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River Deben Alleviation of Low Flows Scheme: An Environmental Appraisal

Final Report

May, 1994

Report No 94/3/821

Client

National Rivers Authority
Anglian Region
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough
PE2 5ZR

Southern Science Ltd
Premium House
Brighton Road
Worthing
West Sussex BN11 2EN
Tel (0903) 823328
Fax (0903) 210474

ENVIRONMENT AGENCY
029135

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SUMMARY

Introduction

1 The River Deben is a rural river flowing through a boulder clay covered Chalk catchment to the Deben estuary near Woodbridge in Suffolk, Figure 1. It was identified by the National Rivers Authority (NRA) in 1993 on a priority list of 40 rivers where low flows, due to authorised abstraction, were considered a potential problem.

2 In 1959 and 1973 the river through Wickham Market is reported as having dried up for several days although flows, due to groundwater baseflow, were still measurable downstream at Naunton Hall (AWA, 1975). During 1976 the river upstream of Debenham STW is reported to have dried up (AWA, 1983) and undated newspaper reports suggest this reoccured in either 1989 or 1990.

3 As part of a NRA (Anglian) appraisal of the feasibility and cost/benefit of possible solutions to low flows in the Deben, Southern Science were commissioned to collate and review available baseline ecological data for the freshwater reach of the river and its adjacent riparian habitat, and to identify the in-river needs of key species or habitats present.

4 A variety of data sources were approached for information including Suffolk Wildlife Trust, English Nature, Suffolk County Council, The Otter Trust, MAFF, local studies libraries and the NRA itself.

5 Key species and habitats were selected because of their rarity, or because they were considered to be characteristic of the river. For each of these species or habitats their in-river needs were assessed with particular attention paid to the impacts of flow, channel maintenance, important habitat features and water quality.

6 A brief hydrological assessment was undertaken to investigate the flow history of the river and also derive relationships between discharge and the key ecological variables of water depth and velocity.

Designated Sites/Areas of Wildlife Interest

7 The freshwater River Deben catchment contains one *Site of Special Scientific Interest* (SSSI), Fox Fritillary Meadow, Framsden, covering 2.3 hectares, near the top of a one of the upper tributaries of the river (NGR TM188606). The site consists of a small, unimproved, water dependant species rich meadow, situated in a valley bottom on heavy alluvial soils and supports the largest and best known population of the nationally rare, snakes head fritillary (Fritillaria meleagris) in East Anglia. This species is water dependant requiring flooding of the meadow in late winter/early spring.

Figure 1 The Freshwater Reach of the River Deben

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8 The majority of the freshwater River Deben falls within the Suffolk River Valleys *Environmentally Sensitive Area* (ESA). This is a voluntary scheme for landowners operated by the Ministry of Agriculture, Fisheries and Food (MAFF) through a local Agricultural Development and Advisory Service (ADAS) contact. It provides grant aid for the creation and sensitive management of grassland and marshland areas, and for carrying out capital works to improve landscape, wildlife or the historic interest of the area. A number of the ESA entry criteria relate directly to on-site water management including ditch maintenance, drainage activity and water level control.

9 The lower part of the study area near Melton is bordered by the Suffolk Coast and Heaths *Area of Outstanding Natural Beauty* (AONB). Over 90 % of the study area (excluding the Soham and the Deben above Debenham) is designated by Suffolk County Council as a *Special Landscape Area* where the protection of the landscape is accorded priority over other planning considerations.

10 One *roadside nature reserves*, as identified by Suffolk County Council, is in the study area located beside the A12 approximately 1 km north of Ufford.

11 A total of 15 known *bat* roost sites were identified in the Deben catchment from information provided by Suffolk County Council of which 6 sites lie within 1 km of the river. Additionally there are 3 known *newt* sites in the catchment none of which are within 1 km of the river.

12 A total of 37 *County Wildlife Sites* (CWS) have been notified in the Deben catchment by Suffolk Wildlife Trust in conjunction with Suffolk County Council, English Nature and the Suffolk Biological Records Centre. These CWS are unprotected sites considered to be of county, regional or national conservation importance chosen because of their naturalness, non-recreatability, rarity, diversity, location or potential value. Of these 37 sites within the Deben catchment 12 sites have been identified by the NRA and SWT as being water dependant sites ranging in size from 0.1 to 7.0 hectares and include the River Deben itself from Brandeston to Wickham Market (NGR TM246600 - 296566). A number of these sites lie on, or close to, land covered commited to the MAFF ESA scheme.

Flora Associated with the River Deben

Conclusions of the Study

13 Two distinct plant communities can be identified associated with the River Deben.

14 The first is found principally upstream of the confluence of the Deben and the Earl Soham watercourse and is characteristic of the upstream reaches of a clay river with narrow channels and steep, high sided physically uniform banks. Such communities are usually in reaches subject to intense management including dredging and re-profiling. The plant community has few characteristic indicator species with virtually all species present being examples of flora that are tolerant of a wide range of habitats.

15 The second plant community found downstream of the Earl Soham watercourse and Deben confluence is characteristic of a mixed sand/clay substrates with slow flowing, good quality water partly derived from calcareous groundwater at a depth of between 0.1 m to 1 m. The most common species are mare's tail, red pondweed, yellow water lily, butter-bur. Others include the calcareous water loving river water dropwort, the floating pondweed and the common reed.

16 Key plant species on the River Deben were identified as:

River water dropwort (Oenanthe fluviatilis) - nationally scarce;
Flowering rush (Butomus umbellatus) - regionally scarce;
Wood club-rush (Scirpus sylvaticus) - regionally scarce;

Yellow water lily (Nuphar lutea) - typical River Deben species;
Starwort (Callatriche sp.) - typical River Deben species;
Creeping bent (Agrostis stolonifera) - typical River Deben species.

17 The distribution of the three scarce species on the Deben has declined between 1981 and 1989, with the reach from Crettingham to Letheringham being the only one that retained a good population of river water dropwort and flowering rush. The decline of these scarce species in the reach downstream of Letheringham may be partly due to channel maintenance activities.

Recommendations

- channel maintenance activities should adopt the following general principles:
  - working from one bank;
  - leaving patches of in-river vegetation undisturbed to act as a source for recolonisation;
  - creation of berms and retention of cattle bays;
  - creation/retention of a variable bank and river bed profile.
- in the reach from Brandeston to Letheringham particular care should be taken during maintenance activities to protect the scarce species (e.g. River water dropwort) that this reach may support;
- currently an arrangement exists between the Suffolk Wildlife Trust and the NRA Ipswich office whereby ecological advice is sought before and during maintenance activities. It is recommended that the relationship between river corridor surveys and channel maintenance activities is formalised with improved record keeping and consultation in good time regarding any pending maintenance activities;
- augmentation (i.e. to maintain a channel water depth of at least 10 cm) together with environmentally sympathetic channel maintenance, when necessary, should act in protecting and conserving the florally diverse reach near Brandeston. It may also serve to increase plant diversity in the upper

Deben and Earl Soham watercourse encouraging colonisation by rare species such as the River water dropwort, particularly if water derived from a Chalk aquifers is augmented.

Riparian Wildlife Sites

Conclusions of the Study

18 Considerable scope exists for raising shallow water tables through controlling ditch water levels, particularly in the light of the MAFF ESA scheme criteria.

Recommendations

- consult with the MAFF representative for the Suffolk River Valleys ESA (Tim Sloane) and Suffolk Wildlife Trust regarding the operation of the scheme and its potential for raising shallow water levels near water dependent County Wildlife Sites and the Fox Fritillary Meadow SSSI.

- conduct field investigation and consultation regarding the possibility of raising shallow water levels at water dependant County Wildlife Sites and the SSSI.

Birdlife

Conclusions of the Study

19 On the Deben the greatest diversity and abundance of birdlife is associated with reaches where woodland is nearby (e.g. near Brandeston). The key bird species were identified as follows:

Barn owl, kingfisher, and little ringed plover - nationally rare;
Shelduck, teal and redshank - nationally scarce;
Snipe - regionally scarce.

20 The in-river needs of birds are largely unrelated to river flow and are more dependent upon channel maintenance activities (e.g. the presence of vertical banks and perches for kingfishers), land drainage (the need for shallow pools and ditches for the redshank) and bankside and riparian vegetation (e.g. for the teal).

Recommendations

- vertical bank kingfisher nesting sites should be protected along the Deben particularly in the reaches near Ashfield Bridge, Kettleburgh and Rendlesham where kingfishers were observed in the 1989 SWT survey;

- the following measures are recommended to conserve kingfisher nesting sites:

- leave the channel and banks untouched;
- conserve meanders particularly where the outer bank is a nesting cliff;
- working from one bank, leaving the opposite, nesting, bank untouched;
- planting alders for future bank protection.

- where kingfisher nesting sites have to be destroyed then new sites can be artificially created during dredging activity by excavating a vertical bank at least 1.5 m above the normal water level;

- the raising of shallow water levels, (e.g. at water dependant County Wildlife Sites), would benefit the redshank and snipe providing an increased number of potential feeding sites.

Fisheries

Conclusions of the Study

21 The River Deben supports a good coarse fish population dominated by pike, roach and eel with perch, bream and dace also found. NRA fish surveys indicate an increase in total biomass and density at nearly all survey sites between 1984 and 1991.

22 Spawning is identified as the key fish life stage with provision of suitable depths, velocities and a suitable spawning substrate important. Of the fish species present in the Deben, all spawn on aquatic vegetation in the channel in late Spring and early Summer and therefore in-river needs will be linked with those of submerged river plants. Roach are the principal species fished by the Woodbridge and District Angling Club near Wickham Market and are thought to spawn in the reach near Brandeston. Protection of aquatic vegetation in this reach is therefore of importance.

23 All the fish species present in the Deben are characteristic of slow or very slow water velocities and shallow to moderate water depths. These needs are evidently being satisfied to some extent, as evident in the gradual increase in fish biomass and density observed since 1981 in the NRA surveys. The presence of a number of weirs, bridges, mills and mill channels along the Deben, particularly downstream of its confluence with the Earl Soham watercourse, increases the diversity of available habitat and in restricting water flow will create deep water pools of great importance to shoaling coarse fish when river levels fall.

Recommendations

- spawning is recognised as a vital fish life stage. Those species found on the Deben spawn on aquatic vegetation (e.g. narrow, submerged species) and channel maintenance activities should take this into account particularly in the reach near Brandeston where Roach (the species principally fished) spawn;

- provided some areas of deep water for adult fish (e.g. over 100 cm depth) plus suitable aquatic vegetation for spawning are available then the minimum depth

requirement for spawning in late Spring and early Summer (i.e. for Roach near Brandeston) is around 30 cm corresponding to a flow during this period of around 0.2 m^3/s at Naunton Hall gauging station;

- maintaining and/or operating weirs and mill controls in order to retain areas of deep water during low flow periods. Channel maintenance activities should also take into account the need for a varied river bed profile.

Mammals

Conclusions of the Study

24 Otters (a protected national rarity), water voles, shrews and bats are all associated with the River Deben. The in-river needs of the otters, released to the Deben in 1993, they are linked primarily to habitat features such as:

- the availability of suitable breeding sites (e.g. roots of mature riverside trees);
- sufficient cover (bramble and willow thickets, scrub and reed or sedge beds)
- a low level of disturbance (e.g. dogs, channel maintenance).

25 The degree and nature of channel maintenance activities will play an important part in the availability and suitability of these three factors. Further in-river needs for otters include good water quality and an available source of food (particularly eels).

26 Thorough consultation with conservation bodies (Suffolk Wildlife Trust, The Otter Trust) prior, and during, maintenance activities is considered vital particularly because the otter can have a territory of upto 50 km.

Recommendations

- In order to conserve and encourage the otters on the Deben the following options are recommended:
  - leaving at least 50 % of one or other bank untouched and leaving patches of dense vegetation;
  - partial dredging leaving 30-50 % untouched including vegetation, riffles and pools;
  - cutting aquatic vegetation in patches and using weed control measures which require less frequent disturbance of the river;
  - retaining patches of tall vegetation as long as possible in the year where banks have to be cut;
  - retaining meanders, islands, and tree and shrub cover;

- When proposing channel maintenance work, particularly tree maintenance, it is strongly recommended that the Suffolk Wildlife Trust and The Otter Trust are consulted specifically with regard to the needs of the otters on the Deben.

Is this defined better in the text?

Water Quality

Conclusions of the Study

27 A gradual improvement in water quality is evident from the records for the Deben with decreases in the concentrations of ammonia and BOD discernable from 1976 to 1993. All monitoring sites show an increase in chloride concentration since 1990 with the increase being most pronounced during drought years in the records for the most upstream monitoring sites (e.g. Debenham, Ashfield Crossroads). This may be due to reduced effluent dilution during low flow periods. One alternative, but more unlikely cause, may be a pocket of high chloride groundwater known to be present in the chalk underlying the upper reaches of the catchment.

28 The lowest dissolved oxygen saturations are found in the upper reaches of the Deben with levels as low as 10 % (1990) recorded at Debenham, and 16 % (1986) and 13 % (1990) at Ashfield Crossroads. Low dissolved oxygen saturations can be correlated with low flows and may be ecologically limiting in the upper reaches of the river particularly for fish and invertebrate populations. Below the confluence of the Deben and the Soham no dissolved oxygen saturation of less than 40 % have been observed.

Recommendations

- consideration should be given to river support by augmentation of the upper reaches of the Deben in drought years in order to maintain flow and dissolved oxygen saturations to the benefit of aquatic invertebrates and fish and kingfisher populations. The water quality of augmented water should be compared with that of the receiving water;

- consideration should be given to the use of spray irrigation abstraction controls in order to protect water quality near Wickham Market;

- the potential consequences of further increases in chloride concentrations on downstream river users including spray irrigation abstractors should be investigated.

Amenity, Recreation and Landscape

Conclusions of the Study

29 The amenity and recreation value of the River Deben is largely confined to club angling near Wickham Market (Woodbridge and District Angling Club), walking (several public footpaths cross the river although only a few run alongside it for any great length) and golf. However, Ash Abbey (converted ruins of a 12th century priory) and Easton Park Farm (a demonstration farm) are both open to the public. With no in-river recreation other than angling, the in-river needs for recreation should largely be met by adopting the measure to protect and enhance the river fishery. Maintenance of flow in the river will be of great importance in the publics perception

of the amenity and landscape value of the Deben.

30 The value of the landscape surrounding and including the River Deben is evident from its designation as a Special Landscape Area by Suffolk County Council. This designation allows the protection of this high quality landscape to be accorded priority over other planning considerations. Changes in landscape are primarily the responsibility of the farmers and landowners however land close to the river is often uneconomic to farm. Maintenance of trees and shrubs at wetlands along these watercourse margins can add appreciable to the quality of the landscape. Tier 1 of the MAFF Environmentally Sensitive Area's scheme provides a financial incentive to farmers to maintain, and in some instances restore, trees, pollarded willows and hedges using traditional methods and also to provide public access.

Recommendations

- where possible provision should be made in capital works for the replacement of lost or damaged trees, shrubs and hedgerows. Meanders should be retained and care exercised regarding the deposition of spoil;

- consideration should be given to the siting of trees as screen for river structures such as sluices and flow gauging stations;

- opportunities for increasing public access tothe Deben via the MAFF ESA scheme could be considered however the potential impacts of increased disturbance on species such as the otter would need to be weighed against the benefits to the public;

- consideration should be given to the possibility of providing a 'permissive' bankside path along the River Deben. However, planning such a scheme would need to take into account the possible impact of disturbance on key species such as the otter.

Invertebrates

Conclusions of Study

31 From the limited data available a gradual increase in invertebrate diversity is observed from sites at the top of the catchment (e.g. Debenham) to sites near Wickham Market and Ufford (e.g. Eyke Ford) including an increase in the occurrence of 'clean water' species such as mayflies and caddisflies. This increase in diversity is likely to be due to the combination of a number of factors, including:

- greater in-river plant diversity downstream of the Soham confluence;
- better water quality downstream of the confluence;
- the occurence of very low flows in the upper reaches of the Deben.

Recommendations

- sympathetic channel maintenance activities (leaving patches of in-river vegetation undisturbed, creation/retention of a variable bank and river bed profile).

- consideration should be given to river support by augmentation of the upper reaches of the Deben in drought years in order to maintain flow and water quality;

- improvements in record keeping and archiving of invertebrate data.

The Potential Environmental Benefits and Threats from the Proposed Measures to Alleviate Low Flows on the Deben

32 A number of measures have been considered by the NRA to alleviate low flows on the River Deben (Smith, 1992). Options considered include:

- do nothing;
- changes or controls on spray irrigation;
- augmentation;
- river channel management.

33 The environmental consequences of each of these options are briefly summarised below and in Table 1 and 2. Table 1 presents the key species/indicators, sites, environmental objectives and possible methods for achieving them. Table 2 presents a subjective comparison of the potential ecological benefits to the River Deben of each of these options and various combinations.

Do Nothing

34 The do-nothing option is not viewed as a preferred option from an environmental standpoint for the following reasons:

- it leaves the river ecology vulnerable during low flow periods and heavily dependant on effluent returns and the prompt use of spray irrigation bans. The river could also be deleteriously affected by changes in agricultural practice and possible long term climate change;

- it would allow the continued possibility of low flows, and drying out of the river channel, particularly in the upper reaches of the River Deben and Earl Soham watercourse. These low flow events may damage the existing ecology of the river and will limit any increase in ecological diversity.

Changes or Controls on Spray Irrigation

35 The level of spray irrigation abstraction from the River Deben is generally small in relation to river flows with the notable exception of low flow periods. When these occur surface water abstractions have the potential for critically affecting river flow, particularly in the Wickham Market area where the licences are concentrated. The problem is exacerbated by the fact that peak abstractions take place over the same period as the lowest flows (i.e. mid-summer). As a consequence historical practice has been to impose voluntary or compulsory spray irrigation bans during very low flow periods (e.g. in August 1990 and 1991).

36 Of additional concern to the NRA is the scope for an increased level of spray irrigation abstraction in the future should farming type or practices change, since there are a number of under utilised licences in existence.

37 Several options have been proposed for limiting the impact of spray irrigation including the revocation of existing licences with compensation, the replacement of surface irrigation licences with groundwater abstraction and the replacement of surface water abstraction with storage of high winter flows.

38 All three options would result in environmental benefits in the Wickham Market reach during low flow periods in terms of water quality and the additional water depth available to satisfy the in-river needs of adult fish species such as roach and dace. If accompanied by a switch to storage of high winter flows, local shallow water levels may be raised and the storage area may provide an additional wildlife resource. However, little environmental benefit of spray irrigation controls can be foreseen for either the richest ecological reach near Brandeston or the poorest reaches upstream of the confluence with the Earl Soham watercourse.

Augmentation

39 The findings of this study indicate augmentation may be a suitable support method for conserving or enhancing the flora and fauna of the Deben (particularly in upper reaches) during low flow periods.

40 With regards to aquatic flora an in-river need for a water depth of approximately 10 cm has been identified for the key species in the channel. This would require an

estimated discharge at Winston Grange (TM187622) and on the Earl Soham watercourse (TM233621) of approximately 0.01 m^3/s (this corresponds to a flow at Naunton of between 0.049 and 0.076 m^3/s). Examination of flow records calculated for these sites indicates that only in 1976 would the transposed Q95(10) have fallen below this value near Brandeston (TM250601), and in 1976 and 1990 at Winston. However, on the Earl Soham watercourse the Q95(10) flow would have fallen below 0.01 m^3/s in 1973, 1974, 1976, 1977, 1990 and 1991. It is of note that but for borehole pump testing of possibly augmentation boreholes during 1976 it is probable that significant stretches of the middle and lower river would have dried up.

41 It is therefore provisionally recommended that:

- in order to conserve the ecological value of the reach from Brandeston to Letheringham, and to potentially enhance the upper reaches of the River Deben and Earl Soham watercourse, consideration is given to augmentation of the Earl Soham watercourse (e.g. from the existing borehole site) and the upper Deben near Debenham (e.g. from Anglian Water's PWS borehole at Winston) when the flow as measured at Naunton falls below a naturalised flow of 0.076 m^3/s;

  On this basis, augmentation would have been necessary in 1973, 1974, 1976, 1977, 1990 and 1991. This augmentation trigger of 0.076 m^3/s at Naunton Hall compares to a recommended rmf of 0.057 m3/s in the Section 14 Survey Report and a value of 0.105 m^3/s suggested by Hydrotechnica (Hydrotechnica, 1993);

- should augmentation be pursued then the limitations of the above assessment should be borne in mind and it is recommended that a more thorough hydrological investigation, using detailed NRA cross-sectional information, be commissioned;

- any attempts to maintain a depth of water to benefit aquatic plants should be carried out in conjunction with sympathetic channel management practices;

- a full Environmental Assessment should be commissioned if augmentation is a pursued option. This assessment should utilise ecological data from a more recent ecological survey of the river than the 1989 SWT survey used in this study.

River Channel Management

42 Good, environmentally sympathetic river channel management has been shown by this report to be of great importance to the ecology of the river particularly for key species such as the river water dropwort, the kingfisher and the otter.

43 An opportunity exists for the NRA to increase its profile and involvement with regards channel maintenance activities and liaison with groups such as the Suffolk Wildlife Trust, The Otter Trust and the MAFF ESA representative for the Deben.

Maintain or improve. Target? Why?

Table 1 Summary of Key Species/Indicators, Sites, Objectives and Possible Methods for Achieving those Objectives for the River Deben

Environmental Receptor	Key Species/Indicators	Key Sites	Objective	Possible Method
River Plants	River water dropwort Flowering rush Wood club rush	Brandeston to Crettingham	To maintain and if possible encourage the proliferation of these scarce species	**Augmentation** - maintain water levels of at least 10 cm **Sympathetic channel management** - working from one bank; leaving patches of in-river vegetation undisturbed to act as a source for recolonisation; creation of berms and retention of cattle bays; creation/retention of a variable bank and river bed profile;
Riparian Habitats	Rare plant and bird species	Water dependant grassland County Wildlife Sites	To raise shallow water levels	**Raising shallow water levels** - Site specific methods of raising ditch water levels, NRA consultation with MAFF regarding their ESA scheme and project grant aid,
Invertebrates	Mayflies Freshwater shrimps Caddisflies	Upstream of Soham confluence	To maintain and increase diversity particularly in the upper reaches	**Augmentation** - maintain flow and water quality in the upper reaches **Sympathetic channel management** - leaving patches of in-river vegetation undisturbed to maintain habitat, creation/retention of a variable bank and river bed profile
Fish	Roach Dace Perch Pike Eels	Brandeston to Crettingham - spawning Wickham Market - deep water	To protect spawning grounds and areas of deep water needed by adult fish	**Sympathetic channel management** - protection of in-stream vegetation in spawning grounds, retention and creation of deep water areas (> 1 m). **Augmentation** - protection of in-stream vegetation in spawning grounds, retention and creation of deep water areas (> 1 m). Spray irrigation controls - protection of deep water areas in the lower Deben
Birds	Kingfisher Redshank Snipe	Ashfield to Crettingham and downstream A12 roadbridge	To increase diversity and abundance	**Sympathetic channel management** - protection of nesting cliffs and roosting sites, site specific raising of shallow water levels
Mammals	Otter Bat Water vole Shrew Barn Owl	Whole river particularly Brandeston to Glevering	Protect existing breeding and resting sites by maintaining and creating suitable habitat	**Sympathetic channel management** - protection of otter holts and resting sites, retention of cover and minimising disturbance. Protection of bat roosting sites.
Amenity, Recreation and Landscape	None.	Easton Park Farm Wickham Market	Maintain flow and protect the river fishery	**Augmentation** - maintain flow particularly downstream of Brandeston **Sympathetic channel management** - retention of character of river (e.g. trees, meanders, avoid canalisation and uniformity of habitat)
Water Quality	Dissolved oxygen Ammonia Chloride	Debenham to Ashfield Crossroads and Wickham Market	To maintain flow in the upper Deben and ensure adequate effluent dilution throughout the river	**Augmentation** - maintain flow and effluent dilution in upper reaches of Deben and Soham during drought summers **Spray Irrigation Controls** - maintain flow and effluent dilution in the lower Deben during drought summers

Which are simply good practice & which involve money?

Options ?

Table 2 Subjective Comparison of the Potential Ecological Benefits of Potential Remedial Options for the River Deben

Environmental Receptor	Augmentation	Augmentation with Enviromentally Sympathetic Channel Management	Spray Irrigation Controls	Spray Irrigation Controls with Environmentally Sympathetic Channel Management	Augmentation and Spray Irrigation Controls with Environmentally Sympathetic Channel Management
River Plants	•	•••	?	•	•••
Riparian Habitats	•	•	?	•	•
Invertebrates	•	•••	•	••	•••
Fish	•	••	•	••	•••
Birds	?	••	?	••	••
Mammals	?	•••	•	••	•••
Landscape and Amenity	•	•••	••	••	•••
Water Quality	••	••	••	••	••

••• high positive impact
•• moderate positive impact
• slight positive impact
? unknown impact (full EA required)

What about just sympathetic channel maintenance.

1 INTRODUCTION

1.1 The River Deben is a rural river in a boulder clay covered Chalk catchment rising near Debenham in Suffolk and flowing to the Deben estuary east of Ipswich. In 1993 it was identified by the National Rivers Authority (NRA) on a priority list of 40 rivers where low flows were considered a potential problem (NRA, 1993). These were rivers where problems were thought to be caused by excessive authorised abstraction rather than being due to drought.

1.2 In 1959 and 1973 the river through Wickham Market is reported as having dried up for several days although flows, due to groundwater baseflow, were still measurable downstream at Naunton Hall (AWA, 1975). During 1976 the river upstream of Debenham STW is reported to have dried up (AWA, 1983) and undated newspaper reports suggest this reoccured in either 1989 or 1990.

1.3 The NRA are in the process of appraising the low flow problem of the River Deben and an investigation into the groundwater resources of the Deben and associated management options for development has been undertaken (Hydrotechnica, 1993).

1.4 As part of a NRA (Anglian) appraisal of the feasibility and cost/benefit of possible solutions to low flows in the Deben, Southern Science were commissioned to collate and review available baseline ecological data for the freshwater reach of the river and its adjacent riparian habitat, and to identify the in-river needs of key species or habitats present.

1.5 The study area was defined in the terms of reference (NRA, 1993) as being the River Deben catchment downstream to the tidal limit of the river examining the freshwater river channel and adjacent riparian habitats.

1.6 A review of the historic and current ecological status of the river is made in Section 2 of the report. Key species within each ecological grouping (e.g. plants, birds, fish, mammals) are identified, either because of their rarity or because they are characteristic of the river. A hydrological and brief hydrogeological review is presented in Section 3, and has been used in conjunction with the ecological data to determine a series of in-river needs for key species associated with the river, Section 4. The conclusions of the study are presented in Section 5 together with recommendations and objectives for conservation and enhancement.

2 ASSESSMENT OF HISTORIC AND CURRENT STATUS OF THE RIVER DEBEN - ECOLOGICAL ASSESSMENT

Aquatic, Riparian and Wetland Species and Habitats

Sites of Nature Conservation Value Identified in the Freshwater Deben Catchment

Sites of Special Scientific Interest

2.1 One SSSI is located in the freshwater catchment of the River Deben (Figure 2.1). The Fox Fritillary Meadow, Framsden, covering 2.3 hectares, is found at the top of a one of the upper tributaries of the river to the south-east of Boundary Farm (NGR TM188606). It was first designated an SSSI in 1958 and is managed by the Suffolk Wildlife Trust (Appendix A). The site consists of a small unimproved species rich meadow situated in a valley bottom on heavy alluvial soils and is therefore likely to be sensitive to water level fluctuations. It supports the largest and best known population of snakes head fritillary (Fritillaria meleagris) in East Anglia. This plant is rare because of its limited national distribution.

2.2 A second SSSI is located at below the tidal limit of the River Deben at Bromswell Green (NGR TM295504). This possesses a mosaic of habitats including saltmarsh, reedbed, herb-rich grassland and bramble scrub, alder carr and oak/birch woodland and is managed as a Suffolk Wildlife Trust Nature Reserve.

National Nature Reserves

2.3 No National Nature Reserves as designated by English Nature (formerly the Nature Conservancy Council) are located in the River Deben catchment.

Area of Outstanding Natural Beauty

2.4 Although the freshwater reach of the River Deben is outside the designated Suffolk Coast and Heaths Area of Outstanding Natural Beauty (AONB) the reach below Melton forms its westernmost boundary. (Figure 2.1).

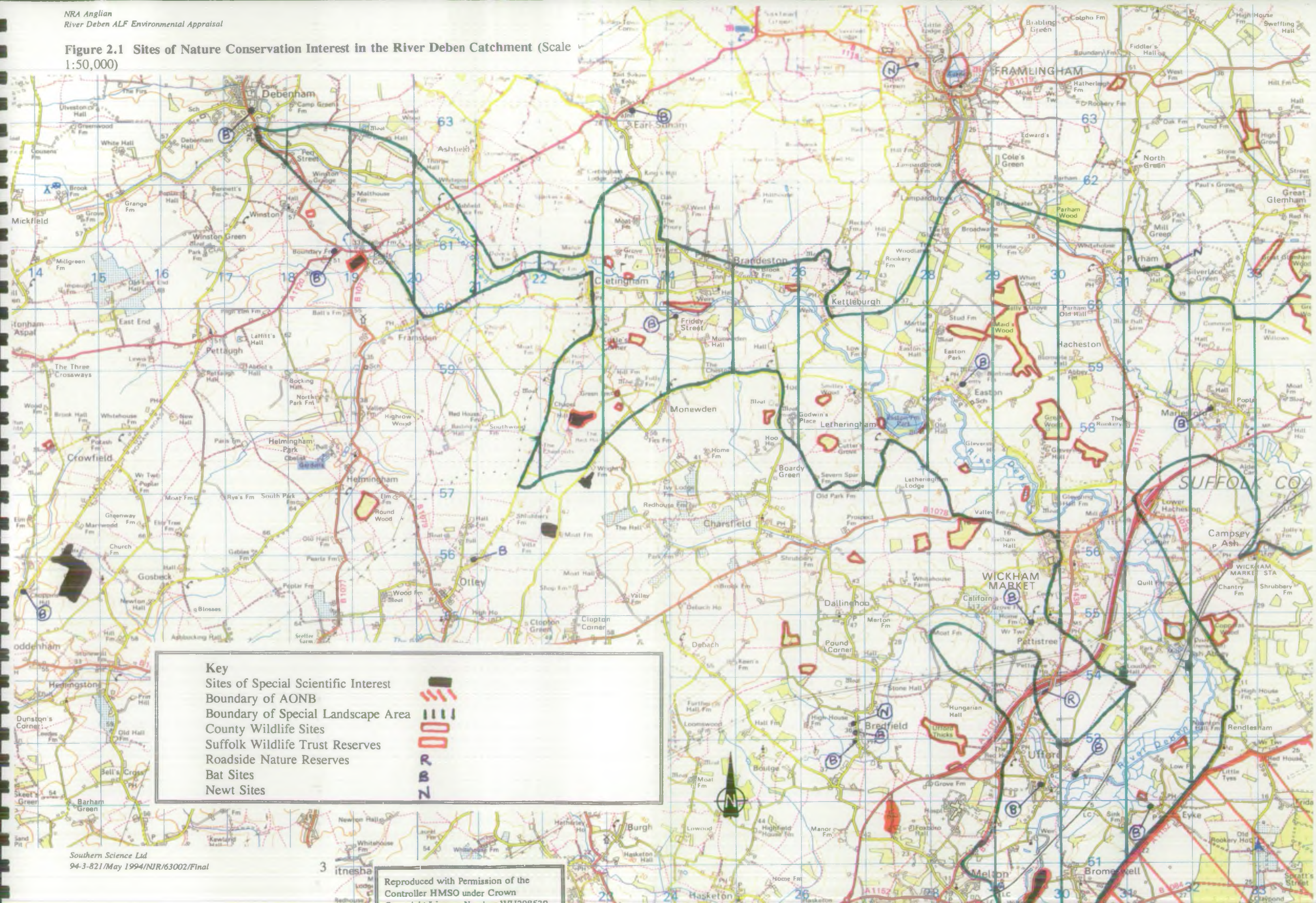
Special Landscape Area

2.5 Almost the whole of the freshwater reach of the River Deben and the lower half of Earl Soham watercourse lie within an area designated as a Special Landscape Area. The protection of this high quality landscape is accorded priority over other planning considerations.

Environmentally Sensitive Area

2.6 The River Deben falls within the Suffolk River Valleys Environmentally Sensitive Area (ESA) (Figure 2.2) as designated in the 1993 Statutory Instrument No 458 (Appendix F). The scheme is operated by the Ministry of Agriculture, Fisheries and Food through a local ADAS contact.

Figure 2.1 Sites of Nature Conservation Interest in the River Deben Catchment (Scale 1:50,000)



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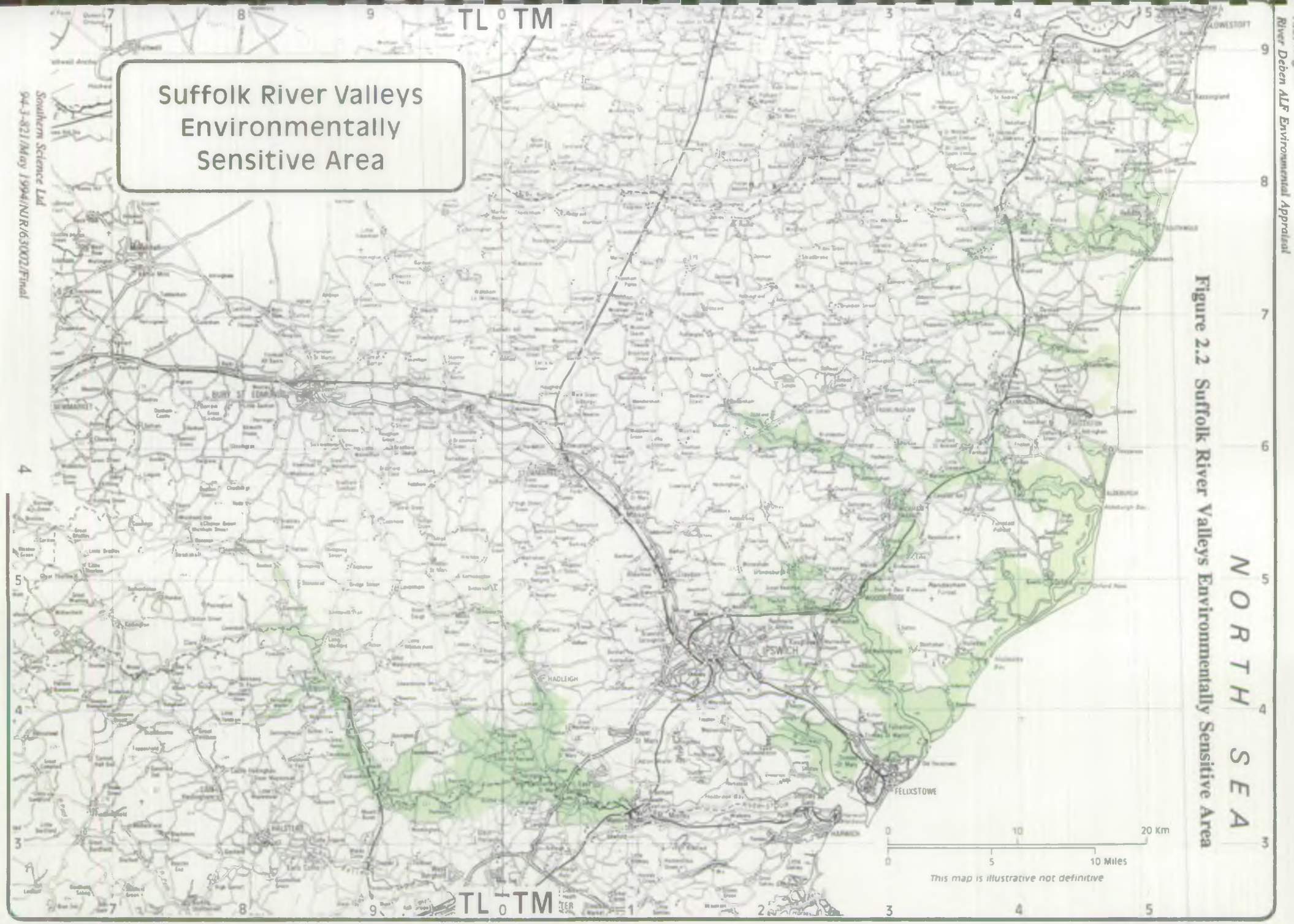

Figure 2.2 Suffolk River Valleys Environmentally Sensitive Area

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Ministry of Agriculture Fisheries and Food

SRV/ESA/7

ADAS Cartography Gloucester 1992 ADAS

2.7 An ESA is defined as:

'an area where farming practices have helped to create or protect distinctive landscapes, wildlife habitats or historic features. The purpose of the scheme is to support the continuation of these practices and to encourage measures that will enhance the environment'

2.8 Participation in the scheme is voluntary with entry into a management agreement binding for 10 years with an annual payment per hectare made to the landowner. The ESA has several tiers of entry, (Table 2.1) with each tier requiring different levels of agricultural practices for the farmer to follow. Additional payments may be made if new public access is allowed and if an optional conservation plan is adopted. This latter plan allows for grant aid for carrying out particular capital works to improve landscape, wildlife or the historic interest of the area.

