NRA

PHOSPHATE IN THE CUT-OFF CHANNEL

National Rivers Authority
Anglian Region

PHOSPHATE IN THE CUT-OFF CHANNEL

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SUMMARY

This report considers only the impact on the Cut-off Channel of phosphate removal from STW's serving more than the equivalent of 10,000 people, i.e. UWWT Directive Qualifying Discharges. The additional impact of other eutrophication control measures is not assessed.

Phosphate removal at qualifying discharges is likely to reduce mean concentrations of phosphate in the Cut-off Channel by about 24%. In some locations the reduction could be up to 62%.

Phosphate removal at Bury St Edmunds and RAF Lakenheath STWs would have the biggest impact on the level of eutrophication in the Cut-off Channel, particularly in the stretch to the south of Blackdyke, to the River Lark.

The degree of reduction will depend on the average concentration of phosphate achieved in the effluent of qualifying discharges.

Even if we went further than required by the Directive, and phosphate was completely removed from all effluents entering the system, it is likely that the phosphate concentration in the Cut-off Channel, although significantly reduced, would still exceed 0.1 mg/l along much of its length.

The biological response to a reduction in phosphate concentration would depend on the size of the reduction, and also on the length of time (ie number of years) for which the reduced levels could be maintained. However, if phosphate were removed from Bury St Edmunds and RAF Lakenheath STWs then it is likely that the Cut-off Channel between Blackdyke and the River Lark would show a reduction in the incidence of filamentous algae such as *Cladophora*, and would move toward a dominance of higher plants. Invertebrate diversity would also be expected to improve.

Experience from systems where nutrient removal has been carried out for several years suggests that nutrient removal should be seen as only one of a series of eutrophication control measures for a watercourse.

Since the modelling predicts that nutrient removal at Bury St Edmunds and RAF Lakenheath STWs will have the largest effect on nutrient concentrations in the Cut-off Channel between Blackdyke and the River Lark, and this stretch is physically distinct from the rest, we suggest that P-removal should be introduced initially at Bury St Edmunds and RAF Lakenheath STWs.

The situation should be re-evaluated at the second review of Designations, in the light of future phosphate concentrations, the effect of any P-removal at Bury St Edmunds and RAF Lakenheath STWs, and the interaction with other eutrophication control measures.

CONTENTS

SUMMARY i

1.0 **Introduction** 1

2.0 **SIMCAT Modelling - Great Ouse Catchment** 4
- 2.1 **Sources of Phosphorus in the Ouse** 4
- 2.2 **SIMCAT Model Runs** 7
  - Run 1: Flow Calibration 7
  - Run 2: Quality Calibration and Current Quality 8
  - Run 3: Effect of P-removal at Cambridge STW 8
  - Run 4: Effect of P-Removal at all Qualifying Discharges 9
- 2.3 **Summary of Great Ouse Modelling** 10
- 2.4 **Conclusions** 10

3.0 **SIMCAT Modelling - Cut-off Channel** 11
- 3.1 **Model 1 - Lark to Denver** 11
  - Run 1: Flow Calibration 12
  - Run 2: Quality Calibration and Current Quality 12
  - Run 3: Effect of P-removal at Qualifying Discharges 13
- 3.2 **Model 2 - Denver to Blackdyke** 14
  - Run 1: Flow Calibration 14
  - Run 2: Quality Calibration and Current Quality 15
  - Run 3: Effect of P-removal at Qualifying Discharges 16
- 3.3 **Summary of Cut-off Channel Modelling** 17

4.0 **Biology** 17
- 4.1 **Biology of the Cut-off Channel (River Lark to Blackdyke).** 18

5.0 **Conclusions** 18

Appendix 1: STWs included in the Study 19

1.0 **Introduction**

In May 1994, the UK Government designated the Cut-Off Channel as a Eutrophic Sensitive Area (SA[E]) under the Urban Waste Water Treatment Directive (UWWTD). However, no sewage treatment works (STWs) were identified as requiring phosphate-removal (P-removal) by the first Directive deadline, at the end of 1998. Other stretches, such as the Rivers Cam and Ely Ouse and the River Lark, were proposed as SA[E]'s, but were not designated. These will be reconsidered separately at the first review of designations in 1997.

At the time of designation, the DoE asked the NRA to carry out a study to determine whether P-removal at qualifying discharges upstream of the SA[E] would have an effect on phosphate concentrations in the Cut-Off Channel.

The Cut-Off Channel flow regime is complex and varies depending on the need to transfer water to Essex and the frequency of flood events. During operation of the Ely Ouse-Essex transfer scheme, water from the Ely Ouse is diverted into the Cut-Off Channel at Denver and flows south to the Blackdyke intake, a distance of approximately 25km. At Blackdyke water is drawn off into a tunnel and transferred, via the Rivers Stour and Blackwater, to Abberton and Hanningfield reservoirs in Essex. At these times water levels in the Cut-Off Channel between Blackdyke and the River Lark, a distance of about 20km, are maintained by physical structures and transfer of water from the Lark. This section of the Cut-Off Channel is not affected by the transfer of water from the Ely Ouse but receives a constant flow from the Lark which increases during flood events.

During potential flood events water is transferred from the Lark, Little Ouse and Wissey into the Cut-Off Channel and flows north into the Flood Relief Channel at Denver, for release into the Tidal River Great Ouse. In these conditions the channel design results in high flow rates which tend to remove the sediment, hence preventing a build up of phosphate in the system. Figure 1 shows a diagram of the Cut-off Channel and the rivers which provide its flow.

It was thought that phosphate concentrations at Denver on the Ely Ouse were critical to phosphate concentrations in the Cut-Off Channel. With this in mind we took the opportunity to model the whole of the Great Ouse catchment upstream of Denver, since the results will also be useful for the 1997 review of SA[E]s. Figure 2 shows the Great Ouse catchment, including all of its tributaries.

The results of the modelling work would indicate whether or not we needed to extend the model into the Cut-off Channel itself. If P-removal at the qualifying discharges caused reduced phosphate concentrations at Denver, we would need to model explicitly the impact of the reduced concentrations on phosphate concentrations in the Cut-off Channel.

River phosphate concentrations were modelled using SIMCAT, our river quality model, which describes the quality of river water throughout a catchment. Technical detail of the model can be found in the SIMCAT User Guide, available from Water

