# MESOTROPHIC RIVERS IN THE ANGLIAN REGION OF THE NATIONAL RIVERS AUTHORITY
## Fourth Progress Report: December 1995

D. M. Harper, G. Evans

Research Contractor:
Ecology Unit, University of Leicester

National Rivers Authority,
Kingfisher House,
Orton Goldhay
Peterborough,
PE2 5ZR

# CONTENTS

## 1 INTRODUCTION

Phase Two of this Mesotrophic Rivers investigation was planned to terminate in February 1996 with a full year's data on phosphorus forms (total and dissolved), downstream fluxes and biological indicators of river eutrophy for the selected six study river systems in the two layers of the investigation.

Part of the programme has slipped due to problems with analytical data. This report therefore reveiews the achievements to date and then proposes a revised timetable to completion and a modification to the investigatory programme.

Progress has been made on all the original objectives and this report therefore serves as a fourth progress report.

## 2. TIMETABLE OF ACTIVITIES

Since the last progress report, the regular sampling of the 'layer two' rivers (Great Eau/Waithe Beck in Lincolnshire, Wensum/Bure in Norfolk, Wissey/Little Ouse in Cambridgeshire, Welland/Eyebrook in Leicestershire and Deben/Alde in Suffolk) continued with the exception that the Alde was taken out of the project's sample runs and its NRA routine sample analysis was upgraded to total P as well as soluble P.

Analytical phosphorus data to the end of July was received and preliminary interpretations made.

Four M.Sc. students completed projects on topics associated with the project and their results, summarised here, will be incorporated into the final analyses.

Two workshop presentations were made (both will remain unpublished outside the delegate information pack), based upon the preliminary findings; one at Wexford, Ireland "Phosphorus loss from Agriculture" and one at Silkeborg, Denmark, "Phosphorus in Water and Sediment". The general conference proceedings of each of these meetings are directly relevant to the project and the information from them will be incorporated into the final information review.

## 3. WORKSHOP PRESENTATIONS

The text of the presentations is repeated here.

### Introduction

Water management authorities, in the UK at present the National Rivers Authority, require three types of information about phosphorus and eutrophication.

Firstly, they need an accurate knowledge of the phosphorus status of watercourses in order to implement legislation. This comes both from the European Community, particularly the Urban Wastewaters Treatment Directive, and the UK government, particulary the Special Ecosystem Use Class of the Statutory Water Quality Objectives of the 1991 Water Resources Act. With this knowledge, they can effectively target rivers receiving excessive amounts for remedial action and, equally important, they can also recognise rivers in a semi-natural state, receiving the lowest inputs of phosphorus, then target and protect these from further deterioration.

Secondly, they need to know the nature of the phosphorus and its sources. The Anglian Region is the area of most intensive agricultural production in the British Isles, as well as being densely populated. Few rivers are affected by agriculture or sewage effluent alone. Consequently a detailed knowledge of the sources of phosphorus as well as their levels and ecological effects is needed.

Lastly, and arguably most importantly, must come a clear demonstration of the ecological value of low-phosphorus watercourses in their own right, as opposed to the value of oligotrophy in any lakes or reservoirs that they may drain into. Up to now society has largely directed its efforts at understanding and protecting standing waters, so we know very little about how stream ecology is impacted by phosphorus enrichment. Eastern England however, contains few standing waters and although the Norfolk Broads and several reservoirs are ecologically important these account for only a few catchments, so phosphorus standards for the whole area should logically be based upon river ecology. The greatest amount of knowledge of river eutrophication relates to macrophytes (Mainstone, Gulson and Parr 1994) and classification of river plants throughout the UK shows clear trophic differences between rivers (Holmes 1991). In lowland enriched rivers, particularly small ones, small differences in trophy are harder to detect and the use of algae and macroinvertebrates may be necessary.

The National Rivers Authority (Anglian Region) had commenced routine analyses of soluble phosphorus in its rivers, most at monthly intervals, from 1990. It had started biological investigations under the UWWTD on rives below large sewage treatment works where phosphorus-removal had been implemented. In 1993 it also began the present project with four broad objectives. These were:

i) to identify low-nutrient rivers within the region;

ii) to investigate the nature and sources of their nutrients, particularly phosphorus and

iii) to demonstrate the ecological value of such rivers using macrophytes, algae and macroinvertebrates

iv) to characterise low-nutrient rivers using the best possible biological syatem.

## Preliminary analyses

The majority of rivers within the Anglian Region are rich in phosphorus. The majority of sites sampled, including nearly all the sites on the large rivers and in rivers in the more urbanised south of the Region, have mean soluble phosphorus concentrations in excess of 100μg/l P (Figure 1). All catchments are affected by sewage effluent discharges, and the majority of these are from smaller town and village sewage works. Closer examination of NRA monitoring data shows that all rivers receiving sewage effluent from large works (over dry weather discharge of 20,000 $m^3$/day) have median soluble phosphorus values above 1000 μg/l P and that there is a tendency for streams without, or with very small, effluents to have lower median soluble phosphorus values (Figure 2). There is a good deal of noise in the data, caused by such factors as infrequent sampling, catchment geology and river channel character, but nevertheless the trends are clear:

i) large rivers are always high in phosphorus (with the one exception of the Bure where P-stripping has been implemented to protect Norfolk Broads)

ii) small tributary streams are often low in phosphorus, but

iii) there are still a substantial number of streams without effluent discharges or with very small ones, which have high phosphorus levels.

