The Craven Fishery and Sir Richard Sutton's Settled Estate Park Fishery

Assessment of Potential Causes of Sediment Deposition Problems in the River Kennet

December 2007 Environmental Planning & Assessment Ltd.

Contents

1.0 Introduction

1.1 Preamble

Environmental Planning & Assessment Ltd (EPAL) has been retained by the Craven and Park Fisheries to advise on the possible reasons for the deposition of anorganic –rich sediment in their respective fisheries.

Witness Statements by the river keepers of both fisheries have attributed the deposition of the sediment to the activities of narrow boats and other craft on the Kennet and Avon Canal, which is con-joined in part with the River Kennet in the vicinity of the two fisheries concerned. Copse Lock is the point at which the Kennet and Avon Canal and the River join for a stretch of about 500 m. The Morewood Fishery is upstream of Copse Lock. Downstream of Copse Lock, these are the Craven Fishery and the Park Fishery owned by Sir Richard Sutton's Settled Estates. The investigations undertaken have also encompassed the Morewood Fishery, since it provides a "baseline" condition of the river that is unaffected, in the main, by boating.

Discussions with the river keeper of the Park Fishery also indicated that two small water courses on the estate, the Parliament Draft and the Dead Stream (reverse), are affected and unaffected, respectively, by discharges related to the canal.

The studies carried out have encompassed the following:

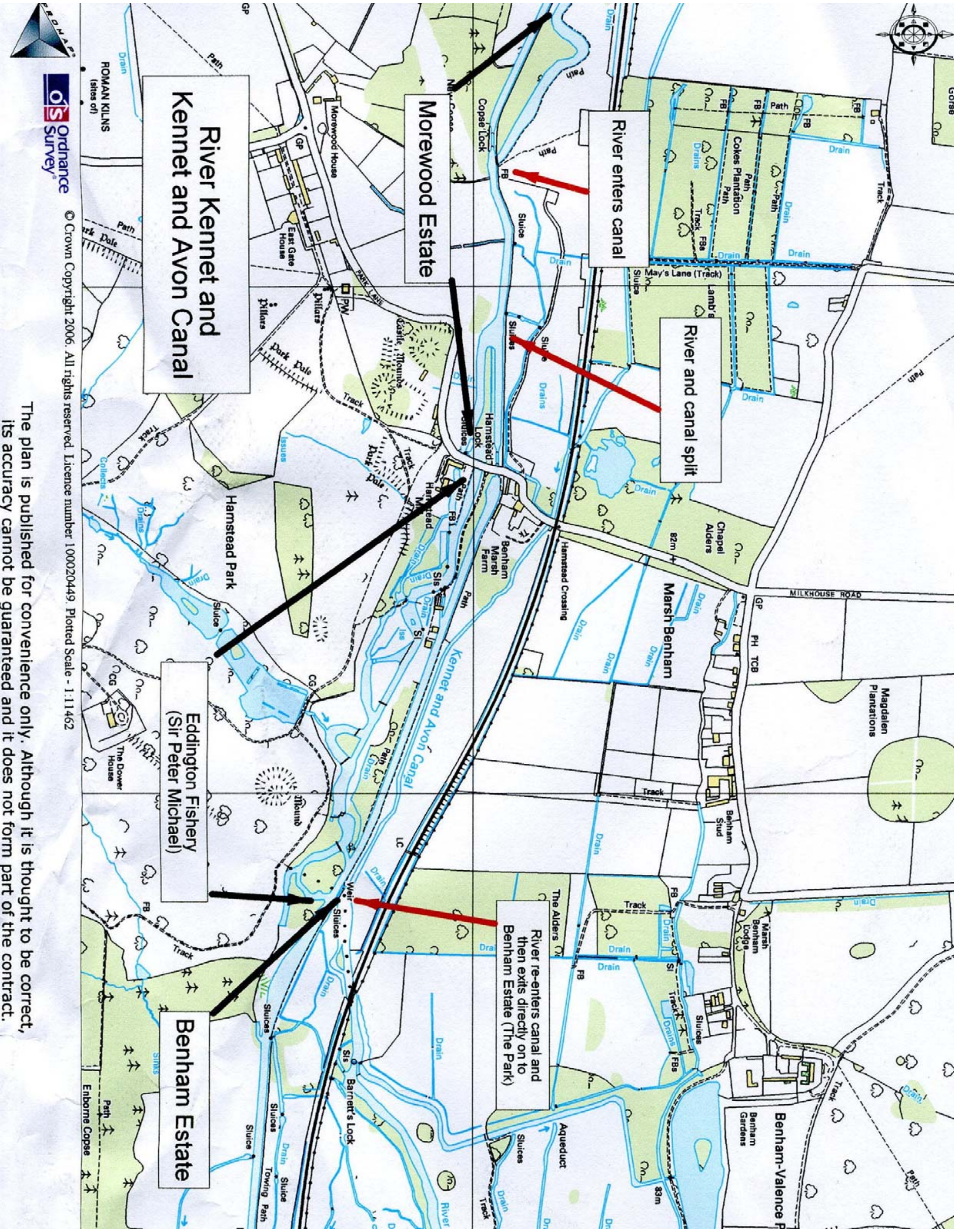
1. A review of published data for the River and Canal and data available from the EA web-site;

2. A review of data obtained by the EA as part of their on-going investigations, which were provided in relation to a meeting on 20th July 2006 with John Hallett of the EA, who is leading their Kennet Chalkstream Restoration Project;

3. Site visits and field investigations at the fisheries on 20th January (visit only), 28th April, 2nd May, 29th May and 15th July 2006.

4. A further site visit and survey at the fisheries undertaken on 11th February 2007 to ascertain the water quality prior to the onset of the Spring algal bloom.

Figure 1: Location Plan



1.2 Objectives of Field Work

The principal aim of the first field work campaign of 28th April - 2nd May 2006 was to characterise the general water quality of the River Kennet and the Kennet and Avon Canal. An important objective was to examine those characteristics that might distinguish the water quality of the two water bodies. This was supplemented by measurements of water quality in the wake of two passing barges to examine how turbidity increased and dropped off following passage of a boat. Additional measurements were made on two streams at the Sir Richard Sutton's Settled Estate Park Fishery, of which one, Parliament Trap, is apparently unaffected by the Kennet and Avon Canal, and the Dead Stream, which conveys water that is affected by the canal.

The principal aim of the second field work campaign undertaken on 29th May 2006 was to sample the water quality of the Kennet and the canal, from the Morewood Estate Fishery upstream of Copse Lock to the Park Fishery at the weir and sluices where the River Kennet discharges from the canal. The key objective of this exercise was to examine the spatial variation in water quality and the influence that the canal has on the distribution of chemical constituents.

The third sampling campaign of 15th July 2006 was undertaken to confirm the main findings of the survey of 29th May 2006, examine the degree to which seasonal factors might have changed matters and to undertake additional measurements of algal primary production at five locations.

A fourth sampling campaign was undertaken on 11th February 2007 to assess water quality conditions during winter, prior to the spring algal bloom. Algal primary production measurements were made at three locations. During this period, the canal was being dredged, and it is understood that enhanced turbidity related to this activity would have been experienced both within the canal and the River Kennett at the Morewood Fishery.

2.0 Overview of the River and Canal System

2.1 Catchment Character and Hydrology

The catchment of the River Kennet, which is the largest tributary of the Thames, is bounded by the Berkshire and Marlborough Downs to the north and the Hampshire Downs to the south. The River rises to the north west of the town of Marlborough and flows eastwards to its confluence with the Thames at Reading, some 70km east of its source. It passes through the towns of Marlborough, Hungerford, Newbury and Thatcham. The catchment area of the Kennet Valley is 1164km^2, comprising 315 km of Main River. The Kennet and Avon canal runs parallel with the River Kennet downstream of Hungerford, at times sharing the same channel. The catchment area whilst predominantly rural in character, includes some large towns including Hungerford, Newbury and Thatcham. Around 211,000 people live within the Kennet Valley catchment with the population concentrated mainly in the larger towns of Reading, Newbury, Thatcham and Newbury.

The Kennet Valley's solid geology consists of chalk overlain in the east by the clay sands of the western end of the London Basin syncline. The Lower chalk outcrops along the northern boundary of the catchment with progressively younger rocks to the south east. These include the Middle and Upper chalk and above those the tertiary Clays and sands of the Reading beds, London clay and Bagshot beds.

In addition to the upper Kennet (the main river upstream of Hungerford), the river has seven tributaries, the Lambourn, Enbourne, Foudry Brook, River Dunn, Aldbourne, Shalbourne and the River Og. The Kennet catchment has a maximum altitude of 297 mAOD, the river itself flows from an altitude of 190m AOD at its source to 50 mAOD at its confluence with the Thames.

The Kennet catchment receives a Standard Average Annual Rainfall (SAAR) of 764mm, although spatial variation in topography and climate cause rainfall totals to range from 900mm on the Hampshire Downs to 650mm at Reading. The hydrological regime of the catchment is typical of a Southern English Chalk stream. A permeable geology creates a flow regime that reacts relatively slowly to rainfall events with variations in flow occurring at a seasonal temporal scale. Peak flow occurs between January and March with a steady decline in discharge throughout the year until October.

