 22 | 27 | 27 | 34 | 34 | 44 | 44 | 38 | 55 | 16 | 23 | 26 | 33 | 43 | 57 | 22 | 27 | 15 | 25 | 27 | 50 |
| Farming | FE | Fertilisers | 15 | 19 | 19 | 23 | 12 | 14 | 9 | 7 | 19 | 0 | 13 | 16 | 16 | 8 | 5 | 13 | 15 | 14 | 11 | 11 | 6 | 0 |
| Farming | FA | Farming | 14 | 13 | 15 | 16 | 12 | 19 | 14 | 5 | 13 | 0 | 10 | 17 | 18 | 10 | 10 | 13 | 12 | 7 | 12 | 11 | 16 | 0 |
| Run-off | UR | Urban run-off | 14 | 3 | 11 | 10 | 8 | 23 | 38 | 46 | 50 | 65 | 3 | 5 | 20 | 39 | 54 | 69 | 3 | 7 | 5 | 19 | 37 | 75 |
| No perceived problem | NP | No perceived problem | 12 | 22 | 17 | 6 | 12 | 1 | 3 | 0 | 7 | 0 | 29 | 12 | 2 | 0 | 0 | 0 | 16 | 0 | 8 | 0 | 0 | 0 |
| Sewage Treatment Works (STW) | CS | Combined sewer overflow | 10 | 3 | 3 | 11 | 12 | 14 | 17 | 37 | 32 | 30 | 2 | 5 | 16 | 24 | 33 | 32 | 1 | 0 | 16 | 17 | 37 | 0 |
| Land use | IA | Intensive arablisation | 9 | 9 | 9 | 15 | 4 | 5 | 3 | 5 | 7 | 0 | 6 | 10 | 13 | 8 | 2 | 0 | 7 | 14 | 8 | 21 | 0 | 0 |
| Other | CL | Cladophora | 9 | 3 | 7 | 14 | 4 | 13 | 11 | 17 | 19 | 5 | 3 | 9 | 15 | 13 | 14 | 0 | 4 | 0 | 8 | 9 | 0 | 0 |
| Channel at the site | CA | Channelisation | 8 | 6 | 11 | 11 | 12 | 13 | 17 | 8 | 7 | 10 | 2 | 9 | 7 | 6 | 12 | 19 | 11 | 0 | 11 | 0 | 0 | 0 |
| Sediment at the site | IS | Inert siltation | 7 | 6 | 3 | 9 | 12 | 10 | 3 | 5 | 0 | 10 | 5 | 5 | 10 | 8 | 9 | 13 | 6 | 7 | 2 | 9 | 11 | 25 |
| Sewage Treatment Works (STW) | ST | Sewage Treatment Works | 6 | 3 | 9 | 7 | 4 | 7 | 0 | 4 | 7 | 0 | 2 | 4 | 14 | 14 | 9 | 0 | 3 | 0 | 11 | 23 | 6 | 25 |
| Channel at the site | BG | Bridge | 6 | 9 | 3 | 11 | 8 | 5 | 11 | 10 | 7 | 0 | 5 | 7 | 7 | 3 | 4 | 7 | 2 | 14 | 3 | 5 | 0 | 0 |
| Land use | US | Urban/suburban | 6 | 4 | 7 | 5 | 8 | 8 | 9 | 5 | 7 | 10 | 3 | 3 | 8 | 15 | 19 | 19 | 2 | 0 | 3 | 7 | 6 | 0 |
| Pesticides | HE | Herbicides | 5 | 5 | 7 | 7 | 0 | 5 | 3 | 2 | 7 | 0 | 3 | 6 | 7 | 4 | 2 | 7 | 5 | 0 | 0 | 3 | 6 | 0 |
| Pesticides | IN | Insecticides | 5 | 5 | 7 | 7 | 0 | 4 | 3 | 4 | 0 | 5 | 3 | 6 | 8 | 5 | 2 | 7 | 5 | 0 | 0 | 3 | 11 | 0 |
| Sediment at the site | TX | Contaminated sediment | 5 | 5 | 7 | 7 | 0 | 4 | 3 | 0 | 0 | 5 | 3 | 6 | 7 | 5 | 7 | 19 | 5 | 0 | 2 | 3 | 6 | 0 |
| Run-off | HY | Highway run-off (including salt) | 5 | 4 | 7 | 6 | 4 | 4 | 3 | 13 | 19 | 10 | 4 | 3 | 4 | 6 | 10 | 7 | 5 | 0 | 5 | 5 | 6 | 0 |
| Pesticides | PE | Pesticides | 4 | 5 | 3 | 7 | 0 | 4 | 0 | 0 | 0 | 5 | 2 | 4 | 5 | 5 | 3 | 7 | 2 | 0 | 5 | 11 | 0 | 0 |
| Waste | SL | Slurry | 4 | 6 | 9 | 3 | 4 | 6 | 0 | 0 | 0 | 0 | 4 | 4 | 2 | 2 | 2 | 0 | 8 | 14 | 3 | 3 | 0 | 0 |
| Sewage Treatment Works (STW) | SS | Storm sewer overflow | 4 | 3 | 5 | 3 | 4 | 4 | 3 | 5 | 7 | 25 | 1 | 2 | 6 | 11 | 15 | 13 | 2 | 0 | 3 | 5 | 11 | 75 |
| Run-off | LR | Light industry/commercial runoff | 4 | 1 | 5 | 3 | 12 | 10 | 11 | 8 | 13 | 5 | 1 | 2 | 5 | 11 | 12 | 13 | 0 | 0 | 2 | 5 | 27 | 0 |
| Artificial bank at the site | SB | Consolidated (stone/brick/concrete) | 4 | 3 | 0 | 3 | 8 | 6 | 3 | 4 | 0 | 0 | 3 | 3 | 6 | 6 | 9 | 0 | 2 | 0 | 3 | 0 | 16 | 0 |
| Bank practices at the site | LV | Livestock poaching, trampling | 4 | 5 | 3 | 3 | 8 | 2 | 0 | 5 | 0 | 0 | 7 | 5 | 2 | 0 | 0 | 0 | 9 | 0 | 2 | 7 | 0 | 0 |
| Low flow | LF | Low flow | 4 | 2 | 7 | 5 | 0 | 4 | 3 | 4 | 0 | 0 | 3 | 4 | 5 | 4 | 3 | 0 | 2 | 0 | 2 | 9 | 0 | 0 |
| Agri-industry | DA | Dairy | 3 | 4 | 0 | 3 | 0 | 3 | 9 | 16 | 0 | 0 | 4 | 2 | 2 | 4 | 2 | 13 | 3 | 0 | 0 | 0 | 6 | 0 |
| Industrial discharge | LI | Light industry/commercial | 3 | 2 | 5 | 3 | 0 | 4 | 9 | 7 | 7 | 10 | 1 | 1 | 3 | 8 | 4 | 19 | 0 | 0 | 5 | 5 | 6 | 0 |
| Sewage Treatment Works (STW) | SE | Septic tank | 3 | 3 | 0 | 3 | 0 | 5 | 9 | 11 | 7 | 0 | 2 | 2 | 5 | 2 | 3 | 0 | 4 | 0 | 2 | 3 | 6 | 0 |
| Run-off | RO | Run-off | 3 | 1 | 0 | 5 | 12 | 6 | 3 | 5 | 7 | 0 | 1 | 2 | 7 | 4 | 2 | 0 | 1 | 7 | 9 | 11 | 11 | 0 |
| Mining, quarries and extraction | MM | Metal mine drainage | 3 | 3 | 5 | 2 | 0 | 0 | 3 | 2 | 0 | 5 | 3 | 4 | 2 | 1 | 2 | 0 | 6 | 0 | 3 | 0 | 0 | 0 |