## Methodology

A sample programme was designed to provide the following specific objectives:

i) a higher frequency of analytical data than routine monitoring frequency (at least fortnightly instead of monthly)

ii) total and soluble phosphorus measured together in all samples

iii) a range of sites for the above two objectives covered, in order to enable streams influenced by sewage effluent-to be compared with streams only influenced by agriculture.

The project is executed by only one person and so had to work around the logistics of this restriction: a two-level sample programme was therefore designed to supplement the NRA monitoring programme, which has the following characteristics:

i) at the broad level a range of ten streams typical of the Anglian region was chosen, in five pairs of high phosphorus-low phosphorus each geographically adjacent, a total of thirty sites. These are sampled monthly, in between the NRA's own monitoring dates, to provide a fortnightly frequency of soluble phosphorus analysis.

ii) these stream sites are also analysed for total phosphorus, to provide a monthly frequency of total/soluble comparison.

iii) at the more specific level one catchment was selected for more detailed investigation, to sample a variety of potential contributors to phosphorus. This gives 29 sites, sampled at monthly intervals in between the broad level sampling. Six of these sites are common to both sampling levels, and are thus covered with an increased frequency approximately equal to once every ten days for soluble phosphorus and once every fortnight for total phosphorus.

Figure 1. The distribution of phosphorus concentrations in river systems of the Anglian Region in 1994.

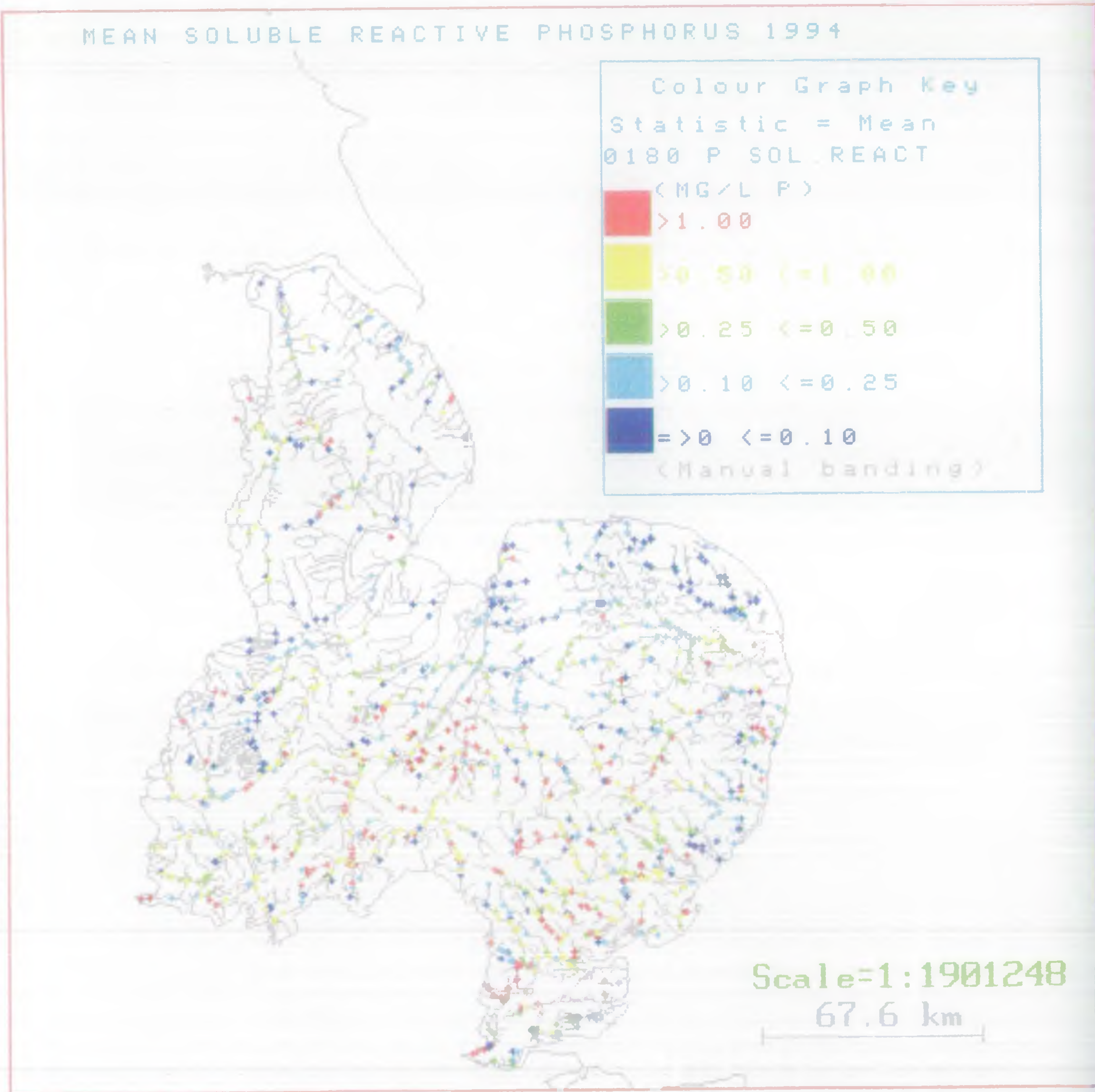
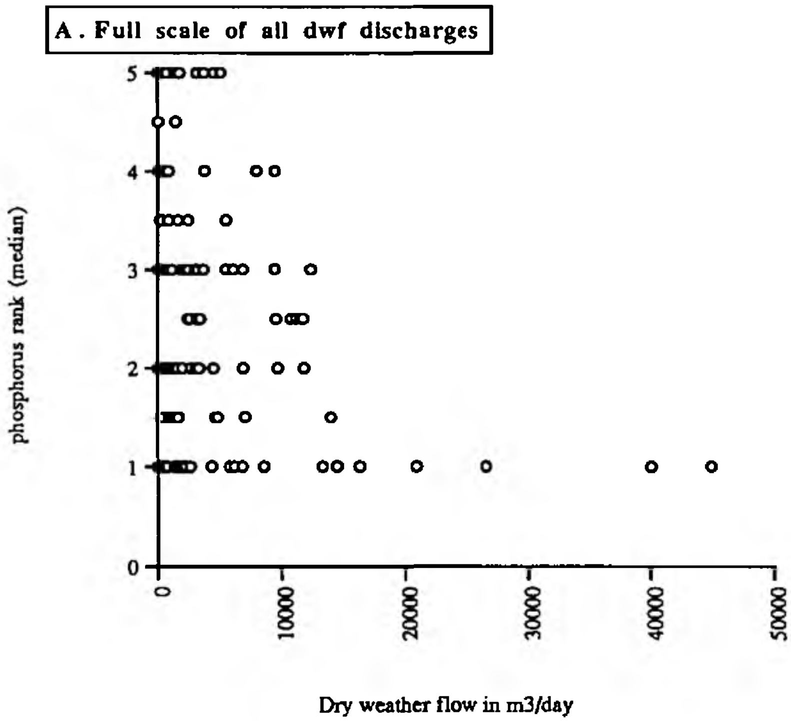
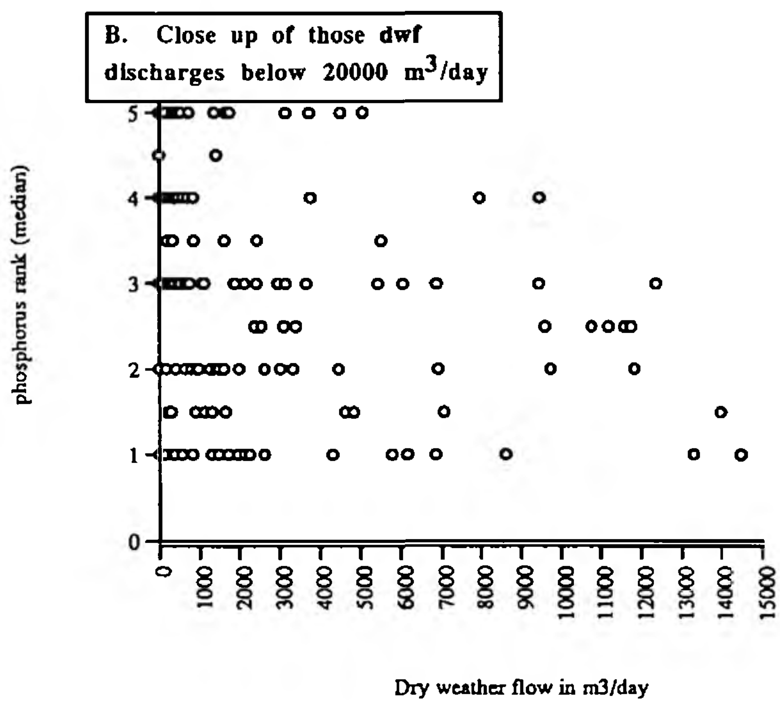