2.2 The Kennet and Avon Canal

A key element in the original design of the canal was the provision of sources of water. The section of the canal from the Crofton Flight (height of in excess of 134.0m AOD - 440ft) to the Kennet at Blake's Lock in Reading (elevation of about 36 m AOD - 118 ft) decreases in elevation progressively from west to east over a distance of about 56 kilometres (35 miles). Thus, gravity will impose an eastward flow of water on the canal. This flow will vary in rate depending on the number of lock openings required to allow the passage of craft, and the operation of by-pass and overspill weirs. Essentially the rate of flow would be expected to increase when large numbers of lockings (lockage) of craft take place, and this is the reason for compensatory inputs from rivers further down-gradient within the canal.

The main water source is Wilton Water, which has an area of about 3.3 ha (8 acres) and is apparently spring-fed from the Chalk aquifer. It is further understood that the pounds immediately east of the summit (in the vicinity of the Crofton Flight) are unlined, allowing groundwater to percolate up through the canal bed.

However, at various points along the canal, river water is introduced into the canal. In the vicinity of Hungerford and upstream, river water is taken from the Shalbourne and Froxfield Brook and then discharged back to the River Dun, one of the tributaries to the upper Kennet. Downstream of Hungerford, the Kennet and the Kennet and Avon Canal remain separate. However, at Copse Lock the river and canal join (see Figure 1) and for 500-600 m the navigation is within the river. The river and canal then separate again at Hamstead Lock. Importantly, though, the canal enters the river from the south at Copse Lock and then exits to the north at Hamstead Lock. The river then remains separate from the canal, for a further 1-1.2 km, as it flows through the Craven Fishery, before briefly rejoining the canal at the weir that discharges to the river on the Park Fishery.

Historically, when the canal was in commercial use, it is probable that the canal craft traffic would have been reasonably consistent through the year. Thus, the rate of flow of water and requirements for compensation water from the rivers would have changed seasonally only in response to losses of water due to evaporation and the variations in rainfall run-off from the surrounding land. The overspill weirs provided a mechanism for controlling water levels when too much water was entering the system.

In the modern canal, the largely recreational traffic has highly seasonal characteristics than was originally envisaged when the canal design was conceived.

Nevertheless, the greatest seasonal period of need for compensatory flow would historically have during the summer period, as it is now. However, because of the more even distribution of commercial canal traffic over the year there would have been a need for compensatory flows to make up for losses due to lockage throughout the year. In the current situation, there is very little need for compensatory flows in winter. Nevertheless, in summer the use of the canal is substantial, as is the need for compensatory flows. Thus, as boats lock out eastward flow is generated throughout the summer in the canal, which will be topped up from compensation flows from the upper reaches of the Kennet and its tributaries. Flows are still generated in the winter since the canal tends to receive too much water in this season, and these are discharged via overspill weirs where necessary. In the pounds immediately upstream of Copse Lock there is not a major problem of such flows and the lock does not appear to have an overspill requirement.

2.3 Sewage Discharges and Potential Sources of Pollution

The major sources of water quality problems for the canal and River Kennet would appear to be related to nutrient inputs and organic matter from sewage works and also diffuse agricultural sources.

There are two significant sewage inputs to the canal itself at Kintbury and Great Bedwyn. The former is made to the pound upstream of Copse Lock. Table 2.1 summarises the main inputs and the AMP4 (Ofwat approved Asset Management Plan) upgrades to these works. In most cases these involve introduction or improvement of phosphate stripping technology

Table 2.1: Discharge Standards for Sewage Works on the River Kennet and Kennet & Avon Canal

Works	Population Equivalent	BOD mg/l	Suspended Solids mg/l	Ammonia mg/l	Phosphorus mg/l	AMP 4 Programme
Kintbury	2,470	30	30	20	None	P< 1 mg/l
Great Bedwyn	-	30	45	None	None	Investigations
Fyfield	1,580	15	15	3	2	P< 1 mg/l
Hungerford	5,950	20	45	15	2	P< 1 mg/l
Marlborough	11,600	16	30	6	2	P< 1 mg/l
Newbury	68,400	10	30	2	None	P< 1 mg/l
Wilton	-	30	30	20	None	-

3.0 Review of EA Data

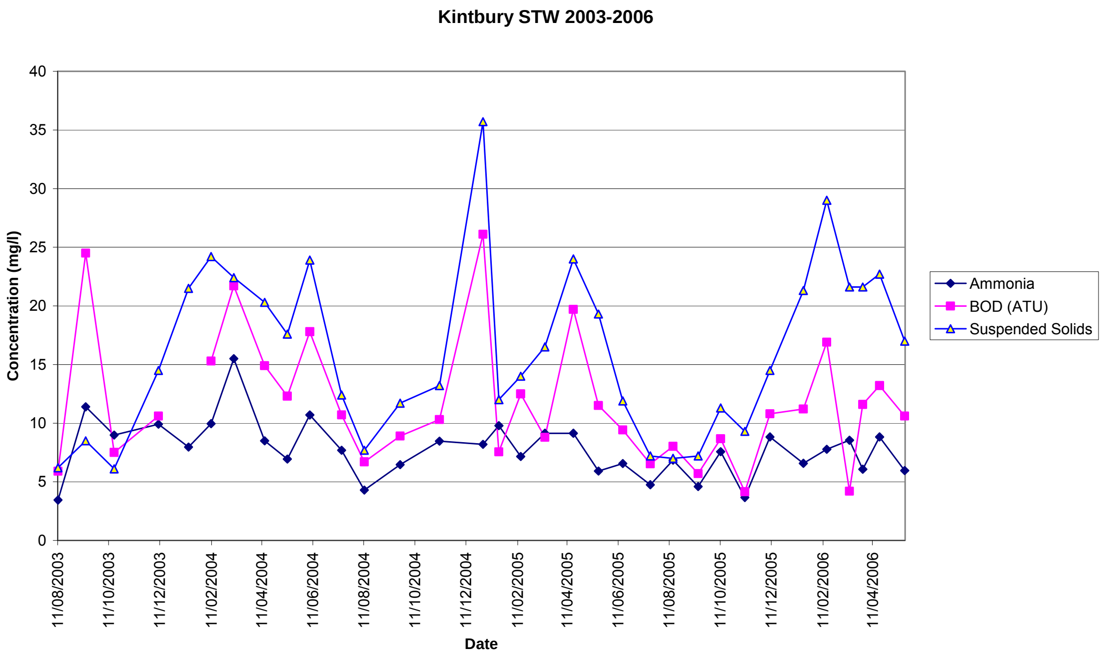
3.1 Introduction

The Environment Agency has been carrying out largely unmanned surveys using automated sonde (YSI) loggers that collect data automatically over extended periods. These provide good temporal coverage that can help understand variability within the system. Very limited additional data have been collected using manual sampling and laboratory analysis. The YSI sondes are multi-sensing probes that are able to measure dissolved oxygen, pH, temperature, conductivity, ammonia, turbidity and chlorophyll (an indicator of plankton biomass). The data collected were kindly provided by the EA as excel files. In addition data were provided in relation to sewage works compliance.

3.2 Sewage Works Data

Figure 2 shows the data for Kintbury sewage treatment works (STW) between 2003-2006. As mentioned earlier, this discharge is made to the Kennet and Avon Canal. Currently there is no discharge condition relating to phosphate, although the AMP 4 programme envisages the introduction of phosphate stripping in 2007 (see Table 2.1).

Figure 2: Effluent Discharge Concentrations for Kintbury STW



The data indicate compliance with discharge conditions, except for a minor excursion in relation to suspended solids in February 2004; it is likely that compliance is based on 95 percentile compliance, which would indicate compliance with discharge conditions.

3.3 Automated Data Collected

The EA has deployed loggers at the following locations:

- Wilderness (Automatic Water Quality Monitor): SU408679;
- Newbury Wharf (Automatic Water Quality Monitor): SU472671;
- Copse Lock (data logger): SU417671;
- Craven Fishery (data logger): SU423670
- Bridge by Copse Lock (data logger): SU417672

In addition, physical samples were taken at the following locations:

- PKER0316: Kennet and Avon Canal upstream of Copse Lock: SU416670
- PKER0317: River Kennet upstream of confluence with Kennet & Avon Canal and the overspill from Dreweats Lock: SU414673.
- PKER0318: River Kennet just downstream of Copse Lock adjacent to the Copse Lock data logger: SU417670

A summary of the data for the most recent deployments of the data loggers is shown in Table 3.1. Data are plotted for key determinands in Figures 3-8 for Craven Fishery and Copse Lock deployments.

A review of the data collected by the EA has revealed few clear relationships between different determinands monitored. The data for pH, conductivity, temperature and dissolved oxygen (DO) appear to be reliable and consistent. The data for ammonia and turbidity show signs of instrumental instability. However, it is likely that the data for turbidity relate to discharges from the lock as well as responses to rainfall events and soil run-off–related turbidity peaks.