Figure 1: Diagram of the Cut-off Channel

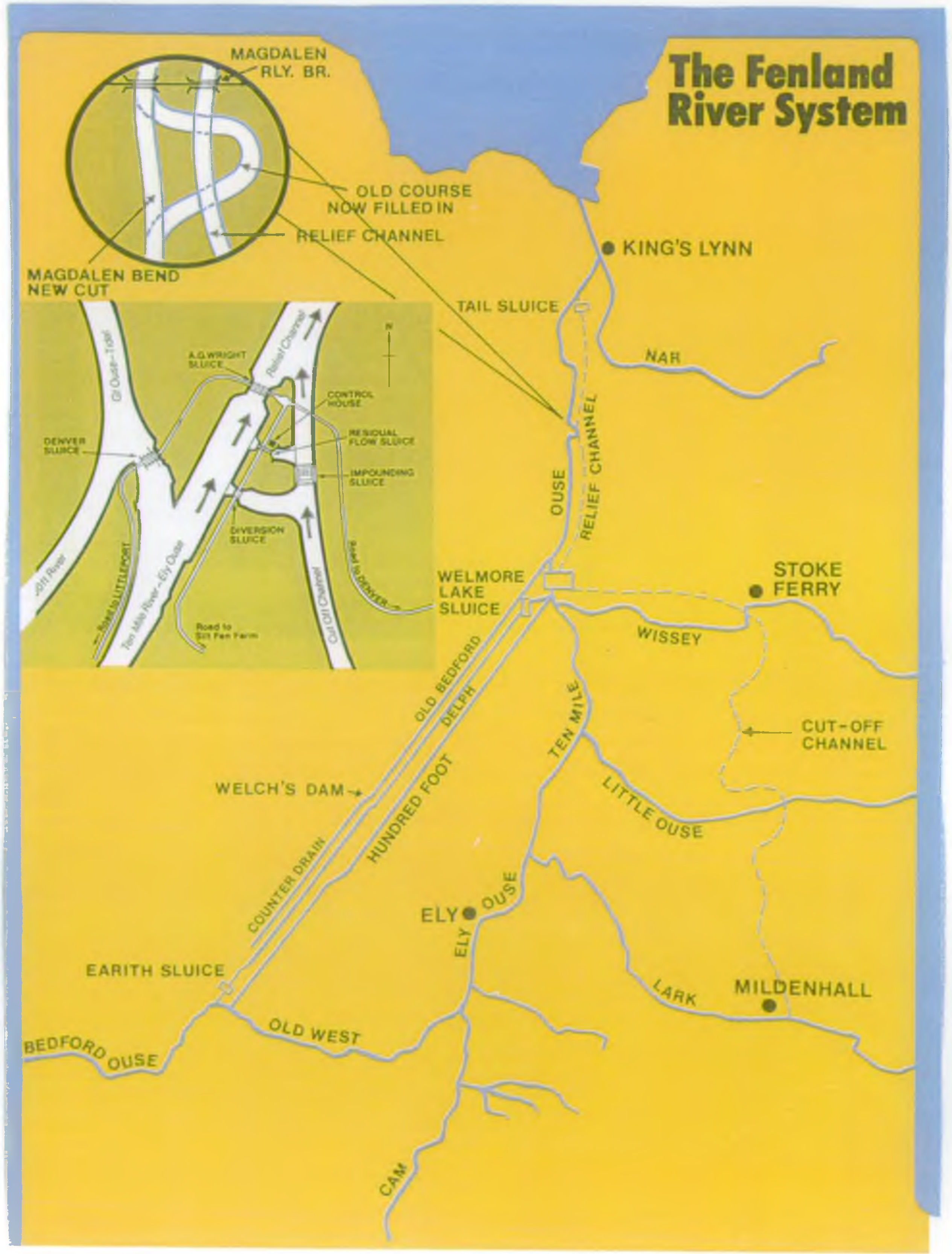
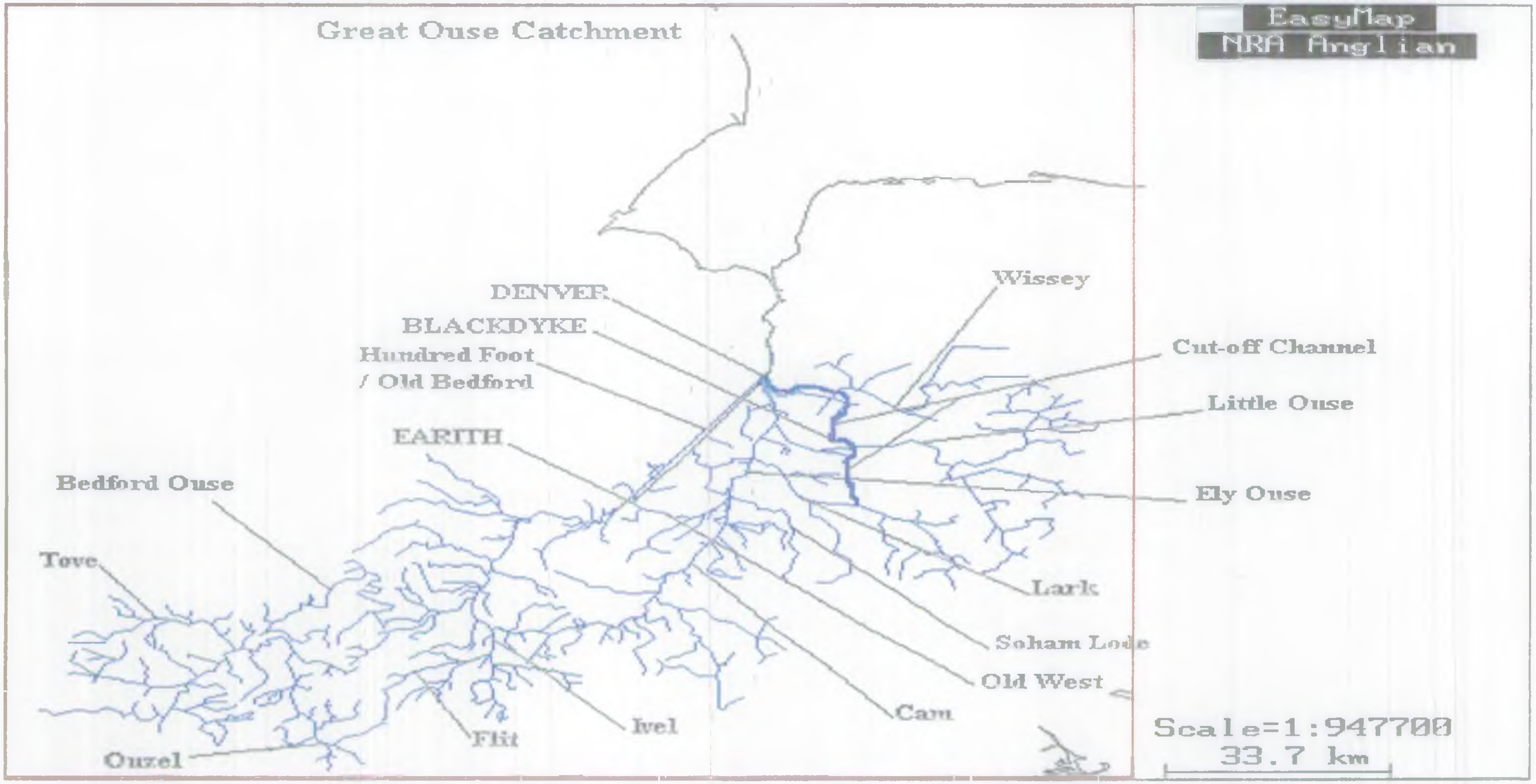


Figure 2: Location of the Cut-off Channel



2.0 SIMCAT Modelling - Great Ouse Catchment

The model of the Great Ouse includes the Bedford Ouse and all its tributaries (Flit, Ivel, Ouzel, Tove, etc), the Old West, Cam, Lark, Little Ouse, Wissey, and Ely Ouse. The length of river modelled, from the top of the Bedford Ouse to Denver, was 240 km in length.

In Anglian Region, our routine river and STW effluent monitoring programme three year period 1991 to 1993 were used to set up the model. River flows were obtained from gauged data or calculated by the Water Resources department. Sewage effluent flows were estimated from the population equivalent served by the works, and industrial effluent or privately owned STW flows from the consented DWF.

The whole catchment was characterised by 96 reaches. We included:

- 266 river flow data sets;
- 232 river quality data sets; and,
- 262 effluent flow and quality data sets

The model was calibrated against 60 sets of flow and 154 sets of water quality data. This included 9 sets of flow and 25 sets of quality data along the main channel of the Ouse.

In total 685 features were modelled, including:

- 156 river quality modelling stations;
- 114 small streams or tributaries;
- 217 STW effluent discharges;
- 53 river flow gauges;
- 34 industrial effluent discharges; and,
- 33 abstraction points.

2.1 Sources of Phosphorus in the Ouse

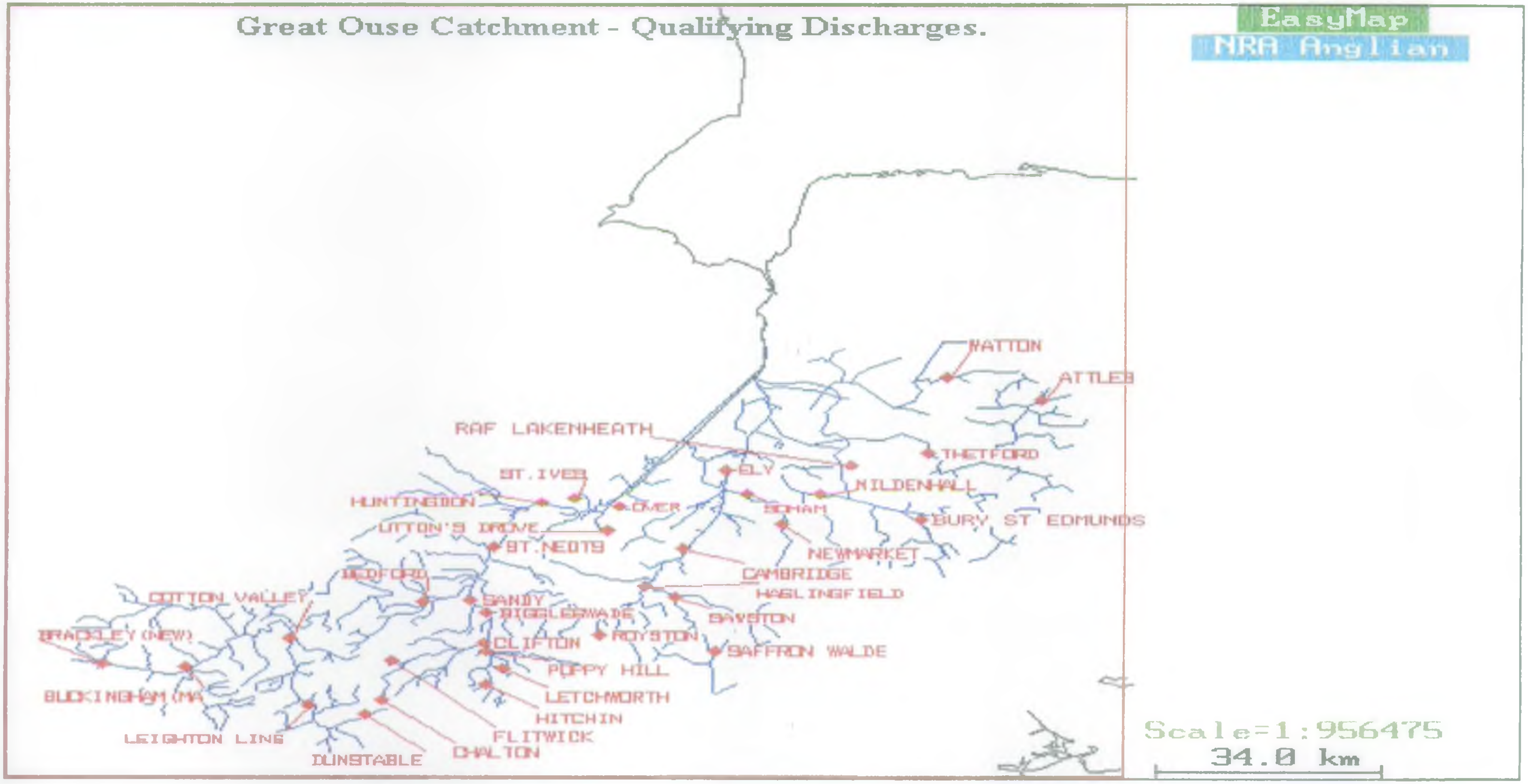
Sewage effluent is believed to be the main source of phosphorus in the Ouse catchment. There are 217 STWs which were included in the study. Details of the main discharges, their population equivalent or DWF, and phosphate concentrations are included in Appendix 1.

There are 34 discharges in the Great Ouse catchment, upstream of Denver, with population equivalents of more than 10,000 which may, therefore, qualify for phosphorus removal under the UWWTD. These are shown in Table 1 and Figure 3.