2.9 Approximate areas of land within the various tiers of the Suffolk River Valleys ESA scheme are presented in Figure 2.3. It can be seen that participation in the scheme is spread across the river valley of the Deben with the majority of the riparian habitat of the river near Wickham Market entered into Tier 1 agreements. The reaches from Easton to Wickham Market and from Brandeston to Kettleburgh are well represented on the scheme and include several areas that have reverted to grassland from arable.

2.?? Of importance to this study are the ESA entry criteria relating to water management, for example the Tier 2 criteria for ditch water level maintenance and the provision of grants for the creation of water penning devices and ponds. These features of the scheme present an opportunity for raising shallow water levels in the River Deben catchment.

Figure 2.3 Approximate Areas of Land within the Various Tiers of the Suffolk River Valleys Environmentally Sensitive Area

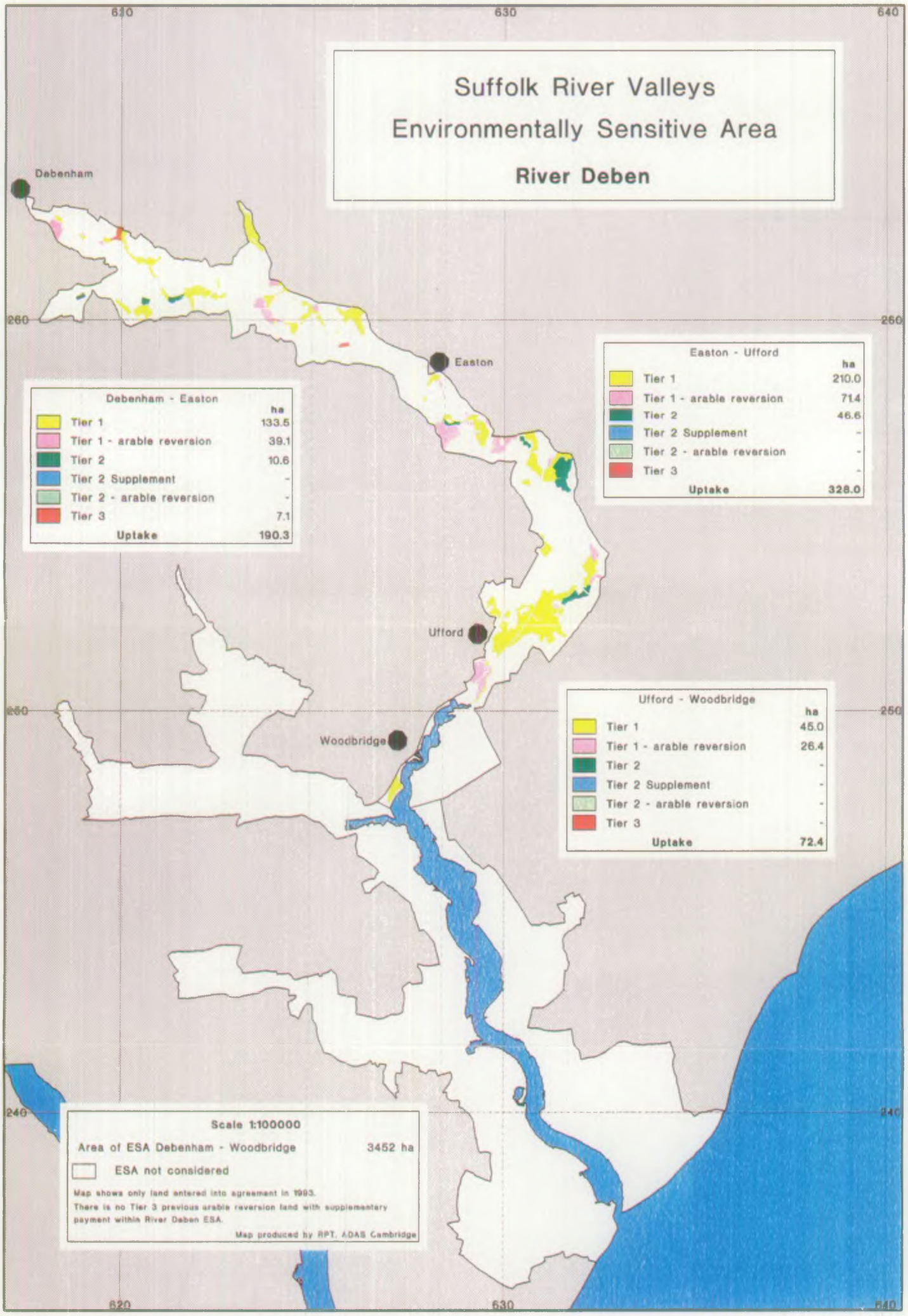

Table 2.1 Suffolk River Valleys Environmentally Sensitive Area Tier Criteria Relevant to this Study

Tier 1 - Grassland (this is the normal entry tier):

- maintain grassland and do not plough, lever or re-seed the land. Graze with livestock other than pigs or poultry;
- do not use insecticides or fungicides. Do not apply herbicides except to control certain listed species;
- maintain existing ditches and dykes and do not remove hedges, banks or parts thereof;
- do not damage destroy or remove any feature of archaeological or historic value or interest;
- do not install underdrainage or mole drainage and restricting the modification or improvement of the existing drainage system so as to bring about improved drainage;
- maintain trees, pollarded willows, ponds and reedbeds using traditional methods.

Tier 2 - Low Input Grassland (entry requires satisfaction of tier 1 criteria plus the following additional criteria)

- do not graze between 1 April and 15 May where the land lies of a flood plain or is inherently wet;
- where the land lies on the flood plain or is inherently wet water levels should be maintained at not more than 45 cm below marsh level from 31 March to 31 October. At least 30 cm of water should be provided at the bottom of ditches between 31 October and 1 March and water levels should be raised no later than 1 March to achieve the required summer freeboard as early as possible.

Tier 2A - Marshland (builds on the requirements of tier 2 and includes the following additional criteria)

- begin to raise water levels to the winter level no later than 1 November and to maintain the water table at marsh level between 1 January and 30 April.

Tier 3 - Arable Reversion to Grassland (criteria are as for tier 1 with certain exceptions in the first year)

Public Access Tier - applications to this tier are assessed against the criteria of situation and accessibility.

Conservation Plan Capital Works - grants are available to a maximum percentage of scheme casts for capital works including restorations of ponds (50%), provision of water penning devices and other structures to control water levels (80%), restoration of ditches and dykes (30%) and the restoration of reedbeds and sedgebeds (50%).

County Wildlife Sites

2.10 A total of 37 County Wildlife Sites have been notified in the River Deben catchment (Table 2.2 and Figure 2.4). These sites have been selected by Suffolk Wildlife Trust in conjunction with Suffolk County Council, English Nature and the Suffolk Biological Records Centre as being **currently unprotected** sites of county, regional or national conservation importance. The sites were chosen using the following evaluation criteria (SWT, 1991):

- Non-recreatability and naturalness (e.g. ancient woodlands and ancient unimproved grasslands);
- Diversity and the presence of indicator species (in general diversity is viewed positively as it increases, the presence of a number of indicator species qualifies a site for inclusion as a County Wildlife Site);
- Rarity (locally, regionally or nationally rare species, nationally rare or scarce species as defined by the British Red Data Books, sites which support species specially protected by the Wildlife and Countryside Act, 1981);
- Potential value (contentious and rarely applied criteria usually only used where a valuable habitat has suffered a 'set-back' through adverse use or neglect);
- Position in county (a borderline site may be selected where it is in an area of little other conservation value).

2.11 Of the 37 sites within the Deben catchment 12 sites have been identified by the NRA and SWT as being water dependant sites. These are marked with an asterisk in Table 2.2. These water dependant sites range in size from 0.1 to 7.0 hectares and include the River Deben itself from Brandeston to Wickham Market (NGR TM246600 - 296566). Descriptions and site maps of water dependant County Wildlife Sites are presented in Appendix A.

2.13 For the 12 water dependant sites an assessment is made, in Section 3 of this report, of the potential for habitat enhancement via controlling the shallow water table.

Figure 2.4 Location of Water Dependant County Wildlife Sites (Scale 1:50,000)

Site Number	Name	National Grid Reference	Habitat
3 *	John Read's Plantation	TM205637	Mixed habitat
6 *	Grove Farm Golf Course	TM231607	Species rich grassland
12 *	Low Nursery	TM246608	Alder carr
13 *	Home Farm Meadow	TM243600	Species rich wet meadow
19 *	Letheringham Meadow	TM273582	Open water/Species rich meadow
24 *	Wood ad. to River Deben	TM285573	Alder carr
28 *	Rowanwood Cottage Marsh	TM294537	Species rich wet grassland
29 *	Boon's Meadow	TM297532	Species rich wet grassland
32 *	Lower Hacheston Meadow	TM318567	Species rich wet meadow
35 *	Decoy Pond	TM317546	Open water
36 *	Eyke Meadow	TM317528	Species rich wet grassland and dykes
37 *	Reves Hall Meadow	TM314519	Species rich wet grassland and dykes

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Table 2.2 Location and Brief Description of County Wildlife Sites

Site No	Name	National Grid Reference	Habitat
1	Aspall Wood	TM177656	Ancient woodland
2	Debenham Meadow	TM189641	Species rich grassland
3 *	John Read's Plantation	TM205637	Mixed habitat
4	Page's Wood	TM207637	Ancient woodland
5	Round Wood	TM193567	Ancient woodland
6 *	Grove Farm Golf Course	TM231607	Species rich grassland
7	The Spong	TM241608	Species rich grassland
8	Monewden Green	TM230595	Species rich grassland
9	Jope Cottage Meadow	TM232586	Species rich grassland
10	Kiln Wood	TM232583	Ancient woodland
11	Brandeston Chapel Cemetery	TM241608	Species rich grassland
12 *	Low Nursery	TM246608	Alder carr
13 *	Home Farm Meadow	TM243600	Species rich wet meadow
14	Hoo Wood	TM258603	Ancient woodland
15	Smilley Wood	TM264585	Ancient woodland
16	Cutters Grove	TM264572	Ancient woodland
17	Dallinghoo Wood	TM258546	Ancient woodland
18	Dallinghoo Wield Wood	TM261541	Ancient woodland
19 *	Letheringham Meadow	TM273582	Open water/Species rich meadow

Note: * = water dependant County Wildlife Site

Table 2.2 cont. Location and Brief Description of County Wildlife Sites

Site No	Name	National Grid Reference	Habitat
20	Old Park Wood	TM273573	Ancient woodland
21	Page's Covert	TM269559	Ancient woodland
22	Home Covert	TM279561	Ancient woodland
23	Potsford Wood	TM286563	Ancient woodland
24 *	Wood ad. to River Deben	TM285573	Alder carr
25	Maid's/Brockley and Ash Woods	TM293596	Ancient woodland
26	Ufford Thicks	TM281532	Ancient woodland
27	Round Grove	TM284526	Ancient woodland
28 *	Rowanwood Cottage Marsh	TM294537	Species rich wet grassland
29 *	Boon's Meadow	TM297532	Species rich wet grassland
30	Great Wood	TM299582	Ancient woodland
31	Catt's Wood	TM305576	Ancient woodland
32 *	Lower Hacheston Meadow	TM318567	Species rich wet meadow
33	The Oaks	TM318553	Ancient woodland
34	Copperas Wood	TM325547	Ancient woodland
35 *	Decoy Pond	TM317546	Open water
36 *	Eyke Meadow	TM317528	Species rich wet grassland and dykes
37 *	Reves Hall Meadow	TM314519	Species rich wet grassland and dykes

Note: * = water dependant County Wildlife Site

Natural Area Profiles

2.14 Natural Area Profiles of England and Wales are currently being drawn up by English Nature. A draft copy for the area covering the freshwater Deben, the East Anglian Plain, was obtained (English Nature, 1993). The main nature conservation features of this area are identified as:

a) a large number of small ancient semi-natural coppice woods,
b) scattered mesotrophic grasslands including hay meadows,
c) mires and valley fens,
d) ponds containing Great Crested Newts
e) river communities and associated unimproved and improved wetlands and grasslands that make an important contribution to the landscape and provide good feeding areas for bats and barn owls.
f) large prairie fields with remnant hedges
g) soft rock exposures in pits and quarries.

2.15 High biodiversity areas are identified as the fens at the head of the Waveney and Little Ouse valleys.

2.16 The profile covering the freshwater reach of the River Deben identifies a need for a review of current water abstraction licences and rights and the restoration of derelict or neglected ponds.

Roadside Nature Reserves

2.17 The location of roadside nature reserves as identified by Suffolk County Council are shown on Figure 2.1. Only one is marked and this is located beside the A12 approximately 1 km north of Ufford.

Bat and Newt Sites

2.18 The locations of known bat and newt sites as identified by Suffolk County Council are shown on Figure 2.1. There are 15 of the former sites of which 6 sites lie within 1 km of the river. There are 3 newt sites none of which are within 1 km of the river.

Ecological Surveys of the River Deben

2.19 Two detailed ecological surveys of the River Deben have been carried out and have been used as reference material in this study. The first was carried out by the Nature Conservancy Council in the summer of 1981 (NCC, 1981) and the second by the Suffolk Wildlife Trust in 1989 (SWS, 1989). With the exception of these two reports there is very little ecological survey information available for the River Deben other than the fisheries and invertebrate records held by the NRA.

2.20 The NCC survey covers the river from the Ashfield crossroads (NGR TM203615) to

Wilford Bridge (NGR TM295505) and divides the river into 1 km reaches. For the purposes of this study, reach numbers from this survey have been converted to reach numbers from the Suffolk Wildlife Trust survey below.

2.21 The SWT survey covers the river from the north-west of Debenham (TM159636) to Wilford Bridge (TM295505) and divides the River Deben and the Earl Soham watercourse into 57 x 0.5 km reaches (Figure 2.5).

2.22 Where possible the two reports have been compared so that changes in aquatic, riparian and wetland species can be discerned. However, it must be recognised that differences will exist between the two reports in terms of their survey methodologies, thoroughness and reporting style.

Macrophytes Associated with the River Deben

Macrophyte Species Recorded

2.23 The aquatic and non aquatic plants listed in Table 2.3 were recorded as occurring in almost every reach of the river (< 80 %) in the 1981 or 1989 survey whilst those recorded only occasionally (< 5 %) are presented in Table 2.4.

Figure 2.5 Reach Divisions used in the Suffolk Wildlife Trust Survey of 1989 (Scale 1:50,000)

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Table 2.3 Macrophytes Occurring in Most Reaches (>80%)

Species		1981 Survey	1989 Survey
Nuphar lutea	Yellow Water Lily	●	●
Callatriche sp.	Starwort	●	●
Agrostis stolonifera	Creeping Bent	●	●
Sparganium emersum	Bur-Reed	●	●
Lemna minor	Common Duckweed	●	
Veronica anagallis-aquatica	Blue Water Speedwell	●	●
Rorippa nasturtium-aquaticum	Watercress	●	●
Apium nodiflorum	Fools Water-Cress	●	●
Berula erecta	Lesser Water Parsnip	●	
Phalaris arundinaceae	Reed Canary Grass		●
Phragmites australis	Common Reed		●

Table 2.4 Macrophytes Occurring in Some Reaches (<5%)

Species		1981 Survey	1989 Survey
Oenanthe fluvitilis	River Water Dropwort	●	●
Butomus umbellatus	Flowering Rush	●	●
Scirpus sylvaticus	Wood Clubrush	●	●
Scirpus lacustris	Common Clubrush	●	
Rorippa amphibia	Great Yellow Cress	●	●
Iris pseudacorus	Yellow Flag Iris	●	●
Alisma plantigo-aquatica	Water Plantain	●	●
Potamogeton natans	Broad Leaved Pondweed	●	●
Potamogeton alpinus	Red Pondweed	●	
Ranunculus sceleratus	Celery Leaved Buttercup	●	
Elodea canadensis	Canadian Pondweed	●	●
Nymphaea alba	White Water Lily	●	●
Juncus effusus	Soft Rush	●	●
Carex acutiformis	Lesser Pond Sedge	●	●
Carex riparia	Greater Pond Sedge	●	●
Mentha aquatica	Water Mint	●	●
Phalaris arundinaceae	Reed Canary Grass	●	●
Myosotis scorpioides	Water Forget-Me-Not	●	●
Lythrum salicaria	Purple Loosestrife	●	●
Sagittaria sagittifolia	Arrowhead		●
Scrophularia auriculata	Water Figwort		●
Hippuris vulgaris	Mare's Tail		●

Macrophyte Diversity

2.24 Suffolk Wildlife Trust (1993) have ascribed plant diversity scores to the 0.5 km reaches of the River Deben (as surveyed in 1989). The reaches with the greatest plant diversity (>25 species) and the lowest plant diversity (< 10 species) are shown in Figure 2.6. All reaches on the Earl Soham watercourse were of low diversity.

River Classification

2.25 The two surveys produced very comparable species lists with the plant community present being characteristic of an **'A group'** river community (Holmes, 1983). Holmes described A Group communities as typical of lowland, nutrient rich sites. Holmes further sub-classified the Deben as possessing **A1** and **A4** plant communities and this was confirmed in the 1989 survey. Holmes (1983) and SWT (1989) further identified two typical sub-communities, **A4ii** and **A1iv** descriptions of which are provided below.

2.26 A4ii - Impoverished intensively managed clay ditches:

> The upper reaches of the Deben and the Soham above their confluence possess plant communities that are characteristic of the extreme upstream reaches of clay rivers with narrow channels (< 5m width) and steep, high sided banks which are physically uniform. Such communities are usually in reaches subject to intense management including dredging and re-profiling. The typical clay ditch community has few characteristic indicator species and, in general, the flora is impoverished (Holmes, 1983) with virtually all species present examples of flora that are widespread and tolerant of a wide range of habitats.

2.27 A1iv - Mixed sand/clay and peat substrates with a good water quality partly derived from calcareous groundwater:

> Downstream of the Earl Soham confluence the river typically supports the rare A1iv community. This classification group is small and its main features are mixed sand, clay and fenland peat substrates within a channel about 10 metres wide. The group is characteristic of rivers with calcareous water, often partly derived from chalk aquifers, which flow through flat country ensuring a slow water velocity. The substrates usually comprise silts, sands and very fine gravels and the catchments are intensively farmed. Water quality is good and is derived partly from calcareous groundwater. The most common species are mare's tail, red pondweed, butter-bur. Others include the submerged calcareous water lover river water dropwort, the floating pondweed and the common reed. The dominance of the yellow water lily is indicative of the importance of clay. This group is characteristically species rich.

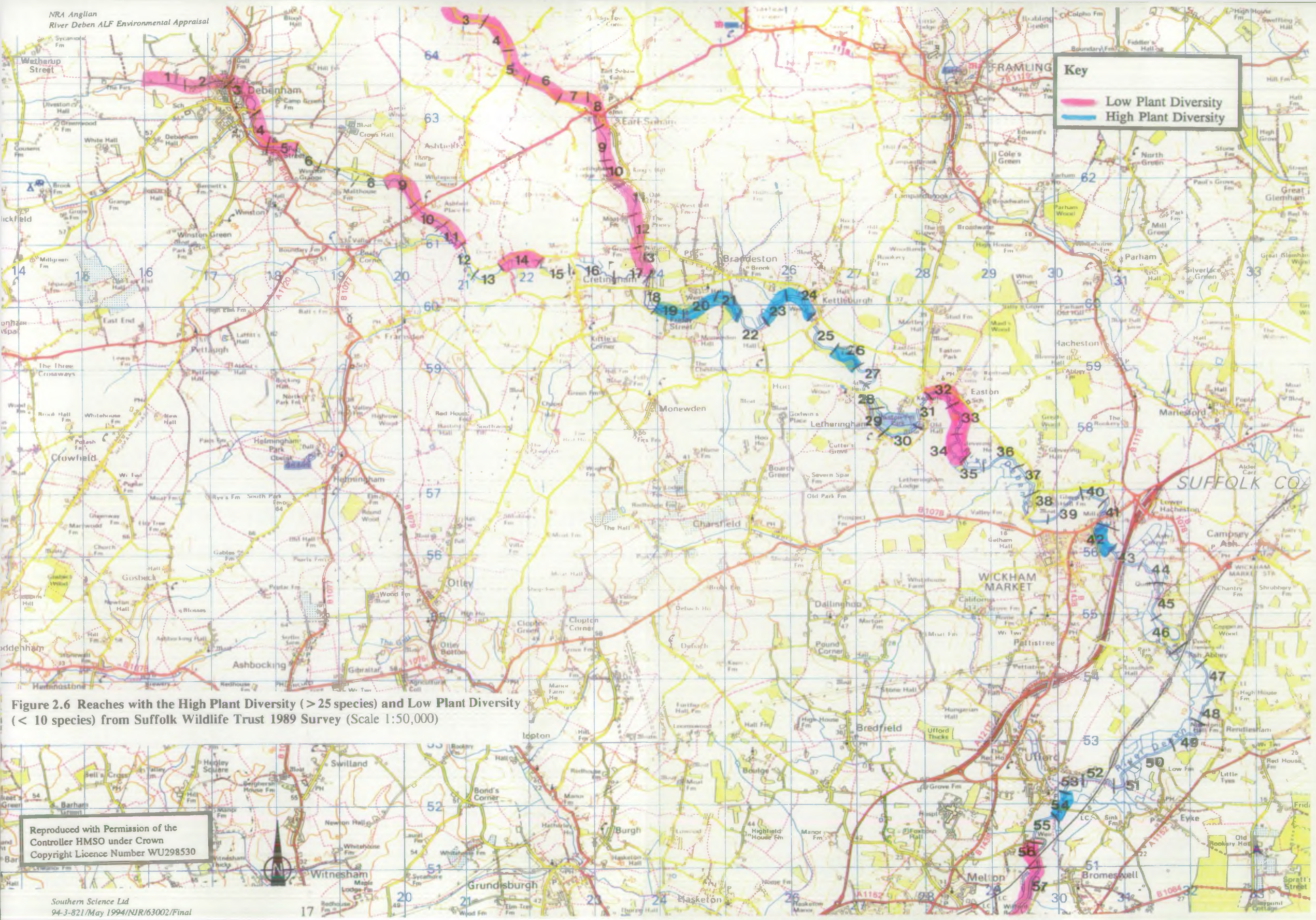

Figure 2.6 Reaches with the High Plant Diversity (> 25 species) and Low Plant Diversity (< 10 species) from Suffolk Wildlife Trust 1989 Survey (Scale 1:50,000)

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Records of Rare Species

2.28 No macrophytes as listed under Schedule 8 of the Wildlife and Countryside Act (1981) were recorded on either the 1981 or 1989 surveys. Additionally, no Red Data Book Species (those species recorded in 15 or less 10x10km squares in Great Britain) were recorded.

2.29 One nationally scarce (those species recently recorded in between 16 and 100 10x10 km squares in Great Britain and which are in need of special protection in the Anglian Region) species is found in both the 1981 and 1989 survey, Oenanthe fluviatilis - the river water dropwort, was recorded in the Deben on both surveys.

2.30 Two regionally scarce species (Simpson, 1983) were recorded on both surveys. They were the flowering rush (Butomus umbellatus) and the wood club-rush (Scirpus sylvaticus).

2.31 The location of these nationally and regionally scarce macrophyte species as recorded on the 1981 and 1989 surveys are presented in Table 2.5. A decline in distribution is evident and possible reasons for this will be discussed later in the report.

Table 2.5 Location of Nationally and Regionally Rare Aquatic Macrophytes as Recorded in the 1981 and 1989 Surveys

	Oenanthe fluvitilis		Butomus umbellatus		Scirpus sylvaticus	
Reach (SWT, 1989)	1981	1989	1981	1989	1981	1989
1						
2						
3						
4						
5						
6						
7						
8						•
9						
10						
11						
12					•	
13						
14						
15						•
16						
17	•		•			•
18	•		•			
19	•	•	•			
20	•	•	•	•		
21	•		•			
22	•		•			
23	•	•				
24	•	•	•			
25	•		•	•		
26	•	•	•			
27	•		•			
28	•					
29						
30	•					
31	•					
32	•					
33	•					
34	•					
35	•					
36	•					
37	•					
38	•					
39	•					
40	•					
41	•			•		
42	•	•				
43	•					
44	•					
45	•					
46	•					
47	•					
48	•					
49	•					
50	•					
51	•					
52	•					
53	•			•		
54						
55						
56						
57						

Reaches of the River Deben Identified as being of Conservation Value

2.32 A number of reaches were identified on the **1981** survey as being of conservation value for their macrophytes, as follows.

1) From Friday Street (NGR TM242599) to Letheringham (TM276579)

Although not considered the best reach in terms of aquatic vegetation due to shading, some high interest areas were identified at the top end and in the middle of the reach. The surrounding land use is reported as being of interest with good rough grassland and meadow sites.

2) From Letheringham (NGR TM276579) to Glevering Hall (TM296565)

This reach was surveyed in detail in 1981 and was considered to possess a good range of physical characteristics and aquatic vegetation. Dredging was considered to be a threat and the bank flora was reported as having been damaged by river management with water forget-me-not a frequently observed coloniser. The typical clay river species starwort and yellow water lily dominate the channel with reed and club-rush occasionally present. Species more indicative of a chalk influence include mare's tail, narrow leaved water parsnip and river water dropwort. This reach of the Deben was considered to be very species rich despite management pressures with a high diversity.

3) From Quill Farm (NGR TM316552) to Ufford (TM307523)

This reach was considered to be the best from a combined land use and diversity standpoint. The river in this reach was reported as having a wider variety of physical characteristics than any other reach with deep and shallow water, silty sandy and stony substrates. This has resulted in a good diversity of aquatic flora.

2.33 A number of reaches were identified on the **1989** survey as being of high conservation value by virtue of the diverse aquatic flora they support, as follows:

1) From Friday Street (NGR TM240599) to downstream of Brandeston College (NGR TM251601)

Flow restriction due to bridges in this reach were reported as causing several deep pools (1.5 - 2.0 m deep). The water was clear with fish, damselflies and dragonflies observed. Canadian pondweed, curled pondweed, unbranched bur-reed and arrowhead were present along with flowering rush and white water lily which are uncommon on Suffolk rivers. Poached shelves provided suitable conditions for lesser water parsnip, gypsywort and water speedwell.

2) From upstream of Kettleburgh Bridge to Kettleburgh Bridge (NGR TM264598)

Water quality was reported as being good with fish present in large numbers. Dragonflies and damselflies were present. A good diversity of aquatic flora was observed including river water dropwort, white water lily, mare's tail, starwort, water speedwell and water plantain.

3) The reach upstream of Low Farm, Kettleburgh (NGR TM267593 - 270591)

The 1989 survey reports flowering rush growing abundantly in mid-channel with bulrush. River water dropwort was also abundant and a poached shelf supported gypsywort, water speedwell, water plantain and lesser water parsnip.

4) Letheringham Mill (NGR TM280580)

A sandy substrate was reported as supporting a floating mat of water cress, unbranched bur-reed and starwort.

5) Reach from NGR TM297569 - 296566

River margins and associated dykes were reported as being particularly rich in species including mare's tail, water plantain, water speedwell and purple loosestrife. Horned pondweed and fennel leaved pondweed were also present.

6) Decoy Pond (NGR TM318547)

White water lily and yellow water lily were both reported as growing in the lake and although it was not surveyed, it was considered likely that it supported a good aquatic flora (SWT, 1989).

Woodland Associated with the River Deben

Woodland near the River Deben

2.34 The 1989 SWT survey reports that there are a number of semi-natural woodlands with a scattered distribution near (i.e. greater than 10 m distant) the River Deben. The larger areas are situated adjacent to the Deben between Debenham and Crettingham particularly downstream of the A1120 roadbridge, both sides of the river near Brandeston College, between Glevering Mill and Wickham Market and around the decoy pond at Ash Abbey. Deciduous woodlands along the Deben consist mainly of species such as Alder, Willow and Ash with occasional Sycamore, Poplar and Oak. These woodlands tend to be of an open structure with a scrub layer comprising small pockets of hawthorn, blackthorn and elder scrub.

2.35 Glades within woodland support a diverse tall fen community including species such as hemp agrimony, ragged robin and purple loosestrife. Many of the Deben's woodlands provide an important habitat for breeding birds and the close proximity of water is of use for feeding, bathing and drinking. As to be expected the diversity of birds observed near wooded reaches is far higher than in sections with less cover.

2.36 A number of plantations are situated alongside the River Deben, for example between Easton Park Farm and Letheringham Mill. The majority of plantations are of poplar although some are planted with cricket bat willow. They tend to have an undeveloped scrub layer dominated by nettle and are of limited botanical value. Where trees have fallen the resultant glades provide opportunities for an increase in diversity.

Woodland in the Immediate Vicinity of the River Deben

2.37 The 1981 survey reports that bat willow is the predominant tree species in the immediate vicinity (i.e. within 10 m) of the river with poplar occasionally present. There was little alder carr although most woodland had some alder present.

2.38 In the 1989 survey the majority of the Deben was reported as being fringed with pockets of scrub or shaded by mature trees. Through intensively farmed areas (e.g. between Ash Abbey and Eyke) tree and scrub cover has been removed leaving scattered shrubs and isolated trees.

2.39 Scrub alongside the Deben is mostly blackthorn, elder, hawthorn and sallow and is particularly abundant between Debenham and Fen Street. Blackthorn scrub (and occasionally hawthorn scrub) is mostly found on the tops of banks overhanging the channel.

2.40 Most mature trees along the Deben are alders, white or crack willow, ash and occasional poplar and sycamore. A number of trees particularly near Kettleburgh were reported as requiring pollarding. Tree species recorded on either survey are listed in Table 2.6.

Table 2.6 Tree Species Observed Along the River Deben in the 1981 and 1989 Surveys

Alnus glutinosa	Common Alder
Fraxinus excelsior	Ash
Sambricus niger	Elder
Fagus sylvatica	Common Beech
Quercus robur	Oak
Salix alba	Cricket Bat Willow
Acer pseudoplatanus	Sycamore
Crataegus monogyna	Hawthorn
Salix fragilis	Crack Willow
Salix caprea	Goat Willow
Salix viminalis	Osier Willow
Aesculus hippocastanum	Horse Chestnut
Acer campestre	Field Maple
Populus sp.	Poplar
Ulmus sp.	Elm
Corylus avellaria	Common Hazel

Grassland Associated with the River Deben

Improved Grassland

2.41 The majority of grassland adjacent to the River Deben is agriculturally improved (SWT, 1989) and is characteristically dominated by perennial rye grass. Most of the meadows are grazed by cattle however on the fringes of villages (e.g. Earl Soham and Debenham) there is a higher proportion of horse paddocks.

Semi-Improved Grassland

2.42 A number of meadows close to the River Deben were recorded as being semi-improved (SWT, 1989). Although not considered to be of high conservation value they supported a richer flora than the majority of grasslands in the Deben valley. These semi-improved meadows include:

NGR TM181617 - a small area of horse grazed grassland. Species such as sorrel, oxeye daisy, birds foot trefoil and goat's beard were present.

NGR TM209609 - a small area of unmanaged grassland behind a willow plantation situated adjacent to the river. Species of interest include cowslip, meadow vetchling and crosswort.

NGR TM236607 - an unmanaged area of wet grassland with a reasonably diverse flora including ragged robin, greater birds foot trefoil and false fox sedge.

Herb Rich Meadows

2.43 A number of unimproved, herb rich meadows were located and surveyed in 1989 and were reported to be of high conservation value. Unimproved wet meadows are important wader breeding sites during the summer and as sheltering or breeding sites in the winter.

NGR TM258602 - a cattle grazed meadow at the top of a slope dominated by sedges including lesser pond sedge, distant sedge glaucous sedge and false fox sedge. Cuckoo flower, marsh marigold and ragged robin were also present.

NGR TM273582 - an interesting area of wet grassland situated between a poplar plantation and two artificial ponds. A number of uncommon species were recorded in this area in 1989 including skullcap, southern marsh orchid, yellow rattle and valerian.

NGR TM316527 - spring fed cattle grazed wet meadows on the edge of the flood plain supporting a wide range of wet meadow species including valerian, southern marsh orchid, meadow saxifrage and oval sedge.

NGR TM296504 - small areas of herb rich grassland which form part of the Suffolk Wildlife Trust Reserve, Bromswell Green, close to the River Deben upstream of Wilford Bridge. Species of interest include southern marsh orchid, lesser spearwort and fen bedstraw.

Fen Vegetation Associated with the River Deben

2.44 Small pockets of fen vegetation are scattered along the River Deben. In their 1989 report SWT consider the water table to be too low to maintain a diverse flora, with plants such as hairy willow herb dominating the community. These areas were considered to be of high importance to bird species such as sedge and reed warbler and reed bunting.

NGR TM196619 - a small unmanaged area adjacent to the river. Species of note include angelical, marsh marigold, lesser pond sedge and false fox sedge.

NGR TM297572 - small glades within open woodland colonised by hemp agrimony, reed, purple loosestrife, angelica and meadowsweet.

NGR TM316555 - fen vegetation surrounds a number of ponds associated with Quill Farm. Plants recorded as being of interest included water figwort, purple loosestrife, hemp agrimony and marsh woundwort.

Tall Herb Vegetation Associated with the River Deben

2.45 Most sections of the Deben were reported in 1989 as supporting tall herb communities along the river banks or in small areas adjacent to the watercourse. Nettle and

hemlock were abundant along with butterbur, comfrey, dock, thistle and goose grass. These plants provide a useful source of seed for birds and cover for mammals however they may exclude less common plants.

Birdlife Associated with the River Deben

2.46 Consultations by Southern Science have shown that the only detailed source of ornithological data for the freshwater River Deben corridor was that collected by the SWT for their 1989 survey. The data were compiled from up to five visits to each section through the breeding season.

Species Diversity

2.47 The number of species recorded per 500 m reach was recorded by SWT (1989). Reaches with greater than 30 species were classed as high diversity and reaches with less than 20 species as low diversity. The findings are summarised in Figure 2.7.

Bird Rarity

2.48 Table 2.7 presents the locations where nationally and regionally rare or scarce bird species were recorded on the 1989 survey.

2.49 Three nationally rare species as classified by Schedule 1 of the Wildlife and Countryside Act (1981) were recorded in the 1989 survey. They were the barn owl, little ringed plover and the kingfisher.

2.50 Three nationally scarce species (Red Data Book) were recorded on the Deben. They were redshank, teal and shelduck.

2.51 One regionally scarce species was recorded on the Deben, the snipe.

2.52 It can be seen from Table 2.7 that the lower reaches of the River Deben support the greatest number of rare species, particularly those species associated with estuarine and coastal habitats.

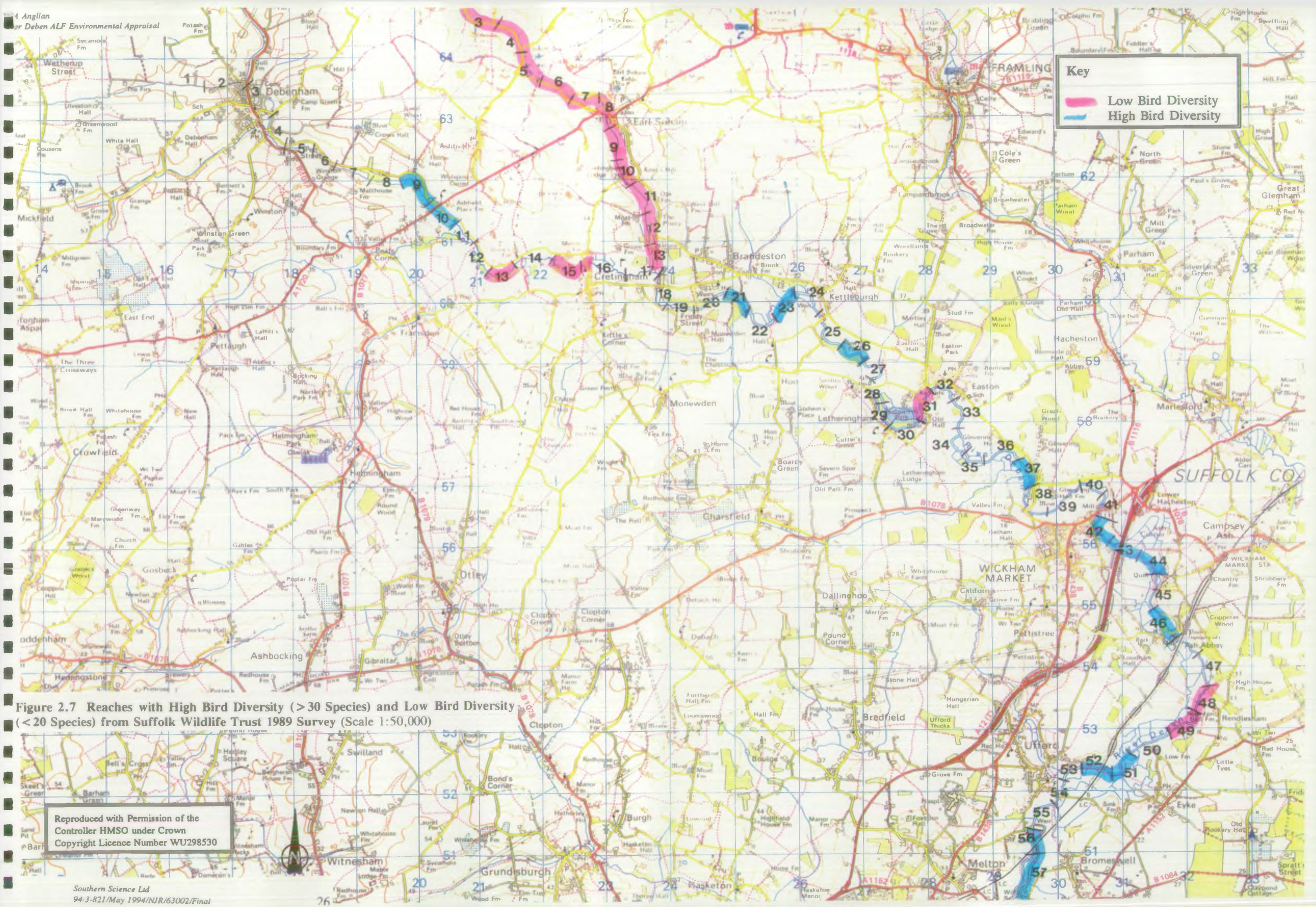

Figure 2.7 Reaches with High Bird Diversity (>30 Species) and Low Bird Diversity (<20 Species) from Suffolk Wildlife Trust 1989 Survey (Scale 1:50,000)

Table 2.7 Location of Nationally and Regionally Rare or Scarce Birds as Recorded in the 1989 Survey (SWT, 1989)

Reach (SWT, 1989)	Barn Owl Nationally Rare	Kingfisher Nationally Rare	Little Ringed Plover Nationally Rare	Shelduck Nationally Scarce	Teal Nationally Scarce	Redshank Nationally Scarce	Snipe Regionally Scarce
1							
2							
3							
4							
5							
6							
7							
8							
9							
10	•	•					
11							
12							
13							•
14							
15	•						
16							
17							
18							
19							
20		•					
21							
22							
23							
24		•					•
25	•						
26	•						
27							•
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35							
36							
37					•		
38							
39		•					
40							
41							
42							
43					•		
44		•		•			
45				•			
46	•						•
47		•		•			
48					•		
49				•			
50							
51		•		•		•	
52				•		•	
53							
54							
55		•					
56		•	•	•		•	
57		•	•	•		•	

2.53 Using a modified version of a scoring system devised by the NCC (1989) to identify sites qualifying for SSSI status, the SWT (SWT, 1993) assessed the relative importance of the various sections of the river to breeding bird communities. The results are presented in Table 2.8 below and confirm that the lower reaches of the Deben are of greatest conservation importance to breeding birds.

