South West Region: River Yarty, Sir Arthur's Pill

Annex of R&D Note 456

Silsoe College, Cranfield University

R&D Project Record 317/21/ST

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National Rivers Authority

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This document describes methods, results and conclusions of a study to evaluate the impacts of alternative river maintenance strategies on the River Yarty and Sir Arthur's Pill in the South Western Region. Its main purposes are to provide supporting information for R&D Note 456 'River Maintenance Evaluation' and to provide data which support routines for the prioritisation and programming of river maintenance.

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RIVER YARTY

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SOUTH WEST

RIVER YARTY

1. BACKGROUND

1.1 Physical Background

The River Yarty rises at Staple Hill in the highland area of Black Down Hills, 6.75 km south of Taunton in Devon. The river is 21 km in length from source to the confluence with the River Axe, 0.75 km south of Kilmington. The catchment area of the River Yarty is 21 km² and predominantly rural in character.

1.2 Study Reach

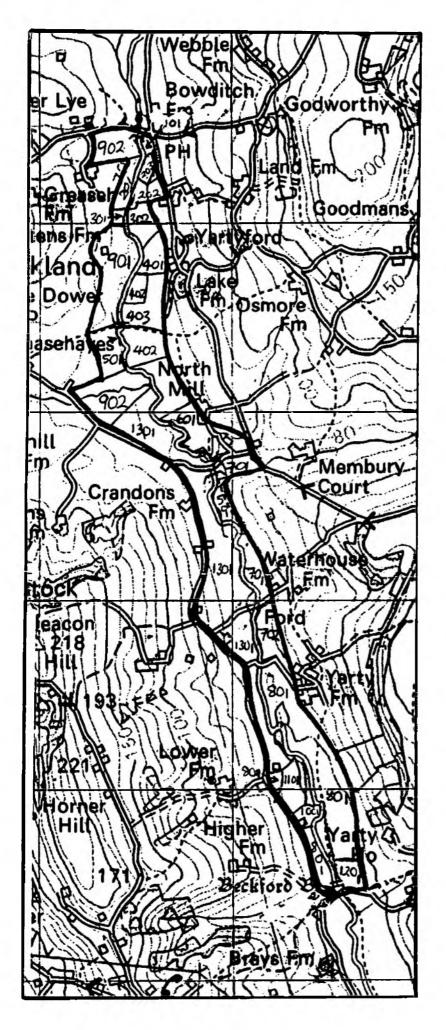
The reach of river selected for study (Figure 1) runs for 5 km from Long Bridge (GR. 256 055) to Beckford Bridge (GR. 266 014). This site was selected for inclusion within the River Maintenance Evaluation study as it is characteristic of main rivers in the region on which maintenance is performed. The area of land deriving benefit from the river maintenance work in terms of its effect on flooding and land drainage is estimated to be 85 ha (Figure 1).

1.3 River Characteristics

The River Yarty is typical of many main rivers in Devon. The river banks are heavily lined with trees, especially alder and willow, along much of the study reach and deciduous broadleaved woodland is common in the lower area of the study reach. The river meanders over a narrow floodplain, constrained by steep valley sides. The meander belt is 450 m wide, containing both large sweeping and tight meanders.

The channel width ranges from 3 to 12 m. Freeboard varies dramatically from 0.25 m with slumped grass banks to 3 m high solid earth cliffs. Bank heights and angles are variable in dimension and change every few metres. Earth cliffs are a common bank feature, especially on the outer bend of meanders.

The River Yarty is a fast flowing river with an average gradient of 1 in 74. Riffles and pools are interspersed with rapids, runs and areas of slack water. Cobbles and pebbles are the dominant bed substrates with areas of gravel and the occasional boulder.



Legend :

Benefit area

Land use blocks

Scale 1:21250

Figure 1 Location of the River Yarty site, benefit area and land use blocks

1.4 Land Drainage

The majority of the benefit area is naturally drained. Figure 2 shows the areas of the benefit area which are drained by pipes. Further information is provided in Section 2.4. Twenty four ditches discharge water into the River Yarty within the study reach.

