NRA Wales 62

National Rivers Authority

Welsh Region

The Rehabilitation of the River Taff

Paper given to the South Wales section of the Society of Chemical Industry with the Water & Environment Groups on 26th February 1991 at the Polytechnic of Wales

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22/2/91

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1. Introduction

The River Taff has experienced major changes over the last 200 years. Before the industrial revolution it was a largely rural river renowned for its beauty and the quality of its salmon fishing. It then suffered a severe decline due to the industrialisation and dense population of the catchment. Gradual improvements occurred during the 20th century resulting from the introduction of various pollution control legislation and in recent years also because of the decline in the basic industries. The river is now supporting the return of migratory fish and the National Rivers Authority (NRA) is actively encouraging this development through continued pollution control and fishery management.

2. The Catchment

The Taff is the largest of the three rivers which enter the Severn Estuary at Cardiff, the capital city of Wales (Fig. 1). It is short and steep, falling 600 metres from its source on the Brecon Beacons along its 60 kilometre length to the sea. It has two major tributaries, the River Cynon and the River Rhondda. Together they form the archetypal 'valley' river of South Wales. Flows are highly variable ranging during the last 20 years from 1.6 cumecs in extreme summer drought to 642 cumecs in winter floods. The median flow is 11 cumecs. Many of the headwaters in the remaining rural areas are impounded for water supply.

3. Pre-industrial History

Before the industrial revolution affected the area, in about 1750, the river was noted for its rural tranquillity and remoteness. It had prolific runs of both salmon and sea trout supporting a variety of commercial fisheries (Mawle et al 1985). In 1803 it is clear that the river was still largely unaffected by the young industries. B.H. Malkin described the rivers Taff and Rhondda in terms of "their perfect clearness, uncontaminated, unless in heavy floods, by the least tinge of muddy soil or any other fortuitous discolouring" (Edwards 1958).

4. Population Growth

The first major industrialisation occurred in Merthyr with the building of the Dowlais Iron Works in 1759. By 1801 Merthyr Tydfil had grown into the largest town in Wales with a population of 7,700, exceeding even Swansea and Cardiff (population 1,870) in size (Fig. 2).

Coal mining gradually developed and eventually replaced the iron industry as the principle basic industry. Mines were sunk throughout the catchment but the development of the Rhondda Valleys was exceptional by any standard. By 1921 there were 149 collieries operating in the catchment, 80 of which were in the Rhondda Valleys alone (Gordon 1921). Here the population grew extremely rapidly and reached its peak of 169,000 in 1924 (Fig. 2)

Because of the steepness of the valleys, housing and industry extended in ribbon development along the banks of the Taff and its tributaries (Fig. 1).

About 400,000 people now live within the catchment, an eighth of the population of Wales.

5. River Decline

5.1 With the coming of industrialisation, effluents from the iron and steel works, coal mines and power stations, coke ovens and by-product plants and sewage from the enormous population was either discharged deliberately or found its own way into the rivers. There is little factual evidence regarding the quality of the waters and we must rely upon descriptions given at the time.

5.2 The Early Iron Industry

In the early days iron ore was extracted by 'scouring'. A dam was built across a stream and then the water was released, washing away soil, gravel and stones from the surrounding hillsides leaving behind the heavier iron ore. This process would have caused considerable river pollution.

In Dowlais water was scarce and every drop was gathered from the surrounding hillsides to run waterwheels and supply a multitude of processes. This water, when finished with, was re-used by works lower down the stream so it is likely that by the time it was eventually discharged to the river it was grossly polluted.

In 1848 G.T. Clarke gave an eye witness account of conditions in Dowlais:- "The footways are seldom flagged, the drainage is very imperfect, there are few underground sewers, no house drains and the open gutters are not regularly cleaned out. Dustbins and similar receptacles for filth are unknown; the refuse is thrown into the streets. The colliers are much disposed to be clean and are careful to wash themselves in the river, but there are no baths or wash houses, or even standpipes. In some suburbs, the people draw all their water from the waste water of the works and in Merthyr the water is brought by hand from springs on the hillsides, or lifted from the river, sometimes nearly dry, sometimes in a raging torrent and always charged with the filth of the upper houses and works" (Owen 1976).

5.3 The Early Coal Industry

Collieries were sources of suspended solids principally but also of iron and heavy metals from minewaters. In the days before steam winders, the principle of the water balance was frequently employed whereby a tank beneath the cage was filled with water at the top of the shaft while water was run out of a similar tank under the cage at the bottom of the shaft (Merthyr Teachers Centre Group 1981). This principle only worked efficiently where a mine enjoyed 'free drainage' by which water could gravitate out of the workings. This could only work for mines situated above river level but it would have meant that drainage from these mines was probably heavily charged with coal solids.

The advent of machine cut coal mining produced a lot of fine coal and in later years coal preparation plants or washeries were installed to separate the saleable coal from the waste shale. In the process a lot of dirty water was produced and up until the 1950's it was common practice to discharge this direct to the rivers. Indeed coal washeries were often sited astride rivers because of lack of space but it also facilitated discharge of effluent.

5.4 Thermal Pollution

By the end of 1880 most of the big collieries had been established and they were all operated by steam (Hopkins 1973). Hot water was discharged from boilers and cooling circuits and even as late as 1956, the rise in temperature from the top of the Rhondda to the bottom was over 4°C (Glamorgan River Board 1952-1965).

Quench water from the many coke ovens and cooling water from powerstations was also discharged to the river. At Upper Boat temperatures as high as 30°C were observed (Glamorgan River Authority 1966-1973).

5.5 Coke and By-products Plants

Coke was manufactured at many works within the catchment and together with their associated by-product plants were sources of serious chemical pollution. Ammonia was the principle problem but phenols, cyanide, thiocyanate, sulphide, oils and polyaromatic hydrocarbons were also discharged. An amusing anecdote relates how the ammonia fumes rising from the river below Merthyr Tydfil were capable of tarnishing the buttons on a policeman's uniform as he walked across the bridge!

5.6 Sewage Pollution

Initially sewage pollution was diffuse in origin arising from the many centres of population. Excreta and refuse were freely deposited in the streets and washed into the rivers along with cinders from domestic fires. Disease was rife and cholera epidemics occurred in 1832, 1849 and 1854 when 160, 1382 and 424 people respectively died. Conditions got so bad that the Government set up a Local Board of Health for Merthyr in 1850 and their first task was to provide a clean water supply. Dolygaer reservoir was built in 1861 and standpipes were erected. By 1868 most of the town was sewered, sewage being conveyed to Troedyrhiw and discharged crude to the river. In 1878 the Merthyr and Aberdare Joint Sewage Farms Committee was set up and trunk sewers were laid to farms at Abercynon, Parc Newydd and Cilfynydd (Merthyr Teachers Centre Group 1981). The Rhondda Valleys and Pontypridd were provided with a trunk sewer outfalling to the Severn Estuary in 1893.

The sewage may well have been stronger than today because of the initial good condition of the pipework and corresponding low infiltration but also because water usage was lower due to the absence of modern bathroom facilities. Nevertheless treatment at the sewage farms was very efficient for many years. The fabric of the sewers gradually deteriorated with time however due to the effects of subsidence, and leaks and premature overflows became commonplace. The river frequently contained crude sewage and the biochemical oxygen demand (BOD) and ammoniacal nitrogen (AmN) were undoubtedly greatly elevated.

Had it not been for the remarkable power of the river for re-aeration and self-purification allowing it to carry higher BOD loads than slower moving rivers, the organic pollution would undoubtedly have led to frequent anaerobic conditions and a foul smelling nuisance. This probably did occur for periods in the summer especially during droughts, and as a result of the artificially low river flows and high temperatures from thermal pollution.

6. The beginnings of concern

In 1872, a Rivers (Prevention of Pollution) Committee was appointed by the Government to look into the best means of preventing pollution of the rivers and when they came to consider the Taff they met in Merthyr Tydfil. By this time, the state of the river had obviously been recognised as a problem as it was uninhabitable to fish throughout its length. The cause was given as:- "The tipping of hot cinders and scouring of the river by the washing down of the cinder dumps" (Glamorgan River Board 1952-1965).

In 1922, a Ministry survey of the Taff was made and they concluded that, although manufacturing conditions had changed little since 1872, improvements had been made to the sewage disposal arrangements and improved conditions in the water were found. The river was still largely sterile, however, because of the coal and other mineral solids and abrupt temperature changes due to discharges of coke quench waters (Glamorgan River Board 1952-1965).

7. Industrial Decline

By the beginning of the 20th Century all but one of the iron and steel works in the catchment had closed down. Only Dowlais soldiered on, but this was a large works producing over 300,000 tons per annum (Owen 1976). Its associated coke works, by-product plants and coal washery all generating effluent. The main works finally closed down in 1930 but the Ivor Works, an off-shoot of the Dowlais works, continued in production and became the British Steel Corporation Dowlais Iron Foundry making steel ingots from scrap. It finally closed down in 1984 but was, right up to the last, a source of solids, phenols and heavy metals pollution in the Morlais Brook.

From 1924 the coalfield began its gradual decline but changes in working practices and the spate of coal tip recovery operations and reclamation schemes in the 1960's and 1970's probably maintained or even increased the levels of suspended solids in the river.

In 1975 there were 42 National Coal Board collieries in operation in South Wales but by 1989 this had dwindled to only four, three of which are in the Taff catchment.

There has consequently been a gradual decline in population throughout the Taff catchment (Fig. 2). Attempts to halt this decline by introducing new manufacturing industries have at best only slowed down the exodus but have created new pollution problems associated with a wide variety of chemical and oil storage and use.

8. The beginning of modern times

8.1 Little quantitative data is available on water quality prior to 1951. In 1948 the suspended solids concentration at Llandaff Bridge was reported as 240 mg/l. When the river was not black with coal solids it was coloured brown by the discharge of acid pickling wastes from various tin plate works. The ammonia concentration in the River Taff below Merthyr Tydfil was reported to be equivalent to that of undiluted sewage.

It was not until 1948 that modern river pollution controls and monitoring were introduced. In this year the River Boards Act was passed but the Pollution Prevention Department of the Glamorgan River board was not set up until 1951. Up until this time no effective legal powers had been available for curbing river pollution.

In 1951 the Rivers (Prevention of Pollution) Act was passed and this allowed new discharges to be controlled. The Board had to wait another 10 years however for the passing of the Rivers (Prevention of Pollution) Act 1961 before all existing discharges came under control. Between 1951 and 1963 (a period of two years grace was allowed for existing dischargers to get their houses in order) the River Board could rely only on persuasion and appeal to the consciences of industries and local authorities to effect improvements.

In the first year of their existence the River Board could do little more than assess the situation with the limited resources at their disposal. They did not have their own laboratory until 1958 and had to rely on the services provided by the Public Analyst and hence numbers of samples were limited. The first comprehensive chemical survey of the Taff system was carried out in 1952.

8.2 Coal Solids Pollution

No less than 48 industries were identified discharging effluent into the river, 21 of these being coal washeries (Fig. 3). In most instances mineral separation and water clarification plants had not been provided and it was estimated that over 80,000 tons of fine coal was being deposited in the river each year. Samples of effluent contained suspended solids concentrations up to 57,000 mg/l (Table 1).

In 1956 a survey carried out under low flow conditions found concentrations of coal solids in the Rhondda Fach in excess of 2000 mg/l. In the Clydach stream at Tonypandy they were in excess of 3000 mg/l. In many instances the proportion of coal in the suspended solids was over 50% and it had become an economic proposition for entrepreneurs to set up coal recovery businesses by digging holes in the river bed at strategic places and collecting the coal which settled out.

In the decade 1951-1961 there was little change in the number of coal washeries operating. The main development was the provision of facilities for recovering fine coal. In 1954 the notorious Trelewis Drift Mine was opened, the minewater from which was to become a major source of coal solids pollution affecting the Taff Bargoed down to Quakers Yard and even the River Taff down to Abercynon. It was closed in 1989.

8.3 Coal Carbonisation Pollution

Without doubt the most widespread and troublesome trade effluent other than coal washery effluent was that from coal carbonisation and associated by-product plants. In 1950 there were four such establishments within the Taff catchment, at Nantgarw, Maritime in Pontypridd, Aberaman near Mountain Ash and at Pant in Merthyr Tydfil. The main pollutants from these plants have already been noted. They originated mainly from gas liquors and quench waters.

These effluents were discharged directly to the river without treatment. In 1954 a biological oxidation plant was installed at Maritime, Nantgarw was connected to the trunk sewer in 1955 and the Pant works was connected to a new sewer in 1960. An ammonia recovery plant was installed at Aberaman in 1956 but the effluent was discharged to lagoons and thence the river until it was provided with a biological oxidation plant in 1973 and connected to the sewer. The Maritime plant closed in 1957 and the by-product works at Pant in Merthyr closed in 1962. The effect of this closure was a considerable reduction of the industrial effluent load arriving at the Troedyrhiw sewage farm which in turn had benefits for the river. Nantgarw works closed in 1986 and the Aberaman works in 1989.

8.4 Other industrial sources of pollution

There were many other industrial effluents discharging to the system. The most notable being from a gelatin factory at Upper Boat which amounted to a BOD and suspended solids pollution load equivalent to that from the sewage from a population of 160,000. This effluent caused wide fluctuations in pH value in the river but the main problem was the organic pollution. In the summer, under low flow conditions and high temperatures, the river below the works and even down to Cardiff was devoid of oxygen and gave rise to objectionable odours. Despite great pressure from the River Board this effluent continued almost unabated until the late 1970's for a variety of complicated legal and technical reasons. Eventually the pressure paid off and the company installed an effluent treatment plant in 1979 only to go into liquidation shortly afterwards. A successor company took over the factory and treatment plant and gelatin production continues to this day. A further significant improvement was achieved in 1989 when the effluent was connected to the trunk sewer.

An aircraft controls factory at Cefn Coed, Merthyr installed an effluent treatment plant in 1955 to deal with plating waste. It closed in 1971. A large washing machine factory also discharging metals to the river at Pentrebach installed a treatment plant also in 1955. Plans are being pursued to have this effluent connected to the sewer this year.

At Treforest Industrial Estate, there were as many as nine different effluents discharging to the river including several electroplaters, a paper and board mill and a chemical works. The majority of these were connected to the sewer by 1960. At Pontygwaith in the Rhondda, a brewery was connected to the sewer in 1954 and at Mellingriffith near Whitchurch, Cardiff, a tin plate works discharging acid and ferrous sulphate which caused the Taff at Llandaff to appear rusty brown and reduced the dissolved oxygen, closed in 1957. Two wire rope works in Cardiff also discharging acid pickling effluents were controlled in the same year.