Table 2.8 Breeding Bird Scores for the River Deben (after SWT, 1989)

Reach	Breeding Score	Number of Scoring Species
Upper Deben (1-17)	34.5	22
Mid-Deben (18-41)	64.5	35
Lower Deben (42-57)	83.0	40
Earl Soham watercourse	0	0

Mammals of the River Deben

2.54 Very few records of mammals exist in connection with the River Deben. Suffolk Wildlife Trust (1993) have reviewed county-wide survey data from the Suffolk Naturalists Society and made an evaluation based upon the following criteria:

National rarity

2.55 These are species protected under the Wildlife and Countryside Act (1981). In Suffolk species of national rarity known to occur include the otter, all species of bat, the dormouse and the red squirrel.

2.56 The only nationally rare species known to be present are the otter and bat. One male and two female otters bred by the Otter Trust were released to the River Deben near Easton (NGR TM271589) on 30/6/93. Post release monitoring of these animals has shown that they have settled down and are thriving and the Trust are confident that in due course they will breed successfully. It was thought that prior to this release the otter had been absent from the Deben for between 10 and 15 years.

County rarity

2.57 These are species recorded in less than fifty 2km^2 tetrads and for the River Deben would include the pygmy shrew, water vole, yellow necked mouse, common seal (bats not included). The pygmy shrew, water vole and yellow necked mouse have all been recorded in association with the River Deben with numerous water vole tunnels recorded in the 1989 SWT survey.

Fisheries of the River Deben

Fishing Clubs

2.58 The Woodbridge and District Angling Club fish the River Deben from Glevering Bridge to Wickham Market road bridge and from Wickham Market road bridge to the A12 road bridge. Consultation by Southern Science with club members indicates that the river fishes well for roach. Concerns were raised about water levels just upstream of the A12 roadbridge being allowed to drop to avoid flooding and the potentially adverse effects this may have in isolating breeding fish populations.

2.59 The club have organised stocking of gudgeon, tench and carp as well as electrofishing of pike near Wickham Market in recent years. Additionally, approximately 60 chub were also introduced in the 1993/94 season.

2.60 Fishing rights along the rest of the river are in the hands of the riparian owners who will usually permit access to the river by anglers.

NRA Fish Surveys

2.61 Data from three NRA fish surveys of the freshwater reaches of the River Deben were collected. Surveys were conducted in 1984, 1987 and 1991 at between 9 to 12 sites, from Crettingham to Melton, using pulsed d.c. electrofishing with quantitative estimates of the number of fish present made be successive removal. The location of the survey sites is shown in Figure 2.8.

Capture Frequencies

2.62 Details of the relative proportions of fish caught at each survey are presented in Table 2.9, with the results summarised below.

2.63 It can be seen that eel and pike were the most frequently observed species in all three surveys. Roach, perch and, to a lesser extent, dace are also well represented.

Figure 2.8 Fish Survey Locations (Scale 1:50,000)

Site No.	Site	NGR
152	u/s Crettingham Bridge	TM226606
155	u/s Kettleburgh Bridge	TM263593
156	Easton Park Farm	TM276579
157	d/s Glevering House	TM295573
158	u/s Wickham Market Mill	TM306568
159	d/s Wickham Market Bypass	TM311557
160	u/s Loudham Decoy	TM315550
161	Naunton Hall Farm	TM322533
162	Low Farm	TM315527
163	Ufford	TM301522
164	Melton Sluice	TM299517

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Table 2.9 Relative Proportions of Fish Caught on NRA Fish Surveys (frequency rankings presented in brackets)

Species	1984 Survey	1987 Survey	1991 Survey
Roach	9 (3)	9 (1)	9 (2)
Eel	12 (1)	9 (1)	11 (1)
Pike	12 (1)	9 (1)	11 (1)
Perch	10 (2)	6 (2)	9 (2)
Dace	5 (4)	6 (2)	6 (3)
Tench	0	3 (3)	4 (5)
Gudgeon	1 (6)	2 (4)	1 (7)
Bream	1 (6)	1 (5)	3 (6)
Stoneloach	4 (5)	6 (2)	5 (4)
Rudd	1 (6)	0	1 (7)
Bullhead	1 (6)	0	0
Roach/Rudd Hybrid	0	0	1 (7)
Roach/Bream Hybrid	0	0	1 (7)
Total Number Caught	1927	2017	2759

Age Structure and Growth

2.64 Age distributions were calculated for each year class of the key species observed on each survey, as follows;

Roach — Between ten and eleven year classes of roach were identified on each survey with good (i.e. high numbers caught) year classes of roach reported to have occurred in 1978, 1981, 1983, 1989 and 1990. Growth rates for captured roach were reported in both the 1984 and 1987 survey to be below the average for both the British Isles and the region.

Dace — Between seven and eight year classes of dace were observed on each of the three surveys with 1981 representing the only year class singled out as being good. Growth rates for Dace were reported to be above the average for the British Isles.

Pike — Between six and eight year classes of pike were observed on the 1984 and 1987 surveys (this information was not recorded on the 1991 survey). In the 1984 survey the growth rate was very low compared to the average for the British Isles and this was attributed to the small overall size of the river. By 1987 the growth rate had risen closer to the norm although it remained slightly below it.

Perch — Between four and five year classes of perch were recorded with their growth rate recorded as moderate.

Fish Density

2.65 Data on the density of each species of fish caught at each site on each survey are presented in Appendix B and summarised for each survey in Table 2.10 below. In the 1984 survey total fish density was reported as being low at 8 sites, moderate at three sites (Crettingham Bridge, Brandeston School and d/s Wickham Market Bypass) and high at one site (Ufford). Since then a general increase in the total density of fish captured on each survey is evident at the majority of sites. Mean fish density recorded in 1991 was the highest of any of the three surveys at 0.13 fish/m^2 as compared to 0.11 fish/m^2 (1984) and 0.10 fish/m^2 (1987).

Fish Biomass

2.66 Data on the biomass of each species of fish caught at each site on each survey are presented in Appendix B and summarised for each survey in Table 2.11. In the 1984 survey total fish biomass was reported as being very low at five sites, moderate at three sites and high or very high at three sites. Pike and eel contributed significantly to the overall biomass at all sites. Since 1984 there has been a general increase in the biomass of fish captured at each site. The River Deben is currently classified as a Class B river based on a total mean fish biomass of 17.3 g/m^2. This represents a steady improvement from the 1984 figure of 12.6 g/m^2 and the 1987 figure of 15.37 g/m^2.

Table 2.10 Fish Densities at the Survey Sites (> 10 cm length)

Site No.	Site	NGR	1984	1987	1991
152	u/s Crettingham Bridge	TM226606	Mod	Low	Low
155	u/s Kettleburgh Bridge	TM263593	Mod	Mod	High
156	Easton Park Farm	TM276579	Low	Low	Low
157	d/s Glevering House	TM295573	Low	Low	Mod
158	u/s Wickham Market Mill	TM306568	Low	Low	Low
159	d/s Wickham Market Bypass	TM311557	Mod	High	High
160	u/s Loudham Decoy	TM315550	Low	N/A	High
161	Naunton Hall Farm	TM322533	Low	Low	High
162	Low Farm	TM315527	Low	Low	Mod
163	Ufford	TM301522	High	N/A	High
164	Melton Sluice	TM299517	Low	Low	Low

Key

High density = >0.2 fish per m^2
Moderate density = 0.1 - 0.2 fish per m^2
Low density = <0.1 fish per m^2
N/A = data not available

Table 2.11 Fish Biomass at the Survey Sites (> 10cm length)

Site No.	Site	NGR	1984	1987	1991
152	u/s Crettingham Bridge	TM226606	High	Mod	Mod
155	u/s Kettleburgh Bridge	TM263593	Mod	High	High
156	Easton Park Farm	TM276579	Low	Low	Low
157	d/s Glevering House	TM295573	Low	Mod	High
158	u/s Wickham Market Mill	TM306568	Low	Low	Mod
159	d/s Wickham Market Bypass	TM311557	High	High	Mod
160	u/s Loudham Decoy	TM315550	Mod	N/A	Mod
161	Naunton Hall Farm	TM322533	Mod	High	High
162	Low Farm	TM315527	Low	Mod	High
163	Ufford	TM301522	High	N/A	High
164	Melton Sluice	TM299517	Low	Mod	Mod

Key

High biomass = >5 g per m^2
Moderate biomass = 5 - 20 g per m^2
Low biomass = >20 g per m^2
N/A = data not available

Summary

2.67 The greatest densities and biomass of roach were recorded at the upstream limit of the river in the Crettingham to Brandeston reach and near the Wickham Market Bypass bridge. Roach were considered to be spawning successfully with large numbers of young fish recorded near Brandeston. The population of roach in the river is thought to rely quite heavily on the reach from Crettingham to Brandeston as a source of young fish which subsequently move downstream and colonise the middle and lower reaches. It was not thought that the roach population was subject to over-predation by the presence of eels and pike in the river.

2.68 Dace have a limited distribution in the river thought to be due to lack of flow (NRA Fish Survey Report, 1984). It was only in faster waters downstream of mills that this species was observed in any great numbers.

2.69 The development of one or more off-river supplementation units (ORSU's) adjacent to the upper and middle reaches of the river was recommended in the 1984 survey.

Fish Mortalities

2.70 The Eastern Area Fisheries Advisory Committee reports held by NRA Ipswich were searched for any reports of fish mortalities and fish stocking exercises. These reports are issued every four months and a set from 1984 to 1993 was available for inspection by Southern Science. The key information extracted from these reports is summarised in Table 2.12. Additionally a fish kill is reported in 1959 (AWA, 1975) when flow through Wickham Market was stopped entirely for several days.

Fish Health Checks

2.71 Fish health checks were conducted in 1984 and 1987 with reports appended to the survey reports examined. In the 1984 health check a total of 30 fish from three species were examined from two sites, Brandeston and Crettingham. Most fish were found to be in good condition and no evidence of any major infectious disease problem. The parasites observed were consistent with those normally associated with roach, pike and perch.

2.72 In the 1987 health check a total of 15 fish were examined and apart from a single roach infected with Sporozoon tincae the general condition of the fish examined was considered to be good with no lesions or parasites of widespread disease concern observed.

Table 2.12 Incidents Reported to have Affected the River Deben Fish Populations
(source Eastern Area Fisheries Advisory Committee reports - NRA Ipswich)

1959	fish kill due to absence of flow in Wickham MArket reach (source - AWA, 1975)
1984 July -	approximately 200 roach, eels and pike killed on 3/5/84 between Crettingham and Brandeston due to a spillage of DDT following the washing out of a spray tank. Approximately 300 roach, pike, eels and stoneloach killed on 24/5/84 after organic effluent entered the river from an unknown source.
1984 November -	approximately 200 roach killed on 27/9/84 between Glevering and Wickham Market due to an accidental spillage of farm slurry. 250 roach were restocked on 6/1/84 at Glevering.
1985 May -	on 14/2/85 and 20/3/85 approximately 240 roach (15-25 cm) and 720 roach (10-15 cm) were stocked at Crettingham Bridge to replace those lost in the DDT spill of 3/5/84.
1987 January -	approximately 25 roach (12-35 cm) were killed between Crettingham and Easton on 28/6/86. Organic pollution was suspected as the cause.
1988 January -	sample of roach and pike sent for routine fish health check.
October 1989 -	a pool upstream of Glevering Mill was electrofished following draining down to facilitate repairs to the structure. Approximately 90 coarse fish were moved to the adjacent river channel.
May 1991 -	reports of illegal fish netting near Wickham Market were investigated with nothing found.
September 1991 -	approximately 6000 roach (12-15 cm), 1600 bream (15-20 cm) and 300 tench (12-15 cm) stocked at Wickham Market on 21/5/91.
January 1993 -	approximately 180 roach (8-25 cm) and 40 perch (8-18 cm) killed on 24/8/92 in a pollution incident near Kettleburgh. Source of pollution unknown although a discharge of effluent from a piggery was suspected.

Chemical Water Quality of the River Deben

Data Used in this Study

2.73 NRA chemical water quality records were obtained in annual summary format for the freshwater sampling points on the River Deben over the period 1976 to 1993. Typically between 12 and 13 individual measurements were taken per year. Data from 1985 onwards is held on computer database at the NRA Headquarters in Peterborough. Pre-1985 data were obtained from the NRA Regional Office in Ipswich.

2.74 The sampling locations used in this report are presented in Figure 2.9 and listed in Table 2.13 together with a summary of the key features of the record for each site. The graphs and tables of annual data from which this summary has been made are presented in Appendix C.

Key Features of the Water Quality Record

Decreases in Biochemical Oxygen Demand and Ammonia Concentrations

2.75 All sites show a general decrease in ammonia and BOD concentration over the period of record obtained with the exception of Debenham where occassionally high ammonia concentrations still occur.

Increases in Chloride Concentration

2.76 All of the monitoring sites exhibit an increase in mean chloride concentration from 1989/1990 to date. It is considered unlikely that this is an analytical artefact. Map 7 of the East Suffolk and Norfolk River Authority First Survey of Water Resources and Demands (1971) does indicate a region of high chloride water (>250 mg/l Cl) in the chalk underlying the upper reaches of the Deben. However, this area of high chloride groundwater is at considerable depth in the Chalk and its presence is unlikely to be manifested in the upper reaches of the catchment largely overlain by boulder clay.

2.77 Increases in chloride concentrations are correlated with low flow periods and reduced effluent dilution during low flows may be an explanation for the observed increases in chloride.

Dissolved Oxygen and Temperature

2.78 The lowest dissolved oxygen saturations over the period 1976 to 1993 are found in the upper reaches of the catchment particularly at Debenham Bridge and Ashfield Bridge. Downstream of the confluence of the Earl Soham watercourse and the Deben very low dissolved oxygen saturations are not found with no records of.saturations under 40 %. Years with the lowest saturations on record include 1977, 1986, 1990, 1991 and 1993.

Figure 2.9 Locations of Chemical Water Quality Monitoring Points used in the Study
(Scale 1:50,000)

Arbitary Sample Point Number	Chemical Water Quality Monitoring Site	National Grid Reference	Period of Record Obtained
1	Debenham Bridge	TM176628	1983-1993
2	A1120 Ashfield Bridge	TM203615	1976-1993
3	Earl Soham	TM233620	1983-1993
4	Brandeston Bridge	TM238603	1976-1993
5	Letheringham Bridge	TM271586	1976-1993
6	Glevering Bridge	TM295566	1976-1993
7	White Bridge, Loudham	TM315553	1976-1993
8	Ufford	TM300519	1976-1993

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2.79 The mean and maximum temperatures recorded over the period 1976 to 1993 are fairly comparable along the whole length of the Deben with only 1 - 2°C increase typical from Debenham down to Ufford. Maximum values of between 19.5 and 22 °C are typical. Years with the highest maximum temperatures on record include 1986, 1990 and 1991.

Suspended Solids

2.80 The data record for suspended solids is very patchy with only occasional measurements present. From the limited available data in can be seen that the greatest values on record typically occurred in 1987 and 1988, especially in the upper reaches of the catchment.

Nitrate

2.81 Nitrate measurements are only on record for part of the period from 1976 - 1993. The greatest nitrate concentrations are found in samples taken from the upper reaches of the catchment (Debenham Bridge, Ashfield Bridge and the Earl Soham watercourse).

River Quality Objectives

2.82 The River Deben from Debenham to Kettleburgh was classed as being of fair quality (Class 2) in 1980, 1985 and 1990 using the National Water Council classification scheme. Downstream of Kettleburgh to the tidal limit it received a good quality classification (Class 1b).

2.83 Statutory Water Quality Objectives have not been set or authorised for the River Deben however use categories for the various reaches of the Deben were identified by Hydrotechnica (1993) as follows:

Reach	Use
Upstream of Debenham (3km) -	Low Amenity
Debenham to Kettleburgh (13km) -	Moderate Amenity, Cyprinid Fishery, Livestock Watering, Spray Irrigation
Kettleburgh to Melton (17km) -	Moderate Amenity, Cyprinid Fishery, Livestock Watering, Spray Irrigation
Earl Soham (9km) -	Moderate Amenity, Livestock Watering

2.84 Of these use categories the most stringent water quality criteria are for the fisheries ecosystem. The occassionally high ammonia concentrations and low dissolved oxygen saturations near Debenham will limit the class into which the upper reach of the Deben would be placed to Class 2 or 3 although both these classes are suitable for high class cyprinid fisheries. Below Kettleburgh the river would be placed in class 1 or 2. Of the other use categories, the use of river water for spray irrigation requires a maximum chloride concentration in the range 100-600 mg/l Cl, depending on the crop type. Further increases in chloride concentration may result in this limit being exceeded.

Table 2.13 Summary of Chemical Water Quality Record

Chemical Water Quality Monitoring Site	National Grid Reference	Period of Record Obtained	Years and Values of Lowest Dissolved Oxygen	Years and Values of Greatest Temperature	Other Comments
Debenham Bridge	TM176628	1983-1993	1990 - 11% 1992 - 30%	1990 - 19.5°C	Significant increase in mean chloride post 1990, mean BOD and ammonia concentration variable
A1120 Ashfield Bridge	TM203615	1976-1993	1977 - 8% 1990 - 13% 1986 - 16%	1986 - 21°C 1990 - 19°C	Significant increase in mean chloride post 1990, decrease in BOD and ammonia concentration post 1989
Earl Soham	TM233620	1983-1993	1986 - 50% 1993 - 52%	1991 - 21°C 1986 - 20°C	Significant increase in mean chloride post 1989, decrease in BOD and ammonia concentration post 1989
Brandeston Bridge	TM238603	1976-1993	1991 - 40% 1993 - 42%	1986 - 22°C 1990 - 20°C	Moderate increase in mean chloride post 1989, decrease in mean BOD and ammonia concentrations post 1989
Letheringham Bridge	TM271586	1976-1993 (1980 absent)	1993 - 48% 1977 - 51% 1978 - 51%	1986 - 21°C	Moderate increase in mean chloride post 1989, decrease in mean ammonia concentrations post 1989
Glevering Bridge	TM295566	1976-1993	1986 - 50% 1992 - 50%	1983 - 21°C	Moderate increase in mean chloride post 1989, decrease in mean ammonia concentrations post 1989
White Bridge, Loudham	TM315553	1976-1993	1993 - 50% 1977 - 51% 1978 - 51%	1991 - 21°C 1986 - 21°C	Moderate increase in mean chloride post 1989, decrease in mean ammonia concentrations post 1989
Ufford	TM300519	1976-1993	1978 - 42% 1993 - 52%	1986 - 22°C 1984 - 22°C	Moderate increase in mean chloride post 1989, decrease in mean ammonia concentrations post 1992

Pollution Incidents

2.85 A database record of pollution incidents from 1990 to date in the River Deben catchment is maintained in the Ipswich regional office of the NRA. A copy of the information held on this database is presented in Appendix D (see also Table 2.12). No major incidents (i.e. causing major fish kills or long term or widespread environmental damage) are on this record with the majority of incidents concerning farm slurry, often derived from piggeries, entering the watercourse. Two road traffic accidents are also reported to have caused minor pollution due to spillage of sump oil.

Channel Maintenance

2.86 Channel maintenance records were not available from the NRA Ipswich Regional Office and the historical information presented in Table 2.14 is based on discussions with long serving members of staff. This may limit the accuracy of the following information.

Table 2.14 Anecdotal Record of Channel Maintenance Activities (reach numbers taken from SWT 1989 Survey, see Figure 2.5

Reach 1-3 Debenham	Dredging or cutting and clearing operations carried out annually
Reach 4-9 Debenham to Ashfield Crossroads	Dredged approximately every 10 years. Last dredged in 1991.
Reach 10-21 Ashfield Crossroads to Brandeston	Not dredged since before 1982. Proposed for dredging in spring 1994.
Reach 22-28 Brandeston to Letheringham	Dredged in 1989 or 1990.
Reach 29-32 Easton Park Farm	Not dredged.
Reach 33-41 Easton to Wickham Market	Last dredged in the late 1980's.
Reach 42-47 Wickham Market	Last dredged in 1989
Reach 48-52 Naunton Hall	Last dredged in the mid-1980's.
Reach 52-55 Ufford to Melton	Last dredged in 1986. Dredging is proposed in 1994 for the bypass channel.
Earl Soham watercourse	May not have been dredged in the last ten years although reach 1-2 is programmed for 1994.

Amenity and Recreation Associated with the River Deben

2.87 In addition to the fisheries interests discussed above a number of other recreational users of the river have been identified.

Public Footpaths and Bridleways

2.88 A number of public footpaths and bridleways cross or run alongside the river. These will be points where deleterious of positive changes in the condition of the river will make a greater impression on the public.

> In the lower reaches of the river public footpaths run alongside or within 50 metres of the river near Ufford (TM310523 to TM299518) and Quill Farm, Wickham Market (TM312557 - 317545).
>
> From Wickham Market upstream to the confluence with the Earl Soham watercourse there are very few footpaths running alongside the river although the channel is crossed by footpaths near Easton (TM283586) and Brandeston (TM257597 & 245599) and a bridleway near Brandeston (TM250600).
>
> Upstream from the confluence with the Earl Soham watercourse to Debenham the river is crossed by a bridleway near Dove Farm (TM218607) and footpaths near Dove Farm (TM210610) Winston Grange (TM188623).
>
> Upstream of Debenham a footpath runs alongside the Deben from TM168635 to TM157636). On the Soham a footpaths cross the channel at Grove Farm (TM238608), Moat Farm (TM238614), Crettingham Lodge (TM234620) and Clowes Corner (TM220637).

Wickham Market Countryside Walk

2.89 Suffolk County Council in their Countryside Walks leaflet series detail a number of walks around Wickham Market. One of these takes the walker alongside the River Deben from the A12 roadbridge to just downstream of the Decoy Pond near Ash Abbey. Walkers are encouraged to look for the yellow water lily and common blue damselfly.

Ash Abbey

2.90 Ash Abbey (TM321544) lies just downstream of the Decoy Pond near Wickham Market. The remains of the priory dating back to the 12th century have been incorporated into a 14th century house, thatched barn, mill and mill house.

Easton Park Farm

2.91 Recognised as a Country Park by the Countryside Commission, Easton Farm Park comprises a series of farm buildings housing demonstrations of farming and related activities including a working dairy, blacksmith, poultry pens, turkey rearing, pigs and a pet centre. The park also advertises a Green Trail which 'explores the lowland meadows of the River Deben'. The farm is open from March to September.

Soham Nature Trail

2.92 A nature trail close to the Earl Soham watercourse is indicated on Ordnance Survey maps of the area near Grove Farm (TM238608). No detailed information has been identified or collected on this trail.

Framlingham Castle

2.93 Framlingham Castle (TM285636) is located approximately 4 km north east of the River Deben. Dating from the 12th century it was built for a local lord, Roger Bigod, Earl of Norfolk, and was used as a prison for recalcitrant priests during the reign of Elizabeth I.

Other Sites

2.94 Suffolk County Council's 1992 Suffolk Tourism Guide, which incorporates a map of the area, identifies arts and crafts interest in Debenham, a vineyard or cider maker at Brandeston, Easton Farm Park, and Ash Abbey.

Parish Histories

2.95 Pocket parish histories, for parishes along the Deben, were obtained from Suffolk County Council's local studies library in Ipswich. These date from the early 1930's and describe the major features of the towns and villages within each parish. They are reproduced in Appendix E.

2.96 Mention is made in the parish history of Debenham that it was once 'a thriving town, for which the River Deben - then a navigable waterway - was, no doubt, partly responsible'. The major site of interest was St Mary's Church.

2.97 In the review of the parish of Brandeston the River Deben is described as 'a mere trickling stream' although a photograph of Brandeston Hall shows the river at close to bankful capacity.

2.98 In the description of the parish of Easton the Deben is described as 'narrow' and 'a small stream' although as with the Debenham mention is made that it was once navigable (i.e. 'the River Deben...on whose broad bosom our Saxon ancestors sailed their ships').

2.99 In the description of Wickham Market little mention is made of the Deben however a photograph of the river is included.

Historic Articles and Photographs

2.100 In addition to the parish histories described above, a number of historic photographs and articles about the Deben were found in the local studies section of Ipswich library, copies of these are contained in Appendix E. These include a 1978 article describing the Deben as 'no more than a trickle of water' upstream of Debenham.

2.101 A 1990 article in the Evening Star details the formation of the River Deben Association and contains several photographs of the estuary.

2.102 Another article (date unknown but post 1989) shows a picture of the Deben dried up at Debenham and claims the river is suffering low flows due to the drought and abstraction.

2.103 Two photographs of the Deben were found dating back to 1956, Glevering Bridge, and 1962, Wickham Market.

Land Use and the River Deben

2.104 Up until 1988 census results were available at parish level, however this census series was stopped because of problems with confidentiality. These parish summaries have now been replaced with Small Area Statistics which cover the years 1988 to 1992. These statistics are only available down to parish group level with each parish group containing between 100 and 150 holdings. Sets of parish groups are banded together into Agricultural Districts which are clusters of, on average, 4 parish groups.

2.105 Small Area Statistics were obtained for 1988 and 1992 for the three parish groups which cover the freshwater reach of the River Deben (Agricultural District 5, Parish Groups 1, 3 and 4). The statistics are presented in full in Appendix F and are summarised in Table 2.15 below.

2.106 A slight decrease in the area turned over to crops and fallow is evident for each of the parish groups whilst the total area of woodland in each parish group has risen significantly. The numbers of pigs kept has also increased in each parish group.

Evidence of longer term change?

Table 2.15 Land Use Changes in the River Deben Catchment from 1988 to 1992 (Source - MAFF).

	District 5, Parish Group 1		District 5 Parish Group 3		District 5 Parish Group 4	
	1988	**1992**	**1988**	**1992**	**1988**	**1992**
Total area on holdings (ha)	6083	6338	14842	15636	7024	6965
Recent and temporary grassland (ha)	96	132	435	1112	244	183
Permanent grassland (ha)	575	718	1512	1270	569	506
Total crops and fallow (ha)	5177	4921	11060	10044	5726	5415
Woodland (ha)	31	89	768	1019	216	256
Set-aside (ha)	NA	34	NA	489	NA	251
Total cereals (ha)	3665	3641	5551	4434	3851	3618
Total cattle and calves (no)	2111	2025	3293	3085	1683	1840
Total pigs (no)	24862	26815	18127	39987	30033	31046
Total sheep (no)	1128	1467	3227	6528	1741	557
Total fowl (no)	697804	233231	9656	453	7097	61889
Total agricultural labour force	336	322	707	725	347	297

Invertebrate Records for the River Deben

2.107 The River Deben has been sampled intermittantly for invertebrates by the old Anglian Water Authority and, more recently, the NRA at a number of sites and the records obtained were patchy and required reprocessing to determine BMWP (Biological Monitoring Working Party) and ASPT (Average Score per Taxon) scores. The most complete records exist for the five sites shown in Figure 2.10.

Diversity of Families and BMWP/ASPT Scores

2.108 The diversity of BMWP (Biological Monitoring Working Party) scoring families of invertebrates at these five main sites are displayed in Tables 2.16 to 2.20. The presence of invertebrates at the five sites shown on Figure 2.10 have been used to calculate BMWP scores and to derive ASPT (Average Score Per Taxon) for each sample. The resultant scores for samples at each site are displayed in Figures 2.11 to 2.15.

Upstream of Debenham STW

Diversity of Families

2.109 As Table 2.16 shows, records for the site upstream of Debenham Sewage Treatment Works (STW) only exist from 1989-93. Diversity during this period has been low, with a slight increase in the number of families present in 1993. Prior to 1993, the fauna was largely made up of triclads (flatworms), gastropods (snails), leeches, chironomids (midges) and oligochaete worms. However, in 1990, 1991 and 1993 Baetid mayflies were present, while Sialidae (alderflies) were found in 1990 and in 1991 there were caenid mayflies. From 1990 onwards, water beetles appeared, though in low family diversity. From 1991 onwards, tipulids (craneflies) were recorded, with the demise of flatworms. In 1993, as well as the basic fauna found in earlier years, a greater diversity of beetles was observed along with the appearance of Hemiptera (bugs), Gammaridae (shrimps) and Rhyacophilidae (caddisflies).

BMWP/ASPT Scores

2.110 This site had the lowest BMWP scores and ASPT of the five sites studied, though records only exist for samples taken since 1989. BMWP scores range from as low as 12 in April 1990, to 59 in September 1993. ASPT, which are generally regarded as being less prone to seasonal fluctuation, range from 2.8 to 4.2 for the site. Overall, ASPT appear to have increased slightly since 1991.

Figure 2.10: Invertebrate Sampling Sites on the River Deben (Scale 1:50,000)

Map Ref No	Site Name	NRA Code
1	Upstream Debenham STW	BFDEB010
2	A1120 Road Bridge	BFDEB020
3	Kettleburgh Bridge	N/A
4	Glevering Bridge	BFDEB050
5	Eyke Ford	BFDEB087

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A1120 Road Bridge

Diversity of Families

2.111 The site at the A1120 road bridge has records for 20 samples taken during the periods 1976-79 and 1988-93, but with no records available for years in between. As Table 2.17 shows, the diversity of this section of the river has been consistently higher than the site upstream at Debenham. Samples in 1993 have yielded the highest number of families, though broadly the diversity of families has changed little over the years.

2.112 Across most of the years that sampling has taken place oligochaetes, chironomids, Asellidae (hoglice or water slaters), leeches, flatworms and a variety of gastropods, beetles and Hemiptera (bugs) have been found to be present. In addition, the site has had Gammaridae (shrimps) every year sampling has taken place, apart from the single sample of 1988. Many years have also seen the occurrence of Sialidae (alderflies), Tipulidae (craneflies), Caenidae (mayflies) and Hydropsychidae (caddisflies), both during the late 1970s and during the late 1980s to early 1990s.

2.113 At the A1120 road bridge site Simuliidae (blackflies) have been observed during 1976, 1977, 1990 and 1993 only. Other families which have occurred occasionally are Leptoceridae and Georidae (mayflies) both present only in 1976 and 1977, Psychomyiidae (caddisflies) present in 1977, and Leptophlebiidae (mayflies) which were only seen in August 1988.

BMWP/ASPT Scores

2.114 Scores have been higher at the site next to the A1120 road bridge than upstream at Debenham. Figure 2.12 shows that BMWP scores have fluctuated between a low of 36 in April 1990 and 104 in September 1993, with all but two scores (in 1989 and 1990) being above 50. ASPT have all been 3.6 or above, with a maximum of 4.9 recorded in 1977. 1989 and 1992 samples had lower ASPT than other years, while 1976 and 1977 had the highest ASPT overall.

Kettleburgh Bridge

Diversity of Families

2.115 A site at Kettleburgh Bridge was sampled from 1976-81 and once in 1984, the results of which are summarised in Figure 2.18. The number of families present at this site has largely been similar to samples from corresponding years at the site upstream at the Ashfield A1120 road bridge. Diversity has been highest at Kettleburgh Bridge during the years 1979-81. The same families common to samples at the A1120 road bridge have been found in most years that sampling has taken place, though noticeably a wider variety of gastropod families have tended to occur at Kettleburgh Bridge and only in 1977 were Sialidae (alderflies) found here, while Baetidae (mayflies) were observed in all but the 1976 sample. Occasional invertebrate families have included Leptoceridae and Hydroptilidae (mayflies) found from 1977-78 and in 1981

respectively. Leptophlebiidae (mayflies) were seen from 1978-80, as well as in 1984.

BMWP/ASPT Scores

2.116 BMWP scores and ASPT have been similar in overall range to those at the A1120 road bridge and are displayed in Figure 2.13. ASPT have changed little over the relatively short period that this sight was sampled, ranging from 3.9 to 4.8, while BMWP scores were between 43 and 113.

Glevering Bridge

Diversity of Families

2.117 During 1976-81 and 1989-93, a site at Glevering Bridge has been sampled for invertebrates, with the bulk of sampling having taken place during the most recent of the two periods. In the main, a higher number of families have been identified at this site than from corresponding samples from the three sites upstream, with the majority of samples having in excess of 20 BMWP scoring families. However, families consistently found upstream at Kettleburgh Bridge were also found at this site. Snails have been particularly diverse, with Ancylidae (river limpets) appearing in 1977 and 1993, and Unionidae (mussels) present in 1992. Noticeably, Baetidae and Caenidae (mayflies), along with Gammeridae (shrimps), have been present during every year of sampling. Though no Simuliidae (blackfly) have been recorded at the site, Leptophlebiidae (mayflies) were found in 1977, 1979 and 1980.

2.118 A wider variety of caddisfly larvae have been found to be present at Glevering Bridge than at sites further upstream on the River Deben, though many of these have appeared in a limited number of samples. Polycentropididae and Goeridae were only present in single samples in 1981 and 1979 respectively. In contrast, Hydroptilidae appeared in a sample taken in 1990, while Phryganeidae and Leptoceridae have only been present in several samples from 1989 onwards. Limnephilidae is the only caddisfly family to have appeared in both the late 1970s period of sampling and the late 1980s/early 1990s period.

2.119 Unlike the upstream sites considered, the river at Glevering Bridge has supported Coenagriidae damselfly larvae, in 1977 and from 1989-93, and a family of dragonfly larvae in 1981 and 1993 (recorded in Table 2.19 as Aeshnidae but not actually identified to family level on original results sheets).

BMWP/ASPT Scores

2.120 Though the maximum BMWP score was no higher than that at Kettleburgh Bridge and only marginally higher than at the A1120 road bridge, scores were in the main higher throughout the period sampled. In fact, as Figure 2.14 illustrates, nearly three-quarters of the samples had BMWP scores in excess of 75. ASPT scores were also higher on average, though only ranged from 3.6 to 4.7, these high and low scores both occurring in 1989. Just over three-quarters of the samples had ASPT in the range 4.0 to 4.5, with lower scores only occurring in 1976, 1989 and 1990.

Eyke Ford

Diversity of Families

2.121 Sampling for invertebrates at Eyke Ford, near Ufford has taken place during the years 1976-79, 1986, and 1988-93. Most samples have had over 20 different families present. In August and October 1991, and July and September 1993, between 25 and 30 families were recorded. Overall, the site has historically had a slightly more diverse invertebrate fauna than the other four sites. Lower order groups commonly found at Kettleburgh Bridge and Glevering, such as leeches, flatworms, gastropods, Asellidae, beetles and bugs, are similarly diverse at Eyke Ford. Families such as Sialidae (alderflies), Tipulidae (craneflies) and Simuliidae (blackflies) were present in a number of samples since 1988. Ancylidae (river limpets) were found in 1979 and 1989 only, while Gammeridae (shrimps), Caenidae and Baetidae (mayflies) were found in nearly every sample. The only other family of mayfly to be found has been Leptophlebiidae, in 1988.