Table 1: Qualifying Discharges

Designated SA(E)	Upstream River	STW
Cutoff & Relief Channel	Bears Mouth Stream	RAF Lakenheath
	Wissey	Watton
	Cam & Ely Ouse	Saffron Walden Sawston Royston Cambridge Ely Haslingfield
	Old West	Over
	Soham Lode	Newmarket Soham
	Lark	Bury St Edmunds Mildenhall
	Little Ouse	Thetford Attleborough
Foxcote Reservoir	Great Ouse Headwaters	Brackley
Grafham Water	Great Ouse	Cotton Valley Uttons Drove Bedford St Neots Huntingdon St Ives
	Great Ouse Headwaters	Brackley Buckingham
	Ouzel	Dunstable Leighton Linslade
	Ivel & Flit	Letchworth Poppy Hill Clifton Biggleswade Sandy Flitwick Chalton Hitchin

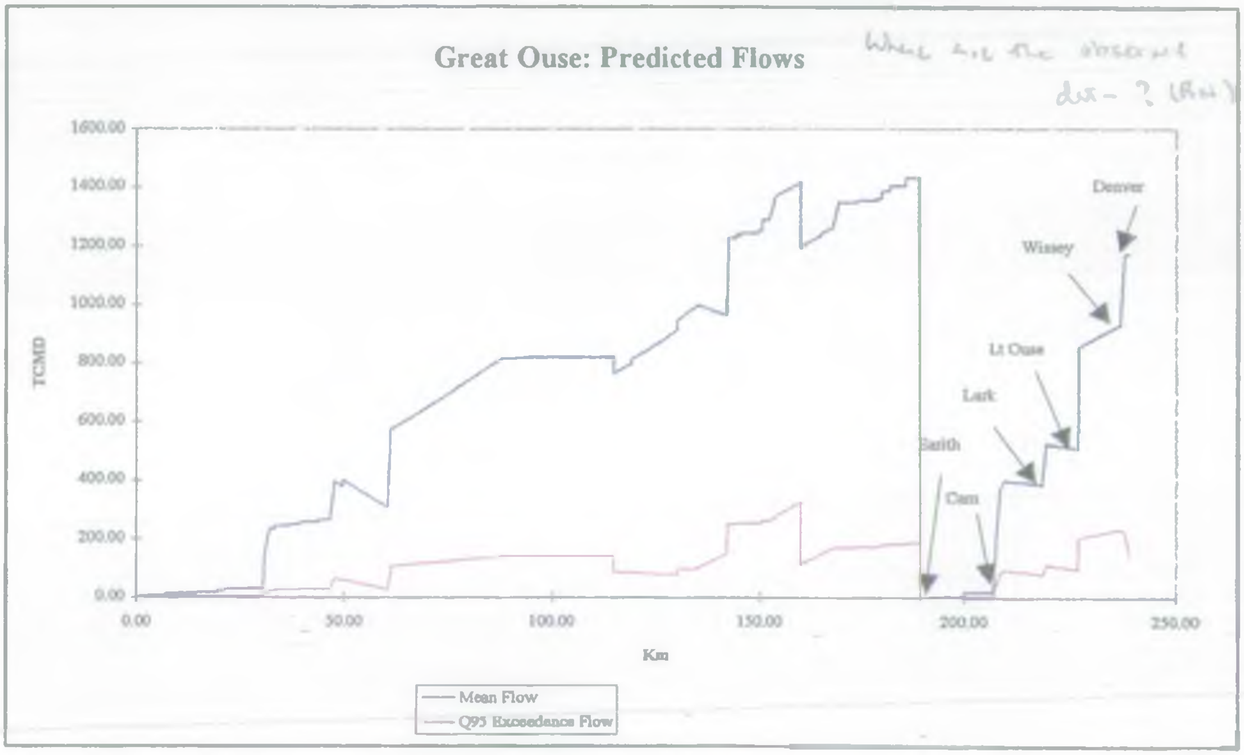
Figure 3: Qualifying Discharges



2.2 SIMCAT Model Runs

Run 1: Flow Calibration

Results of the flow calibration are shown below. The steep decline at Earith marks the end of the Bedford Ouse and the start of the Old West/Ely Ouse.



These results show that very little of the flow of the Bedford Ouse enters the head of the Old West/Ely Ouse system. Most of the flow of the Bedford Ouse enters the Great Ouse Estuary via the Old and New Bedford Rivers.

The Bedford Ouse and Old West/Ely Ouse systems can almost be regarded as independent watercourses. This means that, based on these flow predictions, none of the discharges in the Bedford Ouse can affect the water quality at Denver, or in the Cut-off Channel. However, the flow predictions show that the results downstream of Earith, i.e. from the Old West/Ely Ouse system, are applicable to this study.

It is possible, for reasons of water resource development, that more of the flow of the Bedford Ouse will be passed to the Old West. If this happens, the model is well suited to assess the impact on the Cut-off Channel.

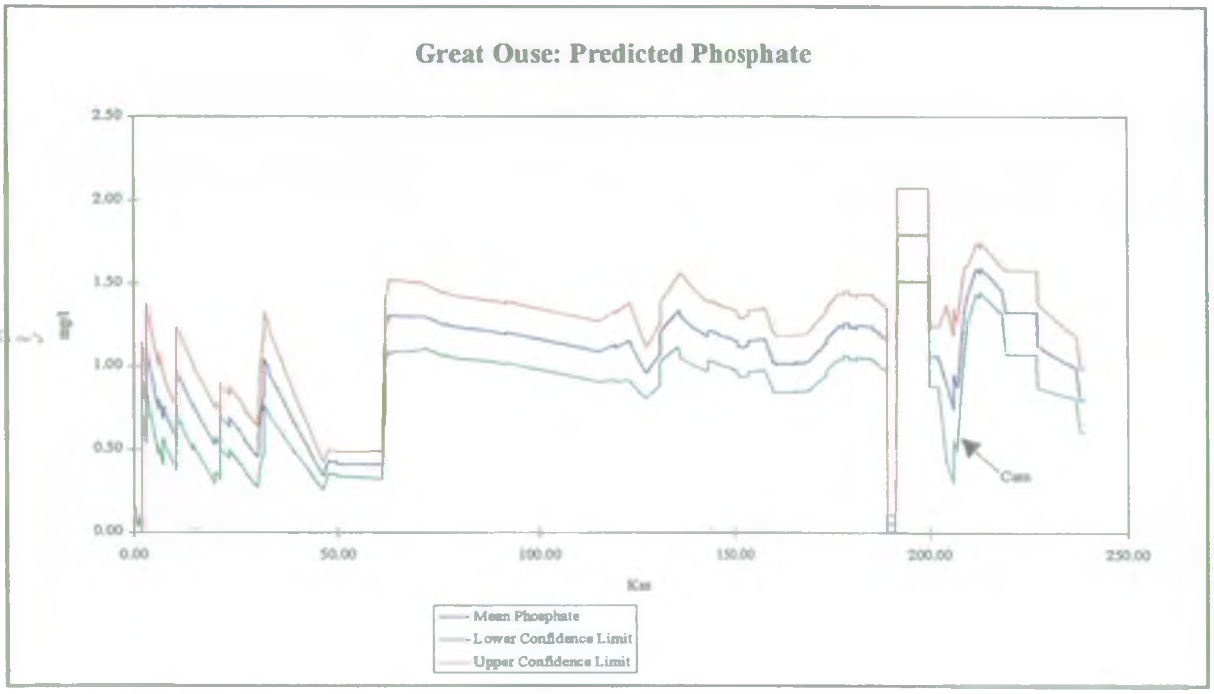
The majority of the Ely Ouse flow comes from its major tributaries: the Cam, Lark, Little Ouse and Wissey.

Our Water Resources department confirmed that the flows predicted by the model were reasonable, based on current knowledge of the system.

Run 2: Quality Calibration and Current Quality

SIMCAT can calibrate automatically. In this study, auto-calibration was used to simulate processes like Natural Purification and Diffuse Sources. During auto-calibration SIMCAT calculates a network of empirical constants and adjustments that reproduce exactly the distributions of water quality recorded at monitoring stations.

Once the calibration was complete, the model was run to predict current phosphate concentrations. The results from the main river are shown below.



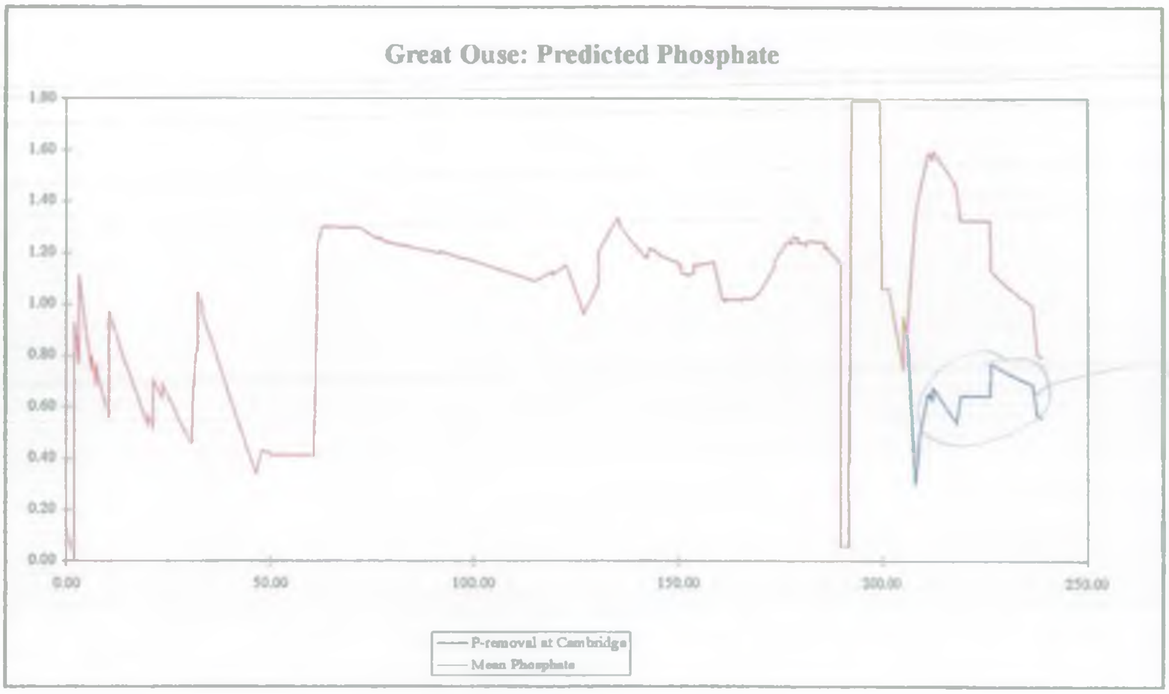
The figure shows the mean phosphate concentration (blue) together with its lower and upper 95-percent confidence limits (green and red respectively) about the estimate of the mean.