Metal analyses of the river water were not carried out in the 1960's so the effect of these improvements cannot be demonstrated although it must have been highly significant.

Ash lagoons were provided at Middle Duffryn power station near Aberdare in 1955. This station closed in the 1960's. Upper Boat power station closed in 1972 and a carbon dioxide factory effluent at Upper Boat was discontinued in 1971.

Also in the 70's other significant developments were the closure of a chromium plating factory at Mellingriffith and an oil blending factory at Dowlais installed an effluent treatment plant to remove soluble oils from their discharge to the Morlais Brook.

8.5 Sewage Pollution

The early history of sewage disposal has already been touched upon. Fig. 4 shows the main discharges of sewage effluent to the system in 1952. Large volumes were discharged into the middle reaches of the Taff at Troedyrhiw and between Abercynon and Pontypridd and, by this time, the condition of the settling tanks and distribution to the farms was far from satisfactory. Owing to an increase in infiltration and water usage, the volumes of sewage had increased, notwithstanding the gradual decline in population. Premature operation of overflows and storm tanks was commonplace. Settled sewage frequently entered the river from tanks at Troedyrhiw, Abercynon, Parc Newydd and Glyncoch. In addition sewage works at Ynysybwl were unsatisfactory. Table 2 indicates the BOD values at Parc Newydd below the worst of the discharges.

The Morlais Brook at Merthyr Tydfil received crude sewage from the Dowlais and Pant areas and in 1952 had a BOD of 27 mg/l.

The Rhondda below Tonypandy was also badly affected by a defective trunk sewer and a BOD of 14 mg/l was recorded in 1952.

Apart from the adverse effects from organic pollution and ammonia, the sewage contained toxic trade wastes, notably metals and cyanide (Table 3) and these components increased as more and more effluents were connected to the sewer. Little remedial work was achieved in the 50's to improve these major sewage discharges, but various local sewerage schemes were completed, notably at Pant in Merthyr in 1960. This considerably reduced the sewage discharges to the Morlais Brook.

The next major development was the building of the Cynon Valley sewage treatment plant at Glyncoch in 1972. This replaced the Abercynon and Glyncoch tanks and farms. Sewage from the whole of the Cynon Valley received full treatment. In 1974 a new trunk sewer was laid down the Merthyr Valley and modern storm sewage overflows were installed. At the same time the Troedyrhiw tanks and farm were abandoned.

Then in 1980 the Cilfynydd sewage treatment works was constructed and gave full treatment to all the sewage from the Merthyr and Taff Bargoed valleys. This allowed the Parc Newydd tanks to be abandoned.

The combined sewage effluent volume discharging to the river at this point is now approximately 45,000 m^3d^{-1} and represents 20% of the low river flow.

Other significant sewerage improvement schemes were a new trunk sewer in the upper Cynon Valley, and various schemes at Bedlinog, Troedyrhiw, Treharris, Abernant, Newtown, Ynysybwl, Treorchy, Ferndale, Gelli, Tonteg and Abercynon.

The overloaded Nelson sewage treatment works was abandoned in 1986 and the Cefn Coed works at Merthyr in 1990. Sewage flows in both cases have been connected to Cilfynydd works.

Significant sewerage improvement works remain to be carried out, notably in the Rhondda and lower Taff valleys, but this work has to be carefully defined and prioritised in an all-Wales context.

9. Pollution Control and Monitoring

In 1952 the Glamorgan River Board established its Pollution Prevention and Fisheries Department but between then and 1963 had to rely on persuasion to effect improvements. This they achieved in no small measure as can be judged from the foregoing.

In 1963 all existing discharges came under control and discharge consents stipulating quality and quantity limits designed to protect the river were applied.

A routine programme of river quality monitoring and consent compliance assessment was established by the Board and this was continued by the River Authority in 1963, the Water Authority in 1974 and finally taken over by the National Rivers Authority in 1989.

Throughout this period control and improvements have been achieved by monitoring, site inspections, regular contact with the dischargers and the application of appropriate pressure. This has included, where necessary, recourse to prosecution in some cases although, it has to be said, that generally dischargers are co-operative and, subject to the usual financial constraints, endeavour to comply with our requirements.

In the context of the Taff catchment, the necessary legal powers to bring about improvements have existed since 1963 with the notable exception of minewaters. These eventually came under control in 1987 but this was almost too late to catch the minewaters in South Wales. There is however a potential risk associated with minewaters overflowing from abandoned workings but these are still uncontrollable.

10. River Quality Classifications and Objectives

10.1 The 1969 Survey

In 1969, a National survey of river water quality was carried out for the Ministry of Housing and Local Government. The criteria for the classification are given in Appendix 1 (Department of the Environment/Welsh Office 1970). It will be noted that the system adopted was rather subjective, the only chemical criteria considered being biochemical oxygen demand and dissolved oxygen. However, the system was considered to be a practical compromise between several criteria which collectively met the general concept of river pollution.

Only those rivers with a dry weather flow in excess of 1 million gallons a day were considered unless they were known to carry significant pollution loads, and in the Taff catchment 142 km were classified. More than 40% of the system was either grossly polluted or in need of urgent improvement. Fig. 5.1 illustrates the results of this survey.

The most polluted stretches were the river Taff from the North Outfall, Treforest to Radyr Weir, 6.8 km, which were placed in Class 4 because of high BOD and low dissolved oxygen resulting from the gelatin factory effluent and 1.8 km of the Morlais Brook, in Class 4 because of BOD from sewage in Merthyr and a variety of trade effluents.

Several stretches were placed in Class 3, notably the river Taff from its confluence with the Taf Bargoed at Quakers Yard to the North Outfall at Treforest, a distance of 14 km, because of coal solids from the Taf Bargoed, ammonia and coal solids from the Cynon, BOD and ammonia from sewage at Parc Newydd and coal solids from the Rhondda, the Rhondda Fach from Maerdy to Porth, 12km, and the Rhondda from Porth to Pontypridd, 6 km, because of coal solids, the Cynon from Phurnacite Plant, Aberaman to Abercynon, 9.2 km, because of ammonia and coal solids, the Taf Bargoed below Trelewis Drift Mine, 3.4 km, because of coal solids and the Taff from Radyr Weir to Blackweir, 5.8 km, because of BOD and low oxygen resulting from the gelatin factory.

10.2 The 1978 Survey

In 1978, the river system was classified using the National Water Council criteria for the first time, which are given in Appendix 2 (National Water Council 1981). These criteria are based more on actual chemical data than the RPS criteria and, although the classes are not absolutely equivalent, they are intended to correspond approximately so that comparisons with the earlier surveys can be made.

The main differences between the 1978 survey and the 1969 survey was a substantial reduction in the length of Class 3 waters from 37.5% of the total to 25.5%. There was still, however, a large proportion (34%) of waters either grossly polluted or with considerable potential for cleaning up. The most polluted stretches were the River Taff from North Outfall, Treforest to Radyr Weir (6.8 km) in Class 4 because of BOD and low DO resulting from the gelatin factory effluent, Morlais Brook (1.8 km) in Class 4 because of BOD from sewage and various trade effluents and the Taf Bargoed below Trelewis Drift Mine (3.3 km) in Class 4 because of coal solids. The last stretch mentioned was not strictly a downgrading but due to the differing criteria applied.

The main stretches in Class 3 were:- River Taff from Quakers Yard to North outfall, Treforest (14 km) due variously to coal solids, BOD and ammonia, River Taff from Radyr Weir to Blackweir (5.8 km) due to BOD and low DO as a result of the gelatin factory effluent, River Cynon from Phurnacite Plant, Aberaman to Abercynon (9.2 km) due to ammonia and Rhondda Fach below Maerdy (2.3 km) due to coal solids. A considerable length of the Rhondda Fach had been upgraded to Class 2 and also the Rhondda from Porth to Pontypridd as a result of improvements at Maerdy Colliery.

10.3 The 1983 Survey

A further quality classification was carried out at the end of March 1983. There was a slight change in the criteria applied - see Appendix 3 - but a further improvement in the general condition of the system was evident, only 29% of the total length being in need of improvement. There was still a short length, 2.1 km (1%) in Class 4 which was on the Morlais Brook, due to sewage and various trade effluents. The significant changes compared with the situation in 1978 were:-

i) The upgrading of the Taff between the North outfall and Radyr Weir (7.8 km) from Class 4 to Class 3 due to the reduction in size of the effluent from the gelatin factory and the commissioning of the new treatment plant;

ii) The upgrading of the Taff from Llandaff weir to Blackweir (2 km) from Class 3 to Class 2 for the same reason as i);

iii) The upgrading of the Taff from Berw Road, Pontypridd, to North Outfall, Treforest (6.9 km) from Class 3 to Class 2 due to the commissioning of the Cilfynydd S.T.W.;

iv) The upgrading of the Taff between Quakers Yard and Glyncoch (5.2 km) from Class 3 to Classes 1 and 2, due to a reduction in the solids load from the Taf Bargoed, a reduction in the ammonia load from the River Cynon, and the final elimination of the sewage overflows from Parc Newydd;

v) The upgrading of the lower reaches of the River Cynon (2.7 km) from Class 3 to Class 2, due to a reduction in the ammonia from Phurnacite Plant;

vi) The upgrading of the Taf Bargoed below Trelewis Drift Mine (3.3 km) from Class 4 to Class 3, due to a reduction in coal solids from the minewater;

vii) The downgrading of the Rhondda Fawr below Tonypandy (1.3 km) from Class 2 to Class 3, due to BOD from the trunk sewer;

viii) The downgrading of the Clydach below Lady Windsor Colliery (3 km) from Class 2 to Class 3, due to increased coal solids;

ix) The downgrading of the Rhondda Fach below Maerdy (7.4 km) from Class 2 to Class 3, due to BOD from the sewerage system.

10.4 The 1989 Survey

The most recent survey to be fully reported was carried out in 1989 and the results are presented in Fig. 5.2. The most notable improvements were the final elimination of the last Class 4 stretch with the sewerage improvements on the Morlais Brook and the closure of the Dowlais Iron Foundry; 6.5 kms of the River Cynon below Aberaman upgraded from Class 3 to Class 2 due to the closure of the Phurnacite Plant; 3 kms of the Nant Clydach from Ynysybwl to the confluence with the Taff upgraded from Class 3 to Class 2 due to the closure of Lady Windsor Colliery; and 12 kms of the Rhondda Fach from Maerdy to Porth upgraded from Class 3 to Class 2 due to the closure of Maerdy Colliery.

Figs. 6.1 - 6.4 illustrate graphically the improving trend in water quality that has been achieved by reference to the lowest monitoring point on the system at Blackweir.

11. River Quality Objectives

In 1978, when the first NWC Classification was carried out, the Authority also established river water quality objectives based on current and potential uses of the river. NWC Class 2 is the minimum long term water quality objective, according to Authority policy as this is the lowest class that will support a healthy fishery. Class 3 on the other hand is regarded as a polluted water where fish are absent or only sporadically present and suitable for low grade industrial use. It has considerable potential for cleaning up.

Of the 142 kms of the classified river in the Taff catchment, the Authority's stated long term quality objective is to achieve 92 km in Class 1 and 50 km in Class 2 (Fig. 5.3 and Table 5).

12. Biological Aspects

12.1 Although this paper deals primarily with river water quality aspects of the Taff system a brief reference should be made to biological aspects.

Because of the intermittent nature of some pollution episodes, results from the relatively small number of chemical samples inadequately reflect the pollution status of the river. The pattern of pollution within the catchment and practical limits of the chemical surveillance programme reinforced the need for an adequate biological description of the system for, initially, effects of pollution are frequently more easily discerned than their causes.

12.2 The 1969 Survey

In 1969, in anticipation of the proposed improvements to the sewage treatment facilities at Parc Newydd and Cilfynydd, a biological survey was carried out in the summer by students from the biological departments at University College, Cardiff (botanical studies) and UWIST (invertebrate and fish studies). This survey was intended to provide useful "base-line" information against which to assess the effect of the imminent pollution abatement programmes on the River Taff (Edwards et al 1972).

The survey found that generally the biological condition of the system was poor, the higher forms of plants and invertebrates being largely confined to the relatively unpolluted upper reaches. Sewage fungus was widely distributed and especially heavy growths were found below Merthyr and below the sewage farms. Algal and faunal diversity were intended to provide an indication of the pollution status of the river and, although diversity indices seemed generally to decrease downstream as the river became more polluted, it was not possible to establish relationships between chemical quality, as determined by samples taken, at most, twelve times a year, and community structure.

The 1969 survey also included a fish distribution study, and eight species of fish were recorded in the whole catchment : trout, bullhead, stone-loach, stickleback, minnow, eel, roach and flounder. Eels were abundant in the lower Taff. Trout were present at all stations on the main river above Pontypridd but were absent in the lower reaches of the Rhondda Fach, polluted by coal solids and sewage, and in the Cynon below the Phurnacite Plant at Aberaman, polluted by solids and ammonia. Bullheads were restricted to the upper reaches of the Taff, Cynon and Rhondda Fawr. They were not found where the average suspended solids exceeded 20 mg/l and it seems likely that these fish are particularly sensitive to suspended solids. Stone-loach were more widely distributed throughout the upper catchment, being present in all the major tributaries but they were absent, as were all other species, from the lower Cynon and middle reaches of the Rhondda Fach. Minnows were widely distributed throughout the system, being found in all tributaries and the main river down to Cardiff, but sticklebacks were patchily distributed.

It was difficult to establish factors determining the limits in downstream distribution of certain species. It seems likely that the bullhead is very susceptible to high concentrations of suspended solids, particularly where extensive settlement occurs on the river bed - this feature alone would have accounted for its confinement to the cleaner headwaters. The trout appeared to be absent from the lower impounded reaches of the river even though stretches in this region appeared to be suitable for it. Periodic pollution, obstructions and the very limited stretches of nursery stream available for providing fish to recolonise the main river could have been major factors responsible for this absence. The high suspended solids load, together with the reduced current speed compared with the headwaters, causing blocking of interstices within bed gravels, could well have prevented successful spawning within the main river in this region.

It seemed likely that availability of food was of any real consequence in restricting downstream distribution of any of these species as chironomids seemed to be the major constituent of their diet and their availability was likely to have been adequate throughout the year. There was an apparent lack of 0+ trout in the major rivers and there was wide variation in the diet of individual trout at certain stations, some feeding exclusively on aerial drifts.