An old weir upstream of the ford at Waterhouse Farm (GR. 261 031) serves to split the channel in two, reducing flow in the main channel which is crossed by a ford. The secondary channel is crossed over a very low concrete slab bridge approximately 18 inches above the river bed. In times of higher flow, this bridge is frequently submerged.

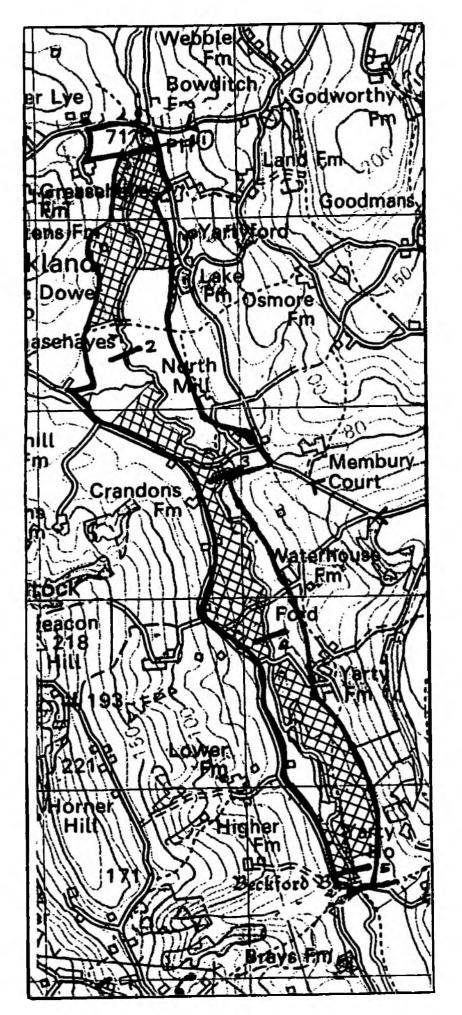
1.5 Geology, Soils and Land Capability

The geology of the area is characterised by the soft red sandstones of Permo-Triassic age. The Permo-Triassic period was an extended episode of continental erosion and deposition under an arid climate.

The Fladbury Soil Association is characteristic of the River Yarty floodplain. The Fladbury series is the dominant soil with the subsidiary Wyre series found on the slightly higher floodplain areas. Both series are deep clayey alluvial soils. The Fladbury soil is a pelo-alluvial gley soil which is characteristically mottled throughout the subsoil. The Wyre series is described as a pelogleyic brown calcareous alluvial soil which lacks mottling above 40 cm in depth.

Soil profiles taken within the reach are shown in Figure 3. The wetter sandy clay soil is characterised by mottling and has a gleyed subsoil. Both the Fladbury and Wyre soils are permeable, albeit slowly. The soil is waterlogged within 70 to 40 cm of the surface for more than 180 days in a year. The primary source of waterlogging is groundwater, the levels of which fluctuate seasonally. The Soil Survey of England and Wales (SSEW) classify soils with this wetness regime as Wetness Class IV (Findlay et al, 1984). Locally, prolonged waterlogging results in a Wetness Class of V during the winter in which soil is waterlogged within 40 cm for 180 to 335 days in the year. According to records from the nearest meteorological station to the site (Twist), the average annual rainfall is approximately 972 mm.

The land is classed as Grade 4 under the Agricultural Land Classification System of MAFF, with the dominant land use being permanent grassland or long leys. The risk of poaching (surface damage by livestock) is high and the incidence of flooding restricts grazing seasons.