| Table 5.14<br>Major stress name | Individual stresses | | Total | upgraded | | | | | | | | | same | | | | | | downgraded | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | b to a | c to a | c to b | d to a/b | d to c | e to a/b/c | e to d | f to c/d | f to e | a | b | c | d | e | f | a to b | a to c | b to c/d/e | c to d/e | d to e/f | e to f |
| | Code | Full name M→ | | 294 | 49 | 247 | 27 | 132 | 37 | 66 | 16 | 20 | 591 | 621 | 377 | 157 | 94 | 16 | 118 | 15 | 69 | 49 | 19 | 4 |
| Mining, quarries and extraction | CM | Coal mine drainage | 3 | 1 | 0 | 3 | 8 | 2 | 3 | 13 | 0 | 0 | 1 | 2 | 3 | 3 | 6 | 7 | 1 | 0 | 3 | 9 | 16 | 25 |
| Choked channel (>33% plant) | CH | Choked channel (>33% plant) | 3 | 2 | 3 | 9 | 4 | 7 | 0 | 4 | 0 | 0 | 2 | 3 | 5 | 4 | 0 | 0 | 3 | 7 | 0 | 3 | 0 | 0 |
| Impoundments | RF | Regulated flow | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 7 | 0 | 3 | 4 | 2 | 0 | 3 | 7 | 1 | 0 | 3 | 5 | 6 | 0 |
| Impoundments | WE | Weirs | 3 | 3 | 0 | 4 | 4 | 0 | 0 | 2 | 0 | 0 | 3 | 5 | 4 | 4 | 2 | 0 | 1 | 0 | 5 | 3 | 0 | 0 |
| Impoundments | RE | Reservoir u/s catchment | 3 | 4 | 5 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 2 | 2 | 2 | 0 | 0 | 0 | 3 | 3 | 6 | 0 |
| Impoundments | LP | Lake or pond close u/s | 3 | 3 | 0 | 5 | 0 | 3 | 0 | 0 | 7 | 0 | 3 | 4 | 4 | 3 | 3 | 0 | 3 | 0 | 3 | 3 | 0 | 0 |
| Sampling difficulty | DR | Dredge used to sample | 3 | 4 | 5 | 5 | 8 | 2 | 3 | 0 | 0 | 0 | 3 | 4 | 3 | 2 | 3 | 0 | 1 | 0 | 5 | 5 | 0 | 0 |
| Sampling difficulty | AC | Access to one bank only | 3 | 5 | 0 | 3 | 8 | 3 | 6 | 4 | 0 | 0 | 3 | 3 | 3 | 1 | 2 | 7 | 0 | 0 | 9 | 3 | 0 | 0 |
| Sampling difficulty | BO | Bouldery site sampling difficult | 3 | 5 | 3 | 2 | 0 | 3 | 3 | 0 | 0 | 0 | 4 | 5 | 2 | 1 | 2 | 0 | 8 | 14 | 2 | 0 | 0 | 0 |
| No information | NI | No information | 3 | 3 | 7 | 2 | 4 | 6 | 0 | 2 | 0 | 10 | 4 | 2 | 3 | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 |
| Other | OH | Ochre | 3 | 2 | 3 | 1 | 8 | 5 | 3 | 5 | 0 | 5 | 1 | 2 | 3 | 5 | 4 | 0 | 1 | 14 | 2 | 3 | 16 | 0 |
| Farming | FF | Fish farm | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 |
| Industrial discharge | HI | Heavy industry | 2 | 2 | 0 | 0 | 0 | 0 | 3 | 4 | 13 | 30 | 0 | 1 | 3 | 3 | 10 | 38 | 1 | 0 | 0 | 5 | 6 | 25 |
| Acid deposition | AD | Acid deposition | 2 | 2 | 3 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 0 | 3 | 0 | 2 | 0 | 2 | 0 | 6 | 0 |
| Mining, quarries and extraction | MI | Mining, quarries and extraction | 2 | 2 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 3 | 3 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| Channel at the site | BE | Bedrock | 2 | 2 | 0 | 1 | 0 | 0 | 6 | 0 | 0 | 0 | 4 | 2 | 1 | 1 | 0 | 0 | 2 | 7 | 3 | 0 | 0 | 0 |
| Channel Management | WD | Weed cutting | 2 | 2 | 0 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Artificial bank at the site | UC | Unconsolidated (Rip-rap/boulder) | 2 | 2 | 0 | 2 | 0 | 0 | 3 | 2 | 0 | 0 | 2 | 1 | 3 | 2 | 4 | 0 | 1 | 0 | 0 | 0 | 6 | 0 |
| Impoundments | FT | Freshwater but tidal | 2 | 3 | 5 | 3 | 8 | 3 | 6 | 0 | 19 | 5 | 1 | 2 | 1 | 1 | 4 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low flow | AG | Abstraction from groundwater | 2 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 |
| Low flow | IR | Abstraction for irrigation | 2 | 3 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| Low flow | DT | Drought | 2 | 2 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 1 | 2 | 0 | 6 | 7 | 2 | 3 | 0 | 0 |
| Land use | CF | Afforestation (conifer) | 2 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 2 | 7 | 0 | 3 | 0 | 0 |
| Land use | MD | Moorland drainage | 2 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 6 | 0 |
| Other | SF | Sewage fungus | 2 | 2 | 3 | 1 | 4 | 4 | 0 | 2 | 0 | 0 | 3 | 2 | 1 | 1 | 3 | 0 | 2 | 0 | 3 | 0 | 6 | 0 |
| Other | MY | Stress could not be identified (mystery) | 2 | 1 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 0 | 0 | 6 | 20 | 3 | 3 | 6 | 0 |

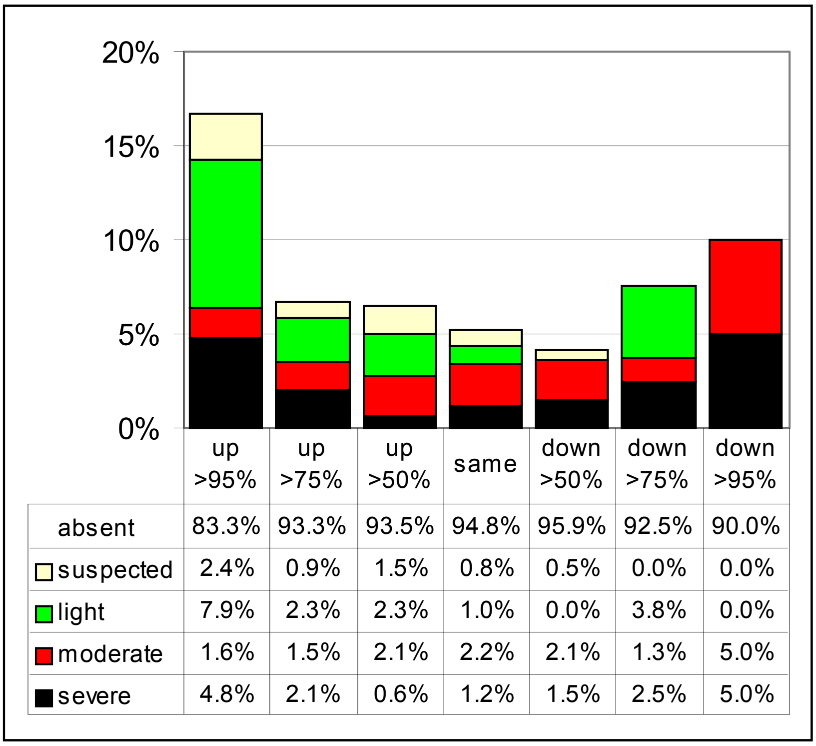
**Figure 5.1 Percentage frequency of occurrence of each severity level of environmental stress attributed to (a) ‘farming’ and (b) ‘industrial discharge’ amongst GQA sites in each category of “likelihood of change in grade” between 1990 and 1995.**

**(a) ‘Farming’**



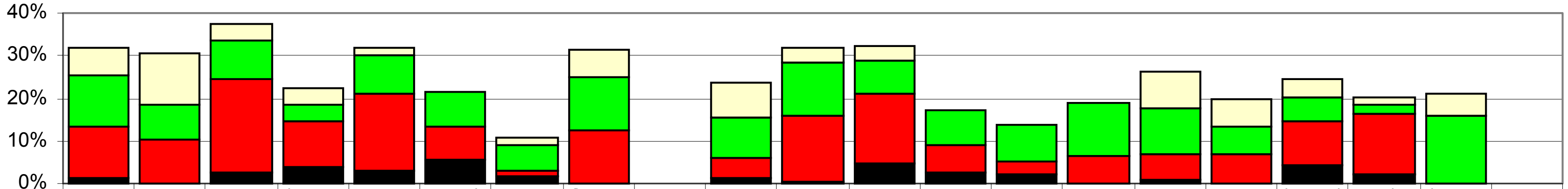
| | up >95% | up >75% | up >50% | same | down >50% | down >75% | down >95% |
|---|---|---|---|---|---|---|---|
| absent | 76.2% | 67.4% | 68.9% | 73.4% | 76.4% | 75.0% | 75.0% |
| ☐ suspected | 4.8% | 5.0% | 4.2% | 4.7% | 6.2% | 3.8% | 5.0% |
| 🟩 light | 8.7% | 9.7% | 10.3% | 9.9% | 9.2% | 6.3% | 5.0% |
| 🟥 moderate | 8.7% | 15.5% | 14.9% | 10.2% | 7.7% | 11.3% | 10.0% |
| ■ severe | 1.6% | 2.3% | 1.7% | 1.7% | 0.5% | 3.8% | 5.0% |