13. Rehabilitation Plan

13.1 By the early 1980's, there had been major improvements in the water quality of the lower reaches due to the continued pollution control and decline in the basic industries. It soon became evident from observations of fish at weirs, electrofishing surveys and anglers' catches that each year scores of sea trout and some salmon were once again entering the lowest reaches of the river in Cardiff (Mawle et al 1985). The capture of a few juvenile salmon also indicated limited reproduction within the river (WWA 1984, Bevan 1983).

In 1984, the NRA's predecessor (Welsh Water Authority) decided to assess the feasibility of further developing the salmon population and the associated fishery in the Taff.

13.2 Factors limiting rehabilitation

Following reviews of the available information (Williams 1984; Winstone 1984), the Authority surveyed the catchment in detail to identify more closely the factors limiting development of the salmon population as part of a wider plan for management of the catchment (Bent et al 1985). The investigation included water quality (Thomas et al 1986), macroinvertebrate communities (Bent et al 1986), fish distribution (Brown et al 1986) and salmonid egg survival experiments (Brown et al 1988).

Given the objective for rehabilitation of the Taff,

i.e. to extend the migratory salmonid fishery into the larger tributaries and the main river downstream of the reservoirs with stocks being supported wholly or at least partly by natural reproduction,

the information collected in 1985 indicated that the following factors were likely to limit development of the population.

13.3 Pollution

Although greatly improved, water quality was still poor over much of the catchment in 1985. The main pollutants were still suspended solids, ammonia and organic loadings. Their impact was firstly to limit the possible spawning and nursery area. Egg planting experiments indicated that successful spawning was likely to be confined to the upper reaches (Fig. 8). In addition, poor water quality might inhibit or prevent salmon migration to and from the nursery areas (Thomas et al 1986).

Aside from the problems of chronic pollution, there is also concern about intermittent pollution caused by spillages of toxic chemicals or by failures of effluent treatment plants or the sewage system. Due to the urban and industrial nature of the catchment, such incidents may occur virtually anywhere. However although there may be occasional fish kills, if fish are well distributed stocks are unlikely to be eradicated, particularly since at any one time part of the population will be at sea.

13.4 Obstructions

Five weirs on the main river are major obstructions for the upstream migration of adults, the four nearest the sea preventing access to any of the spawning areas (Fig. 9). In addition, there are culverts and weirs on some of the tributaries.

13.5 Exploitation

The proximity of half a million people to the river means that stocks may be over-exploited, whether by legal or illegal means. There was evidence even in the early 1980's that salmon were being illegal taken in the sea off Cardiff by driftnets ostensibly used for sea fish. Fixed nets were also being set on the foreshore within and close to Cardiff Bay. Judging by activity off the nearby River Usk, such fisheries were considered likely to expand if Taff stocks increased.

In the lower reaches, angling pressure had increased from virtually nothing in the 1970's, particularly as the coarse fishery had also showed signs of improvement. Although the fishing rights are leased by angling clubs in Cardiff, there was little control and many anglers considered the fishing a free-for-all, giving little heed to regulations.

removal of spawning adults, which are particularly vulnerable, is likely to be extensive.

13.6 Speed of recolonisation

The majority of salmon are thought to return to spawn in their native river (Mills 1989). Tagging studies (Swain 1982) show that some straying occurs. The capture of juvenile salmon in the Taff (Mawle et al 1985) indicates that at least some strays remain to spawn. Nevertheless, unless straying is extensive, full recolonisation of the Taff by salmon is likely to take several generations, even assuming a low exploitation rate and free access to and from the nursery areas.

13.7 Future developments - Cardiff Bay Barrage

Subsequent to the studies in 1985, the local county council promoted the idea of constructing a barrage across Cardiff Bay for amenity purposes. The barrage would impound the rivers Taff and Ely and totally exclude the tide (Fig. 9).

Such a development could impair or prevent the full rehabilitation of the salmon population. Possible effects include physical obstruction to migration and mortality of migrants due to the potentially poor quality of impounded water.

14. Rationale

The rationale for rehabilitation of the salmon population has two dimensions. Firstly, the regeneration of a fishery for migratory salmonids would enhance facilities for angling in an area where access to such fisheries is both limited and expensive.

Secondly, and perhaps more importantly, the return of salmon to the Taff is considered to have significant conservation value. Salmon are symbols of clean water. A breeding population of salmon in the Taff, so grossly polluted for so long, would be the clearest demonstration of its improved quality. It seems likely that most people value improvements in their local environment more highly than similar changes elsewhere. The Taff is part of the local environment for about half a million people. In addition, it might be considered to be the capital river of Wales. As the Thames is to London, so the Taff is to Cardiff. Though difficult to quantify, these factors suggest that the return of salmon to the Taff is likely to be highly valued by the local and Welsh populations, regardless of any fishery.

15. Strategy for Rehabilitation

15.1 Pollution control

Water quality is considered the primary constraint on the potential nursery area available. About 84 hectares of river were considered good or moderate nursery area based on the 1985 data (Fig. 9). Given full utilisation, it is estimated that between 15,000 and 30,000 salmon or sea trout smolts could be produced annually, generating a run of between 350 and 750 adult salmon. Further improvements in water quality were considered desirable to realise the full potential of these areas. Tentative standards to be achieved for water quality in the nursery areas have been defined by both chemical standards and the macroinvertebrate communities present (Table 4).

Further improvements in water quality were also considered necessary to safeguard the passage of adults and smolts to and from the nursery areas (Humphrey 1986). An appropriate criterion for safe passage was considered to be water quality meeting NWC Class 2 (Table 4). Achieving this standard throughout the middle and lower reaches should also permit limited smolt production in this area where a further 73 hectares of potential nursery area is available. Even a productivity of 100 smolts per hectare would generate 7300 smolts per year increasing potential smolt production in the catchment by between 25 and 50 per cent.

Increased powers under the Control of Pollution Act 1974 and the Water Act 1989 have permitted greater control over pollution. In addition there has been a further contraction of the coal industry in the catchment. As a result many of the worst effluents identified in 1985 have been diverted into the sewerage system, receive improved treatment or have ceased (Fig. 8).

The beneficial impact of these changes was assessed in 1990 by a detailed survey of chemical water quality and macroinvertebrate communities. Further egg survival experiments in the middle and lower reaches are planned for 1990/91.

15.2 Fish Passes

Fish passes have been constructed or are proposed for the four weirs nearest the sea. At least 65 hectares of good or moderate nursery area should be accessible to adult fish. The combined cost of these passes is estimated to be £180,000.

15.3 Transport of adult fish

Given sufficient resources the four fish passes will be completed in 1991. Until then adult salmon are being captured by electrofishing or trap and trucked upstream of the main obstructions to suitable spawning areas to accelerate recolonisation. Radio-tagging has indicated that transferred adults remain in the nursery areas and pair up, though there is no confirmation as yet of successful spawning (Strange 1988).

15.4 Artificial propagation

The objectives of stocking the catchment are twofold. Initially, the purpose is pump-priming to accelerate recolonisation. Earliest stockings were with older parr and smolts to make the greatest use of the limited ova available. However, as adult runs to the river are enhanced providing more broodstock, stocking is being switched to younger fish as being potentially more cost effective. In each of the next four years it is intended to stock 100,000 fed fry per year over the nursery area identified. Electrofishing surveys will compare the performance of stocked fry in different areas within the catchment.

The presence of juvenile salmon in the Taff may also induce straying of adult salmon destined for other rivers (Solomon 1973). Tens of thousands of adult salmon migrate past the Taff en route for other rivers further up the Severn Estuary. Even a small increase in the proportion of strays would significantly increase the number of salmon running the Taff.

Even assuming that pump-priming is successful, it is envisaged that some stocking with fry may continue in order to by-pass the most vulnerable stages in the life cycle (i.e. adults on the spawning redds and ova in gravels choked by fine solids). Such stockings will only be made where densities of naturally spawned fry are known to be low, particularly upstream of those obstructions which remain impassable.

15.5 Control of exploitation

Enforcement of salmon fisheries legislation by the NRA has been increased both in the river and in coastal waters. In addition new fisheries regulations are being promoted.

In order to protect the salmon from the coastal fisheries, NRA guidelines prohibiting fixed engines in or close to the estuary have been in force since 1987. In addition, byelaws are being considered which will prohibit driftnetting for sea fish in the vicinity of the Taff to prevent the accidental or deliberate capture of adult salmon.

In Cardiff, the NRA has worked closely with the angling clubs to bring the river fishery under control, with considerable success. A significant rod fishery for salmon has developed with individual anglers catching up to 17 salmon in 1988. However, it was apparent that exploitation rates were likely to be high. In particular, the accumulation of adult fish below the weirs made their capture relatively easy. Consequently a club rule was introduced in 1989 making the weirpools sanctuary areas where no angling is permitted. The club also limits its members to taking two salmonids a day. In addition the predominant method of catching salmon, spinning, can only be practised by anglers with a more expensive 'Salmon' permit and the appropriate NRA rod licence. Angling effort is thereby constrained to an extent by a price mechanism.

When the fish passes are opened and salmon have access further up river, similar constraints on angling will be required. The NRA is therefore considering promoting byelaws that will provide such constraints.

15.6 Habitat improvement

The NRA's Flood Defence department regularly undertakes repair works to flood defence schemes. The opportunity is taken where possible to put in structures to improve the physical habitat for adults and juveniles. Such structures include low blockstone weirs, groynes and salmon stones.

15.7 The Barrage - Fisheries protection

Various measures for fisheries protection have been included in the Parliamentary Bill authorising the barrage and a Memorandum of Agreement has been drawn up between the promoters and the NRA.

i) Fish Passes

The Barrage must incorporate structures approved by the Ministry of Agriculture, Fisheries and Food in accordance with Section 9 of the Salmon and Freshwater Fisheries Act 1975 to safeguard both the upstream migration of adult salmon and the downstream passage of smolts and kelts.

ii) Water Quality

The water impounded by the barrage must contain at least 5 milligrams of oxygen per litre at all times.

iii) Impact Assessment

The return rate of hatchery reared smolts stocked into the lower reaches will be compared before and after impoundment. Then thousand microtagged smolts will be stocked annually and returns monitored over a ten year period by trapping and anglers catches in the lower reaches. Captures in the high seas and coastal fisheries will also be monitored. Radio and acoustic tags will be fitted to adult salmon and, if possible, smolts to identify if and how migration through Cardiff Bay may be impeded by the Barrage.

iv) Mitigation

The monitoring programme is unlikely to be able to demonstrate as statistically significant any reduction of less than 37 per cent in the return rate of tagged salmon. Consequently, the Taff will be stocked annually with smolts to counteract such a presumed loss in the salmon population, regardless of the results of the impact assessment. However, if a reduction of greater than 37 per cent is demonstrated as statistically significant at the 60 per cent probability level then mitigative restocking will be increased accordingly. The fish tracking studies may indicate that any impact of the barrage could be ameliorated by changing its mode of operation. Where practical such changes would be adopted in preference to compensatory restocking.

16. Conclusion

After an absence of over a century, salmon are once again returning to and successfully spawning in the Taff. Natural penetration by adult fish of the river is still limited by an obstruction to the lowest 20 kilometres. In addition, the distribution of the species has been enhanced by transporting adults to, and stocking juveniles into the middle and upper reaches. In 1991, on completion of a further fish pass, adult fish will have access to the greater part of the catchment. With the aid of stocking, full recolonisation should be achieved within ten years. Fishing, pollution and future developments will have to be closely controlled if the population is to be maintained.

The rehabilitation of salmon in the Taff, the 'capital' river of Wales, is indicative of the major improvement which has been achieved in this area over the last four decades.

Acknowledgements

This paper summarises the work of a large number of people in the National Rivers Authority and its predecessors, the Welsh Water Authority, the Glamorgan River Authority and the Glamorgan River Board, over the last four decades. The author would like to acknowledge the work done over this period by members of these former organisations and present colleagues who together have contributed so much to the rehabilitation of the salmon population of the River Taff. The opinions expressed are those of the author and not necessarily those of the Authority.