Table 3.1: Summary of EA Automatic Sonde Data for River Kennet

Location	Period	Temp °C	DO mg/l	pH	NH_4 mg/l	Turbidity NTU	Chlor µg/l
Copse Lock	24/10-9/11/2005	12.3 ± 1.2	9.65 ± 0.97	8.03 ±0.10	0.25 ± 0.05	19.08 ± 11.13	15.18 ± 5.06
Craven	24/10-9/11/2005	11.9 ± 1.2	9.73 ± 0.79	7.98 ±0.04	0.22 ± 0.01	7.74 ± 2.04	3.19 ± 0.79
Copse Lock	9/11-1/12/2005	5.7 ± 2.5	12.23 ± 0.98	8.09 ± 0.09	0.20 ± 0.05	6.60 ± 3.56	25.49 ± 15.29
Craven	9/11-1/12/2005	6.1 ± 2.1	11.60 ± 0.94	7.91 ± 0.03	0.16 ± 0.01	5.41 ± 2.12	2.00 ± 0.59
Copse Lock	1/12-19/12/2005	5.0 ± 1.6	13.11 ± 1.32	7.94 ±0.34	6.74 ±20.86	10.07 ± 40.40	16.34 ± 10.23
Craven	1/12-19/12/2005	6.0 ±1.5	13.38 ± 1.38	7.91 ±0.12	0.34 ±0.79	6.85 ± 23.18	3.10 ±6.57
Copse Lock	19/12/2005-06/01/2006	5.0 ±1.4	11.73 ± 0.59	8.02 ±0.04	0.50 ±0.31	4.82 ± 3.08	9.37 ±7.38
Craven	19/12/2005-06/01/2006	6.0 ±1.2	11.27 ± 0.57	7.95 ±0.04	0.23 ±0.65	4.18 ± 1.49	1.07 ±0.33
Craven	6/1/2006-20/1/2006	7.0 ±1.1	10.87 ± 0.50	7.95 ±0.03	0.28 ±0.03	4.63 ± 1.09	1.74 ±0.43
Craven	7/2/2006-28/2/2006	5.9 ±1.4	11.70 ± 0.86	8.11 ±0.15	896* ±7316	5.89 ± 10.14	2.32 ±3.62
Craven	28/2/2006-24/3/2006	6.2 ±1.2	12.26 ± 1.11	7.92 ±0.07	0.04 ±0.003	5.35 ± 3.26	2.61 ±1.50
Craven	22/3/2006-13/4/2006	9.9 ±1.2	13.35 ± 1.98	8.15 ±0.10	0.14 ±0.005	6.63 ± 2.35	3.17 ± 0.96
Copse	13/4//2006-28/4//2006	11.9 ±0.9	14.09 ±1.80	8.30 ±0.17	No Data	66.03 ± 52.77	21.24 ± 10.97
Craven	13/4//2006-28/4//2006	11.7 ±0.9	11.74 ±2.01	8.02 ±0.13	No Data	7.86 ± 2.53	5.82 ± 1.89
Craven	28/4//2006-16/5//2006	14.4 ±2.8	11.13 ±2.14	7.96 ±0.22	9.81* ±23.43	16.39 ± 18.35	4.93 ± 2.30
Copse	31/5/2006-16/6/2006	17.9 ±2.3	8.69 ±1.89	7.94 ±0.12	0.13 ±0.04	15.60 ± 10.90	11.88 ± 6.32
Craven	31/5/2006-16/6/2006	17.0 ±2.3	9.98 ±2.43	7.96 ±0.15	0.21 ±0.36	28.66 ± 58.45	5.71 ± 1.99

* Data affected by significant instrumental instability.

The timing of turbidity events supports this, moreover, as the peaks often occur at night when boat movements and locking are at a minimum. The chlorophyll data show some erratic trends. Whilst the data loggers can provide a good basis for monitoring conditions, some instrumental stability issues are suggested in the data. No clear or significant correlations were found between turbidity or chlorophyll between the various stations[1]. A weak negative correlation between turbidity and chlorophyll was indicated by data for Copse Lock and Craven Fishery (-0.1608 April 2006, -0.1588 April 2006, $p<0.05$, respectively), although this seems to be related to extreme turbidity values and the relationship between the two variables explains less than 3% of the variations in the variables.

Table 3.1 shows the EA data logger results did not generally indicate significant differences between mean turbidity between Craven fishery and Copse Lock. This in part reflects the aforementioned instrumental instabilities (see e.g. Figure 4), which may have undermined the reliability of some of the potentially more important data sets, and rainfall–related turbidity increases. The chlorophyll concentration data provide an indication of algal biomass, but as mentioned previously showed some instrumental instabilities.

In respect of the June-July 2006 deployment, the sonde deployed at the Copse Lock Bridge across the Kennet was located on the eastern bank of the river. This is generally unlikely to have picked up the lock discharge plume, which, as is pointed out in Section 4.0, generally attaches to the south bank of the canal/river channel due to the effect of the discharge from the Kennet.

Currently, the data-logger sonde data reveal very general trends of the causes of the sediment problems, although instrumental stability problems with the turbidity probes may have occurred and some problems are also apparent for the ammonia and chlorophyll probes. If data were filtered it may be possible to reduce the effect of these problems in the data. The approach remains promising as large amounts of data can be collected over extended time periods. The disadvantage is that the lack of continuous attention from a field worker means that sampling is “unintelligent”, and the reasons for observations are not readily hypothesised. Further data collection problems can only be analysed post-deployment.

[1] Correlation coefficients calculated between measurements of turbidity or chlorophyll during June-July 2006 at Craven-Copse Lock, Copse Lock-Copse Lock Bridge, Copse Lock-Copse Lock Bridge revealed no significant relationships.

