ENVIRONMENT AGENCY

North East Region

INTERIM REPORT ON THE ENVIRONMENTAL IMPACTS OF THE DROUGHT ON YORKSHIRE'S RIVERS APRIL 1995 TO APRIL 1996

November 1996

Frontispiece

The Drought in Yorkshire
Grimwith Reservoir outlet tower on 16th September 1995

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1. EXECUTIVE SUMMARY

This interim report summarises the results currently available from the environmental actions carried out or instigated by the Environment Agency to monitor and reduce the impact on rivers of the severe drought experienced in Yorkshire during 1995 and 1996. The report is confined to those rivers affected by Drought Orders granted to Yorkshire Water Services (YWS) on the rivers Aire, Calder, Don, Ouse, Ure and Wharfe, during the period April 1995 to April 1996.

Comprehensive measures to monitor the effects of the drought and the Drought Orders, to minimise any impact and, where possible, restore or improve the river have started but will take several years to complete. These measures have been agreed and progressed with YWS to meet the concern of potential environmental damage. A large amount of fisheries and other ecological work carried out in the spring, summer and autumn by both the Environment Agency and YWS of 1996 will be reported in spring 1997.

The main information used in this interim report is drawn from surveys in the period April 1995 to March 1996 carried out in relation to water quality, fish populations, riverine invertebrates (including a specialist survey for crayfish in the Wharfe) and aerial photography of the river corridor (Wharfe). In addition, site inspections, Environmental Statements supporting Drought Order and Time-Limited Licence applications, and work carried out as Drought Order conditions provide essential and valuable data and information.

The main findings of this interim report are:

- Yorkshire's rivers experienced extremely low flows for considerable periods during the late spring, summer and autumn of 1995, and subsequent winter river levels did not match normal conditions.

- Localised deteriorations in water quality were observed in the Calder catchment and were probably due to lack of dilution of STW effluents, although improvements in other stretches may have been caused by the lower frequency of storm sewer overflow events.

- Water quality of the Ouse downstream of Naburn WWTW deteriorated in 1995 and ammonia levels breached the EC Fisheries Directive on three occasions. Lack of dilution during extreme low flows may have been responsible.

- However, most of Yorkshire's rivers have not suffered any acute water quality effects during the Drought Orders, although measures were taken to protect fisheries when necessary. Artificial aeration of rivers during periods of critical low dissolved oxygen levels has been required on the Calder catchment, and elsewhere. Equipment was set up (eg. in the Wharfe at Otley) and necessary procedures put in place.

- Reductions in compensation releases from reservoirs in the Calder and Aire (Worth) catchments raised concern about impacts on downstream trout populations and a fisheries survey was carried out on behalf of YWS. This concluded that siltation of spawning gravels was potentially damaging, although reductions in gravel spawning areas was not a significant problem.

- Two fish rescues, because of low flow conditions rather than poor water quality, have been carried out successfully on the Calder .

- Other mitigation work (primarily related to fisheries) has been dealt with. This included clearance of cobble and gravel bars at the mouth of feeder streams on the Wharfe, that are important for salmonid spawning.

- There is some concern that the deterioration in water quality in the lower part of the non-tidal Ouse has led to changes in the benthic invertebrate populations. This is being looked at in some detail by both the Environment Agency and YWS.

- Some changes in the invertebrate populations of the Wharfe and other rivers are predictable responses to natural drought and low flows and reflect the inherent extreme variability in these ecosystems. The most common response has been the increase in numbers of many groups, including pollution sensitive cased and caseless caddisflies, and the increased presence of species favoured by slow flowing or ponded situations. There is no convincing evidence of a decline of any invertebrates as a result of the drought.

- Algal films and extensive covers of filamentous green algae were reported from several rivers, persisting into the autumn when they are usually broken up and dispersed by rising river levels and spates.

- The drought's impact on fish population structure and breeding success was largely investigated by surveys carried out in 1996, after the period covered by this report. However, spawning activity was observed at several traditional sites.

- It was clear that patterns of angling activity were influenced by the hot, sunny weather, the condition of the rivers and possibly by changes in fish distribution during 1995 and early 1996. Angling catches were variable, although lack of success was widely reported.

Potential longer term changes in the river ecosystems cannot be assessed now and it is likely to be April 1997 before sufficient information is available. Survey and analytical work on fish populations, invertebrates and aquatic plant communities will continue as part of this endeavour.

It must be realised that most environmental monitoring is not short term and that the true picture of the drought's impact will only emerge over several years. Many actions on drought monitoring have been targeted to continue over a three year period at least. This is to ensure that we not only look at potential damage long term but also ensure that any 'recovery' is complete.

2. BACKGROUND - DROUGHT OVERVIEW

2.1 What is a drought?

The start of a drought is generally easier to define than its end. The normally accepted start date is the beginning of the month when the rainfall was first below the monthly average, which in this case was April 1995. Therefore, the earliest one could know a potential drought had started would be in early May. This will be taken as the starting point for the consideration of the management of the drought.

More thorough accounts of the drought itself can be found in the following:

Report of the Independent Commission of Enquiry into Water Supply in Yorkshire, chaired by Professor Uff; and proofs of evidence submitted to it.

Review of 1995 Drought in Yorkshire, commissioned by the NRA and prepared by Sir William Halcrow Ltd., February 1996.

2.2 The use of Drought Orders

When water supply problems develop because of a drought, water companies can apply for an Environmental Drought Order, which gives the powers to abstract without a licence from a river or groundwater for up to six months. They must apply to the Secretary of State at the Department of the Environment (DOE) who makes the decision whether to grant the application.

The Drought Order is advertised and the public can object within seven days if they wish. The Agency is asked to comment to the DoE on the proposed order within the same seven days. Normally, if anyone objects to the proposed order, the DoE will hold a public hearing chaired by a planning inspector. Several of these hearings have been held through 1995 and 1996.

For Drought Orders to be obtained it has to be proved that there has been an exceptional shortage of rain. By the end of 1995 the drought in the west of Yorkshire was seen to be the worst on record both judged on lack of rainfall and on river flows.

2.3 How the drought in Yorkshire developed

The shortage of rainfall first caused problems in Bradford and Calderdale. Drought Orders which impact the environment should not be the first measure taken to manage a drought, and it is expected that hosepipe bans should be imposed in sufficient time and in the first instance.

Wharfe

The 1995 environmental Drought Order affecting the River Wharfe was applied for on the 26th July. Under normal circumstances it can take three to four weeks to have an application granted. The Drought Order application attracted much opposition from the public and YWS agreed to defer the implementation.

Calder

Discussions were also starting to be held with the Environment Agency about compensation flow reductions from the Calder reservoirs. The Environment Agency suggested a phased introduction of these reductions keeping the most sensitive rivers to last, when hopefully the drought would have ended. This was adopted by YWS and applications for compensations cuts on the Hebden Water, the River Worth, and Silsden Reservoir were made on 18th August 1995.

Further compensation flow reductions were applied for in August from the Calder reservoirs. At this stage the choice of which Drought Orders to consider was made following precedent set from previous droughts. It was the drought intensification in August that started to move the drought beyond those previously experienced. This intensification, coupled with the continuing rapid fall of the reservoirs, brought the emergency application for rota cuts in Bradford and Calder in September and a simultaneous application for an emergency order to take more water from the River Wharfe at flows below that had previously been contemplated.

The new Wharfe Drought Order did allow enough water to be abstracted to cause an improvement in the stocks. YWS decided to put the rota cuts application on hold while waiting to see the further improvements that could come from the Wharfe Drought Order.

The problems in Bradford, Calderdale and Kirklees became very public with the application for rota cuts, resulting in much concern being expressed by the residents of these areas, as well as concern expressed by environmentalists in relation to the further application on the Wharfe.

Ouse

In early October 1995, YWS indicated to the Agency that a Drought Order for the River Ouse would be required. Most historic droughts end or lessen between September and late October sufficient to allow refill of the upland reservoirs: it is quite unusual for intense droughts of the severity of this one to extend into November.

All rivers

With refill still not having started in late autumn 1995, further compensation reductions were applied for on those rivers already affected and on rivers previously considered too environmentally sensitive. In addition, further proposals to abstract from the Wharfe were applied for under Emergency Drought Orders. During this period conditions deteriorated and culminated in a further application for rota cuts in Calderdale and parts of Wakefield, made on 1st November 1995. The Calderdale reservoirs were at this stage into marginal stocks and tankering of water was taking place.

2.4 Winter refill

Later in November 1995 a slow recovery of the reservoir stocks started to occur in the west of Yorkshire, but the southern reservoirs continued to decline. Attention then started to turn more to the issue of refilling the reservoirs for 1996. Up to this time the immediate problems of continuing to supply water through to the end of the drawdown period had to have precedent. The measures in place would also help with recharge but further measures were clearly required. With so many drought orders already in place, it was becoming more difficult to find alternate sources of water within Yorkshire to help with refill.

2.5 Drought continuing into 1996

The drought could have broken any time, and previous history suggested it would break by the end of October. Although reservoirs have been refilling since November, they have been doing so at a very slow rate. It was clear that without exceptional rain in the late winter or spring, the impact of the 1995 drought was going to be carried through into the summer of 1996 as indeed has been the case.

Many of the Drought Orders granted since August 1995 have not been used before in previous droughts, giving YWS the ability to abstract at low river flows and to cut compensation flows from reservoirs to only one third of their normal levels. The environmental issues created by these conditions are considered in this report.

The full list of Drought Orders and Permits applied for is shown in Table 1.

2.6 The role of the Environment Agency in relation to Drought Orders

The Environment Agency's views are considered by the planning inspector and by the Department of the Environment (DoE), but the Environment Agency's views do not have to be followed. From the 1st April 1996, the water company (or other abstractor) could apply for a Drought Permit from the Environment Agency rather than the DoE if the proposed permit relates to changes in abstractions or changes in compensation flows. The Environment Agency will then decide whether to grant the application. As with Drought Orders currently, the company will not have to pay a fee for the additional water.

2.7 Balancing the needs of the Abstractor and the Environment

When commenting on Drought Order applications, the Environment Agency has to consider the needs of the abstractor, have particular regard for the needs of public water supply *and* has to consider its environmental duties to further conservation and enhance the environment. This requires a balance to be struck as the needs of public water supply in a drought generally conflict with the needs of the environment. As the drought developed and the needs of public water supply increased, the balance point of necessity shifted further towards the needs of water supply.

The balance was set by multifunctional teams of Environment Agency staff covering water resources, water quality, fisheries, and conservation in relation to the particular river under question. The needs of public water supply were assessed based on the demand, rainfall, reservoir stocks, the river flows, the time of year, the likely gains in terms of water supply to be made from the drought order, and other measures that could be taken. There is no Environment Agency policy defining the balance point, as it is very dependent on both the specifics of the river and the proposals; it also includes counsel's opinion.

2.8 Drought Orders - format of submissions

Any water company, in making its submission for a Drought Order, is expected to provide sufficient information to the inspector to allow for a judgement to be made. There is no standard format and no requirement for an Environmental Statement. However, YWS did provide fairly comprehensive reports with each of their submissions. These contained the following information: -

1 Drought Order Application Notice
2 Technical Brief
3 Reasons for requiring the Order
4 Location maps
5 Copies of Abstraction Licences
6 Strategy for dealing with shortages
7 Assessment of expected effects
8 Notice that Environment Agency will respond direct
9 Drought Order Draft Statutory Instrument

2.9 Environmental Statement

Despite there being no legal requirement for Environmental Statements these were produced as separate documents and contained:-

1 Introduction
2 Hydrology
3 Water Quality
4 Biology
5 Fisheries
6 Other Ecology
7 River Users
8 Mitigation & Conclusions

The amount of data available to define an environmental statement for the proposed drought order varied between catchments: generally the Wharfe and Ouse had far more data than the rivers of southern Yorkshire, such as the Calder and Don tributaries. This has meant that the statements submitted by YWS have been limited sometimes, and it has been compounded by the short time YWS staff have had to produce these statements, although YWS have had the opportunity to acquire these data since the droughts of 1989. This was part of the reason for insisting on the ecological monitoring to continue for some time until the river has recovered from the impact of the drought.

The Environment Agency expects YWS to have emergency plans that detail which rivers are to be used to maintain public water supplies in a serious drought and to ensure they have adequate data to produce satisfactory environmental statements of the likely impacts on these rivers. This can be achieved by forward planning, including environmental monitoring.

2.10 Drought Orders - format of responses

The Environment Agency has invariably referred to the inadequacies of the Environmental Statement provided by YWS and as a result the quality has improved with each new submission. The response is coordinated by Regional Water Resources from detailed functional responses. The responses include observations on:-

1. Rainfall, soil moisture deficit, reservoir contents (where applicable), river flows.
2. Compliance with any operating rules.
3. Whether use restrictions have been imposed appropriately.
4. The Agency's consideration of the necessity for the Order
5. The need to protect environment dealing with specific reference to:-
    a) Protecting current licensed abstractions
    b) Lack of dilution for effluents with deterioration in water quality
    c) Potential impact on fisheries
    d) Potential impact on biology/ecology

These have formed the basis of the Environmental Action Plan agreed with YWS for monitoring the environment, taking action to reduce the impact and restoring the river where damage occurs.

2.11 Predicting the impact of a Drought Order

In assessing the likely environmental impacts, the guiding principles were:

- the rivers are of high ecological quality and should be protected as far as possible;

- a precautionary approach to be adopted wherever possible, as many of the impacts take time to be evident;

- cumulative effects of more than one order need to be considered;

- environmental impacts need to be monitored to give better data for future occasions;
- mitigation should be sought wherever possible;
- a comprehensive environmental statement was expected given the high ecological value of the rivers.

The predictions were evaluated to produce an action plan that it is anticipated will eventually provide sufficiently detailed information not only to assess any damage but to suggest the mechanism by which it occurred and what can be done (**Figure 1**).

2.12 Making Drought Order responses - action to protect the environment

Many of the Environment Agency's responses contained specific conditions, which required agreement before the application could be supported. Agreement with YWS on these conditions was obtained in all cases, generally after negotiations. These conditions were referred to in the inspector's reports following public hearings, but were not specifically part of the resulting official Drought Order: the DoE took the opinion that they could not be included. The agreement was effectively made by an exchange of letters between the Environment Agency and YWS. Some issues required more time to resolve and were left "as to be agreed with the Environment Agency".

The Environment Agency has provided a comprehensive list of potential requirements for action under a Drought Order. These are shown in Table 2 and described more fully below:-

Monitoring to collect data to understand the impact of the Drought Orders, and how these related to the original prediction. Monitoring is also used to target mitigation measures where immediate action is required such as where fish are in distress and need to be rescued. The type of work covers physical habitat, aquatic flora and fauna including fish, birds and mammals and also the water quality and flows in the river. These measurements were required over a period up to three years, as appropriate, to ensure that adequate data were available.

Mitigation measures include the provision of aeration facilities on standby, cutting weeds where this improved oxygen levels, carrying out fish rescues and the use of fish screens to prevent fish getting pulled into the intakes at abstraction points from rivers. In addition, control of water levels was altered to increase soil moisture content where appropriate and "freshets" were released from reservoirs to improve quality. YWS were also required to provide measures that would alleviate any acute problems of water quality by maintaining sewage works and combined sewer overflows to the highest possible standard.

Restoration and improvement measures include work to restore the river where necessary by fish restocking, removal of obstructions to access to fish spawning areas, providing fish havens and improvements to fish passes.

Some of the conditions will be followed over several years. The Environment Agency and YWS have been sharing data to help define the best monitoring to carry out. With any balance between the needs of the public and the environment, an element of subjectivity is inevitable. Whether the Environment Agency has achieved the correct balance only time will tell. To judge whether any changes can be classed as unacceptable damage will also take time and, consequently, continued monitoring is vital.

The Environment Agency has not tried to pretend that many of the later measures taken by YWS will not cause environmental damage in the river, rather that the seriousness of the public water supply situation then and now has made the acceptance of this damage necessary. The solution is to ensure that if any of the problems with public water supply are the company's fault, mechanisms are found and developed so that this situation does not recur.

2.13 Environment Agency actions

The following were undertaken during 1995 to manage and measure the effects of the drought. Many of these actions are still being pursued as the drought conditions persist during 1996.

- Close liaison with Water Resources & Quality Departments was kept to monitor river water quality, especially at high vulnerability locations, notably downstream of waste water treatment works. Towards the end of the summer the frequency of monitoring surveys was increased as water quality data suggested conditions likely to result in fish mortalities.

- Towards the end of the summer weekly liaison meetings were held with YWS to review and modify as necessary the river water quality monitoring. The provision of aeration equipment was made at high risk locations to maintain minimum threshold oxygen levels.

- Using the water quality survey data as a trigger point, an 'Emergency Fish Rescue Action Plan' was developed by the Southern Yorkshire Area of the then NRA (see **section 3.2.3** and **Figure 3** for details). This was in preparation for possible isolation of fish in tributaries when compensation flows from reservoirs were reduced. The plan identified equipment and staffing needs and, due to the extensive lengths of possible high risk areas, called upon fisheries teams from neighbouring Environment Agency areas/regions to be placed on standby for mobilisation at short notice.

- As reservoirs became seriously reduced in volume the impacts of high suspended solids in their outflows became a concern. These levels were monitored both by chemical analysis and visual assessment. Measures to reduce this material by installation of straw bale dams to filter and settle the solids were trialled at a few locations. It remained a serious problem and fish recruitment was forecast to be adversely affected in 1996.

- Access arrangements to high risk locations requiring emergency fish rescues were investigated, and relevant angling interests were notified of possible emergency transfers. Locations for short and long term storage of rescued fish stocks were identified to allow restocking to take place on restoration of 'normal conditions'. The aim of fish rescues in small streams is to retain genetic identity of local stocks by leaving the smaller fish and allowing the transferred larger individuals to migrate back upstream when higher flows return.

- In preparation for predicted fish rescues and transfers to other waters, samples of fish were obtained and health tested according to fisheries legislative requirements. Indications of poor health, general condition and signs of reproductive failure were also investigated.

- On receipt of Drought Orders, angling interests were notified and potential impacts on fisheries were identified to allow these groups to formulate comments for submission at Drought Order public hearings.

- Photographic records were obtained at key locations downstream of reservoirs affected by compensation flow reductions. Features such as reduced flows, reduced channel widths, siltation effects, etc. were recorded.

- Regular inspections were made on river and reservoir conditions.

2.14 Yorkshire Water Service's actions

It was vital that the water company undertook the agreed conditions set under the Drought Orders and Time Limited Licences as well as continuing to run its own routine operations efficiently. Up to the time covered by this report:

- YWS have to date maintained high operational standards at their sewage works and combined sewer overflows.

- YWS have almost completed the improvements to the fish screens on their abstractions and will do so on new structures during construction.

- YWS have carried out, or are carrying out, all the monitoring agreed but full evaluation of the results is still awaited.

- The Environment Agency and YWS have provided and used emergency aeration equipment, when required, to prevent fish mortalities on the Calder in particular.

3. ENVIRONMENTAL IMPACTS OF THE DROUGHT ON RIVER CATCHMENTS

The following sections summarise the basic monitoring work and data analysis that has been completed to date on the river catchments affected by Drought Orders and Licence Variations. The rivers have been dealt with in alphabetical order.

3.1 River Aire

3.1.1 Summary

The River Worth is a tributary of the River Aire flowing from its headwaters above Haworth and joining the Aire at Stockbridge near Keighley. The Worth is regulated by compensation flows discharged from Ponden and Lower Laithe Reservoirs. It is joined by Bridgehouse Beck at Mytholmes downstream of Haworth. Flows on this tributary are also regulated by compensation water from Leeming and Leeshaw reservoirs. Upstream of its confluence with North Beck, the Worth is a predictive trout stream and provides a valuable nursery stream for the Aire. Other reservoirs on the Aire were subject to Drought Orders but the Worth is an important fishery and spawning ground and so was perceived to be at greater risk.

The effects of the reduced flows from the reservoirs in the Aire catchment have not had as deleterious impact as reduced flows in the Calder catchment.

Results of the monitoring programme to date suggest that apart from a decline in quality below Oxenhope STW, chemically the river remained in the same water quality class. It is still not possible to quantify the impact on the biology until later this year. The Worth is an important fishery and it may be three years before the full extent of any damage to the fishery is known.

3.1.2 Hydrology and water resources

The flows in the Aire catchment are measured at Kildwick, Fleet Weir and Beal.

The flows in February 1995 were well above average - rates of over fifty times the dry weather flow, the highest in the 15 years of recording, were measured at Kildwick and led to flooding in the upper Aire valley. Further downstream the flows were less extreme and were below historic maximum values. Flow rates fell during the spring of 1995 and in April the river fell below its average, the minimum values occurred towards the end of August and remained at a very low level until December.

Typically the Aire catchment has around 960mm of rain each year. In 1995 the catchment had only 678mm amounting to only 70% of the Long Term Average (LTA) and over half of this had fallen before the end of March.

Reduced compensation flows from the reservoirs of the Aire catchment do not have such a major effect on the main river as was seen on the Calder catchment. The effects were more localised to the tributaries leading from the reservoirs and the River Worth, whose headwater streams are impounded, was considered most at risk.

Drought orders currently in force reduce the overall compensation level to one third of its original. In November 1995, Leeshaw Reservoir, which supplies the Keighley area, was down to 3% and so compensation releases stopped. To mitigate for this, releases from Leeming Reservoir, itself down to 10%, were increased so that the net effect on the Worth was no change: however, the minor tributaries did suffer.

3.1.3 Water quality

To assess the effects of reduced compensation flows in the Worth catchment, extra samples at GQA and non GQA sites have been taken. Most of the sample points comply with their objective, except the site below Oxenhope STW downgraded by one class from B to C. It is not known how far downstream the downgrade effect continues, and further monitoring is planned to identify the extent of the deterioration.

Bridgehouse Beck is affected by compensation releases from Leeming and Leeshaw reservoirs. Chemical monitoring points on Leeming and Leeshaw Becks and on Bridgehouse Beck upstream of Oxenhope STW have allowed these stretches to be classified as GQA grade B, which complies with their objective. The Bridgehouse Beck sample point is downstream of the village of Oxenhope.

Recent samples from Bridgehouse Beck below Oxenhope STW (a non GQA site) have shown that this point is grade C and does not comply with its objective of B. However, the downstream GQA site on the Worth at Ebor Mill does comply with its objective and further work is being done to find out how far downstream this downgrade remains.

Samples taken recently from Morkin Beck below Keighley Reservoir (non GQA site) have shown that this sample point is grade B, complying with its objective. This sample point is immediately downstream of the reservoir and there are no consented sewage or trade discharges.

The remaining Worth catchment is covered by the following GQA sample points:

River Worth u/s Bridgehouse Beck
River Worth at Knowles Park
River Worth Below Keighley
North Beck u/s R. Worth

Samples at all these points comply with quality objectives. It should be noted that 34 combined storm overflows (CSOs) discharge to the Worth catchment and so there is potential for significant water quality problems. It has been recommended that any extension to drought orders should require increased monitoring of these CSOs by YWS.

3.1.4 Ecology

The River Worth is of excellent biological quality in its upper reaches. Adjacent to Knowles Park (which is some distance downstream of the confluence with Bridgehouse Beck) quality is reduced somewhat. By the centre of Keighley slight recovery is achieved. Bridgehouse Beck upstream of Oxenhope Sewage Works is of good biological quality but the faunal diversity deteriorates downstream of the input from the sewage works and again upstream of the confluence with the River Worth.

3.1.4a Invertebrates

The Environment Agency has carried out two special macro-invertebrate surveys in the Aire catchment downstream of eight reduced reservoir compensation flows, ie. at Lower Laithe, Leeshaw, Leeming, Eldwick, Weecher, Reva, Keighley Moor and Ponden reservoirs. The first survey was undertaken during autumn 1995 and the second during June 1996. This survey will be repeated in autumn 1996. Routine sampling has been extended to include certain sites in the upper reaches of the main river and in the River Worth catchment to investigate the effects of the low flows and reduced compensation releases. Some samples have been sorted and identified to family level but initial results are not yet available.