List of Tables

List of Appendices

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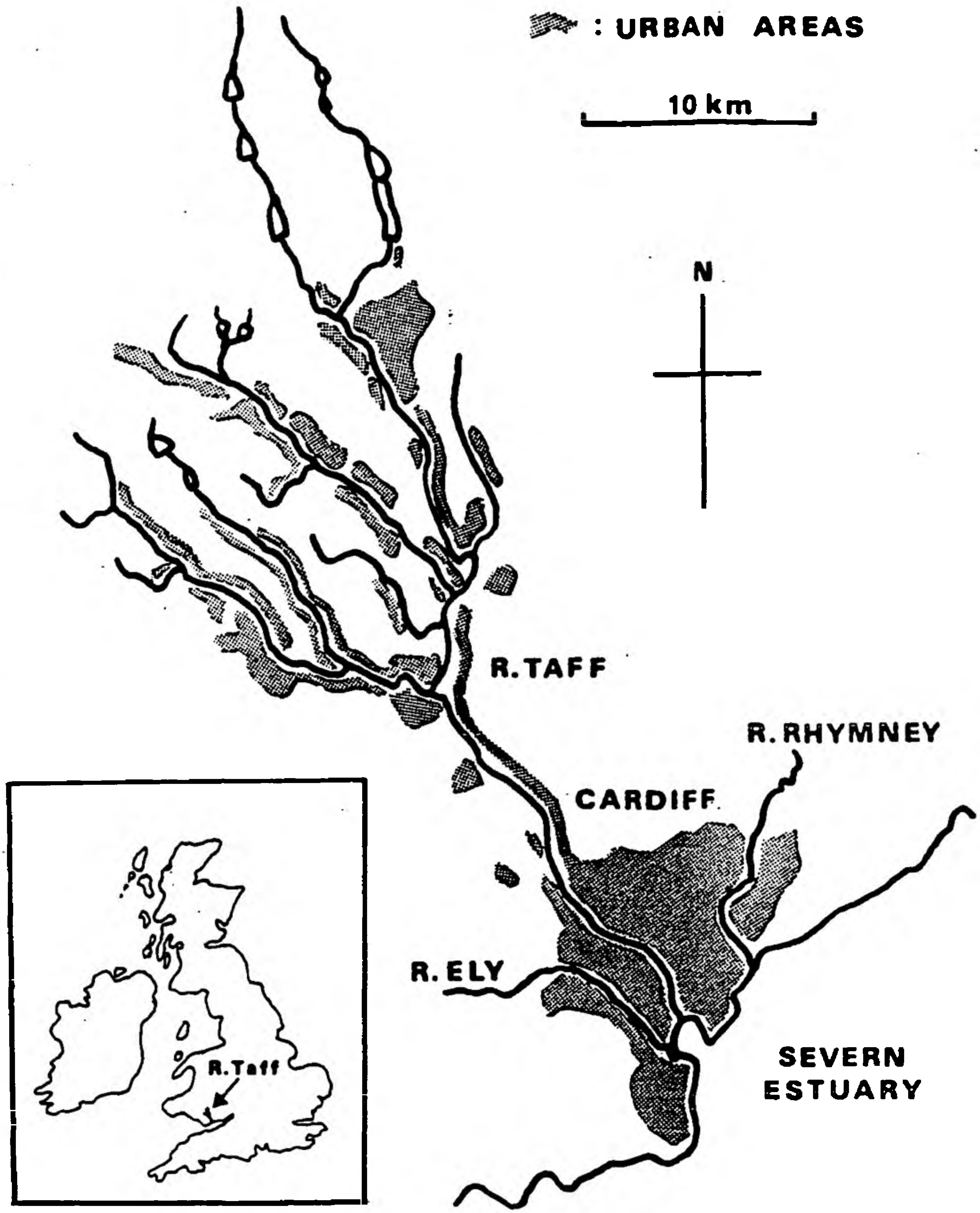
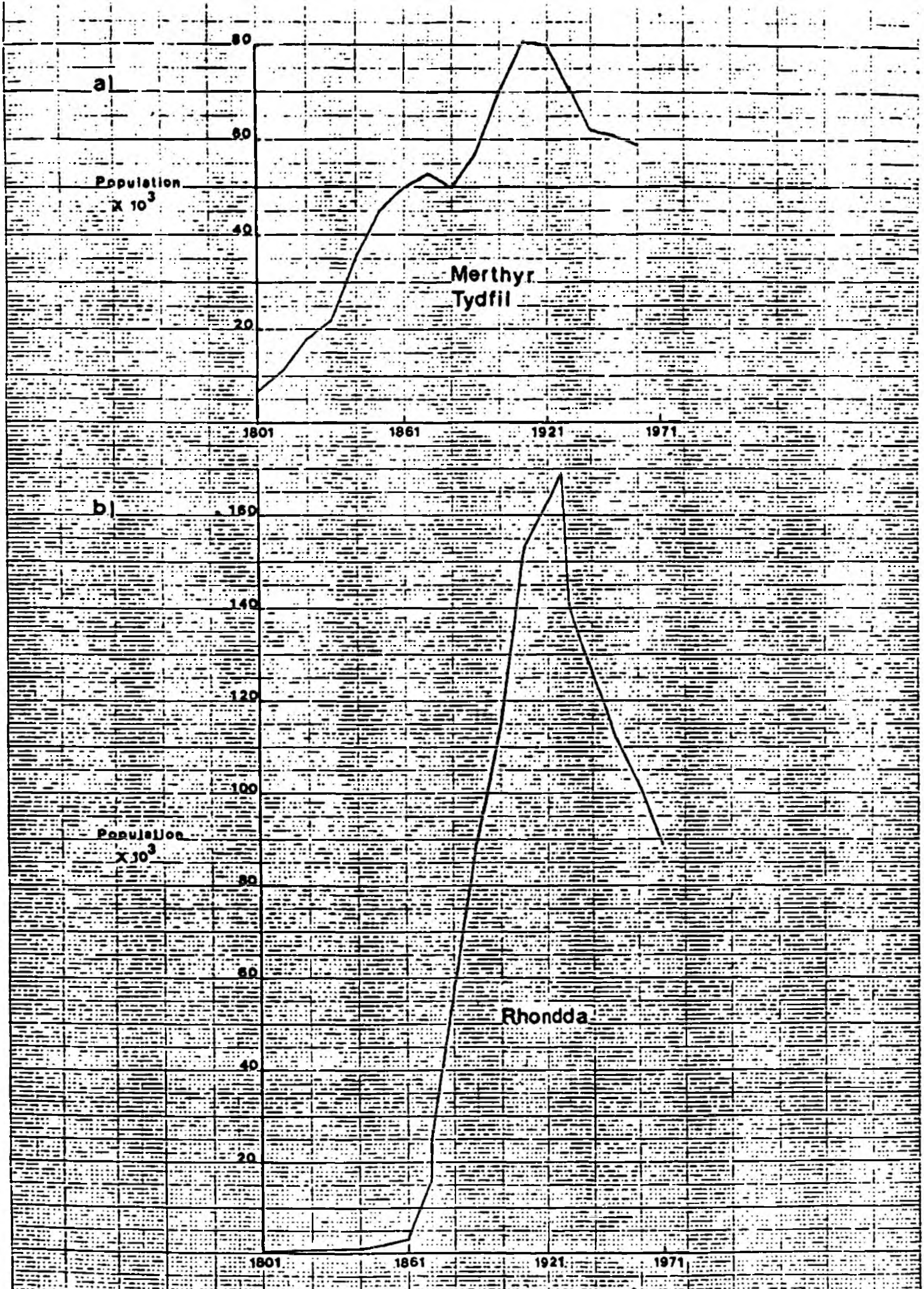
Fig 1 : The Taff system showing its position within the British Isles and the extent of urban development within the catchment.





a)
80
60
Population
x 10³
40
Merthyr
Tydfil
20
1801
1861
1921
1971
b)
160
140
120
100
Population
x 10³
80
60
Rhondda
40
20
1801
1861
1921
1971

FIGURE 3.

THE DISTRIBUTION OF N.C.B. COAL WASHERIES IN 1952

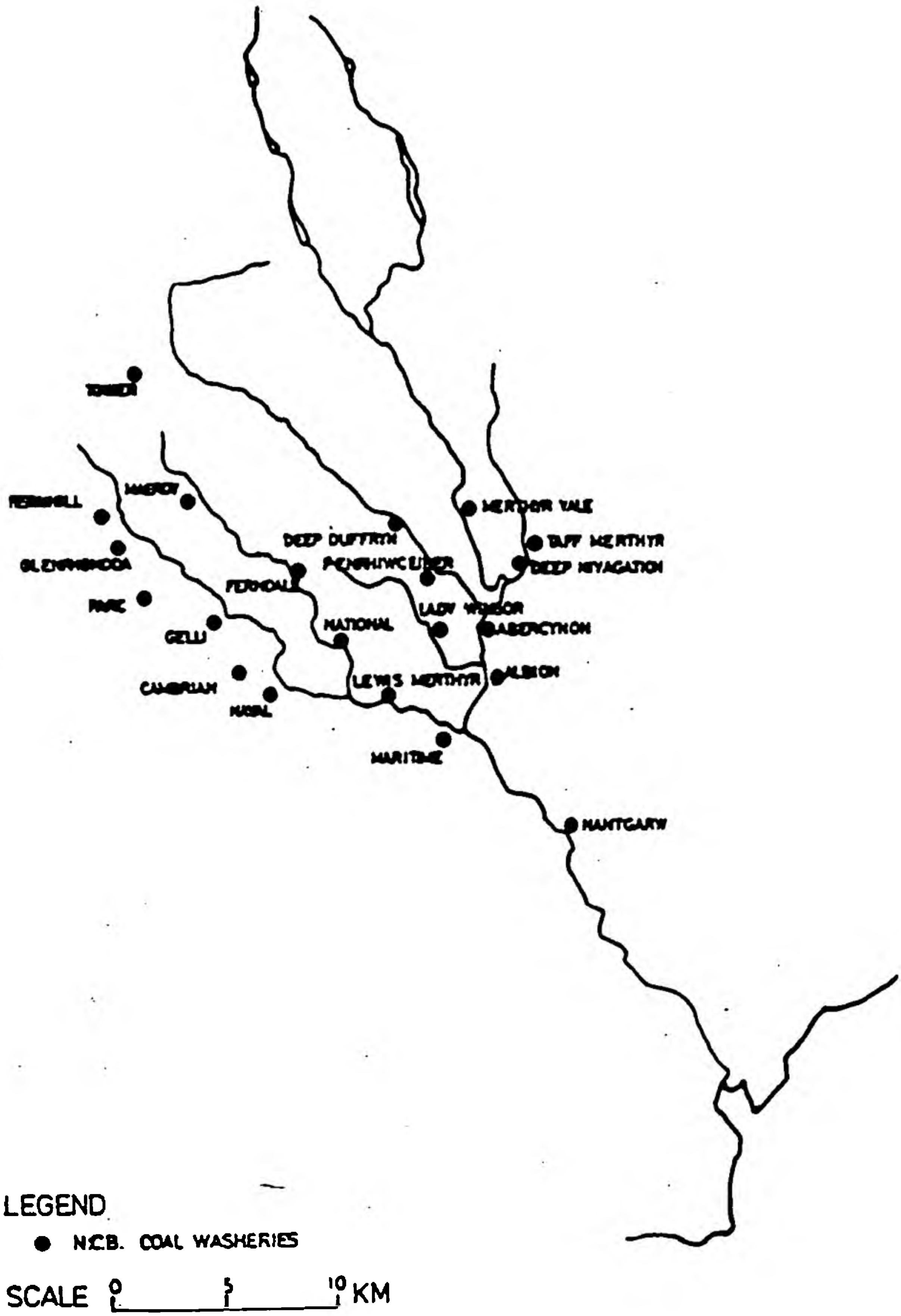


FIGURE 4

DISTRIBUTION OF MAIN SEWAGE EFFLUENT IN 1952

Schematic Distribution of River Quality in Taff Catchment

1969

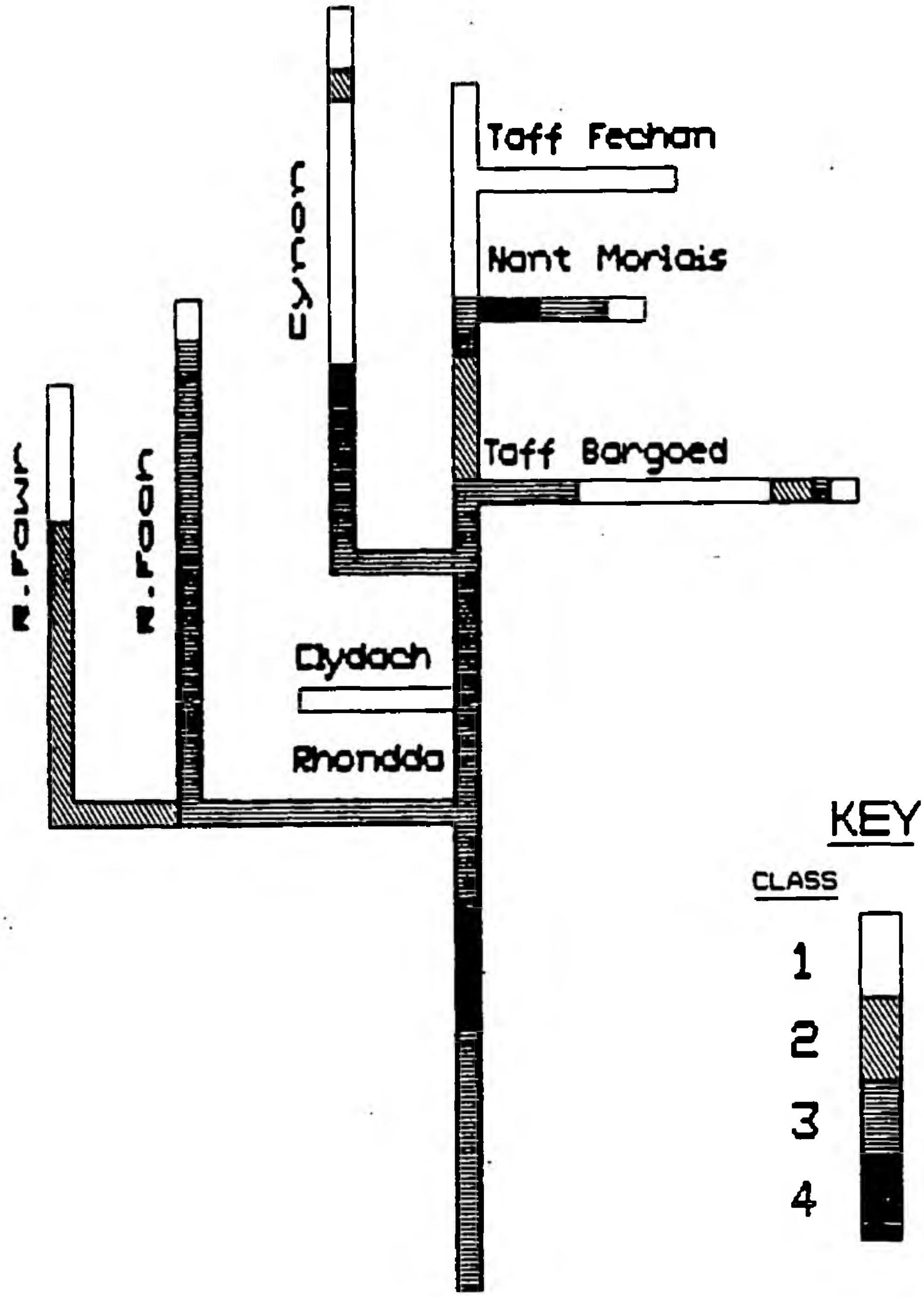


FIGURE 5.2.