2.122 Caddisfly larvae have been more diverse in terms of the number of families found than at any of the other four sites. For example, Hydropschidae (caddisflies), historically absent from the site at Glevering Bridge, were present in many samples from 1977 onwards. Georidae and Leptoceridae caddisfly larvae were found in more than half the samples at Eyke Ford, while those found in less than half the samples include Hydroptilidae, Limnephilidae, Psychomiidae and Molannidae. Interestingly, these families were present both in the late 1970s and in samples taken more recently during the late 1980s to early 1990s.

2.123 From 1986 to 1993 Coenagriidae damselflies have been recorded and in 1993 a single dragonfly larvae family was observed (recorded in Table 2.20 as Aeshnidae but not actually identified to family level on original results sheets).

BMWP/ASPT Scores

2.124 BMWP scores for Eyke Ford, shown in Figure 2.15, have been consistently higher than at the other four sites upstream. BMWP scores have ranged from 47 to 143, in 1977 and 1993 respectively. In fact, over half of the 20 samples taken have yielded scores of 100 or more. ASPT are also higher for samples taken at this site and range from 3.9 to 5.1. 65 % of samples have attained an ASPT of 4.5 or over. No marked trends in the scores appear to exist, apart from a possible slight increase in scores for 1992 and 1993.

Summary

2.125 From records of the five sites studied, there is an increase in the diversity of families of invertebrates present in the River Deben the further downstream sampling has occurred. At the site upstream of Debenham STW most families have been from lower orders, with a lack of Gammeridae (shrimps), mayfly, dragonfly, caddisfly and bugs, apart from in 1993. At sites downstream of Debenham, Baetidae and Caenidae

mayflies have been found in most samples, along with Gammeridae (shrimps) and a variety of beetles and bugs. The further downstream the sample sites are found, the more families of mayflies, caddisflies and beetles occur. Interestingly, Simuliidae (blackflies) do not occur at the site upstream of Debenham STW and much further downstream, at Glevering Bridge. Lower sites on the river have supported occassional damselflies, dragonflies and river limpets.

2.126 Historical data on the above five sites show the River Deben to have higher BMWP scores and ASPT the further downstream samples are taken. Apart from a slight increase in scores in 1993 at some of the sites, and with the possible exception of the Debenham site, there appears to be no marked trends or fluctuations that can be accounted for by periods of low or high flow.

2.127 BMWP scores and ASPT are widely used as indicators of water quality but may also be a product of river morphology. The lower scores at the top of the river, especially near Debenham, may be due to a combination of occassional low flow (and therefore reduced water quality) coupled with the channel morphology present in this reach. Here the river is channelised and less diverse in habitat composition (e.g. in-stream vegetation) than further downstream which may be giving rise to a less diverse fauna.

Table 2.16: Presence of Invertebrates in the River Deben Upstream of Debenham STW (BFDEB010)

Group	Families	Score	Nov 89	Apr 90	Jul 90	Oct 90	May 91	Jul 91	Nov 91	May 92	Jul 93	Sept 93
Mayflies	Siphlonuridae	10										
	Heptageniidae	10										
	Leptophlebiidae	10										
	Ephemerellidae	10										
	Potamanthidae	10										
	Ephemeridae	10										
Stoneflies	Taeniopterygidae	10										
	Leuctridae	10										
	Capniidae	10										
	Perlodidae	10										
	Perlidae	10										
	Chloroperlidae	10										
River Bug	Aphelocheiridae	10										
Caddisflies	Phryganeidae	10										
	Molannidae	10										
	Beraeidae	10										
	Odontoceridae	10										
	Leptoceridae	10										
	Goeridae	10										
	Lepidostomatidae	10										
	Brachycentridae	10										
	Sericostomatidae	10										
Crayfish	Astacidae	8										
Dragonflies	Lestidae	8										
	Agrilidae	8										
	Gomphidae	8										
	Cordulegasteridae	8										
	Aeshnidae	8										
	Corduliidae	8										
	Libellulidae	8										
Caddisflies	Psychomyiidae	8										
	Philopotamidae	8										
Mayflies	Caenidae	7					1					
Stoneflies	Nemouridae	7										
Caddisflies	Rhyacophilidae	7										1
	Polycentropodidae	7										
	Limnephilidae	7										
Snails	Neritidae	6										
	Viviparidae	6										
	Ancylidae	6										
Caddisflies	Hydroptilidae	6										
Mussels	Unionidae	6										
Shrimps	Corophiidae	6										
	Gammaridae	6										1
Dragonflies	Platycnemididae	6										
	Coenagriidae	6										
Water Bugs	Mesoveliidae	5										
	Hydrometridae	5							1			1
	Gerridae	5										
	Nepidae	5										
	Naucoridae	5										
	Notonectidae	5										
	Pleidae	5										
	Corixidae	5									1	1
Water Beetles	Haliplidae	5									1	1
	Hygrobiidae	5										
	Dytiscidae	5			1	1		1	1	1	1	1
	Gyrinidae	5							1			
	Hydrophilidae	5									1	1
	Clambidae	5										
	Helodidae	5										
	Dryopidae	5										
	Elmidae	5										
	Chrysomelidae	5										
	Curculionidae	5										
Caddisflies	Hydropsychidae	5										
Craneflies	Tipulidae	5							1	1	1	1
Blackflies	Simuliidae	5										
Flatworms	Planariidae	5	1	1	1	1						
	Dendrocoelidae	5										
Mayflies	Baetidae	4			1	1			1			1
Alderflies	Sialidae	4			1							
Leeches	Piscicolidae	4										
Snails	Valvatidae	3										
	Hydrobiidae	3										
	Lymnaeidae	3	1	1	1	1	1	1	1	1	1	1
	Physidae	3										
	Planorbidae	3						1		1		
Cockles	Sphaeriidae	3								1		
Leeches	Glossiphoniidae	3			1	1			1		1	1
	Hirudidae	3										
	Erpobdellidae	3	1	1	1	1	1			1	1	1
Hoglouse	Asellidae	3										
Midges	Chironomidae	2	1		1	1	1	1	1	1	1	1
Worms	Oligochaeta	1	1	1	1	1	1	1	1	1	1	1

Scoring Families	5	4	9	8	5	5	9	8	10	14
BMWP	14	12	30	26	16	14	33	25	37	59
ASPT	2.8	3.0	3.3	3.3	3.2	2.8	3.7	3.1	3.7	4.2

Figure 2.11: BMWP Scores and ASPT of the River Deben Upstream of Debenham STW (BFDEB01)

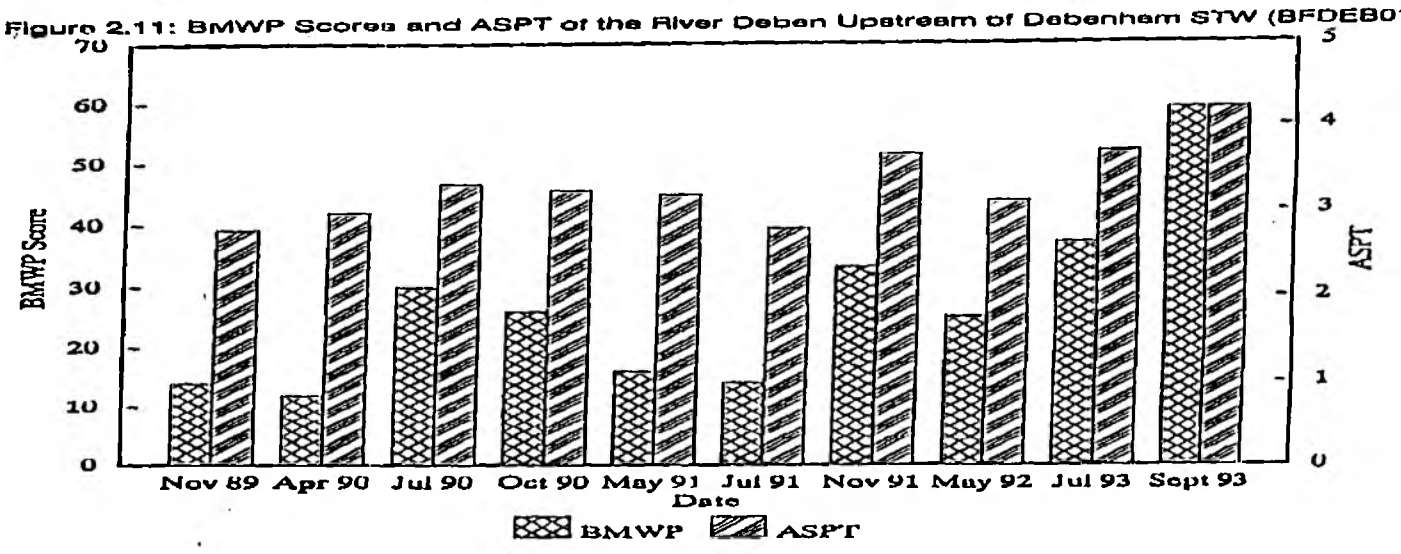


Table 2.17: Presence of Invertebrates in the River Deben at the A1120 Road Bridge (BFDEB020)

Group	Families	Score	Jan 76	Jul 76	Feb 77	Jul 77	Jun 78	Jul 79	Aug 88	May 89	Aug 89	Oct 89	Apr 90	Jul 90	Oct 90	May 91	Jul 91	Oct 91	May 92	Aug 92	Jul 93	Sep 93
Mayflies	Siphlonuridae	10																				
	Heptageniidae	10																				
	Leptophlebiidae	10							1													
	Ephemerellidae	10																				
	Potamanthidae	10																				
	Ephemeridae	10																				
Stoneflies	Taeniopterygidae	10																				
	Leuctridae	10																				
	Capniidae	10																				
	Perlodidae	10																				
	Perlidae	10																				
	Chloroperlidae	10																				
River Bug	Aphelocheiridae	10																				
Caddisflies	Phryganeidae	10																				
	Molannidae	10																				
	Beraeidae	10																				
	Odontoceridae	10																				
	Leptoceridae	10	1		1																	
	Goeridae	10	1	1	1																	
	Lepidostomatidae	10																				
	Brachycentridae	10																				
	Sericostomatidae	10																				
Crayfish	Astacidae	8																				
Dragonflies	Lestidae	8																				
	Agriidae	8																				
	Gomphidae	8																				
	Cordulegasteridae	8																				
	Aeshnidae	8																				
	Corduliidae	8																				
	Libellulidae	8																				
Caddisflies	Psychomyiidae	8			1																	
	Philopotamidae	8																				
Mayflies	Caenidae	7	1	1	1		1			1			1		1	1		1				1
Stoneflies	Nemouridae	7																				
Caddisflies	Rhyacophilidae	7																				
	Polycentropodidae	7																				
	Limnephilidae	7																				
Snails	Neritidae	6																				
	Viviparidae	6																				
	Ancylidae	6																				
Caddisflies	Hydroptilidae	6																				
Mussels	Unionidae	6																				
Shrimps	Corophiidae	6																				
	Gammaridae	6	1		1	1	1	1		1		1	1	1	1	1	1	1	1		1	1
Dragonflies	Platycnemididae	6																				
	Coenagriidae	6																1				1
Water Bugs	Mesoveliidae	5																				
	Hydrometridae	5																				
	Gerridae	5																			1	
	Nepidae	5																			1	1
	Naucoridae	5																				
	Notonectidae	5				1		1		1								1		1	1	1
	Pleidae	5																				
	Corixidae	5	1	1		1		1	1		1	1		1	1	1	1	1	1	1	1	1
Water Beetles	Haliplidae	5				1	1	1	1		1	1		1	1	1	1	1	1	1	1	1
	Hygrobiidae	5																				
	Dytiscidae	5	1	1		1	1	1	1	1	1			1	1	1	1	1	1	1	1	1
	Gyrinidae	5					1	1	1					1						1	1	1
	Hydrophilidae	5																	1			
	Clambidae	5																				
	Helodidae	5																				
	Dryopidae	5																				
	Elminthidae	5	1		1		1					1				1						
	Chrysomelidae	5																				
	Curculionidae	5																				
Caddisflies	Hydropsychidae	5	1		1						1	1		1	1	1		1		1		1
Cranefllies	Tipulidae	5	1		1		1	1	1	1				1		1				1	1	1
Blackflies	Simuliidae	5	1		1								1	1								1
Flatworms	Planariidae	5	1	1	1	1	1		1					1	1	1	1	1	1	1	1	1
	Dendrocoelidae	5	1			1		1										1				
Mayflies	Baetidae	4		1	1	1	1	1			1	1		1	1		1	1		1	1	1
Alderflies	Sialidae	4		1	1	1		1						1	1		1	1			1	1
Leeches	*Piscicolidae*	4																				
Snails	Valvatidae	3									1											
	Hydrobiidae	3																				1
	Lymnaeidae	3			1				1	1	1	1					1			1	1	1
	Physidae	3																	1		1	1
	Planorbidae	3	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1
Cockles	Sphaeriidae	3	1	1	1		1		1	1	1	1	1	1	1	1		1	1	1	1	1
Leeches	Glossiphoniidae	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Hirudidae	3																				
	Erpobdellidae	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hoglouse	Asellidae	3	1	1	1							1	1	1	1	1	1	1	1	1	1	1
Midges	Chironomidae	2	1	1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Worms	Oligochaeta	1	1				1	1	1	1	1	1	1	1		1	1	1	1	1		1

Scoring Families	19	13	19	12	12	15	14	11	14	14	10	17	16	15	15	19	14	16	20	25
BMWP	91	57	94	53	52	61	58	43	50	51	36	67	68	61	57	80	52	60	82	104
ASPT	4.8	4.4	4.9	4.4	4.3	4.1	4.1	3.9	3.6	3.6	3.6	3.9	4.3	4.1	3.8	4.2	3.7	3.8	4.1	4.2

Figure 2.12: BMWP Scores and ASPT of the River Deben at the A1120 Road Bridge (BFDEB020)

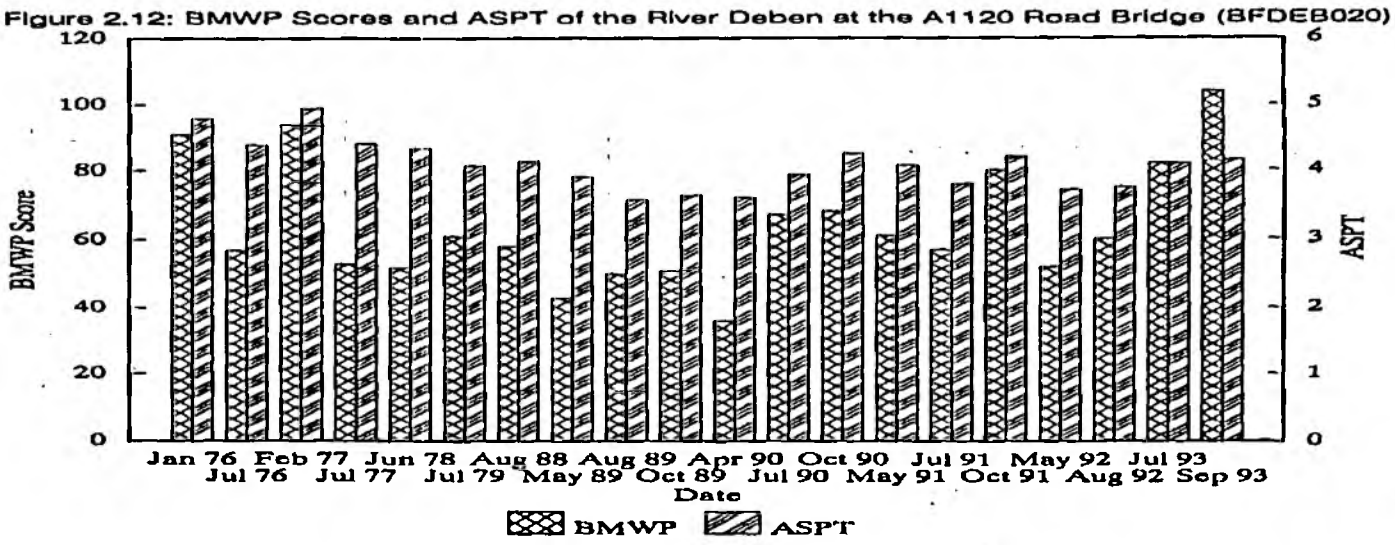


Table 2.18: Presence of invertebrates in the River Deben at Kettleburgh Bridge

Group	Families	Score	Jan 76	Feb 77	Jul 77	Jun 78	Jul 79	Aug 80	Aug 81	May 84
Mayflies	Siphlonuridae	10								
	Heptagenildae	10								
	Leptophlebiidae	10				1	1	1		1
	Ephemerellidae	10								
	Potamanthidae	10								
	Ephemeridae	10								
Stoneflies	Taeniopterygidae	10								
	Leuctridae	10								
	Capniidae	10								
	Perlodidae	10								
	Perlidae	10								
	Chloroperlidae	10								
River Bug	Aphelocheiridae	10								
Caddisflies	Phryganeidae	10								
	Molannidae	10								
	Beraeidae	10								
	Odontoceridae	10								
	Leptoceridae	10		1		1				
	Goeridae	10								
	Lepidostomatidae	10								
	Brachycentridae	10								
	Sericostomatidae	10								
Crayfish	Astacidae	8								
Dragonflies	Lestidae	8								
	Agrilidae	8								
	Gomphidae	8								
	Cordulegasteridae	8								
	Aeshnidae	8								
	Corduliidae	8								
	Libellulidae	8								
Caddisflies	Psychomyiidae	8								
	Philopotamidae	8								
Mayflies	Caenidae	7	1	1		1			1	1
Stoneflies	Nemouridae	7								
Caddisflies	Rhyacophilidae	7								1
	Polycentropodidae	7	1		1	1	1	1	1	
	Limnephilidae	7						1		
Snails	Neritidae	6								
	Viviparidae	6								
	Ancylidae	6								
Caddisflies	Hydroptilidae	6							1	
Mussels	Unionidae	6								
Shrimps	Corophiidae	6								
	Gammaridae	6	1	1	1	1	1	1	1	1
Dragonflies	Platycnemididae	6								
	Coenagriidae	6								
Water Bugs	Mesoveliidae	5								
	Hydrometridae	5								
	Gerridae	5								
	Nepidae	5								
	Naucoridae	5								
	Notonectidae	5						1		
	Pleidae	5								
	Corixidae	5		1	1		1	1	1	
Water Beetles	Haliplidae	5					1	1	1	
	Hygrobiidae	5								
	Dytiscidae	5	1	1	1	1	1	1	1	
	Gyrinidae	5					1	1	1	
	Hydrophilidae	5								
	Clambidae	5								
	Helodidae	5								
	Dryopidae	5								
	Elminthidae	5			1	1	1	1	1	1
	Chrysomelidae	5								
	Curculionidae	5								
Caddisflies	Hydropsychidae	5		1			1	1	1	1
Craneflies	Tipulidae	5								
Blackflies	Simulidae	5		1				1	1	
Flatworms	Planariidae	5		1	1	1	1	1	1	
	Dendrocoelidae	5								
Mayflies	Baetidae	4		1	1	1	1	1	1	1
Alderflies	Sialidae	4		1						
Leeches	Piscicolidae	4						1	1	
Snails	Valvatidae	3		1		1	1	1	1	
	Hydrobiidae	3	1	1	1	1	1	1	1	
	Lymnaeidae	3			1		1	1		
	Physidae	3		1			1	1		
	Planorbidae	3		1	1	1	1	1	1	1
Cockles	Sphaeriidae	3	1	1		1	1	1	1	1
Leeches	Glossiphoniidae	3	1	1	1	1	1	1	1	1
	Hirudidae	3								
	Erpobdellidae	3	1	1	1	1	1	1	1	1
Hoglouse	Asellidae	3	1	1	1	1	1	1	1	1
Midges	Chironomidae	2	1		1	1	1	1	1	1
Worms	Oligochaeta	1	1		1			1	1	1

Scoring Families	11	18	15	17	21	26	23	14
BMWP	43	80	58	82	91	113	98	62
ASPT	3.9	4.4	3.9	4.8	4.3	4.3	4.3	4.4

Figure 2.13: BMWP Scores and ASPT of the River Deben at Kettleburgh Bridge

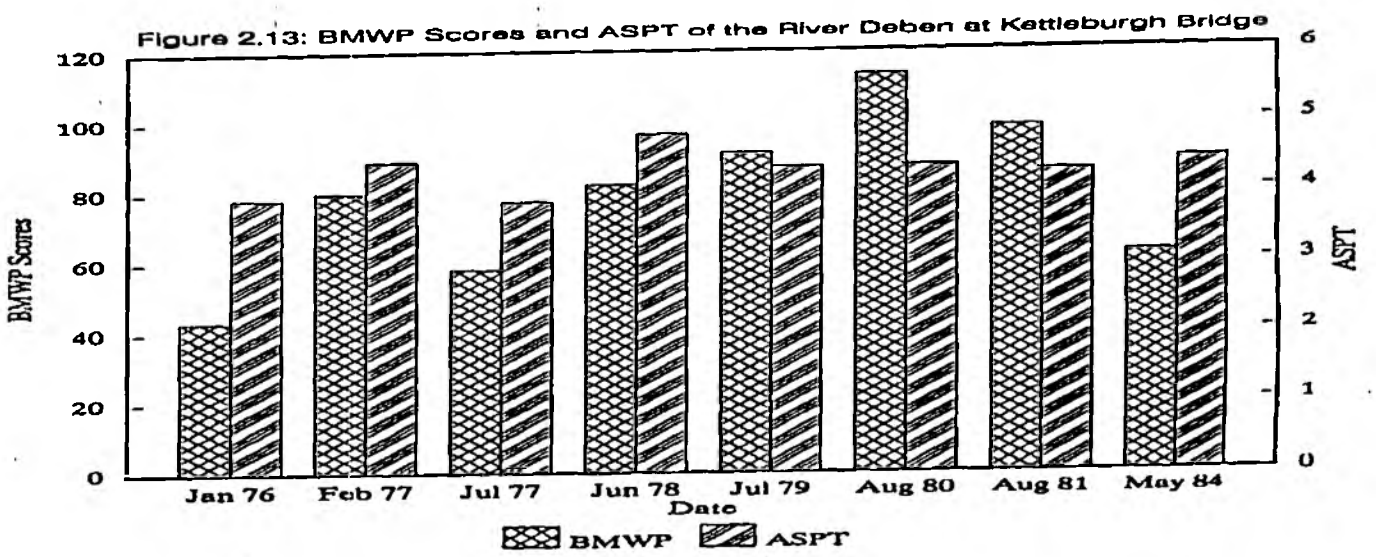


Table 2.19: Presence of Invertebrates in the River Deben at Glevering Bridge (BFDEB050)

Group	Families	Score	Jan 76	Feb 77	Jul 77	Jul 79	May 80	Aug 81	May 89	Aug 89	Nov 89	Apr 90	Aug 90	Oct 90	May 91	Aug 91	Oct 91	May 92	Jul 92	Jul 93	Sept 93
Mayflies	Siphlonuridae	10																			
	Heptageniidae	10																			
	Leptophlebiidae	10		1		1	1														
	Ephemerellidae	10																			
	Potamanthidae	10																			
	Ephemeridae	10																			
Stoneflies	Taeniopterygidae	10																			
	Leuctridae	10																			
	Capniidae	10																			
	Perlodidae	10																			
	Perlidae	10																			
	Chloroperlidae	10																			
River Bug	Aphelocheiridae	10																			
Caddisflies	Phryganeidae	10								1						1			1		
	Molannidae	10																			
	Beraeidae	10																			
	Odontoceridae	10																			
	Leptoceridae	10								1		1			1	1	1	1			1
	Goeridae	10				1															
	Lepidostomatidae	10																			
	Brachycentridae	10																			
	Sericostomatidae	10																			
Crayfish	Astacidae	8																			
Dragonflies	Lestidae	8																			
	Agriidae	8																			
	Gomphidae	8																			
	Cordulegasteridae	8																			
	Aeshnidae	8						1												1	
	Corduliidae	8																			
	Libellulidae	8																			
Caddisflies	Psychomyiidae	8																			
	Philopotamidae	8																			
Mayflies	Caenidae	7	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Stoneflies	Nemouridae	7																			
Caddisflies	Rhyacophilidae	7																			
	Polycentropodidae	7						1													
	Limnephilidae	7		1								1			1			1	1		
Snails	Neritidae	6																			
	Viviparidae	6																			
	Ancylidae	6		1																	1
Caddisflies	Hydroptilidae	6												1							
Mussels	Unionidae	6																	1		
Shrimps	Corophiidae	6																			
	Gammaridae	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dragonflies	Platycnemididae	6																			
	Coenagriidae	6		1					1	1		1	1			1	1	1			1
Water Bugs	Mesoveliidae	5																			
	Hydrometridae	5																			
	Gerridae	5											1								
	Nepidae	5																			
	Naucoridae	5																			
	Notonectidae	5			1	1	1		1	1		1					1				
	Pleidae	5																			
	Corixidae	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Water Beetles	Haliplidae	5				1	1	1					1	1			1	1	1	1	1
	Hygrobiidae	5																			
	Dytiscidae	5	1	1	1	1	1	1	1	1		1	1		1	1	1	1	1	1	1
	Gyrinidae	5						1									1	1			1
	Hydrophilidae	5																			
	Clambidae	5																			
	Helodidae	5																			
	Dryopidae	5																			
	Elminthidae	5		1	1	1	1		1	1			1		1				1		
	Chrysomelidae	5																			
	Curculionidae	5																			
Caddisflies	Hydropsychidae	5																			
Cranelflies	Tipulidae	5																			
Blackflies	Simuliidae	5																			
Flatworms	Planariidae	5	1	1	1	1	1	1	1	1				1	1	1		1	1	1	1
	Dendrocoelidae	5	1	1													1		1		
Mayflies	Baetidae	4	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1
Alderflies	Sialidae	4	1	1		1	1	1		1	1	1	1	1		1	1	1	1	1	1
Leeches	Piscicolidae	4				1		1						1		1	1		1		1
Snails	Valvatidae	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Hydrobiidae	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Lymnaeidae	3			1	1	1	1		1	1		1	1		1	1			1	1
	Physidae	3	1	1			1	1					1	1			1		1	1	
	Planorbidae	3	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1	1	1
Cockles	Sphaeriidae	3		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
Leeches	Glossiphoniidae	3		1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
	Hirudidae	3																			
	Erpobdellidae	3	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hoglouse	Asellidae	3	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1	1	1
Midges	Chironomidae	2	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Worms	Oligochaeta	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Scoring Families	16	23	14	23	22	23	16	20	14	19	20	20	18	21	24	20	24	20	23
BMWP	62	102	56	102	91	95	65	93	50	83	79	76	78	93	101	90	105	87	99
ASPT	3.9	4.4	4.0	4.4	4.1	4.1	4.1	4.7	3.6	4.4	4.0	3.8	4.3	4.4	4.2	4.5	4.4	4.4	4.3

Figure 2.14: BMWP Scores and ASPT of the River Deben at Glevering Bridge (BFDEB050)

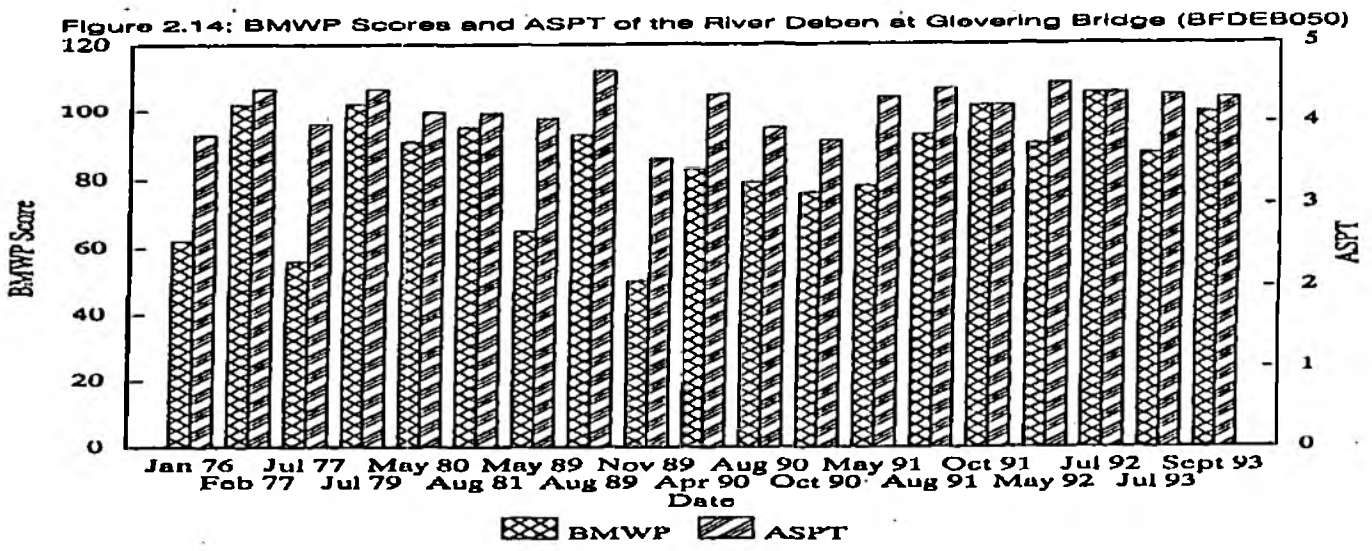
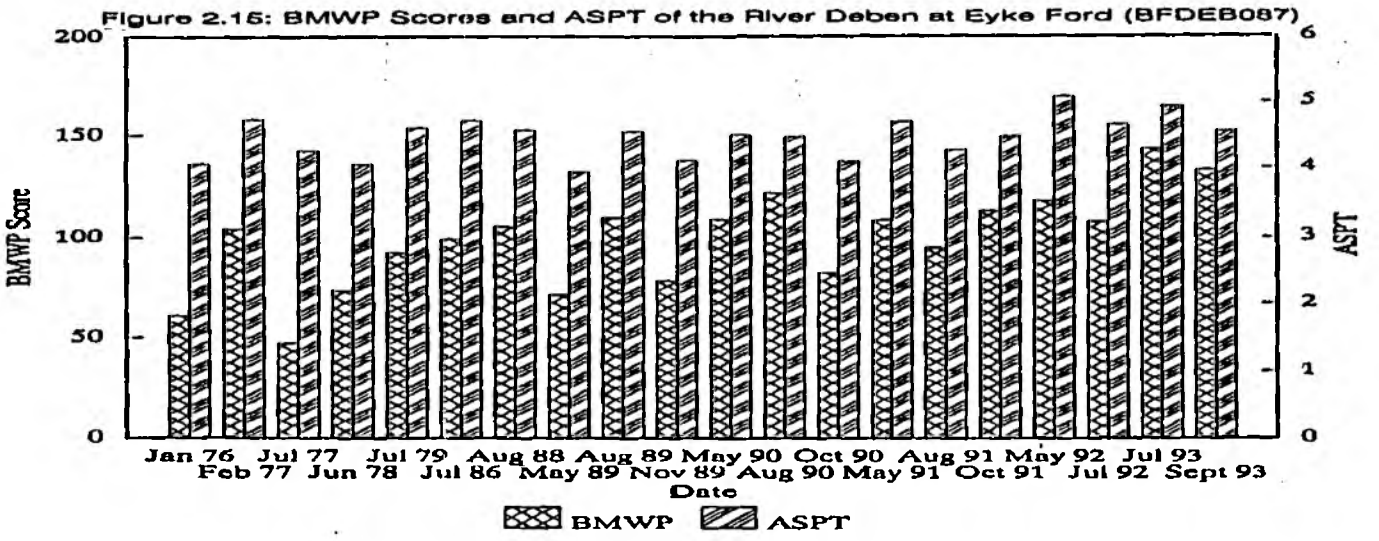


Table 2.20: Presence of Invertebrates in the River Deben at Eyke Ford (BFDEB087)

Group	Families	Score	Jan 76	Feb 77	Jul 77	Jun 78	Jul 79	Jul 86	Aug 88	May 89	Aug 89	Nov 89	May 90	Aug 90	Oct 90	May 91	Aug 91	Oct 91	May 92	Jul 92	Jul 93	Sept 9
Mayflies	Siphlonuridae	10																				
	Heptageniidae	10																				
	Leptophlebiidae	10							1													
	Ephemerellidae	10																				
	Potamanthidae	10																				
	Ephemeridae	10																				
Stoneflies	Taeniopterygidae	10																				
	Leuctridae	10																				
	Capniidae	10																				
	Perlodidae	10																				
	Perlidae	10																				
	Chloroperlidae	10																				
River Bug	Aphelocheiridae	10																				
Caddisflies	Phryganeidae	10																	1			
	Molannidae	10						1							1							
	Beraeidae	10																				
	Odontoceridae	10																				
	Leptoceridae	10		1							1		1	1		1		1	1	1	1	1
	Goeridae	10		1			1	1	1			1	1	1		1	1	1	1	1	1	1
	Lepidostomatidae	10																				
	Brachycentridae	10																				
	Sericostomatidae	10																				
Crayfish	Astacidae	8																				
Dragonflies	Lestidae	8																				
	Agriidae	8																				
	Gomphidae	8																				
	Cordulegasteridae	8																				
	Aeshnidae	6																			1	
	Corduliidae	8																				
	Libellulidae	8																				
Caddisflies	Psychomyiidae	8		1				1			1					1			1	1	1	
	Philopotamidae	8																				
Mayflies	Caenidae	7	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1	1
Stoneflies	Nemouridae	7																				
Caddisflies	Rhyacophilidae	7																				
	Polycentropodidae	7																				
	Limnephilidae	7	1	1												1			1		1	
Snails	Neritidae	6																				
	Viviparidae	6																				
	Ancylidae	6				1					1											
Caddisflies	Hydroptilidae	6					1		1					1								1
Mussels	Unionidae	6																				
Shrimps	Corophiidae	6																				
	Gammaridae	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dragonflies	Platycnemididae	6																				
	Coenagriidae	6						1		1	1	1	1		1	1		1	1		1	1
Water Bugs	Mesoveliidae	5																				
	Hydrometridae	5																				
	Gerridae	5						1									1				1	
	Nepidae	5												1								
	Naucoridae	5																				
	Notonectidae	5						1		1	1										1	1
	Pleidae	5																				
	Corixidae	5	1			1	1	1	1		1	1		1	1	1	1	1		1	1	1
Water Beetles	Haliplidae	5		1		1	1	1	1	1	1		1	1			1	1	1	1	1	1
	Hygrobiidae	5																				
	Dytiscidae	5		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1
	Gyrinidae	5							1													
	Hydrophilidae	5																	1			
	Clambidae	5																				
	Helodidae	5																				
	Dryopidae	5																				
	Elminthidae	5	1	1		1	1		1	1	1		1	1		1	1	1			1	1
	Chrysomelidae	5																				
	Curculionidae	5																				
Caddisflies	Hydropsychidae	5		1			1	1	1	1		1	1	1			1	1		1	1	1
Craneflies	Tipulidae	5							1			1	1				1				1	
Blackflies	Simuliidae	5							1				1						1	1		1
Flatworms	Planariidae	5	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
	Dendrocoelidae	5	1		1														1		1	1
Mayflies	Baetidae	4		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1
Alderflies	Sialidae	4							1					1						1		1
Leeches	Piscicolidae	4							1					1	1				1			1
Snails	Valvatidae	3	1	1						1	1	1	1	1	1	1	1	1	1	1	1	1
	Hydrobiidae	3	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1	1		1
	Lymnaeidae	3		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Physidae	3		1		1	1			1		1	1	1	1	1		1		1	1	1
	Planorbidae	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cockles	Sphaeriidae	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Leeches	Glossiphoniidae	3			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Hirudidae	3																				
	Erpobdellidae	3	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hoglouse	Asellidae	3	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Midges	Chironomidae	2	1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Worms	Oligochaeta	1	1	1		1			1	1	1	1	1	1	1	1	1	1	1	1	1	1

Scoring Families	15	22	11	18	20	21	23	18	24	19	24	27	20	23	22	25	23	23	29	28
BMWP	61	104	47	73	92	99	105	71	109	78	106	121	82	108	94	112	117	107	143	132
ASPT	4.1	4.7	4.3	4.1	4.6	4.7	4.6	3.9	4.5	4.1	4.5	4.5	4.1	4.7	4.3	4.5	5.1	4.7	4.9	4.6

Figure 2.16: BMWP Scores and ASPT of the River Deben at Eyke Ford (BFDEB087)



3 ASSESSMENT OF HISTORIC AND CURRENT STATUS OF THE RIVER DEBEN - HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENT

Sources of Historical Morphological Information

3.1 A channel cross-sectional survey was completed by Ipswich NRA in March 1994. Channel cross-sections have been recorded at 200 m intervals along the Deben, upstream of the tidal limit. This survey also covers all tributaries which join the Deben. The cross-sectional survey data is held at the Suffolk Catchment Office at Ipswich NRA. Contact name is Chris Finbow.

3.2 There are two other sources of channel morphology data. The first is a Nature Conservancy Council survey of the middle and lower reaches of the river carried out in 1981 (NCC, 1981). This was primarily an ecological survey, however, the survey does catalogue bank slope and bank type for the whole length of the river. A second ecological survey was carried out by the Suffolk Wildlife Trust in 1989 (SWT 1989). This survey summarised geomorphological features under the headings Riffles, Pools, Cliffs, Meanders, and Trapezoidal channels. This latter report also has diagrammatical representation of each river stretch showing areas of deposition, and also a crude channel cross-section.

