National Rivers Authority
Severn Trent Region
TRENT LICENSING POLICY REVIEW
DRAFT FINAL REPORT

0	For Comment	14-2-92 RPC Brown	17-2-92 [signature]	17-2-92 [signature]
VERSION	PURPOSE	PREPARED BY	CHECKED BY	REVIEWED BY

K1051/060/0/019

TRENT LICENSING POLICY REVIEW

DRAFT FINAL REPORT

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

WS Atkins were appointed by the Severn-Trent Region of the National Rivers Authority on 11 September 1991 to review the licensing policy for the Trent Catchment. One of the main reasons for the study is the increasing demand being placed on the Trent for public water supply.

We have investigated the existing uses of the river, their requirements and the ability of the Trent to meet them. These uses include the power generation industry, effluent disposal, navigation, recreation and the very good coarse fishery. We have assessed the potential impact of proposed abstractions on these uses in particular, and on the river environment in general.

There are significant water resources available in the River Trent, particularly in non-drought years. This is due both to the size of the catchment and the large augmentation it receives via sewage treatment works. However, during dry periods the river is affected and many of the existing users of the river suffered stress in one form or another during the 1989 to 1991 droughts. For this reason we consider that the aspirations of future abstractors in terms of the amount and timing of water they require are not compatible with the needs of the river environment and its existing users. We therefore feel that a Minimum Residual Flow policy is necessary to protect the river.

For this Draft Final Report we have kept the Executive Summary to a minimum. We would propose that following discussion and receipt of comments, we would produce a short Executive Summary Report of 6 to 10 pages. This would detail the principal findings of the study and its main conclusions.

At this stage we recommend that readers of this report with insuffiicent time to consider it fully concentrate on Sections 7 and 9 which deal with the proposals for water abstraction and the Options for a Licencing Policy.

2.0 INTRODUCTION

WS Atkins were appointed by the Severn-Trent Region of the National Rivers Authority (NRA-ST) on 11 September 1991 to review the licensing policy for the Trent catchment. An Inception Meeting was held on 19 September 1991 to consider the study in detail and, in particular, the data requirements. A number of subsequent meetings were held, both with the NRA and interested users of the river, to discuss the implications of a change in licensing policy. This final report is based on the views expressed at those meetings and analysis of the data provided by NRA-ST.

One of the main reasons for the study is the increasing interest being taken in the River Trent for water abstraction, and public water supply in particular. This reflects the significant improvement in the water quality of the Trent and the continuing rise in per capita water consumption. However, any further abstraction must take account of traditional interests in the river, particularly the power generation industry, and the importance of the Trent as a coarse fishery and recreational resource.

A preliminary report was prepared for NRA-ST in November 1991 which primarily addressed a particular proposal by the South Staffordshire Water Company to abstract water from the River Trent for public water supply.

This final report assesses the state of the River Trent as a whole, summarising the various uses made of, and demands placed on the river. It seeks to pull together the aspects of the various interests relevant to abstraction of water from the river. From these the report presents some alternatives for establishing a framework within which a licensing policy can be formulated.

3.0 SCOPE OF THE STUDY

The principal aim of the study is to review the current policy of NRA Severn Trent for considering and granting licences to abstract water from the River Trent, and to present alternatives for formulating a revised policy. The study does not review the licensing policy used on the Trent tributaries, although the volumes of water licensed for abstraction from these tributaries are considered as a potential depletion to the natural flow in the main river.

In order to achieve this aim, we have considered the main uses of the river, and their individual requirements, particularly where these are sensitive to changes in the flow regime. To this end, we have met or spoken with the following bodies:

NRA - Severn Trent (Regional and district offices)
NRA - Anglian Region
PowerGen
National Power
South Staffordshire Water Company
Severn-Trent Water Plc
Anglian Water Services Plc
British Waterways Board
National Sports Council (Holme Pierrepont)
Nottingham County Council
Scottish Hydro Electric Plc

We describe the current state of the catchment in terms of its ability to meet these requirements, and the possible effects of future water abstraction. We then present various alternatives for future licensing policy on the river which take account of these requirements and demands.

Confidential information relating to meetings and actual abstractions is presented in a separate document containing the appendices.

4.0 DESCRIPTION OF THE CATCHMENT

The River Trent drains the Midlands region of England and has a catchment area of nearly 10,500km^2, containing a population of over 5.5 million people. The river has five major tributaries as can be seen on Figure 4.1. The Dove and the Derwent originate in the Peak District; the Tame drains the industrial West Midlands; the Soar drains the agricultural areas of Leicestershire; and the Idle joins the Trent in its lower reaches. The mean annual effective precipitation varies from over 1000mm in the headwaters of the Derwent to as little as 100mm in the Idle catchment. However, the majority of the catchment experiences less than 300mm a year.

The catchment contains substantial urban and industrial areas, with consequently high volumes of effluent being discharged to the river. Historically, this led to poor water quality within the catchment, and particularly in the Tame and Trent itself. The cleaner rivers were the Derwent and Dove which were therefore exploited for public water supply for the major cities in the area, including Nottingham, Derby, Leicester and, outside the catchment, Sheffield. The water supply for Birmingham and the West Midlands, however, is imported from outside of the Trent catchment. Primarily these imports come from the Welsh Mountains through the Elan Valley aqueduct, although in more recent years a considerable amount of water has been taken from the River Severn. This imported water then discharges, through water reclamation works, firstly to the Tame, and then to the Trent, thus augmenting flows in the river.

The relatively large flows in the river, and the proximity of coalfields and demand centres, led to the establishment of a substantial power generation industry along the Trent. There are currently 10 power stations on the Trent and 1 on the Tame, as can be seen from Figure 4.1. However both Meaford and Hams Hall are now being de-commissioned.

The Trent is a navigable river as far upstream as Nottingham and is heavily used as a through route to the canal network in the rest of the country. Access to the river is therefore generally very good and the river has become an important recreational resource. This is particularly evident in the Nottingham area where the development of the rowing course and canoe slalom at Holme Pierrepont are of national importance.

The Trent supports an abundant and diverse coarse fish population throughout much of its length. This has led to the development of an intense recreational fishery along the river, which provides enjoyment for a large number of people. It is regarded by many as the best coarse fishery in the UK. The NRA would also like to see the return of migratory salmon to the Trent.

5.0 USES OF THE RIVER TRENT

The following sections describe the uses of the River Trent and their particular requirements. They provide a necessary background against which to consider any changes to licensing policy, including new abstractions for public water supply.

5.1 Water Abstraction

Abstractors taking water from surface and groundwaters were first required to obtain a licence from the local River Authority in the Water Act of 1963. Those who could demonstrate that they had been abstracting water at a certain rate over the previous 5 years were automatically entitled to a licence to allow them to continue to do so indefinitely. These 'Licences of Right' exert the first claim over any water available in the water body, and the statutory authority acting as the licensor is obliged, under the Act, to ensure that no future abstraction may derogate from these licences.

Under the Water Act of 1989 and Water Resources Act of 1991, the authority to grant licences and the duty to protect those already in existence was transferred to the National Rivers Authority.

5.1.1 The Power Generation Industry

The principal abstractions from the River Trent are the nine power stations which are still operational. The water requirements of the stations are a function of the method of cooling which they employ.

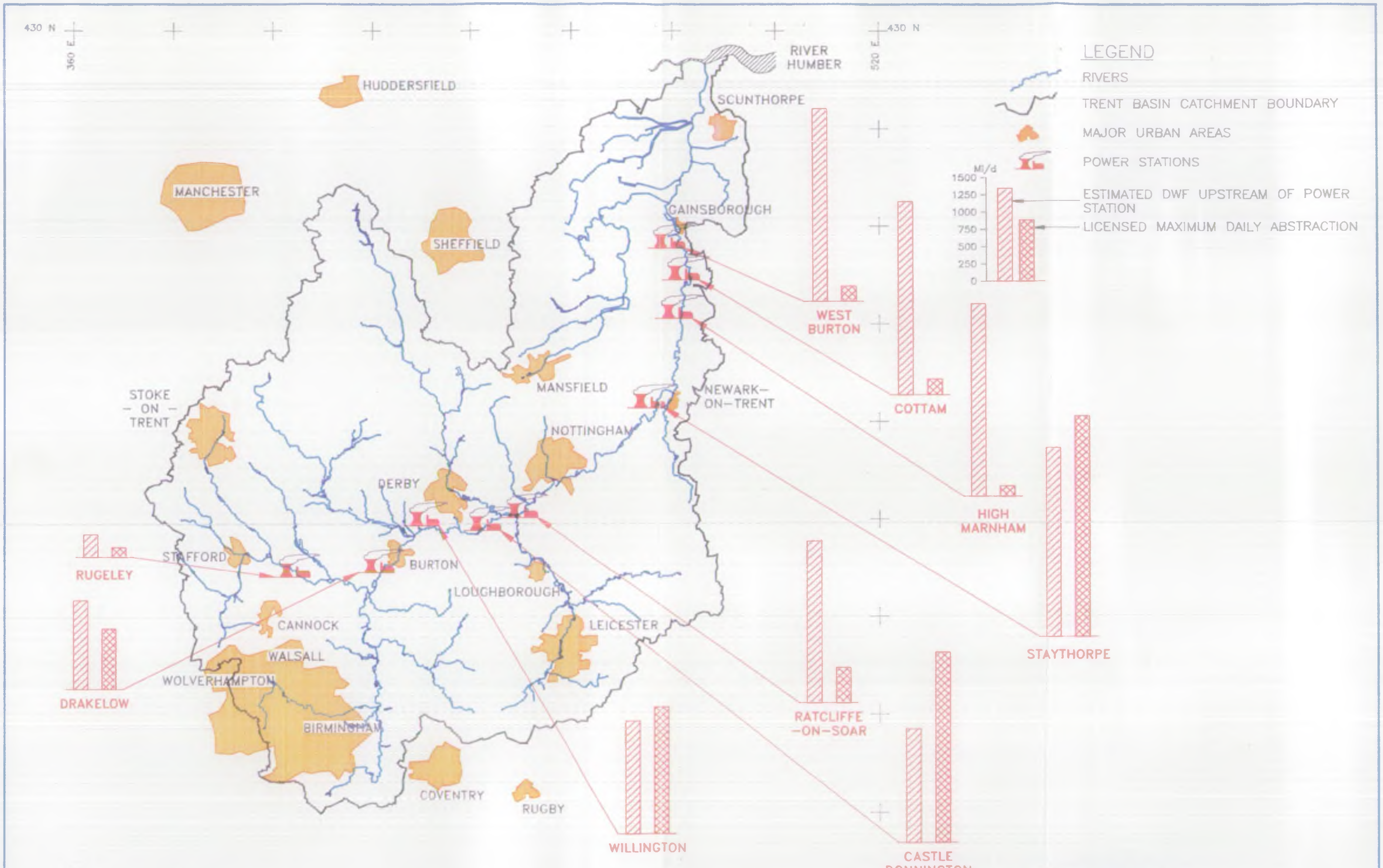
The older stations use direct cooling whereby water is abstracted from the river, passed though the condensers and returned to the river, typically 8° to 10°C warmer. Direct cooled stations therefore abstract large volumes of water, around 3000 Mld in some cases, but return it to

the river with very small losses. However, it is important to note that subsequent increased evaporation will occur from the warmer river water, resulting in some indirect losses. There are three stations on the Trent that use this method: Willington, Castle Donnington, and Staythorpe B.

The more recent stations employ evaporative cooling. This process involves abstracting water from lagoons below the cooling towers, passing it through the condensers and then discharging the warmer water into the cooling towers. Some of the water is then lost through evaporation with the remainder falling back into the lagoons. Abstractions from the river to the cooling water lagoons are required to replace the water lost through evaporation and to achieve flushing to minimise the accumulation of sediment and minerals. Typically, daily abstractions from the river are 3% of the total cooling system volume, two thirds of which is returned to the river with the remainder being evaporated. These stations therefore require lower volumes of water to be taken from the river, although the direct consumptive use is higher due to evaporation from the cooling towers. On the Trent, five stations are entirely evaporative cooled: Rugeley, Ratcliffe, High Marnham, Cottam and West Burton.

Mixed cooled stations can use either method, but predominantly rely on direct cooling as it is the more efficient process. The evaporative cooling systems on these stations are used only when the station is having difficulty achieving its discharge consent in terms of the temperature of the downstream river water. Drakelow is the main mixed cooled station on the Trent.

The location of the power stations in the Trent basin can be seen on Figure 5.1. The figure compares the relative size of the maximum daily licensed quantity with the 'dry weather flow' of the river (equivalent to the 7 day annual average minimum) for each of the stations. For clarity this information is also listed in Table 5.1. Table 5.1 is reproduced along with the average daily abstraction and evaporation quantities for 1990 in Appendix B of the Appendix document.



POWER STATIONS IN THE TRENT BASIN

FIG 5.1

It can be seen from Figure 5.1 that the direct cooled stations at Willington, Castle Donnington and Staythorpe have maximum daily licences greater than the dry weather flow.

The typical pattern of water usage can be seen from Figures 5.2 to 5.10 in Appendix B. These show actual monthly abstraction and evaporation quantities for 1990 and early 1991. It can be seen that there is some seasonality in abstractions, particularly for the direct cooled stations. This is more evident for the evaporation losses from the evaporative cooled stations. These variations reflect seasonal trends in power demand. During the summer months electricity requirements are lower and therefore power stations do not have to operate as often, thus reducing water usage. Some of the more efficient stations, such as Rugeley and Ratcliffe, operate as base load stations supplying power to the National Grid. These stations tend to operate almost continuously, except when essential maintenance work is being carried out. The less efficient stations are then used as required by demand.

Although a seasonal variation can be seen in the figures it is important to note that they only cover 1990/91. They could therefore be affected by planned maintenance activities. In addition, the impact of the privatisation of the power industry should not be overlooked. As can be seen from Table 5.1 the stations are almost equally split between National Power and PowerGen. The rules for the supply of electricity to the National Grid mean that individual stations bid for a variety of different strategies. This may mean bidding, for example, to supply electricity the following day or over the next 8 days. The effect of this competitive environment on the operating characteristics of individual stations is yet to be determined, but will inevitably lead to a certain amount of volatility.

Figures 5.2 to 5.10 (Appendix B) show average monthly volumes abstracted and evaporated by each of the power stations in recent years. A further useful guide to the water requirements of the power stations can be seen from Figure 5.11 to 5.19 (Appendix B). These show the maximum actual daily abstractions in individual months for a selection of representative years. It can be seen that generally there is very little variation, with maximum daily abstraction equally as likely to occur at any time of the year.

Power Station	Operator	Dry Weather Flow Ml/d	Max.daily licensed abstraction Ml/d
Rugeley	National Power	330	141
Drakelow	PowerGen	1285	873
Willington	National Power	1625	1826
Castle Donning.	PowerGen	1640	2749
Ratcliffe	PowerGen	2350	217
Staythorpe	National Power	2750	3211
High Marnham	PowerGen	>2800	154
Cottam	PowerGen	>2800	227
West Burton	National Power	>2800	218

Table 5.1 Abstraction Data for Power Stations.

The peak flows during the summer may be for maintenance purposes, such as flushing, as well as meeting peak power demands.

There are a number of pressures on the power industry which could lead to changes in water usage over the next ten years or so. However, it is important to note that reliably predicting future changes is practically impossible since the industry is controlled almost entirely by market forces. There will therefore be a high degree of uncertainty over at least the next 2 to 3 years until the market conditions become more established. The following points can therefore only be considered as guidelines at this stage:

a) The older, direct cooled stations are approaching the end of their design life. It is unlikely that stations such as Willington, Staythorpe 'B' and probably Castle Donnington will be operating much beyond 2000 to 2010.

b) New power stations will probably employ Combined Cycle Gas Turbine (CCGT) technology. These stations have a lower water requirement than traditional "steam only" stations of the same generating capacity. It is also likely that most new stations will use evaporative rather than direct cooling, such as the proposal for Staythorpe C. However, there is another proposal for the Keadby site in the lower reaches of the Trent for which direct cooling is proposed, and an abstraction in the order of 1000 Ml/d would be required. This proposal is described in more detail in Chapter 7.

c) A Flue Gas Desulphurisation (FGD) plant is being constructed at Ratcliffe-on-Soar power station. There is a possibility that a further plant could be required at some stage in the future, with Cottam power station being a potential site. The FGD plants are unlikely to have a great effect on the water requirements of the power stations, although there may be significant difficulties arising from the chloride content of the effluent discharge.

d) The NRA wish to change the temperature consent for the power stations from 30°C in the receiving water down to 28°C. This would prove extremely difficult for many of the power stations to achieve economically, as the only way to reduce river temperatures is to reduce the heat load to the river. The cost of providing the additional cooling plant could be uneconomic thus leading to the closure of these stations. The power companies will therefore strongly resist any moves to lower the consent temperature.

5.1.2 Public Water Supply

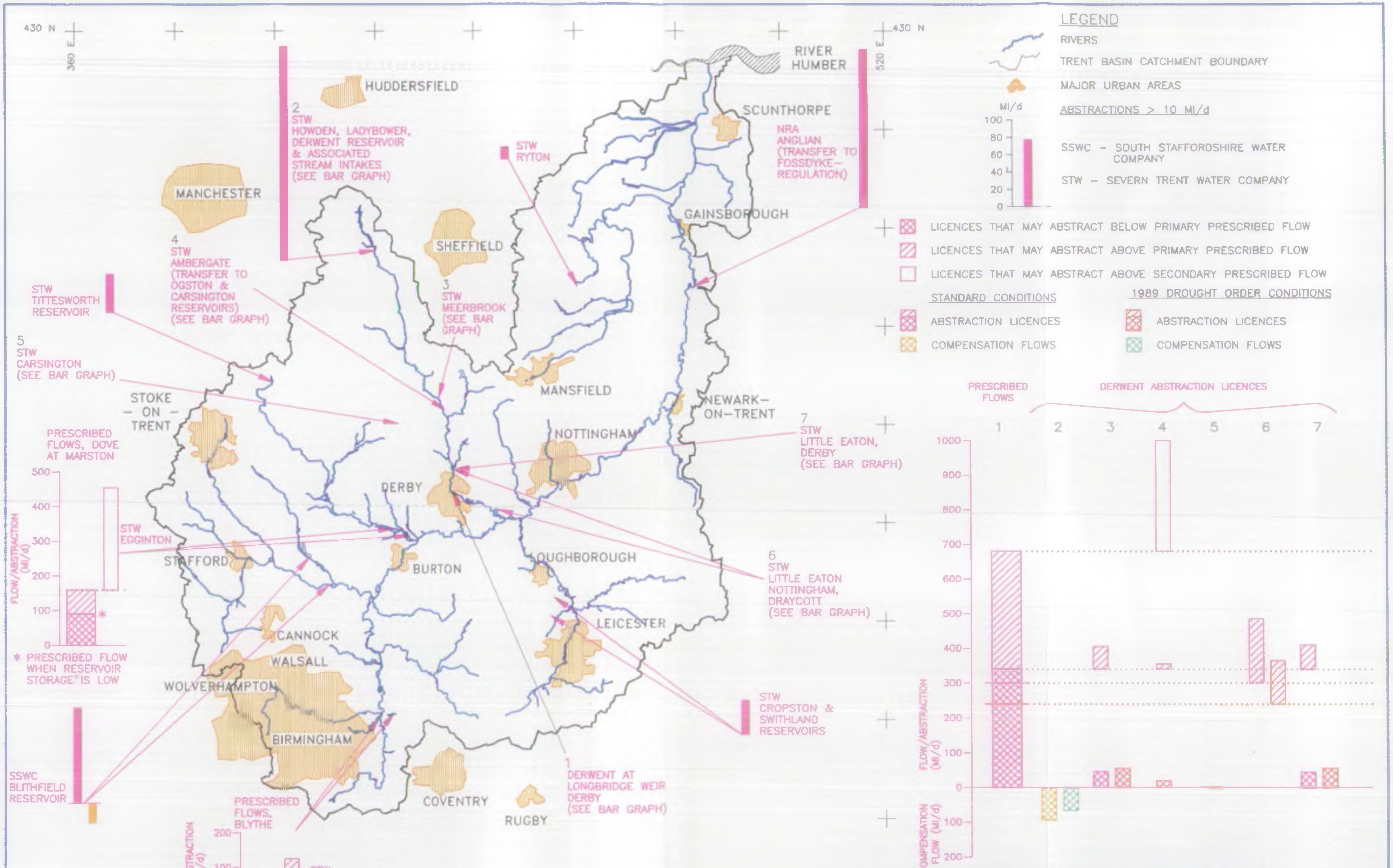
Until recently, the River Trent had no abstraction for public water supply along its length. However, during the drought of 1991, a part of the abstraction from the Trent at Torksey by NRA-Anglian was used for potable supply through an abstraction at Cadney on the River Ancholme after a subsequent transfer.

Water for potable supply within the Trent basin is taken from four main sources: surface water reservoirs in the tributaries of the Trent, groundwater, and two transfers.

Birmingham, in the south western part of the basin, is supplied primarily by a transfer from the Elan Valley reservoirs in Wales along the Elan Valley aqueduct, and imports from the River Severn by abstractions at Hampton Loade and Trimpley. These are supplemented by abstraction from groundwater within the catchment, and a surface-water reservoir at Blithfield on the River Blithe.

The Derwent, the and Soar catchment areas and the East Midlands towns of Derby, Nottingham and Leicester are supplied almost completely from the Rivers Dove and Derwent which are extensively developed for public water supply. There are also ground water supplies from boreholes in the Permo-Triassic strata in the east Midlands. The Derwent Valley reservoirs also support the supply to Sheffield. The major abstraction licences (greater than 10Ml/d) for public water supply are indicated on Figure 5.20. Note that quantities refer to maximum daily abstraction volumes. Re-abstraction licences, referring to water abstracted at one point and stored at another before being taken into supply (for example Carsington), have not been included in the Figure to avoid double counting the volume of water abstracted from rivers. The Figure also indicates the prescribed flows to which licences are tied, and the effects of the 1989 Drought Order.

The Figure demonstrates the large quantities of water licensed for abstraction relative to the prescribed flows on the Rivers Derwent and Dove. For example, the Severn-Trent Water abstraction at Egginton can abstract up to two thirds of a normal summer flow at the bottom of the River Dove, and reduce the dry weather flow of the river from 300Ml/d to 160Ml/d. Similarly, the Severn-Trent Water abstractions at Ambergate, Meerbrook, and Little Eaton (Derby and Nottingham) are licensed to effectively reduce flow in the river by 270Ml/d to 340Ml/d at Longbridge weir, Derby. The natural dry weather flow of the river, estimated by Pirt and Simpson (1983), would have been 417Ml/d.



MAJOR PUBLIC WATER SUPPLY ABSTRACTION LICENCES (>10 Ml/d) IN THE TRENT BASIN

FIG 5.20

The Dove and the Derwent are extensively used for water supply because of their high quality water. Flows that would have come down these rivers would have joined the Trent, diluting its effluent load, and thereby generally improving water quality in the Trent itself. However, the improvement in the quality of Trent water which has been sustained over the last 10 years has led to interest in using it as a source of potable supply. Three proposals for the potential development of Trent water as a potable source are currently being considered. They are described more fully in Chapter 8 of this report, but briefly they are:

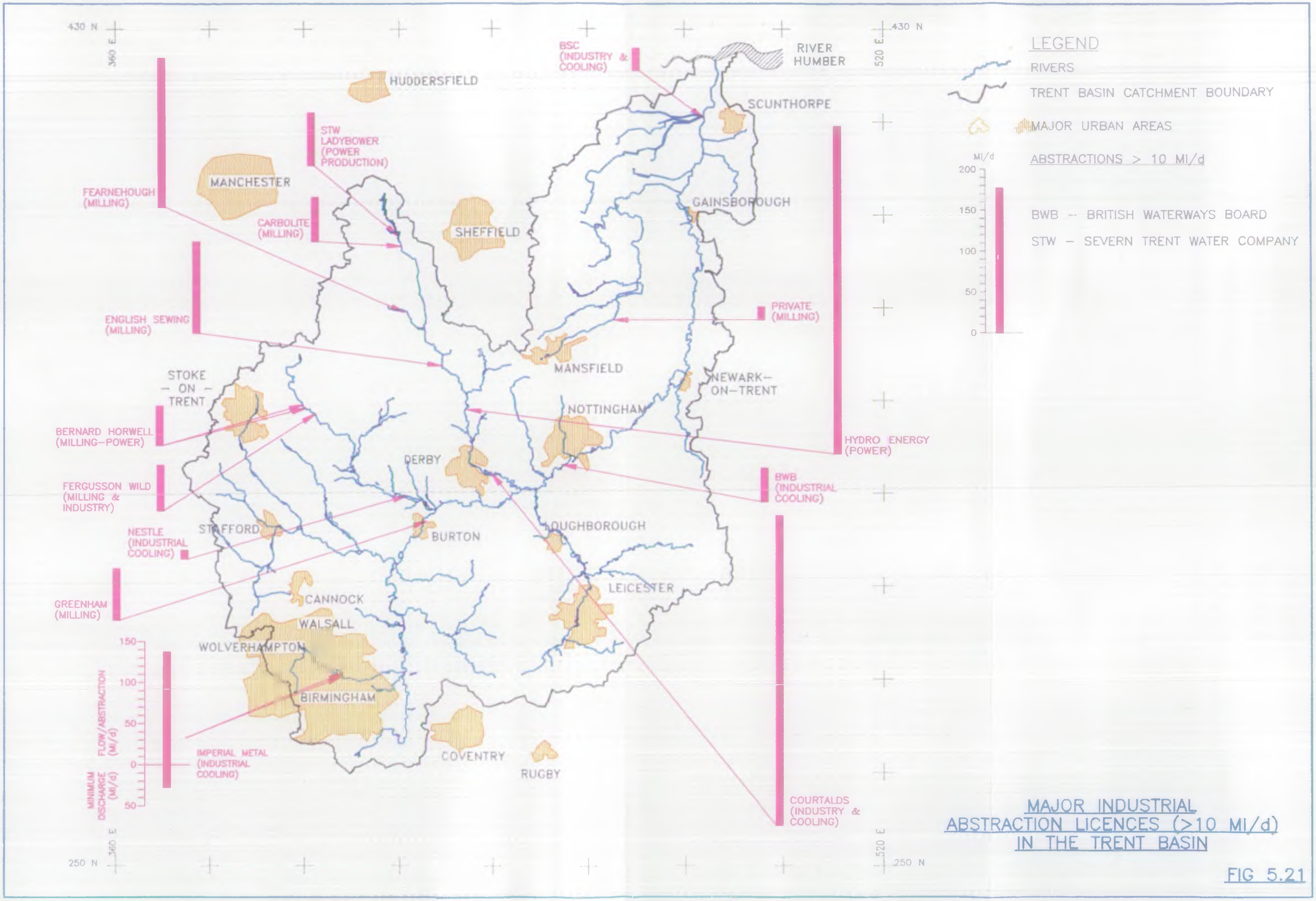
- an abstraction of 35Ml/d from the Trent at Rugeley by South Staffordshire Waterworks Company.
- an abstraction in the order of 150Ml/d around Nottingham by Severn Trent Water plc.
- an additional abstraction of the order of 600Ml/d in the tidal stretch of the river at Torksey by NRA-Anglian.