Schematic Distribution of River Quality in Taff Catchment

1989

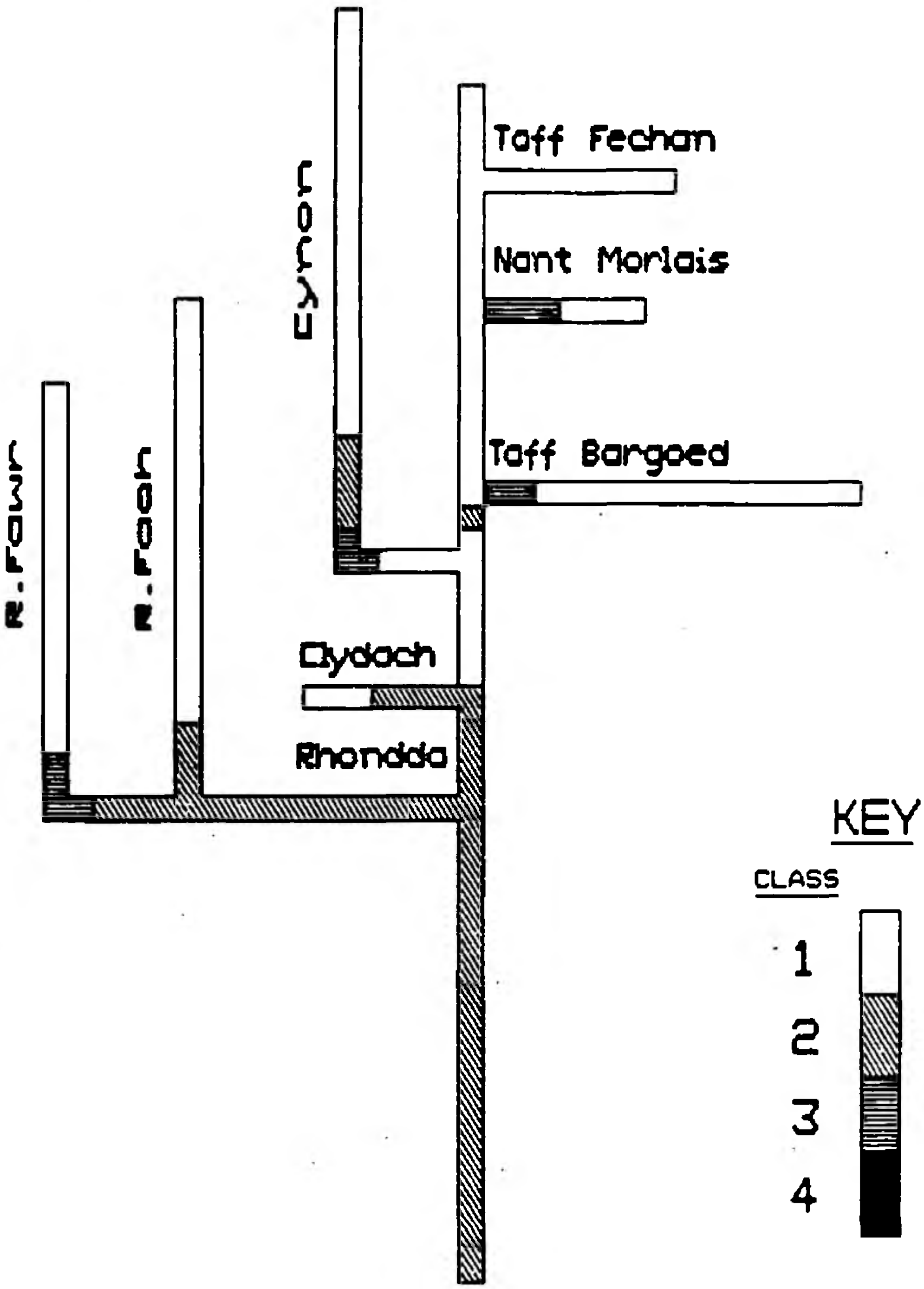


FIGURE 5.3

Schematic Distribution of River Quality in Taff Catchment

Long Term Objective

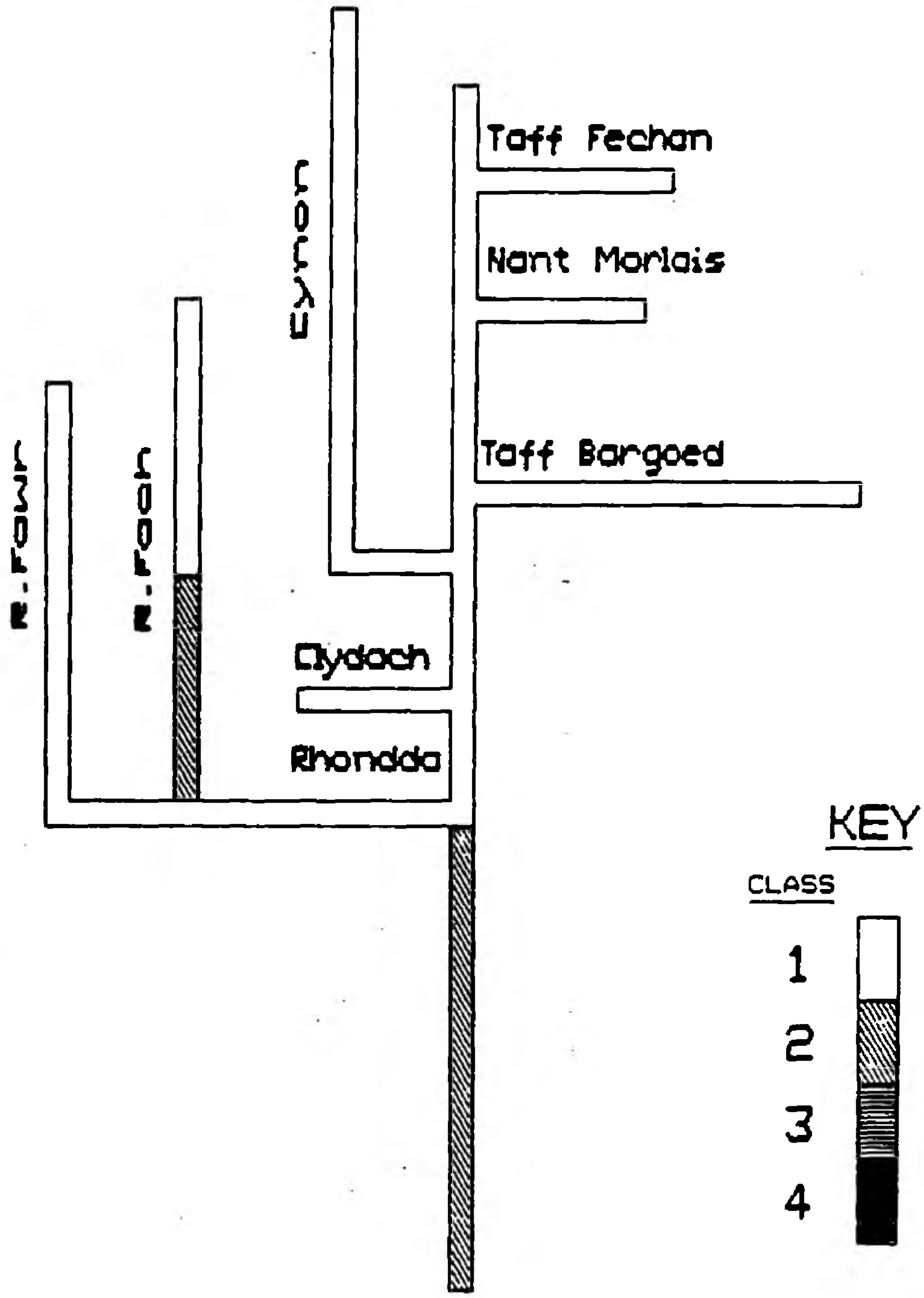


FIGURE 6.1

RIVER TAFF CATCHMENT
ANNUAL MEAN VALUES BOD mg/L

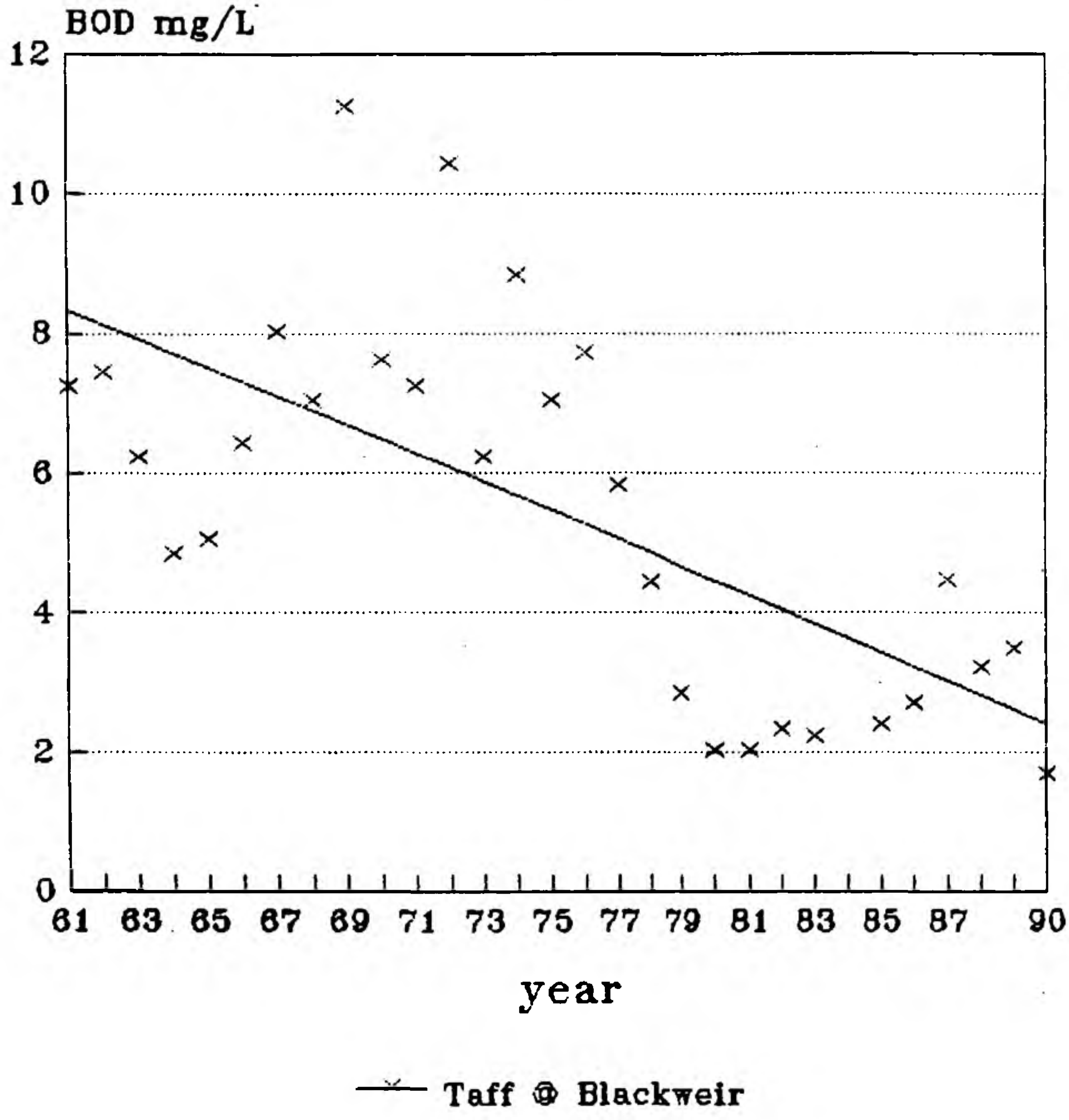


FIGURE 6.2

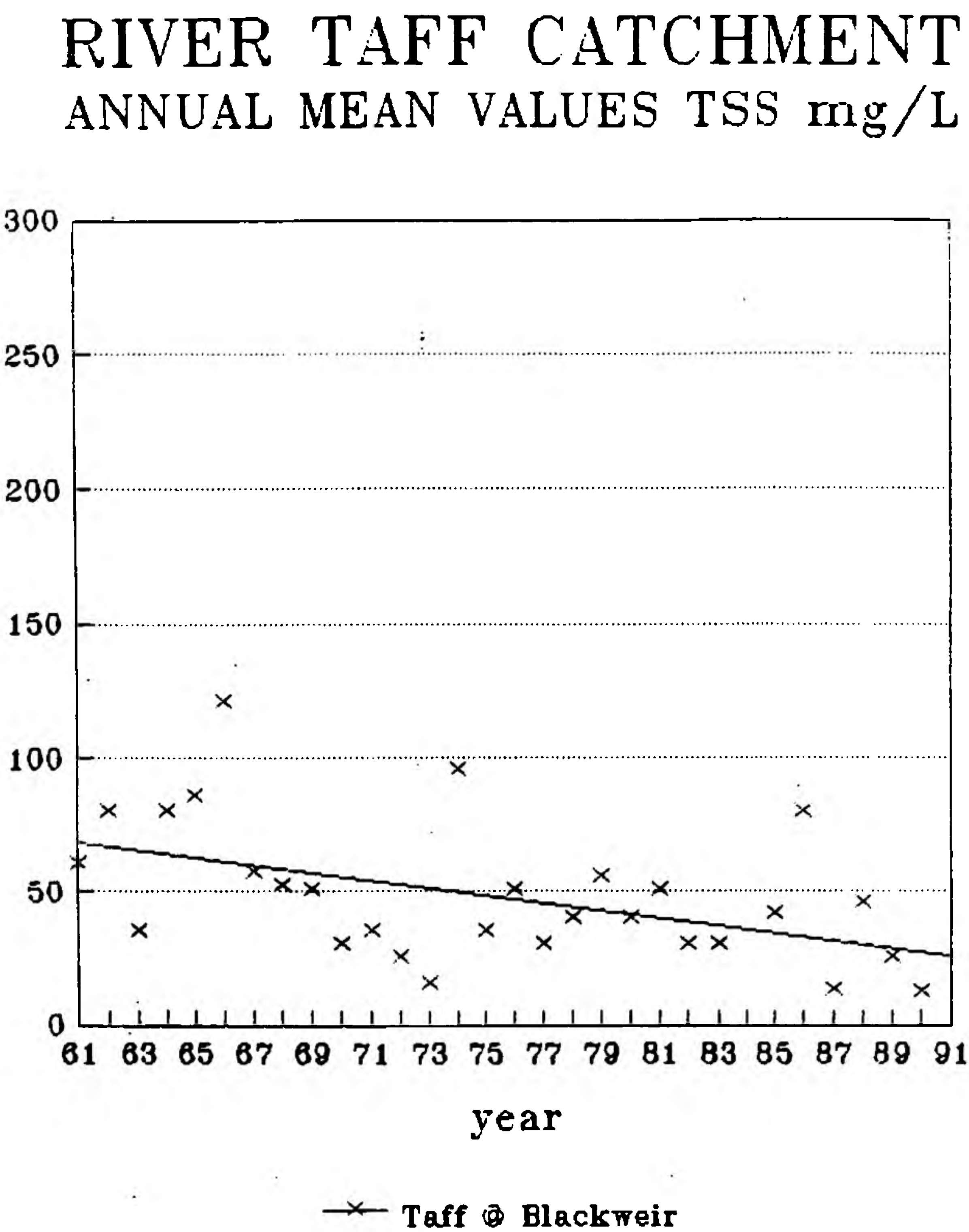

RIVER TAFF CATCHMENT
ANNUAL MEAN VALUES TSS mg/L
300
250
200
150
100
50
0
61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91
year
Taff @ Blackweir