Taken together, the results for flows and phosphate suggest that the biggest impact on phosphate concentration in the main river of the Ely Ouse system is the input from the Cam. This is indicated by the steep rise in the predicted quality at about 210 km.

The results show that the mean phosphate concentration at Denver is 0.77 (0.63-0.91) mg/l. (Throughout this report, the figures in brackets give the 90 percent confidence interval about the mean).

Run 3: Effect of P-removal at Cambridge STW

To assess the impact of Cambridge STW on the predicted current quality at Denver, Cambridge effluent quality was set to a mean effluent quality of 1 mg/l. The results are shown overleaf. The red line shows the predicted current mean phosphate. The blue line shows the effect of P-removal at Cambridge STW.

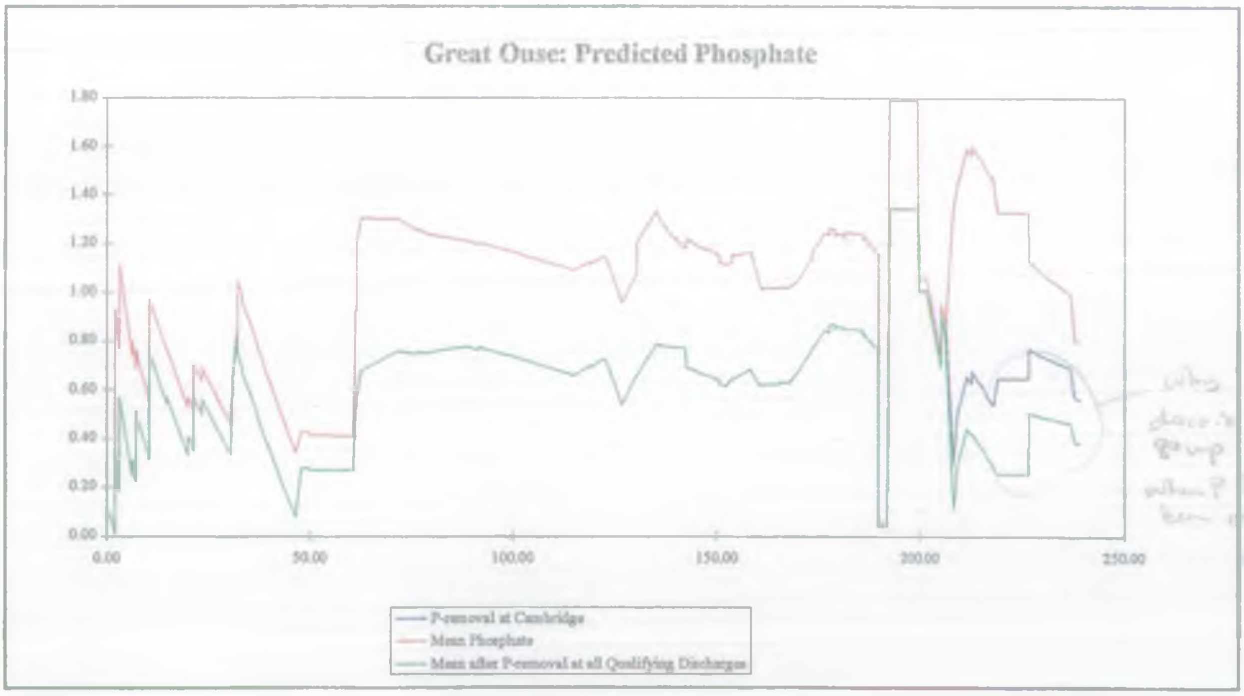


The results suggest that if Cambridge achieved this level of P-removal, the mean concentration at Denver would be reduced by 23% to 0.59 (0.45-0.72) mg/l.

Run 4: Effect of P-Removal at all Qualifying Discharges

Qualifying discharges are shown in Table 1. The mean concentration of phosphate discharged from these works was reduced to 1 for works with > 100,000 pe, and 2 mg/l for works with between 10,000 and 100,000 pe.

The results are shown below, and the green line shows the predicted effect of P-removal at these works.



The results suggest that if concentrations of phosphate discharged by the qualifying discharges were reduced, then the mean concentration of phosphate at Denver is reduced by 44% to 0.43 (0.30-0.56) mg/l.

The large drop in phosphate concentrations between 190 km and 200 km is the effect of P-removal at Over STW, whose effluent forms a large proportion of the flow until it is diluted by the flows from the Cam, and is not caused by P-removal at discharges in the Bedford Ouse. This is to be expected because so little of the Bedford Ouse flow enters the head of the Ely Ouse system.

2.3 Summary of Great Ouse Modelling

SIMCAT has been set up to predict phosphate concentrations in the whole Ouse Catchment.

The work has shown that changes to the system upstream of Earith (the Bedford Ouse) do not have an effect on phosphate concentrations at Denver.

The model predicts that P-removal at qualifying discharges downstream of Earith and upstream of Denver will reduce the mean concentration of phosphate at Denver from 0.77 mg/l to 0.43 mg/l. This is a reduction of more than 40% in the mean concentration, and is equivalent to a move from Grade V to Grade IV of the proposed NRA nutrient GQA bands.

This is a move towards, but does not achieve, the concentration (0.1 mg/l) which is taken as being the threshold for eutrophication in running freshwaters (as set out in the DoE/Welsh Office Consultation Paper (March 1993)). Furthermore, it is still not known whether a reduction towards 0.1mg/l phosphate will realise pro-rata improvements in water quality (see section 4.0).

The reduction in phosphate concentration at Denver means that concentrations in the Cut-Off Channel itself may also be reduced during periods when water is transferred from the Ely Ouse at Denver into the Cut-Off Channel.

2.4 Conclusions

The results of modelling the Great Ouse catchment indicated that further work should be carried out to estimate the relative contributions to the Cut-Off Channel from the Ely Ouse at Denver, and the other rivers. We also needed to check that our assumptions about freshwater inputs to the Cut-Off Channel were correct.

3.0 SIMCAT Modelling - Cut-off Channel

The Cut-off Channel has a complicated flow regime because it is used for both water transfer and flood relief purposes. There is a constant flow into the Cut-off Channel from the Lark of about 4 TCMD. There is a base flow in the Cut-off Channel of about 50 TCMD.

During flood conditions overflows from the Little Ouse, Lark and Wissey enter the system and are carried to discharge into the Great Ouse Estuary at Kings Lynn via the Flood Relief Channel. The overflows from the Little Ouse and Lark operate for about 4% of the time, and that from the Wissey for about 12% of the time. The average flow through the overflow sluices is about 260 TCMD. In these conditions the channel design results in high flow rates, which remove the sediment, hence preventing a build up of sediment phosphate in the system.

When the Ely-Ouse to Essex transfer scheme is in operation, excess flow from the Ely Ouse is sent from Denver to Blackdyke where it is drawn off into a tunnel and transferred via the Rivers Stour and Blackwater to Abberton and Hanningfield reservoirs in Essex. During the operation of the Ely-Ouse Essex transfer, water levels in the Cut-off Channel between Blackdyke and the River Lark, a distance of about 20km, are maintained by physical structures and transfer of water from the River Lark. This section of the Cut-off Channel is not affected by the transfer of water from the Ely Ouse, but receives a constant flow from the River Lark, which increases during flood events.

Because of the complicated flow regime we decided to model the Cut-off Channel twice, once with the flow moving from the Lark to Denver, and once with the flow moving from Denver to Blackdyke.

The Cut-off Channel is characterised by 5 reaches. We included:

- 6 river flow data sets;
- 15 river quality data sets; and
- 6 effluent flow and quality data sets.

The effluents discharging directly into the Cut-off Channel are all too small to qualify for P-removal under the UWWTD. However R.A.F. Lakenheath STW discharges to a small stream which enters the Cut-off Channel after about 1 km. RAF Lakenheath has a dry weather flow of 2,200 m^3/day. This means that its population equivalent is likely to be greater than 10,000, therefore making it a Qualifying Discharge. We are in the process of obtaining an accurate population equivalent figure, but this is complicated because of the large transient population on the site. For the purposes of this report we have treated RAF Lakenheath STW as a Qualifying Discharge.