YWS have also been carrying out surveys, agreed with the Environment Agency, and these data have been received. Semi-quantitative and quantitative samples have been taken of the invertebrate communities and River Habitat Surveys have also been undertaken to monitor habitat changes along the river corridor. Some sites sampled by YWS have also been sampled by the Environment Agency to check results. Both the Environment Agency and YWS results will be sent to the Institute of Freshwater Ecology for external audit.

3.1.5 Fisheries

The River Worth is a valuable nursery stream for the River Aire, and trout populations upstream of Bridgehouse Beck are predictive. In comparison with other catchments affected by the drought, the impact on the fishery was not as critical. The length of river affected by reduced compensation water was approximately 4km. Within this reach there are no major effluent inputs and consequently water quality impacts were not a major issue. Reduced flows to the lower river were compensated by increased discharges from reservoirs on the Bridgehouse Beck system, thus alleviating any effluent dilution problems in the lower reaches.

3.1.5a Fisheries Surveys

As the Worth was included in the Pennine Drought Orders, fish population surveys were carried out on the upper Worth in the reaches affected by reduced flows, for YWS by Fisheries Surveys Ltd (alongside similar work on the Calder), between 12th and 26th October 1995. The Executive Summary of their final report is included in the present report as **Appendix A**. The main conclusions concerning the Worth were:

- The River Worth was found to support moderate to good populations of brown trout and bullheads. The presence of a high percentage of fish in their first year may be indicative of good spawning gravels at both sites (Stanbury and Haworth) and suggests that the river is of generally good status.

- Given the fact that significant levels of potentially usable spawning gravels were submerged at the time of the survey and that access to such areas for fish is not limited it is considered that the continuation of existing water levels in the Worth would not deleteriously effect overall salmonid spawning potential.

These surveys are to be repeated for the next three years to identify any recruitment losses.

3.1.5b Other Actions

As identified in other fisheries surveys, siltation of spawning gravels may require remedial action upon the restoration of normal flows.

Mitigation fish restocking has not been required to date in the Aire catchment. If losses to fish populations are identified in surveys this option will be carried out on restoration of normal flows.

3.2 River Calder

3.2.1 Summary

The River Calder rises west of Todmorden on the Pennine Moors and flows 87 kilometres to join the River Aire at Castleford. Many moorland streams at the head of the Calder Valley are uncontaminated and consequently have been heavily exploited for public water supply. There are 39 reservoirs licensed for this purpose and the area's needs are supplemented by imports from the Winscar Reservoir at the head of the Don catchment and from the rivers of North Yorkshire.

The Calder Valley has a history of industrial exploitation and neglect and the legacy of this can be seen throughout the river's length from Todmorden down to its confluence with the Aire at Castleford. Water quality in the main river remains a restricting factor in the development and maintenance of its fish populations. Above Todmorden, the effects of long abandoned mine workings still exert an impact, while further downstream discharges from several sewage treatment works continue to limit the development of sustainable fisheries.

During 1995 the Calder catchment had only 79% of the long term average rainfall, with most rain falling before the end of March. The hot, dry summer meant that reservoir stocks were severely depleted and drought orders were sought and put in place that continued throughout the winter.

The Pennine Reservoirs Drought Order was the first order to be applied for by YWS. The Order covered many reservoirs and involved proposals for reductions in the compensation releases for a range of tributaries of varying ecological importance. The likely impacts of the reductions were prioritised and initial cuts involved only those identified as likely to have a 'low' effect on the watercourse. However, as the effects of the drought worsened, reduced compensation releases from those reservoirs listed as likely to have a medium and high effect were of necessity included - see **Table 5**.

The Environment Agency already had a comprehensive monitoring programme in place covering flow, quality, biology and fisheries interests. This work was enhanced as a condition of the Drought Order with extra ecological work to be carried out by YWS in 1995 and throughout 1996. At the start of the drought an action plan was devised to manage and measure its effects, and included an emergency fish rescue plan. Various monitoring programmes were set up to investigate the drought's impacts, supplementing the already existing programme. The extent of the drought monitoring work done in the Calder catchment can be seen in **Figure 2**.

Some sections of river showed a general improvement in chemical quality possibly due to the less frequent operation of combined sewer overflows. Other sections, most notably downstream of major discharges, showed a decline in quality due to reduced dilution. There have been several areas where the dissolved oxygen fell to critical levels and aeration was put into place to prevent fish mortalities. At Brookfoot, despite continuous aeration, dissolved oxygen levels remained low, especially at night and, suggested that excessive weed growth was involved. Weed was cut to alleviate the situation.

Biological monitoring took place at routine sites in 1995 to assess the quality of the catchment. These sites were not ideally located to monitor the problem areas identified in relation to the drought and extra sites were added in the autumn. The full impact of the drought will only become clear after reviewing the data from the next two years in detail, and initial results serve to confirm the findings of the water quality monitoring.

Fisheries surveys were carried out in the headwaters of the catchment with the most serious impact identified as the siltation of spawning gravels. There is also evidence of downstream displacement of fish and further surveys are proposed to monitor this impact.

3.2.2 Hydrology and Water Resources

The flows in the Calder are measured at Caldene Bridge in Mytholmroyd, at Elland, and at Methley, which is just upstream of the confluence with the Aire. Several of the main tributaries are also monitored. The upper Calder responds rapidly to rainfall, but the response of the lower Calder is both later and less pronounced.

The Calder catchment typically has around 1290mm of rain per annum, but in 1995 the catchment had only 1019mm amounting to only 79% of the LTA (long term average), with most of this falling before the end of March. The hot dry summer meant that reservoir stocks were severely depleted and drought orders were put in place and continued throughout the winter. During the first six months of 1996 the catchment had only 419 mm of rain, 68% of the LTA of 618 mm.

When rain fails to occur in large quantities, any that does fall upstream of the Pennine reservoirs is retained to raise reservoir stock levels. This results in the rivers being only provided with the minimum compensation flows required by statute, or even a reduced figure allowed under a Drought Order.

Across the reservoir groups that impound the headwaters of the Pennine rivers, Drought Orders are currently in force that reduce the level of release of compensation water to one third of the statutory amount. The Calder group supply Kirklees and Calderdale and total flows for the group as a whole has been reduced from 97.6 tcmd to 32.6 tcmd.

In 1995 the river fell below its average level in April and while there were occasional peaks, the trend remained below average throughout the rest of the year. The low rainfall figures and the very low base flows resulted in a drop to Dry Weather Flow again in 1996. This happened around two months earlier than 1995 for the upper Calder, and around the same time for the lower river. Drought Orders remained in place throughout the winter 1995/96 and water was retained in the reservoirs in an attempt to replenish stocks; the flow rates as compared to the average were at their lowest during November and December.

An assessment of the vulnerability of each watercourse to the proposed reductions in compensation flows can be seen in **Table 5**. The initial phase of compensation cuts involved only those reservoirs identified as 'low' priority. However, as the effects of the drought worsened, the reservoirs listed as medium and high priority were included.

3.2.3 Water quality

In addition to water quality samples taken by the then NRA, initially, regular spot sampling, boat surveys and continuous dissolved oxygen monitoring was also undertaken by YWS throughout the affected catchment. Subsequently, this monitoring programme was focused on specific reaches identified as likely to be affected during a continued drought.

To assess the effects of the drought on chemical water quality an assessment using GQA methodology was carried out on river samples taken during 1995. This was then compared to a baseline GQA for 1992-94 (**Table 3**).

Mostly the downgrades in quality were thought to be due to reduced dilution available for the STW's. However, some stretches showed an improvement in water quality and usually this was thought to be due to less frequent operation of combined sewer overflows.

Some of the tributaries were not affected by reduced compensation flows and yet most still showed a deterioration in quality: for example, the quality of Red Beck deteriorated from grade B to D due to BOD (90%-ile of 6.4mg/l). This was due to the reduced dilution available for Shibden Head STW. As there are no compensation releases to the beck, the deterioration is an indication of the effect of the drought on a catchment receiving STW effluent but unsupported by compensation releases.

On Clifton Beck quality deteriorated from grade C to D due to a reduction in dissolved oxygen (10%-ile was 62% saturation). As this beck receives neither STW effluents nor compensation flows the quality deterioration was due solely to low flows/high temperatures. Similarly, Walsden Water and Ramsden Clough have low flows and are likely to be adversely affected by drought conditions and hot weather. Neither receives STW flows and any discharges from CSO's and compensation releases take effect downstream of the monitoring points.

Particular stretches were thought to be vulnerable to low dissolved oxygen (DO) levels:

1. The Cragg Brook to Luddenden Brook stretch of the River Calder showed a deterioration from grade B to C. Although quality deteriorated, the DO was maintained at adequate levels, the 10%-ile value was 66% saturation. Both the NRA and YWS installed DO meters at the bottom of this stretch during the early part of the drought, until it was established that, even in low flow conditions, low DO was not threatening the fishery.

2. The Black Brook to River Colne stretch of the Calder was also considered vulnerable and, as it was a long stretch, it was further subdivided by a non-GQA sampling point. While the lower section showed an improvement, the additional sampling point at Brighouse indicated reduced DO levels, pointing to a possible dissolved oxygen sag within the stretch. This was confirmed by boat surveys that pinpointed the sag in the Cromwell Bottom - Brookfoot area. Aeration was put in at the former Elland Power Station site in November 1995 and its effectiveness monitored by means of boat surveys. The surveys suggested that the type of aeration used was very limited in its effectiveness with more re-aeration being provided by the weir at Cromwell Bottom. Aeration of Halifax STW was carried out using the works screw flood pumps and flood outlet cascade.

   By mid December, due to increasing natural dissolved oxygen levels and much lower river temperatures, aeration was stopped. The boat surveys were replaced by a recording DO meter positioned at Brookfoot. Control levels were agreed with YWS at which aeration and *daily bank walking* would commence, based on the information from the Brookfoot (and other) DO metres. *If any dead or distressed fish were observed this would have triggered the emergency fish rescue procedure.* **Figure 3** summarises this Action Plan.

3. The River Rybum was also seriously affected. Its GQA grade deteriorated from B to C, confidence levels being 46% for B and 48% for C. The 95%-ile values

for BOD and ammonia were 4.06mg/l and 0.18 mg/l respectively.

The cause of the downgrade was the reduced dilution available to Ripponden Wood STW effluent. Because the Ryburn is an important trout fishery, to mitigate the STW's impacts, 'aeration' of the STW effluent and the upstream river was carried out using pumps and splash plates. A recording DO meter was installed downstream of the works. The meter showed that DO levels did not fall to values that put at risk the trout fishery and were in agreement with the GQA dissolved oxygen 10%-ile of 83% saturation. As a further mitigation measure, YWS released additional compensation flow when the Ripponden Wood storm sewage overflow operated. A telemetry link was set up to enable this.

4. A recording DO meter was installed on the River Holme at Honley, downstream of Neiley STW. Information from this was in line with the results from the GQA samples that have a 10%-ile dissolved oxygen of 77% saturation.

As reservoirs became seriously reduced in volume the impacts of high suspended solids became a concern. These levels were monitored both by chemical analysis and visual assessment. Measures to reduce these suspended solids by installation of straw bale dams to filter and settle the solids were experimented with at a few locations. It remained a serious problem and fish recruitment was forecast to be adversely affected in 1996. Work has begun to try to identify the areas where the fish spawning gravels have become impacted with silt due to the increased suspended solids in the water column. Mitigation of these effects will begin shortly. No acute toxic effects were caused and no fish mortalities occurred as a direct consequence of suspended solids.

3.2.4 Ecology

The Calder catchment supports several conservation sites that are important at international, national and county levels. Some of the wildlife depends upon small acid flushes, marshy areas etc, which are sensitive to low flow conditions. In general, streams in the upper reaches of the Calder catchment are of good biological quality, supporting stonefly dominated faunas although the minewaters in the upper reaches of the river appear to restrict the abundance of some taxa.

Some of the upper tributaries are vulnerable to acidification because of their poorly buffered nature (these have been identified as Alcomden Water, Luddenden Brook, Booth Dean Clough, Merrydale Clough, Walsden Water, Holywell Brook, River Ribble, and New Mill Dyke). The main river channel is heavily engineered in this urbanised valley throughout most of its length, especially through Todmorden. This reduces the river's capacity for self purification downstream of polluting inputs. The urban runoff from Todmorden causes a reduction in biological quality and is further reduced by the effluent from Eastwood STW. By the time the river reaches Hebden Bridge some recovery is achieved. At Sowerby Bridge there are problems with intermittent pollution that have been difficult to trace.

Biological quality decreases further in Sowerby Bridge, and from Copley downstream the quality remains generally poor. Downstream of Huddersfield STW final effluent, the fauna supported by the river is seriously restricted and little recovery is achieved. In general the more urbanised areas have problems with mild sewage pollution and the heavily industrialised rivers Colne and Holme have considerable problems with chemical pollution.

Invertebrates

Before the 1995 drought many sites were already routinely monitored by the NRA for their biological quality. During 1995 an increased sampling programme for the GQA survey was carried out. This involved the sampling of sites twice during the year, once in spring (March to May) and again in the autumn (September to November). This allowed a rough comparison for the sites before and during drought conditions. The general biological quality of the Calder catchment did not appear to have deteriorated during 1995 when compared with previous years data **(Table 4)**.

The routine sampling programme for 1996 has been extended to include sites that may be sensitive to the current drought conditions, and the samples will be sorted to species level.

Besides the NRA/Environment Agency's routine work, a detailed survey of sites on both impounded and non-impounded watercourses in the upper catchment was carried out. Sampling took place during late autumn 1995 and was repeated during Spring 1996 (it will continue in these two seasons for some time). Sites were chosen preferentially where there were previous data available although for many sites these do not exist. All sampling and sorting have been carried out using standard techniques and a quality audit system is in place.

The results of these surveys should enable the effects of both the drought and the reduced compensation flows to be assessed. At present, the autumn samples from 1995 have been identified to family level but species level identification of these is necessary and will be carried out, as the life cycles and ecology of individual species can vary greatly.

YWS have also been carrying out surveys, agreed with the Environment Agency. Semi-quantitative and quantitative samples have been taken of the invertebrate communities and River Habitat Surveys have also been undertaken to monitor habitat changes along the river corridor. Some of the sites sampled by YWS have also been sampled by the Environment Agency to check results. Both the Environment Agency and YWS results will be sent to the Institute of Freshwater Ecology for external audit.

3.2.5 Fisheries

Almost from its source, the River Calder suffers from the effects of industrial activity. Abandoned mines upstream of Todmorden quickly combine with the river's natural acidity to limit the maintenance and development of the brown trout populations. As the river flows down towards Hebden Bridge, conditions begin to improve as tributaries such as Colden and Hebden Water add their flow. Many tributaries themselves have, in the past, been subjected to industrial development and, although water quality in many has now recovered, there remains a legacy of impoundments that limit the free movement of fish within the system.

Hebden Water is one of the most important of these tributary streams. It is a highly productive brown trout nursery area, contributing significantly to the maintenance of populations of this species in the main river.

Between Hebden Bridge and Sowerby Bridge, the Calder receives discharges from several sewage treatment work facilities which, in the past, have been implicated in major fish kills. The most damaging of these occurred in 1994, when a highly toxic pollutant from a local factory resulted in the almost complete annihilation of fish populations over several kilometres of the Calder, affecting stocks almost to the confluence with the River Colne. The redevelopment of fish populations using money received from a compensation award has been undertaken by the Environment Agency and is still ongoing.

From Sowerby Bridge to Mirfield, the Calder is principally a coarse fishery. Traditionally, natural reproduction has been supplemented by restocking work carried out by, and on behalf of, angling interests. The natural sustainability of these populations remains chronically affected by variable water quality.

Below the outfall from Huddersfield STW at Mirfield, the chemical quality of the Calder deteriorates rapidly, falling to water quality Class 4 (poor). Below this point, fish populations are at best sporadic, and in some areas almost totally absent.

3.2.5a Fisheries Surveys

The priority list of watercourses vulnerable to reduced flows referred to earlier (Table 5) was used to devise a monitoring programme to assess the impacts on fish stocks. It concentrates on those sections of watercourse listed as high priority (vulnerable to change). On behalf of YWS fish population surveys were carried out by Fisheries Surveys Ltd on the Hebden catchment, Hebble Brook and Midgelden Brook during October 1995. A copy of the Executive Summary from their final report is appended to this report (**Appendix A**). Their main conclusions regarding these watercourses were:

Hebden catchment

- Observations would suggest that the middle reaches of both Crimsworth Dean (unregulated) and Hebden Water (regulated) support good populations of trout, with a high percentage of first year fish. Due to the nature of the substrate, gravels tended to be patchy and highly localised by comparison with Welsh and Scottish rivers. For a typical northern river, the middle and lower reaches down to Hebden were found to offer a high percentage of potentially usable spawning gravels and would probably represent the optimum spawning zone. The fact that only a minority of the available gravel was exposed above the waterline at the time of survey would indicate that in both rivers, the availability of spawning gravels would not be significantly improved with increasing depth.

- **Finally the turbidity issue is of concern.** Most of the watercourses examined except Crimsworth Dean, carried a high load of suspended solids and caused noticeable turbidity for 5-10 km downstream of the dams. In the case of Hebden Water, the prime trout spawning reaches from Hardcastle downstream were potentially affected.

- Spawning occurs in shallow gravelly areas mostly from November through to January and the eggs hatch mostly from March onwards. Sediment settling on the eggs during this period is known to affect oxygen diffusion through cell membranes and is a known cause of egg mortality both in the wild and in hatcheries. Similarly, any appreciable accretion of sediment in the gravel interstices can prevent free circulation of aerated water over the eggs, leading to reduced egg survival.

- **The turbidity problem in this case appears to have been associated with the mobilisation of sediments from the bed of the reservoir when water levels are exceptionally low.** Due to the particular timing and nature of this phenomenon in relation to the trout spawning period, we believe that **it represents a serious potential hazard to spawning salmonid populations and therefore ought to be considered in the designation of extreme low flow operating rules for reservoirs.**

Hebble Brook

- Hebble Brook was found to support good to high densities of brown trout, with low populations of bullheads. The comparatively low numbers of fish in their first year may indicate limited spawning success or poor juvenile survival within the catchment as a whole during 1994/5. Since extensive lengths of the river through Halifax is culverted, recruitment from downstream is very unlikely.

- At the upper and middle site all potential spawning gravels were submerged at the time of the survey and, therefore, the spawning potential of the brook at these sites is unlikely to be improved with increased depth. Although an increase in depth would increase the total area of gravel available, extensive areas of potentially usable spawning gravel were submerged at the time of the survey and access to such fish was not limited.

- Given that spawning occurs mostly from November through to January and the eggs hatch mostly from March onward and given deleterious effects of sediment settling on eggs during this period, **the high levels of turbidity at the upper site and the settled sediment at Wheatley represent a serious potential hazard to spawning success in Hebble Brook.**

Midgelden Brook and Gorpley Beck

- The recorded absence of fish from Midgelden Brook and its tributary may be a result of poor water quality within the brook. However, the potential for recruitment from the River Calder is unknown. With the exception of water quality the habitat in both brook and the beck appeared suitable for supporting populations typical of streams of a similar nature.

The most serious impact clearly identified by the report was siltation of spawning gravels. The extent of the effect that this has had on brown trout reproduction in the system has not yet been fully quantified, but should become more apparent when further surveys are carried out in September/October of 1996 by Fisheries Surveys Ltd to assess changes during the interim period.

3.2.5b Other fisheries actions

At the start of the drought the Action Plan, outlined in section 3.2.3. and Figure 3, was devised to manage and measure low flow impacts, and this included an emergency fish rescue plan which fortunately has not yet needed to be implemented.

However, fish rescues were carried out on Digley and Brownhill Becks (11/12/95), following compensation flow reductions. Four hundred brown trout were rescued and relocated downstream in the river Holme at Holmfirth. At this location the river Ribble provides sufficient water to maintain fish stocks. Efforts were concentrated on the larger fish which would have been more vulnerable. Fry and fingerling size groups were left *in situ*.

There has also been anecdotal evidence of downstream displacement of larger trout from the tributaries into the main river during the winter period. These fish were appearing as a regular feature in match angler catches but were not featured in catch records. The extent of this problem will also become more apparent when follow up survey work is carried out in 1996.

In recognition of the above problems an extension of the monitoring programme is planned for the next Drought Order application (extension) due in September 1996. The new programme will include measurement of the accumulation of fine solids in spawning gravels, the collection of angler catch data and the regular health sampling of coarse fish stocks in the middle section of the River Calder where water quality problems have been experienced due to low flows.

A commitment to the continuation of the monitoring programme to identify long term trends over a minimum 3 year period is also being sought from YWS.

3.3. River Don

3.3.1 Summary

The River Don drains the Pennines to the west of Sheffield and flows through Sheffield, Rotherham and Doncaster to join the tidal River Ouse at Goole. The Don catchment can conveniently be divided into the upper Don, comprising the upland headwaters and the stretch of main river through Sheffield to the River Rother confluence, and the lower Don down to the Ouse. The headwater catchments are moderate to steep, undeveloped moorlands which feed reservoirs used for public water supply to Barnsley and Sheffield. The reservoirs are arranged in six groups located on the Don and its five main tributaries in the upper catchment. Each reservoir group makes compensation releases to the river downstream.

Due to pressures on the water supply and exceptionally low levels in the reservoirs, YWS applied for Drought Orders in December 1995 for the Sheffield and Barnsley reservoirs. The Orders reduced the levels of release of compensation water to a third of their licensed statutory amounts. In March 1996 with the drought conditions continuing and with stocks in Winscar Reservoir, which feeds the upper Don, down to less than 20%, a further Order was applied for on this group.

The Environmental Statement accompanying the Drought Order application concluded that the proposed reductions in compensations would have no acute impact on the quality and ecology of the Don and its tributaries. This was a reasonable assumption provided the major effluent treatment works were operated to their maximum potential and that the Order related to the winter period when the impacts could be expected to be less. Conditions were imposed on the Drought Orders that covered the requirements for monitoring, mitigation and restoration of the river. The particular concerns for the Don related to the longer term impact of the reduced flows on the ecology of a river that was just starting to show signs of recovery from more than a century of industrial pollution.

The additional monitoring only started in January 1996 and at this stage there are insufficient results to draw firm conclusions on changes in water quality, biology or fisheries status. It is clear, however, that the river has been managed to ensure that there have been no significant acute effects.

Minor effects recorded to date are the slight increases in BOD noted throughout the catchment but this has not been accompanied by drops in dissolved oxygen levels.

Invertebrate surveys are continuing and a special crayfish survey has been instigated. Fisheries surveys have been carried out on several tributaries influenced by compensation reductions, as well as control sites on tributaries affected only by the natural effects of the drought. The report detailing the initial findings of this work are still awaited. Interim information suggests that similar effects only spawning grounds siltation, as identified on the Calder system, are likely to be recognised as a significant problem.

3.3.2 Hydrology and Water Resources

The flows in the Don are measured at Hadfields (Meadowhall) and Doncaster, and several main tributaries are also monitored.

The Don catchment typically has around 785mm of rain per annum, but in 1995 the catchment had only 633mm, 80% of the Long Term Average (LTA). The drought in the Don catchment was not as severe in 1995 as in the Aire and Calder catchments and rainfall levels were generally nearer to the LTA. However the below average rainfall started earlier, so summer shortages were just as pronounced. After the first six months of 1996 the catchment had only 270mm, 70% of the LTA of 385mm.

Flows were still only just above the dry weather flow by the end of 1995, so despite periods of higher flow in January, February and March, only the highest values for February were above the average; the other winter months remained entirely below average, even when swollen by rainfall.