FIGURE 6.3

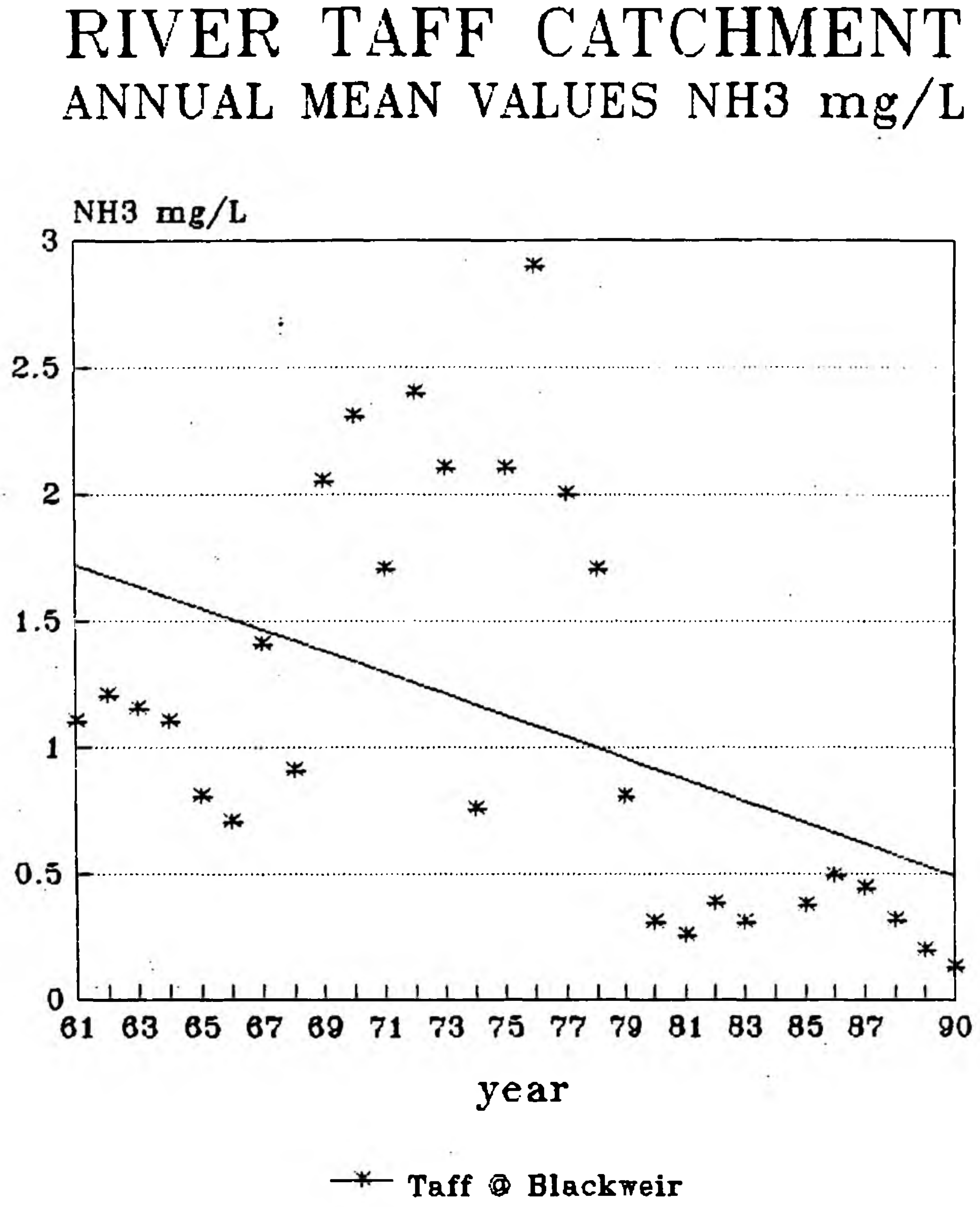
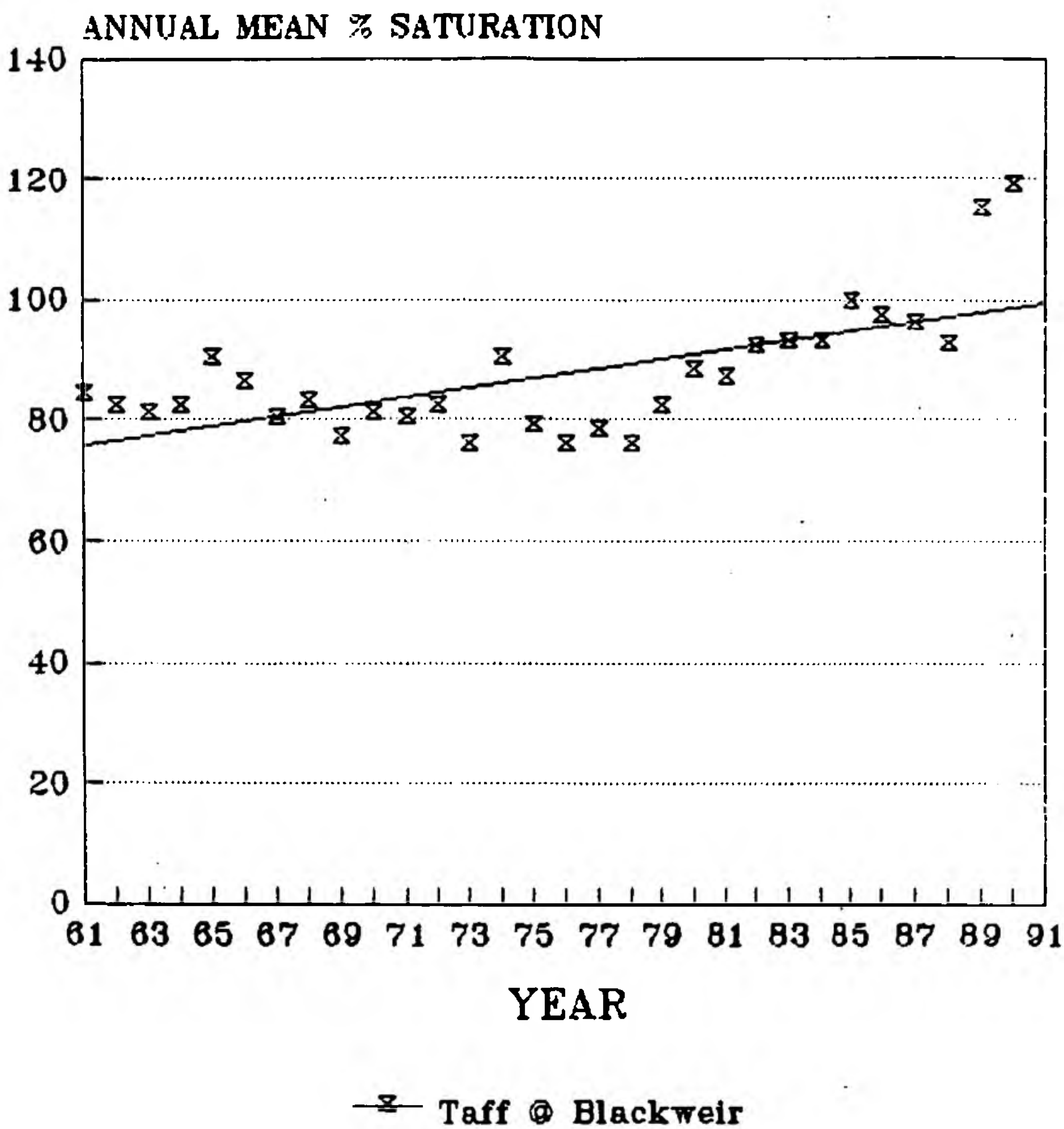

RIVER TAFF CATCHMENT
ANNUAL MEAN VALUES NH3 mg/L
NH3 mg/L
3
2.5
2
1.5
1
0.5
0
61 63 65 67 69 71 73 75 77 79 81 83 85 87 90
year
Taff @ Blackweir

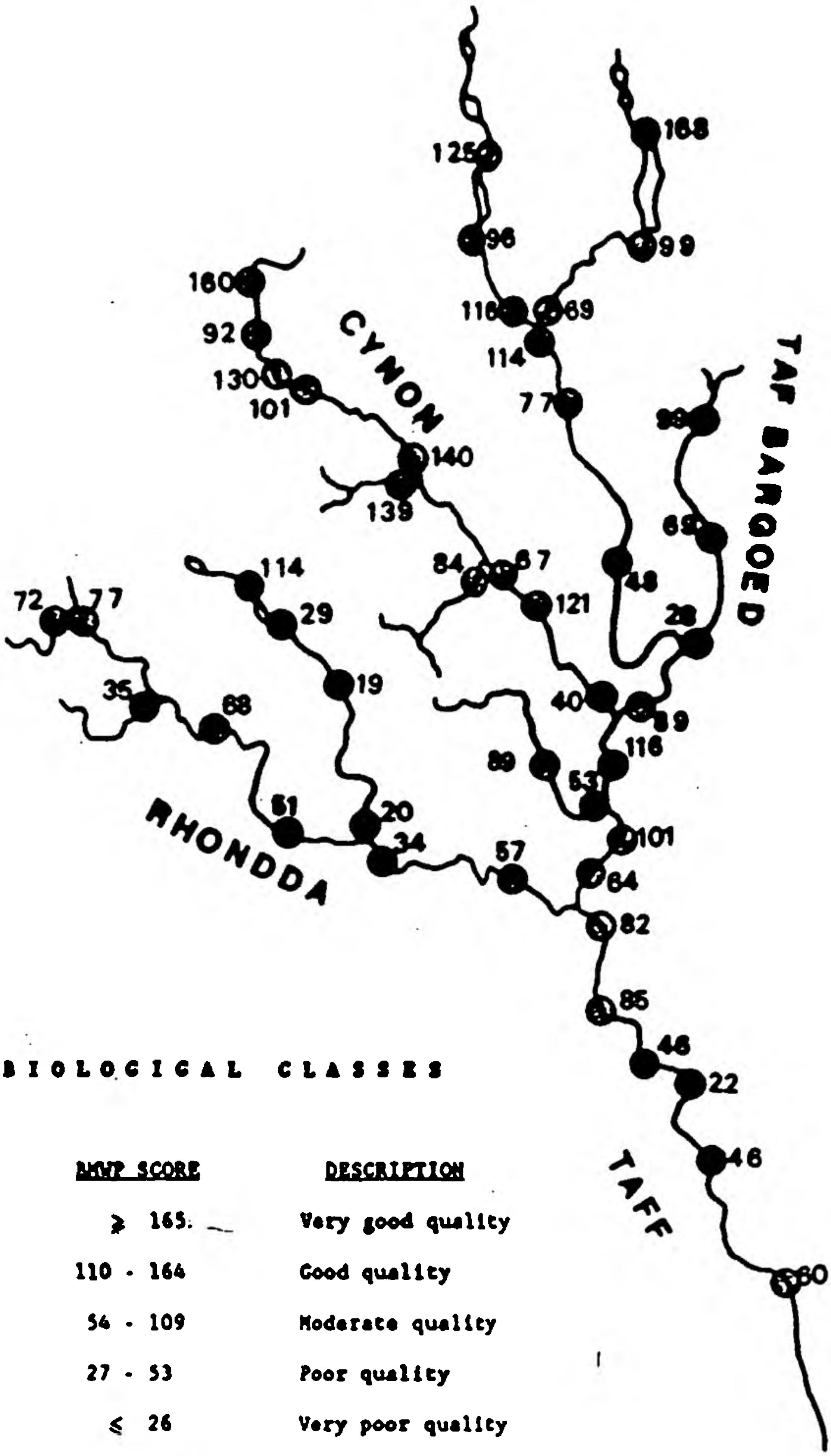
FIGURE 6.4

RIVER TAFF CATCHMENT
DISSOLVED OXYGEN



River Taff Catchment : Biological Sampling Sites

Spring - 1986

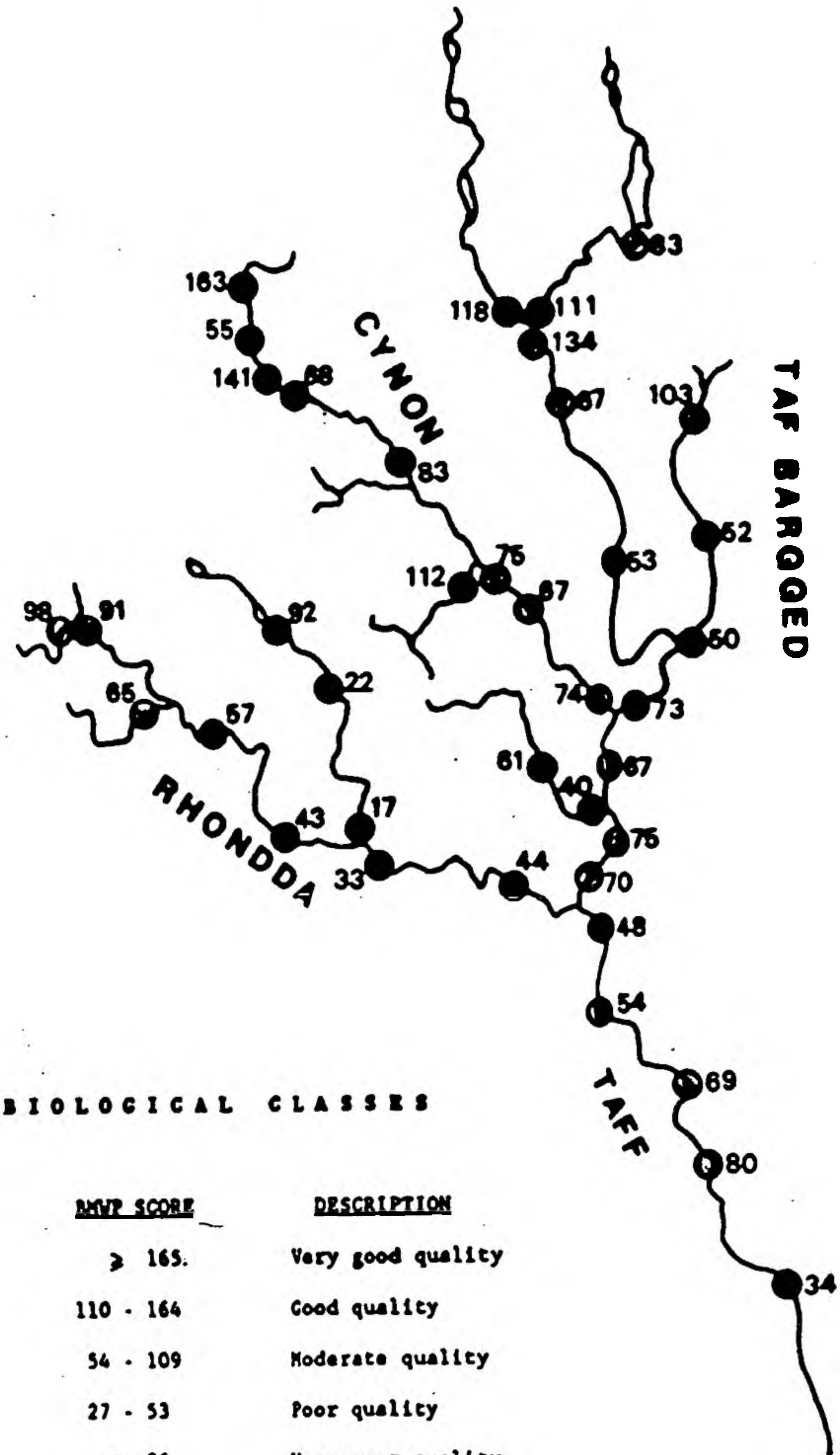


KEY TO BIOLOGICAL CLASSES

CLASS	BMWP SCORE	DESCRIPTION
1	≥ 165	Very good quality
2	110 - 164	Good quality
3	54 - 109	Moderate quality
4	27 - 53	Poor quality
5	≤ 26	Very poor quality