Location of Ditches and Dykes

3.3 Data on the location of ditches and dykes was supplied by the internal drainage board contact for the Upper River Deben and from the Section 24 map held by the NRA in Peterborough. A map indicating their locations is shown in Figure 3.1. Drains numbered 1, 2 and 4 are no longer classed as IDB drains but rather as main river. There are no controls on any of the main drains shown.

Is the main channel main river?

River Control Structures

3.4 There are six fluvial controls on the Freshwater reach of the River Deben associated with weirs and channels. These are located at:

Ufford (TM300523)
Ash Abbey, two sites (TM317547 & TM315553)
Wickham Market upstream (TM296566)
Letheringham (TM279580)
Kettleburgh (TM263599)

Historical Hydrological Assessment

location ?

3.5 Flow data were supplied by NRA Anglian. Permanent long term flow data for the River Deben are only available at Naunton Hall from 1964 to present. Some low flow data is available from temporary weirs located at Ashfield Crossroads TM 203615 (since 1974), Earl Soham w/c (1976) and Brandeston Priory (1976).

what ?

Figure 3.1 Locations of Internal Drainage Board Ditches and Dykes (Scale 1:50,000)

Table 3.1 Calculated Annual Q95(10) and ADF Values at Naunton Hall

River Deben Naunton Hall		
	Annual Q9510 m3/s	Annual ADF m3/s
1965	0.143	0.718
1966	0.151	0.875
1967	0.146	0.813
1968	0.146	1.017
1969	0.188	1.060
1970	0.107	0.874
1971	0.151	0.796
1972	0.119	0.545
1973	0.057	0.204
1974	0.056	0.628
1975	0.091	0.750
1976	0.016	0.301
1977	0.073	0.674
1978	0.123	0.673
1979	0.112	0.920
1980	0.084	0.666
1981	0.144	0.960
1982	0.103	0.646
1983	0.104	0.629
1984	0.100	0.803
1985	0.186	0.826
1986	0.117	0.840
1987	0.248	1.418
1988	0.192	1.313
1989	0.080	Missing
1990	0.029	0.267
1991	0.065	0.297
1992	0.093	0.499
Long term Average	0.087	0.688

Is the timing important

3.6 The long-term flow record at Naunton Hall was used to analyse the flow history of the River Deben. The NRA has previously calculated the Average Daily Flow (ADF) as 0.758 m^3/s and the 95 percentile flow Q(95) as 0.085 m^3/s using the record period 1964 to 1990.

3.7 In order to determine whether changes have occurred in the historical flow regime of the Deben, the long-term flow record was analysed to supply annual values for ADF and Q95(10) (ie the 95 percentile flow occurring over ten consecutive days). The Q95(10) was used as this smooths the flow record and eliminates the effect of one off extreme flows. The average long term values calculated were an ADF of 0.67 m^3/s, and a Q95(10) value of 0.087 m^3/s. The slightly higher than previously calculated value for Q95 reflects the use of the Q95(10) value.

3.8 The Annual ADF and Q95 (10) values for each year of record are shown in Table 3.1 and Figures 3.2 and 3.3. Missing data during January to April 1989 result in no estimate of ADF being made during that year, however as flow during the low flow period is available, an estimate of Q95 (10) has been made. No long term trend is apparent from these graphs.

3.9 Lowest flow values occur during the drought years of 1976, 1989 and 1990. During 1976 (AWA, 1983) the river upstream of Debenham STW is reported to have dried up (AWA, 1983) and undated newspaper reports suggest this reoccurred in either 1989 or 1990 (Appendix E). In 1959 and 1973 the river through Wickham Market is reported as having dried up for several days although flows, due to groundwater baseflow, were still measurable downstream at Naunton Hall (AWA, 1975). However, over the record period since 1964 the data does not indicate the flow regime is worsening with time.

3.10 The Q95(10) and ADF values were calculated for the period of April to June during key low flow years. These values were calculated because flows during the April to June period are critical for the spawning of fish (See Section 4 of this report). These values were calculated for the years 1984, 1986 and 1990. During 1976 there was too much missing data during April and May to allow these values to be calculated over the April to June period. However the Annual Q95(10) value calculated for that year relates to a 10 day period from 1-10 July.

Table 3.2 Key year Q95(10) and ADF values for April-June period.

Year	ADF (April-June)	Q95(10) (April-June)	Timing of annual Q95(10)
1984	0.43 m^3/s	0.167 m^3/s	5-15 July
1986	0.572 m^3/s	0.156 m^3/s	19-29 August
1990	0.138 m^3/s	0.074 m^3/s	2-12 August

3.11. Rainfall data was supplied by the NRA for station No 219902. This rainfall station located at the head of the catchment, has a record which covers the period 1970 to 1991. The rain data was analysed to supply an Annual Average Daily Rainfall (AADR) for each year of the record. These values were then plotted against annual ADF and Q95 (10) values for the Naunton Hall record. These results are also shown in Figures 3.2 and 3.3. Although no statistically significant results can be derived from this data there does appear to be a relationship between rainfall and flow. As expected, especially in relation to ADF, the years of lowest flow correspond to the years of lowest rainfall.

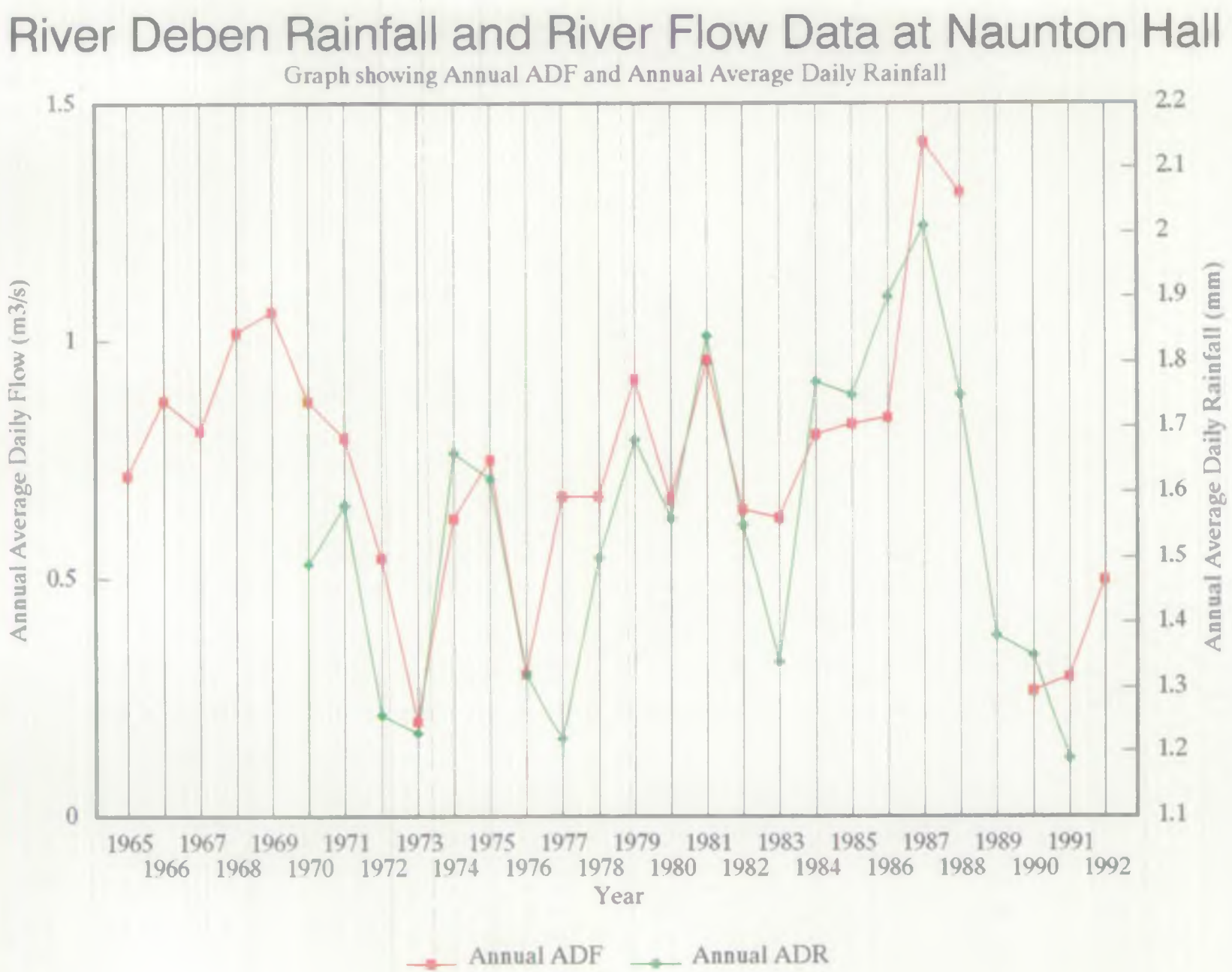


Figure 3.2 Annual ADF Values at Naunton Hall

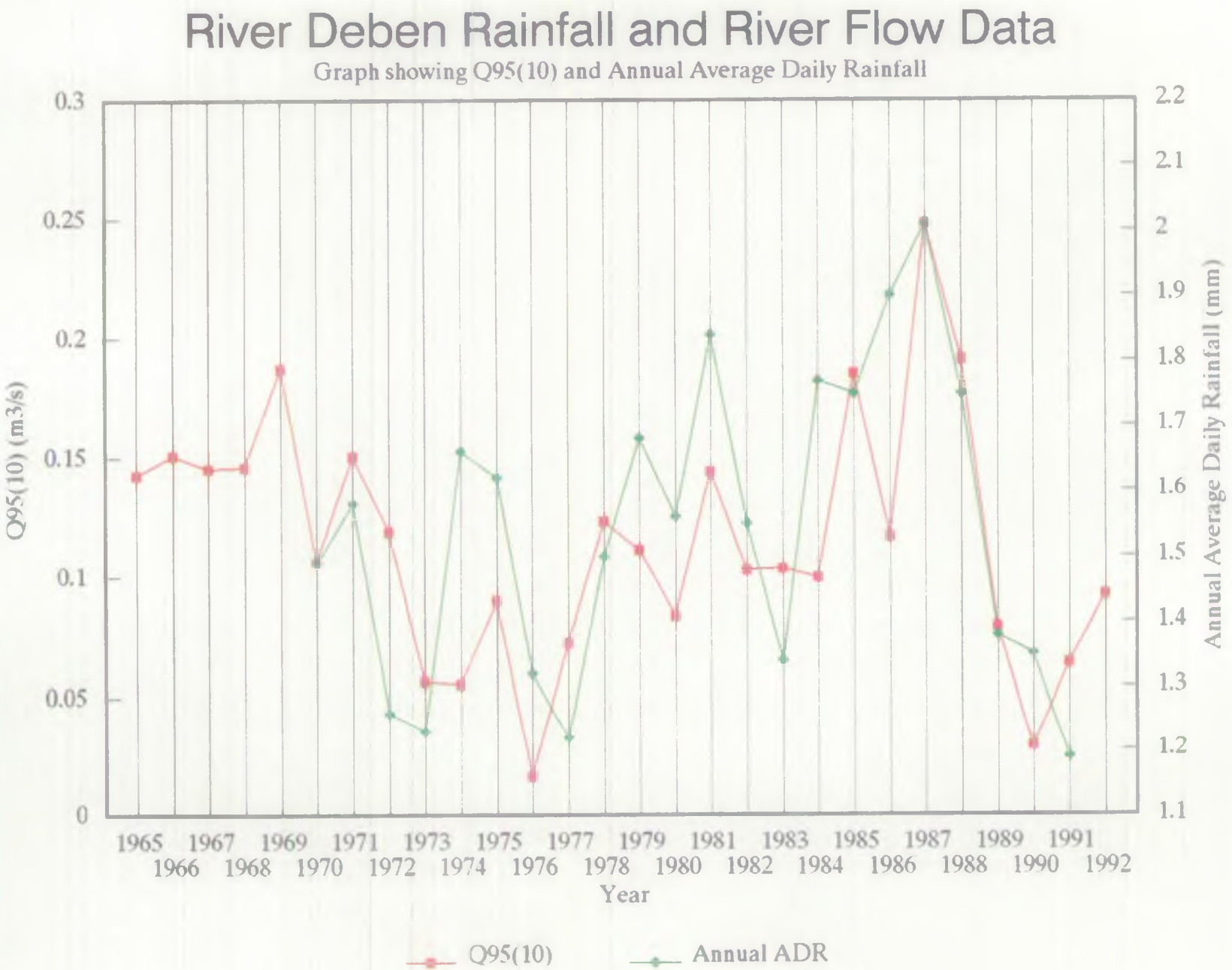


Figure 3.3 Annual Q95(10) Values at Naunton Hall

3.12 The Naunton Hall flow record was naturalised in order to remove the influence of effluent discharges and surface abstractions from the data. Surface abstractions from the River Deben are primarily for spray irrigation needs. Actual data for spray irrigation returns as compiled by Pauline Smith (File Note, August 1992) are shown in Figure 3.4 and their location marked in Figure 3.5. This gives actual spray irrigation returns for 1970 until 1991. This data has been reproduced and is shown in Appendix G. In order to extend this record back until the commencement of the flow record in 1965, an average value from the succeeding years was used. When converting the annual total surface abstraction values to averages to compare with the ADF and Q95 (10) values, the data was averaged over 6 months only, as spray irrigation occurs only in the summer months.

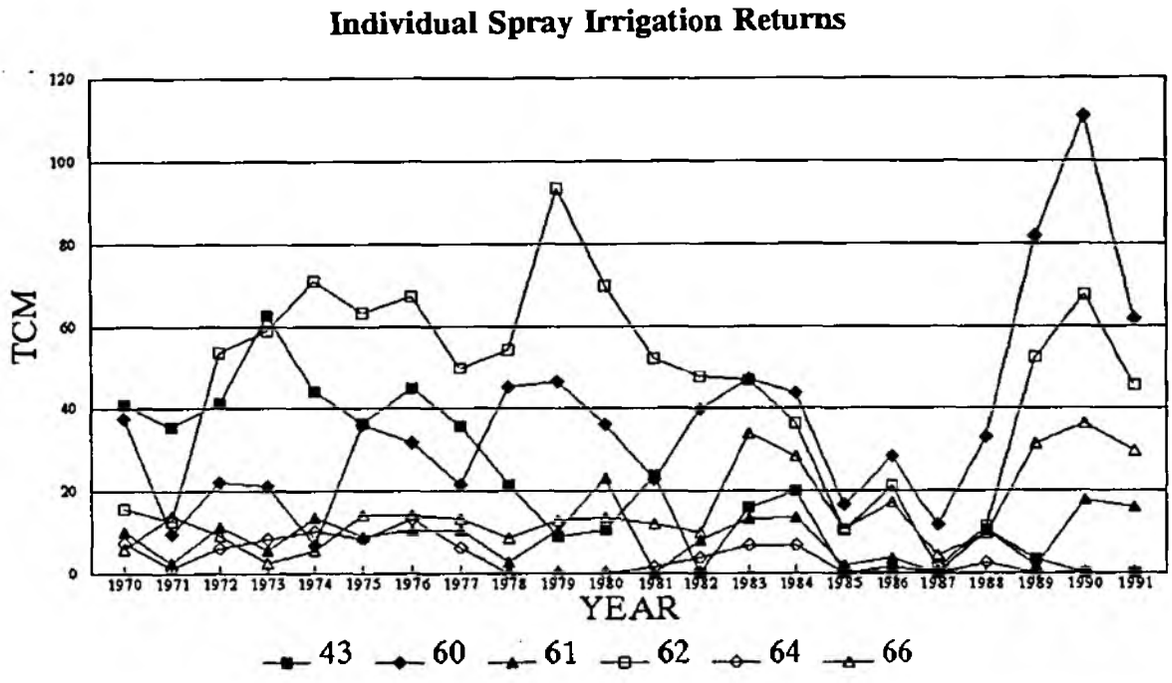
3.13 Dry Weather Flow (DWF) values were used as effluent discharge records, as actual returns were not available. These DWF values were deducted from the flow record from the dates of the discharge consent. The values used are shown in Table 3.3 below and the locations of the works are shown in Figure 3.3D. The naturalised ADF and Q95 (10) flow records were plotted alongside the gauged values, and the results are shown in Figures 3.6 and 3.7.

3.14 These graphs indicate a number of important points. Firstly there has been no significant increase in surface abstractions over the period of the record. In fact, as the graphs show, effluent discharge has a far greater influence on the river than does abstraction. In all cases the naturalised ADF and Q95 (10) values are lower than the actual value, indicating that effluent discharges are greater than surface abstractions. For example in 1991 total effluent discharges amounted to 0.0284 m^3/s, and surface abstraction were 0.0078 m^3/s.

Table 3.3 DWF's and Dates of Discharges Upstream of Naunton Hall

Sewage Treatment Works	DWF (m^3/s)	Date of Consent
RAF Bentwater	0.0131	1963
Wickham STW	0.0064	1966
Earl Soham STW	0.0009	1967
Charsfield STW	0.0006	1967
Debenham STW	0.0039	1973
Rendlesham	0.0035	1980

Figure 3.4 Spray Irrigation Returns (Individual and Total) for the Period 1970 - 1991



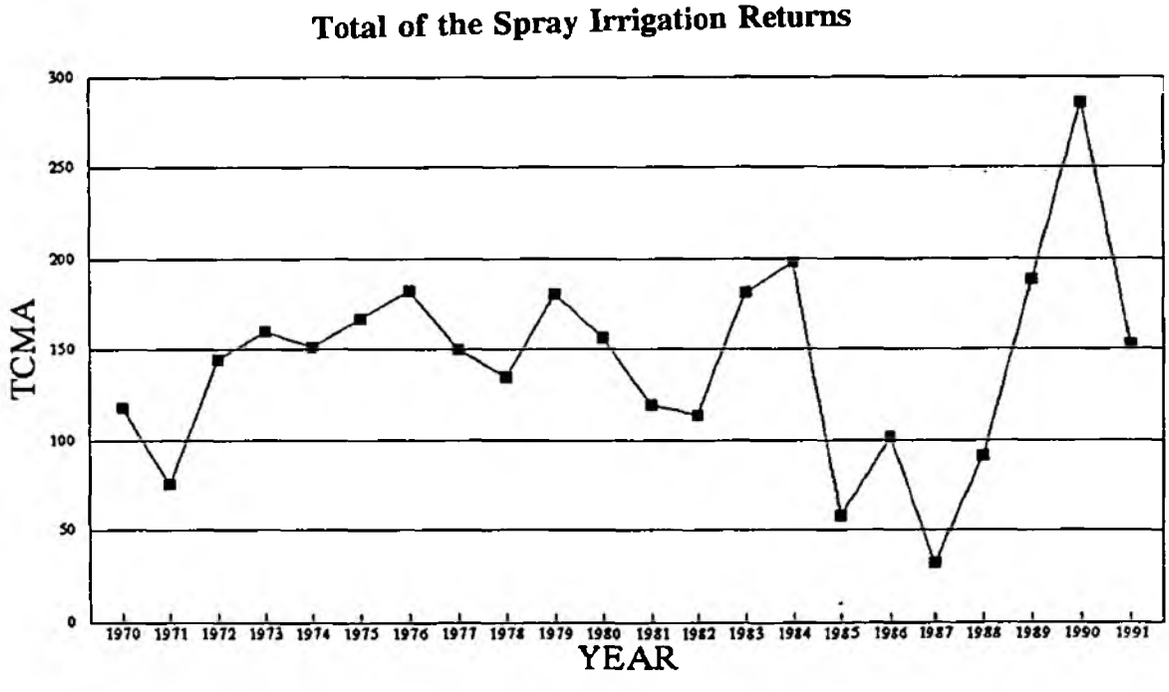


Figure 3.5 Locations of Major Spray Irrigation Abstractions (using data from Hydrotechnica 1993, Scale 1:50,000)

Abstraction Licence Number	Licenced Abstraction (TCMA)
7/35/06/**/043	22.7
7/35/06/**/060	167.2
7/35/06/**/061	18.1
7/35/06/**/062	150.0
7/35/06/**/063	7.2
7/35/06/**/064	36.3
7/35/06/**/066	31.7
7/35/06/**/067	22.7
7/35/06/**/068	37.0
7/35/06/**/073	45.0
7/35/06/**/085	24.0
7/35/06/**/095	45.4

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3.15 Figures 3.6 and 3.7 show that during periods of extreme low flows, the flow is predominately effluent returns from the sewage treatment works. For example in 1976, during the period of the Q95(10) flow, the flow in the river was as follows:

	Q95(10)
Gauged Flow	0.0161
+ Abstractions	0.0102
- Discharges	0.0249
= Naturalised Flow	0.0014

All Figures are in m^3/s.

This indicates the importance of the effluent flow during low flow periods.

3.16 The above figures also indicate that although spray irrigation does not generally have a large effect on river flow, during periods of extreme low flows it can serve to significantly exacerbate the problem. This is graphically shown in Figure 3.8 using data supplied by the NRA. This figure also indicates That the critical month where low flows and spray irrigation abstractions have seriously depleted mean flows is August.

3.17 The naturalised Q95(10) and ADF have not been adjusted to take account of the test pumping of proposed augmentation boreholes which has occurred at various times between 1976 and 1990. Table 3.4 below summarises the timing and magnitude of the test pumping programm. In 1976 the Q95(10) occurred during the period 1-10 of July. The Q95(10) value for this period was 0.016 m^3/s, and the naturalised flow was 0.014 m^3/s. Table 3.4 indicates that during this period the Earl Soham STW bore was providing 0.018 m3/s. The implication is if the pumping test had not been occurring at that time, that little or no flow would have been recorded at Naunton Hall. A further implication is that there may be some bed loss occurring from the River Deben in the upper reaches.

Table 3.4 Summary of Pumping Test Discharges to River Deben from Augmentation Bores

Period	Source	Discharge (m^3/s)
12/7/76 to 20/9/76	Debenham STW Chalk bore TM 179 626	0.012, falling to 0.0075 in September
23/6/76 to 20/9/76	E.Soham STW Chalk bore (exploratory) TM 233 626	0.018, falling to 0.012 in September
28/3/77 to 4/4/77	E. Soham Chalk bore (production) TM 233 626	0.087
14/8/78 to 15/11/78	E. Soham Chalk bore (production) TM 233 626	0.048 falling to 0.037 in November
12/8/81 to 25/8/81	Debenham Crag bore (exploratory) TM 176 643	0.024
6/6/82 to 7/6/82	Debenham Crag bore (production) TM 176 643	0.107
15/10/90 to 16/11/90	Debenham Crag bore (production) TM 176 643	0.088

3.18 Hydrotechnica (1993) looked at the base flow component of the River Deben. They used two methods, firstly based on The Institute of Hydrology (IH) method which produced a baseflow component of 0.288 m^3/s. Secondly, they used their own method which involved the subjective selection of a maximum baseflow rate derived from aquifer springflow alone. This produced a value of 0.178 m^3/s which was lower than the IH method, however this is thought to be a good minimum estimate. The results have been reproduced from the Hydrotechnica report, and are shown in Appendix H. Hydrotechnica states average daily base flows to be in the range 15 to 25 Ml/d. This equates with a baseflow component of 0.25 to 0.35. As a proportion of total flow into the river, the baseflow component is relatively small. Hydrotechnica also state that there are a number of streams in the upper part of the catchment that are dry during recession indicating a low baseflow component.

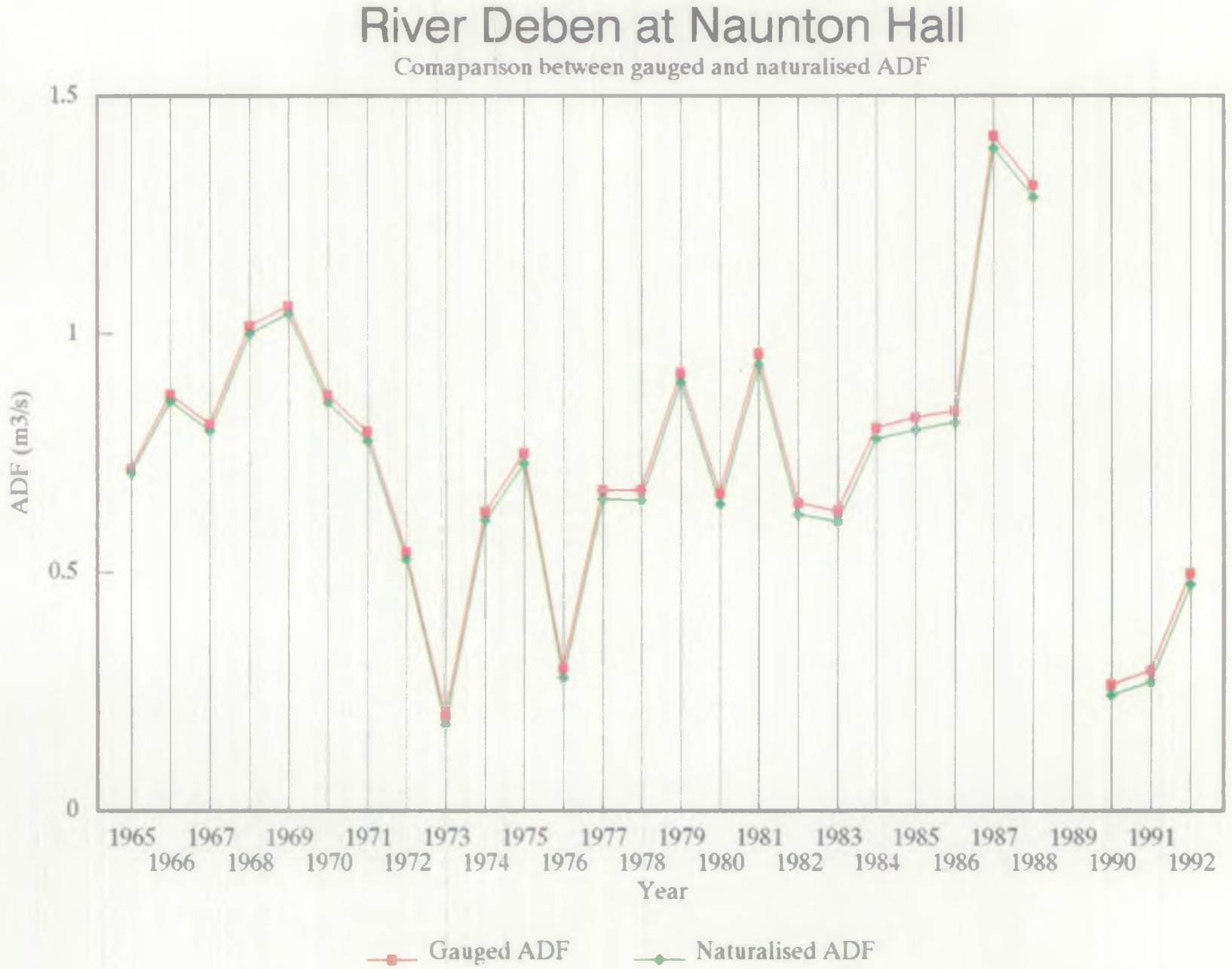


Figure 3.6 Comparison of Actual and Naturalised ADF Values at Naunton Hall

Figure 3.7 Comparison of Actual and Naturalised Q95(10) Values at Naunton Hall

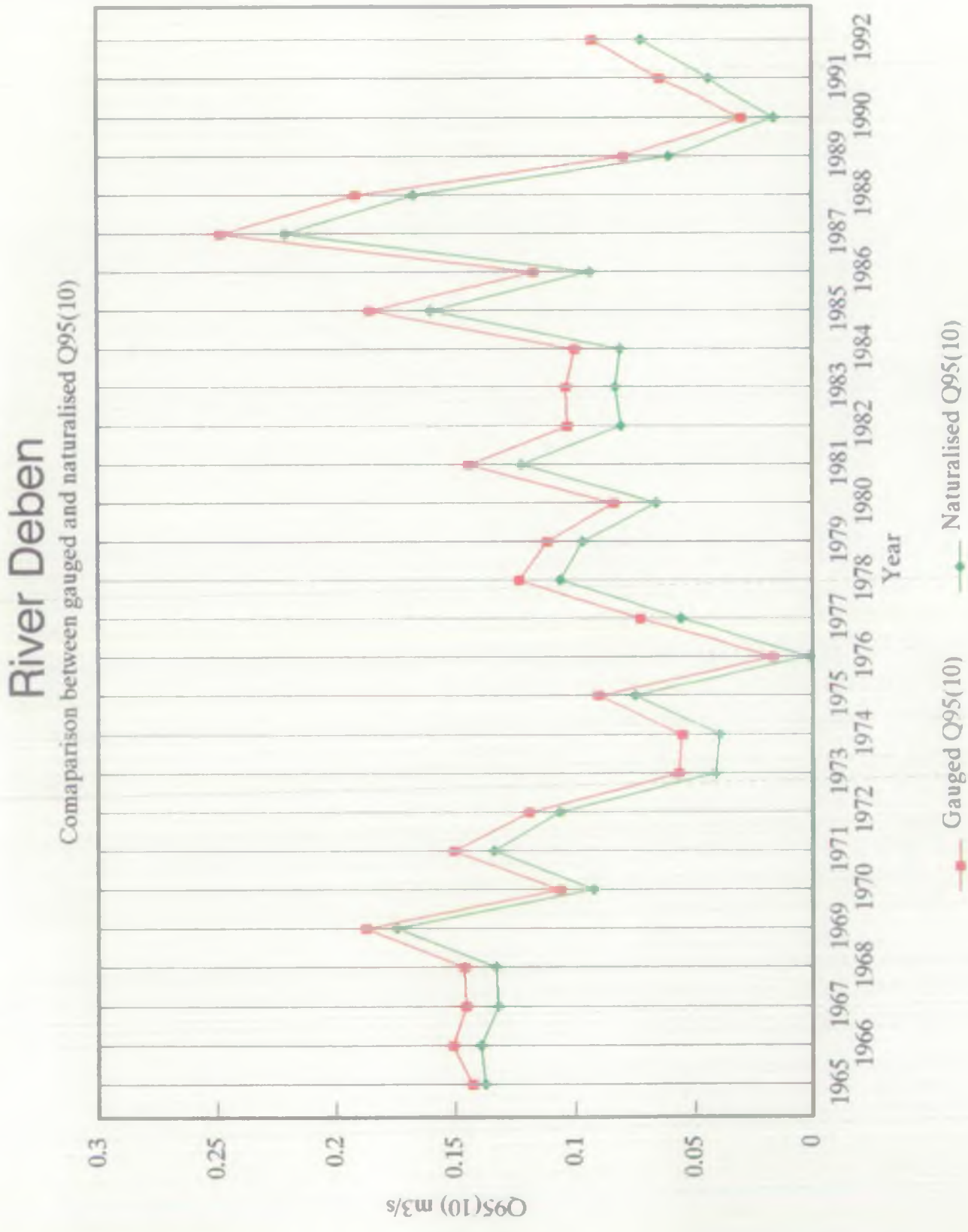


Figure 3.8 Comparison of Spray Irrigation Figures and Mean Flows During the Drought Summers of 1989, 1990 and 1991

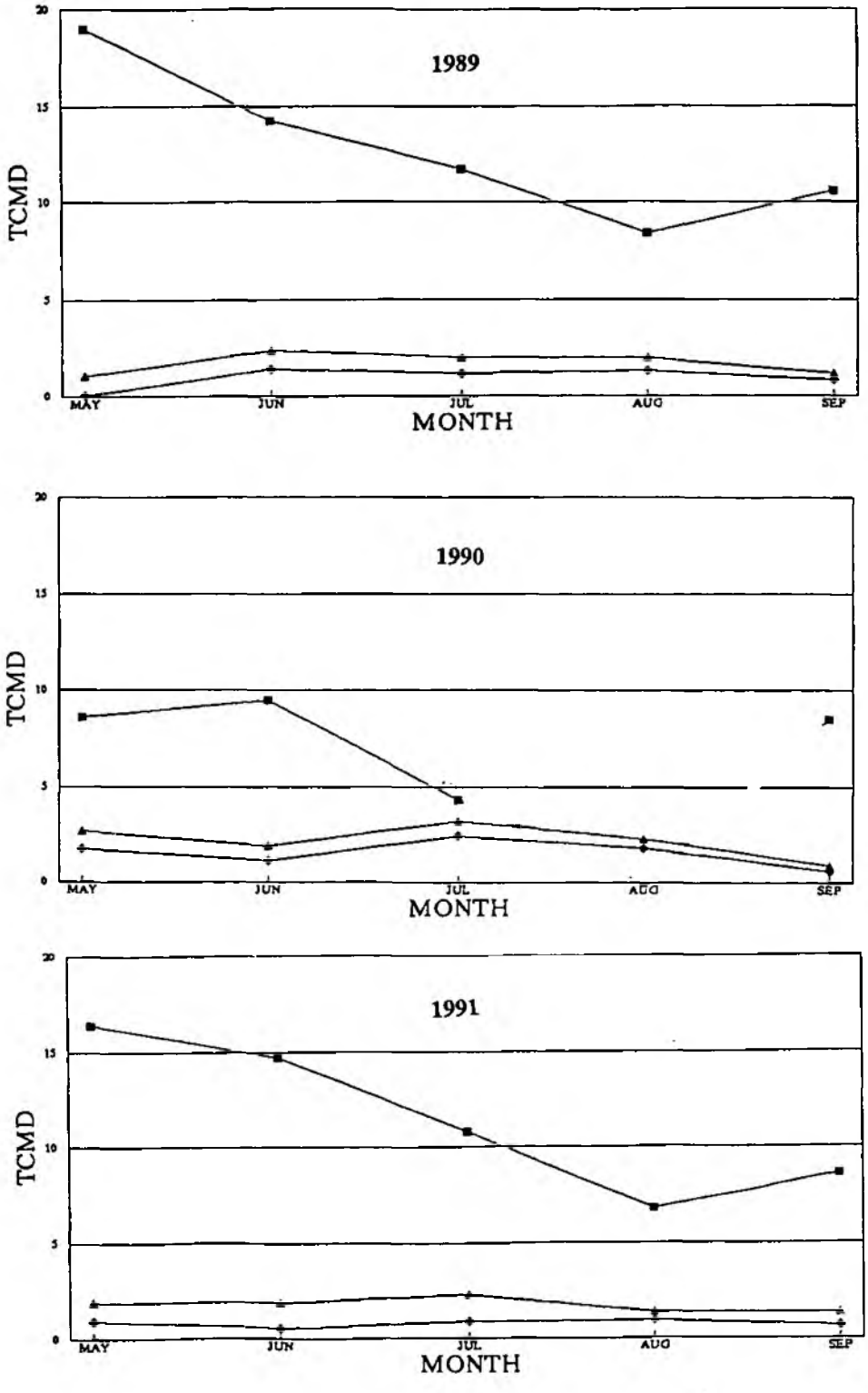


Fig 3.21 location 2

3.19 The principal groundwater abstractions from the Deben catchment are from the two Public Water Supply boreholes at Winston and Pettistree. Figures 3.9 and 3.10 show how abstractions from these boreholes have increased from 1970 to 1991, but during 1992 and 1993 abstractions decreased. Both boreholes are part of a group licence No 35/8/GS/152. The licence has altered over the period of the study, as follows.

Licence of Right, March 1967

Winston 2 boreholes (sources 7 and 8) daily rates 463 m^3/d 655 m^3/d
Pettistree 2 boreholes (source 11) daily rate 4794 m^3/d
Annual quantity aggregated with 14 other sources 13,806,140 m^3/d

Licence Variation, February 1972

Winston Source 7 daily rate 2045 m^3/d
Pettistree Source 9 daily rate 81828 m^3/d
Increase in aggregate annual quantity (with 13 other sources) to 16,888,800 m^3/a but to revert to 15,231,700 on 1 Jan 1975.

Licence Variation, October 1981

Winston Daily rate 2700 m^3/d
Pettistree Daily rate 8183 m^3/d
Aggregate annual abstraction increased from 15,251 tcma to 18,500 tcma for a period of 5 years only.

Further variation is proposed, which will allow firmer control through separate group totals for the R.Gippy and R.Deben boreholes.

3.20 Figures 3.9 and 3.10 below show actual abstraction from Winston and Pettistree PWS's. It must be speculated that the increase in groundwater abstractions from particulary the Winston borehole, may be responsible for exacerbating the low flow problems experienced in the Deben downstream of Debenham. Although Winston PWS abstracts from a chalk aquifer, it is likely that there is a degree of groundwater flow form the overlying Crag.

Why don't we know yet?

Where does the water go?
Has effluent ↑ in line with abstraction?