3.1 Model 1 - Lark to Denver

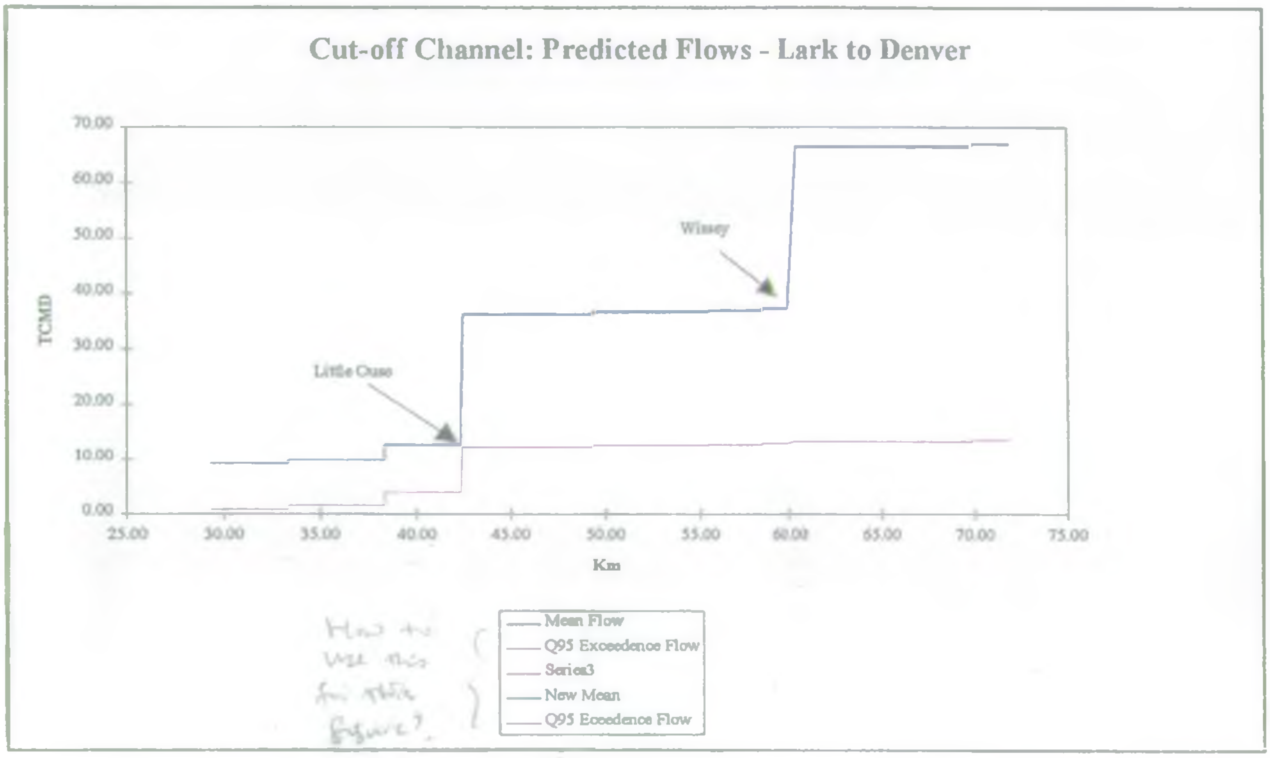
This model was set up to identify the predicted impact on the Cut-off Channel of P-removal at qualifying discharges, assuming that the direction of flow is from the

Lark towards Denver. This ignores the impact of the Ely-Ouse to Essex Transfer Scheme.

The model starts at the head of the Lark, enters the Cut-off Channel 29.3 km downstream, and ends where the Cut-off Channel joins the Ely-Ouse at Denver.

Run 1: Flow Calibration

The flow predictions for the Cut-off Channel itself are shown below.



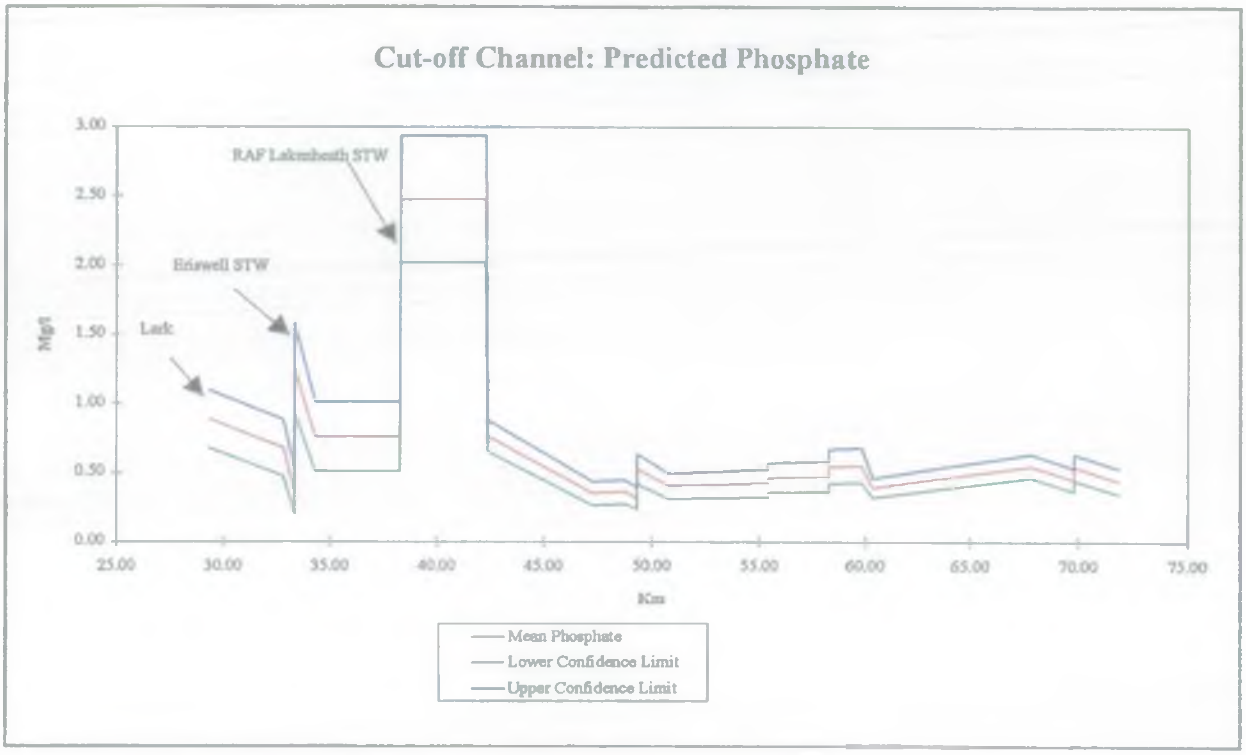
The results show that the main contributions to flow in the Cut-off Channel are from rivers. As mentioned earlier, the effluents discharged directly to the Cut-off Channel are small and have little impact on the flow regime.

Run 2: Quality Calibration and Current Quality

As described for the Great Ouse modelling, auto-calibration was used to simulate processes like Natural Purification and Diffuse Sources. The results are shown overleaf.

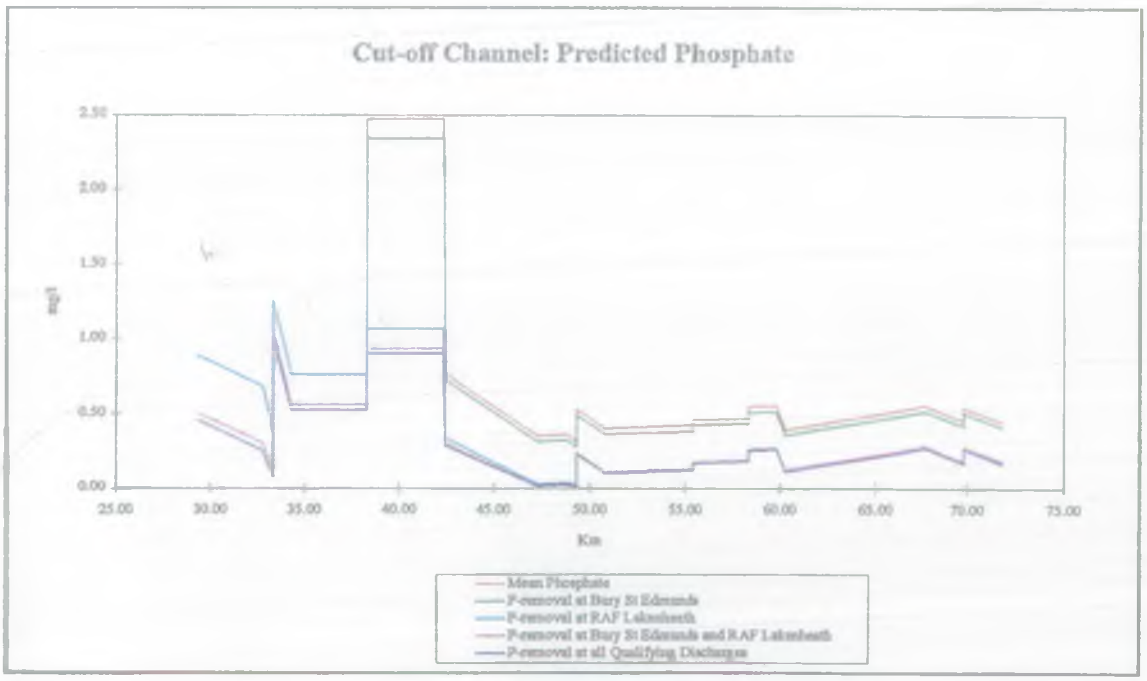
The results suggest that the main impacts on phosphate concentrations in the Cut-off Channel are the input from the Lark, together with Eriswell and R.A.F. Lakenheath STWs at the head of the channel. If improved representation of phosphate concentrations around R.A.F. Lakenheath STW were required, then additional data should be collected in the river up- and downstream of the discharge.

The model predicts that the mean phosphate concentration in the Cut-off Channel varies from 0.32 (0.24-0.40)mg/l to 2.47 (2.02-2.93)mg/l.



Run 3: Effect of P-removal at Qualifying Discharges

This work was carried out in several stages. First the impact of P-removal at Bury St Edmunds STW was assessed, then the impact of P-removal at RAF Lakenheath, and finally the impact of P-removal at all qualifying discharges. Effluent quality for the discharges concerned was set to a mean effluent quality of 1 or 2 mg/l as appropriate. The results are shown below.



The red line shows the predicted current mean phosphate. The green line shows the effect of P-removal at Bury St Edmunds STW, the light blue line shows the effect of P-removal at RAF Lakenheath STW and the purple line shows the combined effect of P-removal at both discharges. The dark blue line shows the effect of P-removal at all qualifying discharges.