5.1.3 Industry

Abstraction for industrial uses in the broadest sense has been declining in recent years in the Trent basin. Output from sewage treatment works (water reclamation works) in the catchment has remained almost constant over the last 15 to 20 years despite continued increase in potable supplies. Additionally, groundwater levels beneath Birmingham are rising, due mainly to the cessation of industrial borehole abstractions.

The major industrial abstraction licences in the Trent catchment (greater than 10Ml/d) are indicated on Figure 5.21. Abstraction quantities refer to maximum daily licensed where these are stipulated.

Most of the large abstractions use water either for cooling, or for power production (including milling) and therefore represent a non-consumptive use. However, there are some very large abstractions, particularly on the Derwent, which require protection from derogation.



MAJOR INDUSTRIAL ABSTRACTION LICENCES (>10 Ml/d) IN THE TRENT BASIN

FIG 5.21

There are two licences on the River Trent itself greater than 10Ml/d, at Burton and Scunthorpe (the BWB abstraction at Nottingham is from the Beeston and Nottingham canal). The Burton licence of 62Ml/d for milling purposes is averaged throughout the year, and could therefore potentially be abstracted as much larger quantities over shorter periods.

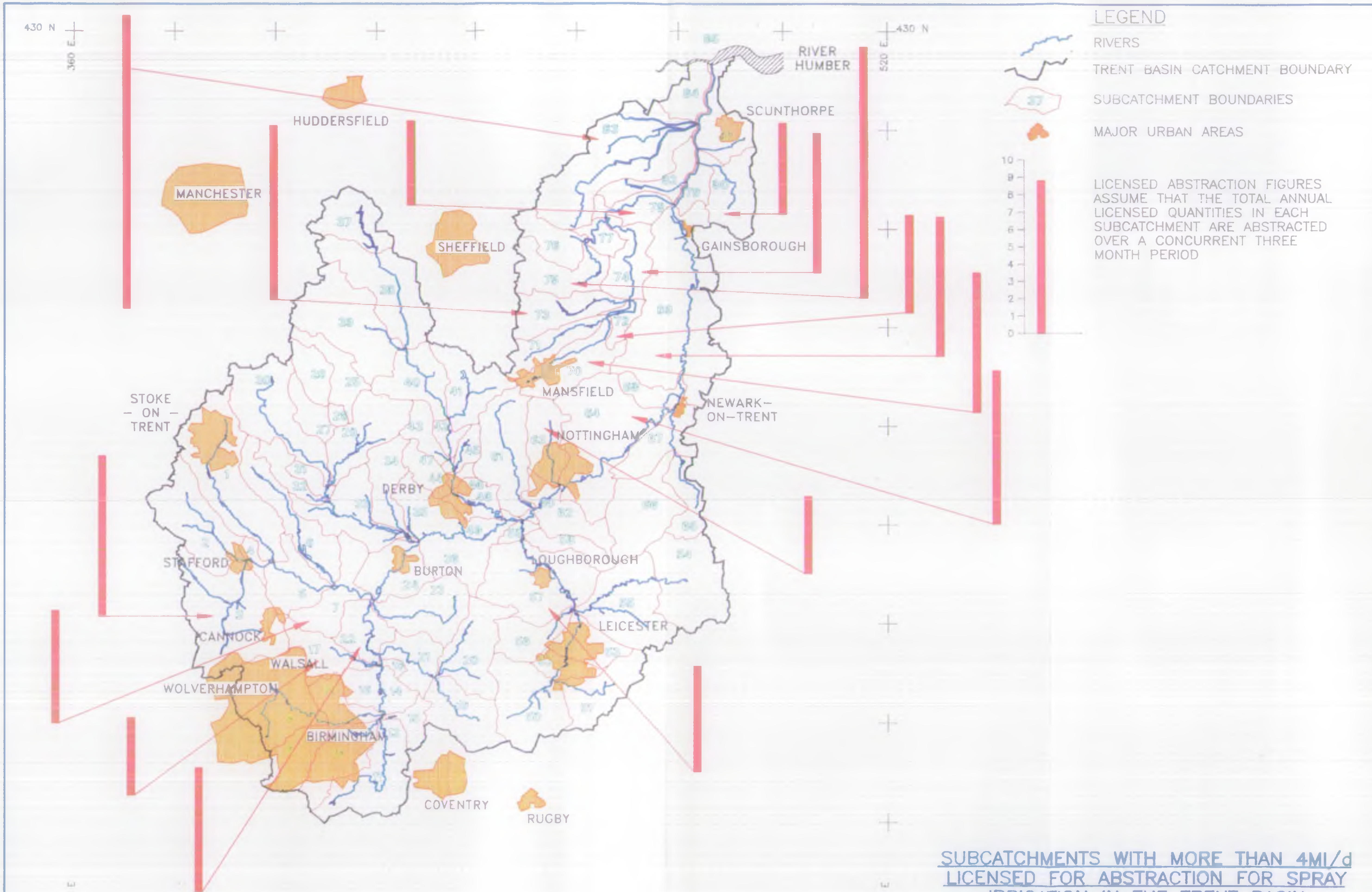
BWB have proposals to apply for new licences for industrial users on the Beeston canal, and as this is fed directly from the Trent, represents a demand on the river. The commercial approach of BWB to selling water from its canals and waterways, under licence from the NRA, to industrial and other abstractors means that this type of abstraction is likely to increase. However, it is unlikely that this will ever represent a major demand on the Trent resources.

5.1.4 Agriculture

The principal abstractions in the Trent basin for agricultural purposes are for spray irrigation. Whilst there are few such licences that alone represent a substantial demand, on aggregate they can be significant. Figure 5.22 presents the aggregated licensed volumes greater than 4Ml/d for sub-catchments within the Trent basin. Spray irrigation usually takes place over a restricted part of the growing season. As the total licensed volume is taken during this period, it is misleading to consider an average abstraction figure spread throughout the year.

For this reason, Figure 5.22 shows the total licensed abstraction for each sub-catchment, expressed as Megalitres per day, but assuming all licences abstract their quotas over a concurrent three month period.

There is some spray irrigation in the south western part of the catchment, outside Birmingham, but the heavy usage is centred around the lower, tidal reaches of the Trent, and Idle and Torne catchments. The main crops requiring irrigation in these areas are potatoes and sugar beet. A more detailed assessment of spray irrigation requirements and cropping patterns is given in Appendix C.



SUBCATCHMENTS WITH MORE THAN 4Ml/d LICENSED FOR ABSTRACTION FOR SPRAY IRRIGATION IN THE TRENT BASIN

FIG 5.22

The total licensed abstraction for the Trent Basin, based on the above assumption about abstraction, are equivalent to 126Ml/d. Of this, approximately 32Ml/d are taken from the non-tidal Trent catchment. A further 21Ml/d are taken in subcatchments bordering the tidal, but non-saline River Trent. The remainder is taken from sub-catchments that discharge to the saline part of the Trent.

Future changes in irrigation demand will be controlled primarily by changes in irrigated areas of specific crops and by refinements in irrigation water management. Controlling factors influencing the changes will be market forces for particular produce, but also to some extent the predicted climatic changes resulting from global warming. Consumer demand and agricultural policy will direct the market forces.

Changes in cropping due to EC policies are likely to have a more significant effect on irrigation water demand than any changes in response to climatic change. In principle this is due to the more gradual nature of climatic change, and consequent gradual adoption of new crops within farmers rotations. Adoption of new crops will though go in hand with demand, developments in technology and economic attractions influenced by EC policy, including subsidies and market barriers.

Various predictions on climatic change have been put forward, but the principle conclusion is that a rise in temperature of 1.5°C is expected by 2030 together with an associated increase in evaporation of around 10%. Summer rainfall is predicted to remain unchanged but could increase in intensity, thus reducing its effectiveness. However, winter rainfall is expected to increase. The interpretation of this for irrigators is an increase in summer demands. These could be met by an increase in winter storage.

An extended growing period and more rapid crop growth due to the combination of temperature rise and atmospheric CO_2 enrichment may be expected. There is no reason to suppose that present crops will be unsuited to the predicted climatic conditions, so long as moisture availability satisfies the evapotransition rates.

The extra evaporative demand could be met by planting earlier so that water demand would remain unchanged. Alternatively planting earlier may be encouraged to enable or increase the area under double cropping, with consequent increases in water demand. The combination of these events might increase net overall irrigation demands by between 15-20% within the next 30 years.

The need for water storage will inevitably increase the cost of irrigation. Therefore in the foreseeable future crops such as sugar beet and cereals will become more marginal for irrigation. However, water demand for sugar beet is unlikely to change. Better management of irrigation water will play an important role.

Investment in irrigation for new areas will be dependant on crops showing a beneficial yield response to water application. Potatoes are likely to be the most popular crop in proposals for irrigation development and will therefore become more important. The area of irrigated potatoes is likely to show the largest increase in future, assuming that extra licences will be granted.

In areas where a good vegetable production infrastructure exists irrigated production is likely to increase, but over the study area as a whole horticulture is expected to decline following national trends. Irrigation demand, however, is expected to remain constant.

The recent nitrate legislation is likely to reduce the overall irrigated water demand although the extent of this is unknown.

In conclusion the changes in cropping due to agricultural policies has a significant effect on irrigation water demand, although it is difficult to quantify the impact of future policies. Current trends in part reflect recent policies and indicate expansion of irrigated area and water demand. It is expected that these levels of expansion will be maintained, demanding an annual increase in water demand of 6% for the next five or ten years. Irrigation in some parts of the area could possibly double in the next 20 years representing a demand for an additional 120-130Ml/d across the Trent Basin. However, further investigation into crop types and cropping patterns in the lower Trent area, particularly, are required to give more confidence to this estimate.

Changes in cropping, in response to climatic change is likely to have an additional steady but small effect on irrigation demand, giving an annual increase rising from a half to 1% by 2030.

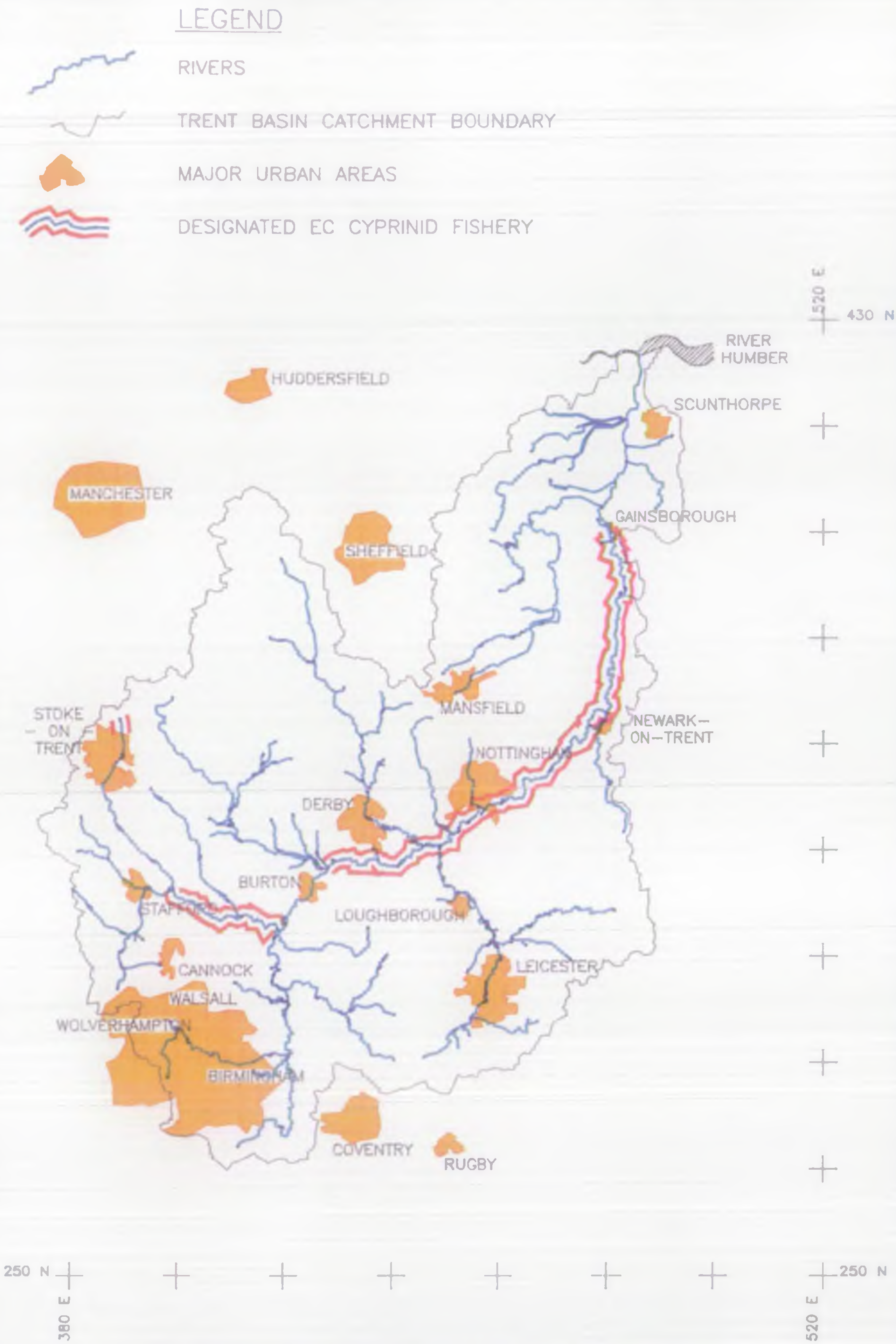
5.2 Fisheries

The River Trent itself supports an extremely abundant and diverse coarse fish population throughout much of its length. Previous water quality problems originating in the Tame catchment caused the Trent to be fishless from the Tame confluence down to Burton-upon-Trent. However, improving water quality over the past 20-30 years has now led to the establishment and maintenance of healthy fish populations along most of the length of the river.

The river supports a recreational coarse fishery from its headwaters to the tidal limit. This is particularly intense in the middle and lower reaches from Burton-on-Trent to Gainsborough. Further discussion of this recreational use is contained in Section 5.3.

Species found in the river during recent routine electric fish surveys include chub, dace, roach, gudgeon, eel, perch, bream, pike and brown trout, with recorded total fish biomass for various sites ranging from 30 to 2188 gm/100m^2.

The River Trent has some 180km designated under the EC Freshwater Fisheries Directive (No.78/G59/EEC), including from Tongue to the Duke Bank; from the confluence of the River Sow to the confluence of the River Tame; and from the confluence of the River Dove to the freshwater limit at Gainsborough (see Figure 5.23). A number of specific fisheries concerns have arisen with respect to increased surface water abstraction, and include the impact on fisheries and general river ecology from:



EC DESIGNATED FRESHWATER FISHERIES ON THE RIVER TRENT

FIG 5.23

i) Impact of effluent discharges on fish populations.

ii) Abstraction from bifurcated sections of the river.

iii) Reduction of river levels and the consequent effect on fringe habitats, particularly for juvenile fry.

iv) Changes to fisheries habitat, particularly the possibility of creating an ideal habitat for the non-native predator species, zander.

v) Effects on rare estuarine fish populations such as smelt.

vi) The proposed restoration of salmon migration and spawning.

Concern over the impact of effluent discharges, particularly from Stoke Bardolph in Nottingham, on fish populations has been expressed in the national press. This is considered further under recreational use in Section 5.3.

Concern for fisheries, and the aquatic environment in general, have been expressed over possible abstraction from bifurcated channels. The abstraction of flows from a split channel will obviously result in a greater proportion of flow being taken than would result from the same abstraction being taken from a single main channel. This disproportional abstraction of flows from one arm of the bifurcated channel is likely to lead to increased stress on fisheries and the aquatic environment. Similarly, large diurnal fluctuations in abstraction rates, such as the full abstraction occurring over 6 hours instead of 24 hours, would be likely to increase significantly the stress experienced by the aquatic environment immediately downstream of the abstraction.

Along the River Trent there are important fringe habitats for juvenile fry and fish, often formed as a result of fishermen-induced bankside erosion. It is thought that these habitats play an important role in the success of the coarse fishery. Reductions in water level could reduce the availability of these river fringe habitats until they became re-established over a number of years.

Concern has also been expressed over the spread of the non-native predator fish species, zander. The species is similar to pike but generally feeds on smaller fish. Potentially this could upset the age structure of the natural fish population and hence reduce the quality of the coarse fishery. It appears that zander prefer slow moving waters and, should abstraction lead to a reduction in flow velocities, their available habitat could increase. There is insufficient information available on both the species' present distribution, and its preferred habitat requirements, to assess their long term impact. However, the river below Shardlow is maintained for navigation and is therefore most likely to experience reduced flow velocities as a result of lower flows. These reaches would then be most sensitive to an increase in zander populations.

Part of the NRA's fisheries management function is the encouragement and conservation of rare fish. Smelt used to migrate into the clay pits in the Lower Trent area to spawn. Improvements in water quality in the estuary are likely to be the major factor controlling the re-establishment and expansion of this species.

The lower River Trent was once also a migratory salmon river with spawning areas primarily restricted to its tributaries, particularly the Rivers Derwent and Dove. A report by the Severn-Trent Water Authority on the re-introduction of salmon in the River Trent concluded that the River Trent is only suitable as a migratory route for salmon, excluding most of the period from April to October due to excessive water temperature (i.e. entire daily temperature range >20°C). Water quality and temperature criteria capable of satisfying the juvenile stages of salmon exist in much of the Dove and Derwent sub-catchments.

The prospect of re-introducing salmon to the Trent has been raised by Scottish Hydro-Electric, who are proposing to build a new power station at Keadby, and who are offering to contribute towards the cost of stocking and construction of salmon passes. Concerns therefore exist that increased abstraction for potable supply from the Trent will result in a deterioration of conditions conducive to salmon, principally with respect to temperature and water quality.

The 1985 Severn-Trent Water Authority report found that during dry years (i.e. 1976) the length of time that the temperature barrier exists in the lower river increased only marginally over that found in average years, thereby indicating reduced flows are unlikely to have a major effect on the temperature regime.

5.3 Recreation and Conservation

The River Trent represents a major recreational resource and, given the density of population within close proximity to its banks, is heavily utilised as such.

The River Trent is considered by many to be one of the best coarse fishing rivers in the country. Fishing rights are rented for between £2 and £5 per yard, and any drop in water levels or flows through future abstraction, which adversely affect the fishing, could lead to claims for compensation. It is worth noting that there were no recorded complaints to the NRA from fishermen with respect to reduced levels or flows, and their consequent impact on fisheries, from either the 1990 or 1991 droughts nor, as far as can be recalled, from the 1975-76 drought period on the main river.

However, concerns have been voiced with regards to certain aspects of angling on the Trent. Some of the power stations have reported being blamed for deterioration in fishing in their vicinity in recent years - an accusation they strenuously deny. They, in fact, consider their contribution to water quality in the river to be positive as they settle out most of the river sediment from the water they abstract before passing it through their condensers and back into the river.

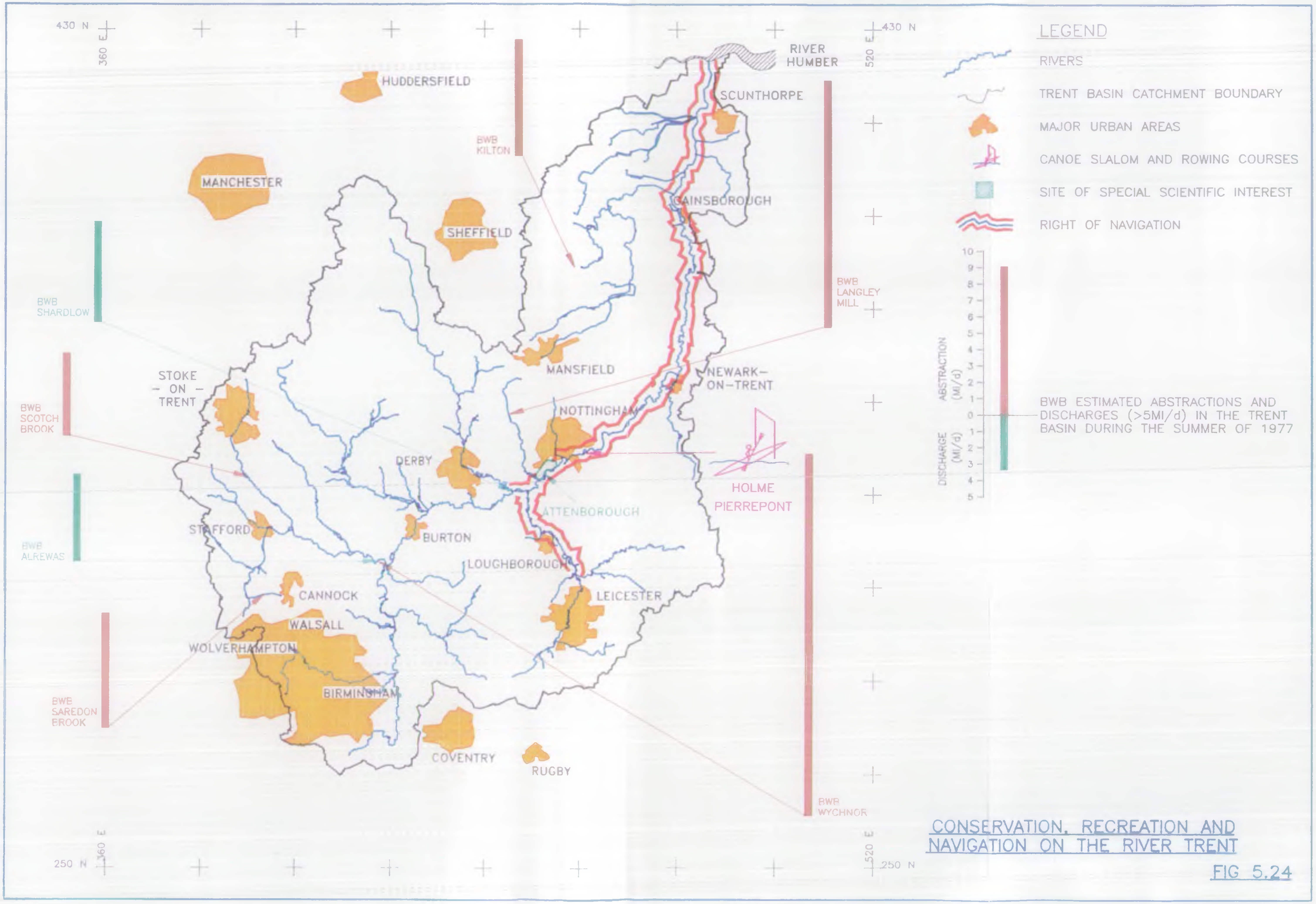
Concerns have also been voiced about angling and fish survival in the stretches downstream of Stoke Bardolph water reclamation works. Nottinghamshire County Council have indicated that fishing in this area is extremely poor with very few fish able to stand the relatively high concentrations of sewage effluent, notably ammonia.

In a recent article in the national press (Daily Telegraph, 29 January

1992) ammonia concentrations from the effluent discharge were blamed for the demise of fishing in the Trent from Nottingham to Newark. Both national and local angling competitions have been cancelled or forced to relocate as recent competition results indicate there are few fish left in this stretch of the river. Competition entries have been suffering as little confidence is now being placed by anglers in the fishery. A decision has yet to be made as to whether the Division One National Championship will be staged at its traditional location on the Trent downstream of Nottingham.

Canoeing and rowing are also major uses of the Trent in the Nottingham area (Figure 5.24). The canoe slalom course at Holme Pierrepont, adjacent to Holme Sluices, utilizes flows directly from the river. During low flow periods these can represent the entire available river flow. The slalom course is owned by Nottinghamshire County Council and the Sports Council, although it is operated by the Sports Council. It is of national importance, being the home training ground of World Champion canoe slalomists and of the British Olympic canoe slalom team. It is the only artificial course in the country. It is also of major national and local recreational importance, attracting canoeists from all parts of the country, including the south west and Scotland. It is currently being promoted regionally as a white water rafting venue, aimed at attracting non-canoeists and in particular, the disabled community. It is used throughout the year with the heaviest use being in the summer. Future use is expected to continue increasing, with plans to floodlight the course in order to extend opening hours.

Significant difficulties in operating the course were encountered during the summers of 1990 and 1991. The right of navigation that exists along the river has first call on the water, and a minimum depth of five feet is required for this purpose at Trent Bridge, upstream of Colwick. The navigation depth is controlled by the operation of Holme Sluices. In order to maintain this depth, the slalom course, which has its own adjustable weir intake and bypasses the sluices, was only able to operate on restricted hours during periods of low flow - two hours in the morning and around three to four hours in the late afternoon to evening, depending on the rate at which the upstream water level



CONSERVATION, RECREATION AND NAVIGATION ON THE RIVER TRENT

FIG 5.24

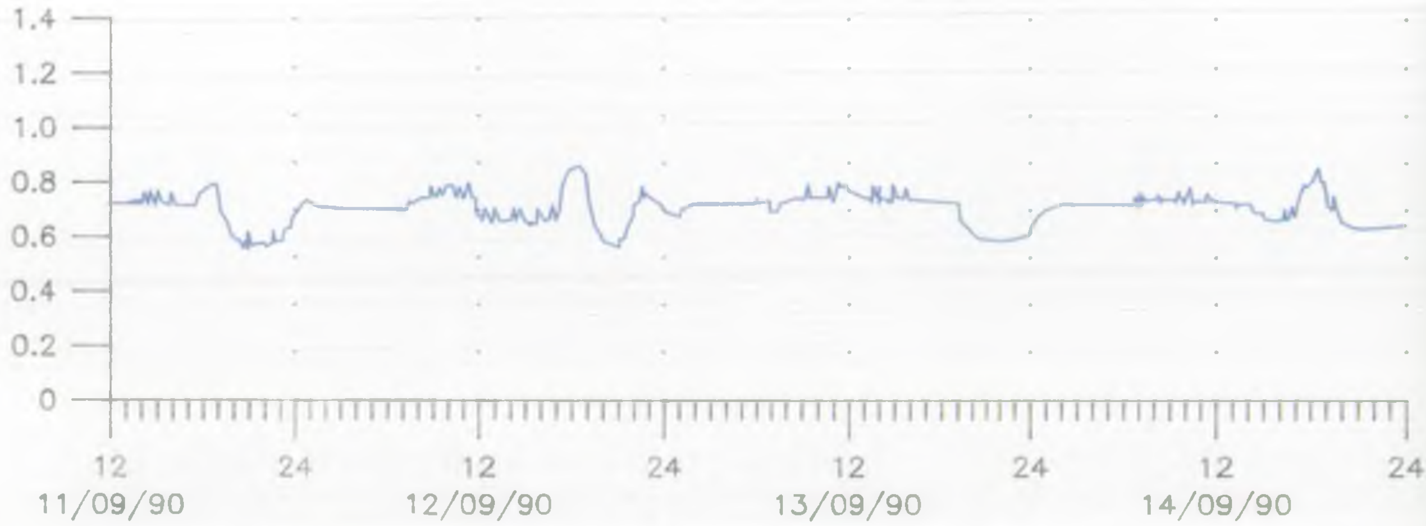
dropped.