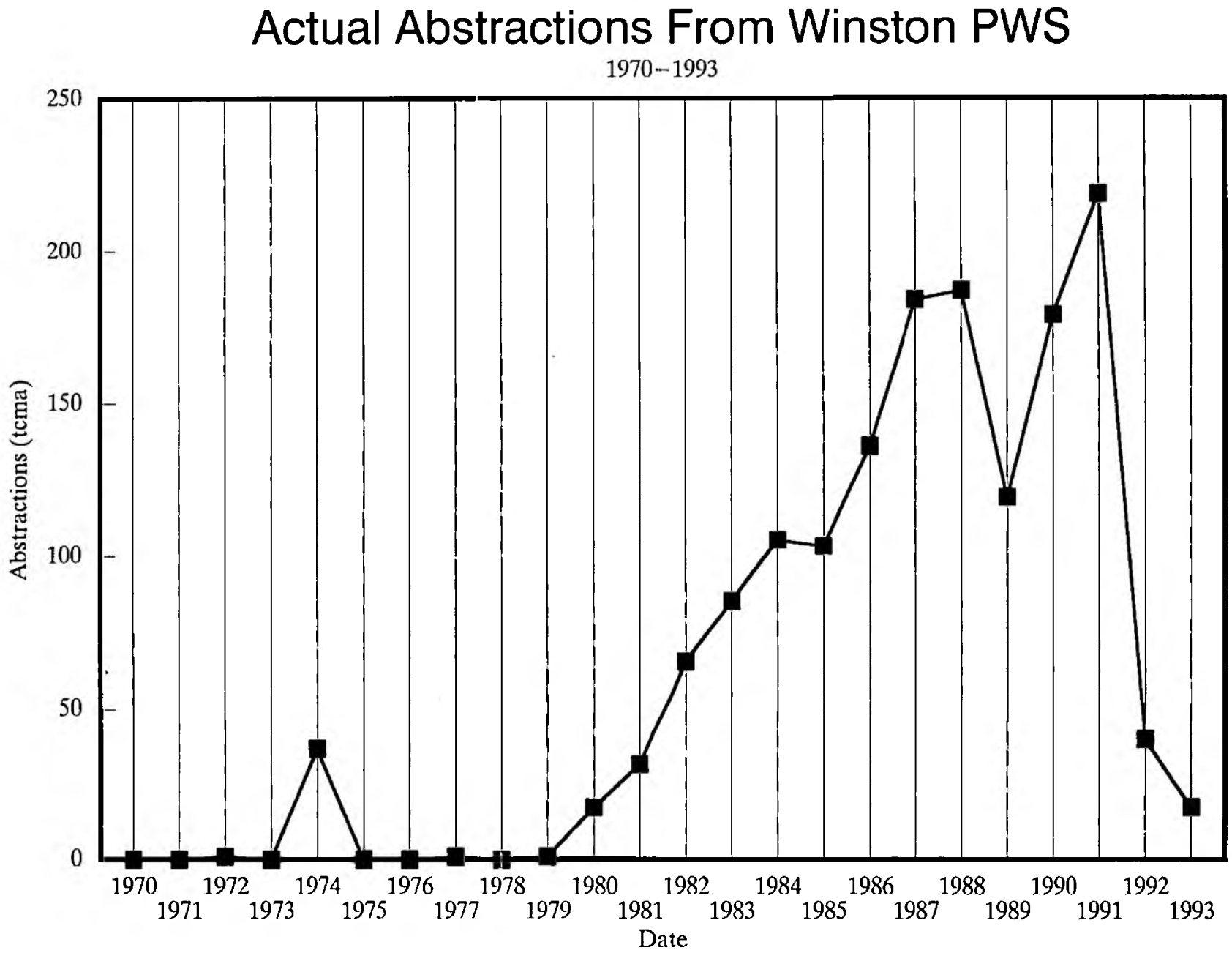
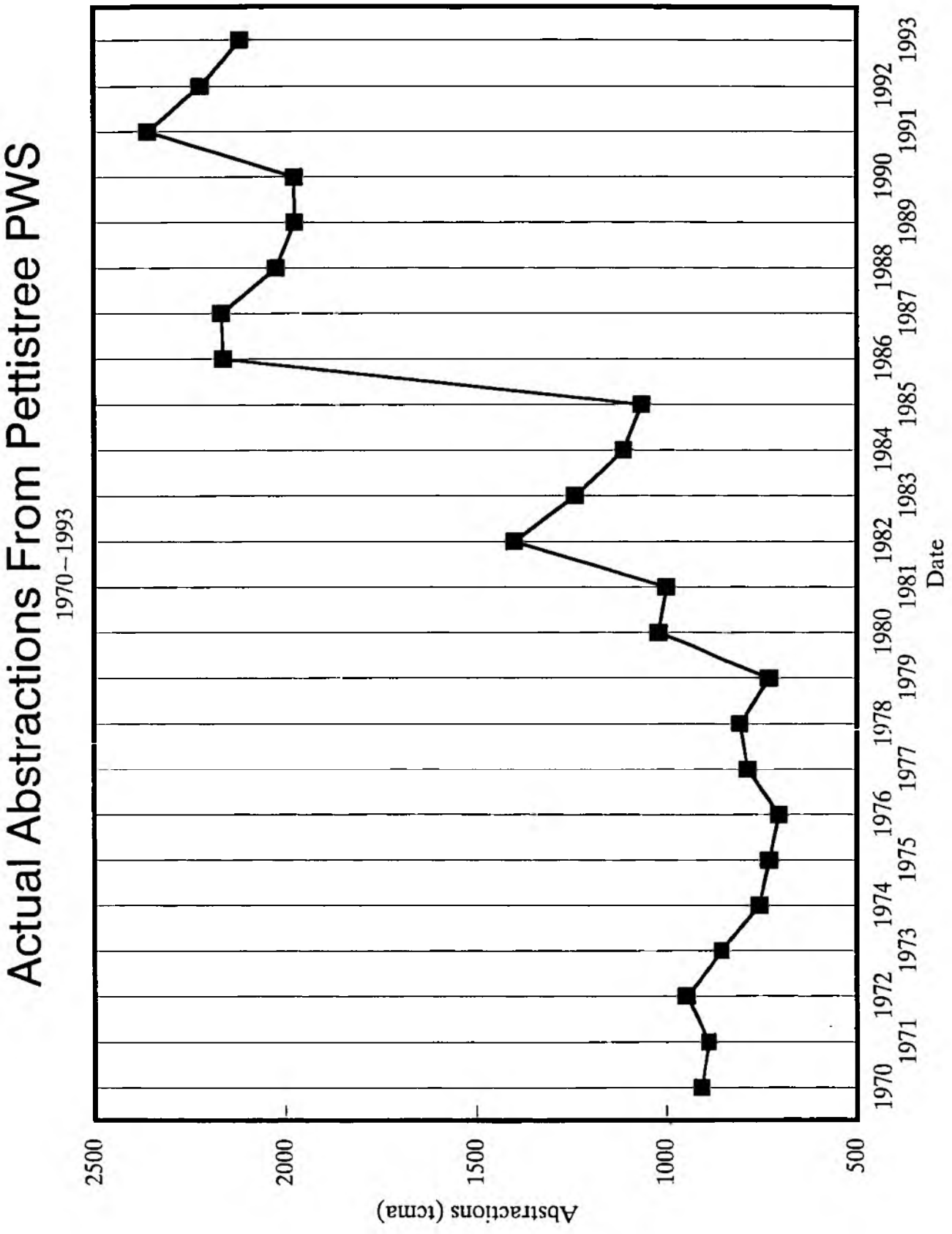


Figure 3.9 Actual Abstraction from Winston PWS

Figure 3.10 Actual Abstractions from Pettistree PWS



3.21 During low flow periods a temporary wier was placed in the River Deben close to Ashfield Crossroads. Data was provided to Southern Science for the period 1976-1983 (exc. 1977). The average gauged flow over a period was compared to estimated flow calculated by proportioning the flow record at Naunton Hall for the same period, and adjusting for intervening abstractions and discharges between the two sites. The results are shown in Table 3.5 below.

Table 3.5 Gauged flow at Ashfield Crossroads compared to flow estimated from Naunton Hall

	Flow m3/s			
Date	Average Gauged Flow	Estimated Flow Proportioned From Naunton Record	Gauged as % of Estimated	Period of Averaged Flow
1976	0.0085	0.0184	46.20	24–31 Aug
1978	0.0218	0.033	66.06	18–31 Aug
1979	0.0085	0.035	24.29	24–31 Aug
1980	0.005	0.01786	27.99	1–31 Aug
1981	0.016	0.033	48.48	7–31 Aug
1982	0.005	0.022	22.78	1–31 Aug
1983	0.008	0.022	36.36	1–31 Aug

3.22 The results indicate that the gauged flow recorded at Ashfield crossroads was significantly lower than would have been expected. Groundwater abstractions from the catchment may have been the cause of this disparity by lowering of the water table resulting in increased bed losses from the River Deben. This is an issue which requires further investigation.

Current Hydrological Status of the River

3.23 During a field visit by Southern Science to the Deben (21-22/3/94) three sites were chosen for a channel survey. These were located at Brandeston NGR TM250601, Winston Grange TM187622, and Earl Soham Watercourse at Kings Hill TM233621. The aim was to use hydraulic calculations to proportion the flow record from Naunton Hall to these three sites, then using channel morphology to convert the flow record to depths and velocities so that for any calculated discharge, the depth and velocity at that site could be found.

3.24 In order to create a flow record for the three sites of interest, the ADF and Q95 (10) records from Naunton Hall were proportioned using the catchment area method. The results were then adjusted to take into account the variations in surface abstractions and effluent discharges between the site in question, and Naunton Hall. The area of the whole catchment to Naunton Hall is 162 km^2. The catchment areas of the three sites were Brandeston 101.4 km^2, Winston Grange 33.4 km^2, Earl Soham Watercourse 21.39 km^2. These represent 62.59%, 20.6% and 13.2% of the whole catchment respectively.

3.25 The ADF and Q95 (10) values from Naunton Hall were proportioned according to percentage size of the catchment, then the values were adjusted to take account of intervening surface abstractions and effluent discharges. Note that the results produced are calculated actual flows not naturalised flows, as the values from Naunton Hall used were gauged values. Figures 3.11, 3.12 and 3.13 show the calculated Q95 (10) and ADF values from 1965 to 1992 for each of the three sites of interest.

3.26 During the field visit channel cross-section measurements and measurements of water surface slope were taken. Spot gauging was also carried out using a flow meter to act as a check against the calculated values of discharge produced. The results from the flow gauging are shown in Appendix I.

3.27 The cross-sectional data was analysed using Mike 11 package produced by the Danish Hydraulics Institute. For each site the cross-sectional survey data was entered into Mike 11, which then produced channel cross-sections for each site. These are shown in Appendix J. For each site the relationship between Depth (level), Cross-sectional Area, Hydraulic Radius, and Width is calculated.

3.28 Using Mannings formula and the Mike 11 output, the relationship between discharge, depth and velocity, was produced for each of the three sites. Figures 3.14 to 3.19 show these relationships both for the type of flow conditions experienced during the field study, and for flow up to the bankfull condition. The calculated figures used to derive these graphs are shown in Appendix K. This calculated relationship means that for any discharge, the corresponding depth and velocity value can be found.

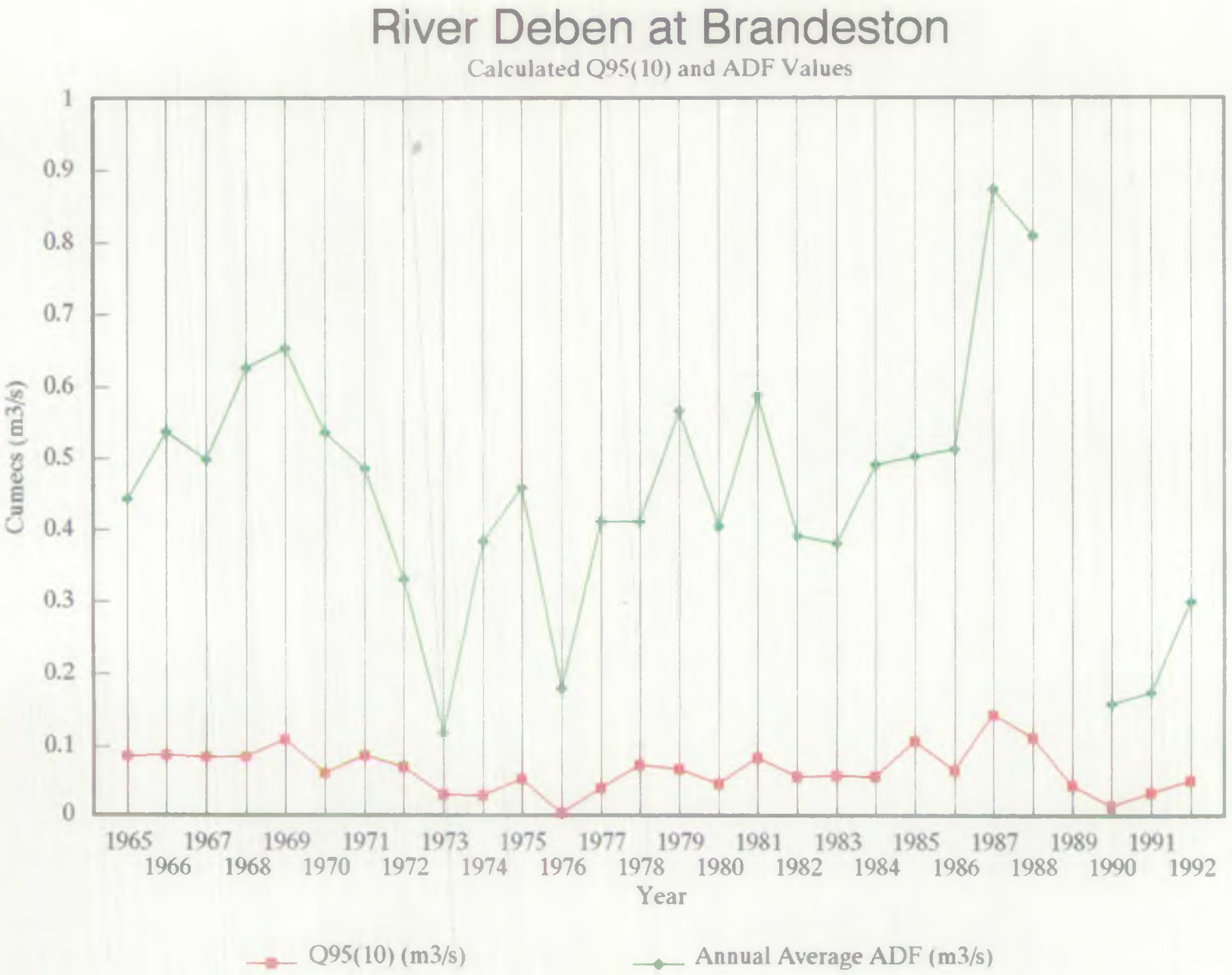


Figure 3.11 Calculated Q95(10) and ADF at Brandeston

Figure 3.12 Calculated Q95(10) and ADF at Winston

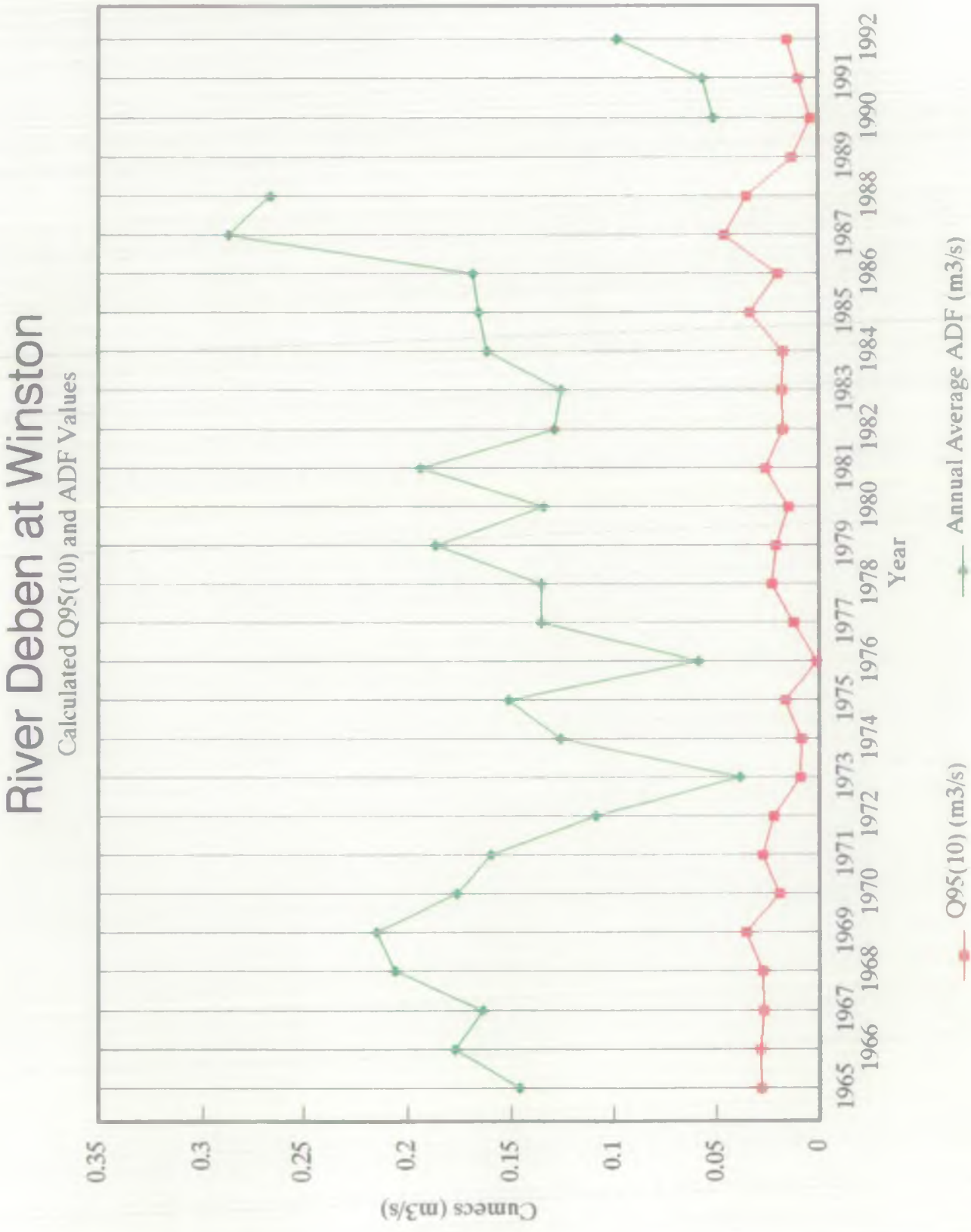


Figure 3.13 Calculated Q95(10) and ADF for the Earl Soham Watercourse - Kings Hill

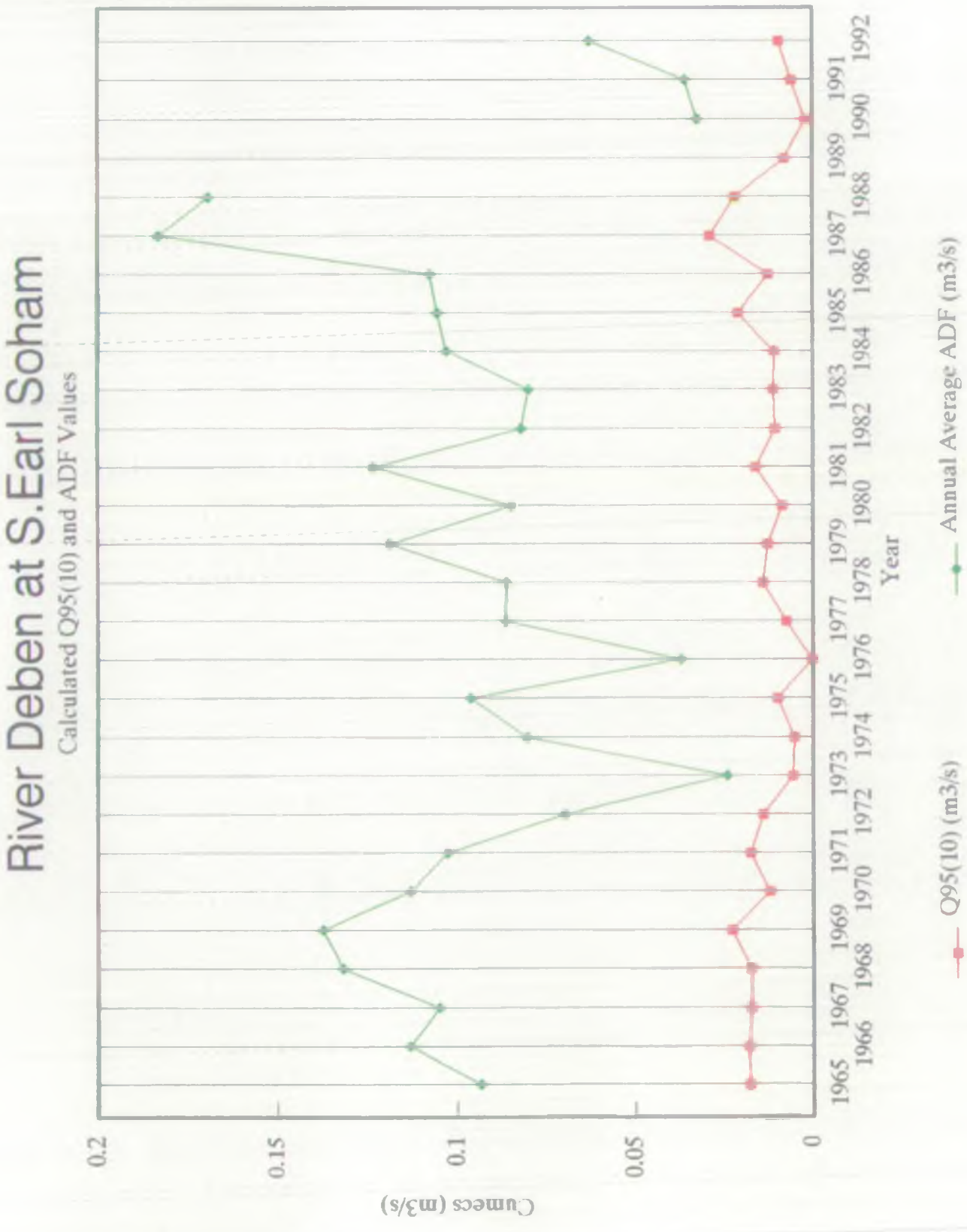


Figure 3.14 Calculated Relationship between Discharge and Velocity at Brandeston

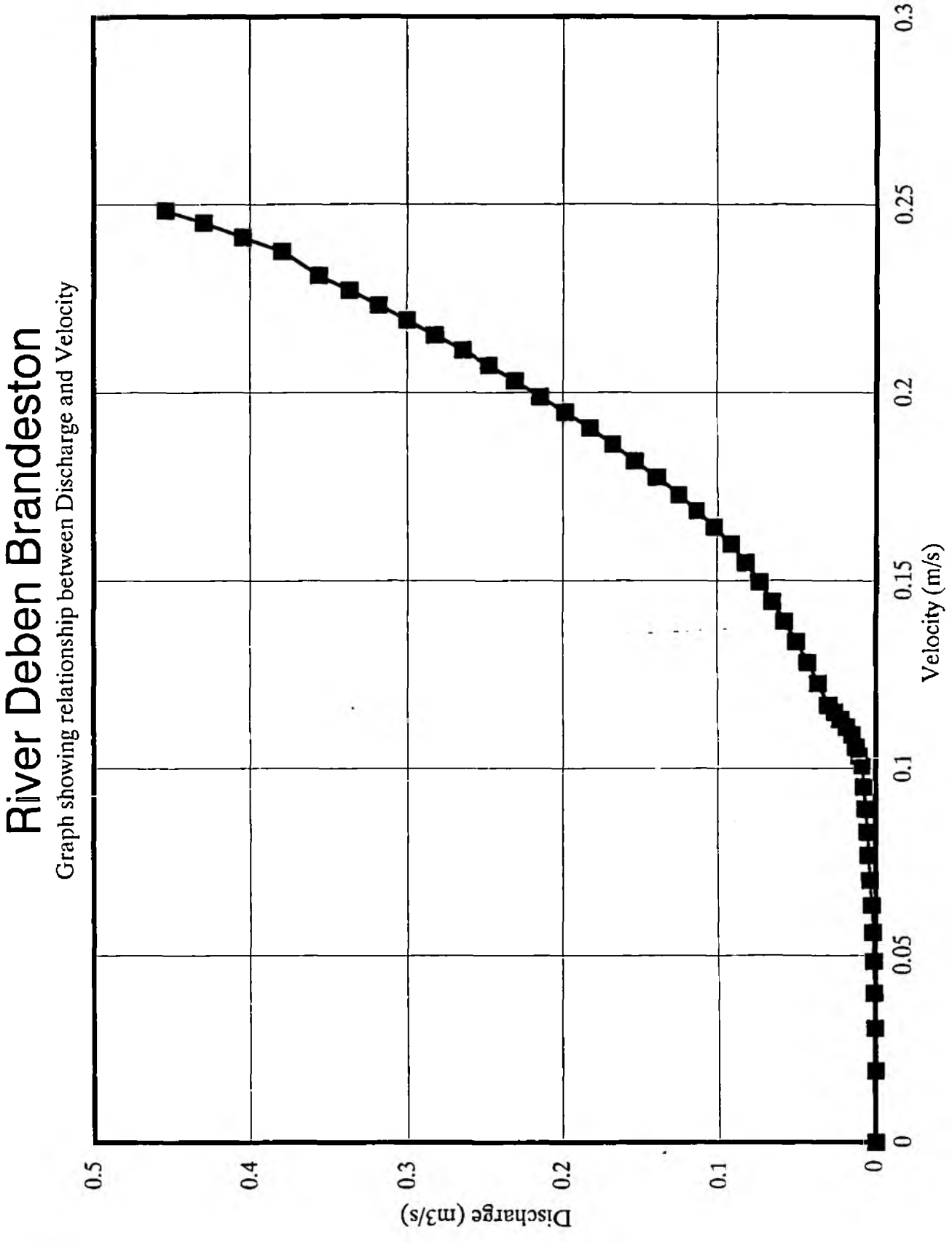


Figure 3.15 Calculated Relationship between Discharge and Water Depth at Brandeston

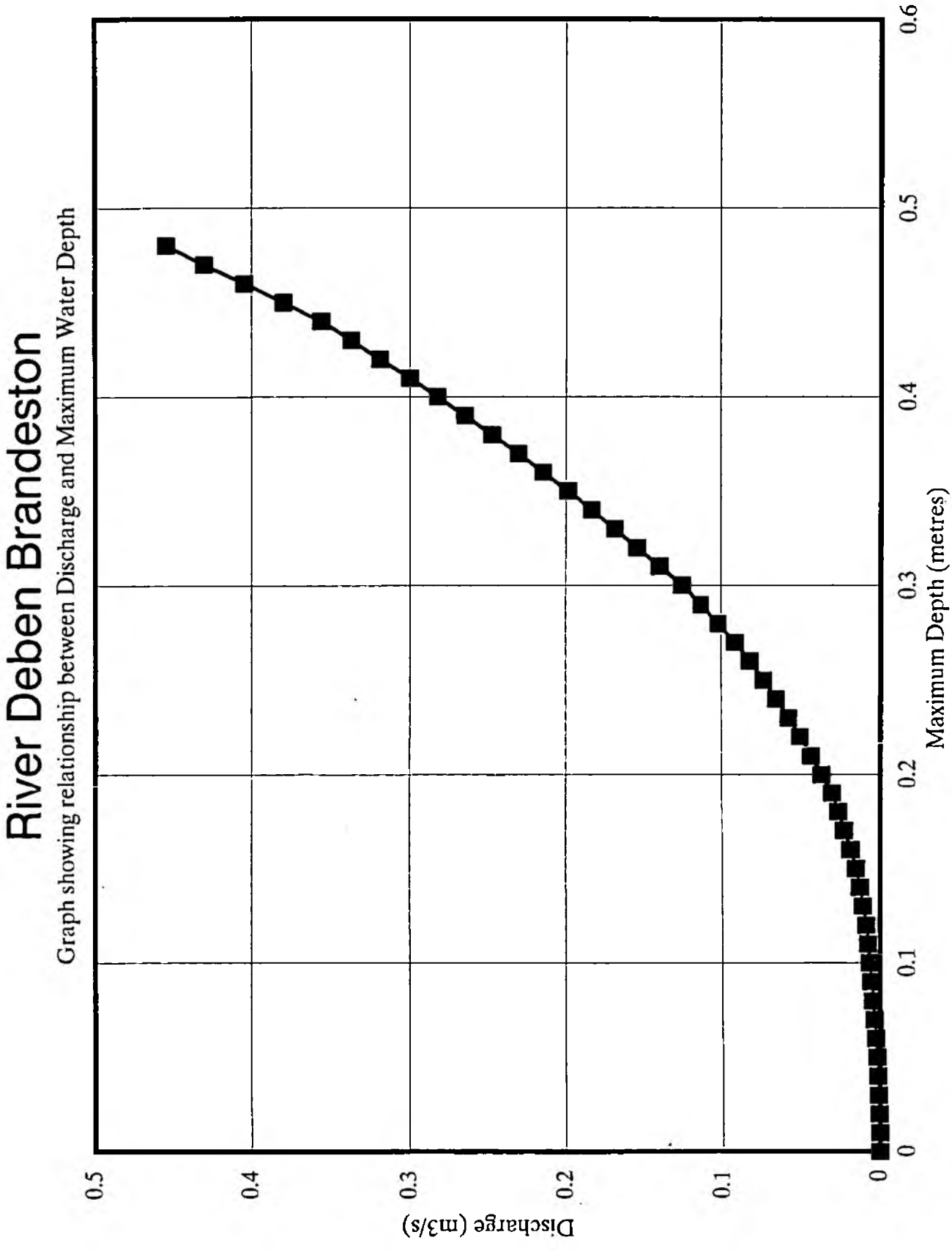


Figure 3.16 Calculated Relationship between Discharge and Velocity at Winston

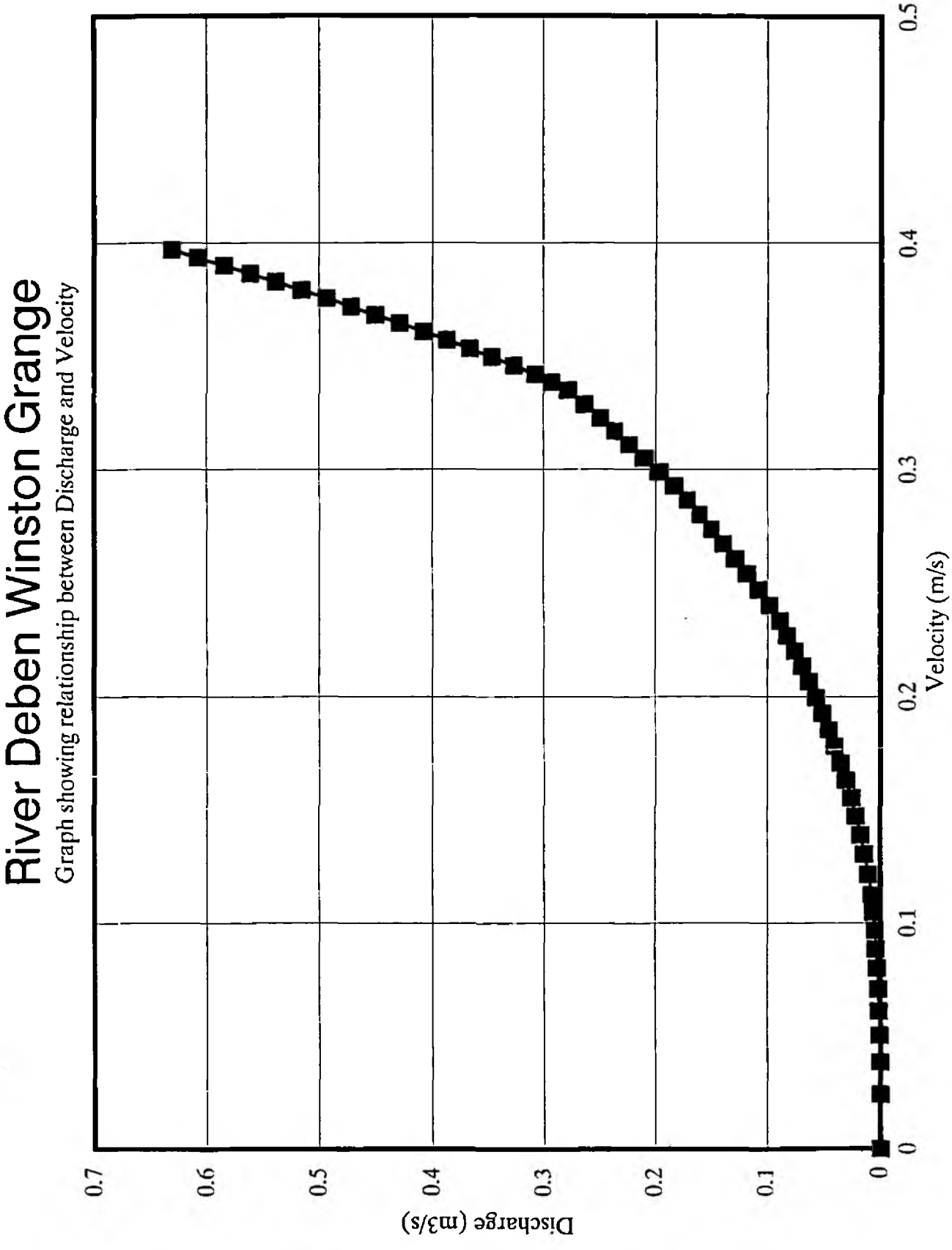


Figure 3.17 Calculated Relationship between Discharge and Depth at Winston

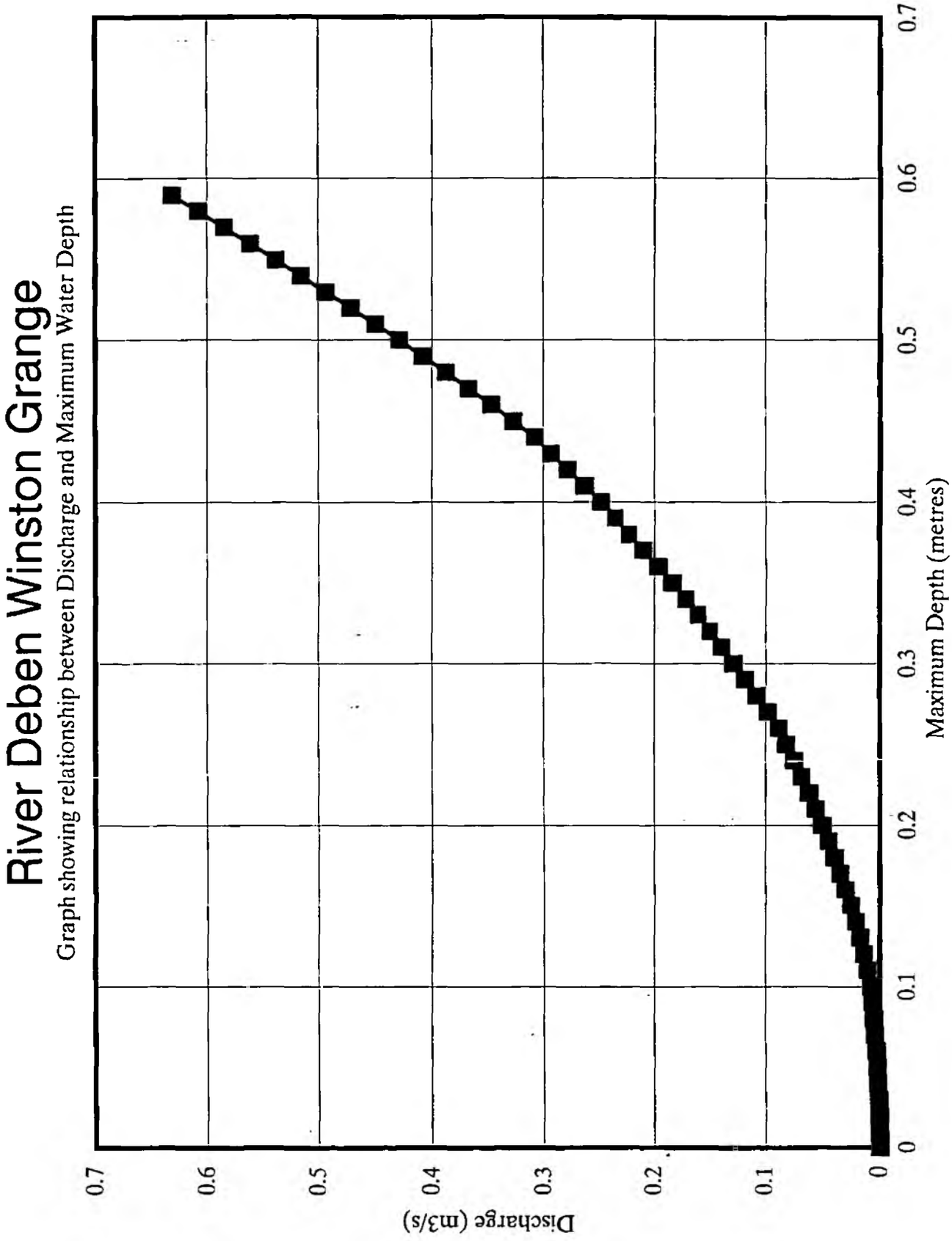


Figure 3.18 Calculated Relationship between Discharge and Velocity for the Earl Soham Watercourse - Kings Hill