Figure 2.Soluble phosphorus class of watercourse (1992) in Anglian Region against size of sewage works (as dry weather flow) discharging into it. The graphs show that low phosphorus watercourses are those with dwf of only 5000 $m^3/d$ or lower: high phosphorus watercourses on the other hand may have either large or small sewage inputs.



The analyses are carried out at the NRA laboratories using the same techniques of auto-analysis as the monitoring programme and all other NRA investigatory work, so that cross-comparisons of results are possible.

## Results

### Level One rivers; Regional comparison

Preliminary results on the five pairs of rivers across the Region suggest:

- mean TP concentrations lie between 60 and 650 μg/l
- the proportion of soluble phoshorus is high, >80% TP, at sites below effluent discharges
- there is no statistical relationship between TP concentration and effluent size but:

  streams receiving small rural discharges (settlements <2500 p.e.) have mean TP concentrations < 200 μg/l

  streams receiving urban discharges (settlements >2500 p.e.) have mean TP concentrations 200-650 μg/l

  some streams without effluent discharges still have TP concentrations > 100 μg/l

### Level two rivers, the Welland catchment

A third phase of the project is studying one catchment, the Welland (Figure 4), in greater detail, in order to compare replicate sites on tributaries free of any effluents with adjacent ones receiving effluents. We concentrated on the western tributaries which are sampled at spatial and temporal frequency higher than NRA monitoring. All these streams except the main Welland are considered to be of high biological quality (1993 River Quality Survey).