**(b) ‘Industrial discharge’**



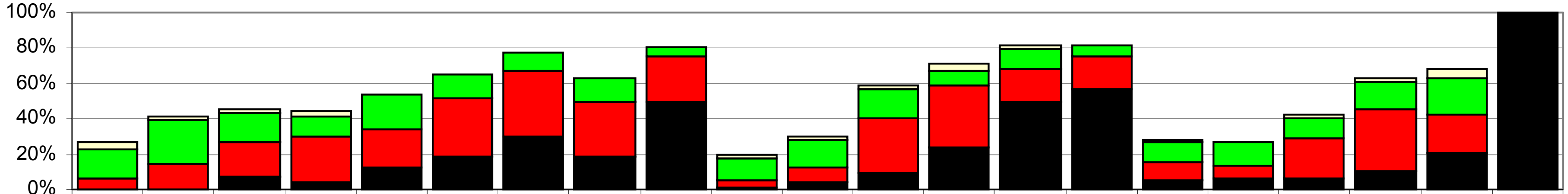
| | up >95% | up >75% | up >50% | same | down >50% | down >75% | down >95% |
|---|---|---|---|---|---|---|---|
| absent | 83.3% | 93.3% | 93.5% | 94.8% | 95.9% | 92.5% | 90.0% |
| ☐ suspected | 2.4% | 0.9% | 1.5% | 0.8% | 0.5% | 0.0% | 0.0% |
| 🟩 light | 7.9% | 2.3% | 2.3% | 1.0% | 0.0% | 3.8% | 0.0% |
| 🟥 moderate | 1.6% | 1.5% | 2.1% | 2.2% | 2.1% | 1.3% | 5.0% |
| ■ severe | 4.8% | 2.1% | 0.6% | 1.2% | 1.5% | 2.5% | 5.0% |

**Figure 5.2 The proportion of matched sites in England and Wales with each degree of severity of particular major types of environmental stress separately for sites in each class of 'most probable change in grade' between 1990 and 1995.**



| | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | e | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| absent | 68% | 69% | 63% | 78% | 68% | 78% | 89% | 69% | 100% | 76% | 68% | 68% | 83% | 86% | 81% | 74% | 80% | 75% | 80% | 79% | 100% |
| ☐ suspected | 6% | 12% | 4% | 4% | 2% | 0% | 2% | 6% | 0% | 8% | 4% | 3% | 0% | 0% | 0% | 8% | 7% | 4% | 2% | 5% | 0% |
| 🟩 light | 12% | 8% | 9% | 4% | 9% | 8% | 6% | 13% | 0% | 9% | 12% | 8% | 8% | 9% | 13% | 11% | 7% | 6% | 2% | 16% | 0% |
| 🟥 moderate | 12% | 10% | 22% | 11% | 18% | 8% | 2% | 13% | 0% | 5% | 15% | 16% | 6% | 3% | 6% | 6% | 7% | 10% | 14% | 0% | 0% |
| ■ severe | 1% | 0% | 2% | 4% | 3% | 5% | 2% | 0% | 0% | 1% | 0% | 5% | 3% | 2% | 0% | 1% | 0% | 4% | 2% | 0% | 0% |

**(a) Farming**

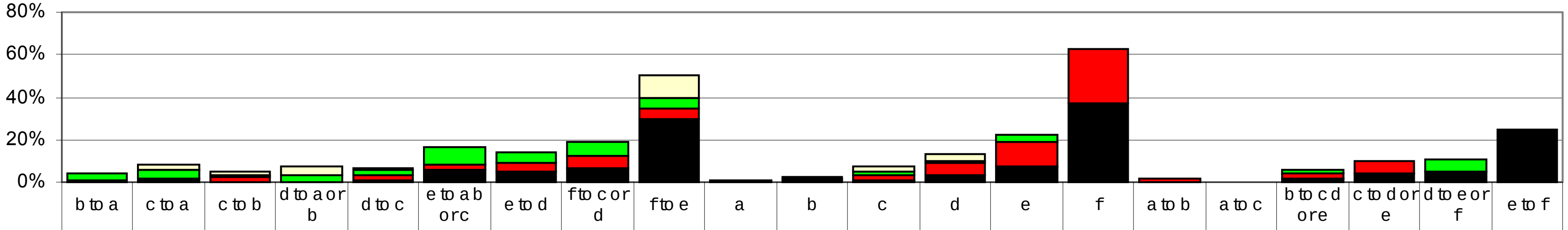


| | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | e | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| absent | 73% | 59% | 54% | 56% | 46% | 35% | 23% | 38% | 20% | 81% | 70% | 42% | 29% | 18% | 19% | 72% | 73% | 58% | 37% | 32% | 0% |
| ☐ suspected | 4% | 2% | 2% | 4% | 0% | 0% | 0% | 0% | 0% | 2% | 3% | 2% | 3% | 2% | 0% | 1% | 0% | 1% | 2% | 5% | 0% |
| 🟩 light | 16% | 24% | 17% | 11% | 20% | 14% | 11% | 13% | 5% | 12% | 15% | 17% | 9% | 12% | 6% | 12% | 13% | 12% | 16% | 21% | 0% |
| 🟥 moderate | 6% | 14% | 20% | 26% | 22% | 32% | 36% | 31% | 25% | 4% | 9% | 31% | 35% | 18% | 19% | 10% | 7% | 23% | 35% | 21% | 0% |
| ■ severe | 0% | 0% | 7% | 4% | 12% | 19% | 30% | 19% | 50% | 1% | 4% | 9% | 24% | 50% | 56% | 5% | 7% | 6% | 10% | 21% | 100% |

**(b) STW**

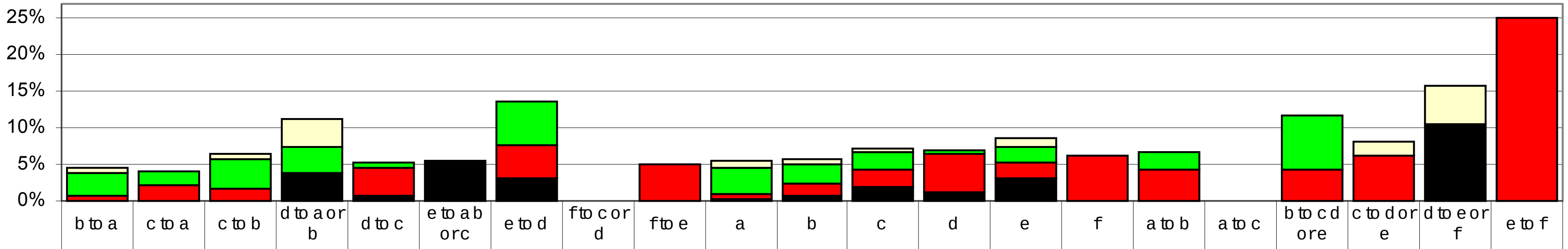
| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of sites | 294 | 49 | 247 | 27 | 132 | 37 | 66 | 16 | 20 | 591 | 621 | 377 | 157 | 94 | 16 | 118 | 15 | 69 | 49 | 19 | 4 |

## Figure 5.2 (continued)



| | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | e | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| absent | 96% | 92% | 95% | 93% | 93% | 84% | 86% | 81% | 50% | 99% | 98% | 93% | 87% | 78% | 38% | 98% | 100% | 94% | 90% | 89% | 75% |
| ☐ suspected | 1% | 2% | 2% | 4% | 1% | 0% | 0% | 0% | 10% | 0% | 0% | 2% | 3% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 🟩 light | 3% | 4% | 1% | 4% | 3% | 8% | 5% | 6% | 5% | 0% | 1% | 1% | 1% | 3% | 0% | 0% | 0% | 1% | 0% | 5% | 0% |
| 🟥 moderate | 1% | 0% | 2% | 0% | 2% | 3% | 5% | 6% | 5% | 1% | 1% | 3% | 6% | 12% | 25% | 2% | 0% | 3% | 6% | 0% | 0% |
| ■ severe | 0% | 2% | 0% | 0% | 1% | 5% | 5% | 6% | 30% | 0% | 0% | 1% | 3% | 7% | 38% | 0% | 0% | 1% | 4% | 5% | 25% |

(c) Industrial discharge

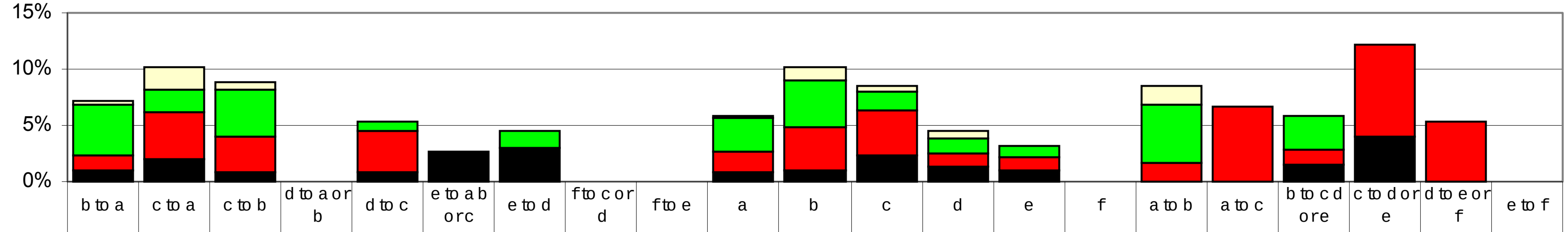


| | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | e | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| absent | 96% | 96% | 94% | 89% | 95% | 95% | 86% | 100% | 95% | 95% | 94% | 93% | 93% | 91% | 94% | 93% | 100% | 88% | 92% | 84% | 75% |
| ☐ suspected | 1% | 0% | 1% | 4% | 0% | 0% | 0% | 0% | 0% | 1% | 1% | 1% | 0% | 1% | 0% | 0% | 0% | 0% | 2% | 5% | 0% |
| 🟩 light | 3% | 2% | 4% | 4% | 1% | 0% | 6% | 0% | 0% | 4% | 3% | 2% | 1% | 2% | 0% | 3% | 0% | 7% | 0% | 0% | 0% |
| 🟥 moderate | 1% | 2% | 2% | 0% | 4% | 0% | 5% | 0% | 5% | 1% | 2% | 2% | 5% | 2% | 6% | 4% | 0% | 4% | 6% | 0% | 25% |
| ■ severe | 0% | 0% | 0% | 4% | 1% | 5% | 3% | 0% | 0% | 0% | 1% | 2% | 1% | 3% | 0% | 0% | 0% | 0% | 0% | 11% | 0% |