River Taff Catchment: Biological Sampling Sites

Spring - 1990

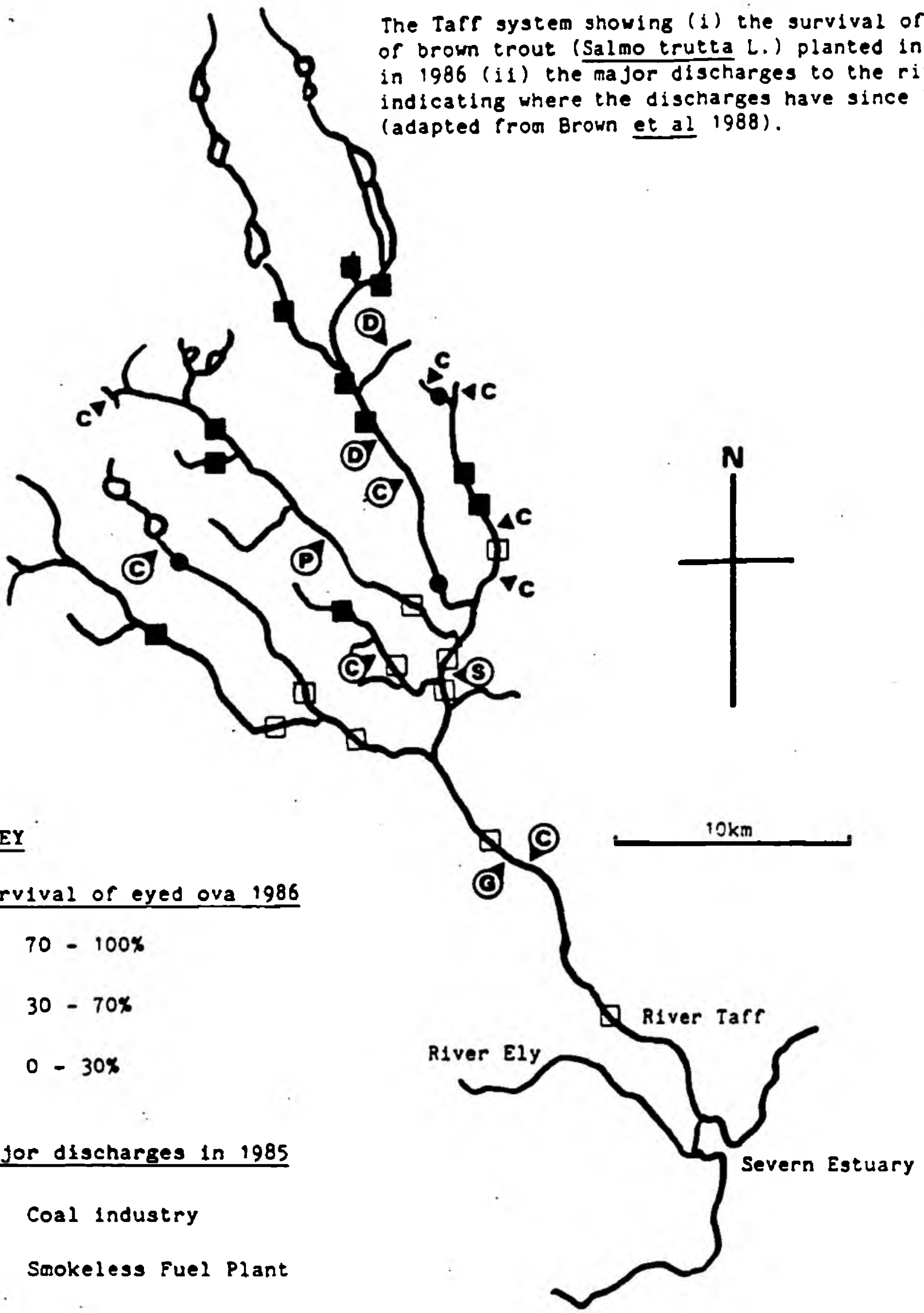


KEY TO BIOLOGICAL CLASSES

CLASS	BMWP SCORE	DESCRIPTION
1	≥ 165.	Very good quality
2	110 - 164	Good quality
3	54 - 109	Moderate quality
4	27 - 53	Poor quality
5	≤ 26	Very poor quality

FIGURE 8

The Taff system showing (i) the survival of eyed ova of brown trout (Salmo trutta L.) planted in egg boxes in 1986 (ii) the major discharges to the river in 1985, indicating where the discharges have since been changed (adapted from Brown et al 1988).



KEY

Survival of eyed ova 1986

■ 70 - 100%

● 30 - 70%

□ 0 - 30%

Major discharges in 1985

C Coal industry

P Smokeless Fuel Plant

S Large sewage treatment works

G Gelatin factory

D Other industrial discharges

○ Discharges which have ceased, been diverted to sewer, or receive improved treatment since 1985

FIGURE 1

Potential salmon spawning and nursery areas in the Taf system identified in 1985/6, showing the positions of four large weirs and the site of the proposed estuary barrage.

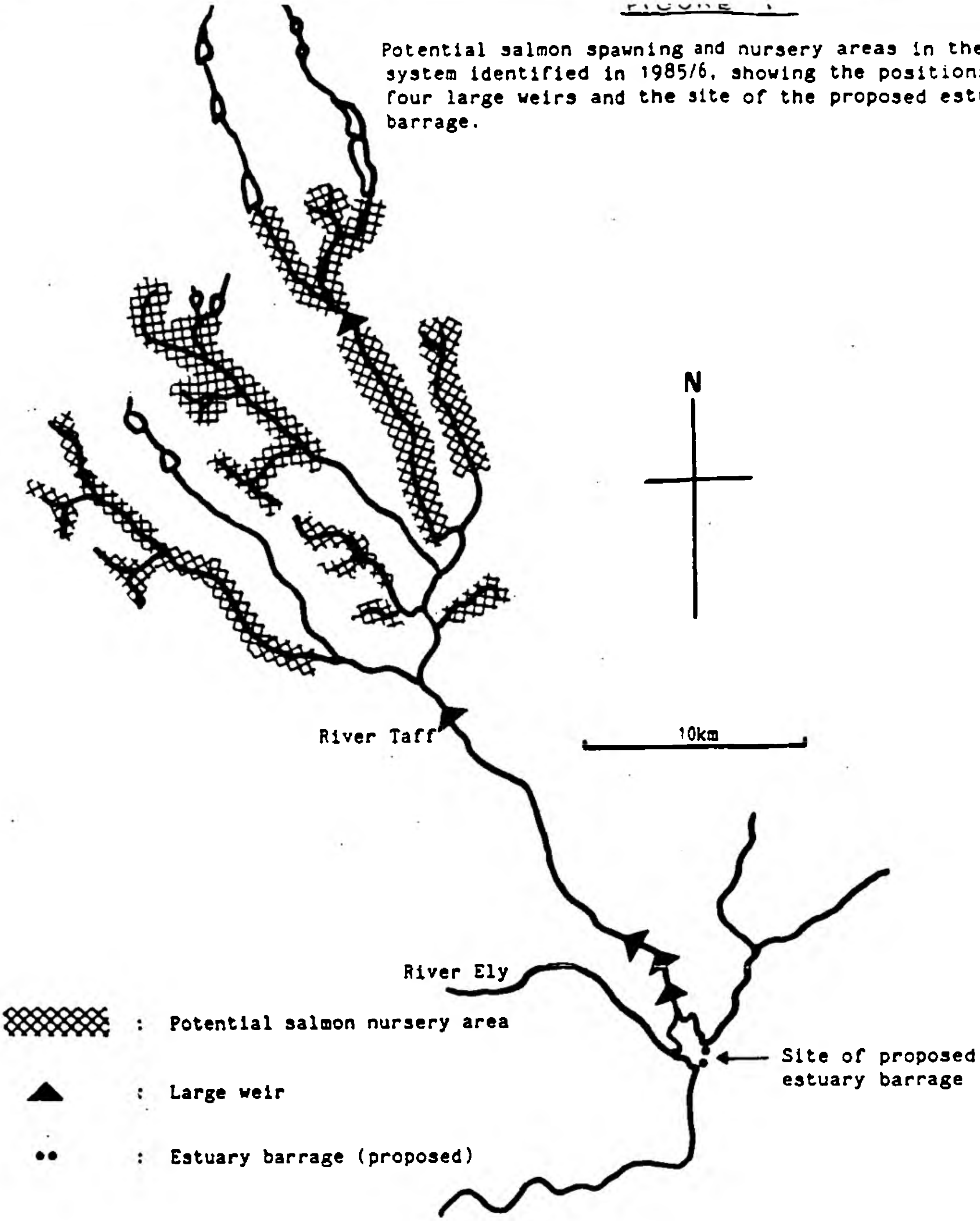


TABLE I

RESULTS OF SURVEYS OF COAL WASHERIES IN TAFF CATCHMENT IN 1952

COLLIERY	Date of Sample	Result of Analysis (parts per 100,000)	Approx. Period of Working Hours	Approx. Total Deposit per Annum (tons)
Abercynon	23.1.52	5,791	8	7,781
Albion	23.1.52	4.707	8	6.300
Cambrian	5.2.52	5,162	16	13,880
Cwmparc	5.2.52	2,530	22	9,337
Deep Duffryn	31.1.52	1.454	10	2,318
Ferndale	19.2.52	2,411	8	3,238
Fernhill	19.2.52	2,029	15	5,459
Gelli	5.2.52	126	15	301
Glyn Rhondda	19.2.52	5,200	8	7,028
Lady Windsor	29.1.52	84	8	113
Lewis Merthyr	4.2.52	46	16	123
Maritime	3.10.51	1,211	8	1,631
Merthyr Vale	19.2.52	650	8	873
Middle Duffryn Power Station (Fine Ash) 365 days	25.1.52	608	24	3,540
Middle Duffryn	25.1.52	650	8	873
Navigation	14.2.52	2,198	16	5,898
National	4.2.52	603	8	803
Naval	4.2.52	4,239	16	11,395
Penrhiwceiber	31.1.52	139	10	225
Taff Merthyr	21.3.52	675	8	903
Tower	28.1.52	2	24	5

TABLE 2

AVERAGE BIOCHEMICAL OXYGEN DEMAND AT PARC NEWYDD 1958 - 1983

YEAR	BOD (mg/l)	
1958	4.0	(3 samples)
1959	7.0	(10 samples)
1960	5.5	(12 samples)
1961	6.1	(10 samples)
1962	5.9	(8 samples)
1963	6.7	(10 samples)
1964	5.2	(? samples)
1965	-	-
1966	5.8	(? samples)
1967	7.3	(8 samples)
1968	5.0	(12 samples)
1969	6.5	(9 samples)
1970	6.2	(10 samples)
1971	4.6	(7 samples)
1972	5.3	(6 samples)
1973	3.3	(10 samples)
1974	4.1	(8 samples)
1975	5.1	(10 samples)
1976	2.8	(11 samples)
1977	2.1	(13 samples)
1978	2.4 (ATU)	(10 samples)
1979	2.5 (ATU)	(12 samples)
1980	2.6 (ATU)	(12 samples)
1981	2.0 (ATU)	(12 samples)
1982	2.1 (ATU)	(12 samples)
1983	1.9 (ATU)	(13 samples)

Discharge from tanks stopped in June 1976

TABLE 3

Cyanide, Phenols and Metals Concentrations in Discharges from Troedyrhiw and Parc Newydd Storm Tanks 1968 - 1974

		Cyanide (mg/l)	Phenols (mg/l)	Zinc (mg/l)	Copper (mg/l)	Chromium (mg/l)	Nickel (mg/l)
Troedyrhiw	max.	0.56	1.50	5.20	0.58	1.70	81.00
	mean	0.17	0.50	1.13	0.29	0.35	7.70
	min.	<0.01	<0.10	0.10	<0.01	<0.01	<0.01
Parc Newydd	max.	3.00	0.40	2.40	0.24	0.10	1.00
	mean	0.48	0.16	0.62	0.06	0.03	0.24
	min.	<0.01	<0.10	0.08	<0.01	<0.01	<0.01

TABLE 4

Tentative Environmental Quality Standards (EQS) for potential salmon nursery areas and the river downstream through which smolts and adults migrate.

	EQS
Spawning and nursery area :	(i) Compliance with the European Community's Directive for Freshwater fish - salmonids.
	(ii) Support benthic macroinvertebrate communities intolerant of pollution: i.e. Groups I and II (Bent *et al* 1986)
Migration zones :	Water samples comply with National Water Council water quality class 2.
	i.e. (i) Dissolved oxygen >40% saturation (ii) BOD ≤9 mgl^{-1} with a mean of <5 mgl^{-1} (iii) Non-toxic to fish as defined in Alabaster and Lloyd (1986)

TABLE 5 DISTRIBUTION (km) OF RIVER QUALITY ACCORDING TO THE CLASSIFICATIONS OF 1969,1978,1983,1985 and 1989. PERCENTAGE OF TOTAL RIVER STRETCH IN PARENTHESIS, 142 km FOR 1969 - 1983 147.9 km FOR 1985 - 1989

CLASS	1969	1978	1983	1985	1989	LTRQO
1	45 (32%)	52.5 (37%)	73 (57%)	110.2 (75%	76.5 (52%)	144.9(98%)
2	34.6 (29%)	41.3 (29%)	28 (20%)	22.4 (15%)	54.3 (37%)	2.9 (2%)
3	53.2 (38%)	36.6 (26%)	40 (28%)	13.5 (9%)	17.1 (11%)	0
4	9.2 (6%)	12.2 (8%)	2.1 (1%)	1.8 (1%)	0	0

River quality

APPENDIX 1.