Figure 3: Data Logger Results for Craven Fishery in April 2006

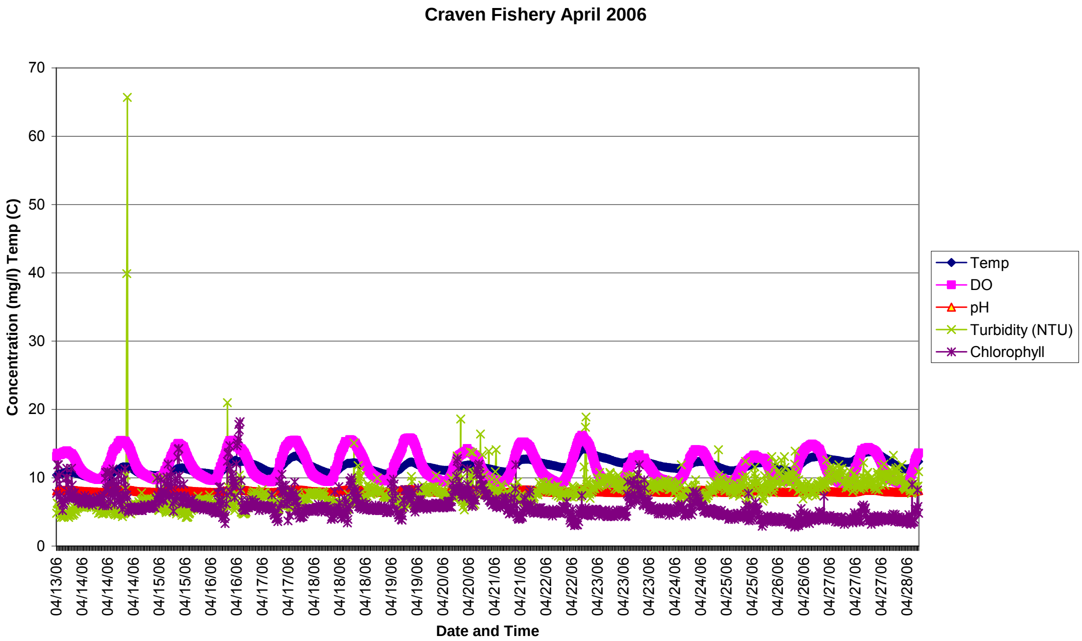


Figure 4: Data Logger Results for Copse Lock in April 2006

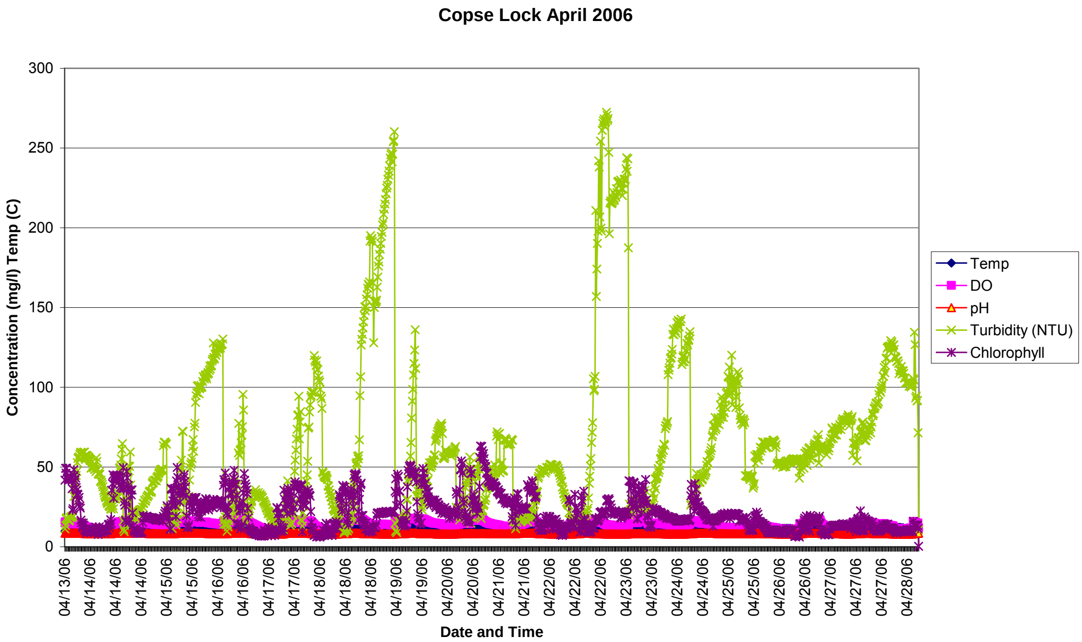


Figure 5: Data Logger Results for Craven Fishery in May-June 2006

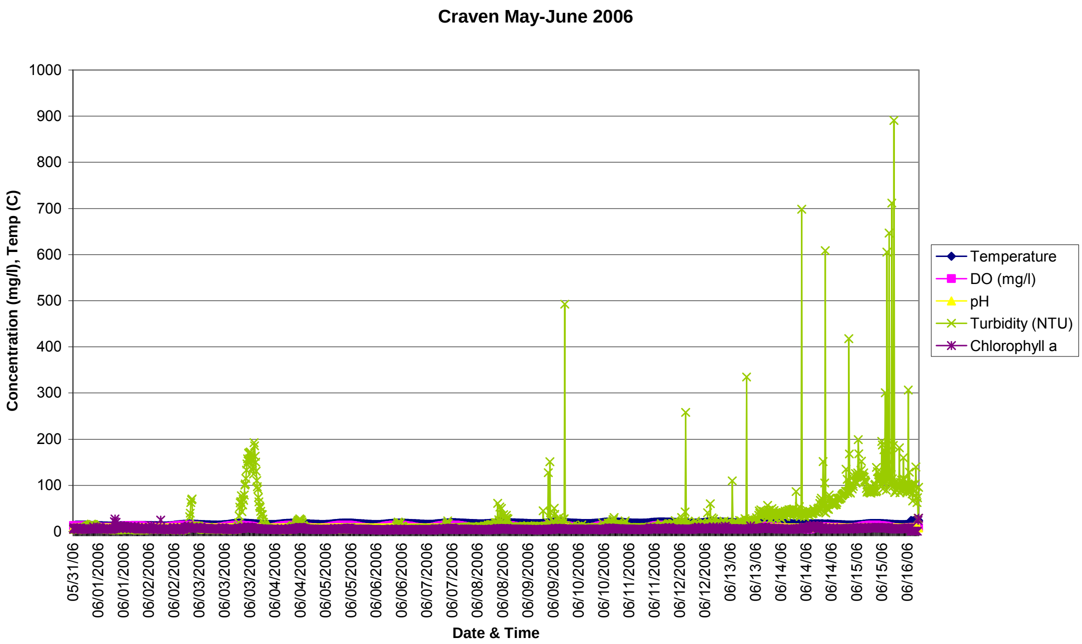


Figure 6: Data Logger Results for Copse Lock in May-June 2006

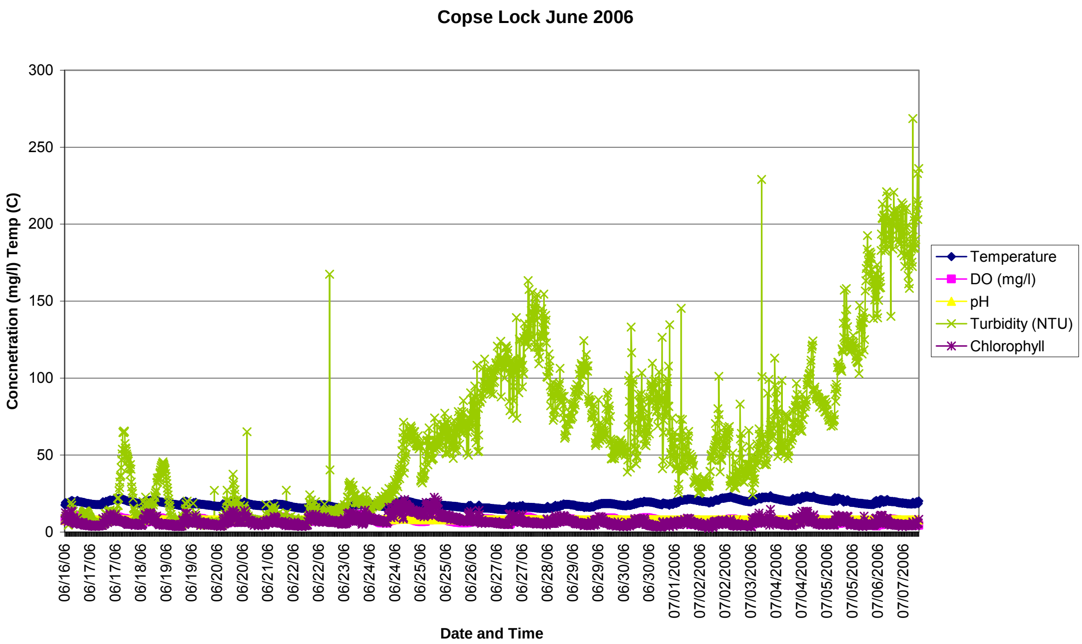
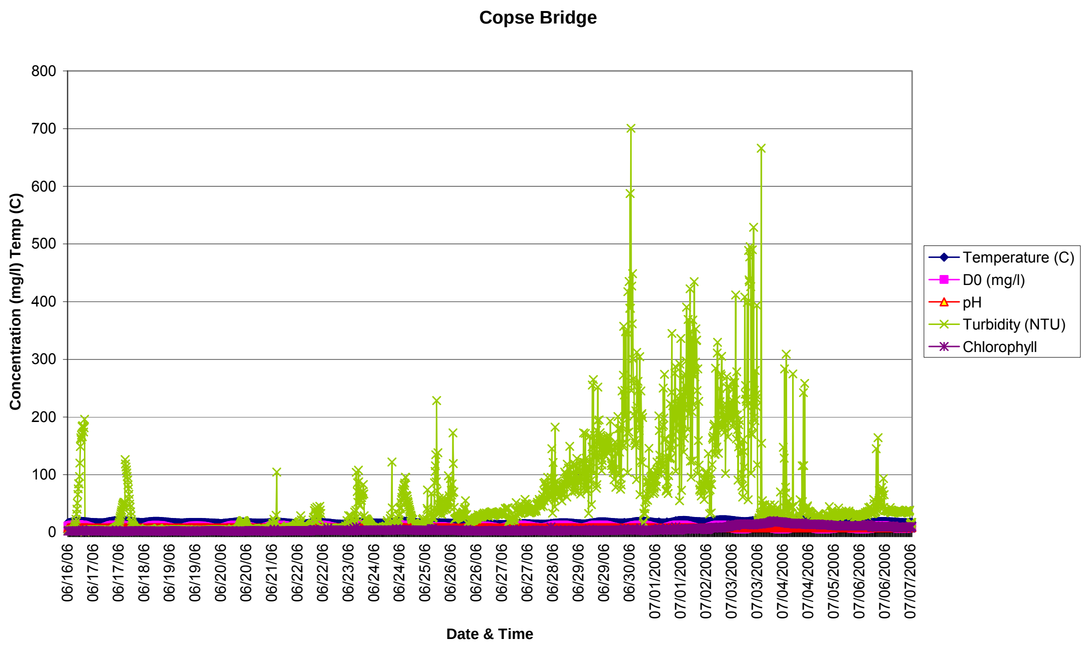


Figure 7: Data Logger Results for Bridge Copse Lock in May-June 2006



3.3 EA Physical Data Collection

The data from the EA's physical data collection exercise are provided in Tables 3.2a and 3.2b. The sampling was undertaken in June 2006. The results are generally consistent, in terms of data ranges reported, to those discussed in Section 4.0. Usefully the data include chlorophyll *a* data, derived from cold acetone extractions of filtrates. These data indicate the following range of chlorophyll *a* concentrations:

- Copse Lock – 39.4- 62.0 μg/l, which indicate reasonably substantial biomass, and substantially higher than the Sonde data (11.88 ± 6.32 μg/l);

- Copse Lock Bridge – 33.0-65.0 μg/l, which indicate reasonably substantial biomass, and substantially higher than the Sonde data (11.88 ± 6.32 μg/l);

- Kennet upstream of the canal-river confluence – 3.2- 4.4 μg/l, which indicate low-moderate algal biomass.

These data clearly indicate that the canal is an important source of algal biomass to the river. The sonde data do not provide such clear-cut evidence of this consistent and clear finding, and this is mainly related to instrumental instability in relation to certain critical probes.

Table 3.2a: Summary of EA Physical Sample Results

Site	Short Name	Sample Date	Time	DO (mg/L)	DO (% satn)	pH	Solids Suspended @105C mg/l	Temp (ºC)
PKER0316	Kennet And Avon Canal Just Above Copse L	06-Jun-06	14:20	9.04	99.4	7.93	27	19.84
PKER0316	Kennet And Avon Canal Just Above Copse L	14-Jun-06	14:17	7.93	85.5	8.22	21	18.84
PKER0316	Kennet And Avon Canal Just Above Copse L	22-Jun-06	14:40	8.22	87.8	7.8	26.4	18.4
PKER0317	Kennet Just Above Kennet And Avon Canal	06-Jun-06	13:45	13.3	138	8.2	5.1	17.04
PKER0317	Kennet Just Above Kennet And Avon Canal	14-Jun-06	13:47	9.3	101.9	8.63	7.5	19.7
PKER0317	Kennet Just Above Kennet And Avon Canal	22-Jun-06	14:10	12.3	126.9	8.2	25.3	16.64
PKER0318	Kennet Just Below Copse Lock	06-Jun-06	14:05	8.79	94.4	7.94	38.4	18.7
PKER0318	Kennet Just Below Copse Lock	14-Jun-06	14:05	9.21	98.8	7.81	15.4	18.62
PKER0318	Kennet Just Below Copse Lock	22-Jun-06	14:30	11.6	121	7.92	28.3	17.4