(d) Mining

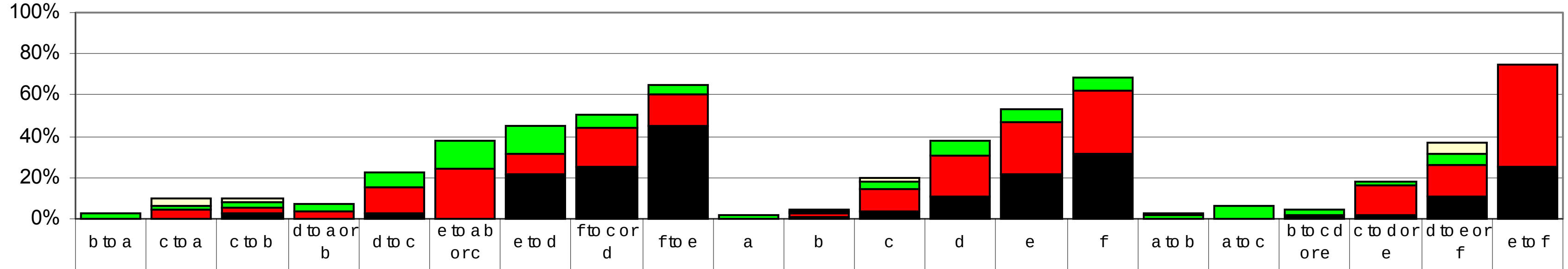
| No. of sites | 294 | 49 | 247 | 27 | 132 | 37 | 66 | 16 | 20 | 591 | 621 | 377 | 157 | 94 | 16 | 118 | 15 | 69 | 49 | 19 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

## Figure 5.2 (continued)



| | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | e | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| absent | 93% | 90% | 91% | 100% | 95% | 97% | 95% | 100% | 100% | 94% | 90% | 92% | 96% | 97% | 100% | 92% | 93% | 94% | 88% | 95% | 100% |
| ☐ suspected | 0% | 2% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 1% | 1% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% |
| 🟩 light | 4% | 2% | 4% | 0% | 1% | 0% | 2% | 0% | 0% | 3% | 4% | 2% | 1% | 1% | 0% | 5% | 0% | 3% | 0% | 0% | 0% |
| 🟥 moderate | 1% | 4% | 3% | 0% | 4% | 0% | 0% | 0% | 0% | 2% | 4% | 4% | 1% | 1% | 0% | 2% | 7% | 1% | 8% | 5% | 0% |
| ■ severe | 1% | 2% | 1% | 0% | 1% | 3% | 3% | 0% | 0% | 1% | 1% | 2% | 1% | 1% | 0% | 0% | 0% | 1% | 4% | 0% | 0% |

(e) Low flow



| | b to a | c to a | c to b | d to a or b | d to c | e to a b or c | e to d | f to c or d | f to e | a | b | c | d | e | f | a to b | a to c | b to c d or e | c to d or e | d to e or f | e to f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| absent | 97% | 90% | 90% | 93% | 77% | 62% | 55% | 50% | 35% | 98% | 95% | 80% | 62% | 47% | 31% | 97% | 93% | 96% | 82% | 63% | 25% |
| ☐ suspected | 0% | 4% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 2% | 2% | 1% | 0% | 0% | 1% | 0% | 0% | 0% | 5% | 0% |
| 🟩 light | 2% | 2% | 3% | 4% | 8% | 14% | 14% | 6% | 5% | 1% | 1% | 3% | 7% | 6% | 6% | 2% | 7% | 3% | 2% | 5% | 0% |
| 🟥 moderate | 0% | 4% | 3% | 4% | 12% | 24% | 11% | 19% | 15% | 0% | 2% | 11% | 20% | 26% | 31% | 0% | 0% | 0% | 14% | 16% | 50% |
| ■ severe | 0% | 0% | 2% | 0% | 3% | 0% | 21% | 25% | 45% | 0% | 1% | 4% | 11% | 21% | 31% | 0% | 0% | 1% | 2% | 11% | 25% |

(f) Urban run-off

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of sites | 294 | 49 | 247 | 27 | 132 | 37 | 66 | 16 | 20 | 591 | 621 | 377 | 157 | 94 | 16 | 118 | 15 | 69 | 49 | 19 | 4 |

## 5.5 Summary

A questionnaire sent out to the Environment Agency regional staff was used to provide information on the type and character of environmental stresses thought to be influencing the biological condition of each GQA site in 1995. The proportion of GQA sites for which information was provided and the detail of the responses was both impressive and encouraging. Responses were received for a total of 6570 GQA sites, which included practically all of the 6016 sites used for analysis of site quality and taxon distribution in 1995. The 154 individual stress types catered for within the questionnaire were grouped into 32 major stress types.

The frequency of particular stresses was assessed in relation to biological grade in 1995 and change in grade since 1990. Variations between Regions, and Areas within Regions, were also assessed.

A rather surprising lack of any recorded farming-related stresses in one Area of Anglian Region acts as a reminder that recorders and Regions may have varied in what they considered to be a concern and worth treating as a site-specific stress problem. Thus regional variations in the frequency and perceived severity of particular stresses should be interpreted with some caution.

The most widely reported major type of stress across England and Wales was from sewage treatment works (STW) (41% of all sites). STW was the most commonly recorded major stress type in every Region except Anglian, South West and Wessex Regions where stresses from general "farming" were even more common.

Impacts related to STW were dominated by the effects of treated STW effluent (25% of all sites) and combined or storm sewer overflow (14%). At least two-thirds of sites graded d-f were considered to be prone to environmental stress from STW and, surprisingly, also 22% of the highest grade sites. Where present, the impact of treated STW effluent was thought to be severe at nearly 23% of all such sites, but it was most often considered to have only a "light" impact (39%).

Farming in general was recorded as the next most common environmental stress, affecting more than 25% of all sites in Anglian, North West, Midlands, South West, Thames and Wessex Regions. Stresses from farming were common in all except the very poorest grade of site. The most commonly recorded individual farming-related stress was from fertilisers (11%), followed by pesticide, herbicide and insecticide use (jointly 9%). Impacts from fertilisers were considered to be a potential stress at nearly 60% of sites in Anglian Region, far higher than any other Region; they were rarely recorded as a problem in either Welsh or surprisingly, Thames Region.

Stresses from industrial discharge and run-off problems, especially in urban areas, were rare in high grade sites, but were increasingly common in very poor grade sites. Roughly half of all sites graded d-f in 1995 were considered to be affected by run-off problems, especially from urban areas.

Sediment problems, especially from siltation, were recorded at nearly 8% of all sites, am important feature for macro-invertebrate habitats. However, sediment-related stresses were equally common across all biological grades.

Over 50% of the sites in Anglian Region had some form of stress related to channelisation. This was more than three times the equivalent percentage for any other Region.

There was “no perceived problem” at 11% of sites, most of which were grade “a” and none were worse than grade c (Table 5.9), suggesting that the local Environment Agency ecologists have an understanding of what was causing the stress in nearly all sites in their region which were not of the highest grade.

For the GQA sites in 1995, the frequency and severity of many types of environmental stress were more common amongst the poorer condition sites.

However, few stresses showed any strong tendency to be less frequent amongst sites that had improved in grade or more frequent amongst sites which had deteriorated. For example, stresses related to STW occurred in about half of all sites which had “definitely” changed in condition, irrespective of whether they had deteriorated or improved.

A likely explanation is that many of the sites which were subject to a particular stress at the time of the questionnaire in 1995 were also subject to the same stress in 1990. Some of the sites with this stress may have improved, others may have stayed in the same condition or even deteriorated.

An exception was stress from industrial discharges which were most frequent amongst sites which had very likely improved in condition. However, such stress also occurred at severe and moderate intensities in relatively high frequencies amongst sites that had very likely deteriorated in condition.

Numerous sites were known to be affected by drought in both 1990 and 1995. However, low flow problems showed an association with sites which had deteriorated in condition. Moderate and severe stresses from low flow problems were more common amongst sites which had declined to grades e or f by 1995 than for sites which were already in such poor condition in 1990.

Together, these results support the general view that poor biological condition resulting from low flow problems is an increasing problem whereas many previously severe problems of environmental stress from industrial discharge and urban run-off have been partly alleviated since 1990.