The results suggest that, if Bury St Edmunds STW achieved this level of P-removal, the mean concentration at the head of the Cut-off Channel would be reduced by 43% from 0.89 (0.68-1.10)mg/l to 0.51 (0.34-0.67)mg/l. For P-removal at RAF Lakenheath STW, the results suggest that the mean concentration immediately downstream of the discharge would be reduced by 57% from 2.47 (2.02-2.93)mg/l to 1.07 (0.86-1.28)mg/l. P-removal at both discharges, would reduce the mean concentration immediately downstream of RAF Lakenheath by 62% from 2.47 (2.02-2.93) to 0.94 (0.73-1.14).

P-removal at all qualifying discharges would result in a mean concentration of 0.46 (0.32-0.60)mg/l at the head of the Cut-off Channel and 0.9 (0.69-1.12)mg/l immediately downstream of Lakenheath. This drops further in the stretch between Lakenheath and Blackdyke, a reduction of about 62%.

A further model run was carried out to predict the effect of completely removing all phosphate from all point source effluent discharges to the system.. This work showed that concentrations of phosphate still exceeded 0.1 mg/l along much of the length of the Cut-off Channel.

3.2 Model 2 - Denver to Blackdyke

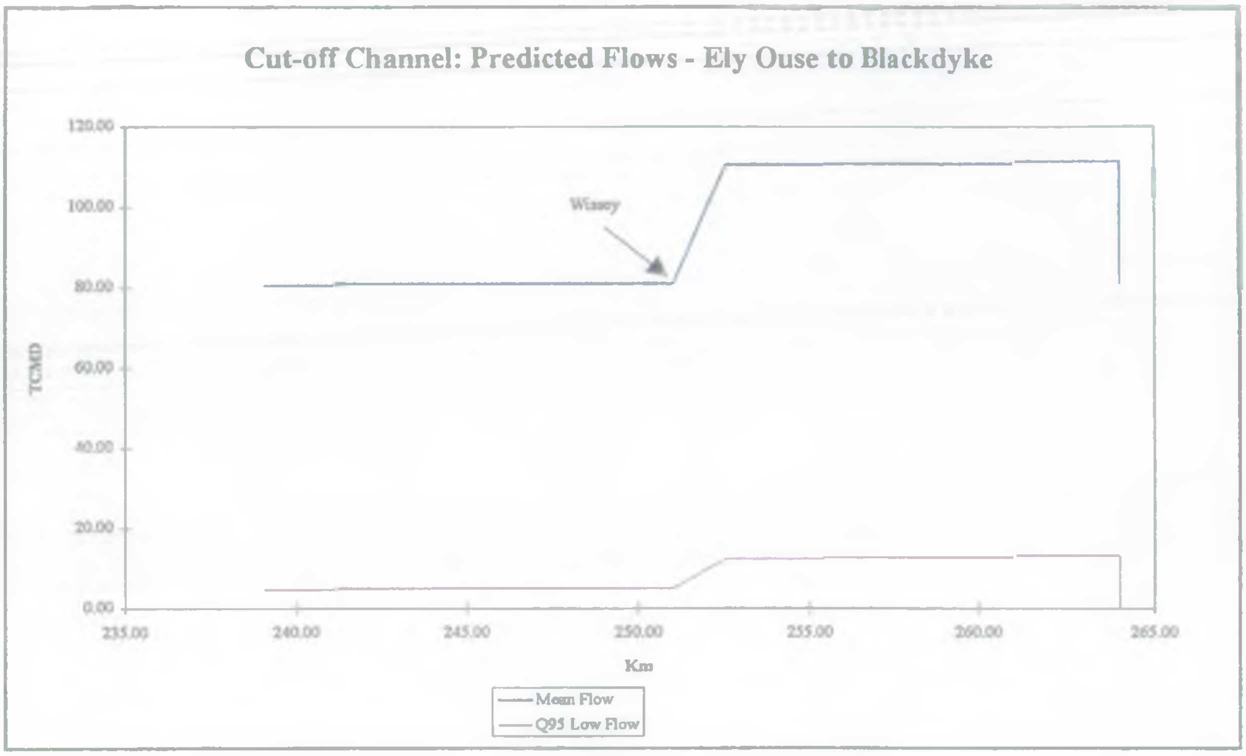
This model was set up to identify the predicted impact on the Cut-off Channel of P-removal at qualifying discharges, when the direction of flow is from Denver to Blackdyke. This model takes account of the Ely-Ouse to Essex Transfer.

The model includes the whole of the Great Ouse system upstream of Denver. The Cut-off Channel starts 239 km from the head of the Great Ouse and ends 25 km later at Blackdyke.

Run 1: Flow Calibration

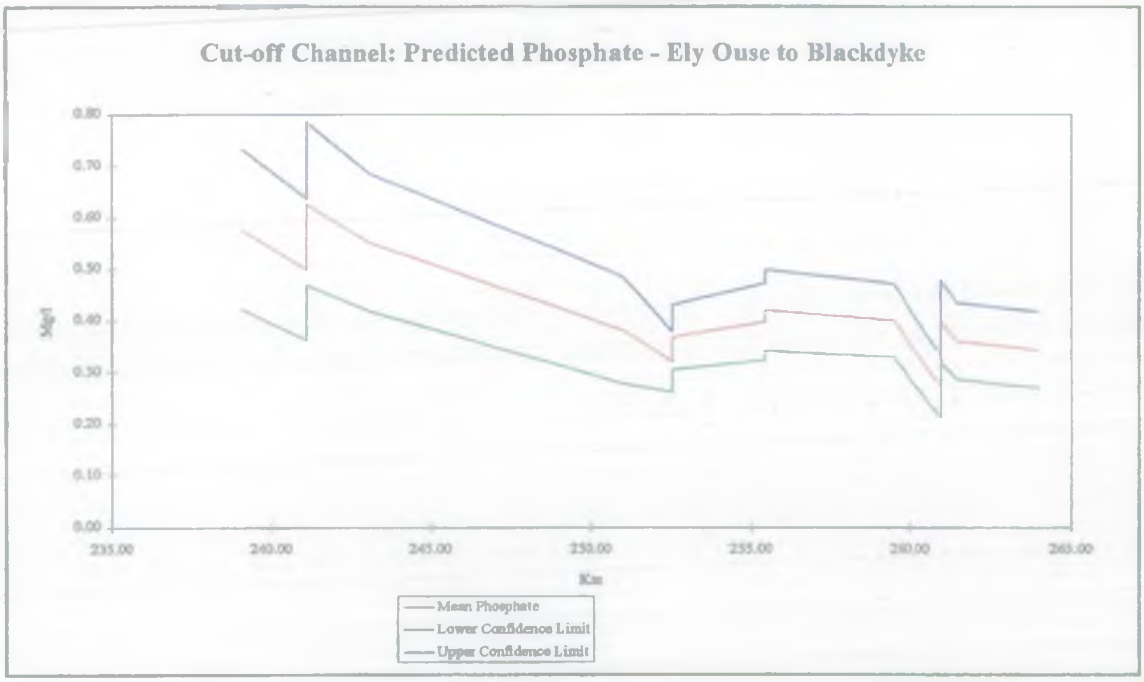
Flow predictions for the Cut-off Channel between Denver and Blackdyke are shown overleaf.

The drop in flow at the right-hand side of the figure represents the flow that is abstracted at Blackdyke.



Run 2: Quality Calibration and Current Quality

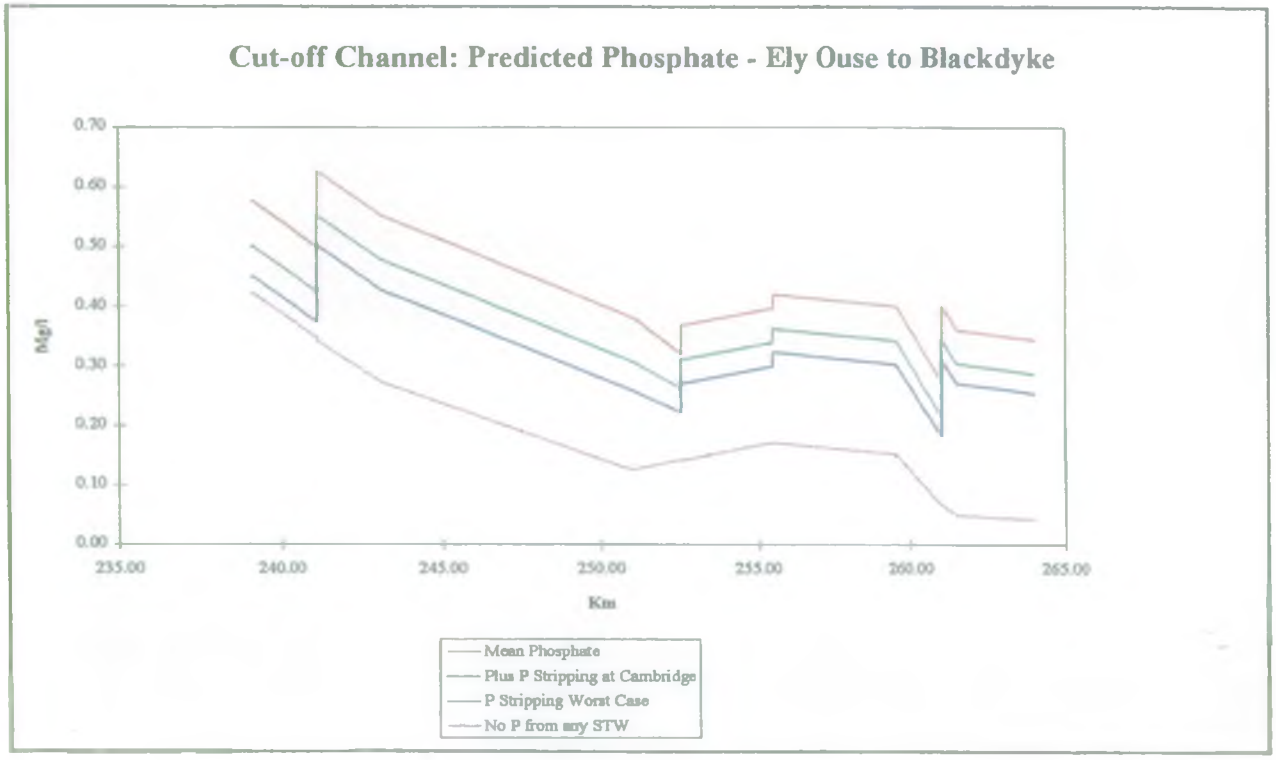
As described for the Great Ouse modelling, auto-calibration was used to simulate processes like Natural Purification and Diffuse Sources. The results are shown below.