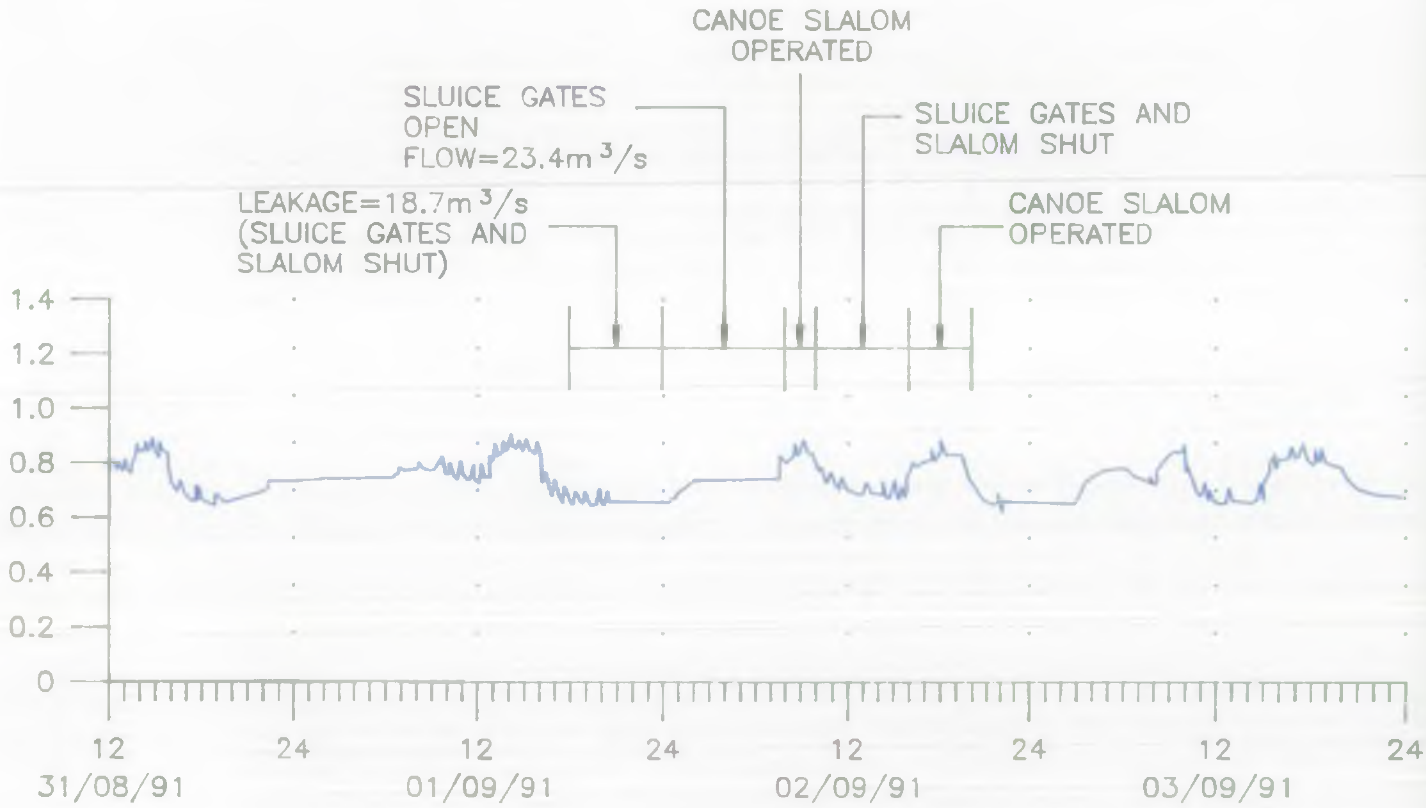
This restricted opening resulted in a severe loss of income. The flow requirements of the course are well known and controlled by the operators depending on the type of activity taking place (beginner, intermediate, advanced, white water rafting). A residual flow of around $2m^3$/sec is required down the course when it is not operating to avoid the concrete base lifting.

When the course is operated, the Holme Sluice gates close thus diverting all available water through the slalom course. Optimum conditions on the course are attained when the flow through it is between 18 and 21 m^3/s. This was only achieved for short periods of the day during several months in the summers of the last two years. The course may not take any water when the water level upstream falls below 60mm above the statutory minimum required for navigation.

Inspection of the flow record at Colwick gauging station indicates that the flow in 1990 did not fall below an average daily of 21 m^3/s. Figure 5.25 shows the level hydrograph for two periods, in 1990 and 1991, at the Colwick gauge, downstream of the sluice and slalom course. The operation of both the slalom course and the locks at the sluices can be seen, as indicated on the figure. After the operation of the slalom course, the level recedes to a minimum. The sluice gates are shut by this time in order to maintain the upstream level, so this minimum represents the residual $2m^3$/sec left running down the slalom course plus leakage through the sluices.

The minimum level recorded at around midnight on 1 September 1991 corresponds to a flow of around 18.7 cumecs at the Colwick gauge. The minimum level recorded at around 2000 hours on 12 September 1990 corresponds to a flow of around 15.3 cumecs. If it is assumed that $2m^3$/sec was flowing down the slalom course at these times, the leakage through the closed sluices would be between 13 and 17 m^3/s.





WATER LEVEL HYDROGRAPHS AT COLWICK GAUGING STATION IN 1990 AND 1991

FIG 5.25

The gates were designed as a flood protection measure and were not designed to seal completely. Approximate hydraulic calculations indicate that a gap of around 20-30mm beneath each gate would account for this leakage.

Additionally, the 2000m rowing course, parallel to the canoe slalom course, was abstracting water from upstream of Holme sluices during 1991, to help alleviate algal bloom problems in the summer. An estimated $2m^3$/sec were abstracted continuously, and discharged back into the river downstream of Colwick gauging station. The rowing course is heavily utilised for rowing, novice canoeing, and angling competitions.

Nottinghamshire County Council have drawn up a Trent Valley Plan which extends along the length of the river to the Humber estuary. The plan encompasses recreation, conservation and the general environment. The plan does not have any defined flow or quality targets but does indicate certain aesthetic requirements. The landscape quality of the Trent in the reaches above Rugeley is very high, with little development along the river apart from Stoke. Similarly, in the lower reaches below Newark, the river retains much character at high tides.

A Regional Recreation Strategy has also been adopted, which was drawn up by the Regional Council for Sports and Recreation (made up of the County Council, local councils and the Countryside Commission). This strategy proposes that fewer sporting activities should take place on the river (such as rowing, yachting, water skiing etc). These activities should rather be encouraged in old gravel pits and other bodies of water.

Instead it indicates that an increase in cruising and pleasure boating should occur on the main river. It is likely that commercial traffic will also increase. However, there is already a shortage of moorings and marinas on the river, and this is likely to become more acute unless addressed.

Currently, certain marinas already experience problems with water levels. In Nottingham, one yacht club complains that its centre landing stage is frequently submerged. On the other hand, Parkside Lake yachting club complains that boats coming out of the lake into the river start grounding when the water level falls to 160mm above the statutory minimum. However, this could be due to the lack of dredging in the lake since the 1950s.

The maintained nature of the river and its immediate banks, for either flood defence or navigation reasons, has resulted in there being little high value conservation habitat adjacent to the river. The Attenborough gravel pits, where the River Erewash meets the Trent (see Figure 5.24), are designated as SSSI but are unlikely to be affected unless river levels in the area dropped significantly. The Humber Estuary is a designated Ramsar site for its mudflats and resulting bird populations. However, the Humber estuary is not greatly affected by flows in the River Trent.

5.4 Navigation

A right of navigation exists up the main River Trent as far as Shardlow, Nottingham (Figure 5.24). A minimum depth of 5 ft is required throughout the length of this navigation.

The main point of control for which the NRA are responsible is Trent Bridge, where the minimum 5ft depth is statutory. This is controlled by means of the operation of Holme Sluices. The operation of the sluices is complex but the control of levels is crucial to navigation. The sluices operate to maintain the water level within a 150mm range, the bottom of which is 310mm above the statutory minimum level required for navigation (20.54m AOD). This excess margin is to help maintain levels for the operation of the canoe slalom course.

The navigation is used both for commercial purposes and for recreational purposes. Pleasure boating is a major use of the river, with in the order of one third of all pleasure craft using the river as a means of connecting the Fossdyke Navigation to the canal network in the Midlands.

The main discharges and abstractions from the Trent to BWB canals were estimated for the summer of 1977 by Pirt and Simpson (1983). These are presented in Figure 5.24, and indicate that a net export from the catchment of around 45-50 Ml/d took place through the canal network during this time.

The Lower Trent, downstream of Newark, suffered from low flows in 1989, 1990 and 1991. Ordinarily BW have to dredge the river once every three years, but increased siltation due to low river flows has led to dredging in each of last three years. The last time such regular dredging was required in 1976.

The main area experiencing siltation lies between Chruch Laneham (downstream of Dunham) and Marton (downstream of Torksey). The substrate interface betwen river sands and gravels and estuarine silts occurs around Church Laneham, but has been moving upstream in recent years. Some shallows at Torksey (Torksey Shoals) exert significant influence on river levels upstream, where tidal variation is minimal. Over-dredging in this area can therefore cause significant problems for the navigation as far upstream as Newark, as the water level in this reach is flow dominated. BW have expressed concern in this context, that any further abstraction at Torksey, and even more so at Newark, would exacerbate the low flow, and hence siltation problems currently experienced.

BW are presently negotiating to supply Cottam, High Marnham, and West Burton with low sulphur coal. The river is navigable at all tides as far up as Gainsborough. The supply of coal to these power stations is not dependent on full time navigation, but would be made more efficient if larger, 500 tonne barges could be used at all times. In order to do this a lock would have to be built at Gainsborough in order to maintain a navigation depth upstream of this point at all times.

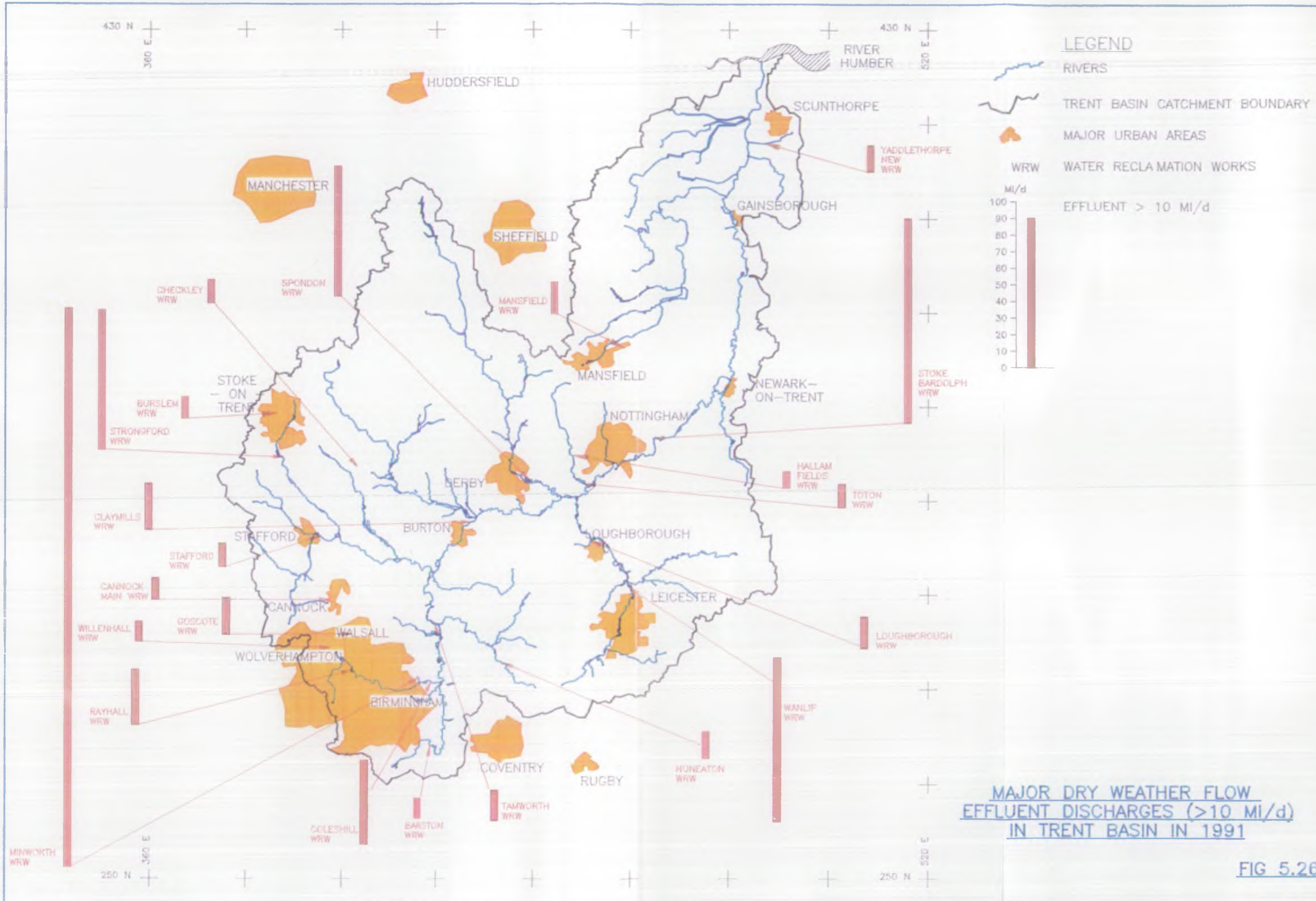
The introduction of a lock at Gainsborough would have major implications for the lower part of the river, as it would effectively move the tidal limit of the river downstream by around 40km. Certain authorities such as the County Council would welcome such a proposal as it would increase the recreational value of the lower stretch of the river. On the other hand, it is likely that river flow velocities in this stretch will, when ponded, be much lower than the tidal velocities currently experienced and water temperatures higher with consequent problems for the power stations. Another possible consequence might be the potential for algal blooms and other water quality problems exacerbated by low velocities. Any abstraction of water in this stretch would be subject to the reduced water quality and cause even lower velocities downstream. Similarly, a reduction of summer flows entering the reach also has the potential of adding to any water quality problems.

In addition to the navigation below Shardlow, several canals, including the Fossdyke Navigation and the Trent and Mersey Canal, are linked with the river, and can take water from it. BWB do not require licences to abstract this water and can therefore potentially take an unlimited volume for navigational purposes.

5.5 Effluent Disposal

The major effluent discharges (greater than 10 Ml/d) in the Trent catchment are shown in Figure 5.26. A total of 320 water reclamation works (WRWs) discharge more than 0.1 Ml/d each during dry weather within the Trent basin. The total dry weather flow of these WRWs was in the order of 1,430 Ml/d in 1991. 22 WRWs accounted for 74% of this figure, with Minworth alone accounting for 24% (346 Ml/d).

There are only four water reclamation works discharging directly to the river with flows greater than 5 Ml/d, the most significant of which are Stoke (Strongford), Burton (Claymills) and Nottingham (Stoke Bardolph). There are major water reclamation works on other tributaries of the Trent, the largest of which is Minworth WRW which serves Birmingham and discharges to the Tame.



MAJOR DRY WEATHER FLOW EFFLUENT DISCHARGES (>10 Ml/d) IN TRENT BASIN IN 1991

FIG 5.26

The majority of water discharged through Minworth is imported into the catchment from the Welsh hills (Elan Valley) and the River Severn (through Hampton Loade and Trimpley). This water therefore supplements the natural flows in the rivers Tame and Trent. However a component of discharge from Minworth is derived from within the catchment, notably from the sandstone aquifers around Birmingham and Blithfield reservoir.

Most of the other discharges in the Trent basin are derived from water taken from within the catchment. This water would therefore have naturally flowed down to the main river had it not been abstracted in the first instance, albeit possibly at another time of year.

Freshwater dilution flows in all rivers which receive effluent discharges are necessary to enable the river to meet its quality objectives whilst maintaining its effluent disposal function. The ability of the Trent to fulfil its effluent disposal role will be discussed in Chapter 6.

5.6 Flood Defence

The Trent is a major river catchment draining both rural and highly urbanised areas. Flooding along the river has been a feature, particularly in the Burton and Nottingham areas. The river has extensive flood plains in the reaches broadly upstream of Nottingham and is embanked in its lower reaches. The flood plains play a vital role in both the attenuation and conveyance of flood flows. Any development in the flood plains will be resisted and, if allowed to proceed, will need to include compensatory features to avoid an increase in flood risk.

The embanked reaches of the river are protected from erosion during high river flows. However, the protection typically extends down to normal low water levels. A significant reduction in these low water levels could lead to undermining of the protection.

The principal operational flood alleviation works on the Trent comprises the Holme sluice gates at Colwick which helps protect Nottingham. These are operated automatically to maintain a minimum navigation depth upstream, and are raised to allow more flow through when a flood wave passes down the river.

5.7 Other Uses

The potential for establishing small scale run-of-river hydropower schemes is currently being investigated by British Waterways, possibly as a joint venture with another organisation. Interest in this area has been stimulated by the Governments recent initiative to allow non-fossil fuel deprival power to be sold to the National Grid at a premium rate. Proto-types being considered are low-cost, low-head turbines to operate at existing sluices. If ready-built units can be developed that require simple installation and are easily connected into the National Grid, then they may prove economic. BWB consider run-of-river hydropower schemes to be exempt from licensing.

6.0 EXISTING STATE OF THE CATCHMENT

6.1 River Flows

A considerable amount of work has been carried out on river flows in the Trent basin, including the important study "The Estimation of River Flows" (Pirt and Simpson, 1983). We have used this work as the basis for this section, supplemented with additional data collected for this project.

Figure 6.1 shows dry weather flow conditions (defined as 7 day mean annual minimum flow) along the length of the Trent, adapted from Pirt and Simpson. The total mean annual minimum 7 day flow relates to that calculated from gauged flows at each of the Trent gauging stations for the standard period 1973-90. Flows between the gauging stations have been proportionally adjusted. The 1976 and 1990 flow profiles have been simplified to indicate the scale of flows relative to the gauged dry weather flow. The artificial flow line is not the 'quality' line defined in Pirt and Simpson (1983), but represents the net balance of licensed abstractions and consented discharges. The figure shows the growth of dry weather flows along the river and also the high proportion that is derived from artificial sources, such as effluent discharges.

The spikes on the diagram represent the maximum daily licensed abstraction for each of the Trent power stations. It can be clearly seen that the licensed quantities for Willington, Castle Donnington and Staythorpe exceed the dry weather flow. In order to investigate this more fully we have prepared Figures 6.2 to 6.5 (see Appendix B). These show the lowest flow remaining in the river in each month over a number of years for the stations at Rugeley, Willington, Castle Donnington and Staythorpe. These flows have been evaluated by subtracting the daily abstraction returns for the power stations from the estimated river flow based on gauging station records.

D Evans

N. R. A. ANGLIAN REGION - INTERNAL MEMO

FAX	URGENT	ROUTINE	COURIER

TO: Geoff Mance | FROM: R Hyde
POST: Regional Manager | POST: Regional General Manager
LOCATION: Severn Trent Region | LOCATION: Kingfisher House, Peterborough

OUR REF: DE/DH/656/4
WP-1/DH/11MARDH

DATE: 11th March 1992

SUBJECT: Trent Licensing Policy Review

Thank you for your memo of 4th March 1992 and copy of your Consultant's draft report on Licensing Policy for the Trent.

A meeting has been arranged at this office on 26th March between Atkins, your staff (Gwyn Williams, I think) and ourselves to discuss the issues. I trust that our formal comments can wait until after that meeting. At this stage I would just remark that there seems to be many conflicting demands on the Trent in your region, our region and beyond, and that we need to work together to decide how to secure the proper use of this very major water resource.

Roger

Roger Hyde
Regional General Manager

We should apply for a licence !!

Tony Warn needs to have a look

Suggest we keep comment brief

Roger Cook

National Rivers Authority
Severn-Trent Region

NRA

Our Ref: GM/PMM/MM/2228

Your Ref:

From: Dr G Mance
Regional General Manager
Sapphire East

To: R Hyde
Regional General Manager
Anglian Region

Date: 4 March 1992

Re: Joint RMT and River Trent Water Resources

Enclosed is a copy of the draft consultants report on Water Resources issues on the River Trent.

The content of this report will indicate our concern about the ability of the Trent to satisfy your region's needs. If you or your staff have any comments on this draft, could they please be sent to Mr N Flew at W S Atkins by March 13. We will send you a copy of the Final Report in early April.

This issue could usefully form the basis for a joint RMT meeting. Can I suggest either 6 or 13 April for a joint meeting here in Solihull, in Peterborough, or if you prefer, somewhere in between!

G Mance (Dr)

Enc:

ROGE[redacted]OK
REGIONAL MANAGER (WATER RESOURCES)

(1)

DATE RECEIVED ....12\3\92....

PASSED TO ....DE....

FILE NO ....

ACTION

PLEASE PREPARE A REPLY BY ....

PLEASE DISCUSS ....

RETURN CORRESPONDENCE ....

COMMENTS

WS Atkins Water
a division of WS Atkins Consultants Limited

Woodcote Grove
Ashley Road
Epsom
Surrey KT18 5BW
Telephone (0372) 726140
Telex 266701 (Atkins G)
Fax (0372) 740055
Ext no

NRA
ANGLIAN REGION
11 MAR 1992
No
REF
ORIG (RC)
COPY

Your ref
Our ref CJAB/vb/0030
Date 10th March 1992

Mr G Williams
Severn Trent NRA
Sapphire East
550 Streetsbrook Road
Solihull B91 1QT

Dear Gwyn

Re: Trent Licencing Policy Review

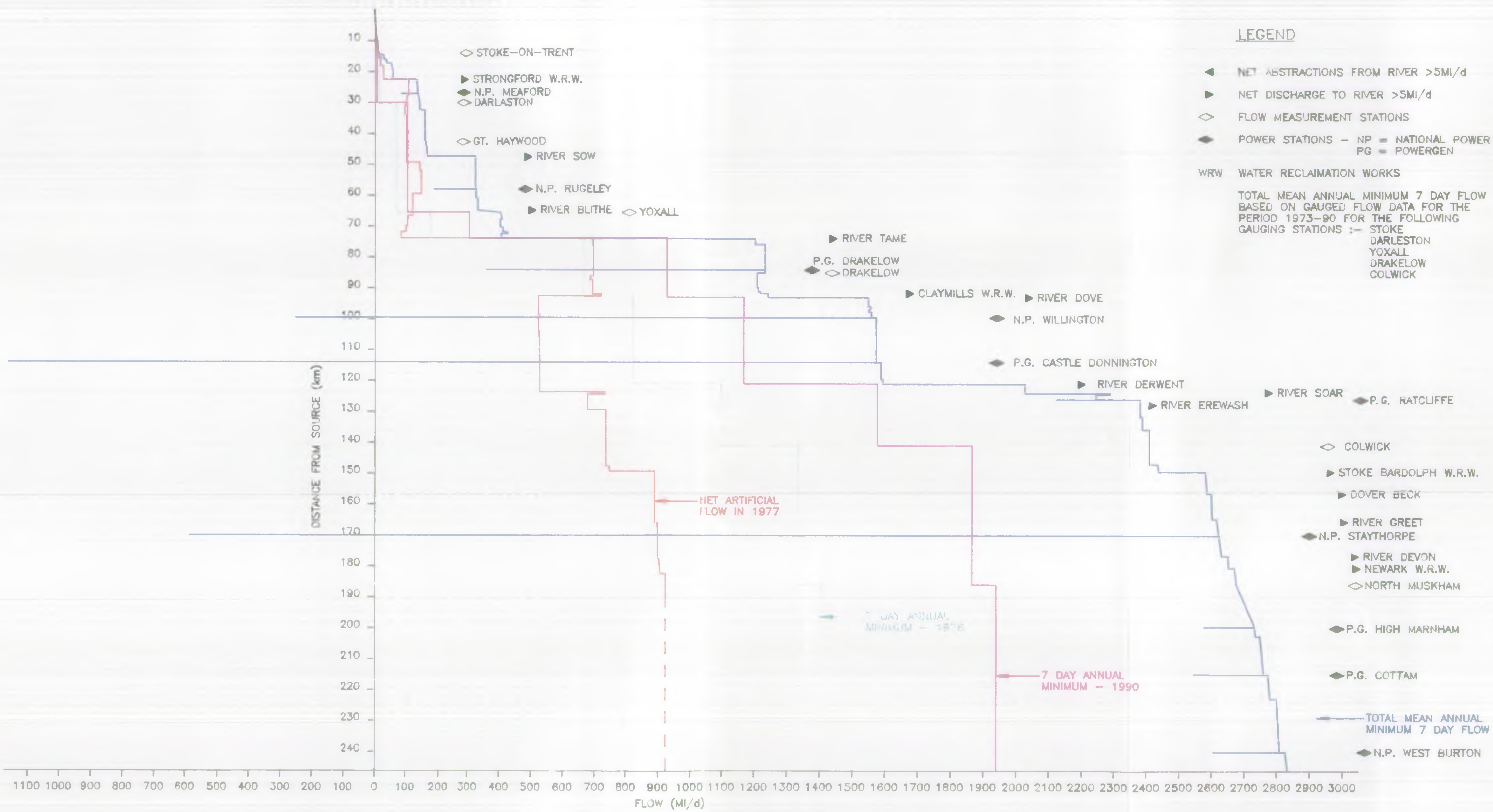
I confirm a meeting on the 26th March at the NRA Peterborough offices at 10.30 am to discuss the Atkins draft report on the Trent Licencing Policy Review, any aspects which need greater consideration, the impact this could have on the water resources of the Anglian region and any aspects which need greater consideration and the way ahead.