Table 3.2b: Summary of EA Physical sample Results

EA Reference	Sample Date	Ammonia - as N mgN/l	BOD ATU as O_2 mg/l	Chloride mg/l	Chlorophyll *a* µg/l	Nitrogen Total Oxidised mgN/l	Ortho-phosphate mgP/l
PKER0316	06-Jun-06	0.069	4.1	22.6	39.4	2.06	0.081
PKER0316	14-Jun-06	0.168	2.9	23	62	1.35	0.161
PKER0316	22-Jun-06	0.155	4.1	24	58.8	1.32	0.129
PKER0317	06-Jun-06	<0.03	1.3	18.7	3.8	5.23	0.045
PKER0317	14-Jun-06	0.055	<1	20.5	4.4	4.67	0.103
PKER0317	22-Jun-06	<0.03	1.7	18.7	3.2	5.07	0.04
PKER0318	06-Jun-06	0.084	3.7	22.6	65.6	2.24	0.078
PKER0318	14-Jun-06	0.108	2.1	20.4	33.2	3.00	0.11
PKER0318	22-Jun-06	0.109	2.9	21.7	42.2	2.81	0.101

4.0 Water Quality Investigations

4.1 Fieldwork and Methods

The investigations comprised field measurement of water quality determinands, as follows:

- Dissolved oxygen by use of a hand-held polarographic meter;
- pH and temperature by hand-held meter;
- turbidity by a field meter, providing results in formazine turbidity units (FTU – this is equivalent to the NTU units used by the EA YSI sondes);
- total dissolved solids measurements using a hand-held conductivity meter;
- dissolved nitrate, nitrite, phosphate and ammonium, using a portable colourimeter, using standard colourimetric procedures;
- carbonate alkalinity by titrimetric methods;
- chloride concentrations by titrimetric methods.

All instruments were calibrated prior to use, and standard solutions checked with the colourimeter to ensure that the instrument was not showing bias. Periodic calibration checks were made to check for instrument drift during use.

Samples were taken by hand from locations and DO, pH, temperature and turbidity measurements made within 5 minutes of sampling. Nutrient and titrimetric analyses were completed on each sample within no more than 5 hours of the sample being taken. In most cases the analyses were carried out at field laboratory facilities to reduce sample holding times.

On 15th July a series of light and dark bottle field experiments was carried out. This involved deployment of 300 ml bottles of water sample in the water column of either the River Kennet or the canal. The dark bottles were covered in duct tape to ensure that light would not penetrate into the bottle. Samples were incubated under field conditions for approximately 3 hours. At the end of the period, dissolved oxygen and pH measurements were made using the aforementioned field meters. The difference on oxygen levels between the dark and light bottles provides a measure of primary production.

The sampling locations for the main investigations of the 28th May 2006, 15th July 2006 and 11th February 2007 are shown in Figure 8.

4.2 Results of Field Investigations of 28th April and 2nd May 2006

This sampling exercise was undertaken following the long period of persistent dry weather that affected South East England during the winter and spring of 2006.

The results of the first field-work carried out are provided in Tables 4.1 and 4.2, which show the data for the work carried out at the Craven Fishery on 29th April 2006 and the Sir Richard Sutton's Settled Estate Park Fishery on 2nd May 2006.

Table 4.2: Analytical Results for Craven Fishery 29th April 2006

Sample	Time	DO (mg/l)	pH	Temp °C	Turbidity FTU	NO_3 mgN/l	NO_2 mgN/l	NH_4 mgN/l	PO_4 mgP/l
Weir Sample 1	17.50	10.56	8.26	13.30	4.43	3.10	<0.1	<0.04	0.28
Weir Sample 2	18.15	10.48	8.25	13.10	7.03	3.00	<0.1	<0.04	0.26
Weir Sample 3	18.45	10.51	8.27	13.00	7.90	2.90	<0.1	<0.04	0.27
Weir Sample 4	19.35	10.60	8.29	12.90	7.82	2.90	<0.1	<0.04	0.26
Upstream Weir	18.35	10.49	8.33	13.00	12.59	2.80	<0.1	0.04	0.08
Canal boat pass	18.05	10.51	8.13	13.10	14.25	1.40	<0.1	0.05	0.17
Canal boat pass +10 mins	18.25	10.53	8.13	13.00	9.99	1.40	<0.1	0.05	0.17
Boat Wash 1	18.53	10.56	8.18	13.00	18.34	1.50	<0.1	0.04	0.17
Boat Wash 2	19.10	10.55	8.19	12.90	15.14	1.40	<0.1	0.05	0.16
Boat Wash 3	19.25	10.58	8.17	12.80	13.42	1.40	<0.1	0.05	0.16
Boat Wash 4	19.45	10.58	8.20	12.60	12.73	1.40	<0.1	0.05	0.16

Table 4.2: Analytical Results for Sir Richard Sutton's Settled Estate Park Fishery 2nd May 2006

Sample	Time	DO (mg/l)	pH	Temp °C	Turbidity FTU	NO_3 mgN/l	NO_2 mgN/l	NH_4 mgN/l	PO_4 mgP/l
Parliament Trap	19.05	10.9	8.00	12.6	5.97	1.0	0.01	0.05	0.19
Upstream Dead Stream	19.10	10.9	8.25	12.3	5.84	2.5	0.01	0.05	0.18
Downstream Confluence	19.15	10.9	8.17	12.4	5.94	1.6	0.01	0.05	0.19

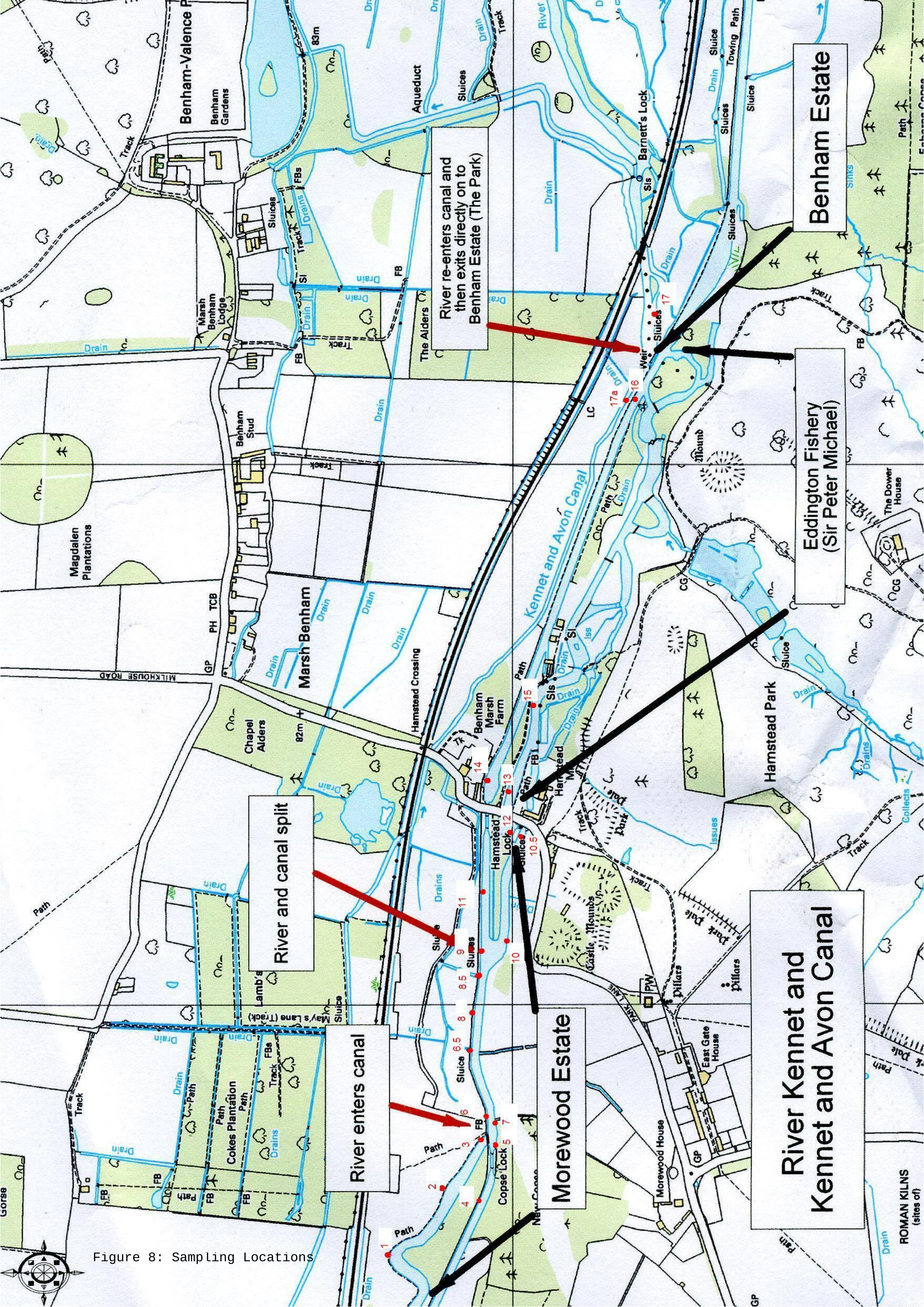


Figure 8: Sampling Locations

4.3 Results of Subsequent Surveys

The 28th May 2006 survey was undertaken during fine weather at the end of a moderately wet May, following previously dry weather. The results of the first field-work carried out are provided in Tables 4.3 and 4.4, which show the data for the work carried out on 28th May 2006. A repeat survey was carried out on 15th July 2007 to further assess water quality in mid-Summer. The results are given in Tables 4.5-4.7, which include primary production rate measurements. A final survey was then carried out during the mid-winter on 11th February 2007, and the results are given in Tables 4.8-4.10.