The Don Pennine reservoirs supply Sheffield and Barnsley and have had their compensation cut from 85 tcmd to 23.2 tcmd overall. While the drought was not as bad in the Don catchment as the Calder and drought restrictions did not come into force until later in 1995, the situation is now considered just as critical.

The low rainfall figures and the very low base flows have resulted in a drop to Dry Weather Flow occurring again in 1996. This happened around a month earlier than 1995 for the Don at Doncaster, and six weeks earlier for the Rother and the Dearne. The Don catchment has had lower rainfall figures than the Aire and Calder catchments in the first half of 1996, so the river levels are causing even greater concern than for those rivers.

3.3.3 Water quality

A potential problem with low flows was identified in the lower river. At present, a significant quantity of water is abstracted by British Waterways for the South Yorkshire Navigation Canal network. This denies the lower Don valuable dilution water and could result in problems downstream of sewage treatment works. Meetings are pending with BW to look at options to reduce this abstraction.

None of the compensation flows in the River Don catchment were reduced before January 1996, therefore comparison of this with the 1995 GQA quality is not possible (unlike the Calder where drought orders started earlier).

For the purpose of this report, an initial comparison of analytical results from samples taken after compensation flows were reduced with those from the previous year or period has been made: however, the data should be treated with caution as the number of samples taken may be insufficient to be statistically significant.

From Winscar Reservoir to its confluence with Scout Dike, there had been no significant changes in the water quality of the Don. From Scout Dike to its confluence with the Little Don, BOD levels appear to have increased slightly, but changes in dissolved oxygen levels were not significant. Total iron concentrations appear to have actually decreased, due presumably to the ochre from Bullhouse Minewater precipitating out earlier under lower flow conditions.

The next stretch, to its confluence with Ewden Beck, showed significant increase in BOD levels but little change in dissolved oxygen, and a slight decrease in total iron concentrations.

There was a marginal increase in BOD levels, but no significant changes in dissolved oxygen levels, downstream as far its confluence with the Rother. These stretches include the confluences with the Loxley and the Sheaf, and the discharge from Blackburn Meadows STW

On the Little Don from Underbank Reservoir to its confluence with the Don there has been no significant change in dissolved oxygen levels, but slight increase in BOD. There was a significant reduction in total iron at Deepcar due to earlier precipitation of ochre from Sheephouse Wood minewater.

Other major tributaries with reservoir impoundments have shown no significant changes in water quality from the reservoirs to their confluences. These are:-

Ewden Beck (More Hall Reservoir to confluence with Rother)
River Loxley (Damflask Reservoir)
River Rivelin (Rivelin Dams)

3.3.4 Ecology

3.3.4a Drought monitoring Programme

In a meeting between the Environment Agency and YWS a joint biological sampling programme on the Upper Don catchment was derived, which began in the spring of 1996. This included an extension of the Environment Agency's routine monitoring programme, and river habitat surveys.

Full details of this ecological programme will be covered in the next monitoring report (spring 1997).

3.3.4b Special crayfish surveys

The white-clawed crayfish, *Austropotamobius pallipes* has been recorded at some sites in the Don catchment. This species is protected under the Wildlife and Countryside Act 1981 and various other legislation. Populations nationally are generally in decline and it was felt that more information on their distribution in the Don catchment and how they are affected by the low flows would be very important.

3.3.5 Fisheries

The River Don, once a prolific salmon river, has suffered from over a century and a half of industrial degradation. Extensive lengths of the river were rendered devoid of aquatic life due to the effects of both urban and industrial pollution. Major improvements in water quality achieved within the last decade have led to the restoration of fish populations throughout its length. The first salmon to return to the river, found in Doncaster in January 1996, is testimony to these improvements. The headwater streams including the rivers Loxley, Rivelin and Sheaf all support significant trout populations and trout are also now present in the centre of Sheffield.

The middle and lower reaches also support valuable coarse fish stocks and angling in these reaches is popular again.

3.3.5a Fisheries surveys

The fish population data supplied by YWS to support the Environmental Statement for the River Don Drought Orders were based on out-of-date surveys. Advice was given to instigate a more relevant investigation into the status of the fish populations. Details of sites likely to be affected were identified and surveys arranged. Repeat surveys to measure post drought effects have been arranged and these will be undertaken throughout the next three years.

Close liaison was kept with the 'Salmon and Trout Association' who control much of the angling in the upper reaches of the river. Details of angler catch data for previous years were reviewed and examined concerning Drought Order proposals. The collection of data for 1996 was requested to investigate changes in species composition, changes in population densities, and size frequencies.

Fisheries surveys have been carried out on several tributaries influenced by compensation reductions as well as control sites on tributaries affected only by the natural effects of the drought. The report detailing the initial findings of this work is still awaited. Interim information suggests that similar effects of spawning grounds' siltation, as identified on the Calder system, are likely to be recognised as a significant problem

Two photographic surveys have been carried out to monitor the effects of the initial compensation reduction and subsequent further reductions.

3.4. River Ouse

3.4.1 Summary

The non-tidal River Ouse results from the combination of the rivers Swale, Ure and Nidd. The river, draining as it does the bulk of the Yorkshire Pennines, is particularly flashy by lowland standards, and subject to vast variations in flow. Abstractions for Leeds at Moor Monkton and York at Acomb Landing make the river a key provider of water for public supply. In February 1995, YWS were granted a variation in their licence to increase the abstraction when the flows at Skelton were higher than 1000 tcmd, but retaining the current abstraction rate at lower flows.

Low-flows in the Ouse started in early May 1995 and persisted largely uninterrupted until November. Due to pressures on the public water supply and the forecast of below average winter and spring rainfall, YWS were granted a Drought Order in November 1995 to abstract more water at all flows. This was followed in January 1996 by a one-month Emergency Drought Order allowing a further increase. Also, a Time Limited Licence was granted for three years from March 1996, permitting further abstractions when flows in the Ouse are greater than the naturalised 650 tcmd flow at Skelton. While the lowest flows in the river are affected by the Drought Orders they are not by the revised licence. This Licence does not result in an increase in the duration of low flows in the river but, by taking more water when the flows are higher, this can increase the time when flows are at or near the critical level.

YWS's Environmental Statement accompanying the Drought Order application concluded that the proposed increase in abstraction would have little significant impact on the quality and ecology of the Ouse. The Environment Agency's main area of concern was the impact on the river downstream of Naburn WWTW (which serves the city of York). In view of this situation, enhanced monitoring and mitigation actions were required, particularly at the sewage works.

The Environment Agency already has a comprehensive monitoring programme in place on the river covering flow, water quality, biology and fisheries interests. This work was enhanced as a condition of the Drought Order with extra ecological work to be carried out by Yorkshire Water Services throughout 1996. This report provides an update on the results of this programme including the extra ecological work carried out as a result of the Drought Order.

The results of water quality surveys have shown a deterioration during 1995 downstream of the Naburn WWTW. This was primarily due to higher levels of ammonia, which exceeded the EC Fisheries Directive limits on occasions, and lower concentrations of dissolved oxygen. The biological quality has also deteriorated, even more than in past years, showing strong signs of being organically polluted. It is apparent that there is insufficient dilution for the Ouse to cope with the current effluent quality from Naburn WWTW during periods of low flows. In response to the NRA's concerns about the impact of low-flow on the ecology of the Ouse, YWS undertook a biological survey in November 1995 using divers. Although the results were not completely similar to the NRA's, because of different sampling techniques, both showed a general increase in abundance of oligochaete worms and chironomid midge larvae, many of which are pollution tolerant.

NRA fisheries surveys in 1995 concentrated on examining the longitudinal pattern of fish distribution and abundance in the Ouse particularly in the upper reaches between Niddsmouth and Linton-on-Ouse. Fish were recorded in abundance but they were not distributed in their more usual way. Further surveys are being carried out in this year, supported by electrofishing techniques, to further assess the impact of the drought and the likely effect of the proposed Tees transfer.

3.4.2 Hydrology and Water Resources

The river flow in the Ouse is gauged at Skelton, downstream of the YWS abstraction at Moor Monkton but upstream of the York Waterworks abstraction. In 1995 the flow in the Ouse fell below the 582 tcmd critical level in late June and this continued largely unbroken until the second week of September (**Figure 6**) although this value was not attained again during late September and early November. Winter flows through to March 1996 were unexceptional compared to previous years and brief periods of spates quickly receded to low levels. In the first three months of 1996 river flows were generally lower than in the same period in 1995 although the critical value was not breached.

Water is abstracted from the Ouse at Moor Monkton by YWS to serve the Leeds area, via Eccup Reservoir. The normal licence conditions allow an abstraction rate of 99 tcmd when flows at Skelton are above 1000 tcmd, and 68 tcmd when the river flow is less than 1000 tcmd. York Waterworks Company also abstract from the Ouse at Acomb Landing to serve York and are licenced to take 96 tcmd under any flow conditions, although in practice this is rarely greater than 60 tcmd, as happened in the summer of 1995.

In February 1995, YWS were granted a variation in their licence to abstract 99 tcmd when the flows at Skelton were higher than 1000 tcmd, but retaining the 68 tcmd abstraction rate when the flows were less than this. From November 1995 YWS was granted a six-month Drought Order enabling them to abstract 99 tcmd from the Ouse at all flows (expired on 31st March 1996). This was followed in January 1996 by a one-month Emergency Drought Order allowing a maximum of 144 tcmd, with a prescribed flow conditional on the Leeds area reservoir stocks.. Also, a time limited licence (for three years from March 1996) was granted, with the use of SWALP, permitting an abstraction of 144 tcmd when flows in the Ouse are greater than the naturalised 650 tcmd flow at Skelton, and at 68 tcmd when the flows are lower than this threshold value. In effect, the actual flow at Skelton is required to be 582 tcmd or above for abstractions greater than 68 tcmd.

3.4.3 Water Quality

The Ouse upstream of York has higher water quality than the lower non-tidal reaches that receive effluents from combined sewer overflows in York, the Foss and Naburn WWTW.

Modelling by YWS of the impact of the increased abstraction had suggested that changes in dissolved oxygen would negligible, less than the resolution of the model, and within any variation that occurs across the channel. Dissolved oxygen levels are believed to decline gradually in the York to Naburn stretch naturally, as the river becomes increasingly ponded behind Naburn Weir. This situation was exacerbated in 1995 as it was an exceptionally dry year and flows in the Ouse were significantly lower than normal; there was less dilution for the discharges to the river, the most significant of which is Naburn WWTW.

Actual monitoring of water quality in 1995 through to 1996 was covered by the NRA's GQA and existing effluent sampling programme. There are three GQA sample points on the non-tidal Ouse below Moor Monkton: at Nether Poppleton, Scarborough Railway Bridge and Naburn Weir. Data for the years 1993 to 1995 show that the Ouse at the two upstream sites maintained its level in GQA class B. However, the Ouse at Naburn Weir was in GQA class B for the years 1993 and 1994 but in 1995 the quality declined to GQA class C.

By using GQA methodology the changes in the water quality of the Ouse at Naburn Weir over the period 1993 to 1995 can be seen in **Tables 6 & 7**. As can be seen from these data, the significant change in water quality is the rise in the levels of ammonia at Naburn Weir and in the increased variation in the levels of dissolved oxygen. Three samples in 1995 exceeded the 1mg/l of ammonia that meant a failure of the EC Fisheries Directive.

In addition, a more detailed analysis of the water quality data indicate that levels of dissolved oxygen later in the year were declining towards GQA class D (and on three occasions between 29th August - 11th September dissolved oxygen fell to 56-61% saturation at Naburn Lock). This change in class is due to the lack of dilution for the effluent from Naburn WWTW, although storm events in the period mentioned above may have been responsible for the notably low values.

Naburn WWTW is due for improvement under the Asset Management Plan 2 (AMP2) by 1998 and YWS have had problems with a new primary settlement system at Naburn, which actually consists of three works. Works No.2 final effluent was in breach of the BOD consent of 50 mg/l on three occasions in 1995 and early 1996, on 5th May (66.5), 21st November (70.3) and 2nd February (61). Among the recommendations put to YWS by the Environment Agency to protect the Ouse under the prevailing low flow conditions, has been that filter effluent from No.2 is recirculated in order to improve its quality.

The decline in water quality in the lower non-tidal Ouse after the summer of low flows was mirrored by an apparent fall in biological quality.

3.4.4 Ouse Ecology

3.4.4a Invertebrates

Before the introduction of the Time Limited Licence at the Moor Monkton abstraction, the Environment Agency had in place its GQA monitoring network on the Ouse system, consisting of three sites u/s of Naburn Weir, and three on the tidal section of the river down to the confluence with the River Aire. The non-tidal sites were sampled twice in 1995 (spring & autumn) by airlifting/sweep sampling and identified to mixed taxonomic level. Design of the 1996 routine monitoring programme incorporated all the Ouse sites (3-season sampling) and was supported by additional sites on the Ouse upstream of Moor Monkton (2-season sampling). This is to facilitate assessment of the proposed Tees-Wiske river transfer and establish control sites to interpret any changes that may be attributed to the abstraction itself.

Following concern about the apparently very poor faunal situation in the lower Ouse in Autumn 1995, and supporting their application for the Time-Limited Licence, YWS agreed to repeat the survey carried out in 1993, which involved collection by divers of quantitative benthic samples from the Ouse at six sites from Nether Poppleton to Acaster Malbis, repeating their 1993 sampling regime.

Results from these surveys were compared with extensive historical and long term data held by the Environment Agency and YWS. These include information from detailed surveys of the Ouse (from Nether Poppleton to Acaster Malbis) carried out in July 1993 by the NRA (report DAB 1/94) and in May, August and October of that year by Yorkshire Water. The latter were part of a Water Resource Development Environmental survey.

Biological classifications of the NRA's 1995 invertebrate data (**Table 8**) show that the Ouse maintained quality at Nether Poppleton (B1B) but suffered a fall in quality at Acaster Malbis from B2-poor in 1994 to B3 in 1995.

Within these general results is that from the NRA's combined airlift/sweep sample from Acaster Malbis during October 1995. Although this was a large sample including shell gravel, the biotic scores were very low (BMWP 15, ASPT 2.5), following a relatively poor fauna in the spring (BWMP 45, ASPT 4.09). These samples were dominated by oligochaete worms, chironomid midge larvae and pea mussels, with single figure values of abundance of the remaining types of animal. These results were consistent with a deterioration in water quality downstream of Naburn WWTW during the uninterrupted low flow conditions of the summer and early autumn of 1995, during which time ammonia levels had breached the 1.0 mg/l level on three occasions.

Analysis of long term data from 1981-96 clearly shows that the fauna at Acaster Malbis is distinct from that at Nether Poppleton and the fauna in the Ouse cannot be considered homogeneous throughout this length (**Figure 7**). The lower site, downstream of Naburn WWTW, is characterised by higher numbers of oligochaetes, chironomids, and to a lesser extent by glossiphonid leeches, hydrobid, valvatid and unionid molluscs (**Figure 8**). Within the oligochaetes, species tolerant of organic pollution largely replace more sensitive types. Pollution sensitive species are less frequent at Acaster Malbis although present in low numbers, often occurring as singletons in the airlift/sweep samples.

The quantitative invertebrate data from the YWS survey of 21st/22nd November 1995 (Entec Report No 28124RR010 i1) suggested higher biological quality at Acaster Malbis (aggregate BMWP 78, ASPT 5.2) than the Environment Agency's results, but these samples were still dominated by high numbers of oligochaetes and chironomids. Small numbers of caseless caddisflies (*Cyrnus trimaculatus*, *C. flavidus*, *Lype phaeopa*) and a single leptocerid caddisfly nevertheless did occur in the Surber samples from Acaster Malbis. An even poorer fauna was collected downstream of Naburn WWTW and it is possible that at Acaster Malbis the Ouse is actually supporting a 'recovery' fauna.

A full analysis of the comparison between the 1993 and 1995 surveys is still awaited from YWS, although comment was made in their interim report that the 1995 samples contained "very high abundance scores and correspondingly very low diversity scores compared with the 1993 data. This appears to be primarily due to increased abundances of both Oligochaeta and Chironomidae in 1995".

The Environment Agency's spring 1996 data indicate that a more diverse fauna was present at Acaster Malbis (BMWP 81, ASPT 4.50), more consistent with the YWS data from the previous November, although many taxa, especially the more pollution-sensitive groups, were in single figure abundance including a large proportion of 'singletons' (seven of the 18 BMWP families). It is interesting that before the YWS survey in November 1995, during the period 12-18 November, some relatively high flows were recorded which may have brought down extra drift of pollution-sensitive species from the richer sections of the Ouse upstream of York, if the hypothesis recently offered by YWS is supported.

The overall conclusion is that both the YWS and Environment Agency data from the autumn of 1995 show poorer biological quality in the lower Ouse than in 1993.

3.4.4b Macrophytes and algae

A detailed survey of the macrophytes of the Ouse was carried out for YWS during July 1993 and it was concluded that the communities were similar throughout the stretch from Nether Poppleton to Acaster Malbis, and were dominated by fennel-leaved pondweed, unbranched bur-reed and flowering rush, although yellow waterlily, common clubrush and filamentous green algae were also common. Recent observations by the Environment Agency of the vegetation upstream of Moor Monkton to Niddsmouth suggest that the macrophyte communities are somewhat richer in species, and less dominated.

Nevertheless, in 1995 and 1996 fennel-leaved pondweed was again present throughout much of the stretch, usually in linear beds close to each river margin, as might be expected in a river of this type and under similar conditions.

A belated report of a turquoise paint-like scum downstream of Naburn WWTW during 1995 may have been attributable to blue-green algae, which do not normally form blooms in the Ouse, although they are usually present in low numbers (from YWS monitoring of water at the abstraction point at Moor Monkton). It is not unexpected that, with the prevailing conditions of low flow, high temperatures and nutrient enrichment, this phenomenon was observed.

3.4.5 Fisheries

The Ouse is a productive lowland fishery with roach, perch and bleak the dominant species. However the fish populations are not distributed evenly in the stretch from Linton to Acaster Malbis and are extremely patchy; the highest densities of fish recorded in the detailed electrofishing and hydroacoustic surveys of 1993 and 1994 were found immediately downstream of Naburn WWTW probably because of enrichment.

3.4.5a Fish populations and ecology

With the acquisition by the NRA of side-scan sonar, hydro-acoustic monitoring of fish populations and distribution in the deep non-tidal Ouse from Linton to Acaster Malbis was initiated in June 1995 and continued until November 1995. No lack of fish was observed as a result of the drought and large numbers were recorded shoaling at Niddsmouth. Whether this is a natural, regular phenomenon or an aberrant behaviour induced by the drought remains uncertain because of a lack of previous data.

Although a few fish kills were reported in 1995, including two on the tributary River Foss, none were recorded on the main river in spite of high temperatures and low flows. Intensive electrofishing and hydro-acoustic surveys of the Ouse are being carried out by the Environment Agency and YWS in the Summer of 1996 that should allow an evaluation of the impact of the 1995-96 drought.

3.4.5b Angling

Monitoring of angler activity and other fisheries concerns continued through the 1995 drought.

A bailiff received comments from anglers during August/September 1995 when catches were reported to be falling off rapidly in comparison to previous years. He noted that some sections of the Ouse had fished better than others and in particular the river below Naburn Weir had given good results fairly consistently. A record catch of bream was obtained during a match held in the summer of 1995, but this was a large event with 200 or more anglers and most failed to catch any fish.

Almost stationary areas of water were observed in some marginal sections of the river during inspections in July/August 1995. Bailiffs also noted the river appeared to have carried less colour than normal and from December 1995 had shown a green tinge (probably algae) instead of the usual brown colouration. Water colouration and clarity may be a factor linked to a report of a drastic fall in angling catches around January 1996 on both the upper Ouse and lower Ure. However, hydro-acoustic surveys showed that fish were present on the lengths of river concerned.

On the evidence so far examined it seems that further analysis of catch returns would be helpful to evaluate the observed lack of angling success, and could also encompass any changes in angler abundance and match frequency.

3.5 River Ure

3.5.1 Summary

The Ure rises on the Pennines and is joined by a series of tributaries such as the Cover, Bain, Burn and Skell before it joins the Swale near Boroughbridge. The flow of the River Ure is predominantly unregulated and therefore follows a natural pattern of seasonal variations largely determined by recent weather conditions. There is relatively little abstraction, with the only potable river abstraction at Kilgram Bridge formerly serving just Thornton Steward Reservoir.

The amount that can be abstracted is reduced when the flow falls below a defined critical level. This occurred from June 1995 for most of the summer months. Autumnal and winter rain provided brief periods of high flows, but these receded quickly to base levels lower than the previous year. Due to pressures on the public water supply and the forecast of below average winter and spring rainfall, YWS were granted a Drought Order in January 1996 to abstract extra water when the river was above the critical flow. This Order does not result in an increase in the low flows in the river but, by taking more water when the flows are higher, this can increase the time when flows are at or near the critical level. The abstraction criteria were continued in the subsequent Time Limited Licence granted in May 1996.

The Environmental Statement accompanying the Drought Order application concluded that the proposed increase in abstraction would have no significant impact on the ecology of the Ure, which is characterised by very variable flows. This is not an unreasonable assessment of the situation, but the precautionary principle required enhanced ecological monitoring, particularly as the river is host to protected species such as otters and white-clawed crayfish, as well as supporting invertebrate faunas and fish populations of high quality.

The Environment Agency already has a comprehensive monitoring programme in place on the river covering water flow, quality, biology and fisheries interests. This report provides an update on the results of this programme including the extra ecological work carried out as a result of the Drought Order and Time Limited Licence.

The Ure is a high quality river with only localised impacts on water quality, biology and fisheries status below a few, relatively minor, effluent discharges. In spite of the low flows experienced in 1995 the quality remained high and overall remained the same as in 1994. The exception was a minor shift downwards in water quality at Boroughbridge where highly variable levels of dissolved oxygen, Biochemical Oxygen Demand (BOD) and ammonia were observed. This, however, was commonly seen in the lower reaches in many rivers in the Region.

Biological quality also remained excellent or good in the Ure when compared to previous years. Indeed, the invertebrate communities observed in autumn 1995 and the spring of 1996 were comparatively richer in individuals than preceding years. It appears that the drought has benefited several groups, such as snails and caddisflies, while some stoneflies and mayflies may not have found the low-flow conditions quite as favourable. The impact of the 1995-96 drought on the Ure's fish populations is still being assessed ,but it is evident that changes in fish distribution and angling activity were related to the low flows and hot, sunny weather. Hydro-acoustic surveys in the early spring of 1996 proved the existence of fish in stretches where anglers had complained of poor catches, and these surveys are being followed up in the summer of 1996.

3.5.2 Hydrology and Water Resources

River flows in the Ure are gauged or recorded at several locations from Bainbridge to Aldwark Bridge (**Figure 9**). The station at Kilgram Bridge (SE190860) is used to monitor the flows in relation to the abstraction to Thornton Steward, upstream. The hydrograph (**Figure 10**) suggests that the river, as with the neighbouring Swale and

Wharfe, is extremely prone to spate episodes that rapidly fall away when there is no sustained rainfall.

YWS abstract from the Ure upstream of Kilgram Bridge and have the ability to fill Thornton Steward Reservoir and/or Leighton Reservoir, or feed directly into the Harrogate raw water main. The original licence conditions included a prescribed residual flow of 161.49 tcmd above which flows of up to 22.73 tcmd could be taken. An abstraction of 3.27 tcmd could be taken at all flows.

The Drought Order granted to YWS increased the abstraction by 30 tcmd, to 52.73 tcmd when the net flows are greater than a revised prescribed flow of 163 tcmd. The Time Limited Licence granted on 16th May 1996 continues these values. The value of 163 tcmd is known as the critical flow and has been derived to protect the river environment downstream, using a Surface Water Abstraction Licencing Policy (SWALP) methodology.