The results of this, the first attempt to assemble and analyse information on environmental stresses has indicated the potential value of the exercise. However, not surprisingly, the consistency of the data provided showed scope for improvement. The analyses also illustrated the importance of collecting change information on environmental stresses in order to help interpret, and ultimately predict, their impact on macro-invertebrate assemblages.

# 6 IMPLICATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH AND DEVELOPMENT

## 6.1 Prediction of Faunal Response to Changes in Environmental Conditions

### 6.1.1 Background

An important long-term aim of the Environment Agency must be to develop procedures to help predict the consequences of changes in the environmental conditions and their impacts on the faunal composition, diversity and overall biological condition of rivers.

In this report, the associations between the (perceived) presence of particular environmental stresses and the biological condition of sites have been quantified. Moreover, the companion report (Davy-Bowker *et al*. 2000) contains details of the relationships between the frequency of occurrence of individual taxa, the biological condition of sites and presence of particular environmental stresses. An obvious question arising from these established relationships is: how can we progress with predicting the faunal consequences of changes in environmental conditions and impacts from stresses?

This line of enquiry forms a major component of a separate Environment Agency R&D project (E1-007) placed with IFE. The principal objective of this project, as stated in the project specification, is:

> *To investigate approaches for producing dynamic models of macro-invertebrate response to changes in environmental conditions and to produce a pilot dynamic model which can be used by Agency biologists and which has operational benefits.*

Two potential functions of the dynamic version of RIVPACS are envisaged:

- To predict the effects of altering physical environmental parameters which are already used as predictors in RIVPACS

- To predict the effects of changes in water quality.

### 6.1.2 The capacity of existing versions of RIVPACS to predict change

RIVPACS, as originally developed is designed to predict what taxa should be at a site if that site was unstressed/unpolluted and in good biological condition. It is therefore based on a static model and RIVPACS III+, the latest version, can still only be used to predict the faunal composition expected at the site on the assumption that it is at the highest grade of biological condition.

However, RIVPACS can, and has been, used to predict the changes in occurrence and abundance of taxa to be expected if the physical conditions (i.e. as represented by the RIVPACS environmental variables) at the site changed, but assuming the site remained otherwise unpolluted and still in good biological condition.

Such an approach was adopted by Armitage (1989), who plotted the changing probabilities of occurrence of individual families and species at a hypothetical upland site whose substratum characteristics he gradually modified within RIVPACS, whilst holding the values of all other predictor variables constant. The resultant taxon response curves matched ecological expectations, with the expected abundance of taxa characteristic of coarse-bottomed streams, such as Baetidae and Nemouridae, decreasing with increased siltation and the sediment-dwelling Sphaeriidae showing the reverse trend.

The outcome was far less clear when Armitage *et al.* (1997) applied the same principles to real streams of differing character, including a lowland chalkstream. The same was the case when Armitage (in press), within RIVPACS III, simulated increases in siltation at sites on a small Dorset stream, which mimicked real increases in siltation at other sites on the same stream. He concluded (Armitage in press) that, whilst faunal predictions based on these simulations lacked sensitivity, "it [is] possible to simulate faunal changes in response to environmental disturbance provided that the disturbance directly involves the environmental variables used in RIVPACS predictions. These variables relate to channel shape, discharge and substratum".

At present, RIVPACS III+ only achieves limited success at forecasting the probable consequences of changes in the value of one or more of the environmental variables it uses to make predictions. Even this is only possible because these variables were chosen to be both good predictors of the macro-invertebrate fauna at high quality sites and also to be largely independent of the effects of pollution. Thus, the only artificial stresses whose consequences may be indicated by RIVPACS are those environmental changes which are likely to alter the channel shape and wetted area (i.e. stream width and depth) and/or substratum characteristics.

Consequently, RIVPACS III+ is designed to quantify the effects of pollution on the biological condition of a site. It cannot be used to predict the faunal changes to be expected following changes in the impacts or stresses that affect the quality of the site but do not affect the values of the RIVPACS environmental variables. Thus, it cannot be used to predict the effects of organic or heavy metal pollution.

This agrees with the overall conclusion of Armitage (in press), that "RIVPACS is a static model and cannot be used … as a forecasting system …. to predict or forecast the effects of environmental impacts".

### 6.1.3 The development of RIVPACS procedures for predicting the impact of environmental stresses

As part of the R&D Project E1-007 "Testing and Further Development of RIVPACS: Phase 3", IFE are already contracted to investigate the potential to develop a completely new dynamic form of RIVPACS (RIVPACS DYNAMO = RIVPACS DYNAmic MOdel). The aim is to eventually develop quantitative predictions of the consequences of specific changes in the environmental conditions at a site on its (macro-invertebrate) fauna.

Current thinking is that the model development will be in two successive and inter-linked phases. The first phase will be the development of a static model that will extend the scope of RIVPACS III+ to include sites of a broad spectrum of biological condition and degree of environmental stress, as generated by organic pollution. The model will be developed around a nested classification which first divides the overall galaxy of sites into major constellations based on their environmental types and then develops clusters of sites of apparently similar biological condition, within each constellation, as based upon their macro-invertebrate fauna.

The need to impose an over-arching physical structure on the classification is because the fauna of sites of a particular environmental type may respond differently to a given type of stress than the fauna of another type of site. For example, a certain level of nutrient enrichment may lead to an entirely different response in an upland oligotrophic site than in a southern chalkstream.

Predictive models would then be developed that utilise chemical as well as physical variables to predict shifts in cluster membership within constellations, together with subsidiary models that will allow shifts of marginal sites between constellations. The mechanism for predicting change may rely on the, now traditional, discriminant techniques adopted within RIVPACS or may benefit from the consideration of alternative approaches being developed in the Netherlands by Verdonschot (in press) or in Australia by Chessman (1999). Whatever approach is used, the first assignment of a site to classification type will be the use of physical environmental variables to assign a site to the appropriate constellation. The dominant predictor variables will then become those most directly causing the environmental stress. This is because of the similarity of environmental site types within each constellation.

In use, the model (if successful) would operate by allowing the user to hypothetically manipulate the value of the most important predictor variables to elicit an indication of the probable faunal response. In this initial phase, the model remains static and is essentially spatial in character. It will be able to predict the likely composition of the fauna of a site at two fixed instants in time, were that site in two different chemical states. Temporal changes in the fauna would be inferred from the two different spatial states in a manner akin to the approach used by Armitage (1989) in assessing the impact of changing substratum composition on a site.

The development of this initial phase of dynamic RIVPACS would depend on the accession from the Environment Agency, by IFE, of values of the appropriate chemical data for the 1995 biological GQA sites. As a minimum this would need to include the three chemical variables used to determine site chemical class, but the model development would be enhanced by the further availability of many of the other "Sanitary Determinands" routinely acquired by the Agency. A similar, but independent model for the assessing the impact of flow changes would require the further acquisition of much more precise, and time-specific, flow information than those static, map-derived discharge class values, currently used in RIVPACS III+.

Development of this phase of RIVPACS DYNAMO will also depend upon the availability, for site selection, of the biological and environmental RQS database developed by IFE for the current project (Davy-Bowker *et al.* 2000). Critically, it will also benefit from the environmental stress component of the database that will greatly improve the capacity to select sites where the predominant, or exclusive environmental stresses are of an organic nature. Furthermore this dataset includes information on both the intensity and persistence of the stress and its type of origin (e.g., farming, agri-industry or STWs etc.).

The second stage of the model development would be the testing and enhancement phase and will require real temporal change data. In this phase, the ability of the static model to predict faunal response to temporal changes in environmental features will be tested against real, observed change in both the environmental characteristics and fauna of actual sites. The success of the static, pre-cursor model will be tested by its ability to predict the response of the fauna as a whole and individual families in particular. The measured changes in environmental conditions will, in turn, be developed as predictor variables to be incorporated in the erstwhile static model. This would enhance its predictive accuracy and advance the development of the model through the incorporation of a dynamic component in the prediction process. The extent to which dynamic variables will wholly or partially replace static variables will be determined by iterative testing, which will retain the pragmatic approach used in all stages of RIVPACS development.

The development of the dynamic model will depend crucially on data collected for the 1990 RQS and the 1995 GQA since these provide real data, with known levels of bias (e.g. Gunn *et al.* 1996). Thus, Davy-Bowker *et al.* (2000) provide information on observed temporal changes (1990-1995) in the occurrence of individual taxa at a wide range of types of site in relation to observed changes in quality, whilst the current report provides information on whole community response to changes in environmental conditions. These reports are complemented by data, provided by Walley & Martin (1997), on the frequency with which each BMWP family occurs at each of five abundance levels in each of the six biological grades used for the 1995 GQA.