1	
egena	•

Piped drainage

Natural drainage

Cross-section location

Scale 1:21 250

Figure 2 Land drainage and location of cross-sections

Grid Reference

255 044

Soil Core Number

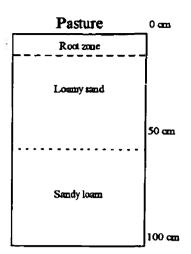
1

Soil Colour

Dark reddish brown

Comments

Uniform profile



Grid Reference

259 037

Soil Core Number

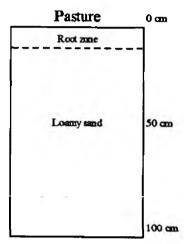
2

Soil Colour

Dark reddish brown

Comments

Uniform profile



Grid Reference

262 027

Soil Core Number

3

Soil Colour

Dark brown

Comments

Mottling of subsoil

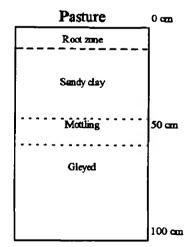


Figure 3 Soil profiles

R&D 317/21/ST

1.6 Capital Works

Capital works were performed on the River Yarty in 1968 following the East Devon floods which were the result of summer storms. These works involved a pioneer timber and bank management scheme when tree clearance and bank maintenance took place. Between 1980 and 1987 a block stone bank revetment scheme was carried out. Bed check weirs were created although these works are just downstream of the study reach.

1.7 River Maintenance

The aim of river maintenance work is to provide a clear watercourse in times of high water and to prevent the flooding and damage of the transport network and numerous low bridges which cross the river. Maintenance is carried out as a preventative measure to minimise the probability of fallen timber accumulating against bridges or as debris dams.

The first tree and bush river maintenance work since the capital scheme was performed during the winters of 1992 and 1993. The return period for future maintenance work is to be five or ten years. Chain-saws and tractors fitted with a winch are the predominant methods used in the tree maintenance. Unstable limbs and low, overhanging branches are removed if they pose a restriction to flow. Willows are pollarded in order to generate regrowth.

Fallen trees and other debris are removed from the channel as required. Since 1968, five gang days per year have been spent clearing debris from the channel.

The level of maintenance on the River Yarty is set following an inspection of the river by the NRA. Availability of equipment and labour also determine the timing of maintenance. In practice, tree and bush maintenance on this section is performed on a 'stop gap' basis. When work gangs have no other maintenance to perform, they are transferred to the River Yarty.

Standards of service (SoS) for the level of maintenance performed are set following an engineers' survey. Watercourse condition and availability of skills and machinery determine the method of tree and bush maintenance performed.

Prior to maintenance, conservation, fisheries and pollution bodies within the NRA and external groups are invited to attend a meeting to discuss the work programme in detail. If necessary, the work programme may be modified following this meeting. Landowners, tenants and

fisheries owners are informed via a telephone call and visit. If public utilities may be affected, relevant bodies are notified via a telephone call which is followed by a letter and map detailing the areas of work.

1.7.1 Farmers views on maintenance

During interviews with farmers, opinions expressed on the maintenance regime were divided. Five farmers expressed their satisfaction with the maintenance regime, stating that it was both beneficial and necessary in order to protect the bridges from flooding and to prevent blockages. However, others stated that it was both a waste of time and pointless as it had no impact on channel capacity. One expressed the opinion that maintenance was carried out at the wrong time and another thought that maintenance worsened the situation as the channel was deepened which resulted in faster flow and increased erosion.

1.7.2 Alternative maintenance strategies

Various alternative maintenance strategies were suggested by farmers during discussions. The dominant suggestion was that some action should be taken to reduce erosion. It was thought that this could be done through planting trees on the river banks and through the use of stone block revetments. Straightening of the bends was suggested as a method of reducing erosion as it would allow a direct route for flow thus reducing the risk of bank erosion. If maintenance were performed in the summer (June onwards) rather than during winter, this is thought by farmers to reduce the incidence of soil compaction as during summer, the load bearing strength of the land is higher than in winter. Stone revetment work has since been carried out in the vicinity of Crandons Farm Bridge (GR. 259 038).

1.8 Climate

The impact of river maintenance on watertable depth and river levels depends on the particular weather conditions, especially rainfall, which vary from season to season and year to year. The seasonal and yearly totals for the period of study (Twist met. station, GR. 290 037) are presented in Table 1.1. The probability of wet, average and dry seasons and years occurring has been determined through analysis of monthly rainfall figures which span a 13 year period. The classification system of the Food and Agricultural Organisation (FAO) was used to determine the wet, average and dry rainfall bands. Wet and dry seasons and years are classed

as those which receive greater than 125 % and less than 75 % of the average rainfall values respectively. Further information on this classification system is presented in the R&D Note 456 Section 3.5.4.