The model predicts that the mean phosphate concentration in this part of the Cut-off Channel varies from 0.27 (0.21-0.33)mg/l to 0.63 (0.47-0.78)mg/l.

Run 3: Effect of P-removal at Qualifying Discharges

This work was carried out in two stages. First the impact of P-removal at Cambridge STW, and then the impact of P-removal at all qualifying discharges were assessed. In both cases, effluent quality for the discharges concerned was set to a mean effluent quality of 1 or 2 mg/l, as appropriate. The results are shown below.



The red line shows the predicted current mean phosphate. The green line shows the effect of P-removal at Cambridge STW, and the blue line shows the effect of P-removal at all qualifying discharges.

The results suggest that if Cambridge STW achieved this level of P-removal, the mean concentration in the Cut-off Channel between Denver and Blackdyke would drop by about 15%. At the Denver end of the channel this means a drop from 0.58 (0.42-0.73) to 0.50 (0.37-0.63) mg/l, and at Blackdyke the concentration would drop from 0.34 (0.27-0.42) to 0.29 (0.21-0.36) mg/l.

P-removal at all qualifying discharges would result in a drop in mean concentration of about 24%. At Denver the reduction is from 0.58 (0.42-0.73) mg/l to 0.45 (0.33-0.57) mg/l, and at Blackdyke the concentration would drop from 0.34 (0.27-0.42) mg/l to 0.25 (0.18-0.33) mg/l.

A further model run was carried out to predict the effect of completely removing all phosphate from all point source effluent discharges to the system (purple line). This work showed that concentrations of phosphate still exceeded 0.1 mg/l along much of the length of the Cut-off Channel.

3.3 Summary of Cut-off Channel Modelling

Model 1 suggests that P-removal at qualifying discharges will reduce mean phosphate concentrations in the Cut-off Channel by about 24%. The actual operating conditions of the Ely-Ouse Essex transfer mean that in some years this reduction will be significantly greater than 24%, and in some years there will be little, or no, reduction.

Model 2 suggests that P-removal at qualifying discharges will reduce mean phosphate concentrations immediately downstream of RAF Lakenheath by about 62%.

The potential affect of such reductions on the biological manifestation of eutrophication is discussed in Section 4.

Bury St Edmunds, RAF Lakenheath and Cambridge STW effluents appear to be the main factors in the reduced phosphate concentrations following P-removal at qualifying discharges.

4.0 Biology

The UK Government has used a figure of 0.1mg/l orthophosphate (as an annual average) as an indicative figure of possible current or future problems with regard to eutrophication[1] in relation to the Urban Waste Water Treatment Directive. Since a variety of other concentrations have been quoted in relation to the effects of eutrophication, such as excessive growth of rooted algae and macrophytes, the Government pointed out that the 0.1mg/l orthophosphate concentration was neither a limit above or below which a state of eutrophication will have been demonstrated to be present of absent.

This value was included with a whole range of parameters which would be used to demonstrate whether the waterbody is eutrophic. Other parameters include the biota (plankton and macrophytes) and diel oxygen concentration changes.

The biological response to specific changes in nutrient concentrations in running freshwaters is not yet fully understood, and is the subject of ongoing debate within the scientific community.

At present there is no body of scientific work which will predict the biological response to a particular reduction in river nutrient concentration. The development of such a model has been identified as a priority for the NRA's eutrophication-related R&D.

Experience from the Norfolk Broads suggests that nutrient removal should be seen as only one of a series of eutrophication control measures for a watercourse. Over time,

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[1] - Methodology for Identifying Sensitive Areas (Urban Waste Water Treatment Directive) and Methodology for Designating Vulnerable Zones (Nitrates Directive) in England and Wales. DoE, MAFF, WO, March 1993.

the combination of nutrient removal with other measures, such as dredging of sediments and the reduction of diffuse inputs of nutrients, can bring about a reduction in the eutrophic conditions of a waterbody.

4.1 Biology of the Cut-off Channel (River Lark to Blackdyke).

As outlined above, it is not possible to state accurately what the biological response to the nutrient reductions outlined in this report might be. However, it is predicted in section 3.1 that the greatest reduction in phosphate concentrations in the Cut-off Channel are likely to be achieved in the section between the River Lark and Blackdyke, in response to phosphate removal at Bury St Edmunds and RAF Lakenheath STWs. It is therefore pertinent to examine the current biological status of the stretch, and the potential response to a reduction in nutrient concentrations.

Heavy plant growths characterise the River Lark to Blackdyke section of the Cut-off Channel. The majority of the length is dominated by the filamentous algae *Cladophora* and *Enteromorpha*, with only a poor to moderate diversity of higher plants. Towards Blackdyke, as the channel deepens, filamentous algae appear to reduce in abundance, but the diversity of higher plants does not improve. The higher plants are dominated by *Callitriche* (starwort), *Myriophyllum spicatum* (spiked milfoil), *Potamogeton pectinatus* (pondweed), and *Sparganium emersum* (unbranded burweed) - all species indicative of eutrophic waters.

Effective phosphate reduction in this stretch of the Cut-off Channel, to the concentrations predicted in section 3.1, would be expected to bring about a dominance of higher plants, and significantly reduce the incidence of filamentous algae. Invertebrate diversity is also poorest where the algal incidence is high. Improvements in invertebrate diversity would be expected once the smothering effects of filamentous algae are replaced by the improved habitats associated with higher plants.

5.0 Conclusions

In the case of the Cut-off Channel, it is unlikely that the reduction in phosphate concentrations brought about by nutrient removal at Qualifying Discharges alone will have a significant effect on the level of eutrophication over the whole of the Cut-off Channel.

However, the physical characteristics of the stretch between Blackdyke and the River Lark, together with the predicted reductions in phosphate concentrations in this stretch in relation to P-removal at Bury St Edmunds and RAF Lakenheath STWs, mean that a reduction in the level of eutrophication in this stretch is possible. We therefore recommend that the introduction of P-removal at Bury St Edmunds and RAF Lakenheath STWs is considered.

We suggest that the situation with regard to other Qualifying Discharges is re-evaluated at the second review of designations. This will give further opportunity to evaluate the efficiency of P-removal in this type of situation, particularly in the light of experience gained from Bury St Edmunds and RAF Lakenheath STWs, and from implementing the Directive elsewhere.

? Why would the mean ortho P not be proportional to population equivalents? (BM)

Appendix 1: STWs included in the Study

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF (dimension)
Bedford Ouse Catchment				
SYRESHAM STW	6.7	1.5	19	601
BUCKINGHAM STW	4.3	1.3	73	? 9,992
WESTBURY STW	8.1	2.3	16	512
STOWE STW	5.7	1.2	38	860
FRITWELL STW	6.7	3.0	19	425
ARDLEY STW	7.4	2.7	19	587
HETHE STW	7.6	2.4	17	258
FRINGFORD STW	6.2	1.7	20	287
TWYFORD STW	7.8	1.7	17	508
NORTH MARSTON STW	4.7	2.1	20	387
SWANBOURNE STW	6.6	2.1	18	730
WINSLOW STW	6.9	1.8	39	5,330
GREAT HORWOOD STW	4.8	1.8	28	1,002
PADBURY STW	6.2	1.4	19	961
SHANKS & McEWAN	0.2	0.1	16	250 m^3/day
BRACKLEY NEW STW	2.9	1.3	22	18,808
WHADDON STW	5.1	1.4	26	681
THORNTON COLLEGE	3.0	0.6	7	30m^3/day
DEANOX	0.2	0.2	18	1,300m^3/day
STANBRIDGEFORD STW	5.7	1.8	40	8,316
LEIGHTON LINSLADE STW	7.3	1.5	74	32,750
DUNSTABLE STW	4.4	1.4	64	50,225
IVINGHOE STW	4.9	1.6	41	2,534
ASTON ABBOTTS STW	5.2	1.7	16	253
WING STW	7.3	2.1	40	2,915
GREAT BRICKHILL STW	7.7	2.4	26	661

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF
DRAYTON PARSLOW STW	6.4	1.4	19	465
TOWCESTER STW	6.1	1.8	74	10,002
COTTON VALLEY STW	3.9	2.2	98	319,252
OLNEY STW	7.0	2.0	61	4,440
CHELLINGTON STW	3.6	1.5	29	2,346
ODELL STW	7.0	2.0	40	5,508
HELMDON STW	6.1	2.2	17	1,516
WAPPENHAM STW	6.3	4.5	16	1,015
BLAKESLEY STW	7.4	2.0	17	718
GREENS NORTON STW	6.0	2.8	23	1,444
SILVERSTONE STW	5.4	2.0	25	1,904
TIFFIELD STW	5.3	2.3	20	400
STOKE BRUERNE STW	6.3	3.0	19	538
ASHTON STW	5.4	1.8	41	4,392
HANSLOPE STW	6.6	1.9	27	2,078
CASTLETHORPE STW	6.3	1.9	17	708
NORTH CRAWLEY STW	7.4	1.9	19	576
SHERRINGTOM STW	6.6	1.3	20	907
STOKE GOLDINGTON STW	5.8	1.4	20	601
LAVENDON STW	6.0	2.4	20	880
NEWTON BLOSSOMVILLE STW	5.9	2.4	17	301
TURVEY STW	7.6	2.0	19	790
BLETSOE STW	7.4	2.0	19	712
OLNEY TANNERY	0.7	0.4	34	580m^3/day
UNILEVER	2.7	0.8	40	1,136m^3/day
BEDFORD STW	3.9	2.4	100	140,505
ST. NEOTS STW	6.0	1.7	73	32,346
MARSTON MORETAINE STW	7.8	2.9	42	7,944