Yours sincerely
for WS Atkins Water

CJABinnie

C J A Binnie
Managing Director

cc R Cook - Anglian NRA
[redacted]
N Flew - WS Atkins
R Brown - WS Atkins



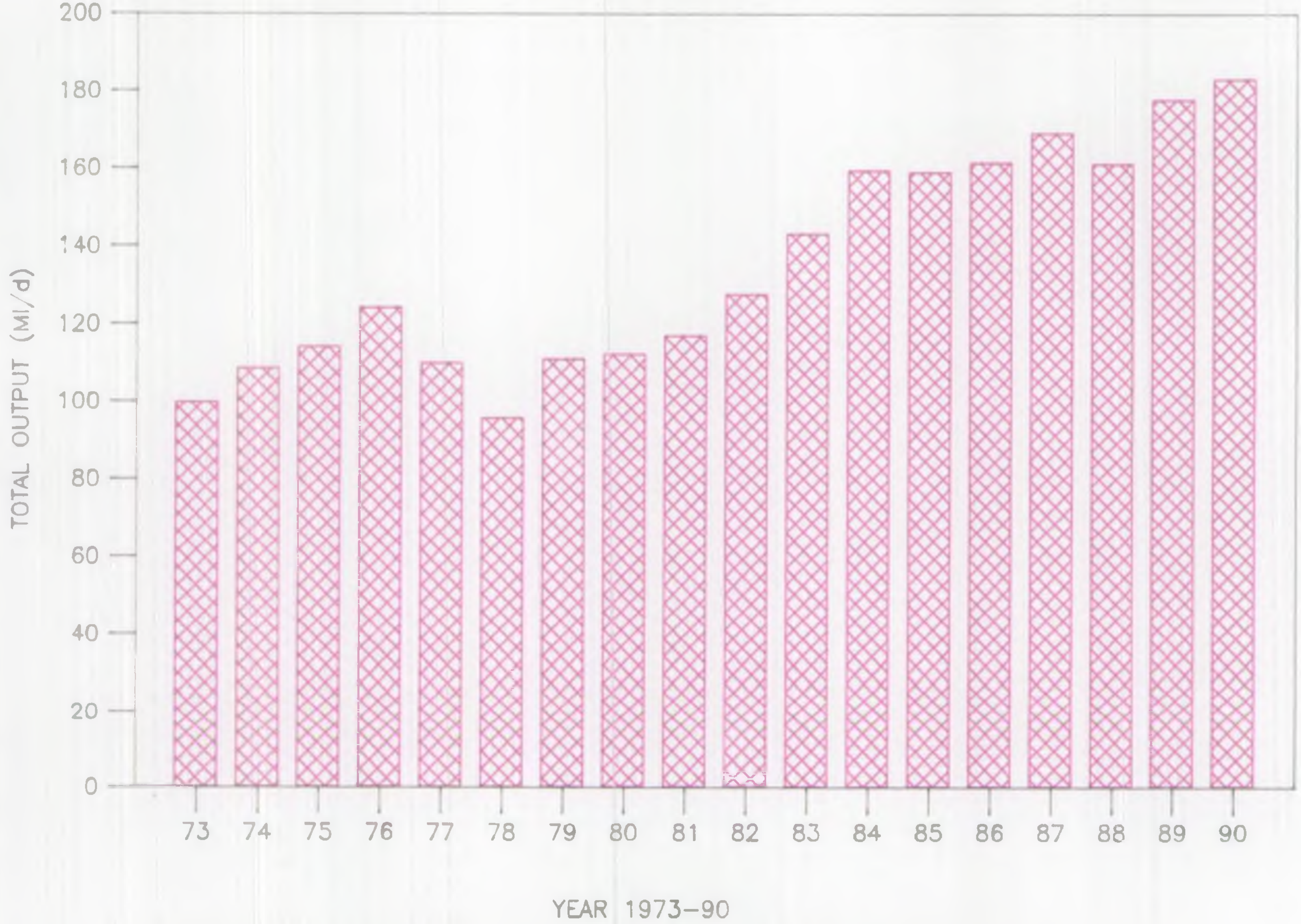
TOTAL RESIDUAL FLOW DIAGRAM (QUANTITY)
DRY WEATHER FLOW CONDITIONS
RIVER TRENT

FIG 6.1

Considering Figure 6.1, the artificial influence on low flows in the Trent is considerable. In the lower reaches, almost 1000 Mld, out of a total dry weather flow of 3000 Mld, is derived from artificial sources. This represents the net augmentation of the river once abstractions have been accounted for during dry weather flow conditions.

A significant proportion of this artificial influence is derived from the Tame catchment. The West Midlands area receives the majority of its water supply from either the River Severn or the Elan Valley system. These imports to the Trent catchment are then collected via the sewerage systems and discharged to the river via water reclamation works. Minworth WRW, to the north east of Birmingham, alone discharges around 350Mld to the River Tame during dry weather flow conditions. The amount of water supplied to these areas has increased due to the continuing rise in domestic water consumption, but data received from Severn Trent Water do not indicate any increase in the volume of effluent discharged during dry weather. Pirt and Simpson (1983) estimate that, during a week in the summer of 1977, the total volume of sewage effluent discharged into the Trent basin from water reclamation works (wrws) with a dry weather flow output of more than 10Ml/d was of the order of 1100Ml/d. Since that time many smaller reclamation works have been closed down and their sewage diverted to larger works. However, the total average dry weather flow (dwf) of all wrws (with a dwf greater than 10Ml/d) in the twelve months to September 1991 was of the order of 1020Ml/d. These largers wrws account for 74% of the total effluent discharged into the Trent basin.

The increase in water imported from the River Severn is indicated in Figure 6.6 which shows the mean daily output from Hampton Loade for each year from 1973-90. In 1973 the import was 100Ml/d. This has steadily climbed, apart from an interlude in the late 1970's to around 183Ml/d in 1990 which represents its licensed, treatment, and distribution limit. The output from Hampton Loade is currently utilised by South Staffordshire Water Company although Severn Trent Water has a share in the licence. A continuing rise in public demand has led Severn-Trent Water to review the present arrangement of



HAMPTON LOADE – TOTAL OUTPUT (INCLUDING WOLVERHAMPTON) IN Ml/d FROM 1973–1990

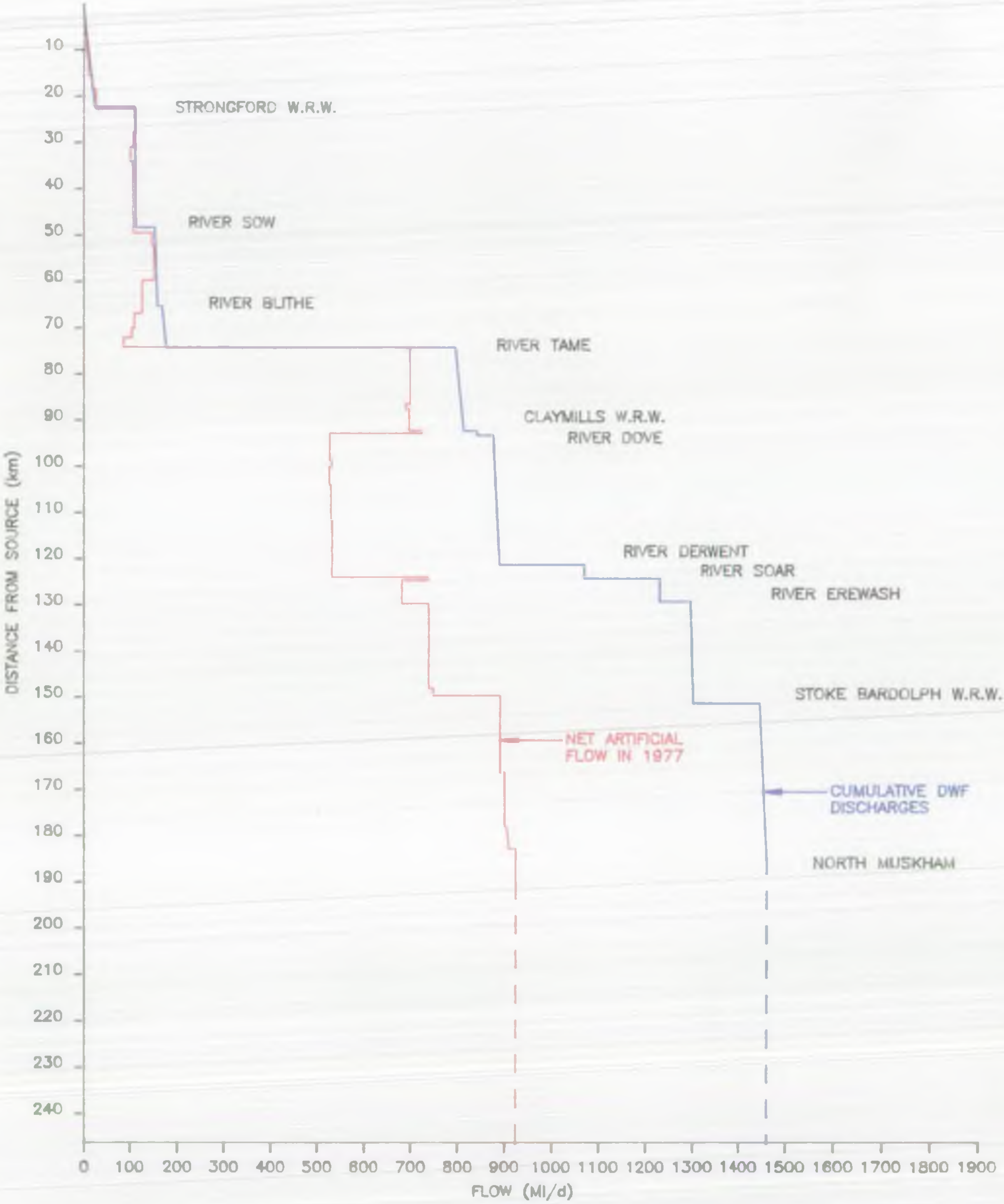
FIG 6.6

utilising their sources. One outcome of this has been a request by Severn-Trent Water to SSWC to allow them to start taking their share of Hampton Loade Water, which consequently places SSWC sources under stress.

The import from the Severn through Hampton Loade and Trimpley has been increasing over the last 19 years as has public demand and the exploitation of resources to meet that demand. However, effluent discharges have not matched this increase - rather they have remained static over the last 15 years. It would therefore appear that the increase in public consumption has been matched by a reduction in industrial usage. This would mean that sources previously used for industrial purposes are no longer being exploited. Indeed, under Birmingham, ground water levels are rising, bringing attendant problems, due to a reduction in industrial abstractions from groundwater.

It is interesting to note that, with reference to Figure 6.1, effluent discharges to the Trent originally derived from imports and groundwater augment the natural flow in the river by around 50%. This augmentation effectively supports abstractions that might not have been able to operate for as long as if they were under natural flow conditions.

The artificial flow component displayed in Figure 6.1 is based on the net effect of all discharges in the Trent basin after surface water abstractions have been taken out, during a week in the summer of 1977. In other, drier years (for example 1976 and 1990) the volume abstracted from rivers may well have been higher, thus reducing the artificial flow component and shifting the line to the left on the diagram. Figure 6.7 shows the gross volume of water discharged to the Trent basin before any surface water abstractions were taken out, during the same week in 1977. The net artificial flow line from Figure 6.1 is also displayed for comparison. The difference between the two lines indicates the gross abstraction taken from surface water sources within the catchment that would have contributed to river flow during this period.



CUMULATIVE DRY WEATHER FLOW DISCHARGES IN THE RIVER TRENT BASIN IN 1977, EXCLUDING ABSTRACTIONS, BUT INCLUDING THE EFFECTS OF RESERVOIRS

FIG 6.7

The frequency of low flows as recorded by the river gauging stations on the Trent at Yoxall and Colwick are shown in Figures 6.8 and 6.9. Both of these stations are natural velocity area sections that rely on rating curves to relate water level to flow. Yoxall, particularly, is known to be insensitive at low flows as it is much influenced by weed-growth, with the consequence that the accuracy of recorded flows is only to within ± 20%.

It is important to note that it is difficult to interpret such diagrams as the flows incorporate a high component of artificial augmentation, which distorts the natural frequency of low flows. If, however, it is assumed that this augmentation has remained constant through time, and there is evidence referred to above to support this assumption, then the distribution of low flows will not change, merely the scale of low flows.

A graphical fit has been applied to the lower ends of both the Yoxall and Colwick data. With, or without augmentation, 1976 appears to have a frequency at both locations of around once in 50 years. Flows in 1990, however, were much less severe, with a return period of between 5 and 10 years indicated at Yoxall, and between 10 and 15 years at Colwick. Flows in 1989 were not as low as 1990, but lower flows than those in both years were experienced in 1959.

Certain power stations have indicated that they sometimes experience operational difficulties caused by low river flows. Two types of problem were identified. One is related to insufficient water in the river to abstract the required volume of cooling water. The other is unique to Staythorpe and relates to the operation of the canoe slalom and sluice gates at Holme Pierrepont. The pulsing effect (see Figure 5.25) is itself a product of low flows brought on by the lack of sufficient flow down the canoe slalom course to allow it to operate continuously. Both types of situation outlined above have occurred consecutively in the summers of the last two years (1990 and 1991).

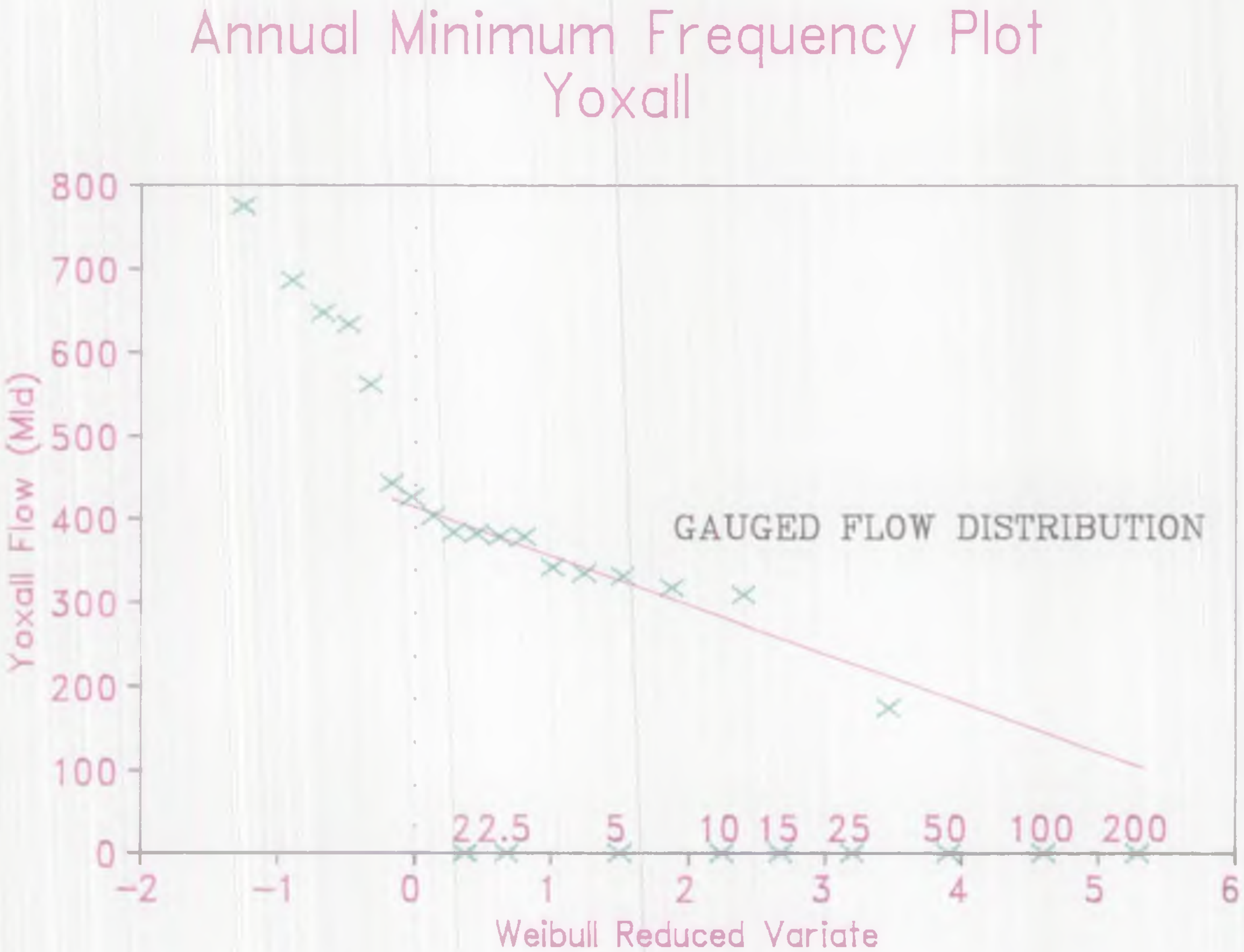
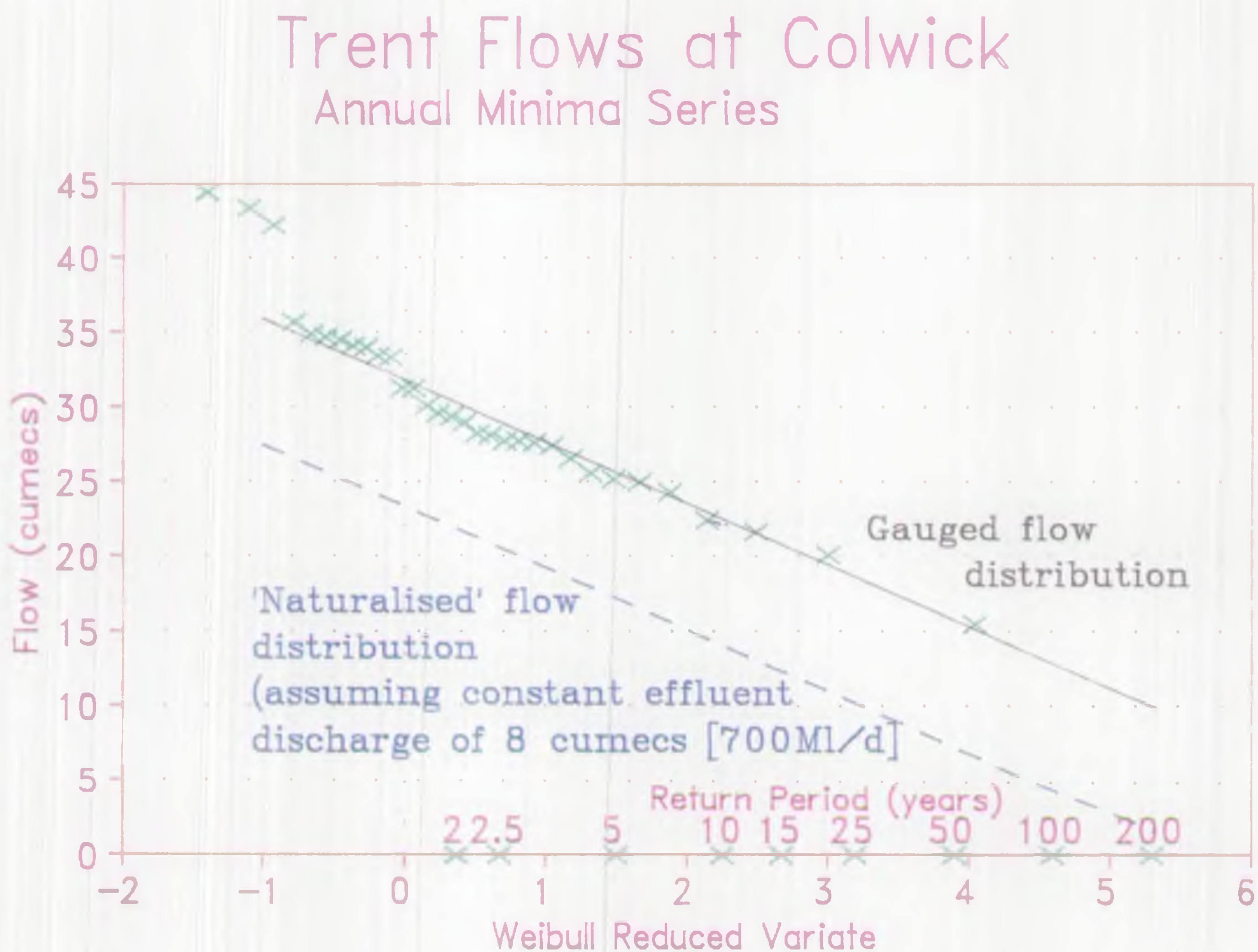

Annual Minimum Frequency Plot
Yoxall
Yoxall Flow (Mld)
800
700
600
500
400
300
200
100
0
GAUGED FLOW DISTRIBUTION
2 2.5 5 10 15 25 50 100 200
-2 -1 0 1 2 3 4 5 6
Weibull Reduced Variate

FIG 6.8



Trent Flows at Colwick
Annual Minima Series
Flow (cumecs)
45
40
35
30
25
20
15
10
5
0
Gauged flow distribution
'Naturalised' flow distribution (assuming constant effluent discharge of 8 cumecs [700Ml/d]
Return Period (years)
2 2.5 5 10 15 25 50 100 200
-2 -1 0 1 2 3 4 5 6
Weibull Reduced Variate

FIG 6.9

6.2 Water Quality

Water quality in the River Trent has shown significant improvements over the past 15 to 20 years. The majority of the river Trent now has a River Quality Objective (RQO) of NWC Class 2. The exceptions are a small reach below the confluence of Fowlea Brook, and in the headwaters, which have RQO's of NWC Class 3 and 1b respectively. The river achieves these objectives for most of its length apart from notable stretches below Stoke and Nottingham water reclamation works (WRW). Improvements to Stoke (Strongford) WRW and the sewerage network in the city are expected to bring significant benefits to the river downstream of Stoke in the near future. However, the high ammonia loading resulting from Nottingham (Stoke Bardolph) WRW is unlikely to be reduced within the near future and the river quality downstream will continue to suffer as far as Newark.

Existing effluent discharges will also influence directly the scope and nature of any future uses of the river. These influences will be manifested either as a restriction to potential future use because of inadequate water quality, i.e. the failure of present water quality to meet specific EC or national standards, or the inability of the river to support both the existing discharge and the proposed future use, i.e. a reduction in dilution of an existing discharge due to a future upstream abstraction.

Unless otherwise stated figures referred to in the following sections give the longitudinal profiles of various average water quality parameters for 1986-1990 and compares these values with recent 95 percentile and maxima values for selected sites. Relevant water quality standards are also shown. The following abbreviations are used to identify sampling locations:

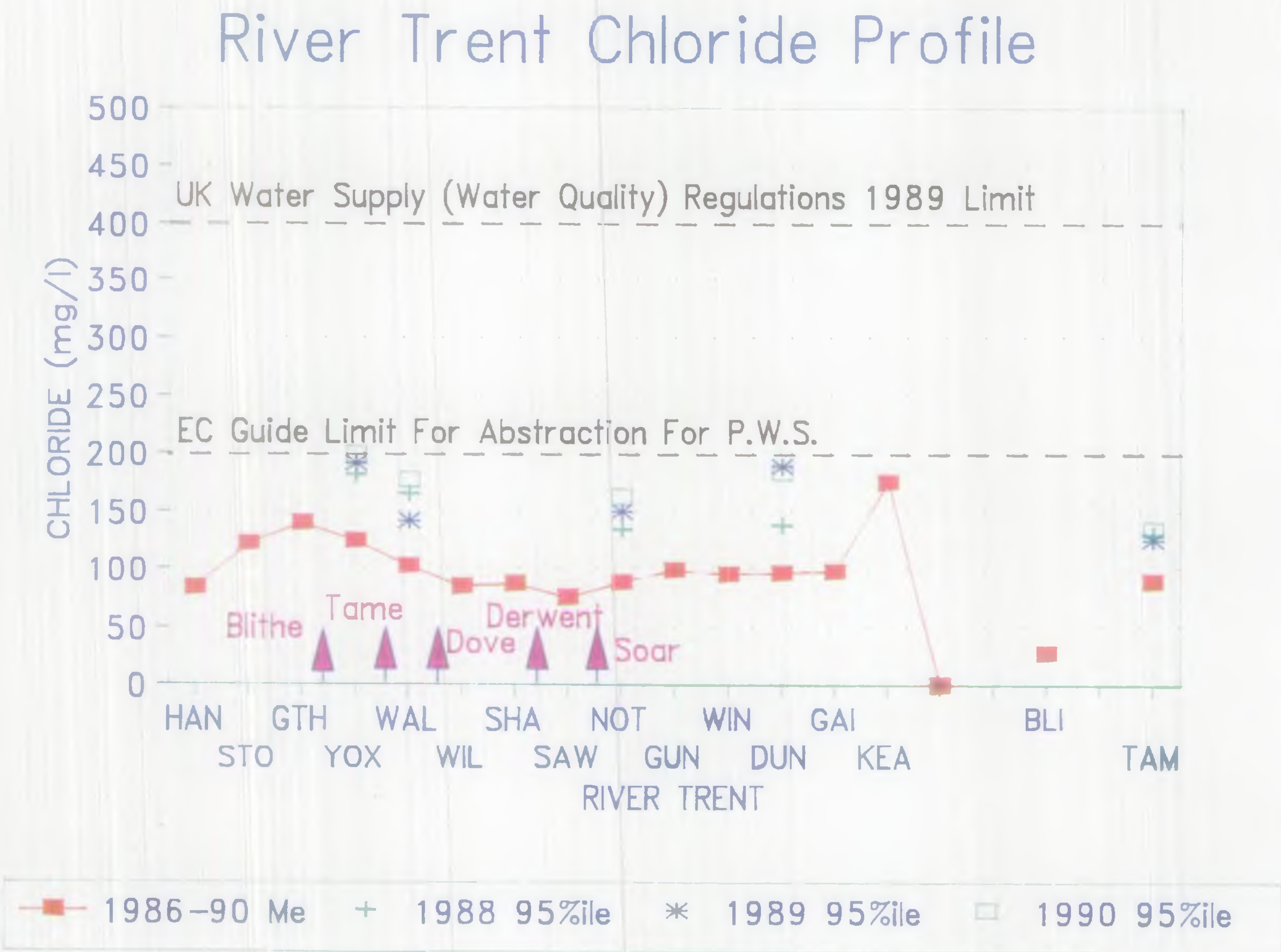
Sampling Locations	
HAN	HANFORD
STO	STONE
GTH	GREAT HAYWOOD
YOX	YOXALL
WAL	WALTON
WIL	WILLINGTON
SHA	SHARDLOW
SAW	SAWLEY
NOT	NOTTINGHAM
GUN	GUNTHORPE
WIN	WINTHORPE
DUN	DUNHAM
GAI	GAINSBOROUGH
KEA	KEADBY

In addition to the standard NWC classification parameters the following determinants are of importance to the uses of the river.

a) Chlorides

Average and 95 percentile chloride concentrations within the river are below the maximum concentration of 400mg/l for new water supply sources as given in the Water Supply (Water Quality) Regulations 1989, and generally below the guideline EC standard of 200mg/l for water abstraction intended for public supply (Figure 6.10). The upper catchment is seen to exhibit higher average and 95 percentile chloride concentrations as a result of WRW discharges and limited diluting flows. The average concentrations tend to decline and level off in mid catchment as a number of tributaries increase the available diluting flows. Given the implications for other uses such as crop irrigation, the NRA are particularly concerned to see the 200mg/l guide limit observed.

There are a number of proposals which could increase the chloride loading to the river including; water supply ion exchange processes for nitrate removal, mine wastewater discharges including the combined discharge at Nottingham, and the new flue gas desulphurization (FGD) plant under construction at Ratcliffe power station. Negotiations are currently being undertaken between the NRA and Powergen concerning chloride discharge consent conditions for the FGD plant. The proposed



River Trent Chloride Profile
UK Water Supply (Water Quality) Regulations 1989 Limit
EC Guide Limit For Abstraction For P.W.S.
CHLORIDE (mg/l)
500
450
400
350
300
250
200
150
100
50
0
Blithe
Tame
Dove
Derwent
Soar
HAN
STO
GTH
YOX
WAL
WIL
SHA
SAW
NOT
GUN
WIN
DUN
GAI
KEA
BLI
TAM
RIVER TRENT
1986-90 Me
1988 95%ile
1989 95%ile
1990 95%ile

FIG 6.10

conditions are complex and relate to different levels of flow in the river, highlighting the NRA's concern to maintain water quality standards in the river.