Summer flows in the Ure are usually at a minimum in July, with an average of 404 tcmd and median of 150 tcmd. However, set against this general pattern, there is high variability (34-6075 tcmd range during 1982-95). During 1995-1996 the river was below its critical flow of 163 tcmd for considerable periods (for the whole of August for example), during which time abstraction from the river was nonexistent or at the minimum value (see above). The first drop below the critical flow was in the second week in June 1995 and this continued, almost uninterrupted, until the last week in September. During the first three months of 1996 the critical flow was not reached, although flows were low during intervals between some episodes of rainfall (eg. first and second weeks in January and mid February).

The Environment Agency received the Drought Order application for the Ure in January 1996 and made representations to the Public Inquiry called following objections. These recognised the need and justification for the Order but outlined additional monitoring, mitigation and restoration requirements to be carried out by YWS to ensure that the environmental concerns were adequately addressed.

3.5.3 Water Quality

The water quality in the Ure is generally high and even at naturally occurring low flows (< 100 tcmd) high dilution is available for all effluent discharges, allowing the river to remain in General Quality Assessment (GQA) classes A and B for its entire length.

The major effluent discharges are in the lower reaches, from Ripon and Boroughbridge sewage treatment works (STWs) and West Cumbrian Farmers Foods Ltd at Boroughbridge.

An *ad hoc* permissive sampling programme was set up to monitor the impact from Masham STW that has been a cause for concern because of localised poor mixing, although the overall dilution for the effluent is in the order of 1000:1, even at low flows.

No significant general elevations in BOD and ammoniacal nitrogen, or decreases in oxygen saturation were observed during the drought period in question. By using the standard General Quality Assessment (GQA) methodology the changes in the water quality of the Ure over the period 1993 to 1995 can be seen in **Table 9.**

It is evident that the quality in 1995 was more similar to that in 1993 at West Tanfield and Hewick Bridge, and at Boroughbridge the quality shifted downwards in 1995 as a result of natural low flows.

3.5.4 Ure Ecology

3.5.4a Invertebrates

The Ure supports a wide range of invertebrate species and exhibits classic longitudinal zonation from stonefly dominated headwaters, species rich middle reaches, through to a lowland river system downstream of Boroughbridge to its confluence with the Ouse. Some of the best concentrations of white-clawed crayfish (*Austropotamobius pallipes*) in England are present in the Ure upstream of Ripon.

No adverse conditions or disturbances to this pattern were noted because of the 1995-1996 drought, although further analysis is planned to examine long term trends. It is also too early to comment about any possible impact of the Drought Order (and subsequent Time Limited Licence), although this is likely to be obscured within the greater overall natural drought impact.

Before the introduction of the Drought Order at Kilgram Bridge, the Environment Agency had in place its GQA monitoring network on the Ure system, including six biological sampling sites on the main river. These were sampled twice in 1995 (spring & autumn) by standard 3-minute kick sample and identified to mixed taxonomic level. Design of the 1996 routine monitoring programme (2-season sampling) incorporated all but one of the Ure sites (dredge sample site at Aldwark Toll Bridge) and these were supported by additional sites on the Burn to help interpret any faunal changes possibly linked to the operation of the Roundhill and Leighton reservoirs.

In addition, the proposed river transfer (Tees-Wiske) has placed even more focus on the Ure so that the routine sites will also be sampled in the 1996 summer season; the GQA site at Aldwark Toll Bridge will also be sampled in summer and autumn 1996.

In support of their application for the Time-Limited Licence, YWS agreed to sample 5 sites on the Ure (spring-autumn/ 3 replicate kick samples) to investigate invertebrate community responses to the licence variation. Two sites, upstream and downstream of the abstraction, will also be surveyed for macrophytes (carried out in summer 1996).

The NRA's 1995 invertebrate data showed that the Ure sites attained biological classifications (Yorkshire Interpretive Index) of very good (B1A) or good (B1B). There were no changes in classification because of the drought. In the section immediately upstream and downstream of the abstraction (and prior to the Drought Order and Time Limited Licence) the Ure was of B1A quality, and only deteriorates slightly downstream of Ripon.

At two sites (Wensley and d/s of Hewick Bridge), rich autumn faunas were recorded in 1995, with high numbers of types of invertebrates and individuals. This phenomenon was seen in other Dales rivers, including the Wharfe and Swale. Apart from this observation, any other impact of the drought on the invertebrate fauna was not readily apparent. Further analysis of the long term data set needs to be completed before a more precise statement can be made about trends.

Detailed results from the Spring 1996 invertebrate samples have been received from YWS and the Environment Agency's spring 1996 samples from Wensley and West Tanfield have also been analysed. The fauna at Wensley is comparable in richness to previous spring examples but is of lower 'quality' as measured by the Average Score Per Taxon (ASPT), ie. 5.92 compared with 6.37-6.74 for the period 1990-94. Animals such as *Sericostoma personatum* (cased caddisfly) were in unprecedented abundance, and the presence of pond snails was unusual. Planorbid snails (ramshoms) had not recorded since at least 1990 and lymnaeid snails not recorded since 1990.

These observations suggest, along with some other faunal data, that the *natural* drought is having an impact through slower water velocities - allowing groups normally poorly adapted to running water (eg snails, whirligig beetles) to persist. Lower flows also allow greater sand deposition for use in larval case construction. The last factor might be responsible for the high numbers of sand-grain-cased sericostomatid and lepidostomatid caddisfly larvae seen in the autumn and spring samples (also seen other Dales rivers).

3.5.4b Macrophytes and algae

During the spring of 1996 sections of the river bed of the Ure had thick growths of algae with a black appearance [almost certainly diatoms of the genus *Nitzchia*]. This observation has been matched by similar ones from Tees and Wharfe during the same period. The upper reaches of the Ure, notably near Bainbridge and Hawes, are regularly dominated by filamentous green algae, probably a consequence of runoff from agricultural land, and 'improved' grasslands.

Results from the YWS macrophyte monitoring carried out in the summer of 1996 will be reported in the Spring 1997 monitoring report.

3.5.5 Fisheries

3.5.5a Fish populations and ecology

Until further information is gained from the electrofishing surveys of the Ure in the summer of 1996, comments about the possible impact of the 1995-96 drought are largely restricted to angling activity and hydro-acoustic surveys in the lower, deep reaches. The general conclusion from the information considered so far is that patterns of angler activity have altered more as a consequence of the drought (more specifically the good weather) than have fish populations in the Ure, although it is likely that local movements and changes in fish distribution have occurred.

Most of the period concerned with the present report preceded the Drought Order and Time Limited Licence applications and the NRA's rolling programme of routine fish monitoring did not include the River Ure during 1995. However, a fisheries survey was carried out on the River Burn during August 1995 in relation to catchment acidification and potential impacts from fish farms. In addition, a hydro-acoustic survey using side-scan sonar was conducted on the lower Ure from Aldborough Grange to Linton-on-Ouse during February and March of 1996 in response to complaints from anglers about an apparent lack of fish in this section. Results from this survey have shown that fish were present in this section of river but were not in their normal winter associated aggregations.

Analysis of angling catch returns continued during this period.

A good number of trout redds were observed in the Skell and evidence of successful trout spawning activity has also been seen in the main river.

3.5.5b Angling

Monitoring of angling activity and other fisheries concerns continued as normal during the 1995 drought and into 1996. Fewer anglers were being seen in the late summer and were fishing at much wider distances apart than usual. Best catches for pleasure anglers were reportedly restricted to the late evenings and early mornings during this period. Observations by bailiffs and angling club officials suggested that fish became concentrated into the deeper pools of the main river as water levels fell rapidly and temperatures remained high during July-August 1995. A major angling club on the Ure reported a 20% fall in the number of day permits sold during the past year and attributed this to difficult weather and water conditions as well as poor catches.

Match angling results have been reported as moderate to poor and there appears to have been a trend for some anglers to desert the rivers to fish stillwaters, where there is a greater probability of catching fish. Match angling catches on the lower Ure were reportedly seriously lower than normal during January 1996.

3.6 River Wharfe

3.6.1 Summary

Severe lack of rainfall during the period after April 1995 had a profound impact on the flows in the Wharfe and a series of Drought Orders followed which generally permitted increased abstraction rates and/or lowered protected flows in the river. A reduction in the *additional* Grimwith compensation releases of 22.7 tcmd to 5 tcmd also occurred from September 1995, although full support was otherwise unaffected at the protected flows. Conditions were set by the Environment Agency for YWS to implement and these involved monitoring and mitigational measures. A plan for a three-year programme of enhanced environmental monitoring was also set, but this started largely after the period dealt with by this report.

Enhanced water quality monitoring programmes were, however, applied on the Wharfe during 1995, with YWS carrying out sampling and surveys in addition to the routine work of the NRA. Water quality in the Wharfe remained good during 1995 according to the GQA scheme and analysis of long term data did not show any significant trends or changes that could be related to the drought, although variability may have increased. Only localised impacts from some STWs were observed during longitudinal surveys carried out by YWS. The performance of the STWs themselves was generally good and most kept within the more stringent consent limits set by the NRA for the duration of the drought. Aeration to protect fisheries was not required although the necessary equipment was installed and trialled downstream of Otley STW.

Routine biology surveys were carried out by the NRA during 1995, but additional sites and sampling effort were set up for the period after March 1996. The drought apparently led to an autumnal increase in numbers across a broad range of invertebrate groups in the Wharfe, and conditions favoured some still-water, or slow-flowing river types such as pond snails, worms, and whirligig beetles. However, some other groups, notably cased and uncased caddisflies (especially the hydropsychid *Cheumatopsyche*) were also relatively more abundant in 1995 than the average over the last ten years. Algal films and suspended detritus may have been enhanced in the low flow conditions and have led to a boosting of food supplies, and the increased deposition of sand particles in areas with slower water velocities would have provided more suitable material for case builders such as the lepidostomatid, sericostomatid, hydroptilid and limnephilid caddis larvae.

A survey of the distribution and general status of crayfish was carried out by YWS during 1995 after concerns were risen about the drought's possible impact on this protected species. White-clawed (native) crayfish were found at all the sites from Grassington to Boston Spa, but it is clear that signal crayfish are dominant in the Grassington area and may ultimately be the nemesis of the former in the Wharfe, rather than drought and low flows.

The impact of the 1995/6 drought on the Wharfe's fish populations can only be adequately assessed after the survey work carried out in 1996 is analysed, but it is clear that patterns of angling activity were changed during the period, probably as result of the weather conditions and the movement of fish into different areas.

The removal of barriers (ie gravel bars at confluences) to migrating salmonid fish was carried out on several feeder streams.

3.6.2 Hydrology and water resources.

The Wharfe is a typical, 'flashy' river with a highly variable flow regime, similar to other Dales rivers such as the Swale and Ure. River flows in the Wharfe are gauged at Addingham (SE092494) and Flint Mill (SE422473) (**Figure 11**). Average flows in the Wharfe during the spring and summer period were extremely low, and were the lowest since 1974 at least (**Figure 12**).

The lowest flow at Addingham during 1995 was 74.9 tcmd, recorded on 2nd September. Compensation releases from Grimwith Reservoir exceeded the abstraction from Lobwood from the last week in April until 29th September, when the Emergency Drought Order came into being, although these releases were stepped down from the 2nd of August. The Protected Flow was initially 150 tcmd, with extra support of 15 tcmd when natural flows were less than this, but this was reduced to 90 tcmd after the Emergency Drought Order of the 29th of September. Flows at Addingham fell below this during the last week of August/first week of September 1995.

During the period from October 1995 to March 1996 there have been brief episodes of high flows (**Figures 13 & 14**) but they have not matched the levels seen in early 1995 and are comparable to those recorded during the dry spring of 1976.

Water is abstracted by YWS from the Wharfe at Lobwood (SE075520), The Hollins (SE090483) and Arthington (SE263454). The original licence conditions for the first two abstractions were:

	Abstraction		Flows at Addingham	Compensation releases
Lobwood	93 tcmd	when	>454 tcmd	none
	89 tcmd	when	<454 tcmd	at flows >364 tcmd
The Hollins	34 tcmd		>454 tcmd	none
	25 tcmd		<454 tcmd	at flows < 227 tcmd

In practice the Hollins operating capacity is only 16 tcmd.

Under these licence conditions compensation releases equalling the Lobwood and Hollins abstractions are made when the flows are less than 227 tcmd at Addingham, with *an additional* 22.7 tcmd.

The Arthington licence is for 100 tcmd when river flows are greater than 580 tcmd at Addingham.

A complex series of Drought Orders and Emergency Drought Orders in 1995 altered the conditions regarding abstraction rates, protected flows in the Wharfe and the compensation release regime. These are summarised in a table produced by YWS (**Appendix B**). Further changes were made after the period described in this report (ie. post April 1996), the most important of which was the granting of a Time Limited

Licence in relation to the Hollins and Lobwood abstractions, and that further downstream at Arthington. SWALP methodology was again used.

3.6.3 Water Quality

Overall there appear to have been no significant water quality problems arising from the drought in the Wharfe. The operations at the sewage treatment works and combined sewer overflows have been maintained at higher operating standards than allowed for by their actual consents.

During 1995 the NRA's GQA water quality sampling programme (12 sites on the non-tidal Wharfe) was supplemented by an additional 18 sites dealt with by YWS for a limited suite of determinands between August and December. These included longitudinal and transverse surveys from Addingham to Pool.

The frequency of sampling at the GQA sites was doubled from the mandatory 12 occasions to 24 (effectively once a fortnight) from 1st April 1996, and final effluents at seven major sewage and trade discharges have been sampled concurrently at normal frequencies (Ilkley, Burley-Menston, Otley, Pool, Thorp Arch, Wetherby and Tadcaster).

The results from the YWS monitoring (available in more detail in their Drought Order submission) indicated that the levels of dissolved oxygen remained high, even where continuously monitored at critical points on the river. Oxygen saturation remained above 80% from October to November, even with a photosynthesis-induced diurnal variation of 10%. Levels did not fall below the value requiring oxygen to be injected into the river. This facility was available at Otley STW and trialled with limited success. A reduction in the level of sampling carried out by YWS was renegotiated as a result.

Temperatures of 20-25°C were recorded in August 1995 when the river was still being fully supported by compensation releases from the Grimwith-Dibb system.

Impacts from individual STWs varied from fairly localised (ie. within 500 m) to 1.5 km (eg. Otley STW), evident in reductions in dissolved oxygen of up to 10% below background. Dissolved oxygen levels sags recovered downstream, often with the assistance from the Wharfe's many weirs. Almost all the effluent samples were within both the standard consent limits and the more stringent limits set by the Drought Order conditions, and only six samples exceeded the temporary BOD and ammonia consents (at Ilkley, Ben Rhydding and Wetherby). It is concluded that YWS operated these installations very effectively during the drought.

Any changes in general water quality classifications in the Wharfe were examined using the GQA methodology. The changes in the water quality of the Wharfe over the period 1993 to 1995 can be seen in **Table 11.**

Statistical trend analysis carried out by the Environment Agency has shown that there have been some significant changes in the pattern of water quality parameters *dissolved* *oxygen*, *BOD* and *ammonia*, but most of these are clearly unrelated to the 1995 drought and low flows (see Cusum tables in **Appendices C-E**). The exceptions are for ammonia levels at Burley Weir and Boston Spa, but the small number of samples and the variability precludes any firm statement about a genuine deterioration. Within the drought period there were high values of BOD and ammonia at some other sites, but these were sporadic and part of a general increase in variability during the period.

An additional focus of concern regarding water quality has been the impact of the compensation releases from Grimwith Reservoir via the River Dibb. Worries have been expressed about long term effects of acidity (and suspended solids) on the receiving ecological communities of the Wharfe. Analysis of long term monitoring data (since 1978) has shown that while there may have been statistically significant periods of different pH values at Hartlington Bridge on the Dibb (**Appendix F**), there have been no instances since 1983 when the recorded pH fell below 7 (neutral). This pattern has been mirrored by the pH values recorded in the Wharfe at Bolton Bridge, downstream of the Dibb confluence. No impact from the drought has been observed, and indeed lower pH values appear to be related to high winter flows rather than low flow period with compensation releases.

Other influences on the Wharfe, such as colour and turbidity, were also higher downstream of the Dibb during the period by a factor of two to four, because of the Grimwith releases, but this is much less than the impact from rainfall, when turbidity in the Wharfe rises by several orders of magnitude. Colour measurements of raw water at Lobwood have also been taken since late 1994 (**Appendix G**) and, because concerns have been raised, additional monitoring of this determinand was instigated in the early summer of 1996 at Burnsall and Bolton Bridge on the Wharfe, and Hartlington Bridge on the Dibb.

3.6.4 Ecology

A classic Pennine Dales river, the Wharfe has a varied and rich ecology and shows a notable zonation in character and habitats from the upper fast flowing and boulder-strewn stretches to the meandering reaches influenced by tidal water downstream of Tadcaster. This is reflected in the fish communities, with trout giving way to grayling and then coarse fish down the system. Invertebrates show a similar, although perhaps not as pronounced a change. The highly spatey nature of the river with its associated fluctuations n the extent of wetted and exposed areas probably accounts for some of the biological diversity and annual variability seen in long-term data.

3.6.4a Invertebrates

The biological quality of the Wharfe can be described as excellent or good but the invertebrate faunas have regularly suggested that the middle and lower reaches of the river are slightly influenced by nutrient enrichment rather than negative impacts from elevated BOD or ammonia. The Wharfe also holds populations of native white-clawed crayfish ***(Austropotamobius pallipes)***, a species that is under threat nationally from introduced signal crayfish (*Pacifastacus lenuisculus* - also present in the Wharfe), pollution and other environmental degradation. A rare, and possibly threatened, species of pea mussel (*Pisidium tenuilineatum)* also occurs in the Wharfe. Responsibility for both these species under the Biodiversity Action Plan now lies with the Environment Agency.

The NRA's National Quinquennial Water Quality Survey was carried out in 1995, and this included thirteen water quality and biology GQA sites on the main river Wharfe, with additional sites on other tributaries in the catchment. Biological samples were collected in spring and autumn. Because of the continuing drought in 1996, these sites were supplemented in spring, summer and autumn 1996 by two sites on the upper Wharfe at Hubberholme and Kettlewell to provide data relevant to the impact of the natural drought alone - results from these and other post April surveys will be discussed in the next monitoring report.

In general biological water quality terms, there was no significant deterioration during 1995, although the autumn samples showed more influence of enrichment than those from the spring, when high river flows were experienced. Some relatively sparse samples were collected in Spring 1995 (notably from Lobwood and Ilkley) where the substrate is rough and difficult to sample effectively, especially during high flows.

The general conclusion is that water quality appears not to have declined sufficiently to have led to the elimination of many (if any) 'sensitive' types of invertebrates although it is clear that a few types were relatively unsuccessful, notably some stoneflies in the upper Wharfe. However, this slight faunal change was a consequence of natural drought and not the operation of the Drought Orders, since the period immediately before the autumn sampling was covered by full compensation releases. While the invertebrate communities in the Wharfe during the autumn of 1995 differed slightly from previous states it can be best summarised as a predictable response in relation to habitat changes, seen in slightly lesser degrees in some previous years.

Multivariate statistical analysis of data from fauna identified to family-level showed that the samples from the Wharfe in autumn 1995 were on the edge of the variation seen since 1985 and that faunal assemblages at each site tended to be more similar to each other than in previous years, indicating a greater homogeneity after the summer drought. This held true (**Figure 15**) even for sites upstream of compensation releases (Grassington) and the abstraction at Lobwood (Burnsall and Bolton Bridge), suggesting that natural drought was the prevalent impact. It should be noted that the upper Wharfe samples from autumn 1995 resembled a series from Addingham collected in previous years (1989, 1990 and 1992). There appears to have been a discernible 'switch' in the Addingham fauna between the summer and autumn of 1989, after which it has tended to be of slightly different character. This may relate to the effects of the 1989 Wharfe Drought Orders No. 1 and No.2 but further analysis will be required to establish whether this still fell within the range of variation normally expressed by the invertebrate communities over time, or was due to some other factors.

The reasons for the multivariate differences among the 1995 samples and previous data lie primarily in the different **abundance** values of the taxa collected:

ie upper Wharfe (Grassington to Addingham) invertebrate groups at present in higher numbers (on average) in autumn 1995 than previous (averaged) autumn values from 1985-1994 -

Lepidostomatidae -	cased caddis ('sedge') larvae
Hydropsychidae -	caseless caddis ('Grey Flag') larvae
Oligochaeta -	segmented annelid worms ('Tubifex')
Elmidae -	riffle beetles
Chironomidae -	non-biting midge larvae
Rhagionidae -	snipe-fly larvae
Caenidae -	mayfly (Angler's Curse) nymphs
Ancylidae -	river limpets
Hydroptilidae -	cased caddis larvae

Three taxa found in previous years were not recorded in the upper Wharfe samples from the autumn 1995 survey - Hydracarina (water mites), Nemouridae and Leuctridae (stoneflies). The Leuctridae are not shown in **Figure 17** as they infrequently recorded and only occur in a small numbers in samples. These apparent absences are probably not statistically significant and small numbers of these three taxa were recorded during the spring 1996 survey - but there may be some cause for some concern if this pattern is continued.

In the lower Wharfe (ie. Ilkley to Tadcaster) very similar faunal patterns were observed although the river's physical character changes to a more lowland type. Very rich populations were collected in autumn 1995, especially of uncased caddisflies. The community response was not as uniform as that from the upper Wharfe, and the fauna at Ilkley did not appear to differ from its composition in previous years (**Figure 16**). An analysis of the differences between the autumn 1995 invertebrate communities and those from the previous ten years showed that many invertebrates responded to the drought in the same way as those in the upper part of the Wharfe:

ie lower Wharfe invertebrates in higher numbers (on average) in autumn 1995 than previous (averaged) autumn values from 1984-94 were as follows:

Hydropsychidae -	caseless caddis ('Grey Flag') larvae
Oligochaeta -	segmented annelid worms ('Tubifex')
Asellidae -	water hog louse
Baetidae -	mayfly nymphs
Lumbricidae -	earthworms
Lymnaeidae -	pond snails
Gyrinidae -	whirlygig beetles
Lepidostomatidae -	cased caddis larvae
Sericostomatidae -	cased caddis (Halford's Welshman's Button) larvae

Other invertebrates were also at higher (averaged) abundance in the lower Wharfe compared with previous autumns (**Figure 17**), but they are not as significant or reliable indicators of change (because of lower numbers and more sporadic occurrence). These were Caenidae (mayflies - Angler's Curse), Sphaeriidae (pea mussels), Planorbidae (ramshorn snails), Limnephilidae (cased caddis larvae), Tipulidae (cranefly larvae) and Muscidae (fly maggots). Only one taxon was not recorded - Ephemerellidae (blue-winged olive mayfly nymphs). However, this is more typically a Summer type and the adults may have emerged before the October sampling date because higher water temperatures may have accelerated the nymphs' development.

Concern about the recovery of the Wharfe faunas from the low-flow conditions of 1995 meant that the biological sampling in spring 1996 had extra significance. A major factor in structuring the invertebrate communities of the Wharfe is winter washout, ie. very high flows between late autumn and spring that scour and redistribute the substrate along with many existing invertebrates, macrophytes and algae. This applies particularly to groups poorly adapted to high water velocities such as snails, whirligig beetles and some heavy-cased caddisfly larvae, as well as weakly attached filamentous algae and diatom colonies.

The change between the autumn 1995 and 1996 spring fauna will be reported in the next Drought Monitoring Report.

3.6.4b Crayfish

Specific concerns have been raised concerning the impact of low flows on populations of crayfish in the Wharfe. Not only is the species protected under the Annex II of the European Union Species and Habitats Directive, the Wildlife & Countryside Act, and features in the UK Biodiversity Action Plan, but it forms part of the diet of predatory vertebrates, including birds (herons, goosanders), fish (trout, chub) and mammals (mink and otters).