Figure 2 provides a plan of the sampling station locations used for the three surveys.

Table 4.3: Analytical Results for Field Measured Determinands (28/5/06)

Sample	Time	DO (mg/l)	pH	Temp ° C	Turbidity FTU	TDS (mg/l)
1	10.15	10.2	8.04	13.7	6.36	262
2	10.30	10.4	8.03	13.7	6.35	264
3	10.40	10.4	8.07	13.6	5.56	264
4	10.57	10.8	8.11	15.4	27.80	213
5	10.54	9.7	8.14	15.4	18.58	211
6	11.20	9.5	8.04	14.3	6.48	262
6.5	11.35	9.7	7.98	14.4	5.89	264
7	11.30	10.1	7.92	15.6	23.16	236
8	11.40	9.5	8.06	14.4	17.80	257
8.5	12.00	10.4	8.06	14.5	9.70	256
9	11.50	10.1	8.13	14.3	11.77	258
10	12.30	10.5	8.10	14.5	10.46	255
10.5	12.25	10.6	8.04	14.5	8.14	263
11	12.40	10.1	8.11	14.5	12.19	260
12	12.50	10.3	8.16	14.6	9.62	257
13	12.55	10.4	8.17	14.6	8.38	256
14	13.00	10.3	8.11	14.9	14.44	261
15	13.15	10.4	8.21	14.9	8.38	254
16	13.45	10.6	8.13	16.6	14.47	259
17	13.50	10.4	8.17	15.2	9.22	261
17a	13.55	10.3	8.09	15.1	10.51	266

Table 4.4: Analytical Results for Nutrients, Carbonate Alkalinity and Chloride (28/5/06)

Sample	Time	NO_3 mgN/l	NO_2 mgN/l	NH_4 mgN/l	PO_4 mgP/l	CA mg/l	Cl^- mg/l
1	10.15	5.20	0.03	<0.010	0.104	273	19.0
2	10.30	5.80	0.03	<0.010	0.098	270	19.0
3	10.40	4.60	0.03	<0.010	0.095	272	19.0
4	10.57	3.20	0.03	0.010	0.000	198	17.5
5	10.54	3.10	0.03	<0.010	0.039	188	18.0
6	11.20	5.20	0.03	<0.010	0.085	278	19.0
7	11.30	2.00	0.03	<0.010	0.039	228	18.0
8	11.40	4.40	0.03	<0.010	0.064	261	18.5
9	11.50	2.80	0.03	<0.010	0.059	255	19.0
10	12.30	4.60	0.03	<0.010	0.127	246	19.0
11	12.40	4.30	0.02	<0.010	0.059	255	19.0
12	12.50	4.20	0.03	<0.010	0.078	276	19.0
13	12.55	4.80	0.03	<0.010	0.059	249	19.0
14	13.00	4.70	0.02	<0.010	0.065	261	18.5
15	13.15	6.50	0.03	<0.010	0.055	238	19.0
16	13.45	3.60	0.03	<0.010	0.020	246	18.0
17	13.50	5.40	0.02	<0.010	0.065	250	19.0

Table 4.5: Analytical Results for Field Measured Determinands (15/07/06)

Sample	Time	DO (mg/l)	pH	Temp ° C	Turbidity FTU	TDS (mg/l)
2	15.25	11.0	8.11	20.9	3.37	237
3	15.30	11.0	8.09	20.9	3.45	236
4	15.10	10.0	7.89	22.6	27.04	245
6	15.40	10.9	8.12	19.6	8.91	243
8	15.55	10.5	8.14	20.1	10.67	244
9	16.05	10.6	8.12	20.1	10.27	243
12	16.15	9.9	8.16	20.2	8.40	256
13	16.40	9.5	8.38	20.3	7.57	257
14	16.35	7.5	8.23	21.3	9.66	262
16	17.15	8.4	8.32	21.4	18.96	260
17	17.10	9.5	8.27	21.4	13.00	279

Table 4.6: Analytical Results for Nutrients, Carbonate Alkalinity and Chloride (15/07/06)

Sample	Time	NO_3 mgN/l	NO_2 mgN/l	NH_4 mgN/l	PO_4 mgP/l	CA mg/l	Cl^- mg/l
2	15.25	4.20	0.03	0.01	0.110	270	15.5
3	15.30	4.40	0.03	0.01	0.115	270	15.5
4	15.10	0.60	0.03	0.02	0.025	238	25.0
6	15.40	3.20	0.03	0.01	0.086	273	18.5
8	15.55	2.10	0.03	0.02	0.073	255	19.0
9	16.05	2.10	0.03	0.01	0.069	250	19.0
12	16.15	2.10	0.02	0.01	0.061	252	19.0
13	16.40	3.80	0.03	0.02	0.104	265	20.0
14	16.35	3.00	0.03	0.01	0.080	270	14.0
16	17.15	2.30	0.03	0.01	0.040	244	19.0
17	17.10	4.00	0.02	0.01	0.089	273	19.0

Table 4.7: Dark and Light Bottle Test Results (15/07/06)

Sample	Times deployed	Period Deployed	Initial DO mg/l	Initial pH	Light DO mg/l	Dark DO mg/l	Light pH	Dark pH	Light T ° C	Dark T ° C
2	15.25-18.10	2.45	11.00	8.11	11.10	10.80	8.19	8.16	21.30	21.90
4	15.10-18.00	2.50	10.00	7.89	10.50	8.50	8.28	8.10	23.00	23.10
6	15.40-18.20	2.40	10.90	8.12	11.10	10.60	8.29	8.20	21.60	20.30
8	15.55-18.25	2.30	10.50	8.14	10.55	10.00	8.30	8.19	21.40	20.40
12	16.15-18.45	3.30	9.90	8.16	9.90	9.30	8.28	8.23	20.60	21.60

Table 4.8: Analytical Results for Field Measured Determinands (11/02/07)

Sample	Time	DO (mg/l)	pH	Temp ° C	Turbidity FTU	TDS (mg/l)
3	12.00	11.4	7.41	9.1	8.09	274
4	11.50	11.8	7.32	7.5	8.08	263
6	12.10	11.3	7.46	9.1	11.01	275
8	12.20	11.3	7.70	9.1	7.60	276
10	12.50	11.2	7.84	9.3	10.64	277
11	12.45	11.2	7.86	9.3	10.40	278
13	13.00	11.1	7.82	9.3	4.82	279
14	13.10	11.2	7.80	7.5	8.04	274
16	14.00	11.2	7.90	9.2	6.91	274
17	13.55	11.1	7.89	9.2	9.25	274

Table 4.9: Analytical Results for Nutrients, Carbonate Alkalinity and Chloride (11/02/07)

Sample	Time	NO_3 mgN/l	NO_2 mgN/l	NH_4 mgN/l	PO_4 mgP/l	CA mg/l	Cl^- mg/l
3	12.00	5.20	0.03	<0.01	0.121	220	21.0
4	11.50	2.70	0.03	0.10	0.522	215	21.0
6	12.10	4.70	0.03	0.01	0.186	232	21.0
8	12.20	3.10	0.03	<0.01	0.121	223	21.0
10	12.50	3.40	0.03	0.01	0.235	232	20.5
11	12.45	3.60	0.03	<0.01	0.101	232	20.5
13	13.00	3.90	0.02	<0.01	0.166	232	21.0
14	13.10	2.60	0.03	<0.01	0.085	245	20.0
16	14.00	3.90	0.03	<0.01	0.111	232	21.0
17	13.55	2.90	0.03	<0.01	0.098	232	20.5

Table 4.10: Dark and Light Bottle Test Results (11/02/07)

Sample	Times deployed	Period Deployed	Initial DO mg/l	Initial pH	Light DO mg/l	Dark DO mg/l	Light T ° C	Dark T ° C
3	11.30-14.45	2.45	11.40	7.41	11.40	11.30	9.30	9.30
4	11.35-14.50	2.50	11.80	7.32	11.50	11.30	8.00	7.90
6	11.45-14.55	2.40	11.30	7.46	11.30	11.30	9.30	9.30

5.0 Discussion of Key Findings

5.1 Field Observations

Having visited the fisheries six times, a visual assessment has been made of the character of the sedimentary material, and how it has changed since the first visit at the end of January 2006. The material is clearly not typical of a pristine chalk stream and was present within the Kennett at the Craven Fishery and the Dead Stream on the Sir Richard Sutton's Settled Estate Park Fishery.

The material clearly has a high organic content, which appeared to comprise diatom planktonic plants (phytoplankton) bound loosely to inorganic sediments. The material seen in April/May 2006 appeared, to this observer, to have fresher appearance than that seen in January 2006. The precise character of the binding could not be assessed. It appears to be quite loose but of sufficient strength to decrease the effective density of the particulate matter, and also achieve quite good adhesion to plant and other surfaces. Large-scale flocs of up to 2-3 cm length were noted floating in the stream upstream of the weir on the Craven fishery during April/May 2006. There is little doubt that this material is derived from the spring "bloom" of diatoms.

It should be noted that the algal biomass in the spring and early summer has a characteristic brown colouration characteristic of diatoms. These algae have silica frustules, which make them the densest algae (specific gravities of typically 1.2) and they have the greatest tendency of any algal groups to sedimentation.