Table 1.1 Rainfall totals

1 able 1	Table 1.1 Raintall totals				
Period	Season	Actual	Average *	% Average	
		Rainfall (mm)	Rainfall (mm)	Rainfall	
1992	Spring	168.4	202.0	83.4	
	Summer	220.8	180.1	122.6	
	Autumn	331.8	282.4	117.5	
1993	Spring	218.8	202.0	108.3	
	Summer	173.2	180.1	96.2	
	Autumn	398.6	282.4	141.1	
1994	Spring	259.0	202.0	128.2	
	Summer	119.9	180,1	66,6	
	Autumn	392.1	282.4	138.8	
1995	Spring	187.0	202.0	92.6	
Total	1992	913.3	970.05	94.1	
	1993	1134.3	970.05	116.9	
	1994	1199.6	970.05	123.7	

^{*} Based on 13 Year record from 1980 to 1993, Twist met. station

The summer and autumn of 1992, autumn of 1993 and spring and autumn of 1994 were wetter than average when compared to the long term average rainfall. This fact is confirmed by farmers who reported some flooding and wet condition underfoot.

The probability of a wet, average and dry season and year occurring is shown in Table 1.2. Rainfall probabilities are based on a 13 year record of monthly rainfall data from the Twist meteorological station (station reference 352 634, GR. 290 037).

Table 1.2 Probability of climatic condition

A M DIV IIM	2100001110, 01 011 <u>111010 001111010</u>		
Season	Dry *	Average *	Wet *
Spring	0.07	0.715	0.215
Summer	0.21	0.43	0.36
Autumn	0.21	0.57	0.22
Year	0.64	0.22	0.14

^{*} Based on records since 1980

The process by which financial benefits of maintenance are calculated according to the probability of each type of season and year occurring is explained in the R&D Note 456, Section 3.5.4.

2. FARM SURVEY

2.1 <u>Introduction</u>

Through site survey, structured interviews and informal discussions with farmers the area deriving benefit from river maintenance in terms of its impact on flooding and land drainage is estimated to be 85 ha. This area is classed as the benefit area (BA). The benefit area has been divided into different blocks (Figure 1) according to land management and land use, drainage conditions and flooding.

2.2 Farm Type, Size and Tenure

Five of the 13 farms within the benefit area are classed as dairy farms according to the European Union (EU) classification system. Three are lowland and livestock farms and one a mixed enterprise. The remaining four are classed as other enterprises. These include small holdings (2 and 5 ha) one of which is grazed by a horse.

Farm sizes range from 2 ha to 202 ha. The average farm size is 65 ha. The Standard Man Day (SMD) or Man-Work-Unit requirement ranges from five to 804, the average is 290. This SMD requirement may be used to assess the labour requirement of the agricultural enterprise. Generally, the higher the SMD value, the greater the amount of labour required.

Ten of the farms are under sole proprietorship. The remaining three are run in partnerships. All the farmers have one holding, although one farmer has two farms. These two farms are run as one unit under the same holding number. The majority of land within the benefit area is owner occupied. Only two farmers have rented land within this area. This comprises 1 ha which is held under a 364 day tenancy agreement and 6 ha held under a summer grazing agreement.

2.3 <u>Livestock Enterprises</u>

The general farming pattern of the Yarty valley is one of mainly beef and sheep enterprises with small areas which are cut for hay and silage.

Six farms have beef herds of various sizes and ages. All the cattle are under two years of age, with four herds following an 18 month grass / cereal system. One is under a system of

fattening with beasts sold on when they reach 400 - 700 kg in weight. The remaining herd consists of store cattle which are fattened off grass and silage and sold on.

Four farms have sheep enterprises. The lambing rate for these Horn Cross ewes under the fat lamb system is above average at 1.6 lambs/ewe tupped. One farm has 300 store lambs under the grass fattening system. These are bought in April and sold in the following February and March after being fattened.