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF
COTTON STW	5.6	1.8	24	768
THURLEIGH STW	3.9	1.3	20	486
MILLBROOK STW	7.3	5.1	10	148
GREAT BARFORD STW	6.1	2.1	26	1,691
ROXTON STW	9.4	3.4	27	563
EVERTON STW	9.3	2.0	19	427
TEMPSFORD STW	6.0	2.0	26	1,818
WILDEN STW	5.4	2.4	20	338
CHAWSTON STW	5.0	2.5	27	506
WARESLEY STW	5.7	1.7	39	1,472
RISELEY STW	6.5	1.7	41	1,205
SWINESHEAD STW	7.7	2.4	20	312
KIMBOLTON STW	7.0	2.0	40	2027
PERTENHALL STW	5.9	2.8	65	115
LITTLE STAUGHTON STW	7.4	2.8	19	147
HAIL WESTON STW	6.9	2.5	19	478
BUCKDEN STW	5.6	1.8	42	5,063
BRAMPTON STW	6.0	2.5	60	5,209
STAGSDEN STW	6.8	2.1	18	264
LETCHWORTH STW	7.1	1.9	78	40,450
ASHBROOK STW	8.2	1.4	27	2,376
HITCHIN STW	5.3	1.7	77	37,176
HOLWELL STW	6.6	1.8	19	327
ARLESEY HOSPITAL STW	4.1	0.8	33	550m^3/day
POPPY HILL STW	6.0	1.48	75	14,571
CLOPHILL STW	9.6	1.9	40	5,394
SHILLINGTON STW	8.4	2.4	40	4,905
BIGGLESWADE STW	6.8	1.4	75	21,881

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF
SANDY STW	6.2	1.7	43	9,496
CHALTON STW	6.9	1.4	77	68,247
FLITWICK STW	7.4	2.0	75	27,274
CLIFTON STW	6.4	2.0	19	11,580
NEWNHAM STW	9.7	2.1	17	90
SANDON STW	7.5	1.7	15	500
BARTON LE CLAY STW	6.2	1.7	29	3,436
GAMLINGAY STW	10.2	2.9	25	2,863
POTTON STW	12.9	2.4	58	6,012
DUNTON STW	6.8	2.1	20	483
SHANKS & MCEWAN	0.2	0.01	7	150m^3/day
BUILDFORM LTD	9.0	4.1	23	6m^3/day
ALCONBURY STW	7.7	2.8	40	3,200
HUNTINGDON STW	5.6	1.5	72	33,564
ST. IVES STW	6.7	1.9	78	16,237
UTTON'S DROVE STW	5.7	1.7	68	11,357
NEEDINGWORTH STW	7.9	1.6	42	2,280
PAXTON STW	6.1	2.1	39	1,214
PAPWORTH STW	7.6	2.2	29	2,119
EASTON STW	6.9	2.6	27	1,080
Old West/Ely Ouse Catchment				
OVER STW	5.1	1.5	62	9,089
COTTENHAM STW	6.0	1.7	40	4,374
LANDBEACH MARINA UTILITY SOUTH	6.42	1.97	3	75m^3/day
LANBEACH MARINA UTILITY NORTH	10.2	2.2	4	15m^3/day
LANBEACH MARINA ADMIN STW	3.4	1.4	5	75m^3/day
STRETHAM STW	6.9	1.9	29	1,662
NEWPORT STW	6.8	1.1	28	2,590

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF
AGREVO (CHESTERFORD)	1.3	1.6	47	450m^3/day
GT CHESTERFORD STW	10.1	0.9	28	2,459
CIBA GEIGY	0.4	0.4	72	18,181m^3/day
SAWSTON STW	6.9	1.7	77	20,470
LINTON STW	6.0	1.2	63	7,665
INSTUTUE OF ANIMAL PHYSIOLOGY	4.2	0.6	31	318m^3/day
SCHERING (HAUXTON)	1.5	0.8	84	1,090m^3/day
ASHWELL STW	4.4	1.2	26	1,320
GUILDEN MORDEN STW	5.7	2.8	27	1,585
LITLINGTON STW	5.7	1.5	28	3,071
BASSINGBOURNE STW	4.1	1.8	27	4,173
ROYSTON STW	5.6	0.8	83	12,852
ETERNIT	0.8	0.7	35	500m^3/day
MELBOURNE STW	7.1	1.5	41	5,970
FOXTON STW	6.1	2.3	41	5,124
HASSLINGFIELD STW	6.6	1.9	41	9,158
CAMBRIDGE STW	6.4	1.6	28	150,913
DULLINGHAM STW	8.2	1.4	18	1,051
NEWMARKET STW	7.4	1.5	81	22,563
LYNXCOURT LTD	5.4	2.8	16	12.5m^3/day
SOHAM STW	5.6	1.1	33	9,762
ELY STW	5.7	1.3	76	13,131
HAWSTEAD STW	5.6	1.6	20	622
STANNINGFIELD STW	6.9	2.4	16	326
GT WELNETHAM STW	9.9	1.7	24	815
ROUGHAM STW	6.3	1.7	27	1,207
CHEDBURGH STW	5.4	2.0	27	1,236
GREENE KING NO1 OUTLET	0.8	1.8	7	1,591m^3/day

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF
GREENE KING NO2 OUTLET	0.2	0.0	4	545m³/day
BSC BURY ST EDMUNDS	0.3	0.1	12	3,000m³/day
BURY ST EDMUNDS STW	7.5	1.3	79	70,180
BARROW STW	6.6	1.9	29	1,638
TUDDENHAM STW	6.9	1.4	36	2,353
MILDENHALL STW	8.5	2.2	80	21,655
LIDGATE STW	5.7	1.1	19	398
GAZELEY STW	9.1	1.2	30	1,710
EAST CAMBS DC KENNETT STW	9.2	2.4	6	34m³/day
CHIPPENHAM STW	9.3	2.0	6	213
ISLEHAM WTW	0.2	0.1	17	280m³/day
ISLEHAM STW	7.9	1.3	25	1,710
PRICKWILLOW STW	10.7	0.0	1	380
BLACK HORSE DROVE STW	8.0	1.5	33	60
EAST CAMBS DC BRANDON CREEK PICNIC AREA STW	4.5	1.8	2	9m³/day
CASTON STW	7.1	2.3	19	62
ROCKLANDS RECTORY STW	15.0	0.0	1	67
GT ELLINGHAM STW	4.6	2.0	20	397
OLD BUCKENHAM STW	8.3	1.8	28	2,626
ATTLEBOROUGH STW	6.1	1.4	77	16,810
HOCKHAM STW	6.9	1.2	20	343
KENNINGHALL SCHOOL LANE STW	11.3	1.3	11	66
EAST HARLING STW	9.2	1.7	28	1,812
ELMSWELL STW	6.2	1.5	42	4,685
NORTON STW	6.2	1.5	20	676
BADWELL ASH STW	6.4	1.6	42	2,000
THURSTON STW	6.8	1.6	59	5,038
STANTON STW	4.4	1.7	61	5,024

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF
HONINGTON STW	8.3	0.9	20	473
CRACKTHORNE BRIDGE STW	5.8	0.9	19	253
BOTESDALE STW	6.8	1.4	20	959
WATTISFILED	7.3	1.8	18	399
GARBOLDISHAM STW	9.8	1.7	12	135
BARNHAM STW	7.0	1.1	20	666
THETFORD STW	6.0	0.9	71	31,415
BRANDON STW	10.6	1.3	42	7,634
WEETING STW	11.1	1.1	26	1,374
LAKENHEATH STW	8.8	2.0	42	3,345
BUXTED DUCKLING	11.5	8.2	24	218m^3/day
BRECKLANDS LODGE MOTEL	5.0	3.1	4	10m^3/day
WATTON PRODUCE, SHROPHAM	0.4	0.4	25	182m^3/day
RAF EAST WRETHAM	7.0	1.6	11	65m^3/day
HARDINGS PIG FARMS, NORTON	23.0	43.0	4	4.1m^3/day
HARRIS BACON	8.5	2.7	22	700m^3/day
THE SHIP PUB BRANDON CREEK	9.1	5.3	13	14m^3/day
SOUTHERY MILL DROVE STW	7.6	1.7	19	1,000
NECTON STW	8.0	1.6	42	2,797
SWAFFHAM STW	7.8	1.4	62	5,258
GT CRESSINGHAM STW	10.0	3.9	17	210
WATTON STW	6.1	1.3	61	10,835
HILBOROUGH STW	1.9	1.1	10	68
MUNDFORD STW	9.7	1.8	28	1,193
BRANDON STW	10.6	1.3	42	7,634
FOULDEN STW	9.4	3.1	28	307
COCKLEY CLEY STW	12.5	3.0	12	86
GOODERSTON STW	9.3	1.7	20	439

Discharge	Mean Orthop-P (mg/l)	Standard Deviation Ortho-P (mg/l)	Number of Samples	Population Equivalent/ DWF
NORTHWOLD GLEBE CLOSE STW	11.3	4.6	12	17m³/day
NORTHWOLD MILL LANE	16.7	3.1	12	12m³/day
BARTON BENDISH STW	11.1	1.3	20	308
STOKE FERRY WTW	1.9	1.1	10	750m³/day
BSC WISSINGTON COOLING WATER	0.6	0.01	1	12m³/day
BSC WISSINGTON	0.6	0.4	35	3,500m³/day
Cut-off Channel				
ERISWELL STW	6.38	2.77	29	2,017
R.A.F. LAKENHEATH STW	6.37	1.62	28	2,200 m³/day
FELTWELL STW	11.56	1.73	29	2,715
FORDHAM STW	7.9	1.9	26	1,933