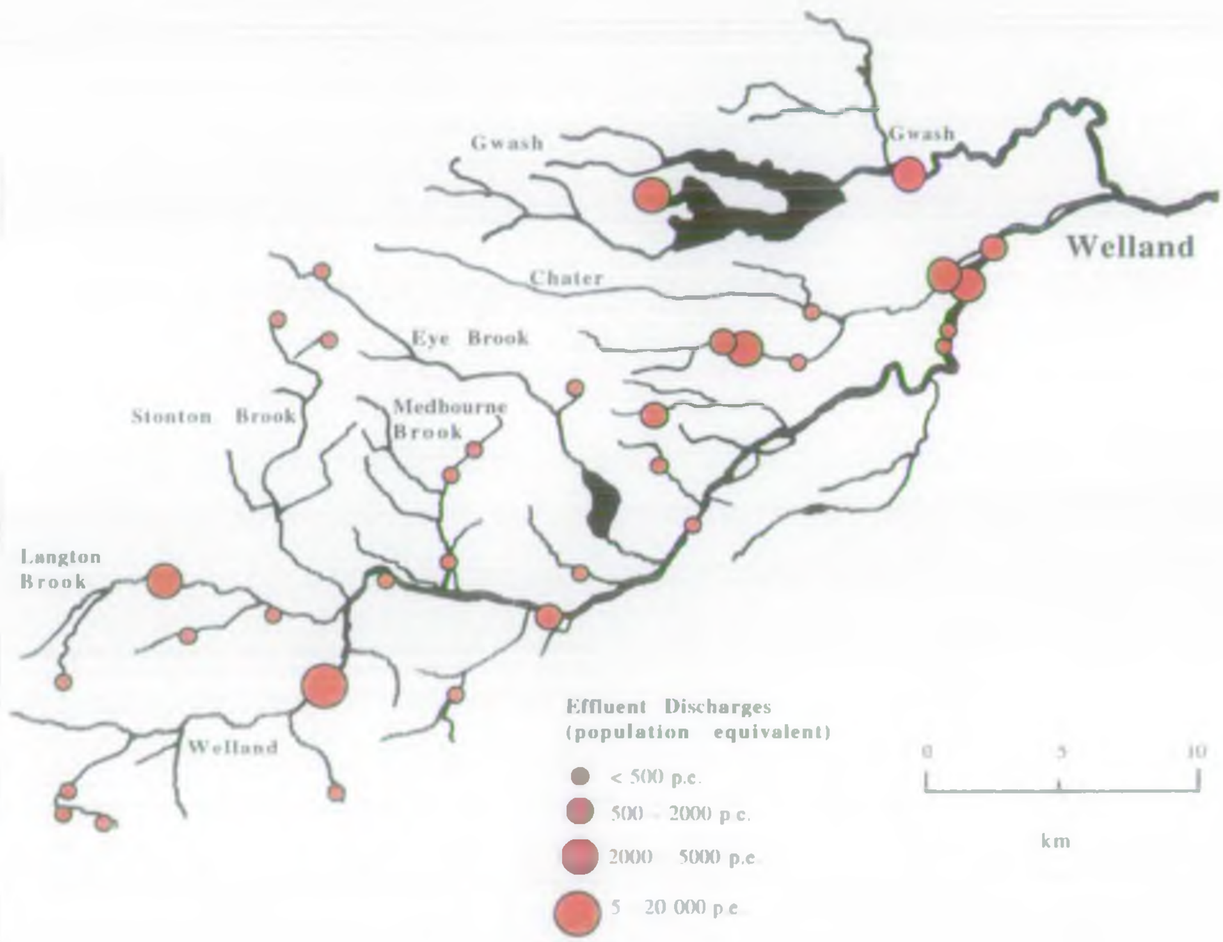
Preliminary conclusions are:

- agricultural streams with no effluent input (n=7) have mean TP concentration of 57μg/l (range 48-92); SRP is 63% of this.
- streams with rural sewage works effluent (n=6) have mean TP concentration of 343μg/l (range 199-875) and SRP is 95% of this
- streams with small urban (p.e. 5-20,000) sewage effluent (n=4) contain TP in very high concentrations (2.8 mg/l SRP 88%)

There are thus three groups of streams, separated by approximately 6-8 -fold differences in their mean TP concentrations, and by their effluent and land use status.

Figure 3. The location of the ten river systems selected across the Region for more detailed analysis.

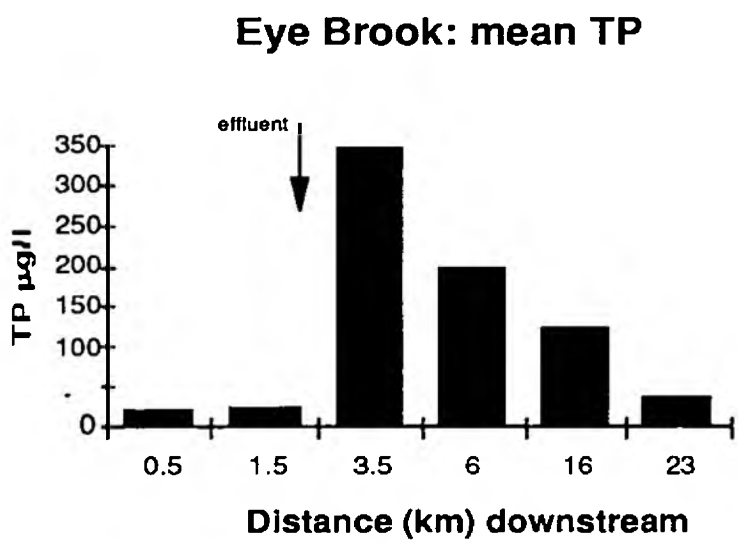
Figure 4. The location of the Welland, its tributaries and its effluent discharges