The possible impacts of poor water quality downstream of STWs, loss of favoured marginal habitats, and stranding in pools were all considered threats to this species. The normal invertebrate sampling technique operated by the Environment Agency does not adequately monitor the status of freshwater crayfish, and they are found in kick samples only sporadically. In order to rectify this situation a specialised crayfish survey involving hand searches and trapping was commissioned by YWS at the behest of the NRA and carried out by Nottingham University. The sites were similar to those in the GQA biology sampling programme.

Native white-clawed crayfish (*Austropotamobius pallipes*) were recorded at all the surveyed sites, including Grassington where they still co-occur in small numbers with signal crayfish (*Pacifastacus leniusculus*). The survey provided direct evidence of the survival of this protected species. Previous reports from anglers of signal crayfish at sites as far downstream as Boston Spa seem unfounded by this survey, but it is clear that the future of the native species is primarily at the mercy of the signal crayfish, rather than threats from low flows and poor water quality.

3.6.4c Macrophytes and algae

Note was taken of the macrophyte associations at each of the invertebrate sampling sites during the 1995 spring and autumn season, but full and dedicated macrophyte surveys will be carried out by YWS in 1996 and the next two years to monitor the status and changes of this important aspect of the Wharfe as there are fundamental relationships between macrophyte distribution and abundance (especially water crowfoots), fish (grayling especially) and invertebrates.

An analysis of the available NRA data collected between 1975 and 1995 was, however, carried out for the Public Enquiry. This suggested that the Wharfe upstream of Ilkley was characteristically dominated by mosses and algae during this period and only small populations of water crowfoot (*Ranunculus* spp.) were present. Water crowfoot was relatively abundant in the stretch at Burnsall, upstream of the Dibb, in the late 1970s and early 1980's but appeared to decline suddenly from 1984 onwards (of note because this was a drought year).

At sites between Burley and Harewood, water crowfoot and water milfoil have been recorded in varying percentages. At The Nunnery, between the Pool and Harewood bridges, summer plant growth (water crowfoot, water milfoil, narrow-leaved pondweed) covering 25-75% of the river channel was recorded during the 1980's and early 1990s. At Harewood vegetation covers of 15-30% were noted between 1992 and 1995 (including water crowfoot, water milfoil, Canadian pondweed and horned pondweed).

During autumn 1995, under low flow conditions, floating masses of filamentous algae and 'scum' occurred along the margins of the Wharfe and were most apparent downstream of Burley. Increased quantities of duckweed (*Lemna*) and Canadian pondweed (*Elodea*), the latter above Harewood Weir, were also observed. This is consistent with changes in the plant community that would be expected under low flow conditions, but are normally reversible with the return of high flows.

Gravel covered with algae was reported in the Arthington stretch in April 1996 and 'black deposits' reported from The Nunnery stretch in April also proved to be diatom growths (*Nitzchia* sp.) when Environment Agency biologists collected the spring invertebrate samples. Dense covers of diatoms were recorded at most sites in April although the films were more species-rich and of different composition in the upper Wharfe (Hubberholme-Addingham).

3.6.5 Fisheries

As outlined in **section 2.12** of this report, the regional drought action plan required a series of investigative and mitigation works concerning fisheries. Since the start of the 1995 drought Fisheries Inspectors have undertaken monitoring of the Wharfe on a regular basis and submitted weekly reports on the current status and significant observations and developments. They have also established a liaison with angling organisations and

and conditions, with a view to carrying out emergency operations to rescue fish if this became necessary.

Mitigation of the drought's impact on fisheries has been a major aspect of the work, specifically in removing barriers to fish migrating to spawning areas (ie. clearing gravel bars blocking entry to small side streams) and in minimising fish losses on screens at the abstraction sites at Lobwood and Arthington.

Supporting these fisheries mitigation actions, an aerial survey was carried out on behalf of the Environment Agency in late September 1995 provided video and still footage of the Wharfe under very low flow conditions. An immediate use of these data was visual analysis for stretches where flow was interrupted or broken and where the potential for fish rescues may have existed. None of these conditions were noted on the main river but it is clear that the amount of exposed river bed varies from locality to locality: in some stretches there are extensive riverine boulder and cobble areas with a reduced flowing channel (Plate I), or very little dry bed and the channel intact with less water depth (Plate II).

3.6.5a Fish populations and ecology

Because effects on fish recruitment cannot readily be monitored immediately, the NRA's fisheries surveys in the Wharfe catchment during 1995 and the early part of 1996 were largely concerned with specific investigations rather than long-term monitoring or drought-related impact assessment. Linton Beck was surveyed in May/June to gain information about fish populations in relation to proposed expansion of activity in Swinden Quarry and its associated water management regime.

The Wharfe at Pool paper mill was surveyed by the NRA in July 1995 to assess possible impact from the abstraction - good mixed fish populations were observed. The mill goit, deeper and with a greater flow than the main river, was indicated to be a nursery area for coarse fish, with the main river supporting a mixed fish population of trout, grayling, chub and dace. Some chub were in poor condition, possibly because of overcrowding or interrupted spawning.

A survey on the Dibb (part of the Environment Agency's rolling programme of monitoring) in Autumn 1995 found that stocks of brown trout were slightly down on previous years but this was not unexpected for a warm dry year.

Good numbers of fry were seen in side streams but the overall recruitment success can only be assessed in subsequent years.

Several reports have been received expressing concern at the increase of pike in the middle reaches of the Wharfe and evaluation of this will take place during survey work planned by the Environment Agency for 1996 to assess the impact of the 1995-96 drought on recruitment of fish from the 1995 year class.

fishery owners. In addition, liaison with YWS was established to check reservoir levels and conditions, with a view to carrying out emergency operations to rescue fish if this became necessary.

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3.6.5b Fish kills

The remains of a small number of dead trout were reportedly found in the Bolton Abbey area during November 1995, but no material was available for postmortem examination. Four other incidents were recorded in the catchment during the last ten months but none was directly linked to the Wharfe low flow situation.

A potential fish kill was averted when 75 brown trout were transferred from a pool in a dried-out section of the River Skirfare - this river is subject to problems each year due to swallow holes in the limestone bedrock.

3.6.5c Fish migration

Obstructions to migration were identified and removed from the outlets of tributary becks into the main river in November 1995: Kex, Hundwith, Bow, Riffa, Collingham and Hambleton Becks were cleared. However, lack of flow to some extent delayed spawning. An attempt is being made to obtain samples of trout from all along the Wharfe to further investigate recovering condition after spawning, after concern was expressed at the thinness of some trout at spawning time in 1995.

3.6.5d Angling

Attempts to evaluate effects on angling catches from the Wharfe have been confounded by the following:

- Angling activity largely confined to late evenings/early mornings because of high temperatures and sunny weather during the late summer and autumn of 1995.

- Few pleasure anglers have been seen and day permit sales are reported to have fallen substantially on the lower Wharfe. Cancellation of angling matches has happened due to lack of water depth in some sections.

- Large areas of the Wharfe became frozen over in the winter and restricted access for anglers during the period December 1995 to February 1996.

- The trout and coarse close seasons also placed limitations on the number of anglers seen.

- Difficulties of collecting and collating individual and match results from fishery occupiers.

Such information as is available tends to suggest that isolated good catches of coarse fish were made from the lower and middle reaches of the Wharfe throughout the latter part of 1995 and early 1996. One angler caught 50 lb of grayling in four hours from the Pool area in September 1995 - this is notable because this species has been frequently reported as scarce. There appears to have been some increase in coarse fish activity in early

February 1996 when a thaw and rainfall increased river levels and quite a few barbel were caught from the lower Wharfe at this time - again notable because this species is usually not so active in winter. Some good results were also obtained in the Otley area, the winner of a match had a catch of 68 lb. However, this should be considered an unreliable guide as more than half of the anglers taking part in this event did not catch any fish.

Besides the reported shortage of grayling, it has been noted that dace are frequently being reported to be declining in the Wharfe. This is a view held by many angling clubs on the middle and lower reaches, but extends back several years.

Trout anglers reportedly had poor success. Some 8 miles of river in the middle reaches produced no fish at the start of the season for a few weeks according to reports. However, just before the season opening a good number of trout to 11/2 lb had been caught inadvertently by coarse anglers in the Otley area.

3.6.6 Birds

Large numbers of goosanders and cormorants were seen on the Wharfe during 1995. Comparison needs to be made with reports from previous years, including the British Trust for Ornithology's report on the Waterways Bird Survey (WBS) for the rivers Wharfe and Ure that was published in March 1996. Goosanders are most abundant on the Wharfe upstream of Bolton Abbey and they started breeding on this river during the late 1970's, as part of a general increase and southward range expansion that has occurred during this century.

The BTO report concluded that "there had been little evidence of major changes in population levels on these rivers in recent years" (1974-), but that monitoring should be continued to enable the impacts of any management change to be identified.

4. Glossary of terms

Abstraction	Removal of water from a source of supply (surface or ground water)
Algae	Simple non-flowering plants including single-celled diatoms, filamentous 'blanket weed' and seaweeds.
ASPT	Average Score Per Taxon. A biotic score based on the BMWP score divided by the number of contributing invertebrate taxa (groups). It is a useful guide to the biological quality of a stream or river.
Ammonia	A chemical which is often found in water as the result of organic effluents. Widely used to characterise water quality. High levels adversely affect the quality of water for fisheries and abstractions for potable water supply.
BMWP score	Biological Monitoring Working Party. A biotic score based on he sensitivity/tolerance of a range of freshwater invertebrate groups; used to assist in classification of water quality.
BOD	Biochemical oxygen demand. A measure of the amount of oxygen consumed in water, usually by organic pollution. Widely used to characterise water quality.
Catch returns	Forms completed by anglers indicating locality, time spent fishing and fish caught, sent to the Environment Agency for data analysis.
Catchment	The total area of land which contributes surface water to a specified watercourse or waterbody.
Classification/ Classes	A method of placing waters in categories (classes) according to assessments of water quality based, for example, on measurements of the amounts of chemicals in the water (especially BOD, dissolved oxygen and ammonia).
Compensation releases/flows	Water released artificially from reservoirs to augment river flows, usually to compensate for water abstracted for supply.
CSO	Combined sewer overflow - an overflow structure which permits a discharge from the sewerage system during wet weather conditions.
Cusum	A statistical technique for separating out periods over which a determinand has different underlying mean (average) levels. It is seen as a plot of the cumulative sum of deviations from a target value against the observation number.

Dissolved oxygen	The amount of oxygen dissolved in water. Oxygen is vital for life, so this measurement is an important, but highly variable, test of the 'health' of a water; it is used to classify waters.
Determinand	A general name for a characteristic or aspect of water quality. Usually a feature which can be described numerically.
Diatoms	Single celled algae with an interlocking pair of siliceous cases; often in the water as plankton but colonies also form brown or blackish deposits on hard surfaces in rivers and streams.
DoE	Department of the Environment.
Drought Order	A change in conditions with regard to abtraction rates, abstraction points, prescribed flows or other matters relating to the use of water by a water company, or by the regulator to protect the water resource and environment; granted by the DoE.
Electrofishing	A sampling technique where an electrical current in water is used to draw fish towards an anode and temporarily stun them, enabling them to be captured, identified and measured.
Faunal assemblage	A group of animal species living in the same basic habitat, but not necessarily interacting (as in a 'community').
GQA	General Quality Assessment; a formal scheme for classifying controlled waters, ie. rivers, lakes, canals, estuaries etc. based on chemical, nutrient, biological and aesthetic quality
Hydro-acoustic survey	The use of high energy sound waves (sonar) to obtain echoes from targets such as fish in deep rivers where electrofishing may be less efficient.
Hydrograph	Plot of flow vs time.
Hydrology	The study of water resources, and the water cycle.
NRA	National Rivers Authority; 1989 to March 1996 now superceded by the Environment Agency
Invertebrate	Animal without a backbone; such as insects, worms,crustaceans, molluscs and spiders. Widely used to assess the quality of aquatic ecosytems such as rivers, lakes and ponds.
Macrophyte	Large algae and higher plants visible to the naked eye, but commonly retained for mosses, liverworts, ferns and flowering plants.

Monitoring	Usually refers to the regular assessment by sampling or measurement of environmental quality in order to detect change, deviation from normal conditions, or attainment of stated conditions.
Multivariate analysis	Techniques of statistical analysis which deal with more than one variable (eg. determinand values or species counts) simultaneously; often used with biological data involving numerous samples and species.
%-tile (percentile)	The value below which falls a specified percentage of the statistical population (ie. set of values)
Prescribed flow	A generic term for any flow 'prescribed' under statute or regulation.
Riparian owner	A person or organisation with proerty rights on a river bank.
River corridor	Land which has visual, physical or ecological links to a watercourse and which is dependent on the quality or level of water within the channel.
Rolling programme	A monitoring programme designed to to be spread over a period of time (such as three years), so that not all sampling points are dealt with simultaneously.
RSPB	Royal Society for the Protection of Birds.
SSSI	Site of Special Scientific Interest. A site given a statutoryd esignation by English Nature or the Countryside Council for Wales because it is particularly important on account of its conservation value.
Standard deviation	A statistical term for the variation of a set values (data).
Statistically significant	A description of a conclusion which has been reached after making proper allowance for the effects of random chance.
STW	Sewage treatment works.
Surface water	Water in ponds, lakes, streams and rivers.
tcmd	Thousand cubic metres per day, a unit of flow, equivalent to a mega litre per day (Mld).
Time Limited Licence	Licence with a specified period of validity (eg five years from date of issue).
WTW	Water treatment works.
WWTW	Waste water treatment works (includes STWs)

Yorkshire Interpretative Index	A system of determining biological water quality based on the types, abundance and pollution sensitivity of freshwater invertebrates; conceived by the then Yorkshire Water Authority.

Table 1. List of Drought Orders applied for by YWS in 1995/1996

Drought Order No.	Title D - Drought R - Refill	Applied Date	Date Granted	Expiry Date	Current Status as of 30/10/96
1	D River Wharfe Abstraction	26/07/95	18/08/95	20/02/96	Extension - see No.31
2	D Restriction of Use (Bradford & Calder supply areas)	26/07/95	25/08/95	25/02/96	Extension - see No. 2Ext
2 Ext.	D Extention to Restriction of Use (Bradford & Calder supply areas)	29/01/96 ?	21/02/96	?	Expired
3	D Hebden Water Compensation (Calderdale, Halifax) D River Worth compensation (Spring Head weir, Worth Valley)	18/08/95	07/09/95	31/03/96	Expired
4	D Silsden Reservoir abstraction	18/08/95	31/08/95	30/04/96	Extension - see No. 15
5	D Sand Hutton Boreholes abstraction	01/09/95			Withdrawn
6	D Stubbing Nook Boreholes abstraction	01/09/95			Withdrawn
7	Pennine Compensation : D Ogden Mixenden D Gorpley D Holestyes D Brownhill	08/09/95	02/10/95	03/04/96	Extension - see No.32
8	D Chellow Dean abstraction	08/09/95	02/10/95	03/01/96	Expired
9	D Emergency drought order on River Wharfe abstraction.	20/09/95	28/09/95	31/10/95	Extension - see No. 31
9 ext.	D Emergency drought order on River Wharfe extension of 2 months abstraction	19/10/95	31/10/95	01/01/96	Expired
10	D Emergency DO - Rota Cuts Bradford & Halifax	20/09/95	Decision Deferred		Withdrawn
11	D/R Moor Monkton abstraction	20/10/95	04/11/95	31/03/96	Extension - see No. 34
12	D Cold Edge Dams abstraction (Haigh Cote)	19/10/95	31/10/95	29/02/96	Extension - see No. 35
13	D Doe Park / Hewenden abstraction	Not Yet Received			Not received
14	D/R Restriction of use (Leeds & Wakefield)	20/10/95	4/11/95	04/05/96	Extension - see No.37
15	D Silsden Reservoir abstraction for 6 months	19/10/95	30/10/95	30/04/96	Expired
16	D River Wharfe Abstraction - Arthington	30/10/95	08/11/95	31/03/96	Extension - see No. 31
17	D Pennines - Reservoirs Compensation No.2 Emergency	01/11/95	09/11/95	31/03/96	Extension - see No.32

	Table 1 continued . Drought Orders applied for by YWS 1995-96				
18	*D Emergency DO - Rota Cuts Kirklees Borough Council*	*01/11/95*	*Decision Deferred*		*Withdrawn*
19	D Pennine Compensation Variations (varies 3&7)	07/11/95	15/11/95	31/03/96	Extension - see No.32
20	*D Yorkshire Borehole Licences*	*13/11/95*	*21/11/95*	*21/02/96*	*Expired*
21	*D Leighton + Haverah Park*	*10/11/95*	*17/11/95*	*31/03/96*	*Expired*
22	*D/R Restriction of Use - Harrogate*	*10/11/95*	*20/11/95*	*21/05/96*	*Expired*
23	*D Pennine Reservoirs (No.4) Emergency.*	*20/11/95*	*04/12/95*	*04/03/96*	*Expired*
24	R Wharfe (Protected Flows)	21/11/95	04/12/95	04/03/96	Extension - see No. 31
25	D Old Town Reservoir Hebden Bridge	27/11/95	05/12/95	05/06/96	Extension - seeNo.35
26	*D/R Sheffield Source compensations*	*07/12/95*	*04/01/96*	*04/07/96*	*Expired - see No.40*
27	*D/R Sheffield Ban on Non Essential use*	*07/12/95*	*04/01/96*	*04/07/96*	*Expired - see No.41*
28	R River Ouse (No.2) Emergency	18/12/95	09/01/96	31/03/96	Extension - see No. 34
29	*R River Derwent Emergency*	*27/12/95*	*Deferred*		*Withdrawn*
30	*R River Ure Emergency*	*27/12/95*	*06/02/96*	*05/05/96*	*Expired*
31	*R River Wharfe No.3*	*26/01/96*	*21/02/96*	*20/08/96*	*Expired - see 42*
32	*R Pennine Res. Compensation No. 5 (Emergency)*	*09/02/96*	*05/03/96*	*04/08/96*	*Expired - see 43*
33	*D Crimsworth Dean*				*not applied for*
34	*D Increased abstraction from river Ouse*	*01/01/96*	*01/04/96*	*30/06/96*	*Expired*
35	*Haigh Cote - Cold Edge Dams*	*18/3/96*	*3/4/96*	*3/10/96*	*Expired*
36	**Winscar Rerservoir - reduction in compensation**	**12/04/96**	**22/05/96**	**21/11/96**	**IN FORCE**
37	**restriction of use Order - Leeds ext.**	**22/4/96**	**3/5/96**	**3/11/96**	**IN FORCE**
38	**restriction of use Order - East Yorkshire**	**25/6/96**	**26/7/96**	**25/1/97?**	**IN FORCE**
39	**Old Town Reservoir**	**21/5/96**	**6/6/96**	**5/12/96**	**IN FORCE**
40	**Sheffield source compensations**	**7/6/96**	**4/7/96**	**4/1/97**	**IN FORCE**
41	**Sheffield restriction of non-essential use order (ext. to no.27)**	**7/6/96**	**4/7/96**	**4/1/97**	**IN FORCE**
42	**River Wharfe No.3 (extension)**	**25/7/96**	**21/8/96**	**20/2/97?**	**IN FORCE**
43	**Pennine Res. compensation No.5 (extension)**	**25/7/96**	**21/8/96**	**20/2/97?**	**IN FORCE**
44	**restriction of use Leeds & Wakefield (renewal)**	**25/7/96**	**21/8/96**	**20/2/97?**	**IN FORCE**

Table 2. Matrix of potential work to be carried out under a Drought Order

WORK REQUIRED	Water Quality & Resources			FRCN		
	Water Resources	Hydrology	Quality	Fish	Ecology	General
PREDICTIVE MODELLING	WR Contingency Plan	Flow forecasting	Quality forecasting	Species affected	Ecology affected	Habitat Survey
MONITORING	Abstraction Conditions	Reservoir Contents	Compensation releases	Quantity	Plant Life	Photographic
	Use restrictions	Flow s	Discharge Sampling	Quality	Invertebrates	[redacted]
	Demand management	Water levels	River Sampling		Mammal	
		Rainfall	Continuous Monitors		Bird	
MITIGATION			YWS Sewage works	Rescues		Water levels
			CSO conditions	Havens		Freshets
			Other Discharges	Screens		
			Pollution Prevention	Aeration		
RESTORATION				Restocking		
				Spawning areas		
IMPROVEMENT	WR Strategy	Revised Compensation	AMP 2 schemes	Fish passes		Habitats

Table 3. Changes in water quality classifications of the Calder pre-1995 to 1995.

River/ Stretch	Change in GQA class	Major Discharges in stretch	Reservoir Compensation Releases affecting stretch
River Calder: Heald Moor to Walsden Water	Improve C - B or no change B	None	None
Walsden Water to Hebden Water	No change B u/s STW D d/s STW	Eastwood STW	Gorpley
Cragg Brook to Luddenden Brook	Deterioration B - C	Redacre STW	Above plus Withens Clough / Turvin Clough
Luddenden Brook to R. Ryburn	No change B	High Royds STW	Above plus Warley Moor group
River Ryburn to Halifax STW	No change C	Milner Royd STW (Ripponden Wood STW)	Above plus Boothwood group
Halifax STW to Black Brook	No change E	Halifax STW	Above plus Ogden and Mixenden
Black Brook - Brighouse	Not GQA but serious reduction of D.O.	(Shibden Head STW) via Red Beck	Above plus Scammonden
Brighouse to River Colne	Improve D - C	Brighouse STW storm	Above plus Scammonden
River Colne to Mirfield	Deterioration E - F	Huddersfield&Brighouse STW	All above
Walsden Water	Deterioration B- C	None	None
Ramsden Clough	Deterioration A - B	None	None
Colden Water	No change B	None	None
Hebden Water	Improve B - A	None	Hebden Group
Cragg Brook	No change B	None	Withens Clough / Turvin Clough
Luddenden Brook	No change C	None	Warley Moor Group
River Ryburn	Deterioration B - C	Ripponden Wood STW	Ryburn and Boothwood Groups
Hebble Brook	Improve D - C	None	Ogden and Mixenden
Black Brook	Deterioration A/B - C	None	Scammonden Reservoir
Red Beck	Deterioration B - D	Shibden Head STW	None
Clifton Beck	Deterioration C- D	None	None
River Colne: Source to River Holme	No change A/B	None	Butterley and Blackmoorfoot and Colne Valley catchwater

Table 3 continued			
River/ Stretch	**Change in GQA class**	Major Discharges into stretch	**Reservoir Compensation Releases affecting stretch**
River Holme to Fenay Beck	No change B/C	None	Above plus Brownhill /Digley and Holmestyes via Holme catchment
Fenay Beck to River Calder	Deterioration D - E	Huddersfield STW	as above
River Holme: Holmfirth to Mag Brook	Improve C - B u/sSTW No change d/s STW	Neiley STW	Brownhill /Digley on R. Holme and Holmestyes via R. Ribble
Mag Brook to River Colne	Improve C-B	None	Above plus Blackmoorfoot
Mag Brook	Improve C- B	Meltham STW	Blackmoorfoot
River Ribble	No change A	None	Holmstyes

Table 4. Biological water quality classifications for the upper Calder and tributaries 1990 to 1995 using the Yorkshire Interpretative Index

River	Site	NGR	1990	1991	1992	1993	1994	1995
Calder	u/s Tannery	SD989267	B2	B1B	B1B	*	*	B1B
Calder	Lydgate	SD917257	B2	B1B	B2	*	*	B1B
Calder	Woodhouse Road	SD951245	*	*	*	*	*	B2
Calder	u/s Hebden Bridge	SD990271	*	B3	*	*	*	B3+
Calder	d/s Hebden Bridge	SD996269	B2/3	B2	B1B	*	*	B1B
Calder	d/s Brearley weir	SE027260	*	*	*	*	*	B1B
Calder	Sowerby Bridge	SE059235	*	B3	B3+	B3+	B2-	B2+
Calder	Copley	SE084223	B3	B2/3	B3-	B3+	B3+	B3+
Calder	u/s Black Brook	SE101214	*	B3-	B3-	B3-	*	B3
Calder	Cooper Bridge	SE176206	-	-	-	-	*	B3+
Calder	Battyeford Bridge	SE189205	B3/4	B4	B4	B4	B3-	B3-
Colden Water	Hebden Bridge	SD985272	B2	*	B1B	*	*	B1B
Cragg Brook	u/s River Calder	SE013258	*	B1B	B1B-	*	*	B1B
Hebden Water	u/s Crimsworth Dean	SD988291	*	B1A	B1B	*	*	B1A
Hebden Water	Hebden Bridge	SD992272	B2	*	B1B	*	*	B1B
Luddenden Brook	Luddenden	SE041260	B1B	*	B1A	*	*	B1A
Ryburn	u/s Ripponden STW	SE045205	B2	B2	B2-	B1B	*	B2+
Ryburn	Sowerby Bridge	SE059235	B3	B2	B2+	B2/3	B2	B3+
Black Brook	Penny Hill	SE064184	B2	B1B	B1B	*	B1B	B1B
Black Brook	Greetland	SE099214	B2/3	B1B	B2-	*	B3-	B2+

descriptive terms for the alphanumeric quality classes:
(+ and - suffixes indicate quality at upper or lower end of the class)

B1A very good
B1B good
B2 fair
B3 poor
B4 bad

Table 5. Sensitivity of fisheries to compensation flow reductions in the Calder catchment

Group	Reservoir	Receiving watercourse	Fishery status	sub*catch ment	Fishery status	Sensitivity to loss of flow	Additonal information required	Comments
Hebden	Gorple Widdop Walshaw	Graining Water Graining Water Alcomden Water	Low no.brown trout, low recruitment Moderate brown trout, modest recruitment	Hebden Water	Very prolific brown trout, strong regular recruitment. Supports the main River Calder fishery	**LOW**		Considerable input to system from ground*water and minor tribs. Alcomden and Graining relatively insignificant trout production cf. main stream. Widdop augmented from NWW.
Withens/ Turvin	Withens Turvin	Withens Clough Turvin Clough	Not presently known	Cragg Brook	No fisheries data but thought to be good brown trout	**HIGH**	Present total flow cf. present compensation	To be surveyed later 1995
Warley Moor	Warley Moor	Luddenden Dean	No fisheries data, thought to be good brown trout			**HIGH**		Of crucial importance to main River Calder recovering from pollution. Few other inputs besides reservoirs. To be surveyed late 1995.
Ryburn	Baltings Ryburn Boothwood Ringstone	Ryburn Boothwood Clough Butts Clough	Prolific trout fishery, thought to be improving No fisheries data No fisheries data	Ryburn Ryburn	Prolific trout fishery, thought to be improving	**HIGH**		River Ryburn is an important nursery river and as a fishery in its own right. Sewage works at Ripponden. To be surveyed autumn 1995.