Equally crucial to the development and testing of the dynamic model of RIVPACS, as a means of predicting faunal response to organic enrichment, is the ready availability of suitable chemical data. In order to progress the model development the Environment Agency must, therefore, supply the IFE with all appropriate chemical data, matched for stretch, for the sites sampled in the 1990 RQS and 1995 GQA. As a minimum, this should include mean, standard deviation and 90- (or 10-) percentile values for the three variables used for chemical classification, namely: Biological Oxygen Demand (BOD) (mg $l^{-1}$ O (5 days at 20°C, ATU inhibited)), with 90-percentile; ammoniacal nitrogen (mg $l^{-1}$ $NH_4$-N), with 90-percentile and dissolved oxygen (% saturation), with 10-percentile. However, the model would be enhanced by equivalent values for other routine sanitary variables, of which nitrate mg $l^{-1}$ $NO_3$ - N and nitrite mg $l^{-1}$ $NO_2$ - N (or Total Oxidised Nitrogen – TON mg $l^{-1}$ N) and orthophosphate (mg $l^{-1}$ $PO_4$ – P) are likely to be particularly important.

The testing of the preliminary version of RIVPACS DYNAMO, due to be completed in 2000, would further benefit from the rapid availability of the biological, environmental and chemical results from the 2000 GQA. It is considered that the more prescriptive and rigorous methodologies, including analytical quality controls, consistently adopted in 1995 and 2000, will provide more reliable sets of comparable data than the 1990 and 1995 surveys.

The current project has also led to a new database on the perceived environmental stresses influencing the biological condition and chemical quality of each GQA site in 1995. Although the database undoubtedly has inconsistencies in the local Agency staff's recording and interpretation of the perceived stresses operating at each site, it is considered to be a valuable extra source of information on a national scale. However, like the current version of RIVPACS, the dataset currently available is predominantly static in character, reflecting the stresses, and their intensity, present at the time of the 1995 GQA but providing no information on changes in occurrence and intensity of stresses between surveys. Changes in the occurrence and intensity of environmental stresses are potentially important dynamic variables for use in the development of RIVPACS DYNAMO.

It is recommended that the collection of environmental stress data is repeated for the 2000 GQA in order to obtain a better understanding, and hence quantification, of the response of macro-invertebrate assemblages to known changes of in the severity of environmental stresses. This information can then be used to further test and improve the version of RIVPACS DYNAMO produced under R&D Project E1-007.

For these purposes, it is further recommended that IFE be contracted to supply the Environment Agency with the information on each site which was supplied for the 1995 GQA.

The layout of the data on environmental stress returned to the Environment Agency, for each individual site, should be in a form which:

- presents the severity and character (point/diffuse//chronic/acute/seasonal) of each recorded stress at each site in 1995

- offers an opportunity for the 1995 data to be re-evaluated for that year (in the light of the different approaches adopted between Regions and Areas)

- allows changes in occurrence/intensity/character of stresses present in 1995 to be noted for 2000

- allows new stresses to be recorded which are present in 2000 but were not present in 1995

This approach will be less time-consuming for Agency staff than the initial dataset assembly, relatively easy to implement and provide an opportunity to increase consistency between Regions. The latter advantage would be enhanced by further explanatory text on how to assess the intensity and significance of individual stresses. With better guidelines and greater consistency in the assessment and recording of the perceived stress operating on a site, the resulting information on changes in stress type and severity can then related to changes in both overall biological condition and the occurrence and perhaps abundance of individual taxa between the 1995 GQA and 2000 GQA. If this approach is adopted the Agency will need to consider how it is to be financially resourced, including possibly input from the Agency's R&D budget.

Another option for the development of RIVPACS DYNAMO is the production of a module that can be used to detect the impact of change in flow. The research schedule for R&D Project E1-007 includes the following specific objectives:

> *2 To investigate the mechanisms by which a dynamic model may be constructed for evaluating the impact of changes in the physical environment on invertebrates, in particular the impacts of changes in discharge.*
>
> *4* [To] *identify the dynamic model relating <u>either</u> to water quality <u>or</u> to discharge which shows the greatest operational usefulness and which is most likely to succeed.*

The methodology for developing this model would follow the same course to be adopted for the organic pollution module and will benefit from the existing, year-specific information on the RIVPACS time variant variables, width, depth and substratum currently contained in the 1990 RQS and 1995 GQA environmental databases held by IFE.

However, in RIVPACS III+, discharge is currently held as time invariant values derived directly from River Quality Survey maps produced in association with the reports on the RQS's of both 1975 (Department of the Environment & The Welsh Office 1978) or the 1985 (Department of the Environment and the Welsh Office 1986). Whilst time specific discharge can be obtained from the product of the standard RIVPACS measurements of width, depth and surface velocity there are many disadvantages in this approach: the latter variable is not always recorded, only three measurements a year are made, normally under non-extreme flow conditions, and the use of width and depth data adds little new information not accounted for by the separate use of these variables.

In order to get more precise information on the variability and temporal trends/inter-annual differences in flow conditions, real gauged data may be required. The disadvantage of this approach is that few GQA sites will have a nearby flow gauge and the variability of flow measurements for sites in complete river catchments may depend on no more than one or two gauges in those catchments. An alternative may be to use the predicted data generated from the Institute of Hydrology's micro-LOWFLOWS package (Gustard *et al.* 1992). The effectiveness of these alternative sorts of data will need to be practically evaluated before proceeding with either approach. If real data are to be used to develop the model, then the Environment Agency will need to supply the IFE with the relevant data for each of 1990, 1995 and, as soon as available, 2000.

In order to investigate the effects of changes in discharge, it is recommended that information on the actual discharges during 1990 and 1995 should be used to develop the model, in addition to (or possibly instead of) the time invariant discharge class currently used in RIVPACS III+, and information from 2000 should be used to test it. The success of this approach will partly depend on regional rainfall and flow conditions during 2000 compared to 1995 and 1990, as this will provide the base data on observed changes in flow conditions.

## 6.2 The Biological Condition of Headwater Streams

This report has shown that sites near their source (defined here as within 5km) are less likely to be of "very good" quality and more likely to be of "poor" or "bad" quality than sites further downstream. This raises the important questions:

- is the phenomena due to a real effect, namely that a high proportion of near-source streams are impacted?
- is the apparent poor condition of near-source streams at least partly as a result of the expected fauna for headwater sites being over-predicted by RIVPACS III+ because of an inadequate representation of these sites in the system?

It is recommended that further research is undertaken to better understand the factors leading to the poor biological condition of so many small streams, and how this can be remediated. In an earlier report to the Environment Agency, Furse (1995) made the following recommendations for research priorities on headwater streams (i.e those watercourses within 2.5km of their source):

! **studies of the sources of macro-invertebrate species richness in headwaters and the implications for the restoration and management of streams for conservation purposes**

! **an understanding of the role played by soils in the transport of agri-chemicals and sediment into streams and the consequences for the habitat diversity and biological condition of those streams, including the development of vulnerability/risk models**

! **the implementation and evaluation of headwater restoration projects**

! **the operational development of a headwaters module for RIVPACS**

! **an evaluation of headwater streams as habitats, spawning grounds and recruitment areas for fish: this project should be linked to the current headwater research programme in order to maximise the benefit of existing information**

## 6.3 Summary

The current research programme, R&D Project E1-036 provides the basic data sets required to establish and test a dynamic version of RIVPACS (RIVPACS DYNAMO), of operational use in predicting faunal response to organic pollution. It does so by:

a) providing a basic understanding of the extent to which the distribution and frequency of macro-invertebrate families vary with changes in physical conditions, the presence or absence of environmental stresses and shifts in biological grade

b) providing an appropriate suite of sites for developing the new model (including identifying sites subject exclusively to differing intensities of organic stresses)

c) providing baseline data on real, temporal changes in both biological and environmental data at over 3000 matched sites.

The early availability of 2000 GQA data is seen as important in the development and testing of RIVPACS DYNAMO because it is considered that the methodologies adopted in 1995 and 2000 are/will be more reliable and consistent with each other than either year is with 1990. As such 1990 and 1995 data can be used to develop RIVPACS DYNAMO but 1995 and 2000 data are better used to test, enhance and operationally develop the model in later phases of this work.

The availability, to IFE, of appropriate 1990 RQS, and 1995 and 2000 GQA, chemical data are essential to the development of RIVPACS DYNAMO.

It is recommended that the collection of environmental stress data be continued in association with the 2000 GQA in order to provide dynamic information on changes in occurrence or intensity of individual stresses. These data are necessarily subjective but protocols and definitions should be established in order to minimise differences in interpretation and recording of stresses and their character and intensity.

Collation of stress data in 2000 should also be used as an opportunity to appraise and, if necessary, refine or correct stress information provided in relation to the 1995 GQA.

In the current R&D Project E1-007, one aim is to investigate the potential for developing a dynamic version of RIVPACS which can be used to predict faunal response to changing physical conditions, particularly flow. If such a system is to be effective then more detailed temporal information on the magnitude and variability of flow, within and between years will be required.

The current investigations have re-emphasised the apparently poor overall condition of headwaters. A series of research proposals, concerned with headwater streams, is provided for the Environment Agency's consideration.

# 7 REFERENCES

Armitage, P D (1989) The application of a classification and prediction technique based on macro-invertebrates to assess the effects of river regulation. In *Alternatives in Regulated River Management*, edited by J A Gore & G E Petts, pp267-293, Boca Raton, Florida: CRC Press Inc.