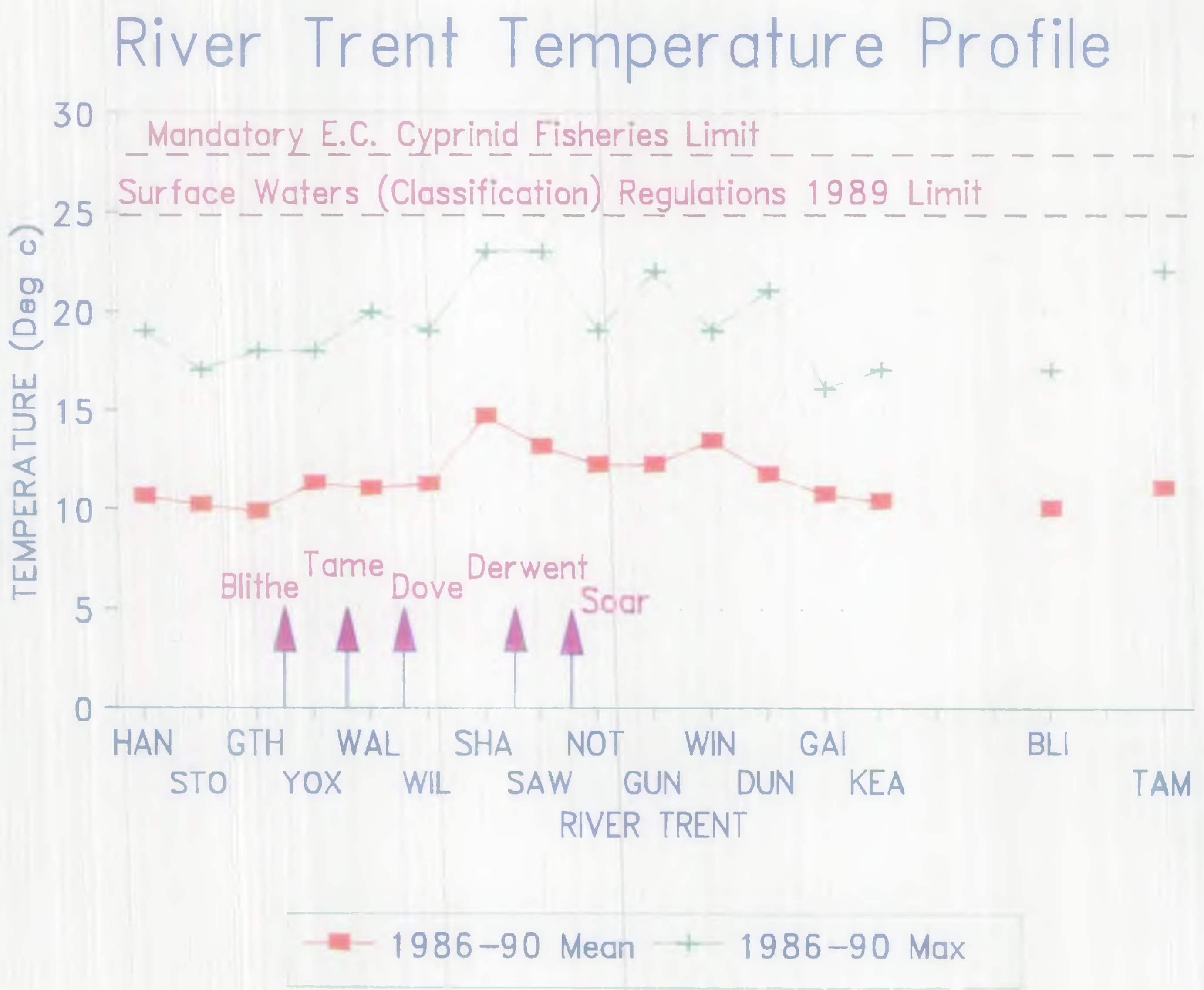
b) Temperature

The temperature regime of the river is heavily influenced by the power station cooling water discharges it receives. Significant increases in mean and maximum recorded values along the river reflect the various power station discharges. The temperature does not exceed the EC maximum limit for cyprinid fisheries at monitoring stations (Figure 6.11), but does approach the maximum of 25°C allowed under The Surface Water (Classification) Regulations 1989 for water intended for potable supply.

The majority of power station cooling water discharge consents have a maximum downstream river temperature of 30°C. The NRA are considering reducing this to 28°C in line with the EC Freshwater Fisheries Directive standard of 28°C maxima for designated cyprinid waters.

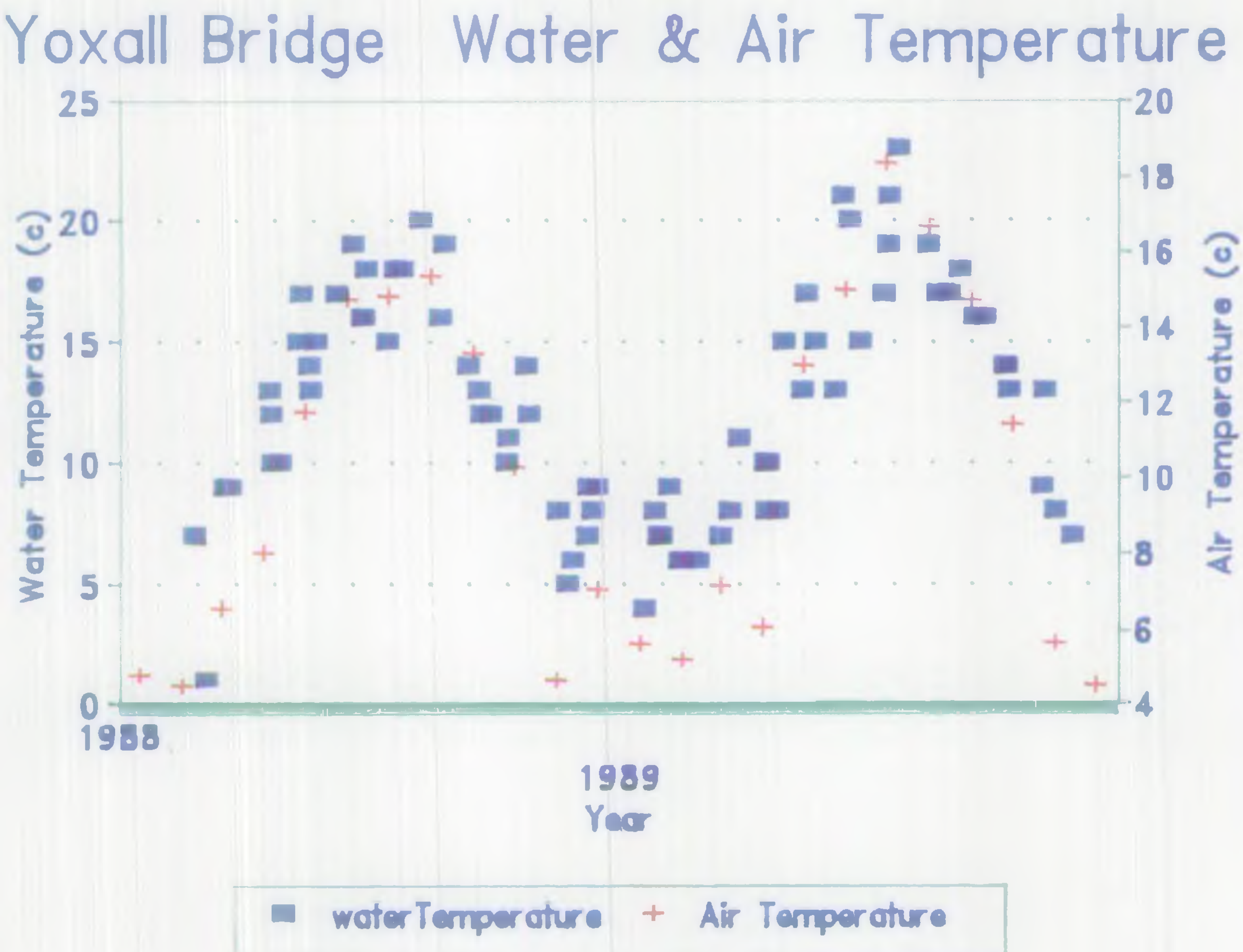
We have examined the sensitivity of the water temperature in the river at Yoxall Bridge to both air temperature and river flows. Figure 6.12 shows the very strong correlation between average monthly air temperatures and the water temperature. The correlation with flows is much less clear, even when plotted on an inverse log scale (Figure 6.13). Even if we accept that there is a correlation, a 30 Mld reduction in dry weather flow would only lead to a 0.3°C increase in water temperature. However, we consider that the true effect would be significantly less than this, and probably negligible.

Yoxall Bridge can be considered to be independent of the effects of cooling water discharges as it is some way downstream of Rugeley. The water temperature in lower reaches of the river will be more affected by river flows due to reduced dilution of the cooling water discharges.



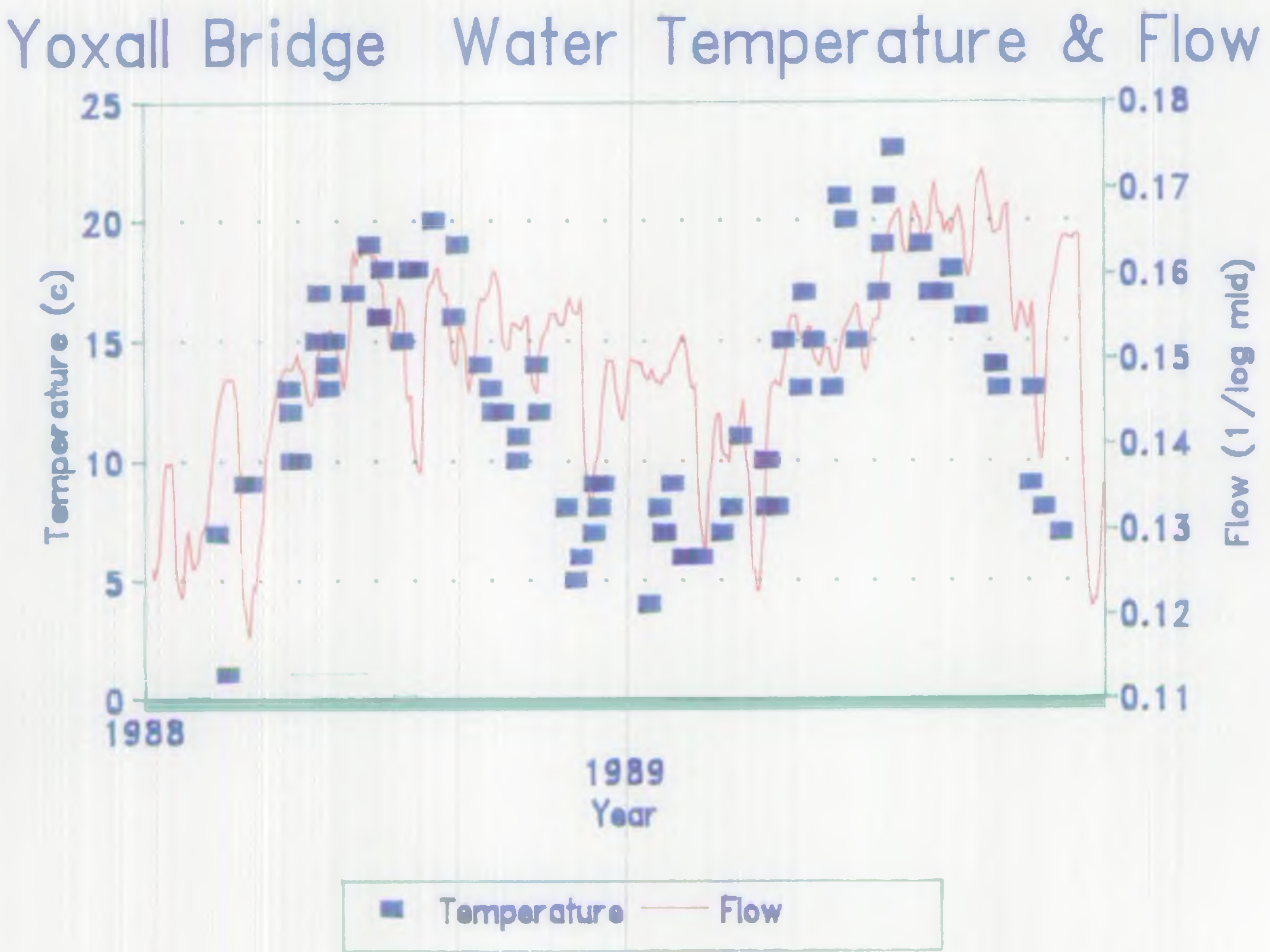
River Trent Temperature Profile
Mandatory E.C. Cyprinid Fisheries Limit
Surface Waters (Classification) Regulations 1989 Limit
TEMPERATURE (Deg c)
30
25
20
15
10
5
0
Blithe
Tame
Dove
Derwent
Soar
HAN
STO
GTH
YOX
WAL
WIL
SHA
SAW
NOT
GUN
WIN
DUN
GAI
KEA
BLI
TAM
RIVER TRENT
1986-90 Mean
1986-90 Max

FIG 6.11



Yoxall Bridge Water & Air Temperature
Water Temperature (c)
Air Temperature (c)
25
20
15
10
5
0
20
18
16
14
12
10
8
6
4
1988
1989
Year
waterTemperature
Air Temperature

FIG 6.12



Yoxall Bridge Water Temperature & Flow
Temperature (c)
25
20
15
10
5
0
1988
1989
Year
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
Flow (1/log mld)
Temperature
Flow

FIG 6.13

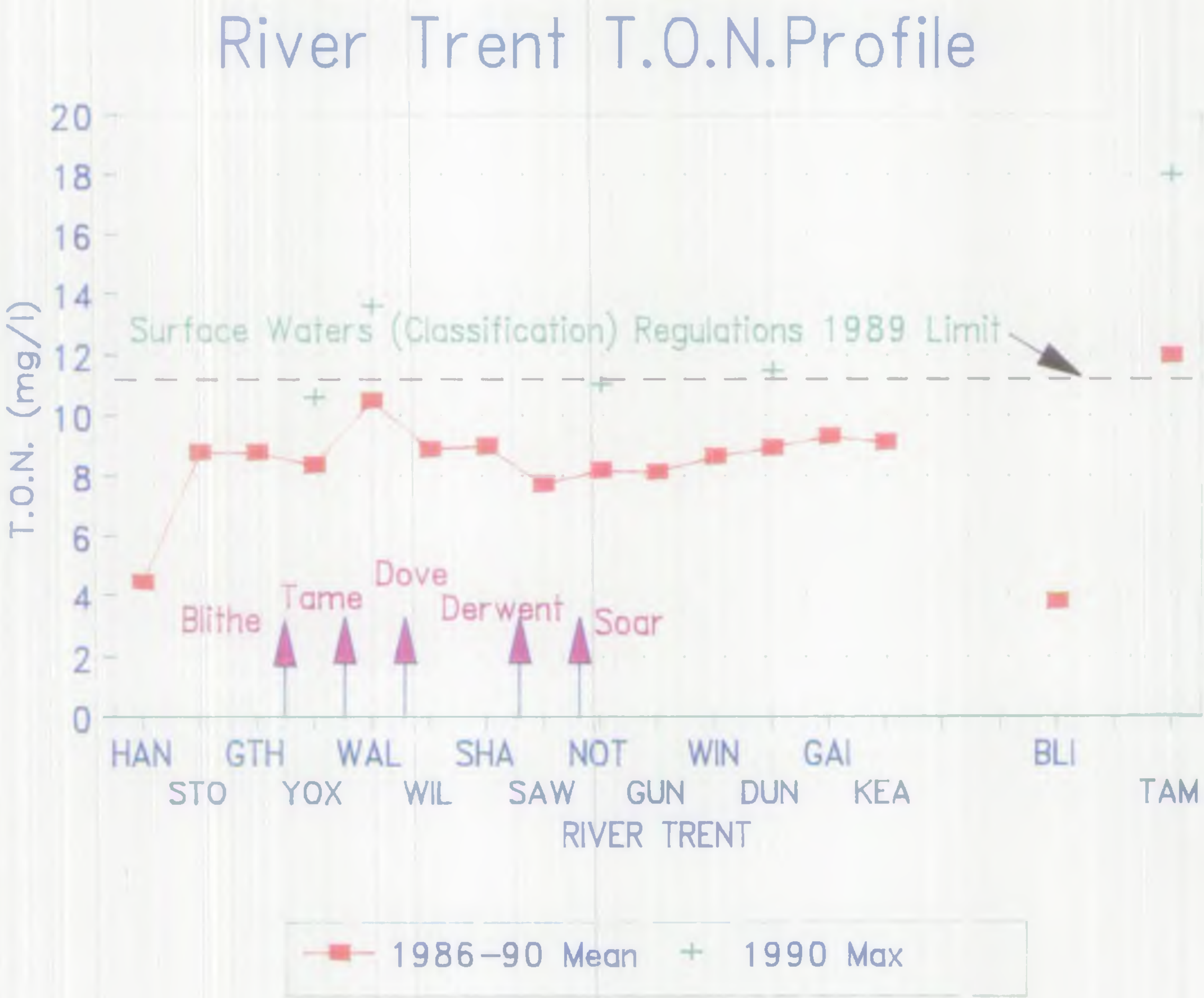
c) Nitrates

Average nitrate concentrations (as measured by Total Oxidized Nitrogen) are relatively high throughout the catchment when compared to the limits set out in The Surface Waters (Classification) Regulations 1989 for abstraction for public supply (Figure 6.14). The high average nitrate values could result in some or all of the Trent catchment being designated a vulnerable area with respect to the new EC Nitrate Directive. Approximately 60% of the nitrate loading to the river originates from water reclamation works.

d) Phosphates

Average and maximum phosphate concentrations are lower than the maximum concentration for Phosphorus (when converted to phosphate) set out in the Water Supply (Water Quality) Regulations 1989 (Figure 6.15). No limit applies specifically for water intended for PWS. The limit shown is post treatment but may be applied to new supply sources. Mean concentrations at all sites downstream of the confluence with the River Blithe, however, are well above the EC Directive guideline limit for water intended for the abstraction of drinking water. NRA will expect to designate sensitive areas in future under urban waste water directives. These concentrations, in conjunction with the high nitrate values, could result in sensitive zones with respect to potential for eutrophication under the EC Urban Wastewater Directive.

Figure 6.16 shows river phosphate concentrations recorded at Yoxall bridge from 1986 to 1990. The diagram indicates a general increase in concentrations, particularly over 1989 and 1990. In both years the phosphate concentrations are highest during the summer low flow periods. These were notably lower than the average summer flows at this site. The quantity of phosphates contributing to the catchment via water reclamation works remains relatively constant irrespective of climatic conditions. It is therefore not surprising that phosphate concentrations should respond to the quantity of available river dilution. Any reductions in flows through abstraction could therefore potentially increase average phosphate concentrations.



River Trent T.O.N.Profile
T.O.N. (mg/l)
20
18
16
14
12
10
8
6
4
2
0
Surface Waters (Classification) Regulations 1989 Limit
Blithe
Tame
Dove
Derwent
Soar
HAN
STO
GTH
YOX
WAL
WIL
SHA
SAW
NOT
GUN
WIN
DUN
GAI
KEA
BLI
TAM
RIVER TRENT
1986-90 Mean
1990 Max

FIG 6.14

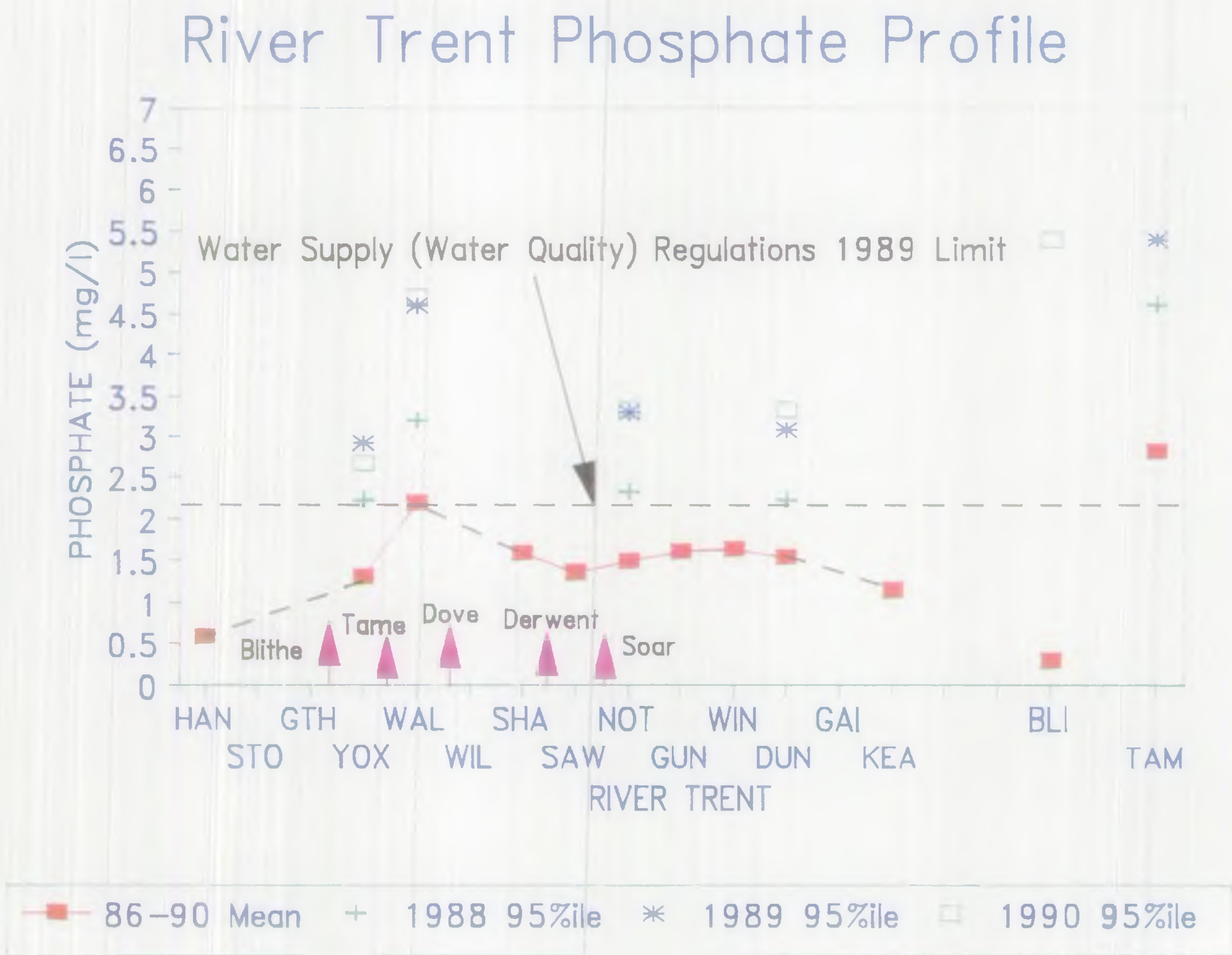

River Trent Phosphate Profile
PHOSPHATE (mg/l)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Water Supply (Water Quality) Regulations 1989 Limit
Blithe
Tame
Dove
Derwent
Soar
HAN
GTH
WAL
SHA
NOT
WIN
GAI
BLI
STO
YOX
WIL
SAW
GUN
DUN
KEA
TAM
RIVER TRENT
86-90 Mean
1988 95%ile
1989 95%ile
1990 95%ile

FIG 6.15

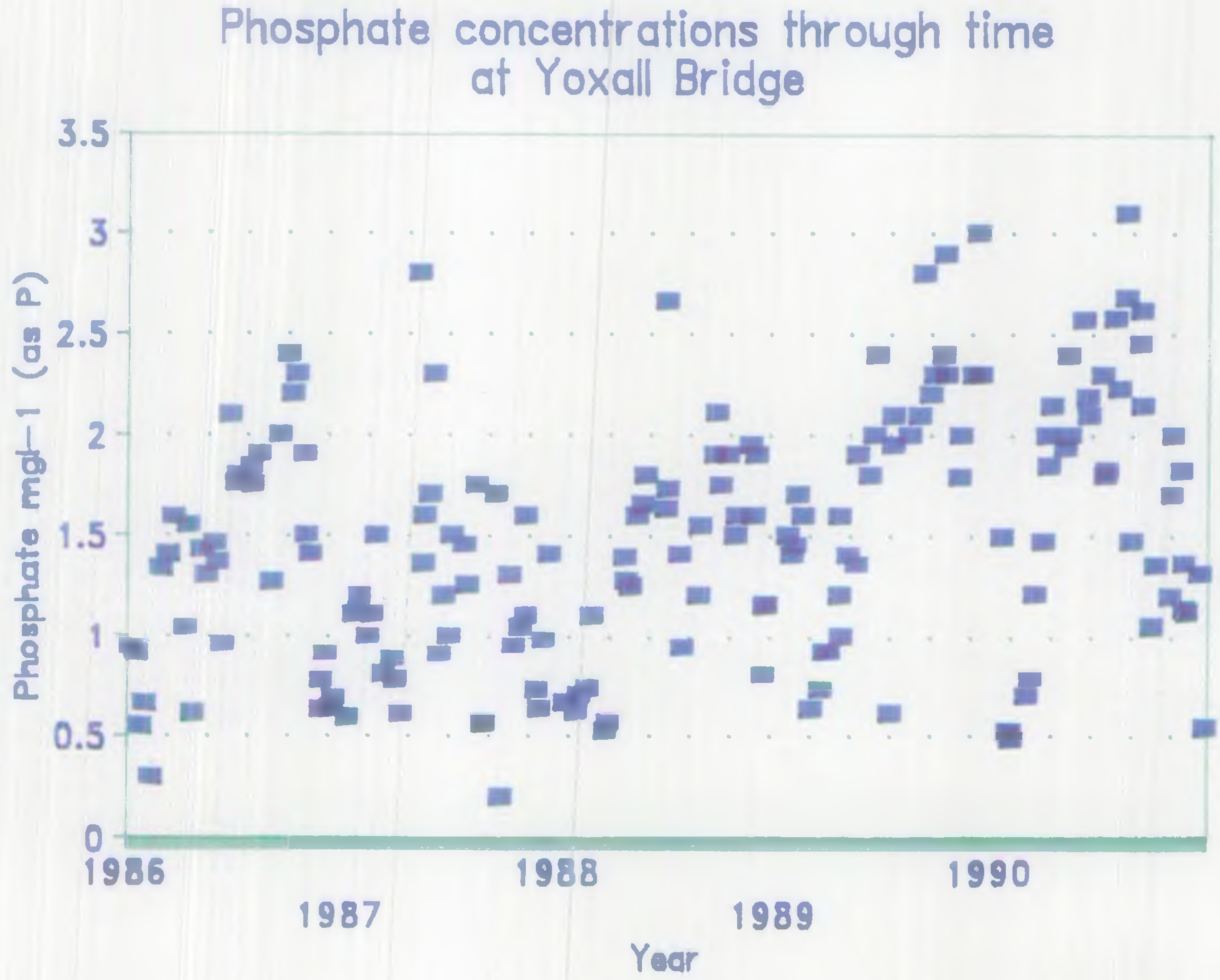

Phosphate concentrations through time
at Yoxall Bridge
3.5
3
2.5
2
1.5
1
0.5
0
Phosphate mgl-1 (as P)
1986
1987
1988
1989
1990
Year

FIG 6.16

Phosphate concentrations in the region of 5 to 6 mg/l (1.5mg/l to 2mg/l when expressed as Phosphate-P) are of concern to the power station operators, as they form deposits at higher temperatures in condensers, drastically impairing their cooling efficiency. In the worst case this has resulted in condenser cleaning every 2-3 weeks during summer periods.