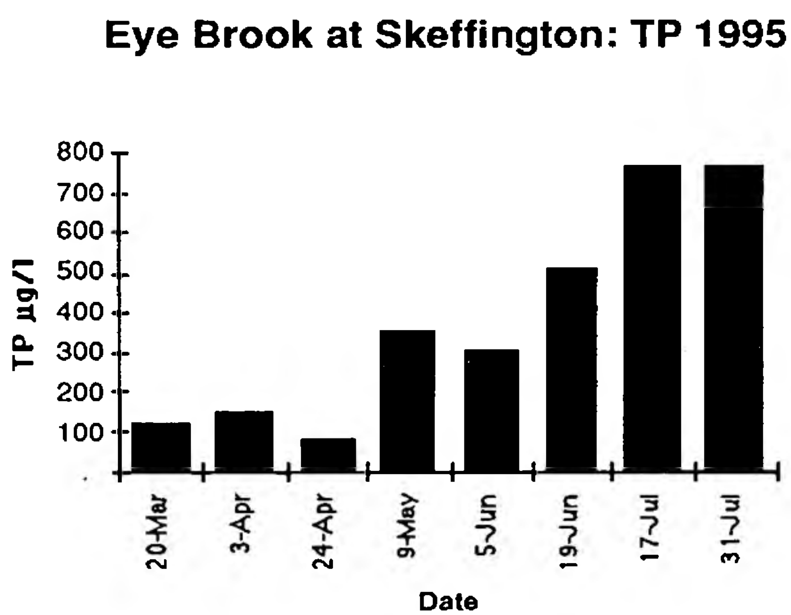


## Spatial changes within the river channels

In streams within the Welland catchment which receive point source effluent inputs (for example the Eye Brook and the Stonton Brook; Figure 5), TP declines with passage downstream and increases as river flows decrease during the summer.

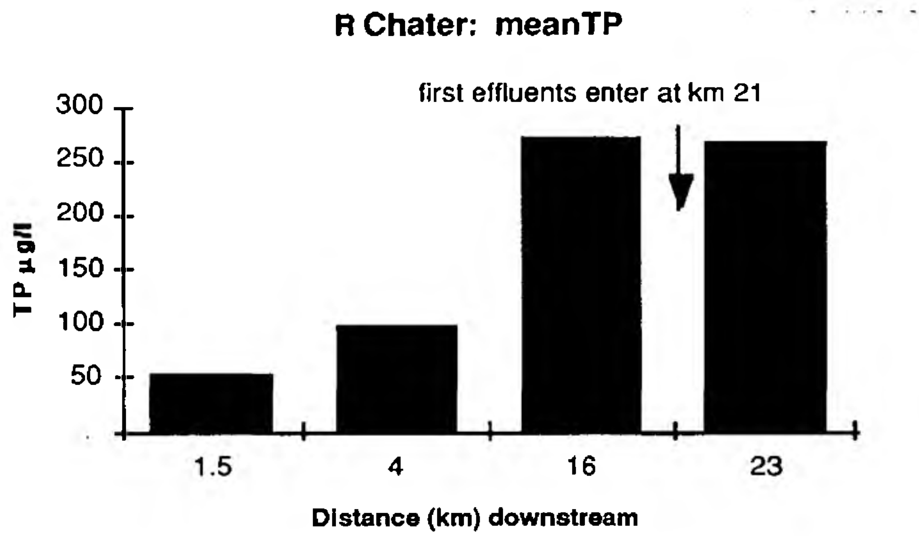
**Figure 5. Effluent pattern in the Eye Brook with station (upper graph) and over time (lower graph).**

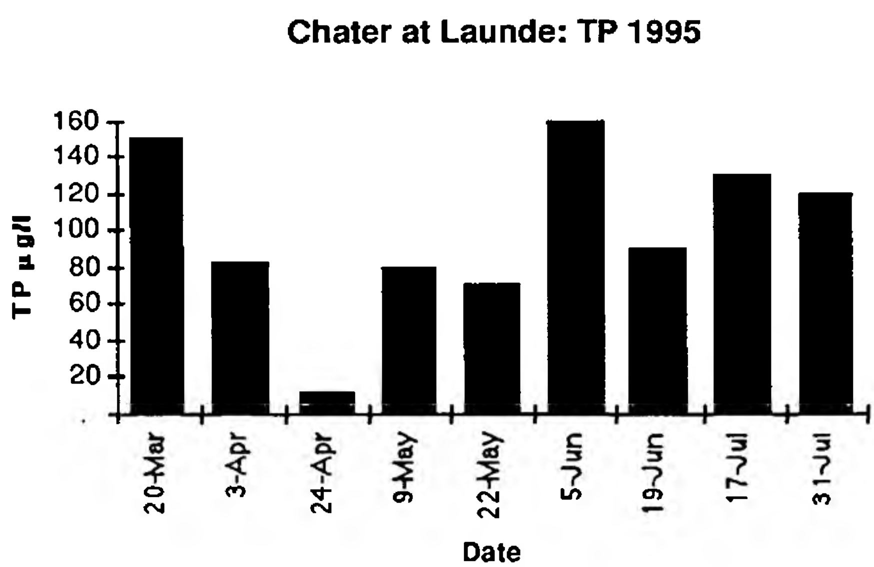


In contrast, in streams with no effluent input (such as the River Chater and Langton Brook; Figure 6), concentrations of TP increase downstream and are more constant as river flows decrease during the summer.