The size of dairy herds on five farms range from one to 80 Freisan cows. Three farms have dairy followers aged between six months and two years. Milk yields range from 5350 litres/cow/year (average yield) to 6000 litres/cow/year (high yield).

One farm has a large pig enterprise under which 300 hogs are kept under a fattening system.

2.4 Arable Enterprises

Two farms have some arable enterprises, although only 0.5 ha lies within the benefit area. Winter cereals, commonly winter barley, turnips and sugar beet are grown under an arable / root crop rotation.

2.5 Land Use In The Benefit Area

Table 2.1 and Figure 4 provide a breakdown of land use within the benefit area. The majority of land is under extensive grassland (76 %). The remaining area is predominantly under intensive grassland with 0.5 ha under cereal and root production.

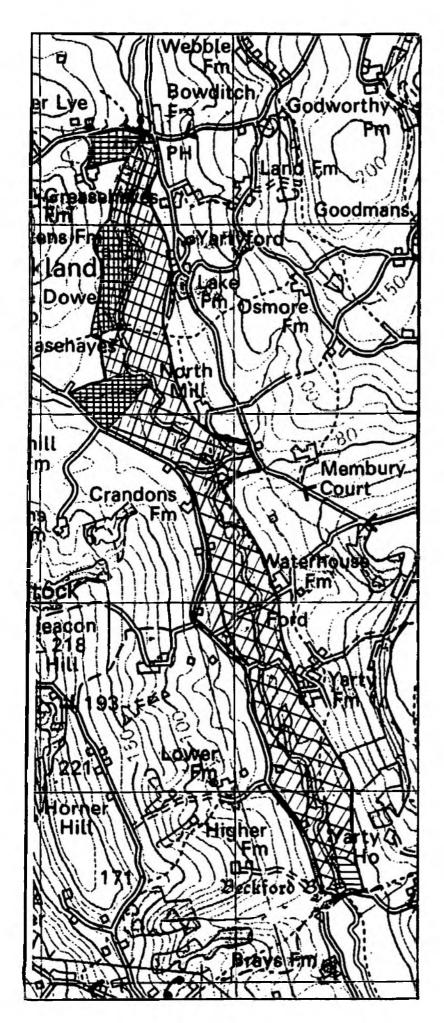
Table 2.1 Land use in the benefit area

Land Use	Area (ha)	% of Benefit Area	% Land With Field Drains
Extensive grass	64.9	76.3	43.9
Intensive grass	19.6	23.1	43.9
Cereal / root	0.5	0.6	0.0

Extensive grassland is classified as that which receives little or no nitrogen input and is subject to little or no grass conservation. If grass conservation takes place, hay rather than silage is usually cut. Beef and sheep commonly graze extensive grassland over a short grazing season.

In comparison, grassland under an intensive system is usually grazed over long grazing seasons by dairy cattle. Multiple cuts of silage are taken and inputs of nitrogen are relatively high (> 50 kgN/ha).

Approximately 44 % of land under intensive and extensive grassland systems is artificially drained by pipes. The remaining areas are naturally drained by gravity. Land under the arable / root crop rotation is not drained by pipes (Table 2.1).



Legend:

Intensive grass

Extensive grass

Cereal / root crop

Scale 1:21 250

Figure 4 Land use in the benefit area

2.6 Turnout and Yarding Dates

Dates for the turnout and yarding of livestock vary within the benefit area as Tables 2.2 and 2.3 indicate. The majority of grassland within the benefit area is grazed from April to October. Drier areas have longer grazing seasons although no livestock are overwintered out to grass within the benefit area - livestock are moved from the valley floor to graze higher areas. Eight percent of the benefit area is not grazed by livestock. A small area is grazed by horses and the remainder is left as meadow.