Increased phosphate concentrations are of concern for their potential to increase eutrophication within the river. The River Avon is a very similar river to the Trent, with much of its middle and lower reaches retained for navigation. The River Avon was found to exceed the threshold criteria for blue green algae in 1989, but, following a revision of the threshold criteria in 1990, the river was not found to be positive. Table 6.1 compares summary average water quality data for selected sites on the Rivers Trent and Avon. The data show that, recently, the River Trent has displayed similar nutrient concentrations, particularly phosphates and nitrates, to those found in the Avon. There are of course a number of other factors which will affect the rate of eutrophication experienced by any given water body, including flow velocities, flow travel time and light penetration.

Of particular concern, also, is the notable rate at which nitrate and phosphate concentrations appear to be increasing at both Yoxall and Nottingham. The increase in nitrate concentrations of 13% between 1989 and 1990 appears at Yoxall and is more or less sustained at Nottingham. However, the phosphate concentration, while showing a 15% increase at Yoxall, shows a 35% increase at Nottingham from 1989 to 1990, and 65% increase since 1988.

It is likely that existing nutrient concentrations within the River Trent are capable of supporting a considerably higher level of eutrophication or biological activity than presently exists. Further work into the susceptibility of increased eutrophication resulting from water supply abstractions will therefore be required to assess their impact on flow and travel times in the river.

e) Sulphates

Average sulphate concentrations are below the EC and national maxima for water intended for public supply, although certain individual results exceed the 250mg/l limit (Figure 6.17). The monitoring of sulphate levels appears to be less than that for other water quality parameters, and it is therefore difficult to infer details from limited data. The maxima exceedances do, however, appear to result from specific events rather than any increasing trends. This is particularly so for the Dunham sampling point where a result of 740mg/l is preceded and followed by samples of 215 and 216mg/l respectively. The sulphate concentrations are a cause of concern because the 250mg/l is a mandatory limit.

Additional sulphate loadings could arise from the flue gas desulphurisation plant under construction at Ratcliffe and from any future mine wastewater discharges.

List I and II substances do not appear at present to cause any problems throughout the River Trent, with mean concentrations well below their respective limits. However, there have been occasions when individual samples have exceeded the Drinking Water Quality Standards for cadmium, lead and mercury.

The estuarine water quality is of importance given the proposals to abstract freshwater further upstream. At present an oxygen sag develops in the estuary and is thought primarily to result from the breakdown of organic materials associated with cohesive sediments resuspended on flood tides. Should a significant proportion of fresh water be abstracted then the oxygen sag could potentially move further up the estuary on any given tide. This aspect will require careful consideration when assessing proposals to increase abstraction particularly from the tidal reaches.

The suspended sediments that occur during tidal cycles also affect the operation of the lower power stations such as West Burton. Any changes to the freshwater discharge to the estuary could affect these

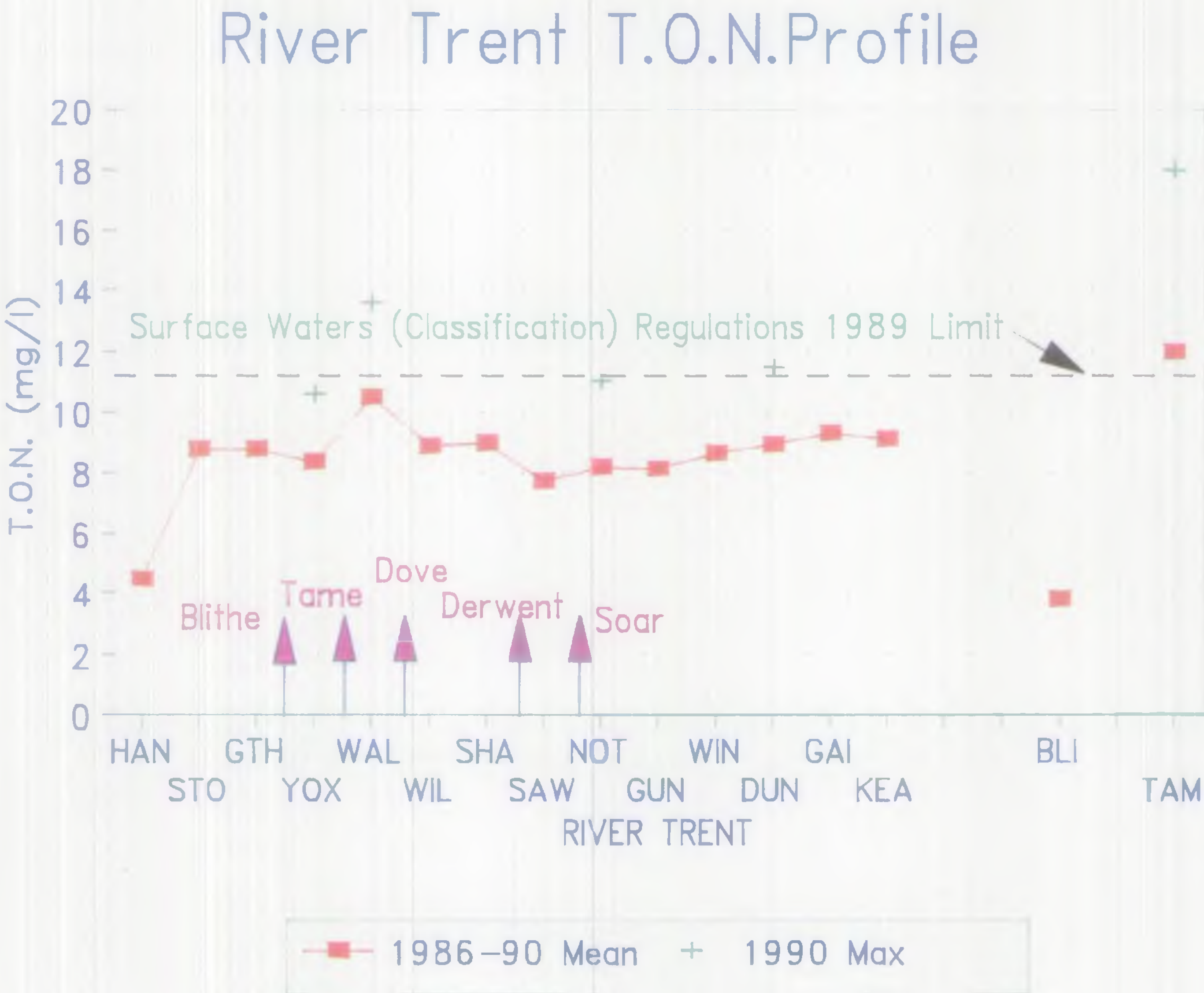
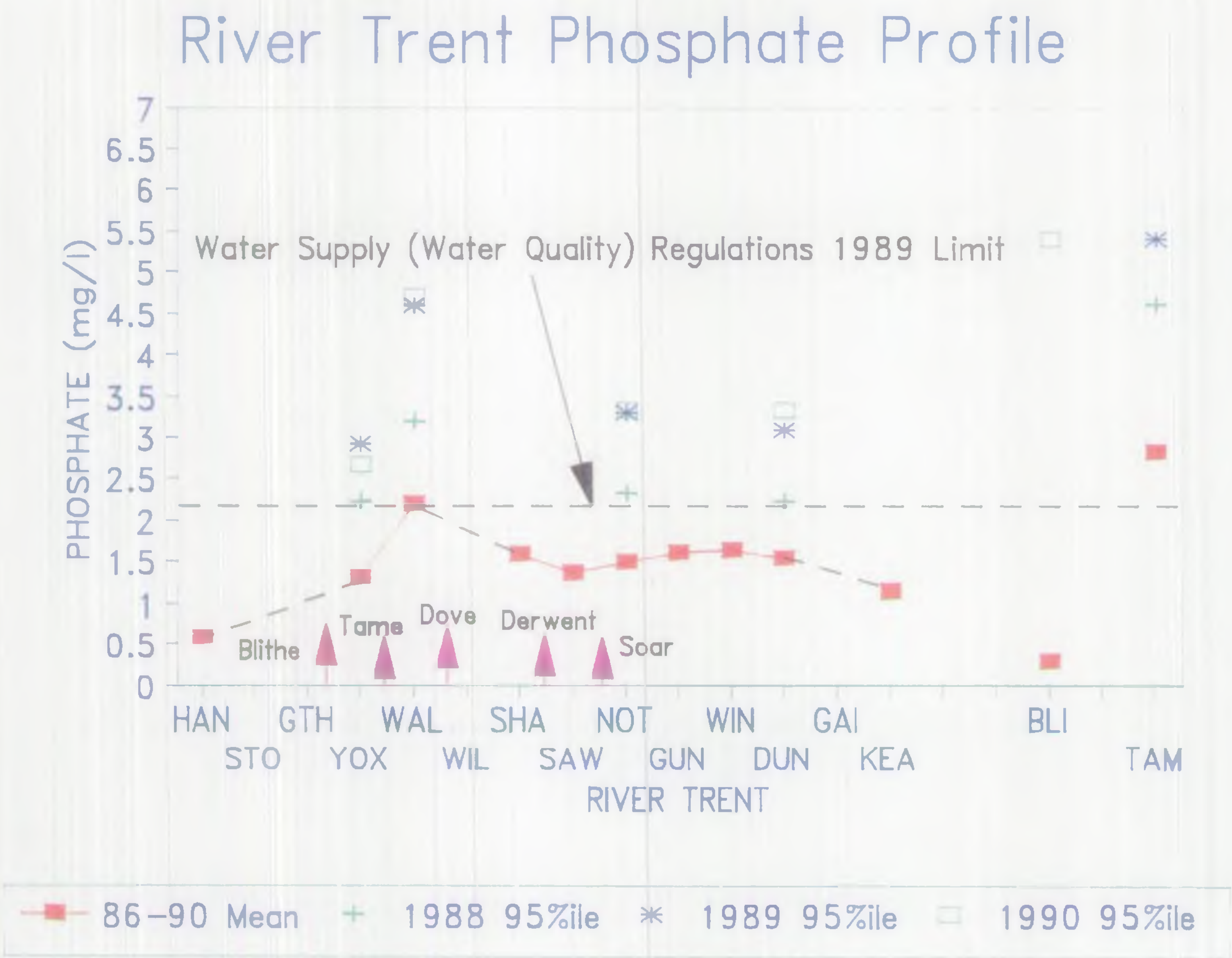
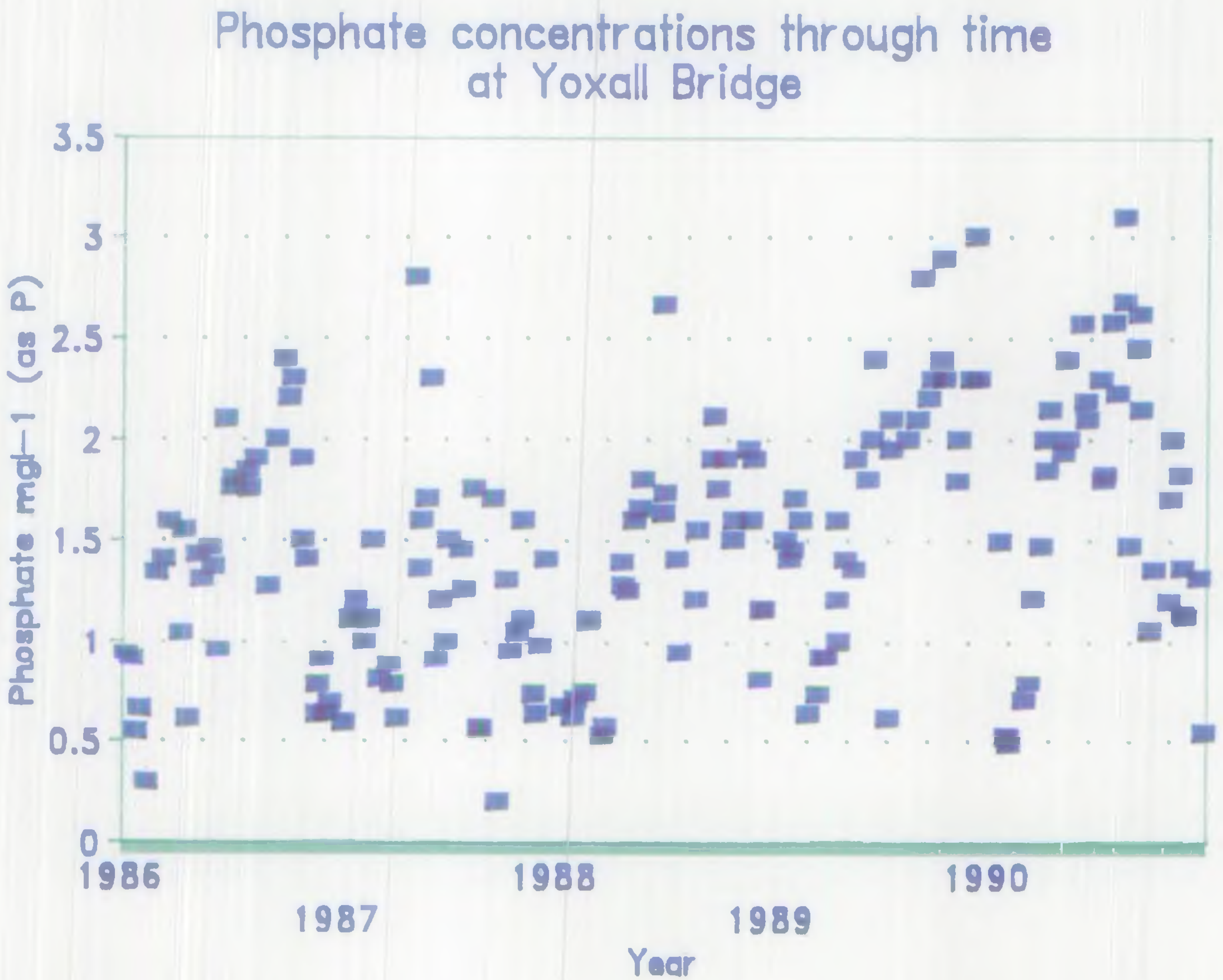

River Trent T.O.N.Profile
T.O.N. (mg/l)
20
18
16
14
12
10
8
6
4
2
0
Surface Waters (Classification) Regulations 1989 Limit
Blithe
Tame
Dove
Derwent
Soar
HAN
STO
GTH
YOX
WAL
WIL
SHA
SAW
NOT
GUN
WIN
DUN
GAI
KEA
BLI
TAM
RIVER TRENT
1986-90 Mean
1990 Max

FIG 6.14



River Trent Phosphate Profile
PHOSPHATE (mg/l)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Water Supply (Water Quality) Regulations 1989 Limit
Blithe
Tame
Dove
Derwent
Soar
HAN
STO
GTH
YOX
WAL
WIL
SHA
SAW
NOT
GUN
WIN
DUN
GAI
KEA
BLI
TAM
RIVER TRENT
86-90 Mean
1988 95%ile
1989 95%ile
1990 95%ile

FIG 6.15



Phosphate concentrations through time
at Yoxall Bridge
Phosphate mgl-1 (as P)
3.5
3
2.5
2
1.5
1
0.5
0
1986
1987
1988
1989
1990
Year

FIG 6.16

abstractions and will require investigation.

At present, however, very little is known of conditions in the tidal reach of the river, particularly with regard to fisheries.

Copper is a List II substance (National Environmental Quality Standards for Dangerous Substances in Water) with relatively high concentrations present in River Trent Water. A particular concern of the NRA relates to the Environmental Quality Standard (EQS) of copper as it passes from river to estuary. The EQS in fresh water is set relative to hardness in the water, and in the Trent this is in excess of 250mg/l. The EQS for copper in this case is 28 ug/l (annual average) in the river, and 25 ug/l in the estuary. The tightening of the EQS as copper passes into the estuary could potentially lead to certain parts of the estuary failing the EQS.

The mean total copper concentration at Dunham (1986-1990) is 18.1ug/l with a 95 percentile value of 38.6ug/l and at maximum of 89ug/l. The mean in 1990 was 13.7ug/l with a maximum of 22ug/l. As the EQS relates to annual average concentrations, this does not appear likely to give any cause for concern.

There is no maximum standard for copper under the Surface Water (Classifcation) Regulations 1989 for water intended for public supply if DW3 treatment is proposed. The maximum concentration for water entering public supply is 3000ug/l.

River Avon				River Trent							
	Evesham			Yoxall Bridge				Nottingham			
	87/88	88/89	86/89	88	89	90	85-90	88	89	90	85-90
BOD	3.4	3.1	3.6	3.3	3.4	3.04	3.1	3.4	2.99	3.7	3.45
Ammonia	0.3	0.29	0.28	0.3	0.25	0.26	0.27	0.4	0.27	0.29	0.36
TON (as N)	10.0	9.9	10.32	7.8	9.4	8.3	8.68	7.8	9.25	9.25	8.64
Phosphate (as P)	1.5	2.4	1.91	1.1	1.65	1.44	1.47	1.3	2.15	2.15	1.75

1) All values in Mg/l

Table 6.1 Rivers Trent and Avon - Comparative Summary of Water Quality Statistics (1985-1990)

6.3 **Conclusions**

The previous sections in this chapter have considered the state of the Trent catchment in terms of flows and water quality. In this section the main features are pulled together from these sections.

The River Trent receives substantial augmentation from groundwater and transfers into the catchment which increase the natural dry weather flow of the river by around 50% at its tidal limit. Approximately 50-60% of the total dry weather flow of the Trent at North Muskham has passed through water reclamation works (Figure 6.7). The total volume of augmentation of the Trent in the summer of 1977 was estimated as around 900 Ml/d. This figure has increased since then. It could be argued that all this water should be available for abstraction since it is over and above the natural flow in the river. Augmentation has been taking place for more than thirty years, however, and the river has adapted to its increased flows, as have its users. Legally the question arises as to whether this augmentation is protected for the sole use of Licenses of Right, such as those of the power stations on the Trent.

The Dove and Derwent valleys are the only major surface water resources within the catchment currently exploited for public water supply. The water from these catchments is generally of very high quality, and in summer particularly, would have contributed substantially to dilution of River Trent water.

In recent years the quality of Trent water has been variable, but has generally been within the UK Water Supply and Surface Water Regulations limits for water intended for public consumption. Phosphates, nitrates, and sulphates, however, are presently approaching those limits and are still increasing. Nitrates, particularly, sometimes exceed the allowable limits under the Regulations. If the river is used as a source for public supply (as it already has been on occasion through the NRA-Anglian transfer at Torksey) then certain sampling points on the river could become designated as a Source for Potable Supply and will be required to conform to the relevant Regulation limits. This may then require that certain effluent discharges have to be tightened if they subsequently cause the river to fail its Regulation limits at the relevant sampling points.

There are three existing Licences of Right on the Trent that exceed even the augmented dry weather flow of the river. These are Willington, Castle Donnington, and Staythorpe power stations. Strictly speaking therefore, any licence issued to abstract water from the Trent upstream of these power stations when the flow in the river is less than their maximum daily licensed quantities may be construed as a derogation to these existing licences.

In reality, a derogation only occurs when a licensee is unable to abstract the amount of water he actually requires because it has already been abstracted upstream. However, the NRA are duty-bound to ensure that existing licence holders are protected from subsequent abstractors upstream. The only instance in which a new abstraction would not cause derogation is if all water abstracted is returned to the river upstream of the existing licence.

It has been noted that users of the river have experienced difficulties caused by low river flows in the last two years. These difficulties are centred around the middle and lower reaches of the river. One power station (Willington) has occasionally found insufficient water in the river to enable full abstraction of its requirement. Holme Pierrepont canoe slalom course has had to operate on a restricted basis as there was insufficient flow in the river to maintain navigational levels and permit continuous use of the slalom course. Anglers have complained, and the national press has reported, of extremely poor fishing conditions downstream of Stoke Bardolph Water Reclamation Works (Nottingham) as far as North Muskham. Low summer river flows have resulted in less dilution of sewage effluent giving rise to concentrations of ammonia stressful to fish. Staythorpe power station has experienced difficulty caused by the pulsing of flows as the canoe slalom course at Holme Pierrepont builds up and then releases water down it to allow recreational use. Both BW and West Burton power station have experienced significant operational difficulties due to excessive silt movement, and siltation.

These conditions indicate that this part of the river currently suffers from some degree of stress during dry summers, such as 1990, caused directly or indirectly by lower river flows. Analysis of low flow frequency curves indicate that 1990 conditions can be expected, on average once every ten to fifteen years.

Future demands on the river, however, are likely to change. Recreation and navigation are likely to increase as both the Sports Council and BWB continue to promote their activities. Statutory Water Quality Objectives (SWQO), when they are agreed, will be set on the river. The demand for use of Trent water as a source of public supply means that SWQO's set will be tighter than they would otherwise be. This may lead to improvements being required in the quality of the effluent currently discharged to the river and its tributaries. The decline of mining operations within the catchment means that discharges of saline mine water are likely to decrease. The closure of the older, direct cooled power stations on the river by the end of the next decade, and their replacement by the less water demanding combined cycle gas turbine plant, should allow the revocation of all the abstraction licences that exceed the river's dry weather flow. A proposal by British Waterways Board to move the tidal limit of the river downstream by 35 to 40 km in order to improve the navigation for large vessels could have a major impact on all users of the tidal reaches as well as upstream polluters. The prospect of salmon being reintroduced to the Trent by Scottish Hydro-Electric plc also raises the potential for eventual use of the river as a salmonid fishery.

While some of these potential changes may appear to be in conflict, we believe they can work together to the benefit of most, if not all, who use, or wish to use the River Trent.

7.0 PROPOSALS FOR WATER ABSTRACTION.

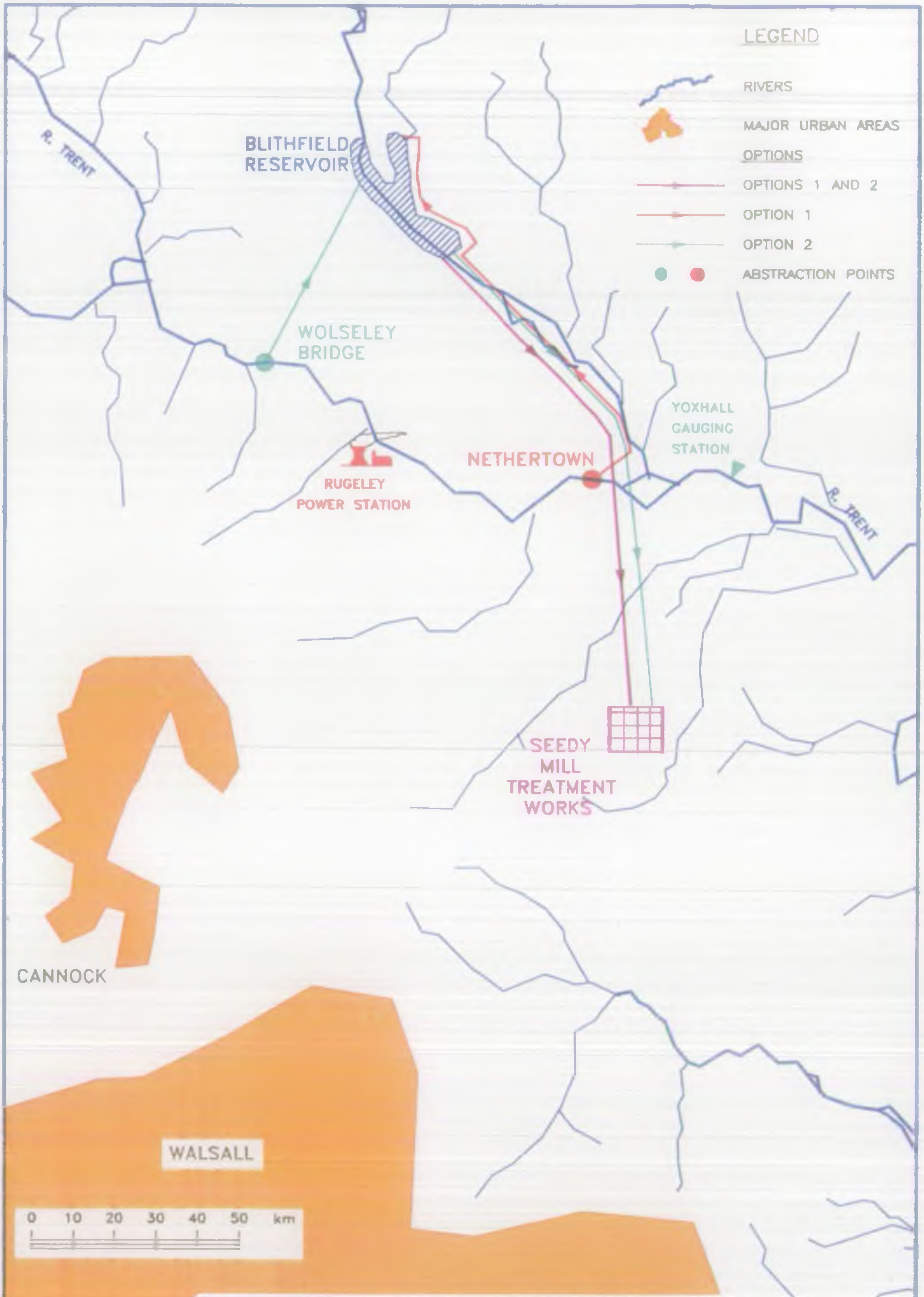
At present, there are five known proposals to abstract water from the River Trent. Four of these include water for public supply, while the fifth is for a new power station. These are each outlined below:

i) The South Staffordshire Water Company Proposal

Two principal options are being considered by SSWC for increasing their current yield from Blithfield Reservoir. These are described in detail in a report prepared by SSWC for NRA dated January 1992, but are illustrated schematically in Figure 7.1. Both require a maximum daily abstraction of 35Ml/d and would operate between April and October.

1) The first option makes use of existing pipework and abstraction facilities at Nethertown, on the confluence of the Blithe with the Trent. The abstraction would take place from the Trent upstream of the confluence with the Blithe. Currently two pipes (36" and 33") pass by the site, feeding Seedy Mill treatment works from Blithfield reservoir. One of these would be used to reverse flow from the Trent up to Blithfield where the Trent water would be mixed with Blithe water at the top end of the reservoir. The main consequence of this option would be the loss of security of supply to Seedy Mill with only one pipeline from Blithfield.

2) The second option involves an intake at Wolseley Bridge, north-east of Rugeley on the Trent. A five kilometre pipeline would transfer Trent water to the top end of the reservoir. Although Trent water quality is marginally poorer at this location than at Nethertown, SSWC are satisfied that with a blending ratio of 1:2 with Blithe water they will not experience significant problems due to water quality. The principle advantage of this option is the retained security of supply to the treatment works. Option 1 would also require a three kilometre pipeline to take Trent water round to the top of the reservoir.



SCHEMATIC OF SSWC OPTIONS FOR PROPOSED ABSTRACTION FROM RIVER TRENT TO BLITHFIELD RESERVOIR

FIG 7.1

On balance SSWC believe Option 2 to be marginally better. The reservoir currently draws down to 50% during dry summers, although demand restrictions (such as hosepipe bans) have not been used since 1976. Water quality is not deemed to be a problem at either site as dissolved air flotation and ozone plant is to be installed at the treatment works in any case.

ii) NRA - Anglian Region

NRA-Anglian presently hold an abstraction licence from NRA-Severn-Trent at Torksey, in the tidal reach of the Trent, for a maximum daily abstraction of 180Ml/d. The forecast increased demand in the Anglian region has precipitated a study by NRA-Anglian to investigate the engineering feasibility of distributing an additional volume of Trent water around the region.