**Figure 6. Effluent pattern in the Chater with station (upper graph) and over time (lower graph).**



One hypothesis explaining this is that effluent phosphorus is in a more available form, which is more swiftly utilised within the river channel, than is agriculturally-derived P. Another is that the difference between channels is independent of the inputs, and more connected with aspects channel structure, such as the physical heterogeneity, which provides greater hydraulic retention (meanders, vegetation, debris dams). Both hypotheses are under further investigation.

**Ecological aspects of phosphorus status**

Phosphorus can be expected to affect the ecosystem of the river channel in several ways, but all of them in a 'bottom-up' mode; that is through the primary producers.

Preliminary results indicate that:

- sediment phosphorus concentration is positively related to water phosphorus
- flowering plant communities recorded on the REDS database and the trophic indices derived from them do not show any differences between streams, but
- flowering plant biomass is positively correlated with sediment phosphorus concentration
- biomass of *Cladophora* ~~is~~ increases with water TP above concentrations of approximately 50 μg/l
- neither invertebrate diversity nor quality score (BMWP) decrease with increasing phosphorus concentrations, but
  - certain rare species are confined to low P sites
  - feeding guild composition changes with increasing TP (reduced scrapers, increased collectors), probably because
  - the attached algal community changes away from encrusting species towards filamentous species with higher biomass

## Conclusions

- 1. The major sources of phosphorus to rural lowland English streams are point sources, chiefly village sewage effluents. Few streams are unaffected by them.
- 2. Sewage-derived phosphorus is around 90% soluble, is found in mean concentrations between 200-2000 μg/l TP, progressively decreases downstream but increases with low river flows.
- 3. Background phosphorus (agriculturally-derived) is found in concentrations below 100 μg/l TP, only about 60% is soluble, and does not change much as river flows fall.
- 4. In these latter watercourses, phosphorus concentrations increase downstream to

between 200-400 µg/l. This is either because agriculture becomes more intensive with changeover from predominantly pasture to predominantly arable in the floodplain and immediate catchment and or because the streams themselves become more straightened and provide sediment phosphorus from channel erosion and resuspension.

- 5. Ecological changes can be detected at levels over about 100 µg/l regardless of source.

## 4. CURRENT PROGRAMME

The workshop presentation above was based upon a resumé of the activities of the project, but with emphasis upon the phosphorus analysis as the fundamental investigation. The full spectrum of work pursued over the past six months and its progress is outlined below:

### 4.1 Phosphorus analyses

The ten rivers of 'level two' ('level one' is the whole Region) have been sampled at fortnightly intervals (with the exception of the Alde, which proved too difficult to reach in a day from Leicester along with other rivers on the sampling schedule without allowing sampling to expand from two days per week). This has yielded total and soluble phosphorus at fortnightly intervals (from the Alde at monthly intervals as the routine monitoring was increased to both P species) and formed the basis for the workshop presentations.

The data available run from the start of the programme in March to the end of July, with a further data set to the end of November recently delivered. A number of problems arose in the first few months associated with changes in laboratories and method sensitivities, such that several data sets show soluble > total phosphorus. These have been resolved so that, from the end of May, the data appear reliable.

The tributaries of the Welland ('level three') have suffered from similar problems of analysis. Nevertheless, a series of trends are apparent which will be further investigated in the August-November data sets to find consistent pattern. Overall, the data confirm the choice of river systems by providing a full range from those with low phopshorus (below 50 µg/l) to high (above 2 mg/l).

Concentrations of phosphorus are being converted into loadings (kg/ha/month) with the application of coefficents from catchment area and flow, based upon models from the nearest available guaging stations.

### 4.2 Plant growth

The most likely direct effect of phosphorus enrichment is upon the growth of plant communities and hence upon species composition, biomass and productivity. Several strands of these effects are under investigation.

#### 4.2.1 Diatoms

The main thrust of the investigation is the identification of epilithic and epiphytic diatom communities at one site in each of the level two rivers and at sites of varying phosphorus status on the Eye Brook. Diatoms have been sampled from July to October 1995. A sample was taken from one site along each level 1 and 2 stream throughout this period. Three sites along the Eye Brook were sampled to aditionally detect any downstream variation in community. The biofilm containing the diatoms was removed from five different stones at each site using a toothbrush and swilled into a 500ml bottle using distilled water. Epiphytic diatoms attached to *Cladophora glomerata* were also collected by detaching segments of this algae from several mats found at the site.

The samples were digested using the method of Round (DOE Blue Book). Samples of *Cladophora* were placed directly into beakers for acid digestion. Epilithic samples were allowed to settle and subsamples extracted for centrifuging to further concentrate the collected material. Approximately 0.5ml of concentrated mixture was placed into a beaker. Acid digestion then proceeded in the same way for both samples. An equal volume (2ml) of potassium permanganate and concentrated hydrochloric acid was added to the samples. The beakers were covered with cling-film and placed on a hot plate at 60°C until the liquid turned a slight yellowish-clear colour. After cooling and removal of the supernatant, distilled water was added and the sample agitated to remove traces of acid. The sample was then allowed to settle. At this point the settled material consisted of very fine grey particles. A fraction of this material was drawn off and placed on a cover slip. This was allowed to dry and the cover slip inverted onto Naphrax (high resolution mounting medium). Contamination of samples with silt and inorganic fragments was sometimes experienced due to the poor quality of stone substrate at some sites.