The attribution of the material purely to barge activity may thus be an insufficient explanation for the events noted in terms of deposition of material and adverse impacts on *Ranunculus* growth. However, this does not mean that a combination of factors is not involved, including boat activity. Indeed this seems more likely.

The presence of the flocs was less apparent in late May 2006 and July 2006. However, it was noted that the canal upstream of the Copse Lock had a rich brown colouration (sample 4) from May-July 2006, which contrasted with extremely clear water in the River Kennet upstream of the lock on the Morewood Estate (samples 1-3). There was a clear discharge plume of canal water downstream of the lock, which was forced onto the southern bank by the flow of the River Kennet where it debouches into the combined river-canal stretch. The plume could be clearly detected by eye on the southern bank for some distance downstream of the lock.

Two samples (5 and 7) were taken in the discharge plume area. As will be seen the water had somewhat different characteristics from the bulk flow in the Kennet. It would appear that it mixes further across the river further downstream. It is notable that the Craven fishery weirs are on the southern bank. During sampling it was noted that barges passing did cause a distinctive brown wake to be formed but this was quite transient, which is consistent with the measurements made in late April 2006 (see Figure 8). Nevertheless, the wake plume had a similar colour to the plume from the locks. However, the discharge rate and sediment levels of the lock plume appeared to be far more substantial.

As was noted in the previous report, the attribution of the material purely to barge passage seems to be an insufficient explanation for the events noted in terms of deposition of material and adverse impacts on *Ranunculus* growth. However, the canal appears to be an important source of organic material, discharged over the Copse Lock that could contribute to the sediment problem since it appears to be a source of the organic component that was noted in the river on the Craven Fishery. There is also likely to be a relationship between the problem and boating activity in that the rates of discharge of material through the lock gates may increase as the boating season progresses. However, it must also be noted that the diatom bloom would coincide in part with this period. A critical factor to be understood is manner in which river flows into the canal in the Hungerford area and discharge through the Copse Lock gates balance to maintain nutrient levels and algal growth in the canal. A further factor is the discharge of sewage effluent from Kintbury STW which tops up the nutrient pool in the canal available for the continuation of algal growth. Most particularly this would be a key source of ammonia and phosphate, of which the latter is the most likely to limit algal growth.

During the February 2007 survey, it was noted that the turbidity of the river was higher than had been noted in the spring-summer 2006 surveys, whilst the canal had no distinctive colouration. It is understood that the turbidity may have been influenced by the re-suspension of low organic matter content bed sediments by dredging in the canal.

5.2 Water Quality

5.2.1 Dissolved Oxygen, Dissolved Solids, Carbonate Alkalinity and Chloride

The water quality measurements have usefully backed up the observations made. The dissolved oxygen levels were high and either close to or slightly in excess of saturation levels in all 20 samples taken.

The pH measurements indicated slight differences related to the presence of algae. The carbonate alkalinity in the canal and plume near Copse Lock (samples 4, 5 and 7) are clearly lower than the River Kennet upstream of the confluence (samples 1-3) and pH was slightly elevated. These characteristics are expected where algal growth is substantial. The carbonate alkalinity decreasing (with a concomitant increase in pH) as algae take up carbon dioxide from the canal water. There is also some indication that this process may have been occurring in the canal between samples 14 and 16, downstream of Hamstead Lock; the latter sample also contained supersaturated dissolved oxygen levels consistent with active and intense photosynthesis in the canal water. Total dissolved solids (TDS) and carbonate alkalinity are as expected positively correlated (Pearson r = 0.911, significant at 95% confidence limit). Chloride levels were fairly constant, but slightly lower in the canal in May 2006. In July, following the dry spell of weather, the chloride levels were higher in the canal. Regardless, the differences in chloride levels are sufficient to provide an indicator of mixing between the two water bodies.

5.2.2 Turbidity

The turbidity of the River Kennet measured in both May and July 2006 was reasonably low upstream of the Copse Lock, and was slightly lower than previously noted at the Craven Fishery in late April 2006.

The turbidity of the canal (sample 4) appeared to be about 4-8 times as high as noted in the river (samples 1-3), and the turbidity in the lock discharge plume was 3 times higher (samples 5 and 7). The turbidity is negatively correlated with TDS (Pearson r = -0.798, significant at 95% confidence limit for May 2006); but no such relationship was apparent in July when TDS in the canal was higher than in the river. The excess turbidity is largely related to algal cells, and the negative correlation seems to reflect the lower carbonate alkalinity which decreases with algal growth. The turbidity and TDS/carbonate alkalinity data correlated with the discharge plume for Copse Lock, and can be used to indicate mixing across the river.

The turbidity in canal samples is consistently higher than in the river samples, although downstream of the canal, in the Craven Fishery, the turbidity is about 1½-2 times as high as in the river upstream of Copse Lock during both sampling periods. These results are consistent with the canal discharge affecting the water quality in the river.

There is also a slight increase in turbidity noted downstream of the weir where the river crosses the canal and discharges into Sir Richard Sutton's Settled Estate Park Fishery (compare data for stations 13 and 17 in Tables 4.3 and 4.5).

The elevated turbidity noted in February 2007 was related to terrestrial sediment derived from run-off and re-suspended sediment derived from the dredging of the canal at that time. Both these would have modest organic contents. Generally the canal water samples (locations 4 and 13) had lower turbidity at this time than the river samples.

5.2.3 Nutrients

In the previous report, the high levels of phosphate found in the River Kennet were noted, which were considered to be far outside of the range of concentrations found in chalk streams. In the present surveys the phosphate levels, whilst still high, were substantially lower than reported from the earlier sampling.

However, the striking finding is that the sample of canal water taken upstream of Copse Lock (sample 4) contained no detectable phosphate in May 2006 and samples from the immediate plume (samples 5 and 6) contained very depleted levels that were probably related to the entrainment and mixing of water from the River Kennet. In July 2006, phosphate levels were also substantially lower than in the river but clearly detectable. The complete lack or substantial depletion of phosphate is consistent with the carbonate alkalinity, pH, dissolved oxygen levels in indicating high levels of algal growth. Phosphate is negatively correlated with turbidity (Pearson r = -0.782, significant at 95% confidence limit for May 2006 and Pearson r = -0.892, significant at 95% confidence limit for July 2006), which again supports the notion that the turbidity is strongly related to algal utilisation of nutrient.

As is typical of fresh water phosphate is the limiting nutrient. Phosphate was also positively correlated with carbonate alkalinity (Pearson r = 0.626, significant at 95% confidence limit for May 2006 and Pearson r = 0.877, significant at 95% confidence limit for May 2006), which is consistent with the fact that the river water tends to have higher alkalinity and phosphate decreases in the canals where strong algal growth occurs. Whilst this observation was very clear in the vicinity of Copse Lock, the phosphate level in sample 16, in the canal near the weir discharge to the Park Fishery waters, was one third of the concentration found in samples 11 and 14 from near Hamstead Lock on the canal during May 2006 and one half of the concentration in July 2006; carbonate alkalinity also decreased substantially in the samples taken during both months. This suggests that primary production in this stretch of the canal is significant, although it was less obvious visually than at Copse Lock.

The phosphate levels in the Kennet upstream of Copse Lock were high but the flow rates of the river reduce primary production rates compared with the canal. This reflects the very different hydrodynamic regimes of the two types of water bodies. The notion follows that the canal acts as a biological reactor converting high phosphate levels, which cannot be converted readily to biomass in the river, into organic matter that contributes to sediment problem.

The nitrate levels were high and consistent with data reported by the EA. As with the phosphate levels, the lowest concentrations of nitrate were found in the canal or canal discharge samples. There was a negative correlation between turbidity and nitrate levels (Pearson r = -0.703, significant at 95% confidence limit in May 2006 and Pearson r = -0.774, significant at 95% confidence limit in July 2006) and a weak positive correlation with TDS (Pearson r = 0.578, significant at 95% confidence limit in May 2006) and carbonate alkalinity (Pearson r = 0.479, significant at 95% confidence limit in May 2006 but Pearson r= 0.885 in July 2006).

The levels of nitrate found over the sampling were consistent with the typical range of concentrations recorded by the EA in the River Kennet and canal system. The level of nitrate was observed to drop along the length of the canal between Hamstead Lock to the weir discharge to the Park Fishery. There was evidence of a relative depletion of nitrate in the canal water samples (station 4) and canal plume samples in both May and July 2006. Again this is consistent with the high levels of algal biomass (see Section 3.3. There was also evidence of loss of nitrate between stations 14 (upstream) and 16 (downstream) within the canal section downstream of Hamstead Lock, in both months (see Tables 4.4 and 4.6).

In February 2007, levels of nitrate, nitrite and ammonium were similar to those measured during the spring and summer of 2006. However, phosphate in the canal (see station 4 results in Table 4.9), and, to a degree, nitrate were substantially higher. This is consistent with the low degree of primary production at the time, but these enriched nutrient levels, especially phosphate, represent the potential for production later in the season.

5.2.4 Biomass and Productivity

The contrast in algal biomass between the river Kennet and the canal is clearly evidenced from the EA data presented in Section 3.3, Table 3.2a-b. These data are consistent with the findings presented above and the visual observations made, which indicate that the canal is the predominant source of algal biomass discharges to the Kennet downstream of Copse Lock. The turbidity measurements made in the present surveys largely reflect algal cell-derived light extinction, and thus indirectly indicate biomass. The studies also indicate, based on water quality measurements, further algal biomass production in the canal stretch downstream of Hamstead Lock, exceeding that achieved in the river.