Several options are being considered in this study, but all involve a phased increase in nett abstraction 600 Ml/d, additional to the present 180 Ml/d at Torksey. Figure 7.2 shows the various options.

The two primary contenders at present are:

1. an increase in the abstraction at Torksey, and transfer into the Fossdyke Navigation. This would involve uprating the existing plant, possibly building new works and a new intake, and negotiations with British Waterways Board concerning the conveyance of water along the Fossdyke.

2. a new river intake upstream of the present tidal limit, in the Newark area. A pipeline would convey the water 4 or 5 kilometres to the nearby River Witham, which might have to be modified to receive such a large transfer.

or possibly a combination of both options.

Water from both schemes is destined for South Humberside in the north (upto 150Ml/d), Norwich in the east, and Chelmsford, and possibly north

ANGLIAN REGIONAL STRATEGIC OPTIONS STUDY

FIG 7.2

east London, in the south (about 450Ml/d but possibly up to 550Ml/d). The possibility of using the water to partly support a new reservoir at Great Bradley is also being investigated.

The present abstraction licence at Torksey has recently been modified (1990) to allow water to be used for potable supply. The Trent and Lincolnshire Water Act 1971 forbids the station from pumping for a three hour period at each high tide. However, heavy siltation problems have still been encountered the past. If the same restrictions are imposed on the proposed nett abstraction of 600Ml/d, the actual abstraction rate for the remaining 18 hours in each day would be around 810Ml/d.

iii) Anglian Water Plc

In addition to the study being carried out by NRA-Anglian, Anglian Water are investigating the potential of using Trent water to meet some of their more immediate demands in, and to the east of, Lincoln. Several options are again being considered, but two appear to be more favoured. Both would abstract at a peak rate of 40 Ml/d with an average of 30 Ml/d.

1. To increase the Torksey transfer into the Fossdyke Navigation by 40 Ml/d and subsequently abstract water from the Fossdyke.

2. A direct abstraction from the Trent in the reaches downstream of Newark and pipe water to a treatment works at Newton.

This abstraction is additional to that being investigated by NRA-Anglian, and a licence from NRA-Severn-Trent is to be applied for by the end of 1992.

Anglian Water are also investigating plans for more long term demand, which, in their present estimates, is expected to be around 140 Ml/d, to supply the Humber area. However, this water, again from the Trent, is included in the NRA-Anglian study.

iv) **Severn-Trent Water Plc**

Revision of Severn-Trent Water demand forecasts indicate that current supplies (including Carsington) will be fully utilised by 2005. A new source is therefore required by this time.

An abstraction from the Trent near the Derwent confluence, upstream of Nottingham, is being considered. Church Wilne reservoir could easily be doubled in size to accommodate the abstraction, but would only represent a month's bankside storage. The abstraction would therefore need to be continuous. It would be phased into an upper limit of between 100-200 Ml/d, probably around 150 Ml/d. The water would be used to meet increased demand in Nottingham, Leicester, and Derby.

The possibility of abstracting the water from river gravels rather than the river direct is being considered for two reasons.

1. abstraction from river gravels would filter out much of the sediment from the river.

2. direct abstraction from the Trent could result in the river being designated as a source for potable supply at the point of abstraction. This would consequently lead to water quality parameters being uprated, with potential knock-on effects for effluent discharges from Severn-Trent's water reclamation works.

v) **Scottish Hydro-Electric Plc**

Scottish Hydro Electric are proposing to build a new direct cooled combined cycle gas turbine station on the Trent at Keadby. The river is saline at this point and dominated by tidal flows.

The station is to be built on the site of the former coal fired power station that used to exist there, and makes use of the intake sluices and outfall of the old station. An abstraction licence for 931 Ml/d is to be applied for shortly.

Scottish Hydro-Electric are keen to stock salmon in the Trent and are willing to pay for the cost of building fish passes at all necessary points up the river, if they are successful in acquiring the various licences and permissions they require.

Discharge temperature consents are presently being discussed with NRA-Severn-Trent, and some temperature modelling of the river at Keadby has been undertaken.

vi) Other Developments

Various other developments are likely to take place within the river basin that may require Trent water. The proposal for a new Staythorpe C power station is one such.

The Environmental Statement produced by National Power for Staythorpe C estimates that the total water requirements from the Trent would be 52Ml/d. This figure is likely to be an annual average, rather than a maximum daily, but is not specified. Of this 52Ml/d, only 13Ml/d are stated to be returned, representing a consumptive use of 39Ml/d. The dry weather flow of the river at Staythorpe is around 2750Ml/d so abstraction represents 2% of the dwf and is therefore likely to be insignificant. However, there are one or two apparent inconsistencies in the report so these figures require verification.

Spray irrigation requirements have been identified in Section 5.1.4 as being likely to double over the next 20 years. This would represent an additional 125Ml/d catchment wide, of which between 50Ml/d and 60Ml/d could be either from the Trent direct or from its non-tidal tributaries. The remaining 70-75Ml/d are likely to be taken mainly from the Torne and Idle catchments which join the Trent at or below its saline limit. These estimates assume that the growth in spray irrigation demand takes place within, or close to, those sub-catchments where the current demand already exists, and is spread evenly across those sub-catchments.

These demands will represent a consumptive use of river water during the summer, unless they are tied to winter storage conditions. An estimated 25Ml/d - 30Ml/d could be abstracted direct from the Trent, but the majority of this is likely to be from the non-saline tidal reach of the river. A further 25-30Mld could be taken from tributaries down its length. For example, 10Ml/d may be taken in the Penk Catchment, a further 10Ml/d in the Tame catchment and 5Ml/d in the Soar catchment. However, these estimates are highly provisional and should be verified by a slightly more detailed study.

British Waterways are applying for a licence for abstraction from the Beeston Canal in Nottingham. The abstraction is for cooling water for an incineration plant for district heating. The abstraction required is for 60-70Ml/d, of which 5% is consumptive. However, in order to meet a temperature consent, a peak flow of 137 Ml/d is required. Although this water is non-consumptive, the river between the two ends of the canal, at Beeston and Meadows, respectively, (a distance of around seven kilometre), would experience this depletion. The plant is expected to commence operations in 1993. BW do not have any other plans for abstraction from the Trent.

Table 7.1 summarises the above mentioned proposals and likely developments, along with their relative timescales. An attempt is made to estimate consumptive and non-consumptive use. Table 7.2 summarises the demands of these proposals on each of the main reaches of the Trent, including the cummulative demand in a downstream direction.

Table 7.1 Summary of Proposals and Possible Future Demands of the River Trent

Proposal	Approximate Location	Likely Timescale (yrs)	Peak Water Demand		River Trent Dry Weather Flow (Ml/d)
			Licence (Ml/d)	Summer Consumptive Use (Ml/d)	
SSWC	Rugeley	1992	35	11	320
STW	Derwent Confluence	2005	150	38	1600
Anglian Water	Torksey	1992	40	40	2800
NRA Anglian to	Torksey[1]				
-Humberside		1994	up to 150[2]	up to 150[2]	2800
-South of Lincoln		2000-2010	up to 550[2]	up to 550[2]	2800
SHE plc	Keadby	1992	931	40	>2800
<u>Others</u>					
BW	Nottingham	1992/3	137	3(137)[3]	2400
Increased spray irrigation	Upper Trent	? 2010	?10	?10	-
	Tame and Soar		?15	?15	-
	Lower Trent		?30	?30	-
	Idle and Torne		?75	?75	-
Staythorpe C	Newark	? 1992/3	?52	?39	2750
Other new CCGT power stations	?	> 2000	?60	?40	?

1. An alternative option proposes to abstract upstream of Cromwell Lock, Newark.

2. Combined total net maximum transfer of NRA-Anglian transfer currently evisaged = 600Ml/d.

3. Consumptive for that section of the Trent parallel to the Beeston Canal.

Table 7.2 Summary of Possible Future Demands on Reaches of the River Trent

Reach	Peak Water Demand (Ml/d)				Dry Weather flow at bottom of reach (Ml/d)
	Licence		Summer Consumptive Use		
	Within Reach	Cumulative	Within Reach	Cumulative	
Upsteam of Tame Confluence	45	45	45	45	440
Tame to Soar	160	205	24	69	2300
Soar to Newark	57	262	44	113	2800
Newark to Estuary	1601	1863	710	823	>2800

8.0 POSSIBLE EFFECTS OF THE PROPOSALS

Four of the five proposals outlined in the previous chapter are concerned with utilising River Trent water as a source for potable supply. Two of these propose to abstract water from the non-tidal section of the river. In the following sections, the possible effects of each proposal are discussed.

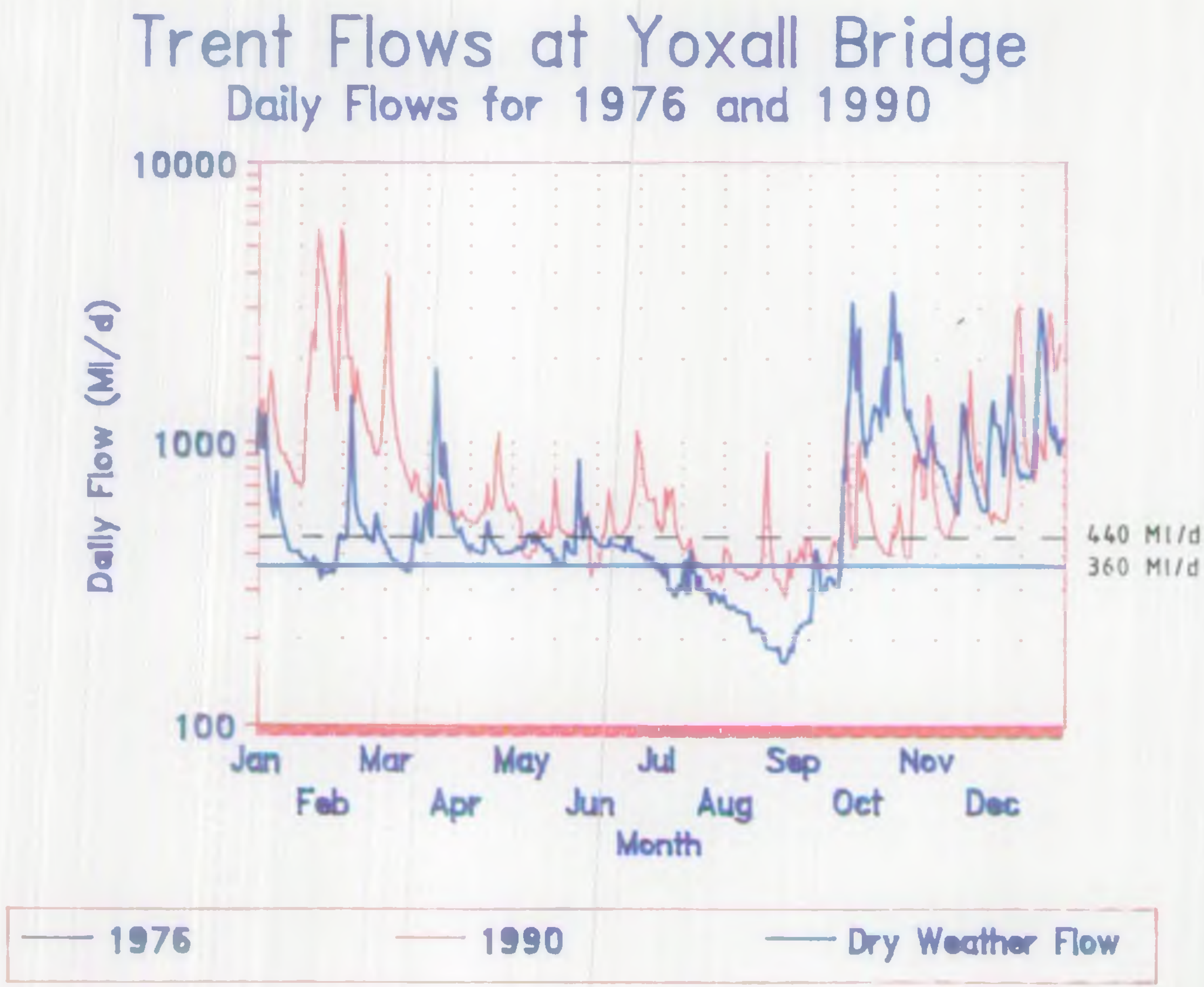
i) The South Staffordshire Water Company Proposal

SSWC have informed us that they require the additional water to meet increased demands throughout their area. The majority of the population is in the West Midlands areas of Walsall, Dudley, Tipton and Sutton Coldfield, with a large proportion of these lying within the Tame catchment. Further supply areas could include the new Toyota plant, the effluent from which will discharge through Derby WRW to the Derwent. The peak abstraction from the Trent is proposed to be 35 Mld, with an average of 15 Mld over the period April to October. We do not yet know the increase in demand that the scheme is designed to meet, but we can assume that it will be somewhere near to the average figure. In the region of 70% to 80% of this supply may be returned to the Trent catchment via effluent discharges, the majority being via the River Tame. For the purposes of this assessment we have assumed that 9 Mld will rejoin the Trent via the Tame, with a further 3 Mld returning via the Derwent.

Considering the possible impacts of the proposal, there will be a reduction of flows in the reach downstream of the abstraction. This will be as high as 35 Mld down to the Tame confluence, perhaps 26 Mld from there to the Derwent confluence and 23 Mld for the remainder of the river.

The abstraction could therefore have the following effects in an average year:-

1. Derogation of the existing abstraction licences for power stations, primarily those at Rugeley, Drakelow, Willington,



Trent Flows at Yoxall Bridge
Daily Flows for 1976 and 1990
10000
1000
100
Daily Flow (Ml/d)
440 Ml/d
360 Ml/d
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
1976
1990
Dry Weather Flow

Figure 8.1

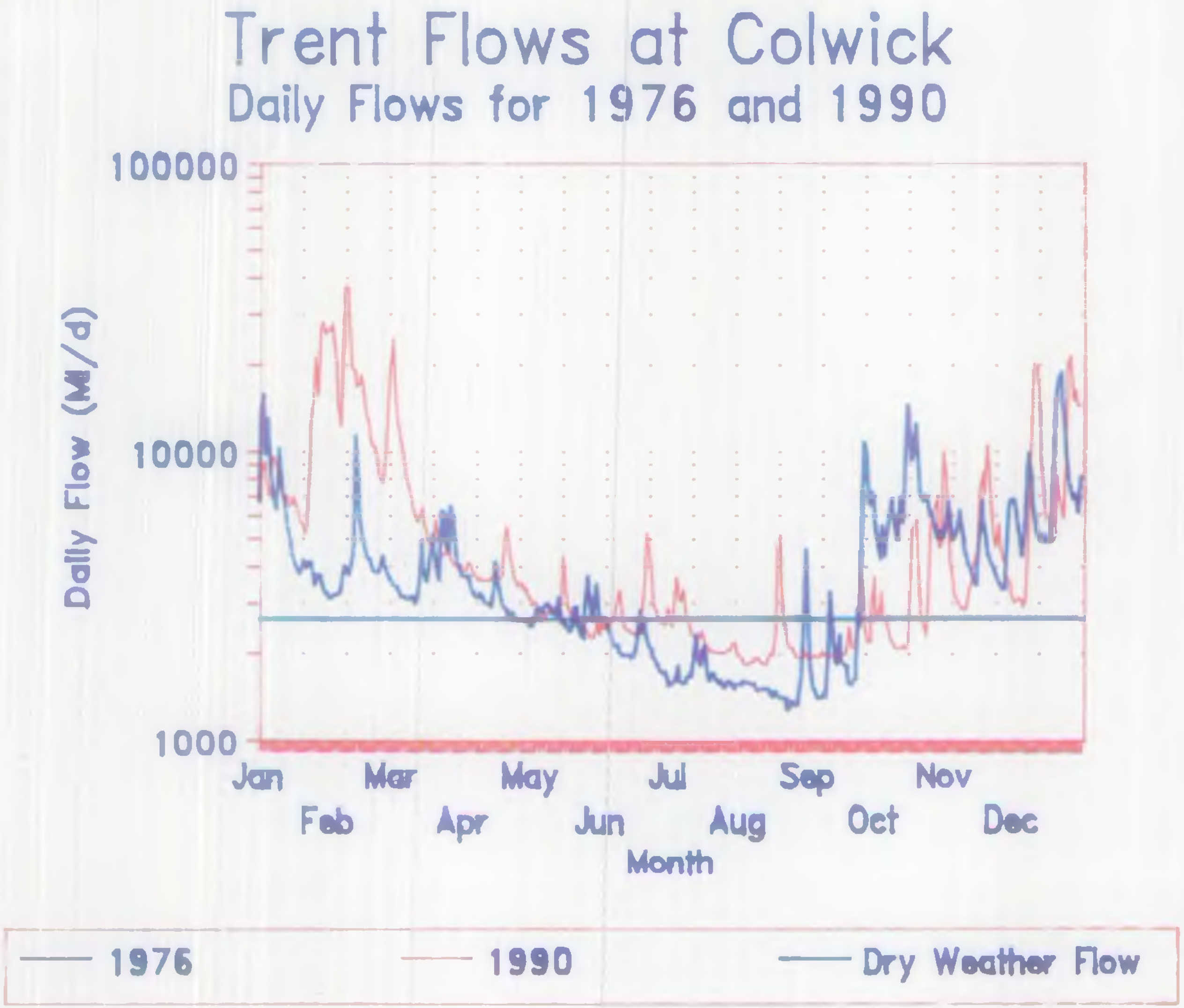

Trent Flows at Colwick
Daily Flows for 1976 and 1990
100000
10000
1000
Daily Flow (Ml/d)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
1976
1990
Dry Weather Flow

Figure 8.2

82

be negligible.

A deterioration in water quality due to reduced dilution (point 3) is possible, although a change in river flows of 1 or 2% is considerably less than the accuracy of sampling river water quality. It is therefore unlikely that any noticeable downstream deterioration would be observed. It should also be noted that if the upstream abstraction point at Wolseley Bridge is adopted, the water quality in the Trent at this point is worse than the tributaries which join the river as far down as the Tame. There could therefore be a slight improvement in water quality in these reaches, although the discharge consent for Seedy Mill Water Treatment Works would need to be investigated. We do not therefore consider that a deterioration in water quality would be noticeable. However, a Prescribed Flow of at least the 1990 7 day annual minimum flow at Yoxall would probably ensure that this is the case. These comments apply to all water quality parameters, including phosphate and chlorides, although temperature is discussed in more detail in the following paragraphs.

The derogation of existing abstraction licences for, and the impact on, the power stations (points 1 and 2) are probably the most important aspects to consider. The stations at Willington, Castle Donnington and Staythorpe all have daily licences in excess of Dry Weather Flows, by 12%, 68% and 17% respectively. The NRA have a legal duty to protect the requirements of existing licence holders. However, the way in which derogation is legally and practically defined is not clear. For example, the most simplistic approach towards potential abstractors would be to not allow any abstractions when the flow in the river, at the point of the proposed abstraction, falls below the largest downstream licence. In this instance the largest downstream licence is that for Staythorpe power station (3211 Ml/d). The river at Yoxall Bridge only exceeded this flow on a handfull of days during flood flows in 1990. Since the river at Staythorpe is six times larger than at Yoxall Bridge (dry weather flows are 2750Ml/d and 440Ml/d respectively) it would be unreasonable to apply this interpretation to the legal requirement.

Alternative interpretations can be devised, such as adjusting the scale of the largest licences on a pro-rata basis (using, for example, contributing catchment area, or estimated dry weather flow) in order to protect that portion of the licence that is derived from the flow at the point of the proposed upstream abstraction. Adjusting the Castle Donnington licence on this basis would give a figure of 738Ml/d at Yoxall Bridge. If this were set as the prescribed flow to avoid derogation the Blithfield abstraction could only have taken place on five occasions, each lasting a few days, during the April to October period in 1990.

More realistic still would be to include the volume of effluent derived form the proposed abstraction that would be returned to the river upstream of the existing licences. In this instance the net maximum abstraction at Willington and Castle Donnington would be in the order of 23Ml/d. To put this figure into context, the Yoxall gauging station is presently only capable of measuring dry weather flows to an accuracy of ±90Ml/d.

We have seen in Section 6.1 and Appendix B that certain power stations have abstracted practically the total daily river flow on a few occasions, although more typically there is 200 Mld to 500 Mld remaining in the river. However, there will be more frequent occasions when the abstraction will exceed the river flows due to the stations operating at full capacity for a part of the day only. Willington has reported experiencing problems meeting its temperature consents and abstracting more than the river flow during both 1990 and 1991 and, to a lesser extent, in 1989. If the proposed abstraction were to be granted a licence linked to a prescribed flow, then summer flows downstream of the Tame and Derwent would be augmented by around 9Ml/d and 12Ml/d respectively, when the abstraction ceased due to the implementation of the prescribed flow.

Point 9 relates to the granting of a licence on the Trent for potable supply. The river at the point of abstraction may have to become designated as a Source for Potable Supply although the fact that the water would be blended with Blithe water prior to treatment makes this unclear. At an allocated sampling point on the river, close to the abstraction, the river would have to meet the criteria for the Surface Water (Classification) Regulations 1989 for water intended for potable supply.

Currently the river appears to meet these regulations at the proposed abstraction point for most of the time. However, the criteria stipulated in the Regulations are maxima, and there is evidence to suggest that, on occasions, the river does fail the sulphate conditions and has come close to failing the nitrate conditions. If any deterioration in water quality, particularly sulphate and nitrate concentrations, were to occur subsequent to the designation of the river as a source of potable water, the source or sources contributing to those concentrations would require improvement. This could have particular consequences for upstream water reclamation works, such as Strongford.

In addition to the effect on flows in the Trent, the abstraction could have a significant impact on Blithfield Reservoir. The Trent is rich in nutrients and when this water is added to the reservoir there will probably be an increase in algal activity. The reservoir already suffers from algal blooms, but these could intensify leading to a significant increase in algal biomass. This would reduce the amenity value of the reservoir as well as making the water more difficult to treat. The death and subsequent decay of the biomass could also lead to the development of anoxic conditions in the lower strata of the reservoir.

The implication of most concern to NRA-ST, however, may be the possible changes to the quality of the compensation releases. These could be nutrient rich and deoxygenated, which would impact upon the downstream River Blithe.

ii) **The Severn Trent Water Plc Proposal**

The Severn Trent Water (STW) proposald is much less definitive at present than the SSWC proposal, being at a much earlier stage. However, all of the points listed under the SSWC proposal are relevant here.

The proposed abstraction is downstream of Willington and Castle Donnington power stations, but is upstream of Staythorpe. The possible derogation of the Staythorpe licence is therefore still an issue. However, as all the water from this proposed abstraction is to be used within the catchment around 75% of it will have been returned to the river upstream of Staythorpe. The net abstraction at Staythorpe is therefore likely to be of the order of 38Ml/d, or 1.4% of the dry weather flow in the river.

Perhaps of more relevance is the relative time scales of the developments. Staythorpe B power station, which holds the existing licence, is likely to have been decommissioned by 2010. Staythorpe C power station, an evaporative cooled CCGT station, is currently at the planning phase and will require significantly less water than the B station. The STW proposal is timetabled for 2005. There is, therefore, the potential that a conflict in licence requirements will not arise. Nevertheless, consultation with National Power will be required before any firm plans are made.

If the abstraction was licensed there would be a short stretch of river that would experience the full depletion of 150Ml/d before any of the derived effluent reached the river down the Derwent from Derby (approximately 23Ml/d). A little further downstream, the Soar joins the Trent and would carry an additional 45Ml/d from Leicester, leaving a deficit of around 83Ml/d. This deficit would continue through Nottingham until an additional 45Ml/d were discharged from Stoke Bardolph, leaving a deficit of around 38Ml/d down the rest of the river to the estuary. The short stretch experiencing the full 150Ml/d depletion would suffer a loss equivalent to 10% of its dry weather flow, although this would have been around 13% in 1990 and 19% in 1976.

The main significance of these figures is likely to be in their impact on water temperature and water quality. High levels of ammonia are discharged by Stoke Bardolph WRW and these led to problems in 1990. Low flows resulting in reduced dilution of effluent similar to those experienced in 1990 would occur slightly more frequently, once every nine or ten years instead of every twelve or thirteen years. The deficit of flow in the river just upstream of Stoke Bardolph would be about 3% of dry weather flow, and 4.5% of the 7 day annual minimum in 1990. As with the SSWC proposal, this variation in flows is not measurable with any degree of certainty at Colwick gauging station, which can achieve an accuracy of ±15-20% at low flows. If the effluent from Stoke Bardolph was improved this would obviously alleviate the stress suffered by fish currently, as well as under any future conditions.

The depletion of flows experienced by the slalom course due to the abstraction is also likely to be negligible. Nevertheless, the situation at Holme Pierrepont could be dramatically improved if the Colwick sluice gates were made water tight. There was sufficient water flowing down the river in both 1989 and 1990 to operate the slalom course at its optimum level continuously. However, most of the water bypassed the course by leaking under the sluice gates. The additional benefit of improving the sluice gates would be increased ease of maintaining navigation levels.

Concerning the other implications referred to in the SSWC proposal, it is unlikely that net reduction in flows of between 5% and 13% (or 5% an 8% if abstraction were located downstream of the confluence with the Derwent) of the 1990 minimum flow would have any material effect. However, a similar situation to the SSWC proposal would arise concerning the designation of the river as a source of potable water at the point of abstraction. If the river were to fail its Surface Water (Classification) Regulation 1989 criteria, then upstream sources causing that failure would require improvement. It is for this reason that STW are considering abstracting from river gravels, rather than the river direct. There are currently no regulations governing the quality of water abstracted from underground strata for potable supply, nor any formal link between the quality of water in the gravels and the quality of water in the river.

iii) The NRA-Anglian and Anglian Water plc Proposals

Both of these proposals are to abstract freshwater from the tidal reaches of the river. The Anglian Water proposal is 6% of the size of the NRA-Anglian proposal, but much more immediate. Both are direct losses to the Trent Catchment.

At the locations being considered around and upstream of Torksey, the downstream uses of the river consist of the requirement of the power stations and freshwater flows for the estuary.

The Anglian Water proposal is around 1% of the dry weather flow in the tidal stretch of the river. It is unlikely that this would have any noticeable effect on either the operation of the power stations, navigation, or the freshwater flows to the estuary.

The NRA-Anglian proposal represents around 20% of the freshwater dry weather flow in this reach, and is therefore much more significant. However, it is difficult to quantify the possible effects of such an abstraction without a more detailed knowledge of conditions in the tidal reaches. It is likely that there will be an effect on river water temperature, as well as the freshwater volume in the tidal section of the river. This could cause higher sediment loads to be carried up the river more frequently, as well as higher penetration of saline water up the river. Both are likely to cause operational difficulties to the power stations on the river, particularly West Burton and exacerbate the problems of siltation already experienced by British Waterways. Further effects would include an impact on the oxygen sag in the river, with consequences for fisheries.

A more detailed study of this reach of the river will therefore be required. The study would include data collection and river modelling of oxygen concentrations, sediment loads, siltation patterns, salinity and temperature, and would need to be undertaken as part of the

Timescale?

David

Timescale - - -

years!

Doubt there will

be an oxygen sag.

consideration of any major abstraction in the reach.