Enumeration and species identification will be carried out under x100 oil immersion objective. In the first instance, epiphytic diatoms will be compared to epilithic communities. The diatom communities will also be assessed using a trophic index. These indices allow meaningful interpretation of diatom assemblages based on known tolerance of particular species for ranges of phosphorus concentrations. Most indices are based on the weighted average equation of Zelinka and Marvan and have been formulated for Belgian and German rivers. This formula includes the number of different species plus two ratings; a 'sensitivity index' or ecological tolerance of a species and an 'indicator value'. The Trophic Diatom Index (TDI) produced by Kelly and Whitton (1995) is one of the first to be formulated for UK rivers based on the equation of Zelinka and Marvan and will be applied to the diatom assemblages. A total of 200 frustules have to be identified and enumerated. The TDI value will then be compared to phosphorus concentrations. A linear relationship between the two will indicate that SRP is of primary influence in determining these assemblages. A lack of correlation may suggest that other factors (current speed, substrate) have greater influence.

### 4.2.2 *Cladophora*

A Regional-wide survey of the incidence of *Cladophora* in river systems was carried out in 1995, with biology staff completing a simple data sheet on each field visit made to river sites. The complete data set is now being entered into a data-base. These sheets will be analysed in the next three months.

An analysis of the biomass of *Cladophora* achieved in different tributaries of the Welland was carried out over the summer months as part of an M.Sc. project by Jane Macalpine. She confirmed that, subject to substrate type and current speed (*Cladophora* grew best on cobbles and stones and at speeds of 30-50 cm/sec), there was an increase in biomass with phosphorus concentration from 100 µg/l total P. There are thus very few streams in the Region free of the alga but the implication is that reduction of phosphorus would lead to a reduction of algal biomass without any thresholds. There was no evidence that the growth of Cladophora itself reduced the growth of submerged flowering plants, and some suggestion that as phosphorus increased, the morphology of the *Cladophora* changed, with decreased branching. This study was only based upon six sites and 28 samples, and so needs repeating on a wider range of streams.

### 4.2.3 Submerged macrophytes

Our initial evaluation of the REDS database for the rivers of the 'level two' study has suggested that there was little difference between the Trophic Ranks of the aquatic plant community and that, therefore, the macrophyte ranking system was not sensitive enough to use in the lowlands. An M.Sc. study by Michael Rose found that there was a relationship between the biomass of macrophytes and the concentration of phosphorus in the sediments of streams within the Welland, and also that there was a relationship between Mean Trophic Rank and sediment phosphorus. Again, the data set was small, but we are now re-examining the REDS data in the light of these conclusions to see whether small differences which we had previously ignored, do in fact show a recognisable pattern which will allow their use for trophic status monitoring in small streams.

## 4.3 Invertebrates

Invertebrates may be expected to show changes with phosphorus enrichment if there is a significant effect upon the algal food available to species within the 'scaper' guild of feeders which alter the balance of guild structure within the community. This was investigated by two students, Lisa Baker and Christopher Ellis.

Lisa examined the communities of headwater streams in four Welland tributaries, as it is already known that the upper few kilometres or even hundreds of metres of headwaters have quite different faunal communities than further downstream. Lisa's work confirmed these diferences, showing that the upper few kilometres were dominated by shredders, usually *Gammarus*, plecoptera or limnephilid trichoptera. These communities change after the upper three-four kilometres.

Chris Ellis examined the communities further downstream to avoid this 'headwater effect', on three of the tributaries (Eye, Langton and Stonton Brooks). He found that there was a difference in community, reflecting a shift in ratios between encrusting and filamentous algae. The ratios decreased from > 100 to <10, measured as chlorophyll *a*., with increased phosphorus concentration from an average of 100 to 3500 µg/l over the summer months. The community changes were not represented as diversity, which bore little relationship to ambient phosphorus concentration, but could be related to changes in functional feeding guilds, with scrapers prominent at the low phosphorus sites and collectors predominant at the high phosphorus ones. The exact reasons for the latter are not clear, but it may be related to rapid turnover and decomposition of filamentous algae, degree of epiphytic colonisation or the associated siltation which occurs.

## 4.4 Nitrogen in the river Welland

The analysis of nitrogen concentrations in river water, and denitrification in river sediments, has been carried out on the 'level three' sites between March and October of this year by a Hungarian research student, Mariann Olah, as part of her studies of the ecological importance of denitrification in river systems. It is important to ensure that the original assumption made by this project, that phosphorus is the limiting nutrient in river systems, is tested. The final report from Mariann is due at the beginning of December and will be incorporated into the final report of this project. On two sample runs we have compared her measurements of nitrogen in water samples with analyses carried out at the NRA national laboratory service labs and found good general agreement but with odd samples where there were considerable diferences. The reasons for the differences are not immediately clear but are being investigated.

## 4.5 Other relevant projects

Two other studies were carried out outside the immediate area of these investigations, which are relevant to this project and used techniques which could be incorporated. One, by Joanna Wray, investigated the growth of algae in two contrasting stretches of the same stream; one shaded and one open. She showed that shading effectively reduced the dominance of *Cladophora* and replaced it with a mixed community of species including red algae.

A second study, by Sharon Grant, used techniques which are under development by Haycock *et al.*, in their MAFF Buffer Zones Project, for estimating the risk of phosphorus loss in a catchment (in units 200 m x 200 m) by developing an index based upon field surveys of soil, land use, slope and watercourse proximity; using phosphorus export coefficients. This was then mapped in a GIS system (Arc-Info) to produce a risk analysis and compared with the measured phosphorus transport in the river system. This is a promising technique which in the particular study was not realised because of difficulties with stream analysis data.