Table 5 continued

Ogden/ Mixenden	Ogden Mixenden	Hebble Brook	Moderate population of brown trout at Mixenden, some recruitment, very poor in lower reaches			**MEDIUM**		Existing population small and isolated, vulnerable to storm sewage events? Proposal will not make situation worse than 1991 when compensation was during working hours only.
Deer Hill/ Blackmoorfoot	Deer Hill	Various minor watercourses	No fisheries data; assumed to be insignificant	Colne	As referred to earlier	**LOW**		Insignificant effects on Colne
	Blackmoor foot	Brow Grains Dyke	Prolific trout stream at head of Mag Brook system	Mag Brook /Holme	Mag and Lower Holme recovering from chronic pollution.	**HIGH**		Recruitment of trout in this stream will assist the rehabilitation of the systemOf minor importance to the Colne
		Hoyle House Clough	Insignificant	Colne	as referred to above	**LOW**		
Holme Valley	Digley	Digley Brook/ Marseden Clough	Small isolated trout populations in upper reaches, vulnerable to low water levels. Prolific population lower down.	Holme	Prolific trout population, good recruitment but numerous small fish kills	**HIGH**		Compensation release major part of flow. Recent move to 24 hour release regime improved fishery. Reduced habitat availability at low flows.
	Brownhill series	Ramsden Clough	Good trout population with strong recruitment	Holme	" " "	**Medium**		As above. Short lengths of beck only. Fish could retreat into Holme.
	Holmstyles	River Ribble	Poor trout population	Holme	" " "	**Low**		Trout population centred in deep pools on steep streams; flows unlike to impact. More significant impact on reduced flows to Holme

Table 6. Water quality of the Ouse at Naburn Weir, 1993-95

1993	1994	1995
confidence of grade (%) *A B C D E F*	confidence of grade (%) *A B C D E F*	confidence of grade (%) *A B C D E F*
- 97 3 - - -	- 97 3 - - -	- - 95 - - -

NB. The grades A-F are not true GQA classes as this particular analysis is based on single year data, not 3 years as in the formal system; as such they are shown in italics.

Table 7. Water quality at Naburn Weir, by determinand, 1993-95

1993

Determinand	mean	standard deviation	No. of samples	%-tile	Confidence of grade *A B C D E F*
BOD	2.2	0.7	47	3.12	- 100 - - - -
Total ammonia	0.3	0.17	47	0.51	- 97 3 - - -
Dissolved oxygen (%)	90	6.88	41	81.1	14 86 - - - -

1994

BOD	2.20	0.80	49	3.25	- 100 - - - -
Total ammonia	0.28	0.16	49	0.48	- 97 3 - - -
Dissolved oxygen (%)	91.75	10.72	48	78.01	14 86 - - - -

1995

BOD	2.30	0.50	47	2.96	- 100 - - - -
Total ammonia	0.49	0.35	47	0.91	- - 99 1 - -
Dissolved oxygen	87.65	16.55	46	66.44	- 11 84 5 - -

NB. The grades *A-F* are not true GQA classes as this particular analysis is based on single year data, not 3 years as in the formal system; as such they are shown in italics.

Table 8. Biological quality classifications for the River Ouse 1990-95, based on the Yorkshire Interpretative Index.

SITE	site code	NGR	1990 class	1991 class	1992 class	1993 class	1994 class	1995 class
Nether Poppleton	0237	SE557552	B1B	B1B	B1B	B1B	B1B	B1B
York*	0919	SE596521	-	-	-	B1B	-	B1B
Acaster Malbis	0236	SE590453	B2p	B2p	B2	B2	B2p	B3

* at Scarborough Railway Bridge

descriptive terms for the alphanumeric quality classes:
(suffix 'p' indicates quality at the lower end of the class, ie. B2 poor)

B1A very good
B1B good
B2 fair
B3 poor
B4 bad

Table 9. Comparison of water quality classifications in the River Ure 1993-95.

Site	1993 confidence of grade % *A B C D E F*	1994 confidence of grade % *A B C D E F*	1995 confidence of grade % *A B C D E F*
Wensley	21 **77** 2 - - -	**88** 12 - - - -	**99** 1 - - - -
West Tanfield	29 **69** 2 - - -	**70** 30 - - - -	23 **75** 2 - - -
Hewick Bridge	14 **82** 4 - - -	**61** 39 - - - -	11 **78** 11 - - -
Boroughbridge	- **60** 31 8 1 -	**57** 42 1 - - -	1 13 **55** 21 10 -
Aldwark Bridge	2 **92** 6 - - -	18 **82** - - - -	3 71 24 2 - -

NB. The grades *A-F* are not true GQA classes as this particular analysis is based on single year data, not 3 years as in the formal system; as such they are shown in italics.

Table 10. Biological water quality classifications of the River Ure sites sampled in 1995, based on the Yorkshire Interpretative Index.

Site	Site code	NGR	1990 class	1991 class	1992 class	1993 class	1994 class	1995 class
Bainbridge	0318	SD933907	B1A	B1A	B1A	*	B1B	B1B
Wensley	0314	SE092894	B1A	B1A	B1A	B1A	B1A	B1A
West Tanfield	0319	SE270787	B1A	B1A	B1A	B1A	B1A	B1A
d/s Hewick bridge	0594	SE334699	*	B1B	B1B	*	*	B1B
Boroughbridge	0323	SE397670	B1B	B1B	B1B	B1B	B1B	B1B
Aldwark Bridge	0315	SE467622	B1B	B1B	B1B	*	*	B1B

descriptive terms for the alphanumeric quality classes:

B1A very good
B1B good
B2 fair
B3 poor
B4 bad

Table 11. Water quality of the Wharfe 1993-95

Site	1993	1994	1995
	confidence of grade % *A B C D E F*	**confidence of grade %** *A B C D E F*	**confidence of grade %** *A B C D E F*
Conistone Bridge	90 10 - - - -	94 6 - - - -	87 13 - - - -
Burnsall Bridge	89 11 - - - -	89 11 - - - -	86 13 1 - - -
Bolton Bridge	94 6 - - - -	99 1 - - - -	90 10 - - - -
Lobwood	no data	73 26 1 - - -	16 72 12 - - -
Hollins	100 - - - - -	61 38 1 - - -	73 26 1 - - -
Denton Bridge	no data	no data	100 - - - - -
Burley Weir	23 68 9 - - -	73 27 - - - -	57 41 2 - - -
Otley	76 22 2 - - -	65 35 - - - -	56 40 4 - - -
Sandbeds	4 96 - - - -	100 - - - - -	70 30 - - - -
Harewood Bridge	70 30 - - - -	76 23 1 - - -	91 9 - - - -
Boston Spa	80 20 - - - -	96 4 - - - -	4 96 - - - -
Tadcaster Weir	- 100 - - - -	73 27 - - - -	3 86 11 - - -
Ryther [tidal]	30 70 - - - -	83 17 - - - -	- 89 11 - - -

NB. The grades *A-F* are not true GQA classes as this particular analysis is based on single year data, not 3 years as in the formal system; as such they are shown in italics.

Table 12. Biological water quality classifications for the Wharfe and Dibb 1990-95, based on the Yorkshire Interpretative Index.

Site	site code	NGR	1990 class	1991 class	1992 class	1993 class	1994 class	1995 class
Grassington	0341	SD997639	B1A	B1A/B	B1A	B1A	B1A	B1A
Burnsall	0343	SE032611	B1B/B2	B1B/B2	B1B	-	-	B1B
Bolton Bridge	2054	SE072528	-	B1B	B1B	-	-	B1A
Lobwood	0932	SE075519	-	-	-	-	-	B1B
Addingham	0344	SE084499	B1B	B1B	B1A	-	-	B1B
Ilkley	2086	SE137482	-	B1B	-	-	-	B1B
Burley Weir	0931	SE165474	-	-	-	-	-	B1B
Otley	0339	SE188455	B1B	B1B	B1B	-	-	B1B
Castley	0337	SE256457	-	B1B	-	-	-	B1B
Harewood	2055	SE309459	-	B1B	-	-	-	B1B
Boston Spa	0347	SE432458	B1A	B1B	B1B	B1B	B1B	B1B
Tadcaster	0930	SE486436	B1B	B1B	-	-	-	B1B
Ryther	0340	SE550393	B2	B2-	B2-	-	B2	B2+
Dibb at Hartlington Bridge	0110	SE040609	B1B	B1B	B1A	B1A	B1A	B1A

descriptive terms for the alphanumeric quality classes:
(+ and - suffixes indicate quality at upper or lower end of the class)

B1A very good
B1B good
B2 fair
B3 poor
B4 bad

Plate I. The River Wharfe at Bolton Abbey on 16th September 1995, showing extensive boulder and cobble areas.

Plate II. The River Wharfe at Esscroft (upstream of Burley) on 16th September 1995, showing marginal strips with filamentous green algae and organic surface scums.

FIGURE 1 . Flow chart showing steps taken in evaluating monitoring, mitigation, restoration and improvement required under a Drought Order, Drought Permit or Time Limited Licence

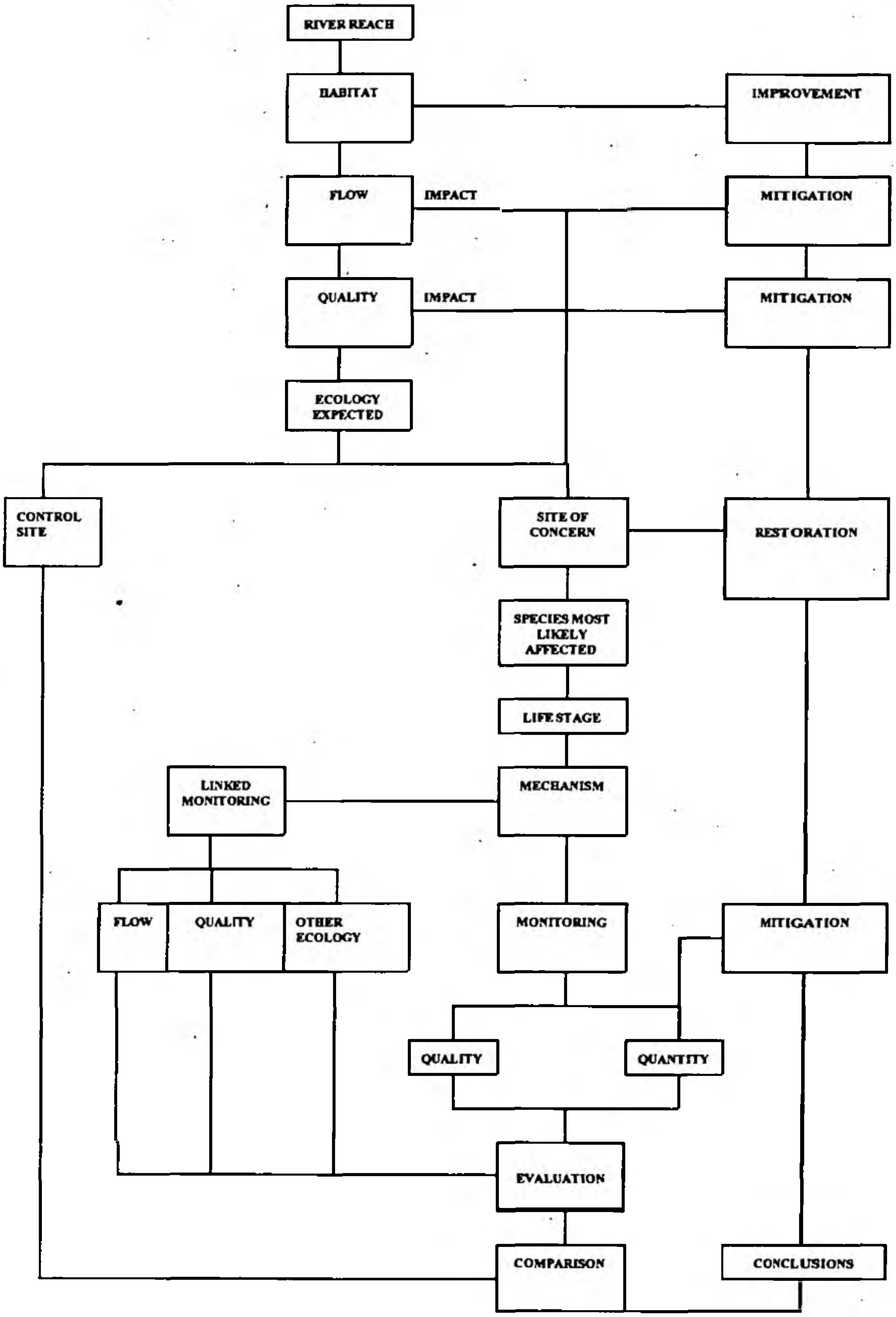
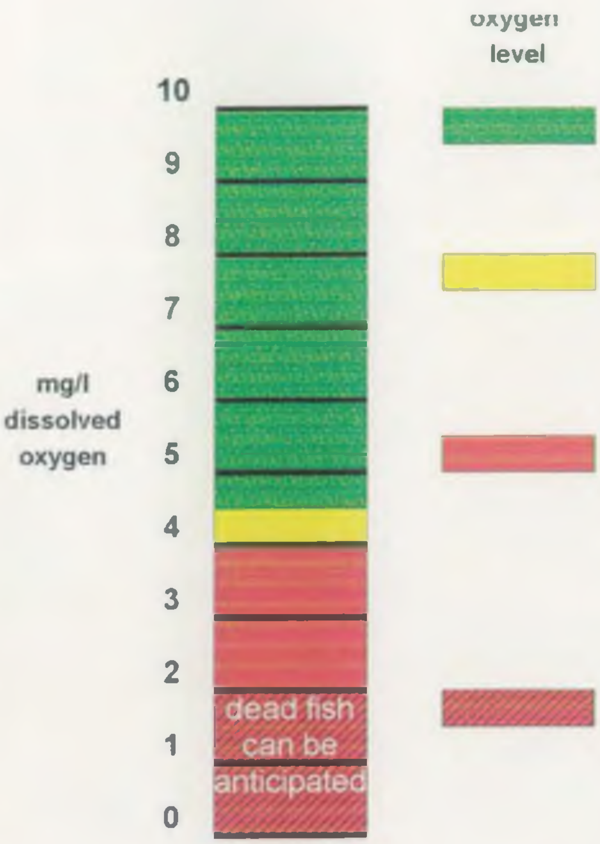


Figure 2. Drought monitoring sites on the River Calder catchment, 1995-96.

Figure 3. River Calder Emergency Action Procedure - YWS and Environment Agency



Action

continuous monitoring of dissolved oxygen by YWS. Results to be supplied to Environment Agency twice weekly

Results of dissolved oxygen monitoring to be supplied daily by YWS to Environment Agency. Fish rescue teams placed on standby.

YWS commence aeration of river. Daily bankwalking to check for signs of dead or distressed fish commences (0600 to 0800). Fish rescue teams placed on alert. Daily DO results to Environment Agency.

Dead or distressed fish observed. Bankwalker notifies Environment Agency Regional Control. Control notifies Fisheries (C. Firth) and YWS on 01274 691111. C. Firth implements fish rescue procedure.

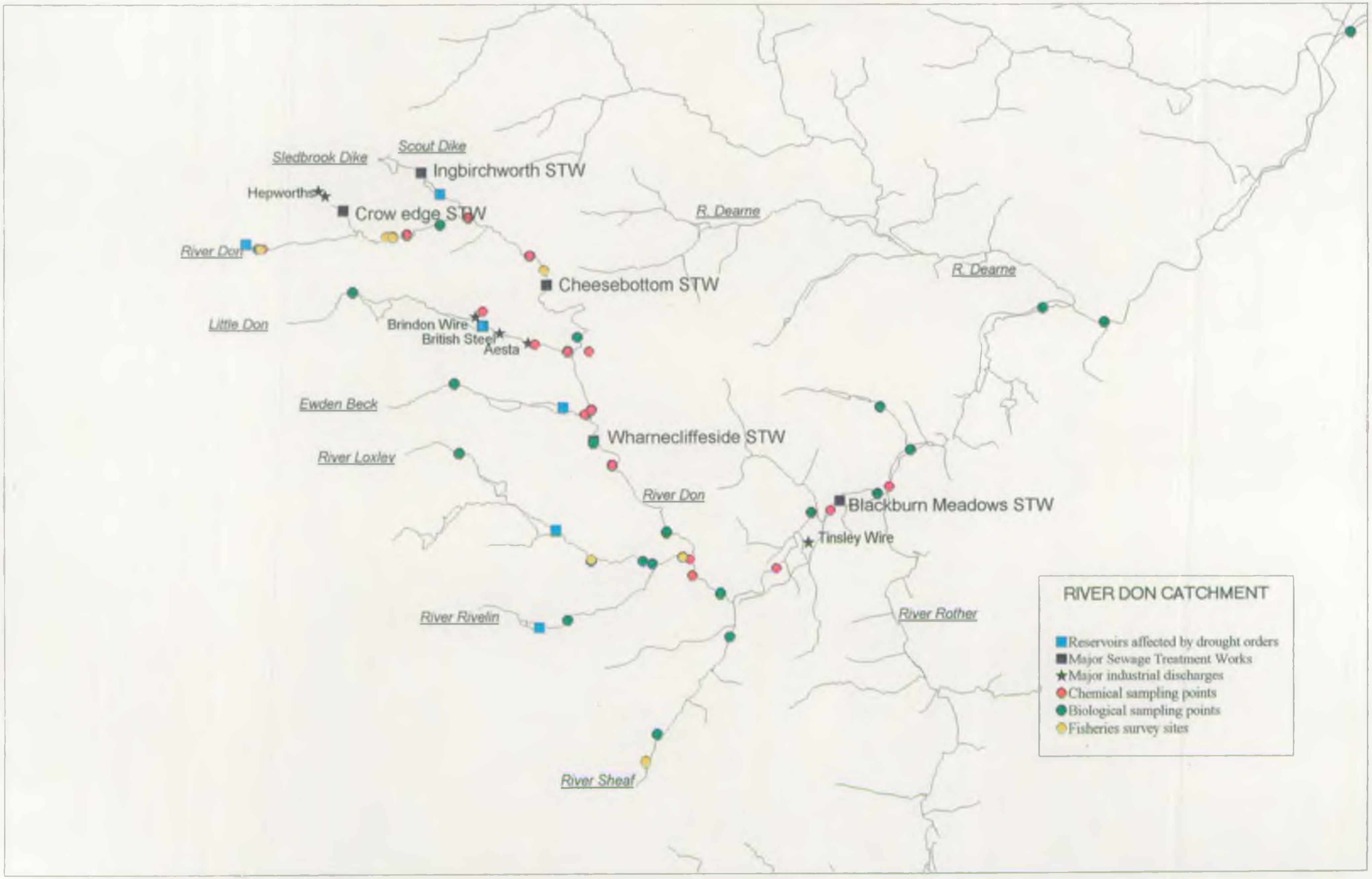


Figure 4. Drought monitoring sites on the River Don catchment, 1995-96.

Figure 5. Drought monitoring sites on the River Ouse, 1995-96.