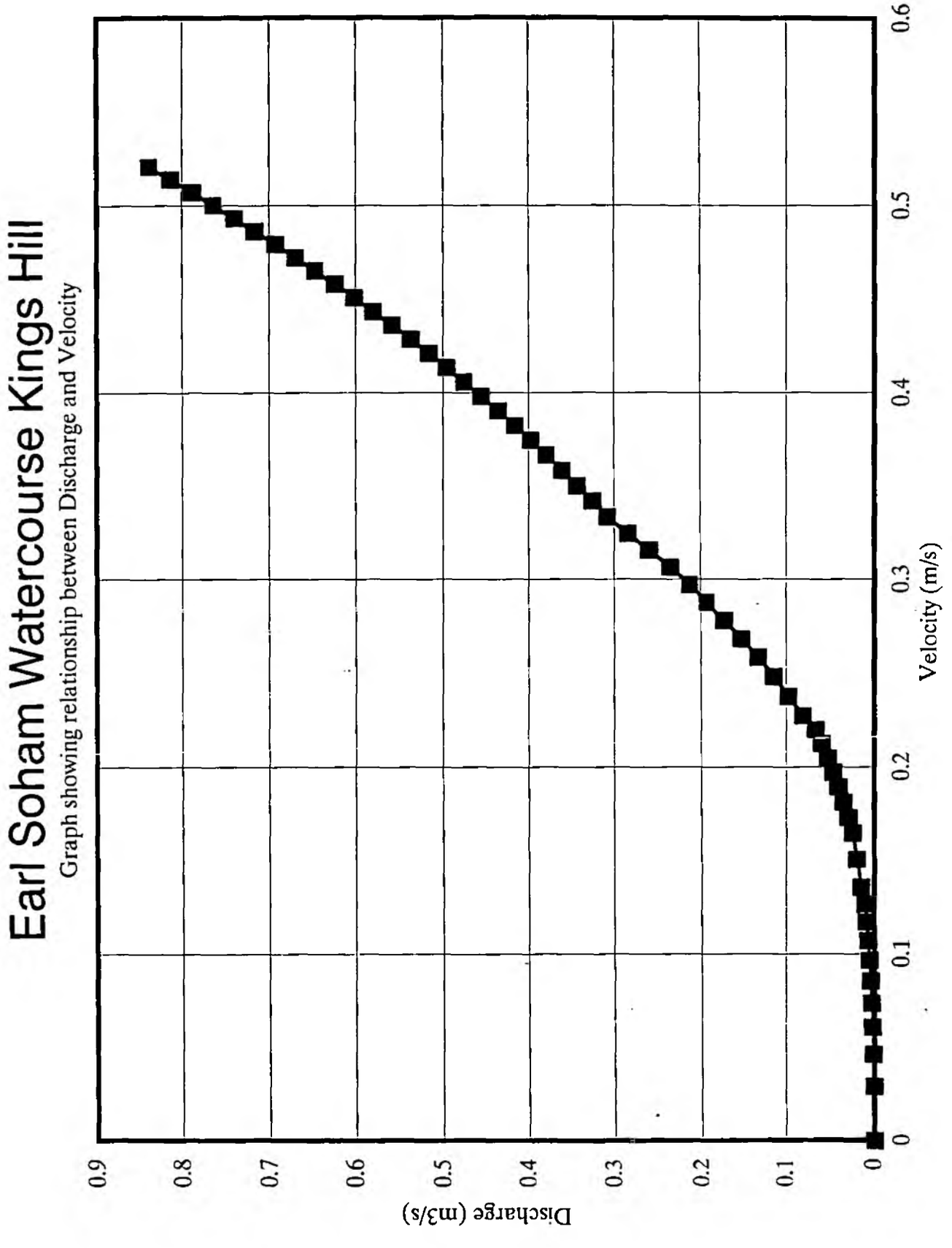
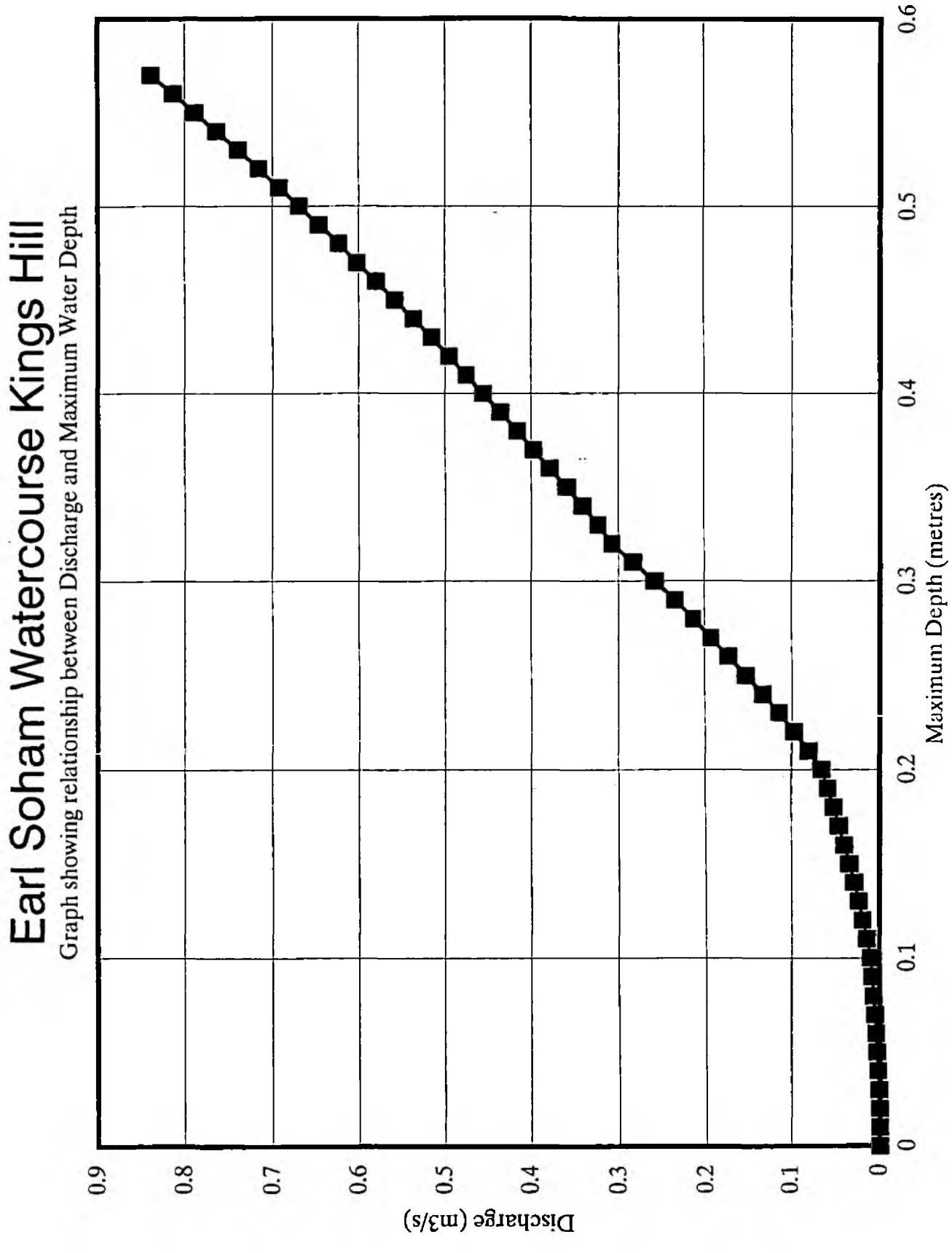


Figure 3.19 Calculated Relationship between Discharge and Depth for the Earl Soham Watercourse - Kings Hill



Draw on the catchment boundary

Geology and Hydrogeology

3.29 The geology and hydrogeology of the study area are shown in Figure 3.20, and have been described in some detail elsewhere (Hydrotechnica 1993). Suffice it to say here that in the north-west of the catchment, the Upper Chalk (which is the main aquifer) is overlain by glacial sands and gravels, followed by Boulder Clay (7 m and 16.5 m thick respectively at Winston Pumping Station, TM 1837 6137). The Deben and its tributaries have cut through the Boulder Clay to reveal the Sand & Gravel. Heading south-eastwards, the Boulder Clay thins and disappears in a feather-edge, and the London Clay starts to appear in the sequence, so that at Pettistree Pumping Station (TM 3121 5475), the Upper Chalk is overlain by about 17 m of Eocene London Clay and Woolwich & Reading Beds (Lower London Tertiaries), followed by about 4 m of Crag/Sand & Gravel.

3.30 Across the whole of the study area therefore, overlying the Crag, the Lower London Tertiaries, or the Chalk, is a blanket of glacial silt, sand, and gravel, which is most important to the River Deben and the present study. The Crag, and various sands and gravels, are usually grouped together as a single Sand & Gravel aquifer. Their combined thickness varies from as much as 95 m, to less than 1 m where the Crag is absent. The hydraulic conductivity ranges from 20 to 50 m/d. Reported values of the storage coefficient range from 0.002 to 0.0003 under semi-confined conditions, although in unconfined areas, it can be as much as 0.15 to 0.25.

P

Drill reports?

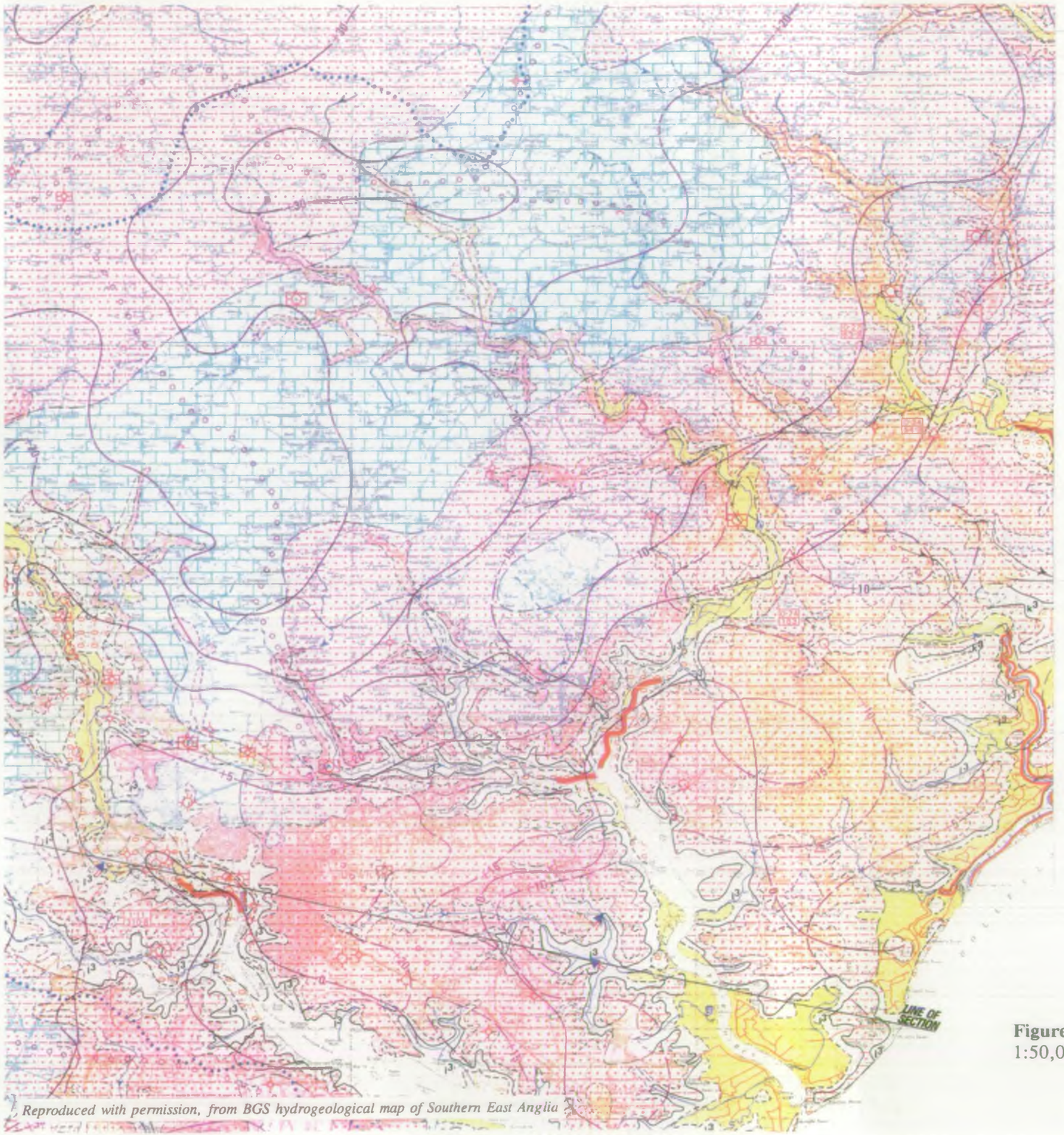
Is it this aquifer which contributes to river baseflow?

3.31 Unfortunately, there are insufficient water level data for the Sand & Gravel aquifer to allow contours to be drawn. Where the London Clay is absent, the levels will be very similar to the underlying Chalk, with the Sand & Gravel and Chalk in hydraulic continuity. Conversely, where the London Clay is present, piezometric levels in the Sand & Gravel can be considerably higher than in the Chalk, with the London Clay acting as a semi-confining layer in between. Seasonal water level fluctuations in the Sand & Gravel are only 1 to 2 m, indicating high storage in the sandy deposits, and the hydrochemistry indicates recent recharge with significant groundwater flows.

3.32 With respect to the interaction between the River Deben and the Sand & Gravel aquifer, four different types of river-aquifer interaction have been recognised (Hydrotechnica, 1993), of which the following three apply to the non-tidal river:

1. In the upper reaches, the river runs over thick boulder clay, which prevents effective river-aquifer interaction;
2. In the middle to upper part, the river has cut through the Boulder Clay, and is able to interact with the exposed Sand & Gravel;
3. In the lower parts, the river level lies below the base of the Sand & Gravel, and water seeps from the aquifer, running to the river over the London Clay.

3.33 These three types have been marked on Figure 3.21, which also shows the locations of Winston and Pettistree pumping stations, the locations of water dependant County Wildlife Sites and the Fox Fritillary Meadow SSSI and points at which water levels in the Sand & Gravel are available. Opportunities for enhancing wildlife by the control of shallow water levels are discussed in Section 4 and 5.



Reproduced with permission, from BGS hydrogeological map of Southern East Anglia

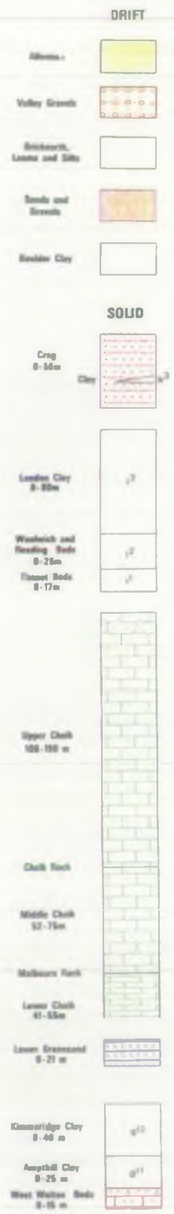


Figure 3.20 Geological and Hydrogeological Map of the River Deben Catchment (Scale 1:50,000)

Figure 3.21 Relative Locations of River Aquifer Interactions, PWS Pumping Stations, Water Level Monitoring Points and Water Dependent County Wildlife Sites in the Deben Catchment (Scale 1:50,000)

Key

- Fox Fritillary Meadow SSSI
- PWS pumping stations
- Monitoring points for water levels in Sand & Gravel aquifer (numbers from Hydrotechnica report 1993)
- Water-dependent County Wildlife Sites
- River running over Boulder Clay, no river-aquifer interaction
- River cut through Boulder Clay, & interacts with Sand & Gravel
- River below base of Sand & Gravel

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4 ASSESSMENT OF IN-RIVER NEEDS

4.1 This section of the report assesses the in-river needs of the various ecological elements associated with the River Deben.

Aquatic Plant Communities

4.2 From the assessment of historical and currently available ecological data, presented in Section 2, the key plant species for which in-river needs have to be defined are the river water dropwort (Oenanthe fluviatilis), the flowering rush (Butomus umbellatus) and the wood club-rush (Scirpus sylvaticus). The former is nationally scarce whilst the latter two are regionally scarce.

4.3 In addition, species such as yellow water lily (Nuphar lutea), starwort (Callatriche sp.) and creeping bent (Agrostis stolonifera) are typical of the river being found in nearly every reach in both the 1981 and 1989 surveys. Therefore the in-river needs are also presented for these species.

Submerged, Narrow Leaved Plants

4.4 This group of plants were represented in the River Deben in both the 1981 and 1989 surveys by **mare's tail, arrowhead** and the nationally rare **river water dropwort**. All three are most frequently found growing in clay substrates in base rich water of moderate to clean water quality as experienced in the Deben. They prefer slow to moderate flow conditions and are rarely found in fast or rapid flows. The optimum depth for all three species is 0.1 to 0.5 m with a width preference greater than 5 m.

4.5 The three species are moderately disturbance tolerant, hence their proliferation in the upper reaches of the Deben, where dredging and weed clearance operations occur at a yearly frequency (Table 2.14). Arrowhead generally grows submerged for only part of the year (i.e. during high flow periods) whilst mare's tail grows successfully out of the water emerging as water levels fall. These three species are important as an invertebrate habitat and to coarse fish for egg laying.

Submerged, Broad Leaved Plants

4.6 This group of plants are represented in the River Deben by **starwort** species. These species prefer clay substrates in clean water preferring slow to moderate water velocities. They are found over the depth range 0.1 to 1 m with a good river width tolerance. They are moderately tolerant to disturbance. Starworts can grow as emergents as a mat on mud. However, they provide a good underwater habitat for invertebrates and fish. Starworts rarely grow large enough to significantly hinder flow, they act to stabilise the stream bed and are broken up and washed downstream in spates.

Rooted, Floating Leaved Plants

4.7 This group of plants are very well represented in the Deben with **yellow water lily** being found in nearly every reach of the river. **White water lily** and **broad leaved pondweed** are also found. All prefer clay substrates with nil to slow flow conditions and depths of 0.1 m or more. They are found through a wide range of channel widths, prefer clean water conditions and are very tolerant to disturbance. Yellow water lily with permanently submerged, cabbage-like leaves in addition to floating ones can become a nuisance restricting flow. White water lily will only occur in the slowest flowing slacks of cut offs and bays. Plants in this group are often used as resting and breeding sites for dragonflies and damselflies.

Emergent, Narrow Leaved Plants

4.8 This group of plants are well represented in the Deben with **water plantain**, the regionally rare **flowering rush**, **common reed**, **common club-rush** and **branched bur-reed** all present. All prefer clay substrates with nil, slow or moderate flow velocities. They are found in shallow water at depths from dry to 0.5 m and across a wide range of channel widths. They prefer moderate to clean water quality with a base rich chemistry and are very tolerant to disturbance.

4.9 Growing in clumps from underground rhizomes they can spread into the channel aggravating sedimentation until checked by deep water, high flow velocities or an unstable substrate. They are relatively resistant to spates but cannot withstand long-term moderate flow velocities. When occurring at the channel edge they can reduce flow velocities and cause sediment accumulation. Weed cutting and desilting may be occasionally be required however water plantain and flowering rush are rarely a weed problem. All can act to protect the banksides against scour. Stands of these plants provide an important habitat for aquatic invertebrates linking the water and air environments for caddisflies, damselflies and dragonflies.

Emergent, Broad Leaved Plants

4.10 **Watercress** and **blue water speedwell** are the representatives of this plant group found on the Deben. They both prefer clay or silty substrates with nil or slow flowing water in a depth range of dry to 0.5 m. They occur in channel widths up to approximately 20 m in moderate or clean water with a base rich chemistry. Watercress is not tolerant of disturbance, whereas blue water speedwell is very tolerant.

4.11 Growing on wet banks as well as the channel edge, they form mats of foliage at the waters edge or close to reedbeds. In narrow, silty channels watercress can be a problem although their hydraulic resistance leads to the breaking up into fragments and regrowing in late summer. Both are valuable to invertebrates by providing additional habitat at the channel edge. Cress can harbour beetles, snails and fly larvae and are a good feeding habitat for birds using the water.

Encroaching Plants

4.12 Two encroaching sedge species are found in the River Deben, the **lesser pond sedge** and the **greater pond sedge**. Both are characteristic of clay or silt substrates and nil to slow flowing water preferring depths ranging from dry to 0.5 m. They are tolerant of a wide range of water qualities and are very tolerant to disturbance.

4.13 Both are commonly found on silty margins of rivers including cattle drinking bays. They are suited to shallow sloping river banks but can be invasive when water levels and velocities fall. Both have been planted in shallow water to prevent scour and encourage sedimentation.

Narrow Leaved, Upright Bank Plants

4.14 This group of plants includes examples found on the Deben that are also represented in some of the groups described above such as **water plantain** and **common reed**. In addition, **yellow iris**, **soft rush** and **reed canary grass** are found. All are characteristic of clay or silt substrates and nil to slow flow conditions. All prefer shallow bank slopes of 30° or less and are usually found just submerged or just above the water level. All act to stabilize the bank and prevent scour.

4.15 The soft rush and yellow iris can withstand some grazing pressure. They provide an important habitat for insects and cover for birds and mammals plus a sheltered area where other plants can grow. Reed canary grass is particularly important to reed warblers as breeding sites and can form day resting sites for otters. Where plants overhang the channel they may contribute organic matter to the river acting as source of food for invertebrates and fish.

Narrow Leaved, Straggling Bank Plants

4.16 The principle representative of this group found on the Deben is the **creeping bent**. Preferring sand or clay substrates it is found where flow velocities are negligible or slow over a wide variety of bank slopes. It is tolerant to shading and provides some scour resistance for the bank. Generally found just above or over 30 cm above the water level it is a low growing plant that rapidly colonizes recently dredged areas and can remain in the later stages of colonisation. Providing good cover for aquatic and marsh invertebrates but little cover for birds. Creeping bent will often be found where cattle graze or trample out taller or broadleaved plants.

Broad Leaved, Upright Bank Plants

4.17 This group, which includes a number of bright flowering species, is represented by **lesser water parsnip**, **water mint**, **water figwort** and **purple loosestrife** on the Deben. All prefer clay or sandy substrates and can tolerate slow to moderate water flow. Lesser water parsnip is only found on shallow banks whilst the other three species are tolerant of a wider range of bank slopes. All are shade tolerant with Lesser water parsnip and Water mint providing stabilisation and scour resistance to the channel.

4.18 They can colonise shoals and beaches in summer because of their high seed output

being washed out when flows increase. The flowers provide important nectar sources for butterflies and other insects. Purple loosestrife and Water mint can attract large numbers of butterflies in July and August.

Bankside Trees and Shrubs

4.19 Bankside trees and shrubs found along the Deben include common alder, ash, elder, oak, sycamore, hawthorn, beech, maple, poplar and various varieties of willow. All grow in clay substrates with all, except oak, buckthorn and poplar, able to tolerate moderate flow velocities. Alder, ash and oak can grow on steep banks with a slope greater than 60° whilst the willow species prefer shallow banks of less than 30° slope. All prefer a habitat greater than 30 cm above the water level and can act to stabilize the bank and prevent scour.

4.20 Most species present can withstand short periods of inundation but not permanently waterlogged or damp conditions. Alder and willow are characteristic riverside trees whilst oak frequently occurs on banktops often associated with hazel, hawthorn or sycamore. Willow have a great number on insects adapted to live in, and on, them and provide a good source of cover for birds and mammals. They should therefore be protected during channel maintenance activities. Alder has a fine penetrating root system which provides a valuable habitat for insects particulary caddisfly larvae and damselfly nymphs and good fish cover.

General Comments

4.21 Using depth:discharge conversions presented in Section 3 of this report (Figures 3.12 and 3.14) it is possible to estimate the flow needs of key in-river plant species. For example, the nationally scarce river water dropwort and the regionally scarce flowering rush and wood club-rush together with the majority of commonly observed species such as yellow water lily and starwort have a minimum depth requirement of around 10 cm. This minimum depth requirement of 10 cm corresponds to an estimated discharge at Brandeston (TM250601), Winston Grange (TM187622) and Soham (TM233621) of approximately 0.01 m^3/s. Examination of the estimated flow records calculated for these two sites (Figures 3.8 and 3.9) indicates that only in 1976 would the Q95(10) have fallen below this value at Brandeston, and in 1976 and 1990 at Winston. However, on the Earl Soham the Q95(10) flow would have fallen below 0.01 m^3/s in 1973, 1974, 1976, 1977, 1990 and 1991. In terms of flow as a habitat variable it would appear that, with the important exception of severe drought years, flow should not be the principle limiting factor in the Deben downstream of Winston for these key species. Other factors, such as shading and channel maintenance activity, may have more of an influence.

Riparian Wetland Sites

4.22 Marked on Figures 2.4 and 3.18 are County Wildlife Sites which have been identified as being water dependent (Suffolk Wildlife Trust 1993), and for which there may be potential for enhancing the habitat by raising shallow groundwater levels. The water

dependant Fox Fritillary Meadow SSSI is also marked. Most of the sites are adjacent to river sections which interact with the Sand & Gravel aquifer, and two are on the London Clay outcrop. The groundwater levels in the Sand & Gravel aquifer will be controlled by many different factors, including for example: the river stage; the run-off from the nearby Boulder Clay; the recharge to the Sand & Gravel itself; and abstractions from the Chalk, where it is in hydraulic continuity with the Sand & Gravel.

4.23 With all these factors involved, it is not really possible to control the shallow groundwater levels on a regional scale, so efforts must concentrate on techniques for raising the shallow water table on a local scale at each site. From an examination of the site locations and characteristics, it can be concluded that potentially the most suitable technique for raising local shallow water tables is that of maintaining high local ditch water levels. Water will then seep through the banks of the ditches, into the site itself. Depending on the tier of entry, the MAFF ESA scheme, as described in section 2, provides financial incentives to farmers to maintain water features and shallow water levels on their land and consultation with the local MAFF representative (Tim Sloane) is recommended.

4.24 Several studies have been conducted on this technique (for example Armstrong *et al* 1993), and it has to be said that attempts to re-hydrate former wetland areas may not necessarily produce the desired ecological objectives. This is mainly because the success of retaining high ditch water levels to control in-field water tables is highly dependent on soil properties at the site, particularly the horizontal hydraulic conductivity.

4.25 If the hydraulic conductivity is high, as in many peat soils for example, controlling in-field water levels by setting the ditch water levels high is perfectly feasible. However, it must be remembered that the evaporative demand in summer from the vegetation may require the import of significant quantities of water. If the hydraulic conductivity is low, as in alluvial clay soils for example, then it is much more difficult to maintain high in-field water tables, because of the difficulty in moving water away from the ditch, horizontally through the soil.

Birdlife

4.26 From the assessment of historical and currently available data presented in Section 2 the key bird species for which in-river needs have to be defined are the **barn owl, kingfisher**, and **little ringed plover** which are nationally rare, the **shelduck**, **teal** and **redshank** which are nationally scarce and the **snipe** which is regionally scarce.

4.27 Of these, the kingfisher and little ringed plover breed in close association with rivers and riverine habitat features. The snipe and redshank breed in wetland sites adjacent to and associated with rivers and the teal and shelduck use rivers for feeding or resting but do not breed there.

4.28 In general the value of a river habitat to birds is related to the diversity of habitats found. Most species are non-specialist and therefore are not dependant upon a single habitat feature. Rather, they require particular habitat structures within which the habitat features can be variable. Ornithological rich lowland rivers tend to be characterised by a variety of persistent habitat features such as reed stands and fallen tree branches providing cover and protection from predators. However a number of in-river needs can be identified for these species, particularly the kingfisher and this are discussed below.

Kingfishers

4.29 Kingfishers were observed at 10 sites along the freshwater River Deben (See Table 2.9).

4.30 Unlike many other bird species associated with the riverine environment kingfishers have a specific habitat requirement for steep, or vertical, banksides, and their preference for lowland rivers may be due to this restriction. Their diet consists mainly of minnows and sticklebacks although they will also feed on insects, molluscs, tadpoles and crustaceans. This dependence on certain aquatic prey makes them susceptible to water quality.

4.31 Nest entrances are usually towards the top of vertical earthbanks between 75 and 2 metres from the water surface, usually within 50 cm of the top of the bank. The nest has a tunnel upto 1.5 m long, close to tree roots, overhanging branches or other points that can be used as perches during resting and fishing.

4.32 Actively eroding banks are usually chosen for nesting, possibly because of ease of excavation. Protecting an earth bank from erosion may make it unsuitable to Kingfishers for several years.

Barn Owl

4.33 The barn owl was found in the reaches specified in Table 2.9. It was considered to be relatively common in lowland agricultural habitats in the mid 19th century although its numbers have decline since then it is still widespread, particularly in Suffolk. The decline has been attributed the intensification of agricultural practices, severe winters,

use of pesticides in the 1950's and 60's and road deaths. Only around 5000 pairs are now thought to be present in Britain (Red Data Book, 1990).

4.34 It is largely nocturnal and nests in buildings, tree cavities and caves. In addition to voles, mice, rats and shrews (contributing 90 % of its diet) it takes amphibians and invertebrates.

4.35 It is unlikely that the barn owl has any specific in-river needs with the exception of the fact that it uses the habitat variation of the river corridor as useful foraging country.

Little Ringed Plover

4.36 The little ringed plover is a coastal and estuarine species hence it has only been found just upstream of the tidal limit on the Deben and had probably strayed from its preferred habitats downstream. Its habitat is threatened by insensitive coastal development and the MAFF Environmentally Sensitive Areas scheme has been used in Scotland to encourage farming methods more sensitive to this species and other waders (Red Data Book, 1990).

Redshank

4.37 The British wintering population of redshank is localized and internationally important and is thought to have declined by as much as 25 % since 1976 (Red Data Book, 1990). Outside the breeding season it inhabits mainly coastal habitats such as saltmarshes and coastal grazing marshes hence the fact that it was recorded on the Deben only in the 4 km upstream of the tidal limit. Breeding occurs further inland, between April and July, on damp pastures, lowland river valleys and on rough grazing land. For nesting it favours tall vegetation comprising tussocks of grass and sedge.

4.38 Access to shallow water such as pools or ditches within 1 km of the nest is important to adults and young which may feed on small insects and aquatic invertebrates. Land drainage and flood alleviation activities may have resulted in a loss of inland breeding sites, particularly where shallow pools and flooded ditches are no longer available.

Shelduck

4.39 The wintering population of shelduck are localised and of international importance. It breeds on coastal marshes, hence the fact it was only recorded in the lower 5-6 km of the freshwater Deben. However, pairs have been recorded as far as 100 km inland. Food consists mostly of invertebrates especially molluscs and worms obtained from wet mud.

4.40 There are few specific habitat measures that can be adopted to maintain or improve the current satisfactory levels of this species. Habitat conservation of known breeding sites is probably the most important measure.

Teal

4.41 The teal overwinters in Britain in internationally important numbers with an estimated 3500 to 6000 breeding pairs in Britain and Ireland (Red Data Book, 1990). It frequents areas of shallow water on estuaries, coastal lagoons, inland marshes and flooded pasture and ponds. They breed near water both inland and near coasts. They feed principally on seed and various small invertebrates (e.g. Chironomids larvae and snails).

4.42 There is no single threat to the teal population however dependence on shallow water puts local populations at risk from habitat loss due to land drainage. Measures to protect wetland areas should serve to protect this species.

Fisheries

Basic Habitat Preferences

4.43 The basic habitat features important to fish are presented in Table 4.1 and are summarised below.

Access to spawning areas	- provision of suitable depths and velocities - absence of barriers to movement
Spawning	- suitable spawning substrate
Incubation of eggs	- stability of substrate - suitable temperature - suitable oxygen supply and water movement
Feeding	- adequate and suitable bankside vegetation - suitable invertebrate community present - supply of allochthonous organic material
Position maintenance and energy	- cover and shade - diversity of flow type - riffle-pool sequences - suitable temperature range
Protection from current and predation	- provision of shelter - varied bed profile - accumulated debris - marginal slacks

4.44 Of these, the most important features for coarse fish are those associated with spawning and the survival of newly hatched fry. Adult coarse fish are more closely associated with territories rather than particular habitat features.

Specific In-River Needs of the River Deben Fishery

4.45 Fish populations in the River Deben were shown in Section 2 to be dominated by healthy populations of **eel, pike, roach, perch** and to a lesser extent **dace** and **bream**. All these species spawn in the spring with in river vegetation the preferred spawning habitat, hence there is a need to conserve in river plants such as the submerged narrow leaved mare's tail, arrowhead and the nationally rare river water dropwort.

4.46 All the fish species found in the Deben are associated with slow, or very slow, water velocities and a bed material of sand or mud. These preferences are likely to be indicative of the prevailing conditions in the Deben over the period that fish records are available, (i.e. from 1984 to 1991).

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4.47 The fact that fish densities and biomass at nearly all survey sites show an increase from 1984 to 1991 suggests the in-river needs of those species present in terms of water quality and available habitat are being met by the river in its current state. It also indicates that the drought years of 1989 and 1990 may not have significantly affected fish populations. This may partly be due to the number of mills and weirs along the river where areas of deeper water may protect fish shoals as general water levels fall.

4.48 Roach are the principal species fished and their population is thought to be heavily reliant on the reach between Brandeston and Crettingham where spawning occurs with this area serving as a source of young fish which move down the river.

4.49 Armitage & Ladle (1991) in work connected with the development of the PHABSIM (Physical HABitat SIMulation) system produced estimated physical habitat preferences for 18 species of fish in terms of velocity, depth and substrate. Those preferences relevant to this study are presented in Table 4.2. The importance of in-river plants to the species present in the Deben is evident.

Table 4.1 Basic habitat preferences of different species of fish (adapted from Lewis and Williams, 1983).

Species	Spawning			Water velocity				Bed material			
	Time	Gravel	Weed	V. Slow	Slow	Moderate	Fast	Mud	Sand	Gravel	Boulders
Trout	Oct-Jan	***			*	**	***			**	**
Salmon	Oct-Jan	***			*	**	***			**	**
Grayling	March-May	***			*	***	**		*	***	**
Dace	March-July	**	**		*	***	**	*	**	**	*
Chub	May-June	**	**	*	**	**		*	*	**	
Barbel	May-July	***			*	**	*		*	***	*
Perch	April-June		***		*	**		*	**	*	
Pike	March-May		***	**	**	**	*	**	**	*	
Roach	April-June		***	**	**	**		*	**	**	
Rudd	April-June		***	**	*			**	*		
Bream	May-June		***	***	*			**	*		
Carp	May-July		***	***	*			***			
Tench	May-Aug		***	***				***			

Key
*** = preferred
** = common
* = present

Table 4.2 Estimated Physical Habitat Preferences of Fish Species Observed in the River Deben (adapted from Armstrong & Ladle, 1991)

Species	Velocity (cm/s)	Depth (cm)	Substrate
Dace - spawning	55-100	20-80	Sand/Gravel
- fry	5-25	10-30	Plant/Mud
- juveniles	15-35	30-70	Mud/Silt/Sand
- adults	20-70	50-100	Silt/Sand/Gravel
Roach - spawning	40-80	30-300	Plant/Mud
- fry	0-20	25	Plant/Mud
- juveniles	0-40	100-300	Plant/Mud
- adults	0-40	100-300	Plant/Mud
Bream - spawning	0-10	50-100	Plant/Mud
- fry	0-5	5-50	Plant/Mud
- juveniles	0-10	50-300	Plant/Mud
- adults	0-10	170-300	Plant/Mud
Pike - spawning	0-10	20-80	Plant
- fry	0-10	20-90	Plant
- juveniles	0-20	10-70	Plant/Mud
- adults	0-20	40-290	Plant/Mud
Perch - spawning	0-30	30-150	Various
- fry	0-10	10-50	Plant/Mud/Silt
- juveniles	0-30	20-80	Plant/Mud/Silt/Sand
- adults	0-40	30-250	Plant/Mud/Silt/Sand

Flow estimate accurate ?

4.50 Using the conversion of depth to discharge at Brandeston (a likely spawning reach for roach) presented in Figure 3.12, discharges can be calculated for the various water depth requirements listed above. For example, a minimum water depth for roach spawning of 30 cm would correspond to a discharge of 0.13 m^3/s at Brandeston and approximately 0.2 m^3/s at Naunton Hall (with the latter figure calculated using catchment area ratios). These estimated discharge requirements can then be compared with the annual ADF and Q95(10) figures presented in Section 3 of this report. In the above case, examination of the flow record for annual ADF at Naunton Hall indicates it has never fallen below the estimated discharge requirement of 0.2 m^3/s (see Table 3.1 and Figure 3.4) with the lowest values recorded in 1973 (0.204 m^3/s), 1976 (0.301 m^3/s), 1990 (0.267 m^3/s) and 1991 (0.297 m^3/s). When the ADF for the period April to June was calculated it was found that it only fell below the 0.2 m^3/s threshold in 1990.

The annual Q95(10) is generally below 0.2 m3/s however this is the lowest flow over a ten day period and is unlikely to coincide with the spawning period for roach between April and June. For example, in 1976, 1984, 1986 and 1990 the annual Q95(10) figure started on 1st July, 5th July, 19th August and 2nd August respectively

(see section 3.8).