Armitage, P D (*in press*) The potential of RIVPACS for predicting the effects of environmental change. In *Assessing the Biological Quality of Fresh Waters. RIVPACS and Similar Techniques*, edited by J F Wright, D W Sutcliffe & M T Furse, pp 93-111, Ambleside: Freshwater Biological Association.

Armitage, P D, Cannan, C A & Symes, K L (1997) *Appraisal of the use of Ecological Information in the Management of Low Flows.* R&D Technical Report W72, 97pp, Bristol: Environment Agency.

Bunce, R G H, Barr, C J, Clarke, R T, Howard, D C & Lane, A M J (1996a) Land classification for strategic ecological survey. *Journal of Environmental Management,* **47**, 37-60.

Bunce, R G H, Barr, C J, Clarke, R T, Howard, D C & Lane, A M J. (1996b) ITE Merlewood land classification of Great Britain. *Journal of Biogeography*, **23**, 625-634.

Chessman, B C (1999) Predicting the macroinvertebrate faunas of rivers by multiple regression of biological and environmental differences. *Freshwater Biology*, **41** (4), 747-757.

Clarke, R T (in press) Uncertainty in estimates of biological quality based on RIVPACS. In *Assessing the Biological Quality of Fresh Waters. RIVPACS and Similar Techniques*, edited by J F Wright, D W Sutcliffe & M T Furse, pp39-54, Ambleside: Freshwater Biological Association.

Clarke R T, Furse M T, Wright J F & Moss D (1996) Derivation of a biological quality index for river sites: comparison of the observed with the expected fauna. *Journal of Applied Statistics*, **23**, 311-332.

Clarke, R T, Cox, R, Furse, M T, Wright, J F & Moss, D (1997) *RIVPACS III+ User Manual. (River Invertebrate Prediction and Classification System with Error Assessments).* R&D Technical Report E26, Bristol: Environment Agency.

Davy-Bowker, J, Furse, M T, Clarke, R T & Gravelle, M J (2000) *Analysis of 1995 Survey Data. Phase 2: Post-Survey Appraisal. Unit 1: Taxon Distribution Studies*. R&D Technical Report E103, Bristol: Environment Agency.

Department of the Environment and the Welsh Office (1978) *River Pollution Survey of England and Wales. Updated 1975. River Quality and Discharges of Sewage and Industrial Effluents*, London: HMSO.

Department of the Environment and The Welsh Office (1986) *River Quality in England and Wales 1985. A Report of the 1985 Survey*, London: HMSO.

Fuller, R M, Groom, G B & Jones, A R (1994). The Land Cover Map of GB – an automated classification of LANDSAT Thematic Mapper data. *Photogrammetric Engineering and Remote Sensing,* **60** (5), 553-562.

Furse, M T (1995) *The Faunal Richness of Headwater Streams. Stage 4 - Development of a Conservation Strategy*, National Rivers Authority R&D Note 455, Bristol: National Rivers Authority.

Furse, M T, Clarke, R T, Winder, J M, Symes, K L, Blackburn, J H, Grieve, N J & Gunn, R J M (1995) *Biological Assessment Methods: Controlling the Quality of Biological Data. Package 1: The Variability of Data used for Assessing the Biological Condition of Rivers.* R&D Note 412, Bristol: National Rivers Authority.

Furse, M T, Clarke, R T, Davy-Bowker, J & Vowles, K E (1999) *Analysis of 1995 Survey Data. Phase 2: Post-survey Appraisal. Unit 3: Post-Survey Appraisal.* R&D Technical Report E102, Bristol: Environment Agency .

Gunn, R J M, Blackburn, J H, Winder, J M, Wright, J F & Symes, K L (1996) *An Audit of Performance in the Analysis of Biological Samples in 1995. NRA Thames Region: Primary Audit.* A report to the National Rivers Authority, Thames Region, 72pp.

Gustard, A, Bullock, A & Dixon, J M (1992) *Low Flow Estimation in the United Kingdom.* Institute of Hydrology Report No. 108, 83pp + appendices, Wallingford: Institute of Hydrology.

Verdonschot, P F M & Nijboer, R C (in press) Typology of macrofaunal assemblages applied to water and nature management: a Dutch approach. In *Assessing the Biological Quality of Fresh Waters. RIVPACS and Similar Techniques*, edited by J F Wright, D W Sutcliffe & M T Furse, pp241-262, Ambleside: Freshwater Biological Association.

Walley, W J & Martin, R W (1997) *Distribution of Macroinvertebrates in English and Welsh Rivers Based on the 1995 Survey.* R&D Technical Report E12, Bristol: Environment Agency .

Warn, A (1996) *The Quality of Rivers in England and Wales (1990 to 1995).* Unpublished report by the Environment Agency.

## APPENDIX I: INFORMATION REQUEST ON ENVIRONMENTAL STRESSES

### Information request for the analysis of data from the 1995 GQA biology survey

*The purpose of the request*

The aim of this request is to obtain information about the environmental stresses at biological GQA sites so that the associations between the invertebrate communities and those stresses can be identified. We also need information about things which may confound these relationships, i.e. factors other than environmental quality, some of which may have affected the biological samples, such as sampling difficulties, and inaccessibility of the site.

This information is needed for a number of R&D projects which aim to improve our ability to diagnose the nature of the environmental stresses at sites from standard invertebrate samples, in addition to classifying the overall quality. These projects are *The analysis of the 1995 biological survey - Phase 2* being undertaken by IFE; a module of *Development of improved methodologies for analysing biological data (RIVPACS)* also being undertaken by IFE, and *Artificial intelligence systems for diagnosis and classification of river quality* by Bill Walley, which is just about to start.

Information about Bill Walley's project is included in the attached document SUMMAR.WP. You are probably familiar with the SOMVIEW software (and RBMS) from the previous R&D which was distributed at the seminar in February. The aim of the next project is to produce software which will tell you want the likely cause of poor biological quality is (i.e. a diagnostic system). IFE's project to analyse the 1995 data will produce a report describing the taxa and communities which characterise different types of pollution - this should be a useful aid to pollution work. The module of the RIVPACS project which will use this data is to evaluate the potential of the RIVPACS approach for diagnostic systems - a dirty water RIVPACS.

I am sure that the information in the tables will also be useful for you. It should help you with your own reports as a handy source of information. I would like to add it to our biology databases so that you access it and use it easily.

*Instructions*

Attached to this E-mail is a list of sites sampled for the 1995 Biology GQA Survey for your Region (former NRA Region because this is how the National Biology Database is arranged). Each site is listed with National biology database site code (SITE REF), Regional site code (OLD CODE), watercourse name, site name, national grid reference and 1995 GQA class, as supplied by Julie Jeffrey. The tables are arranged alphabetically by watercourse name and then site name. NB some watercourses have two 'names' on the national database, the second having a number referring to the region appended in parentheses. See file *.xls in Excel, or *.wk3 in Lotus 1-2-3. The sites are listed alphabetically by Watercourse name, as it appears on the National Database. Note that for some watercourses, two names have been supplied to the National Database. If a 1995 GQA site is missing, please append it to the bottom of the list.

For every site, we would like information on the environmental stresses and possible influences on the biological sample. If conditions at the site have changed since 1995, please give the stresses as they were in 1995 (because we will be linking the information to the 1995 national survey data).

List the known or suspected stresses *at all sites*, regardless of GQA grade or whether the stress affected the biological sample: we will be using sophisticated techniques to look for patterns in the data; we will be looking at abundances, as well as presence and absence; and we need to know which stresses are undetectable from the invertebrate data.

It is important that everyone categorises the same stress in the same way, as far as is possible. To help with this, a list of the more common stresses is provided, together with codes to simplify data entry for you. DON'T PANIC! The list looks complicated at first, but it is organised logically, and a longer but comprehensive list will save you time in the long run.

Use the stress codes given in the table below to help us analyse the data. There are two levels of hierarchy: a high-level one (e.g. Farming) and a more specific second level (e.g. fertilisers). Use the second level whenever you can. If the stress is not listed, write it down in full (but briefly), preceded by an asterisk *. If you can, it would help us if you used the same description every time you record the same un-coded stress. Types of stress not listed should be mentioned in the notes column, or any other column if this already has an entry in it. An example of how to fill the table in is given below, as well as at the top of every Region's table.

Stresses on the list marked “at the site” refer to features within 50 m of the Sampling Area (i.e. within the Survey Area) as defined in BT001. All other stresses could originate beyond the Survey Area, but still influence the site.

You *must* specify the severity (or for site features, their extent) of every stress which you list on a subjective 3-point scale (severe = 1, moderate = 2 & light = 3). Use your expert judgement to do this. This includes stresses for which abbreviations are not listed (in which case, put the qualifier in parentheses). The only exceptions are a couple of categories where we simply ask you to record their presence.

Indicate suspected stresses or impacts by “?”

If you have information about the periodicity of the stress, or whether a pollutant is from a point or diffuse source, there are supplementary abbreviations by which you can indicate this.

Please try to provide as complete information as you can about sampling and sorting for the 1995 samples, in particular identifying samples collected by dredge or air-lift. If one of the categories on the list applies to only one of the samples collected in 1995, mention this in the notes column.