Primary production rates were measured on 15th July 2006 in the field using the light and dark bottle method. These measurements are used purely to assess the relative primary production rates, which will vary during the season and day. However, they usefully indicate the relative importance of production in different parts of the canal-river system. Based on the data, the following carbon production rates have been estimated for the deployment periods:

- Sample 2 (upstream of Copse Lock in Kennet) – 0.04 mgC/l/hour;
- Sample 4 (upstream of Copse Lock in canal) - 0.26 mgC/l/hour;
- Sample 6 (downstream of Copse Lock in joined channel) – 0.07 mgC/l/hour;
- Sample 8 (downstream of Copse Lock in joined channel) – 0.08 mgC/l/hour;
- Sample 12 (downstream of Hamstead Lock in River by main weir) – 0.06 mgC/l/hour.

The rates of primary production are broadly proportional to the turbidity measurements made at these sample stations. These data clearly confirm the key significance of the canal as source of organic matter and algal biomass into the river system. The data are internally consistent with the EA's biomass estimates using chlorophyll *a* and the water quality measurements made during the two main surveys. The possibility of the creation of algal biomass being the source of the sedimentary material in the fisheries downstream is strongly supported by these data.

The production rates indicated for February 2007 (see Table 4.10) were substantially lower than the summer, as would be expected, at <0.01mgC/l/hour.

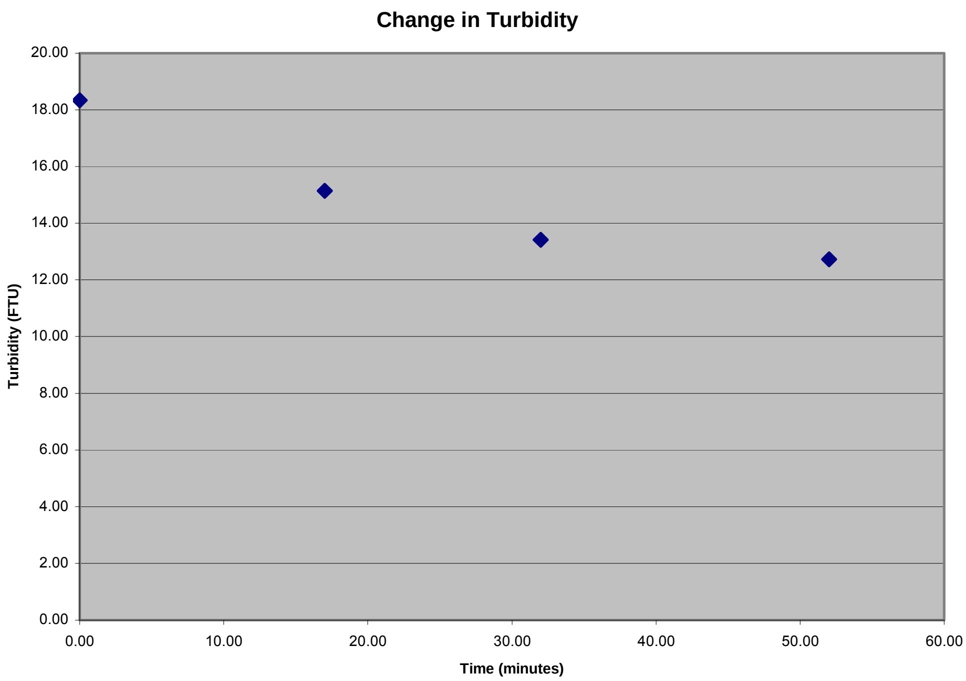
5.3 Discussion: Boat Passage and the Sediment Problem

5.3.1 The Role of Boat Passage Alone

The data presented in Figure 9, which were obtained in April 2006, indicate a steep increase in turbidity immediately following passage. After about 55 minutes turbidity declined to levels similar to those prior to passage. This may, given the low density of the particles noted in the river, lead to re-suspension and aid their transport into the river. However, against this it is also apparent that turbulence can also break up the flocs. Because of the nature and effective densities of the flocs, they may be conveyed more effectively as large structures than when broken up.

It may be that boat passage assists in keeping flocs mobile and in the water column. However, the canal appears to be the source of the organic matter required for the generation of floc and that the growth is due to a combination of high nutrient levels derived from sewage works (and agriculture) and the particular static hydraulic conditions in the canal that allows the nutrients to exert an adverse effect that is not apparent in the faster-flowing conditions of the River Kennet.

Figure 9: Change in Turbidity with Time Following Boat Passage in Kennet & Avon Canal



A relationship between boat passage may be important because of the complex relationship between river flows and canal levels between the Froxfield Brook and

Hungerford. Essentially as rates of boat passage increase discharge rates from the Copse Lock increase, which then draws water from the river system which would replenish nutrient reserves that appear to become depleted in the canal by algal production, and so allow high primary production rates to be maintained. The contribution of nutrient inputs from Kintbury STW is also important in terms of keeping the biological reactor topped up with phosphate. The balance between these nutrient inputs and water flows is likely to be an important factor in the understanding of the problem. Data on boat traffic would be useful to estimate canal water discharge rates to the river. The EA has kindly provided some data, but it doesn't provide sufficient resolution of seasonal trends in boat lockages.

5.3.2 The Role of the Canal as a Source of Suspended Organic Matter

The critical role of the canal appears to be as a biological reactor that converts nutrient from sewage or other sources to algal biomass that then forms floc that causes problems for the two fisheries. The role of boat passage may be more related to the discharge of floc-forming water to the river from the canal, and as a means of replenishing the "reactor" with nutrient and creating flow to prevent the "reactor" running short of nutrient or becoming self-limited by light. The May survey indicated that the nutrient levels were becoming exhausted, but the July data indicate that these had been topped up again.

The contrast of the February 2007 data is notable, with very substantial phosphate levels measured in the canal (0.522 mgP/l compared with <0.19 mgP/l in the river). The additional phosphate is probably related to regeneration and release of accumulated phosphate from the sediments during the winter, due to organic matter decay (and release from iron mineral and complexes), as well as sewage discharges from Kintbury sewage works (see Table 2.1).

The presence of nutrient in high levels in the Kennet upstream of the canal does not appear to cause this problem. The water quality, chlorophyll *a* and primary production estimates all indicate that the river does not convert nutrient into biomass as effectively as the canal.

Thus, the issue of sedimentation seems to be related to the canal and its particular hydrodynamic environment and algal habitat conditions. The issue would appear to attributable to high nutrient levels, the particular hydraulic conditions in the canal, the links between the canal and the river, and the discharge of algae-laden water at Copse Lock from the canal. The role of boat passage appears to be principally related to the increasing of the rate of canal water discharge, although the wakes of the craft may help to keep low density flocs in the water column and recycle them for subsequent deposition.

6.0 Summary and Conclusions

The findings of the present work carried out are as follows.

The nutrient levels found at both fisheries, and most particularly phosphate, were found to be extremely high, and this would seem to be related to sewage and agricultural inputs. The general findings of the present surveys and the EA physical sample data are consistent.

The sedimentary material seems to comprise a complex floc, including either fresh or recently demised diatom (based on colour) material that forms a loose structure (possibly bound by polysaccharides), which adheres to surfaces, including aquatic plants such as *Ranunculus*.

The levels of primary production in the canal appear to be high and the nutrient levels low, due to the high primary production rates as measured in July 2006. The EA's measurements of chlorophyll *a* in June 2006 are internally consistent with the primary production estimates made in the field in July 2006. The canal seems to be the source of the floc material, and the water quality data and field observations are consistent on this point. The water quality measurements made in February 2007 confirm these general observations, by demonstrating high nutrient levels in the canal and relatively low turbidity during the winter when production levels were low.

The turbidity data are consistent with high levels of algal growth in the canal, as confirmed by the productivity measurements. The high nutrient levels in the river do not give rise to such high turbidity and primary production.

The issue is more complex than the simple one of boats churning up sediments but the explanation of the problem is critically dependent on the canal and the indirect consequences of boat passage.

The EA is investigating methods for separating the canal and the river. This requires complex engineering because of the manner in which the canal enters the river from the south at Copse Lock and exits at the north at Hamstead Lock. Achieving a separation between the canal and lock is more straightforward at the weir downstream of the Craven Fishery as it enters the Park Fishery.

The nutrient inputs from the Kintbury STW may be important and the AMP4 programme will restrict inputs. However, this may not necessarily greatly influence overall nutrient inputs to the canal; at this stage an estimate of the relative importance of these inputs has not been possible as phosphate data are not available to estimate the loads. Even if the input were reduced from Kintbury, the rivers that contribute water flows to the canal, to top up losses caused by lockages, also provide substantial phosphate levels; as is evidenced by the high nutrient levels found in the river upstream of Copse Lock.

In order to improve conditions in the river at the Craven and Park Fisheries, it is essential that the canal be separated from the canal. This would, however, not be free of downsides. The separation of river and canal between Copse Lock and Hamstead would require a river diversion and probably a length of underpass beneath the canal, unless the canal were to be raised by a boat lift or other mechanism.

Thus, engineering works may cause some adverse effects on the functioning of the river. However, it must be concluded at this stage that the function of the canal adversely affects the ecological and fisheries functions of the river Kennet downstream of Copse Lock. The main source of algal biomass and sedimenting floc is the canal upstream of Copse Lock, which affects both fisheries. Additionally the data indicate further algal production in the stretch of the canal between Hamstead Lock and weir overflow downsteam of the Craven Fishery. This water discharges into the Park Fishery and may provide an additional floc source affecting this fishery over and above the inputs from Copse Lock.