4.51 A number of depth to discharge conversions have been calculated and are presented in Table 4.3 below.

Table 4.3 Estimated Discharge Requirements in the Deben for Various Fish Life Stages

Fish Activity	Depth Required (cm)	Equivalent Discharge at Brandeston (m^3/s)	Equivalent Discharge at Naunton Hall (m^3/s)	Comparison of Discharge Requirements with Actual Flow Record at Naunton Hall
Roach Spawning	30	0.13	0.20	Annual ADF always exceeds discharge values. Q95(10) below in all record years except 1987
Perch Juveniles	20	0.04	0.06	Annual ADF always exceeds values Q95(10) exceeds values except 1973,74,76,90
Pike Adults	40	0.28	0.45	Annual ADF below values in 1973,76,90, 91. Q95(10) always below values.
Dace Adults	50	0.51	0.81	Annual ADF exceeds values in 1965,66,67,68,69,70,79,81,85,86,87,88.

4.52 This process can be repeated for any known depth or velocity requirement. Additionally, other reference sites other than Brandeston (e.g. the reach fished near Wickham Market) could be used providing cross-sectional information and relative catchment area values are available. Furthermore the flow record could be examined in more detail to determine exactly the periods when estimated discharge requirements are not satisfied.

Conclusion?

Mammals

4.53 As identified in Section 2, otters, water voles, shrews and bats are all associated with the River Deben. Their in-river needs are discussed below.

Otter

4.54 Otter numbers declined in the 1950's and 60's possibly as a consequence of pesticide use (dieldrin, aldrin) and habitat destruction. They are a national rarity and a protected species under the Wildlife and Countryside Act (1981). It is an offence to kill, injure or knowingly disturb an otter or damage an otter holt. A programme of reintroduction has been undertaken in the last decade with two female and one male otter released to the River Deben near Easton in June 1993. Generally a nocturnal species, the otter favours all wetlands from rivers, lakes, streams, ditches and dykes to reedbed, marshes and coastland. It feeds on fish, particularly weaker individuals, and the more easily caught eel and also other small mammals and crustaceans. The habitat features of greatest importance to the otter are detailed below.

Secure Breeding Sites

4.55 Resting and breeding sites for Otters, holts, are often located in the roots of mature trees particularly ash, sycamore and oak. Secure natural breeding sites are usually scarce and should be protected where possible. Artificial holts can be created using piled masonry, rubble or logs covered with turf, leaves and river debris and put together so that at least two tunnels lead into one or more cavities from 0.75 to 1.0 m^3 in size. Tunnel entrances can be above or below water, away from human disturbance.

Cover

4.56 Dense cover is needed for daytime resting sites with a dog otter able to cover a territory of between 15 and 50 km with approximately 30 resting sites required. If good cover is present at frequent intervals (e.g. every 1 km) then otters will be more tolerant of other river users. Examples of good otter cover include bramble and willow thickets, hawthorn scrub, large reedbeds or sedge beds. Bundles of sticks and logs may be used together with holes in bankside tree roots.

Disturbance

4.57 A low level of disturbance (e.g. by anglers, walkers, dogs, channel maintenance and other river users) is very important for otters. As they breed throughout the year, river activities may disturb a breeding female at any season. Where there is good cover some disturbance is tolerated, however, where cover is sparse then even removal of a key tree or clearance of a stretch of riverside scrub may make a reach unusable by otters.

Water Vole

4.58 Water voles are the only day-active mammal confined to the river environment and are found throughout Britain feeding on grass, emergent plants and willow leaves on land. Numbers are thought to be declining due to loss of habitat following river management activities. Each male has a range of around 100 m and the female about half this. One burrow is built with entrances above and below water level and up on the bank. Feeding burrows are also constructed close to preferred feeding grounds to act as 'bolt-holes'.

Shrews

4.59 Water shrews are active day and night and are found throughout Britain preferring slow moving water with abundant aquatic invertebrates as prey (they will also take small fish and amphibians). They are especially common close to watercress beds. They require cover near the channel edge for protection against predators.

Bats

4.60 Sites where bats are recorded are identified in Figure 2.1. Bat numbers have declined in the last ten years possibly because of the use of insecticides (depriving them of prey) and wood preservatives (restricting the availability roost sites) resulting in them becoming protected species under the Wildlife and Countryside Act (1981). It is an offence to carry out work which may affect or disturb a known bat roosting site and English Nature should be consulted for advice.

4.61 Rivers are used as hunting grounds by bats, particularly the Natterer and Daubenton's bats, who chase flying insects over the water surface. Mature tree roosts, with cracks and hollows, along the riverbank are used in summer with bats moving to roof spaces during the winter.

Channel Morphology

4.62 Due to the limited channel morphological data available at the time of writing this report very little can be said about in-river needs in regard to channel morphology. The available morphological and hydrological data does not suggest that the river is in a transient state and there is no obvious increase or decrease in either the ADF or the Q95 (10) of the Deben. Discharge and sediment load will be the dominant controls on channel form adjustment in the Deben and its channel geometry will have formed over time to accommodate the mean conditions of discharge and sediment load. As mean discharge appears to be relatively stable, and no evidence can be found to suggest an increase in sediment load, it can therefore be assumed that the flow regime required to sustain the current channel morphology is that which is already occurring. From the limited information available, channel maintenance activities are considered to have had a greater influence on channel morphology than flow.

Invertebrates

4.63 The River Deben generally supports a diversity of invertebrates often associated with lowland rivers with fairly sluggish flows. However, unlike many rivers, the Deben tends to display an increase in invertebrate family richness down its length. The poorest sites for invertebrates are those furthest upstream, where river management practices have been most intense. In addition the top stretches, especially near Debenham, are most prone to low flows and this may be a contributory factor in restricting the diversity of invertebrates. Because of Geology? → implications for Area factoring?

4.64 The upper stretches have few high BMWP scoring families such as mayflies and caddisflies. (No stoneflies have appeared in the records, their distribution being restricted in East Anglia). Such high scoring families, along with organisms such as plastron-breathing beetles and blackfly, require higher levels of dissolved oxygen than other invertebrates, and their distribution is thus restricted by a lack of the gas's availability. In addition, the impact of organic pollution on water quality will tend to be most marked in sections of the river with the least discharge and lowest velocity, such as in the proximity of Debenham. Here the river can have much of its flow made up of water discharged from treatment works. Though this is treated water, a lack of dilution by the river, especially in periods of low flow, may well cause a further reduction in the amount of oxygen available to invertebrates.

4.65 Further downstream, with the influx of water from more tributaries, particularly near Brandeston, the river widens and is less prone to low flows. In addition, any effects of organic pollution inputs from treatment works and agriculture are likely to be far less, due to increased dilution. Velocity of certain sections of the river is higher downstream compared to the top of the river, particularly downstream of weirs. These factors all have the potential for ensuring that more oxygen is available to invertebrates and that the diversity of mayflies, caddisflies and beetles is greater than the upper part of the river.

4.66 Lower sections of the river also afford the conditions required of dragonfly and damselfly larvae which live in mud or on plants in still or slow-flowing water. This is possible because of less intense management practices employed here, allowing a diversity of river habitats to exist. Not only has this resulted in a wider variety of flow types, but it has allowed the growth of macrophytes. Their presence is particularly important in providing invertebrates with a complex 'substrate' on which to shelter from flow, as well as affording shelter from predators. Also, epiphytic algae which grow upon macrophytes are an important source of food for invertebrates, macrophytes themselves being less commonly eaten.

In summary, the in-river needs of the invertebrates found on the most diverse and high scoring sections of the Deben are as follows:

- adequate flow of water, though invertebrates do rapidly recolonise dried sections of river on the return of water by a number of strategies;

- adequate levels of dissolved oxygen, which may be maintained by a combination of aeration (as a result of fast flows) and minimisation of the impacts of organic pollution;

- overall good water quality, with a minimisation of the influx of organic, as well as inorganic, pollution;

- diversity of flow types, including riffle/run type sections as well as more static pools;

- presence of macrophytes, submergents probably being more important than emergent forms.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 This section of the report presents the conclusions of the study and make recommendations for conservation or enhancement for each of the main ecological variables. It then discusses the various options for environmental improvement in the River Deben.

Aquatic Plant Communities

Conclusions of the Study

5.2 Key plant species, requiring an assessment of in-river needs, were identified in Section 2 of this report. They were selected as being either those species that are nationally or regionally rare or scarce, or those species that are, and have been, typical of the character of the river. These are listed below:

River water dropwort (Oenanthe fluviatilis) - nationally scarce;
Flowering rush (Butomus umbellatus) - regionally scarce;
Wood club-rush (Scirpus sylvaticus) - regionally scarce;

Yellow water lily (Nuphar lutea) - typical River Deben species;
Starwort (Callatriche sp.) - typical River Deben species;
Creeping bent (Agrostis stolonifera) - typical River Deben species.

5.3 In the case of the scarce species their distribution on the Deben has declined between 1981 (NCC Survey) and 1989 (SWT Survey) (Table 2.5) with the reach from Crettingham to Letheringham being the only one that retained a good population of river water dropwort and flowering rush. The decline of these scarce species in the reach downstream of Letheringham is not considered to be due to water quality which is considered to have been sufficient to satisfy the in-river needs of these species even in drought situations. Explanations may include very low flows known to have occurred during drought years and channel maintenance activities. It is interesting to note that a number of the reaches with the greatest retention of these plant species are not thought to have been subject to dredging in the last 10 years.

5.4 The abundance and distribution of plant species characteristic of the River Deben does not show any significant change between the 1981 and 1989 surveys. This is probably because the characteristic species such as Yellow water lily and Starwort are all tolerant of changes in water depth, velocity and channel maintenance activities. The in-river needs of these species can be considered to be met by the existing situation. The greatest diversity of plant species is found downstream of the confluence of the Soham and the Deben.

Recommendations

- channel maintenance activities should adopt the following general principles:

  - working from one bank;
  - leaving patches of in-river vegetation undisturbed to act as a source for recolonisation;
  - creation of berms and retention of cattle bays;
  - creation/retention of a variable bank and river bed profile.

- in the reach from Brandeston to Letheringham particular care should be taken during maintenance activities to protect the scarce species (e.g. River water dropwort) that this reach supports.

- currently an arrangement exists between the Suffolk Wildlife Trust and the NRA Ipswich office whereby ecological advice is sought before and during maintenance activities. An opportunity exists to formalise this arrangement and make it more robust to ensure:

  - improvements in channel maintenance record keeping;
  - consultation, in good time, regarding the pending maintenance programme;
  - increased monitoring of activity/records by ecologists within the NRA.

- the in-river vegetation of the upper Deben (near Debenham) and the Earl Soham is typical of that of a highly managed clay channel subject to regular channel maintenance (Section 2). However, its floral diversity may be limited by very low flows during drought years and consequently reduced water quality due to decreased effluent dilution. Augmentation to maintain a channel water depth of at least 10 cm, together with environmentally sympathetic channel maintenance, when necessary, may serve to increase plant diversity in these two reaches and encourage the colonisation and proliferation of rare species such as the River water dropwort (particularly is calcareous water is augmented). A discussion of the augmentation option is detailed below.

Riparian Wildlife Sites

Conclusions of the Study

5.5 From maps of the locations of the water-dependent County Wildlife Sites, there would seem to be considerable scope for raising shallow water tables through controlling the ditch water levels, as many of the sites contain drainage ditches leading to the River Deben.

Recommendations

- consult with the MAFF representative for the Suffolk River Valleys ESA (Tim Sloane) regarding the operation of the scheme and its potential for encouraging and partial funding of efforts to raise shallow water levels near water dependent County Wildlife Sites and the Fox Fritillary SSSI (see below);

- conduct field investigation and consultation regarding the possibility of raising shallow water levels at water dependant County Wildlife Sites. Such an investigation could run as follows:

  - survey each of the sites in detail, map the ditch layout, and identify which species of flora and fauna are currently occupying the site;
  - define the objectives of any remedial works in terms of the habitats which it is intended to create or enhance;
  - determine the technical feasibility of achieving changes in habitat taking into account water availability (particularly in summer), soil hydraulic conductivity, site topography, and resources available;
  - conduct auger hole tests to quantify the soil hydraulic conductivity, identify the soil types, and conduct tests to predict the behaviour of the soil on re-wetting;
  - coordinate these investigations with plans for higher flows in the River Deben itself, in case the objectives for the sites closest to the river channel can be achieved by higher river flows alone;
  - develop site management plans in consultation with the Suffolk Wildlife Trust.

Birdlife

Conclusions of the Study

5.6 From the assessment of the limited amount of available ornithological data presented in Section 2, the key bird species for which in-river needs have to be assessed are as follows:

Barn owl, kingfisher, and little ringed plover - nationally rare;
Shelduck, teal and redshank - nationally scarce;
Snipe - regionally scarce.

5.7 In general it can be said that most bird species (with the important exception of the kingfisher) are non-specialist and therefore are not dependent on a single habitat feature. Rather, they require a particular habitat structures and a good diversity of habitats. On the Deben the greatest diversity and abundance of birdlife is associated with reaches where woodland is nearby.

5.8 Of the key species identified the kingfisher and little ringed plover will breed in close association with rivers and riverine habitat features. The Snipe and Redshank breed in wetland sites adjacent to and associated with rivers and the Teal and Shelduck may use rivers for feeding or resting but do not breed there.

5.9 The in-river needs for each of these species were identified and discussed in detail in Section 4 of this report. These needs are largely unrelated to river flow and are more dependent upon channel maintenance activities (e.g. the presence of vertical banks and perches for kingfishers), land drainage (the need for shallow pools and ditches for the redshank) and bankside and riparian vegetation (e.g. for the teal).

Recommendations

- vertical bank nesting sites could be created, or allowed to develop naturally, along the Deben but particularly in the reaches near Ashfield Bridge, Kettleburgh and Rendlesham where Kingfishers were observed in the 1989 SWT survey.

- the following measures are recommended to conserve kingfisher nesting sites:

  - leave the channel and banks untouched;
  - conserve meanders particularly where the outer bank is a nesting cliff;
  - working from one bank, leaving the opposite, nesting, bank untouched;
  - planting alders for future bank protection.

- where Kingfisher nesting sites have to be destroyed then new sites can be artificially created during dredging activity by excavating a vertical bank at

least 1.5 m above the normal water level.

- the raising of shallow water levels, as discussed above, would benefit the redshank and snipe providing an increased number of potential feeding sites. Initially, this could be attempted on the water dependent County Wildlife Sites adjacent to the river as discussed above and in Section 5.

Fisheries

Conclusions of the Study

5.10 No salmonids were recorded on three NRA fish surveys (1984, 87 and 91) with the river supporting a good coarse fish population dominated by pike, roach and eel with perch, bream and dace also found. Analysis of data from the three fish surveys (Figures 2.11 and 2.12) indicate an increase in total biomass and density at nearly all survey sites since 1984.

5.11 The in-river needs of individual fish species in the River Deben are described in detail in Section 4 of this report. Spawning is identified as the key life stage with provision of suitable depths and velocities and a suitable spawning substrate also necessary. Of the fish species present, all spawn on aquatic vegetation in the channel in late Spring and early Summer and therefore their in-river needs will be linked with those of plant groups such as the narrow submerged river plants (see above). Roach are the principle species fished spawning in the reach near Brandeston. Protection of aquatic vegetation in this reach is therefore of importance.

5.12 The fish species present in the Deben are also characteristic of slow or very slow water velocities and shallow to moderate water depths. These needs are evidently being satisfied to some extent, as can be seen by the gradual increase in fish biomass and density observed in the NRA surveys. The presence of a number of weirs, mills and mill channels along the Deben, particularly downstream of its confluence with the Soham, increases the diversity of available habitat and in retaining water behind them will create deep water pools of great importance to shoaling coarse fish when river levels fall.

Recommendations

- spawning is recognised as a vital fish life stage. Those species found on the Deben spawn on aquatic vegetation (e.g. narrow, submerged species) and channel maintenance activities should take this into account particularly in the reach near Brandeston where Roach (the species principally fished) spawn;

- provided some areas of deep water for adult fish (e.g. over 100 cm depth) plus suitable aquatic vegetation for spawning are available to the Deben fish population throughout the year then the minimum depth requirement for spawning in late Spring and early summer (i.e. for Roach near Brandeston) is around 30 cm corresponding to a flow during this period of around 0.2 m^3/s at Naunton Hall gauging station;

- maintaining weirs and mill controls in order to retain areas of deep water during low flow periods. Channel maintenance activities should also take into account the need for a varied river bed profile;

- operation of water level controls should take into account the potentially conflicting needs of flood control and the river fishery (as described above).

Mammals

Conclusions of the Study

5.13 From the limited amount of information available Section 2 of this report identifies the otters (a protected national rarity), water voles, shrews and bats as being associated with the River Deben. Their in-river needs are discussed in detail in section 4, particularly those of the otter.

5.14 In the case of the in-river needs of the otters released to the Deben in 1993, they are linked primarily to habitat features such as: the availability of suitable breeding sites (e.g. roots of mature riverside trees); sufficient cover (bramble and willow thickets, scrub and reed or sedge beds) and a low level of disturbance (e.g. dogs, channel maintenance). The degree and nature of channel maintenance activities will play an important part in the availability and suitability of these three factors. Further in-river needs for otters include good water quality and an available source of food (particularly eels) both of which are met in the River Deben.

5.15 Consultation with the Otter Trust has indicated that the released otters are doing well however it is important to note that dredging of part of their territory is planned for this summer. Thorough consultation with conservation bodies (Suffolk Wildlife Trust, The Otter Trust) prior to, and during, maintenance activities is vital, and because the otter can have a territory of up to 50 km a catchment wide policy is necessary.

5.16 Water voles require emergent plants and grasses close to the river for food whilst shrews need an abundant supply of aquatic invertebrates. Bat roosting sites along the river may be affected by channel maintenance activities particularly where trees with crevices and holes are felled.

Recommendations

- In order to conserve and encourage the otters on the Deben the following options are recommended:
  - leaving at least 50 % of one or other bank untouched and leaving patches of dense vegetation;
  - partial dredging leaving 30-50 % untouched including vegetation, riffles and pools;
  - cutting aquatic vegetation in patches and using weed control measures which require less frequent disturbance of the river;
  - retaining patches of tall vegetation as long as possible in the year where banks have to be cut;
  - retaining meanders;
  - working from one bank;
  - retaining islands;
  - retaining existing tree and shrub cover as holt sites and cover.
- When proposing channel maintenance work, particularly tree maintenance, it

is strongly recommended that the Suffolk Wildlife Trust and The Otter Trust are consulted specifically with regard to the needs of the otters on the Deben.

- River management practices which encourage bat populations include:

  - protection of bat roosting trees and a varied tree cover particularly trees with holes or crevices (these are often the trees specifically selected for felling but branch lopping would be preferable);
  - conservation of tall vegetation and trees by working from one bank;
  - planting new trees and scrub particularly where cover may have been lost.
  - use of bat boxes where tree felling has been necessary;
  - restrict large scale weed cutting in early summer.

Water Quality

Conclusions of the Study

5.17 The water quality record discussed in Section 2, and presented graphically in Appendix C, shows a gradual improvement in quality with decreases in the concentrations of ammonia and BOD discernable from 1976 to 1993.

5.18 All sites show an increase in chloride concentration since 1990 with the increase being most pronounced during drought years in the records for the most upstream monitoring sites (e.g. Debenham, Ashfield Crossroads). This is not thought to be an analytical artefact and may be due to effluent discharges (although there is no corresponding rise in BOD and ammonia concentrations at a number of the sites). One alternative, but more unlikely cause, may be a pocket of high chloride groundwater known to be present in the chalk underlying the upper reaches of the catchment. However, this area of high chloride chalk is overlain with boulder clay in the upper catchment where the greates increases in chloride have been observed.

5.19 The lowest dissolved oxygen saturations are found in the upper reaches of the Deben with levels as low as 10 % (1990) recorded at Debenham and 16 % (1986) and 13 % (1990) at Ashfield Crossroads. Years with low dissolved oxygen saturations can be correlated with years of low flow due to drought. Dissolved oxygen saturations of the levels detailed above will be ecologically limiting particularly for fish and invertebrate populations. Below the confluence of the Deben and the Soham no dissolved oxygen saturation of less than 40 % have been observed.

Recommendations

- consideration should be given to river support by augmentation of the upper reaches of the Deben in drought years in order to maintain flow and dissolved oxygen saturations to the benefit of aquatic invertebrates and fish and kingfisher populations;
- should river support by augmentation be pursued, a comparison of the water quality of augmentation water and the receiving watercourse should be made;
- consideration should be given to the use of spray irrigation abstraction controls in order to protect water quality near Wickham Market;
- investigate the potential consequences of further increases in chloride concentrations on downstream river users including spray irrigation abstractors.

Amenity, Recreation and Landscape

Conclusions of the Study

5.20 The amenity and recreation value of the River Deben is discussed in Section 2 of this report and is largely confined to club angling near Wickham Market (Woodbridge and District Angling Club), walking (several public footpaths cross the river although only a few run alongside it for any great length) and golf. However, Ash Abbey (converted ruins of a 12th century priory) and Easton Park Farm (a demonstration farm) are both open to the public. With no in-river recreation other than angling, the in-river needs for recreation can largely be met by adopting the recommendations made earlier in this section concerning fisheries.

5.21 The value of the landscape surrounding and including the River Deben is evident from its designation as a Special Landscape Area by Suffolk County Council. This designation allows the protection of this high quality landscape to be accorded priority over other planning considerations.

5.22 Changes in landscape are primarily the responsibility of the farmers and landowners however land close to the river is often uneconomic to farm. Maintenance of trees and shrubs at wetlands along these watercourse margins can add appreciable to the quality of the landscape. Tier 1 of the MAFF Environmentally Sensitive Area's scheme provides a financial incentive to farmers to maintain and in some instances restore trees, pollarded willows and hedges using traditional methods. The scheme also includes a Public Access tier whereby new public access rights to sites within the ESA is financially encouraged.

Recommendations

- consideration should be given to the possibility of providing a 'permissive' bankside path along the River Deben. However, planning such a scheme would need to take into account the possible impact of disturbance on key species such as the otter;

- where possible provision should be made in capital works for the replacement of lost or damaged trees, shrubs and hedgerows. Meanders should be retained and care exercised regarding the deposition of spoil;

- maintenance of a flow in the Deben, particularly from Easton Park Farm and through Wickham Market is recomended from the standpoint of the public's perception of the 'health' of the river;

- consideration should be given to the siting of trees as screen for river structures such as sluices and flow gauging stations.

- consultation with MAFF regarding the recreational opportunities afforded by the ESA scheme and particularly the Public Access tier.

Invertebrates

Conclusions of Study

The invertebrate record obtained from the NRA was in several formats with scoring not always consistant. As a consequence BMWP and ASPT scores were recalculated for this study from the original field data sheets. Additionally, no records were available for the bulk of the 1980's limiting the conclusions that could be drawn from the historical record.

A gradual increase in invertebrate diversity, BMWP and ASPT scores, is observed moving downstream from sites at the top of the catchment (e.g. Debenham) to sites near Wickham Market and Ufford (e.g. Eyke Ford). There is an increase in the occurrence of species characteristic of water free from organic pollution including mayflies and caddisflies. This increase in diversity is likely to be due to the combination of a number of factors affecting the degree by which in-river needs are satisfied, including:

- greater in-river plant diversity downstream of the Soham confluence;
- better water quality downstream of the confluence;
- the occurence of very low flows in the upper reaches of the Deben.

Examination and comparison of invertebrate records from the late 1970's and records from the period 1990 - 1993 has failed to find any significant trend either in increasing or decreasing invertebrate diversity.

Low flow years (e.g. 1990, 1991) do not appear to have deleteriously affected invertebrate diversity in the lower reaches of the Deben (e.g. Eyke Ford) however a depression in diversity scores during drought years further upstream is discernable (e.g. at Debenham and Ashfield).

Recommendations

- sympathetic channel maintenance activities (leaving patches of in-river vegetation undisturbed, creation/retention of a variable bank and river bed profile).

- consideration should be given to river support by augmentation of the upper reaches of the Deben in drought years in order to maintain flow and water quality;

- improvements in record keeping and archiving of invertebrate data.

The Potential Environmental Benefits and Threats from the Proposed Measures to Alleviate Low Flows on the Deben

5.23 A number of measures have been considered to alleviate low flows on the River Deben (Smith, 1992). Options considered include:

- do nothing;
- changes or controls on spray irrigation;
- augmentation;
- river channel management.

5.24 The environmental consequences of each of these options are discussed below. Table 5.1 summarises the key species, sites, environmental objectives and possible methods for achieving them. Table 5.2 presents a subjective comparison of the potential ecological benefits of each of these options.

Do Nothing

5.25 The do-nothing option is not viewed as a preferred option from an environmental standpoint for the following reasons:

- it leaves the river ecology of the river vulnerable during low flow periods and heavily dependant on effluent returns and the prompt use of spray irrigation bans. The river could also be deleteriously affected by changes in agricultural practice and possible long term climate change;

- it would allow the continued possibility of low flows, and drying out of the river channel, particularly in the upper reaches of the River Deben and Earl Soham watercourse. These low flow events may damage the existing ecology of the river and will limit any increase in ecological diversity.

Changes or Controls on Spray Irrigation

5.26 The level of spray irrigation abstraction from the River Deben is generally small in relation to river flows with the notable exception of drought years. As has been shown in Section 3 of this study, during drought years these abstractions have the potential for critically affecting river flow, particularly in the Wickham Market area. This situation is exacerbated by the fact that peak abstractions take place over the same period as the lowest flows (i.e. mid-summer). As a consequence historical practice has been to impose voluntary or compulsory spray irrigation bans during very low flow period (e.g. in August 1990 and 1991).

5.27 Of additional concern is the scope for an increased level of spray irrigation abstraction in the future should farming type or practices change since there are a number of under utilised licences in existence.

5.28 Several options have been proposed for limiting the impact of spray irrigation including the revocation of existing licences with compensation, the replacement of

surface irrigation licences with groundwater abstraction and the replacement of summer surface water abstraction with storage of high winter flows.

5.29 All three options would result in environmental benefits in the Wickham Market reach (where abstractions are concentrated) during low flow periods in terms of water quality, the additional water depth available to satisfy the in-river needs of adult fish species such as roach and dace. If accompanied by a switch to winter storage local shallow water levels may be raised and the storage area may provide an additional wildlife resource.

5.30 However it is worth pointing out that NRA fish survey results suggest that the low flows experienced during 1990 have had, as yet, no significantly deleterious effect of the fish populations of the lower Deben. Additionally, controls on spray irrigation near Wickham Market are unlikely to benefit either the richest ecological reach near Brandeston, or the poorest reaches upstream of the confluence with the Soham.

Augmentation

5.31 Augmentation has been identified by the NRA as a potential river support option and is suggested by the findings of this study as a suitable support method for conserving or enhancing the flora and fauna of the Deben (particularly in upper reaches) during natural low flow periods.

The NRA has considered two borehole sites for augmenting the Deben. The first near Debenham (TM176643) would draw water from the Crag and has a high estimated yield of 10 Ml/d but high iron concentrations (8-9mg/l Fe) restrict is use. The second is located near Earl Soham (TM233626) and would draw water from the Chalk. This borehole has a satisfactory water quality characteristics but a lower sustainable yield of 2.5 Ml/d, although this can be increased to 3.5 Ml/d for limited periods (Hydrotechnica, 1993).

5.32 With regards to aquatic flora an in-river need for a water depth of approximately 10 cm has been identified for the key species in the channel. This would require an estimated discharge at Winston Grange (TM187622) and Soham (TM233621) of approximately 0.01 m^3/s (this corresponds to a flow at Naunton of between 0.049 and 0.076 m^3/s). Examination of the flow records calculated for these sites (Figures 3.8 and 3.9) indicates that only in 1976 would the transposed Q95(10) have fallen below this value at Brandeston, and in 1976 and 1990 at Winston. However, on the Earl Soham, the Q95(10) flow would have fallen below 0.01 m^3/s in 1973, 1974, 1976, 1977, 1990 and 1991. Augmentation of the Soham borehole of upto 2.5 Ml/d (equivilant to 0.028 m^3/s) would be capable of stisfying these flow needs.

Switch to calculation error ?

5.33 It is therefore provisionally recommended that

- in order to conserve the ecological value of the reach from Brandeston to Letheringham and to potentially enhance the upper reaches of the River Deben and Earl Soham watercourse consideration is given to augmentation of the Earl

Soham watercourse (e.g. from the existing borehole site) and the upper Deben near Debenham (e.g. from Anglian Water's PWS borehole at Winston) when the flow as measured at Naunton falls below a naturalised flow of 0.076 m^3/s. On this basis, augmentation would have been necessary in 1973, 1974, 1976, 1977, 1990 and 1991. This augmentation trigger of 0.076 m^3/s at Naunton Hall compares to a recommended rmf of 0.057 m3/s in the Section 14 Survey Report and a value of 0.105 m^3/s suggested by Hydrotechnica (Hydrotechnica, 1993).

- should augmentation be pursued then the limitations of the above assessment should be borne in mind, and it is recommended that a more thorough hydrological investigation, using detailed NRA cross-sectional information, be commissioned;

- any attempts to maintain a depth of water to benefit aquatic plants should be carried out in conjunction with sympathetic channel management practices;

- a full Environmental Assessment should be commissioned if augmentation is a pursued option, particularly should channel alterations and enlargement (i.e. for settlement purposes) be considered. This assessment should utilise ecological data from a more recent ecological survey of the river than the 1989 SWT survey used in this study.

River Channel Management

5.34 Good river channel management has been shown by this report to be of vital importance to the ecology of the river particularly for key species such as the river water dropwort, the kingfisher and the otter.

5.35 An opportunity exists for the NRA to increase its profile and involvement with regards channel maintenance activities and liaison with groups such as the Suffolk Wildlife Trust, The Otter Trust and the MAFF ESA representative for the Deben.

Table 5.1 Summary of Key Species/Indicators, Sites, Objectives and Possible Methods for Achieving those Objectives for the River Deben

Environmental Receptor	Key Species/Indicators	Key Sites	Objective	Possible Method
River Plants	River water dropwort Flowering rush Wood club rush	Brandeston to Crettingham	To maintain and encourage the proliferation of these scarce species	**Augmentation** - maintain water levels of at least 10 cm **Sympathetic channel management** - working from one bank; leaving patches of in-river vegetation undisturbed to act as a source for recolonisation; creation of berms and retention of cattle bays; creation/retention of a variable bank and river bed profile;
Riparian Habitats	Rare plant and bird species	Water dependant grassland County Wildlife Sites	To raise shallow water levels	**Raising shallow water levels** - Site specific methods of raising ditch water levels, NRA consultation with MAFF regarding their ESA scheme and project grant aid,
Invertebrates	Mayflies Freshwater shrimps Caddisflies	Upstream of Soham confluence	To maintain and increase diversity particularly in the upper reaches	**Augmentation** - maintain flow and water quality in the upper reaches **Sympathetic channel management** - leaving patches of in-river vegetation undisturbed to maintain habitat, creation/retention of a variable bank and river bed profile
Fish	Roach Dace Perch Pike Eels	Brandeston to Crettingham - spawning Wickham Market - deep water	To protect spawning grounds and areas of deep water needed by adult fish	**Sympathetic channel management** - protection of in-stream vegetation in spawning grounds, retention and creation of deep water areas (> 1 m). **Augmentation** - protection of in-stream vegetation in spawning grounds, retention and creation of deep water areas (> 1 m). **Spray irrigation controls** - protection of deep water areas in the lower Deben
Birds	Kingfisher Redshank Snipe	Ashfield to Crettingham and downstream A12 roadbridge	To increase diversity and abundance	**Sympathetic channel management** - protection of nesting cliffs and roosting sites, site specific raising of shallow water levels
Mammals	Otter Bat Water vole Shrew Barn Owl	Whole river particularly Brandeston to Glevering	Protect existing breeding and resting sites by maintaining and creating suitable habitat	**Sympathetic channel management** - protection of otter holts and resting sites, retention of cover and minimising disturbance. Protection of bat roosting sites.
Amenity, Recreation and Landscape	None	Easton Park Farm Wickham Market	Maintain flow and protect the river fishery	**Augmentation** - maintain flow particularly downstream of Brandeston **Sympathetic channel management** - retention of character of river (e.g. trees, meanders, avoid canalisation and uniformity of habitat).
Water Quality	Dissolved oxygen Ammonia Chloride	Debenham to Ashfield Crossroads and Wickham Market	To maintain flow in the upper Deben and ensure adequate effluent dilution throughout the river	**Augmentation** - maintain flow and effluent dilution in upper reaches of Deben and Soham during drought summers **Spray Irrigation Controls** - maintain flow and effluent dilution in the lower Deben during drought summers

Table 5.2 Subjective Comparison of the Potential Ecological Benefits of Potential Remedial Options for the River Deben

Environmental Receptor	Augmentation	Augmentation with Enviromentally Sympathetic Channel Management	Spray Irrigation Controls	Spray Irrigation Controls with Environmentally Sympathetic Channel Management	Augmentation and Spray Irrigation Controls with Environmentally Sympathetic Channel Management
River Plants	•	•••	?	•	•••
Riparian Habitats	•	•	?	•	•
Invertebrates	•	•••	•	••	•••
Fish	•	••	•	••	•••
Birds	?	••	?	••	••
Mammals	?	•••	•	••	•••
Landscape and Amenity	•	•••	••	••	•••
Water Quality	••	••	••	••	••

••• high positive impact
•• moderate positive impact
• slight positive impact
? unknown impact (full EA required)

LIST OF CONSULTEES

Agricultural Development and Advisory Service - Tim Sloane, Southgate Street, Bury St Edmunds, Suffolk IP33 2BD (Tel 0284 753271).

English Nature - Nicolas Sibbett/Jeremy Clitheroe/Richard Rafe, Norman Tower House, 1-2 Crown Street, Bury St Edmunds, Suffolk IP33 1QX (Tel 0284 762218)

Institute of Hydrology - Wallingford

Internal Drainage Board (Upper River Deben) - K.Buckley, 22 School Avenue, Thorpe St Andrew, Norwich NR70QU (Tel 0603 31229).

Ministry of Agriculture, Fisheries and Food - Statistics Division, Epsom Road, Guildford, Surrey GU1 2LD (Tel 0483 403520)

National Rivers Authority - Peterborough. Gerard Stewart (Conservation & REDS), Ann Binks (Water Quality Data), Pauline Smith (Hydrology).

National Rivers Authority - Ipswich. Steve Dines (Water Resources), Jonathan Wortley and Andrea Meakan/Merle Leeds (Fisheries, Recreation, Conservation and Navigation), David Taylor and John Daniels (Chemical and Biological Water Quality), Mick Whiley (Operations Engineer), Tony Hockaday (Licensing), Marcus Huband (Hydrology), Peter Marjoram (Channel Maintenance), Mike Steen and Chris Finbow (Channel Morphology).

River Deben Association - Anne Moore, 2 Grundisburgh Road, Woodbridge, Suffolk IP12 4HG (Tel 0394 383559).

Royal Society for the Protection of Birds - Sandy, Beds (Tel 0767 680551), John Sharp, Norwich (0603 660066)

Suffolk Biological Records Centre - Martin Sanford, Ipswich Museum, Ipswich (Tel 0473 213761).

Suffolk County Council (Planning) - Peter Holburn, St Edmund House, County Hall, Ipswich, Suffolk IP4 1LZ (Tel 0473 230000).

Suffolk County Council - Local Studies Library, Gatacre Road, Ipswich (Tel 0473 264541).

Suffolk Wildlife Trust - Dorothy Casey/Mike Harding, (Tel 0473 890089)

The Otter Trust - Phillip Wayre (Chairman), Earsham, Bungay, Suffolk NR35 2AF (Tel 0986 893470)

Woodbridge and District Angling Club - G. Brown (Tel 0728 643146), David Allett (Tel 0394 382377)

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AUDIT TRAIL

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Project Leader	Nathan Richardson	N J Richardson 20/5/94
Report Author	Nathan Richardson	N J Richardson 20/5/94
Draft Report Proof Read by	Jorgen Schouten Pauline Smith (NRA) Alan Hull (NRA) Gerard Stewart (NRA) Barry Barton (NRA) Andrew Turner (NRA)	20/5/94
Hydrology	Kiersten Munnery	K Munnery 20/5/94
Hydrogeology	Richard Boak	Richard Boak 20/5/94
Invertebrates	William Warner	W F Warner 20/5/94

SOUTHERN SCIENCE

HEADQUARTERS
Southern Science Ltd
Premium House, Brighton Road,
Worthing, West Sussex BN11 2EN
Tel: 0903 823328 Fax: 0903 210474

NORTHERN OFFICE
P.O. Box 400, Warrington WA2 8TZ
Tel: 0925 243253 Fax: 0925 244547

KENT OFFICE
Southern Science Ltd
Capstone Road, Chatham,
Kent ME5 7QA
Tel: 0634 830655 Fax: 0634 831538

SUSSEX OFFICE
Southern Science Ltd
Lewes Road, Falmer,
Brighton, Sussex BN1 9PY
Tel: 0273 625237 Fax: 0273 683412

HAMPSHIRE OFFICE
Southern Science Ltd
Sparrowgrove, Otterbourne,
Winchester, Hants SO21 2SW
Tel: 0962 714585 Fax: 0962 714691

ISLE of WIGHT OFFICE
Southern Science Ltd
Southern House, St Nicholas,
58 St John's Road, Newport,
Isle of Wight PO30 1LT
Tel: 0983 526611 Fax: 0983 522292

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