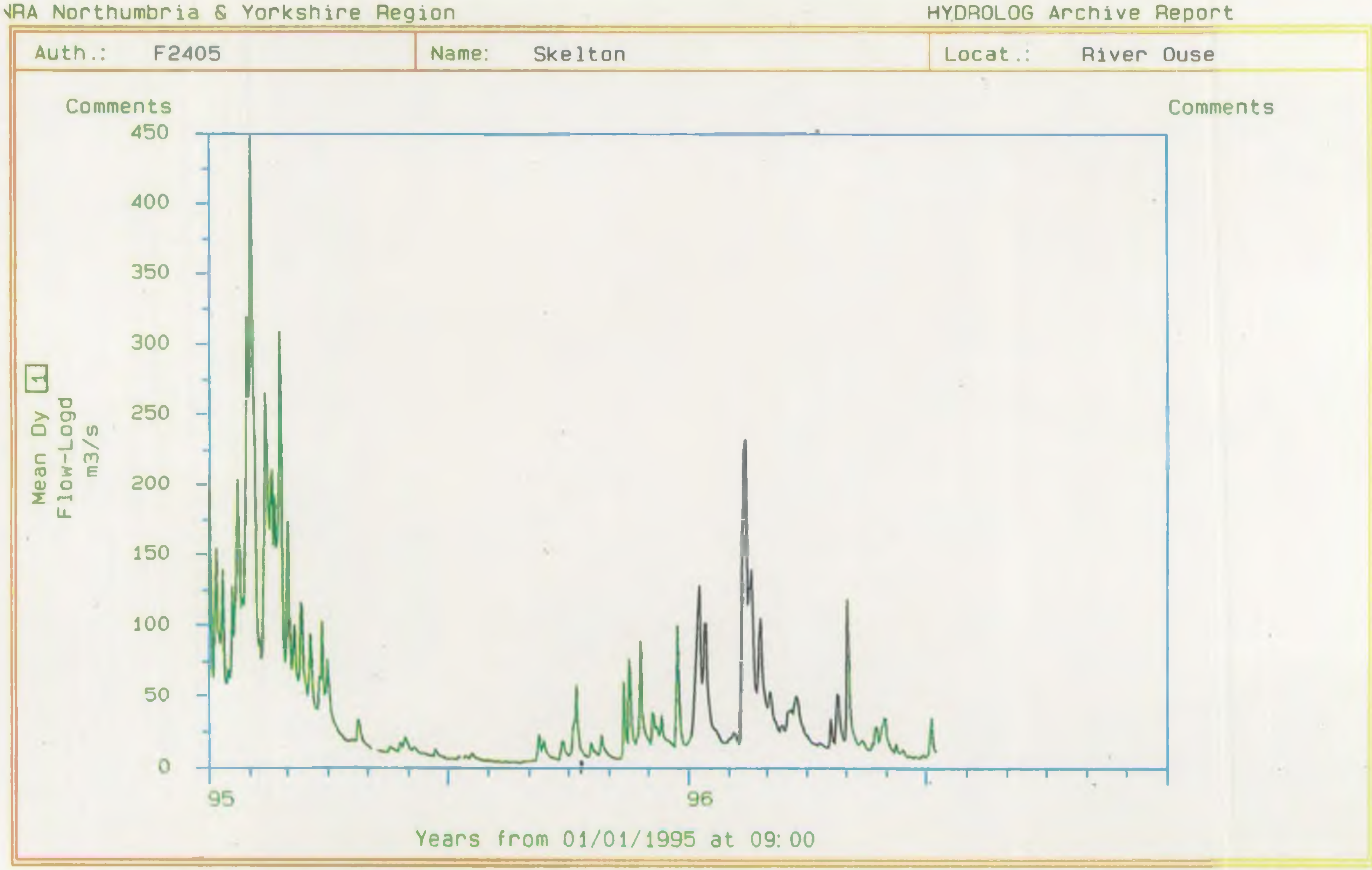


Figure 6. River flows (m³/sec) in the River Ouse at Skelton, 1995 to mid 1996.

Figure 7. Comparison of the invertebrate faunas of the River Ouse, 1981-96, using MDS ordination.

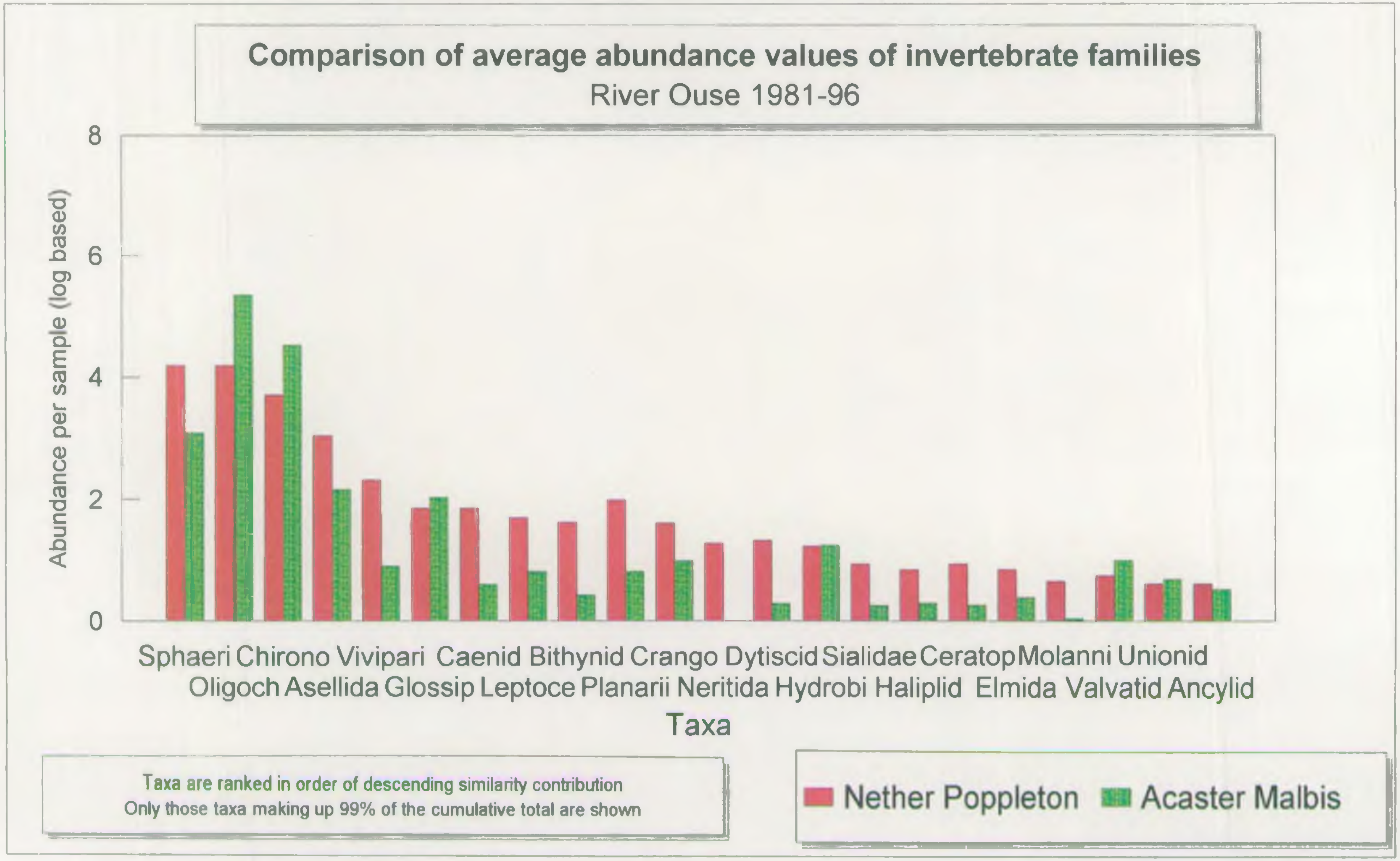
Explanation

This Multi Dimensional Scaling ordination is a 2-d representation of the relationships between individual data-sets, in this instance faunal samples from the River Ouse, 1981-96. The points represent samples from three sites :

- Nether Poppleton
- York at Scarborough Railway Bridge
- Acaster Malbis

The closer the points, the more similar they are in terms of their faunal characteristics; this analysis is based on family-level data, a log scale of abundance and the use of the Bray-Curtis similarity index (an algorithm for calculating faunal similarities).

Figure 8. Comparison of the invertebrate faunas of the River Ouse at Nether Poppleton and Acaster Malbis, based on a similarity analysis.



A key to the abbrevations of the faunal names is shown overleaf

Key to the abbreviated names on Figure 8, invertebrates in the River Ouse.

abbreviated name	Full name	Common name
Sphaeri	Sphaeriidae	pea mussels
Oligoch	Oligochaeta	segmented worms
Chiron	Chironomidae	non-biting midges
Asellid	Asellidae	water hog lice
Vivipari	Viviparidae	river snails
Glossip	Glossiphonidae	leeches
Caenid	Caenidae	mayflies
Leptoc	Leptoceridae	cased caddisflies
Bithyni	Bithynidae	snails
Planarii	Planariidae	flatworms
Crango	Crangonyctidae	'shrimps'
Neritida	Neritidae	nerite snails
Dytisci	Dytiscidae	water beetles
Hydrobi	Hydrobiidae	spire snails
Sialida	Sialidae	alderflies
Haliplid	Haliplidae	water beetles
Cerato	Ceratopogonidae	biting midges
Elmida	Elmidae	riffle beetles
Molann	Molannidae	cased caddisflies
Valvati	Valvatidae	valve snails
Unionid	Unionidae	swan mussels
Ancylid	Ancylidae	river limpets

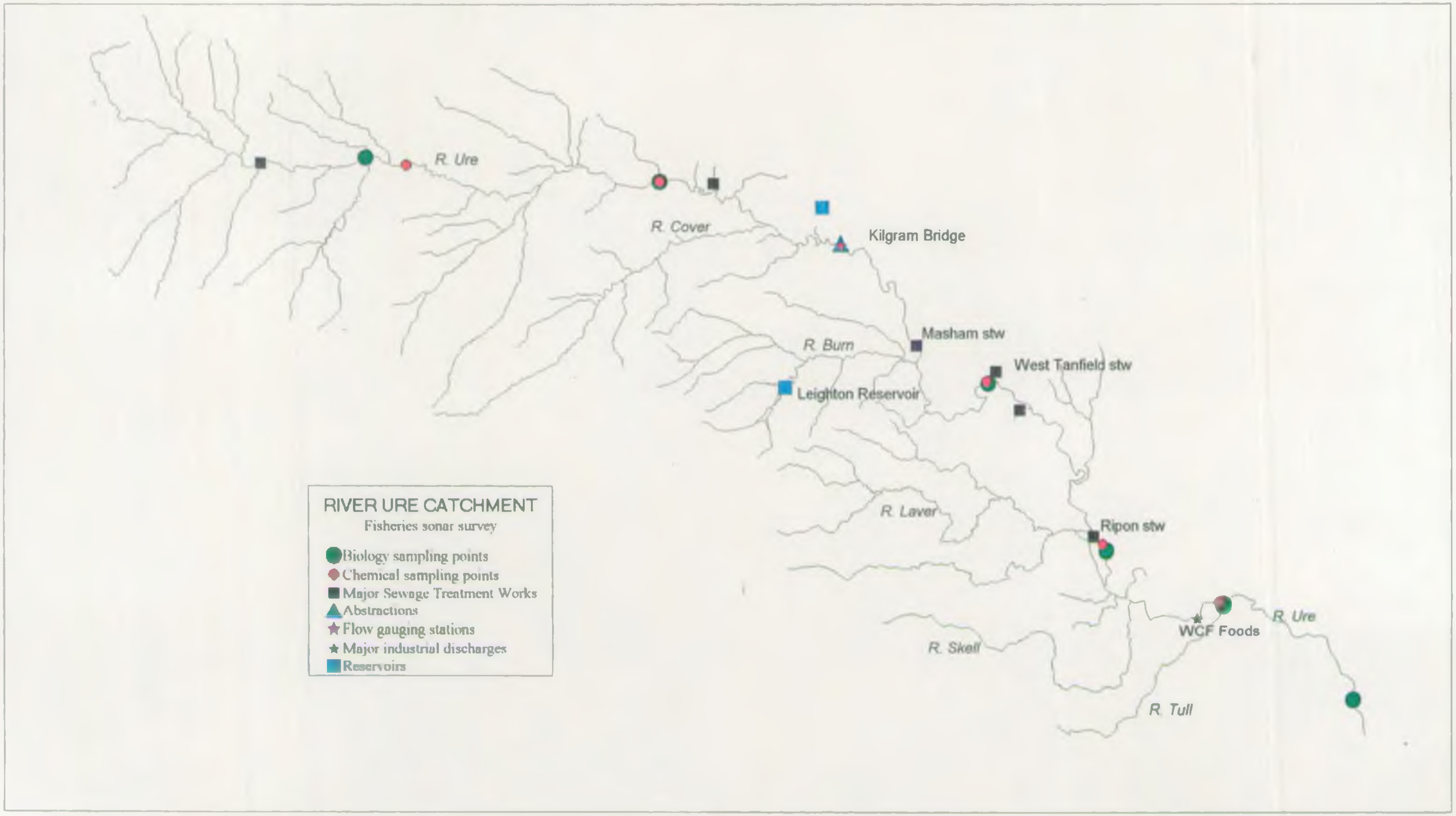


Figure 9. Drought monitoring sites on the River Ure, 1995-96.

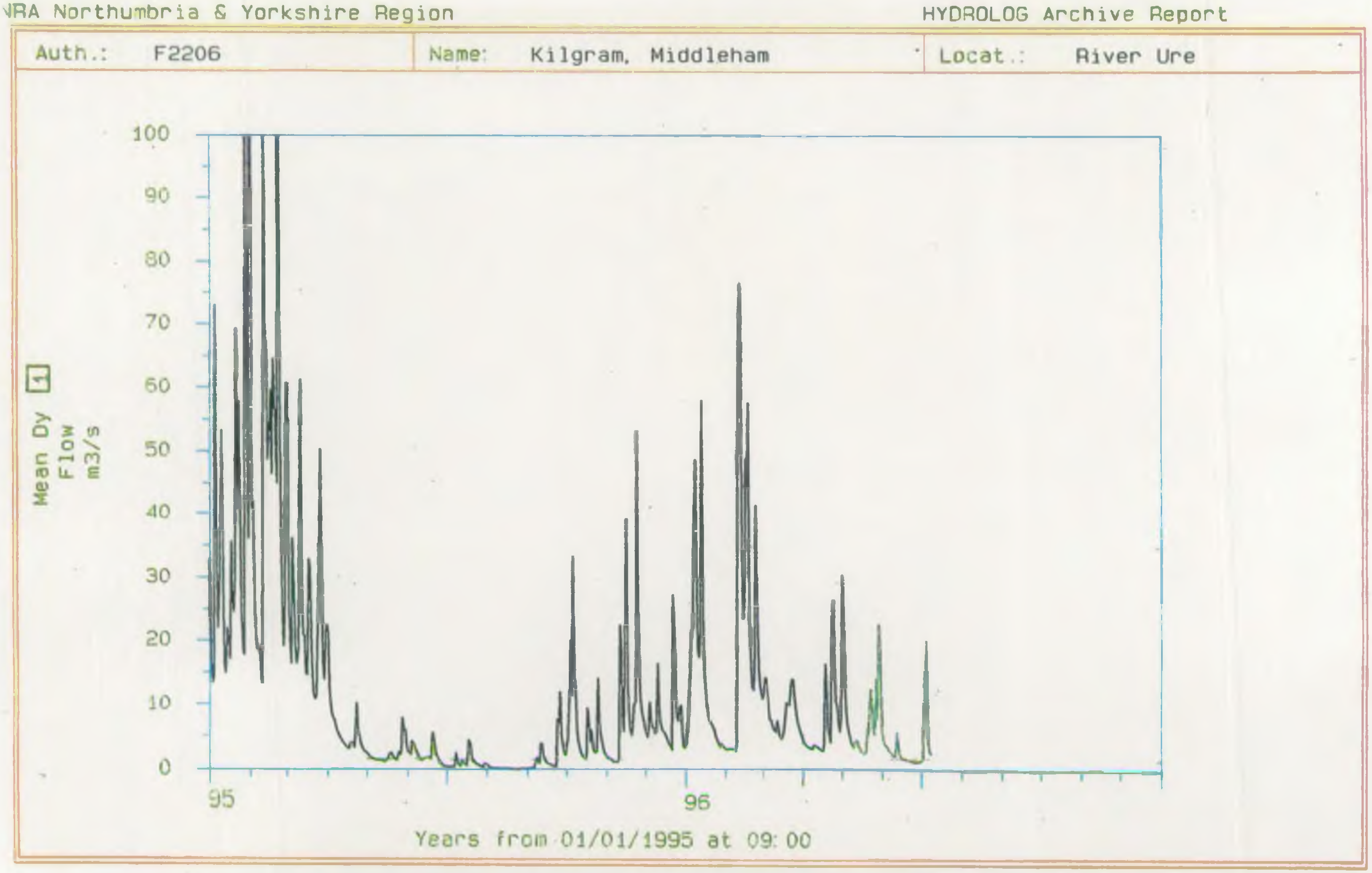


Figure 10. River flows (m^3/sec) in the River Ure at Kilgram Bridge, 1995 to mid 1996.

Figure 11. Drought monitoring sites on the River Wharfe, 1995-96

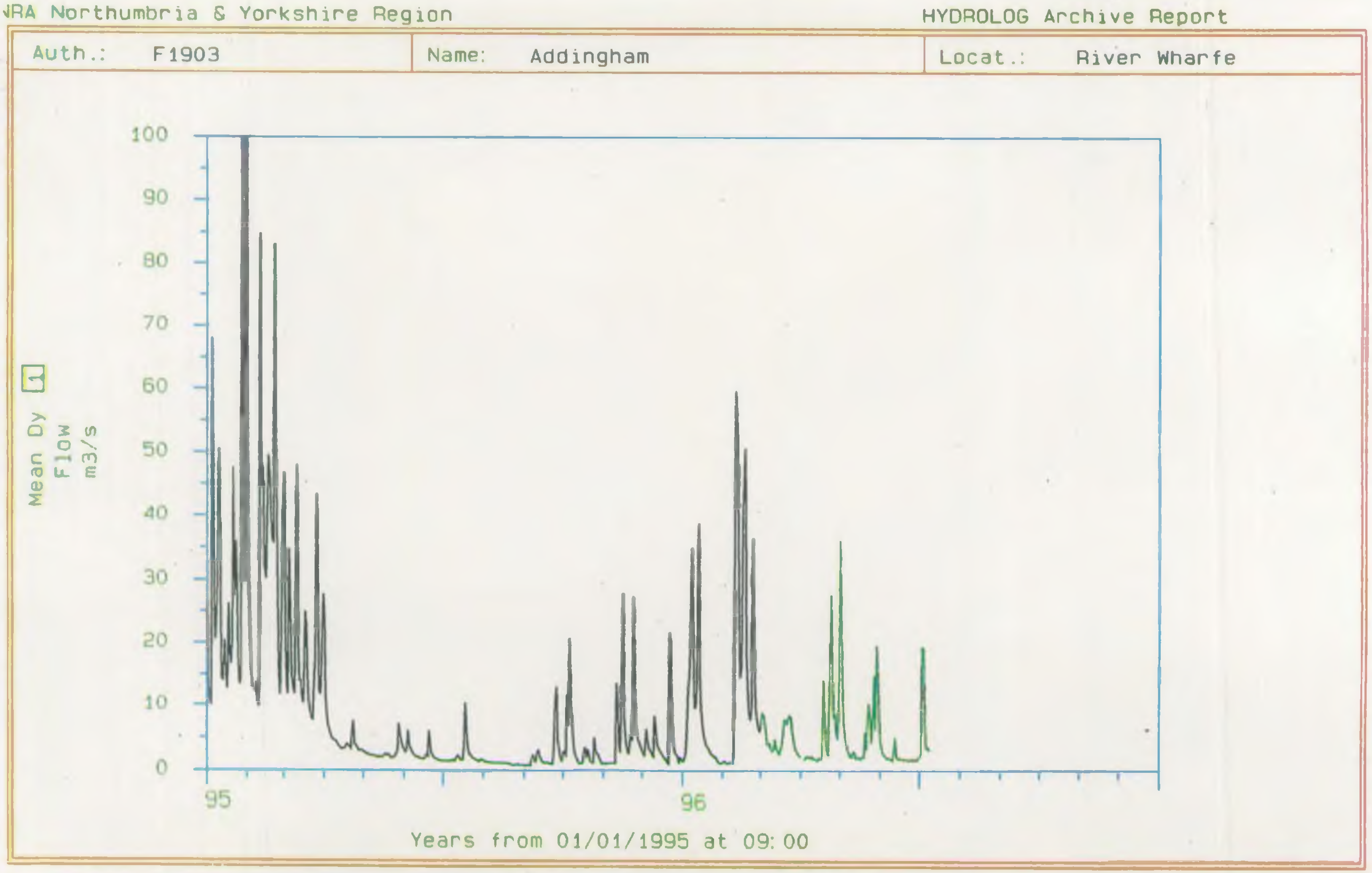


Figure 13. River flows (m³/sec) in the River Wharfe at Addingham, 1995 to mid 1996.

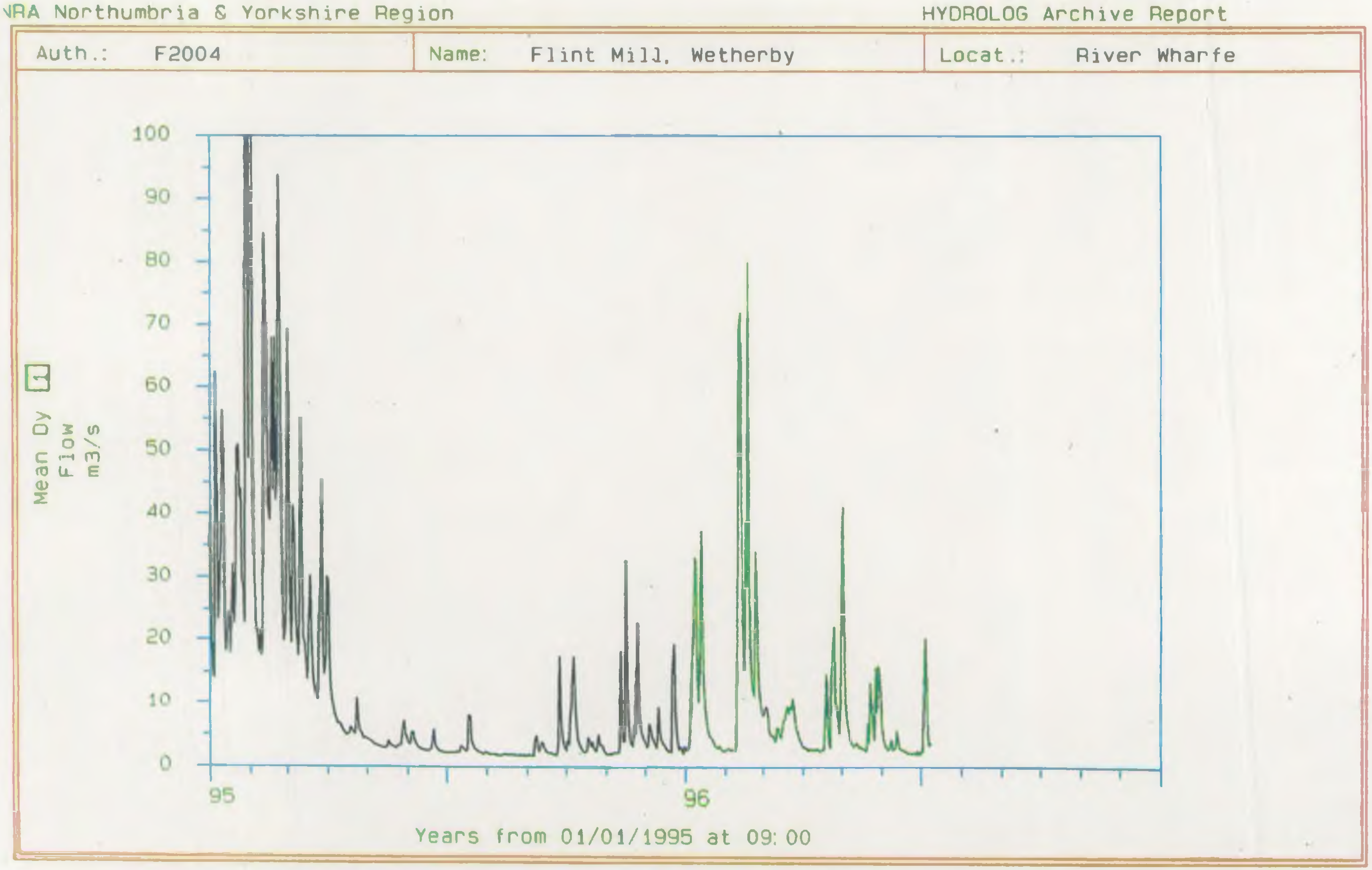


Figure 14. River flows (m^3/sec) in the River Wharfe at Flint Mill, 1995 to mid 1996.

Figure 15. Comparison of the invertebrate faunas of the upper Wharfe, Grassington to Addingham, 1985-95, using MDS ordination.