Introduction

1 Rivers in the upper parts of the catchment are usually clean and relatively free from pollution. On their way towards the sea, however, many are used as sources of water supply which reduces the volume of flow, and as carriers and diluents for sewage and industrial effluent which may cause deterioration in the quality of the river. If the quantity of effluents discharged is small in relation to the volume of natural flow in the river, the pollution may be insignificant and the river will recover by the natural processes of self-purification. The self-purifying properties are, however, limited and excessive discharges of polluting effluent will cause deterioration which may continue progressively to the point where the river begins to show one or more of the familiar signs of serious pollution such as loss of dissolved oxygen, deterioration in appearance, increased turbidity, loss of fish, change in flora, silting, smell and so on; its waters may eventually become of very limited use and, in the extreme, grossly offensive.

Quality criteria

2 For the purpose of the survey rivers were classed by chemical criteria under the following general headings:

- Class 1 Rivers unpolluted and recovered from pollution.
- Class 2 Rivers of doubtful quality and needing improvement.
- Class 3 Rivers of poor quality requiring improvement as a matter of some urgency.
- Class 4 Grossly polluted rivers.

3 The classes are not based on a single criterion but represent a practical compromise of several which collectively meet the general concepts of river pollution, e.g. occurrence of polluting discharges, BOD, dissolved oxygen, turbidity, absence of fish life, frequency of complaints. A fuller description of the relevant parameters is given below:

Class 1

Rivers unpolluted and recovered from pollution

(a) All lengths of rivers whatever their composition, which are known to have received no significant polluting discharges.

(b) All rivers which, though receiving some pollution, have a BOD less than 3 mg/l, are well oxygenated and are known to have received no significant discharges of toxic materials or of suspended matter which affect the condition of the river bed.

(c) All rivers which are generally indistinguishable biologically from those in the area known to be quite unpolluted, even though the BOD may be somewhat greater than 3 mg/l.

Class 2

Rivers of doubtful quality and needing improvement

(a) Rivers not in Class 1 on BOD grounds and which have a substantially reduced oxygen content at normal dry summer flows or at any other regular times.

(b) Rivers, irrespective of BOD, which are known to have received significant toxic discharges which cannot be proved either to affect fish or to have been removed by natural processes.

(c) Rivers which have received turbid discharges which have had an appreciable effect on the composition of the water or character of the bed but have had no great effect on the biology of the water.

(d) Rivers which have been the subject of complaints which are not regarded as frivolous but which have not been substantiated.

Class 3

Rivers of poor quality requiring improvement as a matter of some urgency

(a) Rivers not in Class 4 on BOD grounds and which have a dissolved oxygen saturation, for considerable periods, below 50 per cent.

(b) Rivers containing substances which are suspected of being actively toxic at times.

(c) Rivers which have been changed in character by discharge of solids in suspension but which do not justify being placed in Class 4.

(d) Rivers which have been the subject of serious complaint accepted as well-founded.

Class 4

Grossly polluted rivers

(a) All rivers having a BOD of 12 mg/l or more under average conditions.

(b) All rivers known to be incapable of supporting fish life.

(c) All rivers which are completely deoxygenated at any time, apart from times of exceptional drought.

(d) All rivers which are the source of offensive smells.

(e) All rivers which have an offensive appearance, neglecting for these purposes any rivers which would be included in this class solely because of the presence of detergent foam.

4 These are the same criteria as were adopted for the 1958 survey and, by close contact with the authorities, every effort was made to ensure a uniform approach to the completion of the survey data.

River Class	Quality criteria	Remarks	Current potential uses
	Class limiting criteria (95 percentile)		
1A Good Quality	(i) Dissolved oxygen saturation greater than 80% (ii) Biochemical oxygen demand not greater than 3 mg/l (iii) Ammonia not greater than 0.4 mg/l (iv) Where the water is abstracted for drinking water, it complies with requirements for A2* water (v) Non-toxic to fish in EIFAC terms (or best estimates if EIFAC figures not available)	(i) Average BOD probably not greater than 1.5 mg/l (ii) Visible evidence of pollution should be absent	(i) Water of high quality suitable for potable supply abstractions and for all other abstractions (ii) Game or other high class fisheries (iii) High amenity value
1B Good Quality	(i) DO greater than 60% saturation (ii) BOD not greater than 5 mg/l (iii) Ammonia not greater than 0.9 mg/l (iv) Where water is abstracted for drinking water, it complies with the requirements for A2* water (v) Non-toxic to fish in EIFAC terms (or best estimates if EIFAC figures not available)	(i) Average BOD probably not greater than 2 mg/l (ii) Average ammonia probably not greater than 0.5 mg/l (iii) Visible evidence of pollution should be absent (iv) Waters of high quality which cannot be placed in Class 1A because of the high proportion of high quality effluent present or because of the effect of physical factors such as canalisation, low gradient or eutrophication (v) Class 1A and Class 1B together are essentially the Class 1 of the River Pollution Survey (RPS)	Water of less high quality than Class 1A but usable for substantially the same purposes
2 Fair Quality	(i) DO greater than 40% saturation (ii) BOD not greater than 9 mg/l (iii) Where water is abstracted for drinking water it complies with the requirements for A3* water (iv) Non-toxic to fish in EIFAC terms (or best estimates if EIFAC figures not available)	(i) Average BOD probably not greater than 5 mg/l (ii) Similar to Class 2 RPS (iii) Water not showing physical signs of pollution other than humic colouration and a little foaming below weirs	(i) Waters suitable for potable supply after advanced treatment (ii) Supporting reasonably good coarse fisheries (iii) Moderate amenity value
3 Poor Quality	(i) DO greater than 10% saturation (ii) Not likely to be anaerobic (iii) BOD not greater than 17 mg/l. This may not apply if there is a high degree of re-aeration	Similar to Class 3 of RPS	Waters which are polluted to an extent that fish are absent or only sporadically present. May be used for low grade industrial abstraction purposes. Considerable potential for further use if cleaned up
4 Bad Quality	Waters which are inferior to Class 3 in terms of dissolved oxygen and likely to be anaerobic at times	Similar to Class 4 of RPS	Waters which are grossly polluted and are likely to cause nuisance
X	DO greater than 10% saturation		Insignificant watercourses and ditches not usable, where the objective is simply to prevent nuisance developing

Notes

(a) Under extreme weather conditions (eg flood, drought, freeze-up), or when dominated by plant growth, or by aquatic plant decay, rivers usually in Class 1, 2 and 3 may have BODs and dissolved oxygen levels, or ammonia content outside the stated levels for those Classes. When this occurs the cause should be stated along with analytical results.

(b) The BOD determinations refer to 5 day carbonaceous BOD (ATU). Ammonia figures are expressed as NH_4.

(c) In most instances the chemical classification given above will be suitable. However, the basis of the classification is restricted to a finite number of chemical determinands and there may be a few cases where the presence of a chemical substance other than those used in the classification markedly reduces the quality of the water. In such cases, the quality classification of the water should be down-graded on the basis of biota actually present, and the reasons stated.

(d) EIFAC (European Inland Fisheries Advisory Commission) limits should be expressed as 95 percentile limits.

* EEC category A2 and A3 requirements are those specified in the EEC Council Directive of 18 June 1975 concerning the Quality of Surface Water Intended for Abstraction of Drinking Water in the Member State.

WELSH WATER AUTHORITY - TABLE FOR CLASSIFICATION OF RIVER WATER QUALITY

This table follows NWC recommendations by including NWC criteria for DO BOD and Ammonia, recommendations of EIFAC and mandatory ('I') values of the EEC Directive on Quality of Surface Water Intended for the Abstraction of Drinking Water. For classifying rivers, use this Table with Form R001d.

	Determinand	As	95%ile Class Limiting Criteria (in mg/l, except DO, pH & T°C)							
N	D.O. Satur'n.●	5%ile	≮80%	≮60%	(50%)	≮40%	(25%)	≮10%	<10%	≮10%
W	B O D (ATU)●	O	3.0	5.0	(7.0)	9.0	13.0	17.0+	-	-
C	Ammonia●	N	0.31	0.7	(see	Table)+	-	-	-	-
	Temperature	°C	20°	20°	-	30°	-	-	-	-
E	pH Value	-	5 to 9	5 to 9	-	5 to 9	-	-	-	-
I	Susp. Solids	-	25 x	25 x	-	80 x	-	(400)+	-	-
F	Sol. Copper	Cu	0.005-0.1+	0.005-0.1+	-	-	-	-	-	-
A	Total Zinc	Zn	0.03-0.5+	0.03-0.5+	-	0.3-2.0+	-	-	-	-
C	Mono.Phenols	C_6H_5OH	1.0	1.0	-	2.0	-	-	-	-
	Chlorine	Cl	≡0.004+	≡0.004+	-	≡0.004+	-	-	-	-
	Temperature	°C	25° (O)	25° (O)	-	25° (O)	-	-	-	-
E.	Ammonia	N	1.17	1.17	-	3.1 (O)	-	-	-	-
E. C.	Nitrates●	N	11.3 (O)	11.3 (O)	-	11.3 (O)	-	-	-	-
	Arsenic	As	0.05	0.05	-	0.1	-	-	-	-
O N	Barium	Ba	1.0	1.0	-	1.0	-	-	-	-
L	Cadmium	Cd	0.005	0.005	-	0.005	-	-	-	-
Y	Tot. Chromium	Cr	0.05	0.05	-	0.05	-	-	-	-
I	Lead	Pb	0.05	0.05	-	0.05	-	-	-	-
F	Mercury	Hg	0.001	0.001	-	0.001	-	-	-	-
P.	Selenium	Se	0.01	0.01	-	0.01	-	-	-	-
W. S.	Zinc	Zn	5.0	5.0	-	5.0	-	-	-	-
	Diss. Iron●	Fe	2.0	2.0	-	-	-	-	-	-
A	Cyanide	CN	0.05	0.05	-	0.05	-	-	-	-
B S	Phenols	C_6H_5OH	0.005	0.005	-	0.1	-	-	-	-
T R	Sulphates	SO_4	250 (O)	250 (O)	-	250 (O)	-	-	-	-
A	Colour	Pt	100 (O)	100 (O)	-	200 (O)	-	-	-	-
C T	Hydrocarbons	-	0.2	0.2	-	1.0	-	-	-	-
N.	Tot. Pesticides	-	0.0025	0.0025	-	0.005	-	-	-	-
	Polycyc.Ar. H/c	-	0.0002	0.0002	-	0.001	-	-	-	-
	W.W.A. Sub-Class		-	-	(2A)	(2B)	(3A)	(3B)	-	-
	NWC QUALITY CLASS		1A	1B	-	2	-	3	4	X

+ See overleaf for Notes and additional Tables, under Determinand.

● Under extreme weather conditions or if dominated by plant growth or decay, rivers in Classes 1, 2 and 3 may have DO, BOD or Ammonia levels outside those in the table. This should be noted when classifying.

x EIFAC limits are supposed to be applied as 95%iles. This may be inappropriate, esp. for Susp. Solids in flashy rivers. Note this when classifying.

If a substance NOT in the table markedly reduces water quality, the class should be downgraded on the basis of biota present and the reason stated.

ADDITIONAL NOTES AND TABLES

BOD (ATU) - (NWC Criteria)

For NWC Class 3, 17 mg/l may not apply if the degree of re-aeration is high. If no BOD (ATU) figures are available, (Total BOD x 0.80) may be used.

AMMONIA - (EIFAC Criteria)

In absence of NWC Class 2 limit for Ammonia, the concentration (as N) equivalent to EIFAC limit of 0.025 mg/l as NH_3 (0.021 mg/l as N) may be roughly assessed from the Table using 95%ile Temperature & maximum pH for the river:

At Temp. °C	At pH Value						
	7.0	7.5	8.0	8.5	9.0	9.5	
5	16.1	5.2	1.6	0.54	0.18	0.072	Ammonia concentrations are as N
10	11.0	3.5	1.13	0.37	0.13	0.056	
15	7.5	2.4	0.77	0.26	0.10	0.044	
20	5.2	1.65	0.54	0.18	0.072	0.037	
25	3.6	1.18	0.39	0.14	0.057	0.032	
30	2.6	0.82	0.27	0.099	0.046	0.029	

SOLUBLE COPPER - (EIFAC Criteria)

Class limiting criteria for Soluble Copper for NWC Classes 1A & 1B may be roughly assessed from this Table, using the 5%ile Hardness of the water:

Water Hardness (mg/l as $CaCO_3$)	10	50	100	300
95%ile Soluble Copper as mg/l Cu	0.005	0.022	0.040	0.112

TOTAL ZINC - (EIFAC Criteria)

Class limiting criteria for Total Zinc for NWC Classes 1A, 1B & 2 may be roughly assessed from the Table, using the 5%ile Hardness of the water:

95%ile Total Zinc as mg/l Zn for	Water Hardness (mg/l as $CaCO_3$)			
	10	50	100	500
Classes 1A & 1B (Salmonids)	0.03	0.2	0.3	0.5
Class 2 (Coarse Fish)	0.3	0.7	1.0	2.0

CHLORINE - (EIFAC Criteria)

The NWC Class 1A, 1B & 2 criteria for Chlorine (as Cl) corresponding to the EIPAC limit of 0.004 mg/l as HOCl may be roughly assessed from the Table using the minimum pH Value and 5%ile Temperature of the water :

At Temperature °C	At pH Value			
	6	7	8	9
5	0.004	0.005	0.011	0.075
25	0.004	0.005	0.016	0.121

EEC DIRECTIVE 'I' VALUE LIMITS

Maximum values for these determinands (except Temperature) should not exceed the 'I' values listed by more than 50%. There are waivers relating to natural enrichment and also for :

Values marked '(O)' in exceptional meteorological or geographical conditions.
Determinands marked '*' for shallow lakes and 'virtually stagnant water'.

WELSH WATER AUTHORITY SUB-CLASSES (SUGGESTED)

The divisions between the suggested Sub-Classes have DO and BOD values halfway between those for the NWC classes. Although values for other determinands have not been suggested for WWA Class '2A' they would have to be no greater than those for NWC Class 2. Sub-Classes should not be used in setting RQO's but possibly internally for measurement of progress.

78.DHM.