There is also some other relevant work being carried out independently of this project, both within and outwith the NRA. Two PhD students at the University of Durham are studying nutrient fluxes in northern river systems as part of the LOIS project, and this work is relevant to our calculations of phosphorus fluxes. A PhD student at Newcastle is studying the diatom communities in the river Tyne system, and the classification of diatoms which she achives will be directly comparable (on a river system of different character) to this study. Lastly, some work on invertebrate score systems within the Severn Trent region of the NRA indicates that on a regional scale, detection of eutrophication in rivers may be possible through an increase in the BMWP:ASPT ratio. This means that sites influenced by eutrophication show a good taxonomic richness producing a reasonable BMWP, but the contributing taxa are on average, lower scorers as individuals. Our data can be re-evaluated in the light of this preliminary conclusion.

## 5. FUTURE PROPOSALS

### 5.1 Completion of existing tasks

The main task for the completion of the project as originally planned are the analysis of phosphorus data, calculation of loadings, interpretion of the *Cladophora* and REDS surveys, and completion of the diatom identification. This has to be carried out against a background of two days per week field sampling of level two rivers, which has over the past nine months proved an arduous task. It has now nbeen agreed that for 1996 there will be a cessation of 'level two' river sampling by the project worker and its replacement by total and soluble P analysis on the routine monthly samples of level two river sites. This will continue to provide the seasonal pattern of total vs. soluble phosphorus on ten river systems of contrasting phopshorus status. The 'level three' sampling programme will continue; this will provide a high temporal frequency (three samples pre month of some sites, two per month of many) as well as the full range of phosphorus status (streams from > 3 mg/l to < 50 μg/l in one catchment). It would free up four days per month though for analyses and interpretation of the existing data set between now and March,

### 5.2 Programme extension

The most important future need is for enough time to complete a full year's analysis of the two phosphorus fractions in the chosen river systems at the three different time intervals, because no reliable conclusions can be drawn from a data series that is less than one year long. The implications of this are the extension of the project to the end of June for sample collection (one month overlap), and the employment of project worker to the end of October for completion of analysis and draft report.

This basic requirement, if implemented, would additionally enable enough time to be given to the promising lines of the biological investigations which have developed through 1995, by the inclusion of the 1996 growing season in the revised timetable, and with final report completed by project supervisor end December following NRA responses to the October draft final.

### 5.3 Detailed proposals for project extension to end December 1996

These are as follows:

1. Routine NRA monthly monitoring of level two sites incorporates both total and soluble phosphorus in its analyses to end June 1996.

2. Project sampling of the level three rivers continues at the present set of sites and frequency to end June 1996.

3. The storm-event sampling originally proposed for 1995 be incorporated into the work in early 1996.

4. Analysis of 1995 phosphorus concentration and load trends, and their relationships with suspended solids be completed and reported by end March 1996

5. Analysis of 1995 diatom samples be completed and reported by end March 1996

6. Analysis of 1995 *Cladophora* data sheets be completed and reported by end March 1996

7. A more detailed investigation into the algal community composition, particularly the balance between epilithic adnate (which are chiefly diatoms) and the filamentous (chiefly *Cladophora*) be carried out at the Welland sites with ambient phosphorus levels between 50 µg/l and 3 mg/l in order to pinpoint the differences in species compostion and structural change. This investigation to be carried out by Gaynor Evans, the project employee.

8. A more detailed investigation to be carried out into the causes for the observed reduction in phosphorus concentrations in some stream systems but not others (see Figs 5 & 6) by investigation phosphorus fluxes in relation to channel structure. This investigation to be carried out by Steve Dickinson, a new M.Sc by research student, from January 1996.

9. A more detailed investigation to be carried out into the structure of the invertebrate communities of the Welland sites in relation to the algal community study proposed in 7, above. This to be carried out by a new M.Sc. student in April - September 1996, following consultations by David Harper with Chris Extence over the invertebrate data base held by Northern Area.

10. A more intensive macrophyte survey of the tributaries of the upper Welland, to establish whether the trophic ranking system clearly reflects trophic status to be carried out. This will also be carried out by a new M.Sc. student in April - September 1996.

11. A more detailed investigation into the relationship between sediment phosphorus and macrophyte growth and trophic ranking, to be carried out at the same Welland sites. This also to be carried out by a new M.Sc. student in April - September 1996.

12. A GIS analysis of the land use upper Welland tributaries to be carried out in summer in order to ascertain whether non-effluent phosphorus fluxes in stream systems can be correlated with particular patterns of soils, topography or land use and to determine whether the technique has wider application. This also to be carried out by a new M.Sc. student in April - September 1996.

13. Progress reports to be produced at the beginning of April (covering 1-6 above), end of August (covering points 1,2, 7-12 above). Final Report to be written up by David Harper, with draft final produced by end October 1996 and Final by end December 1996.

## 5.4 Costs of revised proposals

The contractor costs, that is excluding the costs of NRA laboratory services, amount to eight months additional employment at the same rates as originally quoted (plus inflation) together with a repeat support element for the M.Sc. projects. This is broken down as follows:

| | | |
|---|---|---|
| Remuneration: | Gaynor Evans | £7,250 |
| | University on-costs | £1,360 |
| Additional expenses of student assistance 1996 | | £2,500 |
| Travel | | £1160 |
| Consumables and printing | | no additional |
| Total | | £12,270 |