Explanation

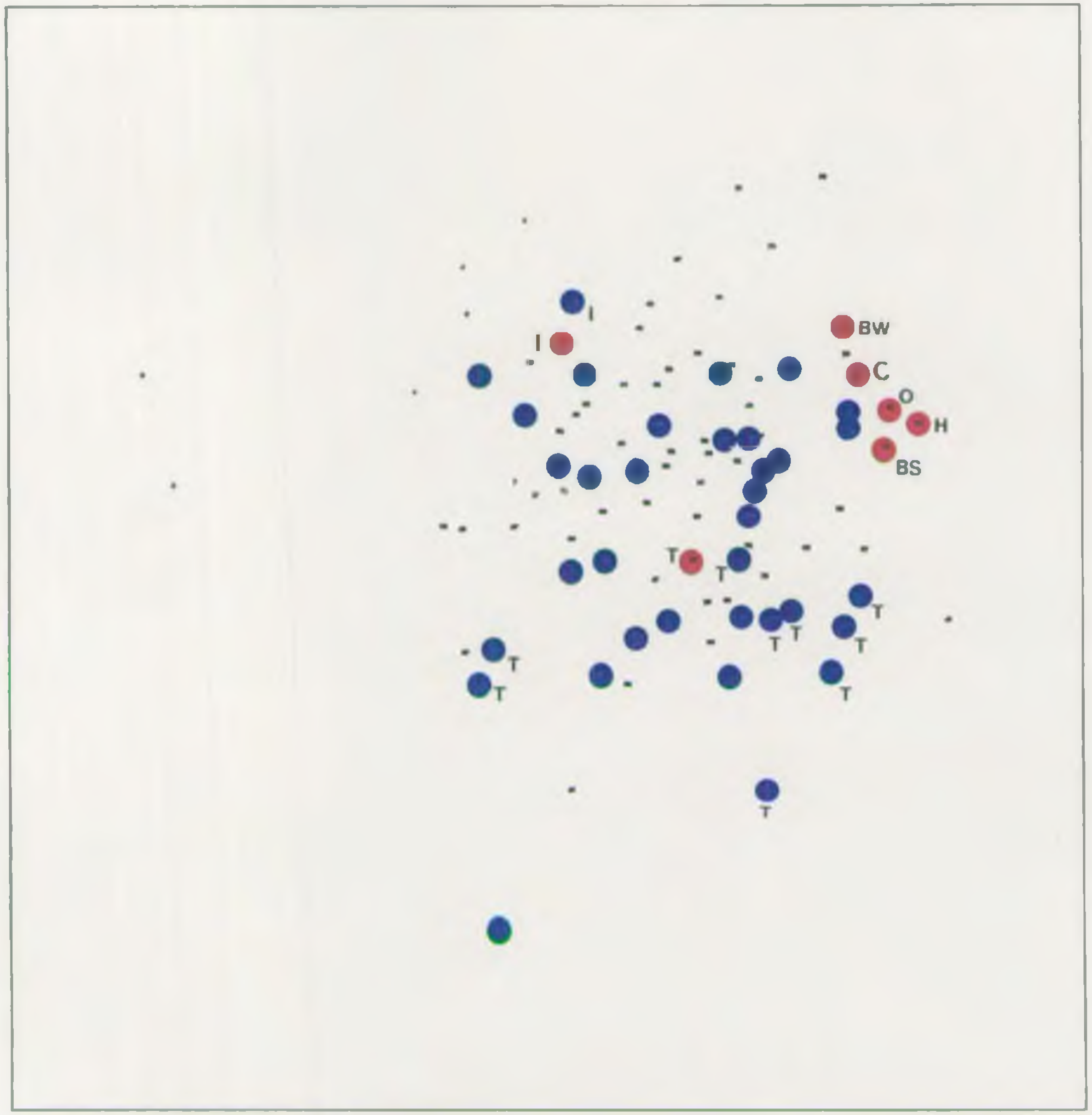
This Multi Dimensional Scaling ordination is a 2-d representation of the relationships between faunal sample from the upper Wharfe, 1985-95. The coloured points represent autumn samples from sites at Grassington (G), Burnsall (B), Bolton Bridge (BB), Lobwood (L) and Addingham (A):

● autumn samples 1985-94 ● autumn samples 1995

spring and summer samples are not highlighted

The closer the points, the more similar they are in terms of their faunal characteristics; this analysis is based on family-level data, a log scale of abundance and the use of the Bray-Curtis similarity index (an algorithm for calculating faunal similarities).

Figure 16. Comparison of the invertebrate faunas of the lower Wharfe, Ilkley to Tadcaster, 1985-95, using MDS ordination.



Explanation

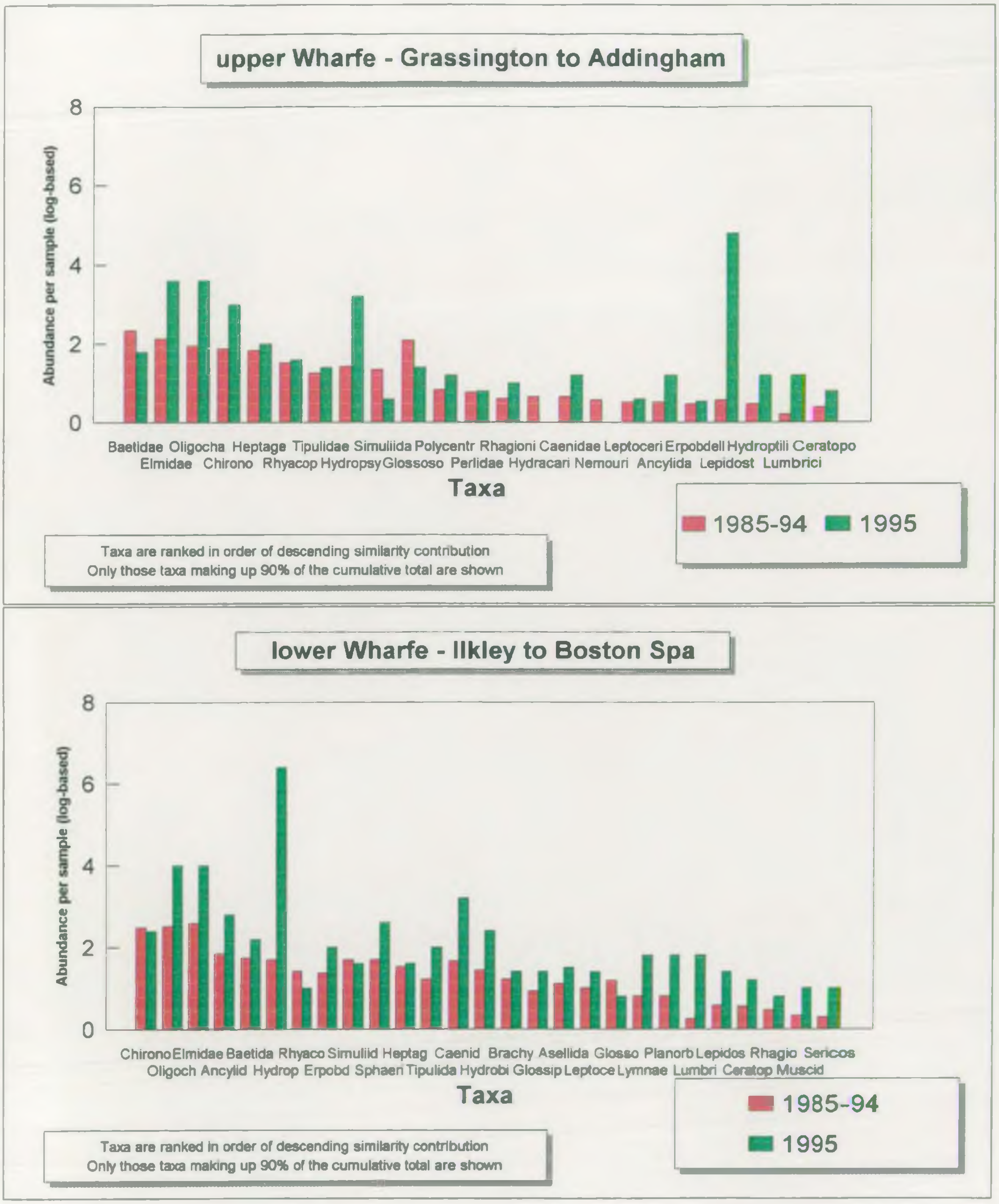
This Multi Dimensional Scaling ordination is a 2-d representation of the relationships between the faunal samples from the lower Wharfe, 1984-95. The coloured points represent autumn samples from sites at Ilkley (I), Burley Weir, Otley (O), Castley(C), Harewood (H), Boston Spa (BS) and Tadcaster (T)

● autumn samples 1984-94 ● autumn samples 1995

spring and summer samples are not highlighted

The closer the points, the more similar they are in terms of their faunal characteristics; this analysis is based on family-level data, a log scale of abundance and the use of the Bray-Curtis similarity index (an algorithm for calculating faunal similarities).

Figure 17. Comparison of the autumn 1995 invertebrate faunas of the upper and lower Wharfe with those from 1985-94.



A key to the abbreviated faunal names is shown overleaf.

Key to the abbreviated names on Figure 17, invertebrates in the Wharfe.

abbreviation	Full name	Common name
Baetidae	Baetidae	mayflies
Elmidae	Elmidae	riffle beetles
Oligocha	Oligochaeta	segmented worms
Chirono	Chironomidae	non-biting midges
Heptage	Heptageneidae	mayflies
Rhyacop	Rhyacophilidae	caseless caddisflies
Tipulidae	Tipulidae	craneflies
Hydropsy	Hydropsychidae	caseless caddisflies
Simuliida	Simuliidae	blackflies
Glossoso	Glossosomatidae	caseless caddisflies
Polycentr	Polycentropodidae	caseiess caddisflies
Perlidae	Perlidae	stoneflies
Rhagioni	Rhagionidae	snipe flies
Hydracari	Hydracarina	water mites
Caenidae	Caenidae	mayflies
Nemouri	Nemouridae	stoneflies
Leptoceri	Leptoceridae	cased caddisflies
Ancylida	Ancylidae	river limpets
Erpobdell	Erpobdellidae	leeches
Lepidost	Lepidostomatidae	cased caddisflies
Hydroptili	Hydroptilidae	cased caddisflies
Lumbrici	Lumbricidae	earthworms
Ceratopo	Ceratopogonidae	biting midges

abbreviation	Full name	Common name
Chirono	Chironomidae	non-biting midges
Oligoch	Oligochaeta	segmented worms
Elmidae	Elmidae	riffle beetles
Ancylid	Ancylidae	river limpets
Baetida	Baetidae	mayflies
Hydrop	Hydroptilidae	cased caddisflies
Rhyaco	Rhyacophilidae	caseiess caddisflies
Erpobd	Erpobdellidae	leeches
Simuliid	Simuliidae	blackflies
Sphaeri	Sphaeriidae	pea mussels
Heptag	Heptageneidae	mayflies
Tipulida	Tipulidae	craneflies
Caenid	Caenidae	mayflies
Hydrobi	Hydrobiidae	spire snails
Brachy	Brachycentridae	cased caddisflies
Glossip	Glossiphonidae	leeches
Asellida	Asellidae	water hoglice
Leptoce	Leptoceridae	cased caddisflies
Glosso	Glossosomatidae	caseiess caddisflies
Lymnae	Lymnaeidae	pond snails
Planorb	Planorbiidae	ramshorn snails
Lumbri	Lumbricidae	earthworms
Lepidos	Lepidostomatidae	cased caddisflies
Ceratop	Ceratopogonidae	biting midges
Rhagio	Rhagionidae	snipe flies
Muscid	Muscidae	flies
Sericos	Sericostomatidae	cased caddisflies

1. SECTION I : EXECUTIVE SUMMARY

1.1 Fish populations in the sampled reaches were comprised almost exclusively of brown trout. Low numbers of bullheads were caught at some sites but these generally represented less than 12 % of the total biomass. Very small numbers of three spined sticklebacks and a single large stone loach were also caught.

1.2 Table 1 gives a summary of brown trout populations calculated from survey results for all fourteen surveyed sites. Population densities ranged between a low of 2.56 fish/100m^2 on Graining Water (site 1) to a high of 79.03 fish/100m^2 downstream of Ogden reservoir on Hebble Brook. The overall mean density based on triple catch estimated was 27.16 fish/100m^2.

1.3 Although there was considerable variation between sites, single shock sub-samples taken from adjacent reaches within each site showed a high degree of conformity. Site 12, downstream of Ogden reservoir on Hebble Brook, was exceptional in showing a high degree of within-site spatial variance. This site was split by a large man-made weir. No fish were recorded above the weir, although a dense population was found in the reach below.

1.4 In general, sites in the very upper reaches of the Hebden catchment, notably Graining Water, Alcomden Water and Wheat Ing on Crimsworth Dean Beck, yielded low brown trout population densities. These sites tended to display a paucity of potentially usable spawning gravels, a relatively steep gradient and waterfalls which will tend to inhibit upstream migration of adult trout.

1.5 Populations in the uppermost reaches tended to be characterised by medium sized trout with few fish in-excess of 25 centimetres. Juvenile fish were either found to be scarce or completely absent from these sites. The upper reaches surveyed on the River Worth and Hebble Brook were not generally comparable with the upper reaches of the Hebden Water catchment. Due to their shallower overall gradient and less harsh conditions, the latter watercourses supported denser populations with good numbers of juveniles within short distances downstream of the regulating reservoirs.

1.6 Sites yielding moderate or high population densities with greatest numbers of juveniles tended to be in the middle to lower reaches, (cf Hebden Water, Crimsworth Dean Beck and River Worth) where there were lower gradients and a broad range of gravel sizes. Greater numbers of larger fish were found at sites with sections of deeper water, notably Rose Hill Mill on Hebden Water (site 7) and Haworth on the River Worth (site 9). Greatest numbers of juvenile fish were found at New Bridge on Crimsworth Dean Beck (site 6), Rose Hill Mill on Hebden Water and both sites on the River Worth (sites 8 & 9). Significant areas of easily accessible, potentially usable spawning gravels were present at these sites.

1.7 No fish were found on Midgelden Brook or its tributary Gorpley Beck. Although the available habitat and substratum may be suitable for supporting populations of brown trout, Midgelden Brook was found to be affected by ochrous water leaching from former quarry workings.

1.8 Mean lengths for age across all sites were 8.61, 13.98 and 18.59 cm for 0+, 1+ and 2+ fish respectively. Greatest mean lengths for age were shown by fish at sites 6 and 14 respectively. Lowest mean lengths for age were recorded at sites 3 and 4.

Appendix B

Table 1.2: Recent Drought Order History

D.O.	Abstraction	Date	Duration	Abstraction / Flow Changes	Flow Support
I	Lobwood & Hollins	21.8.95	6 months	Lobwood abstraction increased to up to 120 tcmd, plus up to 45 tcmd direct support from Grimwith reservoir.	Stage 1: As per licence, but only extra 5 tcmd to Wharfe at flows < 227 tcmd rather than 22.7 tcmd. Stage 2:+ 5 tcmd extra to Wharfe at flows <150 tcmd
2	Lobwood & Hollins	28.9.95	1 month	Lobwood: 120 tcmd abstraction, plus PF regime reduced from 150 tcmd - 90 tcmd	Full support at PF. PF = 90 tcmd
E	Lobwood & Hollins	31.10.95	2 months	Extension to Drought Order No. 2 for two months	Full support at PF PF = 90 tcmd
E	Arthington	8.11.95	3 months	When flow >170 (at Addingham Weir), abstraction up to 50 tcmd. Flow > 580 tcmd, abstract 100 tcmd as per licence	PF = 90 tcmd
E	Lobwood and Arthington	4.12.95	3 months	Lobwood abstraction up to 130 tcmd, reduction in PF to 75 tcmd. Arthington as previously except PF reduced from 170 to 150	Lobwood PF = 75 tcmd Arthington PF = 150 tcmd
3	Lobwood and Arthington	21.2.96	6 months	Lobwood abstraction up to 180 tcmd, PF 120 tcmd. Arthington abstraction 100 tcmd when flow > 580; abstraction 50 tcmd for flow 170-580 tcmd; 21 tcmd for flow <170 tcmd.	Lobwood PF=120 tcmd Arthington, at low flow abstraction at Arthington not more than total released from Washburn Reservoirs. When Bradford Reservoir stocks above thresholds abstraction remains at high level, but Grimwith releases made as for licence.

E = Emergency
Key: tcmd = Thousand Cubic Metres per Day, D.O. = Drought Order, and PF = Protected Flow.

Notes : (1) When the naturalised flow at Addingham GS is at or above the Protected Flow the abstraction is not permitted to reduce the flow below the PF. Hence variable support for the abstraction is made by releases from Grimwith Reservoir.

(2) When the naturalised flow is below the Protected Flow, the abstraction is fully supported and there is an additional release of 5 tcmd from Grimwith Reservoir. This is equivalent to the baseflow from the reservoired catchment during low flows.

(3) Washburn Reservoirs: Lindley Wood compensation release = 18 tcmd, March Ghyll = up to 3 tcmd

(4) The contents for the Bradford Reservoir group (Nidd - Barden) determine the operating regime of the abstractions, either to the Protected Flow regime, or at higher stock levels to the operating rules similar to licensed conditions, but with the additional support for the River Wharfe reduced from 22.7 to 5 tcmd. Full details are given in the Technical Submission p1-4.

Appendix C. Water quality of the River Wharfe - Cusum results for BOD-T (mg/l Oxygen)

In the following Cusum tables the start and end dates of the sample runs identified by cusum analysis (and not *a priori* by the drought period) are shown with the associated values for the parameters. The significance values indicate the likelihood that these changes could be attributed to chance alone.

Site	Start date	End date	No.	Mean	Std Dev	SDD	Significance	1995 Drought?
Conistone	7/1/93 6/8/94	8/7/94 18/12/95	18 17	1.06 1.43	0.299 0.331	0.341 0.349	 0.8%	No
Sandbeds	4/1/93 4/1/94	15/12/93 18/12/95	48 51	1.92 1.65	0.627 0.475	0.545 0.467	 5%	No
Wetherby	12/3/93 16/3/94	12/3/94 18/12/95	56 42	1.74 1.44	0.550 0.385	0.510 0.381	 0.7%	No
u/s Tadcaster Weir	4/1/93 30/3/93 10/1/94	22/3/93 15/12/93 15/12/95	13 38 47	1.48 2.28 1.73	0.555 0.777 0.596	0.445 0.760 0.536	 0.5% 0.1%	No
u/s Bass	6/793 28/7/94	21/7/94 27/3/95	51 18	1.82 1.40	0.515 0.531	0.446 0.425	 3%	No

Appendix D. Water quality of the River Wharfe - Cusum results for dissolved oxygen (%saturation)

Site	Start Date	End Date	No.	Mean	Std Dev	SDD	Significance	1995 Drought
Burnsall	7/1/93 16/4/94	16/3/94 12/12/95	19 22	101.2 114.2	8.810 15.52	8.947 11.14	 0.1%	No
Bolton Bridge	4/1/93 16/4/94	12/4/94 18/12/95	46 37	102.0 108.7	9.561 12.27	9.578 11.08	 2%	No
Sandbeds	4/1/93 16/4/94 28/7/94	16/4/94 21/7/94 18/12/95	47 14 22	99.28 110.1 100.0	7.371 9.742 10.12	5.605 10.02 12.23	 0.3% 0.6%	No
u/s Pool paper mill	4/1/93 25/5/94 14/9/94	21/5/94 7/9/94 12/12/95	52 15 16	95.95 87.27 97.31	6.182 4.350 6.269	5.769 4.387 5.288	 0.1% 0.1%	No
u/s Bass	6/7/93 15/11/94	21/10/94 27/3/95	51 8	93.55 104.1	8.601 5.693	7.124 3.723	 3%	No

Appendix E. Water quality of theRiver Wharfe - Cusum results for ammonia (mg/l)

Site	Start Date	End date	No.	mean	Std Dev	SDD	significance	1995 Drought
Burley Weir	7/1/93 12/5/95	28/3/95 18/12/95	27 8	0.04 0.14	0.028 0.060	0.027 0.055	0.1%	Yes ? small no. of samples
u/s Pool Paper Mill	4/1/93 22/3/93 28/5/94	3/3/93 26/5/94 12/12/95	11 58 29	0.11 0.04 0.07	0.098 0.028 0.059	0.099 0.025 0.061	0.8% 2%	No
Boston Spa	7/1/93 17/2/95	9/2/95 18/12/95	26 11	0.06 0.17	0.049 0.064	0.044 0.071	0.1%	Yes ? small no. of samples
u/s Bass	6/7/93 24/5/94 23/8/94 16/12/94	21/5/94 16/8/94 18/11/94 27/3/95	41 14 8 6	0.06 0.09 0.03 0.13	0.033 0.034 0.014 0.058	0.035 0.039 0.016 0.053	NS 2% 0.1%	No

Appendix F. Water quality of the Wharfe and Dibb - Cusum results for pH

Site	start date	end date	no.	mean	Std Dev	SDD	significance	1995 drought
Dibb Hartlington Bridge	5/1/78	10/11/78	43	7.98	0.356	0.305		No
	16/11/78	21/7/81	143	7.56	0.540	0.472	0.1%	
	27/7/81	29/4/85	181	7.79	0.339	0.277	0.1%	
	29/5/85	19/2/90	59	8.02	0.280	0.306	0.4%	
	27/3/90	11/2/96	72	7.64	0.266	0.226	0.1%	
Wharfe Bolton Bridge	5/1/78	3/4/78	14	8.01	0.216	0.220		No
	14/4/78	1/9/78	19	8.49	0.259	0.175	0.1%	
	7/9/78	25/10/79	60	8.11	0.301	0.304	0.1%	
	31/10/79	25/3/80	22	7.66	0.350	0.317	0.1%	
	3/4/80	10/9/80	24	8.36	0.241	0.228	0.1%	
	16/9/80	1/4/81	29	7.69	0.327	0.313	0.1%	
	7/4/81	16/9/81	25	8.19	0.355	0.355	0.1%	
	22/9/81	15/3/82	18	7.86	0.238	0.238	0.3%	
	26/3/82	3/11/82	33	8.31	0.205	0.154	0.1%	
	9/11/82	15/6/83	33	8.00	0.345	0.380	0.1%	
	21/6/83	7/12/83	25	8.37	0.239	0.161	0.1%	
	13/12/83	15/3/84	14	7.61	0.381	0.367	0.1%	
	21/3/84	11/9/84	32	8.18	0.203	0.172	0.1%	
	17/9/84	24/1/85	17	7.84	0.173	0.198	0.2%	
	22/2/85	26/8/88	43	8.28	0.266	0.267	0.1%	
	26/9/88	24/9/90	51	8.11	0.207	0.161	4%	
	1/10/90	23/2/93	123	7.92	0.236	0.202	0.2%	
	27/2/93	22/1/96	90	8.06	0.243	0.175	0.3%	

Appendix G. Water quality of the River Wharfe - colour levels (Hazens-unfiltered) of Lobwood raw water.

Date	colour (Hazen)
18.11.94	49.3
29.11.94	23.8
6.12.94	59.1
8.12.94	48.8
14.12.94	40.0
17.1.95	19.7
25.1.95	19.4
7.2.95	24.3
16.2.95	33.6
9.3.95	15
11.4.95	31.9
22.5.95	52.4
28.6.95	66.8
18.7.95	57.3
21.8.95	62.5
26.9.95	52.4
23.10.95	23.7
25.11.95	50.5
22.2.96	16.0
7.3.96	15.8

For comparison, levels for surface water used for drinking supplies are set at the following:

no more than 3 basic physical treatment (filtering)
" " " 10 intermediate physical and chemical treatment
" " " 20 full physical, chemical and disinfection treatment

Note that these are based on filtered -water measurements as finely particulate material does contribute to colour as well as truely dissolved substances such as humic acids and the like.