Both proposals are likely to involve the designation of the river as a source for potable supply at the abstraction points. Again, sulphate and nitrate concentrations are close to, and sometimes exceed, maximum allowable concentrations under the Surface Water regulations. This may well, then, have consequences for upstream WRWs, particularly Newark and Stoke Bardolph.

If BWB proposals to move the tidal limit downstream are carried forward, then both of these abstractions will reside in the new non-tidal stretch of the river. The situation would thus have changed, since there would no longer be the tidal velocities or volumes moving in this stretch. The water temperature and quality characteristics are therefore likely to become much more sensitive to river flows.

iv) **The Scottish Hydro-Electric Plc Proposal**

The site of the Keadby power stations is 13km upstream of the Humber estuary, and potentially represents the most downstream user of the river, apart from navigation. Other requirements of the river include water quality standards for esturial waters, spate flows for fish migration, and sediment flushing.

The river at the point of abstraction is saline and dominated by tidal flows. The abstraction itself is non-consumptive as the plant is direct cooled. The only affects due to the power station are therefore likely to be temperature and river velocity dominated. Surface evoporation may, however, take place downstream of the discharge and might possibly be as much as 40Ml/d, based on evaporative demands of other power stations.

The temperature effects of the discharge mainly impact fish migration, and are being considered by NRA.

Yes,

presumably because of intermittent nature of discharge

The abstraction of a large volume of water at the rate proposed (981Ml/d) could potentially cause locally confused currents that change with the tide. This may cause a hazard to navigation and would require to be at least considered, particularly at high and low tides, when the inherent velocity in the river is close to zero.

There is a question concerning derogation of any licence that was granted. Although there is never likely to be a shortage of water for abstraction at the Keadby site, it might be construed that the licence entitled the abstractor to the stated volume of <u>fresh</u> or river water. Any subsequent abstractions that were granted upstream, for example at Torksey, which might affect, for example, river water temperature adversely, may be objected against on the grounds of derogation of the downstream licence. It is therefore important to clarify the duty of the NRA on this point.

Licence is no guarantee of either quality or quantity 'derogation' relates to ability to abstract

9.0 OPTIONS FOR LICENSING POLICY

In this section we consider a number of options for a licensing policy for the River Trent. The options address the likely future abstraction demands on the river and the need to ensure minimal impact on other uses. For each of the options we identify any difficulties there may be with its implementation, the factors in its favour ('pros') and those against ('cons'). We have deliberately kept the options as wide as possible in order to provoke discussion and consideration.

9.1 Key Points

In developing our alternatives, we have considered the following key points, which are noted elsewhere in this report:-

a) There are significant water resources available in the River Trent, particularly in non-drought years. This is due both to the size of the catchment and the large augmentation it receives via sewage treatment works.

b) There are four existing abstractions (Drakelow, Willington, Castle Donnington and Staythorpe Power Stations) which have licences in excess of, or close to, typical low river flows.

c) The main bodies interested in the Trent as a source of water supply are primarily looking for year-round or summer only abstraction. Their proposals depend to a greater or lesser extent on there being no, or minimal, summer restrictions.

d) Many of the existing users of the river (eg. Fisheries, power stations, recreation, navigation) suffered stress in one form or another during the 1989 to 1991 droughts. There would therefore be great resistance to any proposals which increased the frequency with which these conditions occur.

e) The amount of freshwater flow into the Trent estuary has an impact on the uses in these reaches. West Burton power station

has reported problems with high suspended solids in the estuary, which affects the operation of its cooling water system. In addition, discussions with the promoters of the Keadby Power Station suggested that their ability to meet their proposed temperature consent is affected by the freshwater flow. British Waterways have to dredge the river in the Torksey area and depend on freshwater flows to maintain navigation depths. Unfortunately evaluating the flow requirements of a tidal estuary is a complex task and beyond the scope of this study. We therefore recommend that data collection and modelling studies of this stretch of the river are undertaken prior to granting any licences. British Waterways are carrying out a hydrographic survey of parts of the estuary and it may be possible to share the cost of the estuary studies amongst the interested parties.

f) The water quality in the Trent is not a particular restriction to its use for water supply, although advanced treatment and, in some cases, blending will probably be required. The designation of the Trent as a potable supply source should not be a problem except for the nitrate concentrations which will need careful monitoring.

g) The water resources in the Trent have national as well as regional importance. This can be seen from the NRA-Anglian Region study investigating the use of Trent water to provide resources for locations as far away as Essex, and north east London.

9.2 Licensing Strategy

The basic options for individual licences, and hence for a licensing policy, are:-

i) Allow abstraction with maximum annual and daily amounts but no low flow restriction.

ii) Allow all abstractions until a certain amount of water allocated to each reach has been used up. The assessment for each licence would be based on the consumptive use of the abstracted water and the point to which non consumed water was returned.

iii) As i) or ii), but with the licence linked to one or more Prescribed Flows such that abstraction must cease if the river flow falls below the prescribed value. The Prescribed Flows on licenses will normally be set to maintain a Minimum Residual Flow (MRF) in the river to protect other uses. A formal Minimum Acceptable Flow (MAF) could be established for the river, for which Public Consultation would be required. Both MRF or MAF could vary seasonally.

iv) Conjunctive use schemes, whereby two or more abstraction sources are linked together for use at different times of the year. For example, a river source could be used during the winter, and a groundwater source or reservoir storage during the summer.

v) Although not a licence condition, the use of Drought Orders should also be considered. A Drought Order allows the terms of a licence to be varied. This may, for instance, remove or reduce the Prescribed Flow, thus allowing abstraction to continue during drought periods. In order to obtain a Drought Order the NRA should insist that the water company had imposed demand reduction measures such as hosepipe bans. The targets for the water companies are generally that these should not be imposed more than once every 10 years. The use of Drought Orders provides for some flexibility in managing resources during drought periods and for sharing the burden of lack of water between river users and water consumers.

vi) In addition to any of the above approaches, time limits to all licences granted, particularly for power generation and spray irrigation, could be imposed. These could be complimentary to the expected life of the scheme requiring the abstraction.

Options i) to iv), above are listed in Table 9.1, along with the considered benefits and disadvantages of each, and a brief assessment of the impact of the policy on river flows. The effect of different Prescribed Flow conditions for Option iii) are discussed in the next section.

Table 9.1 Benefits and disadvantages of different licensing policies on the River Trent

Option	Description
i)	**No flow restrictions**
Pros	- ease of administration - maximises resource yield whilst minimising costs
Cons	- no regard to requirement of other uses of river - public perception that NRA is not protecting environment - derogation of existing licences (mainly power stations) - increased frequency of 'drought' (eg 1990) flows
Impact	- with all identified future demands in place, the frequency of 1976 conditions would increase from once every 50 years to: - once every 25 years at Yoxall - once every 40 years at Colwick - once every 7 years at Torksey - the frequency of 1990 conditions at Torksey would increase from about once every 11 years to once every two years

Table 9.1 (Continued)

Option	Description
ii)	**All licences up to an allocated limited**
Pros	- relatively easy to administer - can be set to safeguard environment from effects of over-abstraction - takes account of impact of net abstraction on river flows
Cons	- derogation of existing licences - increased frequency and duration of low flow conditions - requires initial definition of appropriate reaches and quantification of abstractable volumes in each throughout the entire length of the river
Impact	- If the abstractable volume was set as 10% of 1990 dry weather flow, the frequency of 1976 conditions would increase from once every 50 years to: - once every 35 years at Yoxall - once every 30 years at Colwick - once every 30 years at Torksey

Table 9.1 (Continued)

Option	Description
iii)	**As i) or ii) plus Prescribed Flows**
Pros	- can be set to protect the environment - can be set so as not to derogate from downstream licences - flexibility to specify impact at various flows and seasons - encourages efficient use of winter flows
Cons	- more difficult to administer - protection of downstream non-consumptive licences may lead to inefficient use of summer resources - setting of formal Minimum Acceptable Flow would require extensive public consultation at each location proposed and could be inflexible. - requires relatively accurate gauging of low river flows
Impact	- Setting a prescribed flow of 738Ml/d at Yoxall Bridge to protect against derogation of Castle Donnington licence would only have allowed abstraction on five occasions, each lasting a few days, between April and October in 1990.

Table 9.1 (Continued)

Option	Description
iv)	**Conjunctive use schemes**
Pros	- relatively easy to administer - efficient use of winter flows in the river - protects downstream licences - protect downstream environment and other uses - encourages flexibility, and therefore efficiency, in the use of catchment resources - bargaining tool for NRA to alleviate stress suffered in certain parts of the catchment
Cons	- may not be suitable for large abstractions from ground water - may place stress on groundwater resources in certain areas - does not utilise summer resources available in the river - Insufficient summer resources available for conjunctive use to meet the likely future demands for water abstraction
Impact	- variable depending on location of groundwater abstractions but little impact on summer river flows

9.3 Prescribed Flow Conditions

Ideally Prescribed Flow conditions should be set to protect a Minimum Acceptable Flow Regime (MAFR). The scope of this study has not extended to the setting of MAFRs, especially for the estuary for which extensive work is required. However, we have considered four different methods for setting MAFRs and the impact that these would have on both river users and proposed abstractions. These alternatives are considered in the following sections.

9.3.1 Minimum Acceptable Flow based on 'Natural' Dry Weather Flows.

The first, and lowest, MAFR that we have considered is the 'Natural' Mean Annual Minimum 7 day flow. This has been considered to be the Mean Annual Minimum 7 day flow at a gauging station, less the artificial influences in the catchment. This flow typically lies somewhere between the 1976 and 1990 flows, with a return period of between 15 and 25 years. Typical values for the Prescribed Flow along the river can be seen on Table 9.2. The table also shows the frequency at which restrictions would be placed on the proposed abstractions, and the likely duration of those restrictions, based on 1990 conditions. Figure 9.1 shows the available resource along the river in a mean year, and compares this with the anticipated future demand.

It can be seen that in a mean year the full extent of future demand would be available for abstraction, but that approximately once every 5 years some restrictions would be placed on the abstractions below Newark , once every 8 years above the Tame confluence and once every 15 to 20 years in the central reaches. The impact on the proposed abstractions would be that:

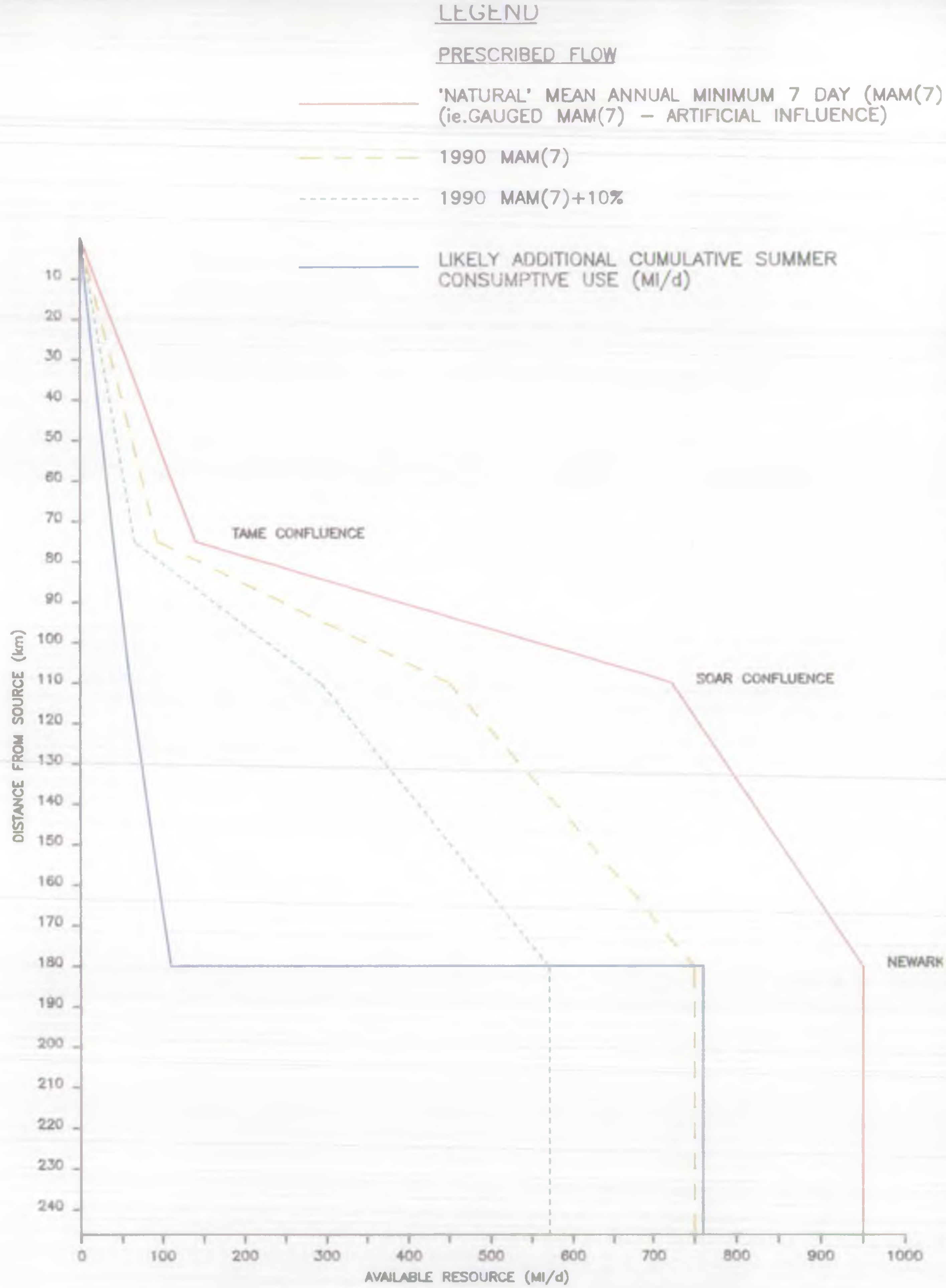
- reservoir storage would probably be required for the NRA-Anglian Region scheme to supply the south and east of its area. However, it should be possible to provide a reliable supply to the Humberside and Lincolnshire areas without storage, which would be difficult in this largely flat landscape. This is because this element of the abstraction would only be restricted approximately

Table 9.2 Frequency and Duration of Restrictions on Possible Future Demands Within Reaches of the River Trent with Different Prescribed Flow Conditions (based on cumulative summer consumptive use from Table 7.2).

Reach	Cumulative Summer Consumptive Use (Ml/d)	Prescribed flow at bottom of reach (Ml/d)			Frequency of Restrictions (once every N years)			No. of months in which restrictions are required under 1990 conditions			Return period of PF as 7 day annual minimum (yrs)		
		PF1	PF2	PF3	PF1	PF2	PF3	PF1	PF2	PF3	PF1	PF2	PF3
Upstream of Tame Confluence	45	260	310	340	8	3	2.5	0	1	2	15	6-7	4-5
Tame to Soar Confluence	69	1300	1570	1730	20	10	6	0	2	3.5	20-25	13-15	8-10
Soar to Newark	113	1750	1940	2130	15	10	5-6	0	2	3.5	20-25	13-15	8-10
Newark to Estuary (Torksey)	783	1750	1940	2130	5	2	<2	4	4.5	5	20-25	13-15	8-10

PF1 = 'Natural' MAM (7)
PF2 = 1990 MAM (7)
PF3 = 1990 MAM (7) + 10%

NOTE: The frequency of restrictions and the number of months in which restrictions are required are based on flow distributions and hydrographs at Colwick for the lower 3 reaches, whilst the first reach is based on Yoxall.



AVAILABLE RESOURCE IN A MEAN YEAR
WITH DIFFERENT PRESCRIBED FLOW CONDITIONS

FIG 9.1

once every 10 years. During droughts more severe than this, a Drought Order would probably be required to ensure the continuity of this supply.

- The proposed abstraction to Blithfield by SSWC would provide the required yield , even in an extreme drought such as 1976.

- The abstractions in the middle reaches, notably by Severn-Trent Water, should be able to provide a reliable yield without the need for large reservoir storage. During severe droughts, such as 1976, Drought Orders would probably be required to ensure continuity of supply.

The impact on the environment of this Prescribed Flow Regime would be that:

- The river upstream of the Tame confluence would suffer reduced flows to the extent that the frequency of flows as low as 1990 would increase from once every 6 to 7 years upto once every 3 to 4 years. The abstractions would typically reduce summer flows by 10 to 15%.

- The river from the Tame confluence to Newark would suffer reduced flows with the frequency of 1990 flows slightly increasing from once every 13 to 15 years upto once every 12-14 years. The abstraction would typically reduce summer flows by 4 to 6%.

- In the river below Torksey, the frequency of 1990 flows would increase from once every 13 to 15 years to once every 2 years. The abstractions would typically reduce summer flows by 25 to 35%.

The impact on river flows below Newark would probably be unacceptable to a number of river users, particularly navigation. Upstream of the Tame confluence, the reduction in low flows could affect fisheries and the ability of Rugeley power station to meet its temperature consents. In the middle reaches the impact would be relatively insignificant, although the effects on the canoe slalom course and the dilution of the sewage effluent from Nottingham need consideration.

9.3.2 Minimum Acceptable Flow based on 1990 low flow.

The second MAFR that we considered is the 7 day minimum flow conditions that occurred in 1990. Several users of the river suffered stress during this drought period and it could be considered as a reasonable basis for a MAFR.

Referring to Figure 9.1 and Table 9.2, it can be seen that in a mean year the full extent of future demand would largely be available for abstraction with a slight shortfall below Newark. Approximately once every 2 years some restrictions would be placed on the abstractions below Newark, once every 3 years above the Tame confluence and once every 10 years in the remaining reaches. The impact on the proposed abstractions would be as for Section 9.3.1 expected that:

- The supply to the Humberside and Lincolnshire areas of the NRA-Anglian Region would be restricted about every 5 years and would therefore probably not provide a reliable source of supply without some form of storage or conjunctive use scheme.

- The impact on the environment of this MAFR would be as for the Natural Mean Annual Minimum, except that the MAFR would prevent conditions more severe than 1990 occurring more frequently.

9.3.3 Minimum Acceptable Flow based on 10% more than 1990 Low Flows.

The final MAFR that we have considered is a value 10% greater than the 7 day minimum flow conditions that occurred in 1990. This would ensure that abstractions did not cause flows in the river to reach the low conditions of 1990.

Referring to Figure 9.1 and Table 9.2, it can be seen that in a mean year the full extent of future demand would be available for abstraction upstream of Newark, but that there would be a shortfall of some 213Mld below this point. Restrictions would be placed on the abstractions in the lower reaches in most years every 2 to 3 years in the upper reaches and every 5 to 6 years in the remainder. The impact on the proposed abstractions would be as for Section 9.3.1. except that:

- Reservoir storage or conjunctive use schemes would be required for all abstractions below Newark.

- The abstractions in the middle reaches would probably not provide a reliable yield without either reservoir storage or conjunctive use schemes. It was the view of Severn Trent Water that this would make their proposed abstraction uneconomic.

The impact on the environment of this MAFR would be that the river would not be subject to the stress caused by low flows of the order of the 1990 drought more frequently due to abstraction. This should be acceptable to most river users upstream of Newark bearing in mind the scale of likely future abstractions. Below Newark the MAFR should be acceptable, but due to the larger scale of abstraction the continuation of low flows over a longer period of the year could be a cause for concern. This would need investigation as part of a detailed study to look at MAFRs for the estuary.

9.3.4 Minimum Acceptable Flow to Fully Protect the Existing Licences

The setting of a MAFR to protect the major existing licences, particularly the direct cooled power stations, would not allow any abstractions to take place in a mean year on the river reaches upstream of Staythorpe. The only abstractions that would be able to operate with such restrictions would be pumped storage schemes or conjunctive use schemes which used the winter resources of the Trent. None of the currently proposed schemes are of this type and therefore these new licences upstream of Staythorpe could not be granted.

9.4 Other Considerations

Apart from the various advantages and disadvantages outlined above, certain other points relating to licensing policy can be made.

The use of Drought Orders has already been mentioned. These have been used effectively in the past, as demonstrated in Figure 5.20. They offer a flexibility to the licensing policy which should not be overlooked. They can be used to enforce efficient use of resources, and the implementation of demand control measures, before causing undue stress to the river environment. Although the granting of Drought Orders is not a foregone conclusion, the procedure for applying is well established and therefore represents an effective tool for the control of resources.

When considering applications from water companies, the NRA might question the efficient use of existing resource, particularly with regards to progress made towards meeting leakage targets, and the introduction of domestic metering. The Director General of OFWAT's report 'Paying for Water: The Way Ahead' (December 1991) suggests the introduction of compulsory domestic metering by water companies "should concentrate on areas where there are shortages in supply or where water resources are under pressure for environmental reasons". Adopting a regional perspective allows negotiations concerning leakage reduction and metering to take place against specific applications for licences by the water companies.

Negotiations relating to other aspects of the river could be entered into on a similar basis. Conditions in other parts of the river basin might therefore be brought into consideration such as improving the water tightness of Colwick sluices so as to avoid further disruption of downstream uses during summer flow (eg Canoe slalom, Staythorpe power station). Other examples might include raising the residual flow at the bottom of the Dove. In this way, the NRA could gain improvements in the environmental conditions in the river as part of the process of granting a new abstraction licence.

The use, or depletion, of tributary water reaching the Trent during summer months should be discouraged. Further reductions in summer flows in the Dove and Derwent rivers, particularly, will give rise to less dilution in the Trent. On the other hand increased dilution of Trent water would make it a more valuable resource.

The granting of certain licences under the Water Resources Act 1963 has effectively placed a moratorium on the use of river water upstream of these licences, even though their use is non-consumptive. In dealing with licence applications from the power generation industry three main points should be considered:

1) Licences to abstract fresh water from the river should only be granted for evaporative cooled plant in the future. Although these stations have a higher consumptive use of river water than their direct cooled counterparts, their overall water requirement is less than 10% of direct cooled station requirements. This then allows other abstractions upstream to be granted without fear of licence derogation.

2) Negotiations for new abstraction licences should include a reduction in, or revocation of, excessive existing licences as a condition for granting new licences. In the interests of promoting the efficient use of water resources within the Trent basin, it is unacceptable that the bulk of the catchment's resources should effectively be tied up in non-consumptive licences that are rarely, if ever, fully used.

3) All future licences should be granted for, at most, the expected life of the power station. It is unreasonable for a licence to be held after a power station has been decommissioned, with small abstractions taking place to ensure that the 7 year no-use lapse period is not achieved, when the water committed to that licence could be more efficiently used in some other way.

Time limits should also be considered for spray irrigation licence abstractions. Where resources are scarce, these could be linked to winter storage conditions, or time-limited until any proposed public water supply abstraction was developed. In this instance licences could be granted for 10 years, renewable every five years, for example.

Run-of-river abstractions for public water supply represent very cheap water, relative to the costs of having to provide reservoir storage. Negotiations with the water companies could therefore be undertaken by NRA to relieve parts of the catchment suffering stress from low river flows or over-abstraction of groundwater in exchange for the granting of a run-of-river licence.

The NRA could draw the water companies into negotiations with the power generating companies. PowerGen, for example, have indicated that they would be willing to discuss tailoring of their licences with SSWC provided the commercial value of the licence was recognised. Although SSWC have spoken to Castle Donnington station directly, PowerGen head office should be involved. While there is no guarantee of agreement, a more long-term approach to the situation is likely to be adopted by head office. However, it should be recognised that SSWC are unlikely to have much to offer PowerGen and the NRA are in a position to bargain on the basis of future licence requests for CCGT power stations. The introduction of time limits on existing power station licences might also be considered at this point.

Finally, all licence applications from BWB waterways should be considered as direct abstractions from the Trent or its tributaries. It has been identified, in Figure 5.24, that a significant volume of water is exported from the Trent Catchment by BWB, with very little imported. Since all waterways link up with the Trent at some point, water abstracted from the waterways is derived from it.

9.5 Conclusions

We consider that the aspirations of future abstractors in terms of the amount and timing of water they require are not compatible with the needs of the river environment and its existing users. There are sufficient resources available in many years, but during drought conditions (of the order of a 1 in 10 year return period) the river needs protection. We therefore feel that some form of Minimum Residual Flow policy is necessary.

The implications of a Minimum Residual Flow policy on the proposed abstractions are that some form of storage or conjunctive use will probably be required as part of their schemes. The extent of this depends on the severity of the MRF regime.

The derogation of the existing licences for the direct cooled power stations is a major restriction to the water resource management of the Trent. We consider that the NRA is likely to be the only body who could effectively negotiate with the power companies regarding these licences. The direct cooled power stations are nearing the end of their useful lives. If they are to be replaced it will probably be with evaporative cooled, combined cycle gas turbine (CCGT) stations. These would require a much lower licensed abstraction, although with more consumptive use. The NRA could use the granting of the new licences as a negotiating tool for the power companies to accept derogation of their existing licences. However, the power companies, and especially the station operators, would need to be convinced that the operability of their stations would be minimally, if at all, affected by the granting of future abstractions.

We consider that the following points could form the basis for a licensing policy on the River Trent.

- Set Minimum Residual Flows for the river. These should be based at, or slightly above, 1990 flow conditions. Further work and discussion will be required to firm up on this figure, especially below Newark where a thorough study is required.

- Use the granting of licences for new evaporative cooled power stations without flow restriction as a negotiating tool for obtaining the agreement of the power companies to accept derogation of their existing licences. New licences should be time-limited to the life of the power station.

- Upon receipt of licence applications from water companies, the efficient use of existing resources should be considered. In particular this refers to progress made towards meeting leakage targets and the introduction of domestic metering. Addressing problems in other areas of the catchment as part of the conditions of granting new licences should also be considered.

- Grant the licence for the abstraction to Blithfield by SSWC. However, the implications for the reservoir and the downstream River Blithe should be studied in more detail before the licence is granted. Alternatively, a time limited licence could be provided to allow the effects to be monitored.

- Encourage Severn-Trent Water to look at the conjunctive use of groundwater with abstraction from the River Trent. The use of Trent water within the overall operation of the Carsington scheme should also be investigated. We consider that with these measures the proposed abstraction in the Derby area should be able to provide the required yield with the licence restricted to a Minimum Residual Flow. During drought periods, Drought Orders could be used both to restrict demand and optimise the use of the reduced resources within the catchment as a whole.

- Encourage Anglian Water and NRA Anglian Region to investigate the conjunctive use of groundwater in the Lincolnshire area.

  This should be feasible, although the very different characteristics of the two sources would mean that considerable blending would be required. It may be that changes in the taste and type of water throughout the year would be unacceptable to customers. The provision of storage in this flat area would be costly and difficult. Therefore, if Trent water is to be used, summer flow restrictions need to be minimal, probably less than once every 10 years. In contrast, the supply to Trent Water to the south and east of NRA Anglian Region's area could be combined with a large reservoir, perhaps at Great Bradley.

The granting of licences linked to a two stage restriction could therefore be considered for these abstractions below Newark. This could allow the supply to Lincolnshire and Humberside to be linked to a relatively low MRF, whilst the larger abstraction to the south and east could be linked to a higher value, thus encouraging more winter abstraction when resources are readily available.

- The licence for Keadby power station should only be granted if the proposer accepts that the NRA must be free to manage the river and not be restricted by the need to protect his licence. A detailed study will be required to determine what residual freshwater flows are required not to affect the operation of this station.

unacceptable

Contradiction

WS Atkins