Use the following format: stress code (two capital letters), followed by question mark if the stress type is only suspected, followed by intensity (1, 2, 3), followed by optional qualifier (a, s, or c and p or d).

*examples*

Severe problem from a dairy effluent discharge = **DA1p** [p because you know it is from a point source]
Good quality site with no known problem = **NP**
Moderate problem from china clay works (silt, turbidity, etc.) = **CC2**
Severe pollution problem, but all efforts to trace the cause unsuccessful = **MY1a** [acute because not continuous]
Severe problem in winter, suspected from salts from road run-off = **RR?1s**
samples collected by air-lift = **AL**
Only the Autumn sample collected by air-lift, the other by pond net = **AL** and in the notes ***AL, Autumn sample only**
**M**oderate problem from deposits from an aluminium smelter = *** deposits from a nearby aluminium smelter (2)**
traces of ochre at site = **OC3**
sampling difficulty: very difficult to sample because of a high density of *Lemna* in both samples = ***sampling difficulty, high density of *Lemna* (1)**

There is no limit to the number of stresses per site, and you can list them in any order. Each stress should be recorded in a separate column. The stresses recorded should be the main ones which affect the biological site. It is very unlikely that there will be more than six, but you are permitted to add extra columns to the spreadsheet if you believe that there are more than six definable influences. Use the wide right hand column to record stresses for which no stress code is listed. You may alter the column width of other columns if you have more than one stress for which there is no code at any site. Each un-coded stress must be preceded by an asterisk (*).

Example:

**FE1c |TS3 | CL2 | DA?3 | AL | | * river bed jetted to unconsolidated gravels to improve fish spawning at beginning of year (3a)**

To provide quality assurance for data entry, please indicate the number of coded stresses recorded for each site (by numeral) and each un-coded stress (by *) in the QA column. For the example above, you would enter **5***. If there were 3 coded stresses and 2 un-coded stresses it would be **3****.

You may wish to make a paper copy of the table in order to fill it in. It may be best to print only the Watercourse name, site name, NGR and GQA class and not other columns, and to do this in landscape format in large enough font to give room for the stresses at each site to be handwritten. This would enable you to pass the list to your colleagues, pollution officers, river wardens, LEAPS officers, for whom it may be easier if the stresses were recorded in longhand (using the stress categories on the list) rather than as stress codes. Alternatively, the spreadsheet could be filled in directly. However you decide to elicit the information, you must submit your results electronically on the spreadsheet provided.

The list of stress codes should be printed on a single side of A4, in landscape (it should do this automatically), so that it can be referred to easily. It should print-out like that automatically. If it does not, let me know and I will post a couple of copies.

Please send your results to John Murray-Bligh no later than **Monday July 20.** If you have any problems with this request, please contact John Murray-Bligh as soon as you can.
This is a substantial request, though you have been warned to expect it. You will probably need to consult your colleagues in other Functions as well as LEAP reports if you do not have the information already. You will need to give them and yourselves time to enable this. Please do not leave your actions until the last moment.

Before you start, please read these instructions again, and call me if you have any problems.

John Murray-Bligh
7-25-5167

On behalf of Bob Dines, Mike Furse, and Bill Walley.

***qualifiers***

| | | |
|---|---|---|
| severe/moderate/light | | **1/2/3** |
| | except * (no qualifier) | |
| suspected/possible/unconfirmed | | **?** |

***additional qualifiers*** (not mandatory)

| | |
|---|---|
| acute/seasonal/chronic | **a/s/c** |
| point/diffuse | **p/d** |

***Impact/problem types***

| | | |
|---|---|---|
| No perceived problem * | | **NP** |
| Stress could not be identified (mystery) | | **MY** |
| No information * | | **NI** |
| Farming | | **FA** |
| | fertilisers | **FE** |
| | water cress beds | **WC** |
| | fish farm | **FF** |
| Pesticides | | **PE** |
| | herbicides | **HE** |
| | insecticides | **IN** |
| | sheep-dip | **SD** |
| Waste | | **WA** |
| | piggery | **PI** |
| | poultry | **PO** |
| | slurry | **SL** |
| | silage | **SI** |
| Agri-industry | | **AI** |
| | dairy | **DA** |
| | abator | **AB** |
| | vegetable processing | **VE** |
| | tanning/leather | **TA** |
| | wool | **WO** |
| | flour mill | **FL** |
| | brewery | **BR** |
| | sugar refinery | **SU** |
| Industrial discharge | | **ID** |
| | heavy industry | **HI** |
| | plating | **PL** |
| | light industry/commercial | **LI** |
| | detergent | **DE** |
| | paper mill | **PM** |
| | brick works | **BW** |
| | cement works | **CE** |
| | cooling water (warm) | **CW** |
| | colouration (dye) | **DY** |

| | | |
|---|---|---|
| Sediment at the site | | **SX** |
| | contaminated sediment | **TX** |
| | inert siltation | **IS** |
| Oils, petrochemicals | | **OI** |
| | crude | **CO** |
| | tar/bitumen | **TO** |
| | vegetable | **VO** |
| | lubricating | **LO** |
| | fuel (diesel/petrol) | **FO** |
| Construction | | **CT** |
| | building & road site | **BU** |
| | acids from exposed rocks | **EX** |
| Leachate | | **LE** |
| | scrap yard | **SY** |
| | slag heap | **SH** |
| | domestic landfill | **DL** |
| | toxic/industrial landfill | **TI** |
| STW | | **ST** |
| | treated STW effluent | **TS** |
| | septic tank | **SE** |
| | storm sewer overflow | **SS** |
| | combined sewer overflow | **CS** |
| WTW | | **WT** |
| | iron sulphate | **FS** |
| | aluminium sulphate | **AS** |
| | swimming pool | **SW** |
| Run-off | | **RO** |
| | urban | **UR** |
| | highway (incl. salt) | **HY** |
| | railway | **RR** |
| | heavy industry | **HR** |
| | light industry/commercial | **LR** |
| Acid deposition | | **AD** |
| Mining, quarries and extraction | | **MI** |
| | metal mine drainage | **MM** |
| | coal mine drainage | **CM** |
| | china-clay extraction | **CC** |
| | quarry (acid rock) | **QA** |
| | quarry (limestone / chalk) | **QB** |
| | sand & gravel | **SG** |

| | | |
|---|---|---|
| Channel at the site | | **AN** |
| | channelisation | **CA** |
| | culvert | **CU** |
| | cave | **CV** |
| | bedrock | **BE** |
| | concrete stream bed | **BD** |
| | bridge | **BG** |
| | canal | **CN** |
| | river navigation (locks etc) | **RN** |
| | artificial ditch or dyke | **DI** |
| | dredging | **DN** |
| | weed cutting | **WD** |
| | choked channel (>33% plant) | **CH** |
| Artificial bank at the site | | **AT** |
| | unconsolidated (Rip-rap/boulder) | **UC** |
| | consolidated (stone/brick/concrete) | **SB** |
| | sheet piling | **SP** |
| Bank practices at the site | | **BP** |
| | livestock poaching, trampling | **LV** |
| | mown/managed riparian zone | **MO** |
| | over grazing | **OG** |
| Impoundments | | |
| | regulated flow | **RF** |
| | weirs | **WE** |
| | reservoir u/s catchment | **RE** |
| | ponded flow (lake or reservoir d/s) | **PF** |
| | lake or pond close u/s | **LP** |
| | hypolimnic water | **HW** |
| | river transfer | **RT** |
| | freshwater but tidal | **FT** |
| Low flow | | **LF** |
| | abstraction (public supply) | **AP** |
| | from groundwater | **AG** |
| | from river | **AR** |
| | abstraction (irrigation) | **IR** |
| | cessation of STW discharge | **CD** |
| | drought | **DT** |

| | | |
|---|---|---|
| No flow | | **NF** |
| | winterbourne (natural) | **WI** |
| | dry channel (caused by man) | **DC** |
| Saline | | **SA** |
| | marine origin | **MA** |
| | inland geological | **IG** |
| | industrial discharge | **IL** |
| Land use | | **LU** |
| | afforestation (conifer) | **CF** |
| | intensive arablisation | **IA** |
| | urban/suburban | **US** |
| | moorland drainage | **MD** |
| | upland overgrazing | **UO** |
| | reedbed at the site | **RB** |
| Reclaimed land | | **RL** |
| | industrial | **RI** |
| | opencast | **OC** |
| Bank erosion at the site | | |
| | clay | **EC** |
| | sand | **ES** |
| | gravel, boulder | **EG** |
| Eroded material in channel | | |
| | inert siltation | **IS** |
| | gravel, boulder | **GS** |
| Sampling difficulty | | |
| | dredge * | **DR** |
| | air-lift * | **AL** |
| | access to one bank only * | **AC** |
| | bouldery site | **BO** |
| Sorting problem | | |
| | bank-side sort * | **BS** |
| | poorly preserved sample | **PR** |
| Other indicators | | |
| | sewage fungus | **SF** |
| | ochre | **OH** |
| | *Cladophora* | **CL** |

**(* = no qualifier)**