Table 2.2 Turnout dates

Turnout Date	% Grassland Area	% of Benefit Area
Mid / late March	12.9	12.8
Early / mid April	10.7	10.6
Mid / late April	59.4	59.0
After first silage cut	8.5	8.4
Not grazed	8.5	8.4

Table 2.3 Yarding dates

Yarding Date	% Grassland Area	% of Benefit Area
Mid / late October	45.9	45.6
Early / mid November	15.0	14.9
Mid / late November	20.6	19.9
Mid / late December	10.0	9.9
Not grazed	8.5	8.4

2.7 Grass Conservation

The majority of grassland is grazed only and is not cut for silage. One cut of silage is taken off 12 % (10.1 ha) of the grassland. Silage is cut in early to mid June. No hay is cut within the benefit area.

2.8 <u>Nitrogen Application</u>

Levels of nitrogen applied to grassland within the benefit area range from zero to 74 kg/ha. Table 2.4 shows actual levels applied. Fifty eight percent of the grassland area receives no

application of nitrogen. Over the remaining area, the compound NPK fertiliser in the proportions 20:10:10 and 29:5:5 are commonly applied.

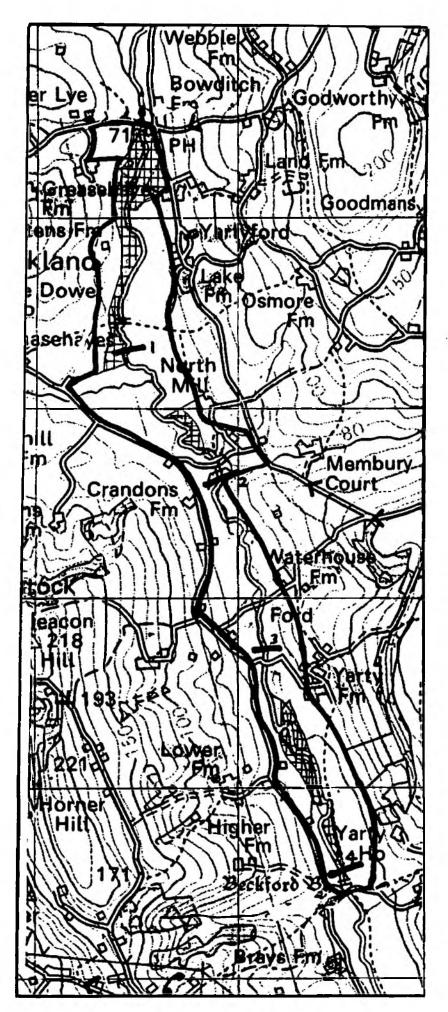
Table 2.4 Nitrogen application rates

Table 2.4 Mitrog	en abblication tar	.63
Rate (kg N/ha)	Grassland Area (ha)	% Grassland Area
	(114)	
0	49.0	58.0
1 - 15	5.7	6.8
16 - 30	28.5	33.7
50 - 74	1.3	1.5

2.9 Flooding

Six farmers within the benefit area reported flooding on their land. In all cases, high river water levels due to excessive rainfall were thought to be the main factor responsible for the flood conditions. On average, 21 % of the benefit area floods (Figure 5) on an annual basis during the autumn and winter months. However, 6 % of the benefit may be subject to flashy summer floods if rainfall is high and the channel blocked by debris.

The duration of flood events is short. All farmers report the flood duration to be of one or two days. Litter and debris on pasture are cited as the main consequences of flooding by many of the farmers. Such debris has to be cleared by hand. Erosion of the river banks is also reported to be a consequence of some significance.



Legend:

Flooded areas

Debris dams

Scale 1:21 250

Figure 5 Areas prone to flooding and location of simulated debris dams

2.10 Waterlogging

Throughout the spring and summer the wetness condition of the land within the benefit area is reported to be relatively dry. During the summer, as Table 2.5 shows, the majority of land is rarely wet with only 12 % being occasionally wet.

In the spring and autumn, a greater proportion of the land is wet. In the autumn, 29 % of the benefit area is reported as being often wet and four percent of the land is permanently wet. These wetter conditions have been attributed to the low lying nature of the land and the weather conditions.

Table 2.5 Farmer assessment of wetness condition

Season	Wetness Condition Area (ha) % Benefit		
БСАЗОП	Werness Condition	Alea (IIa)	70 Belletit Alea
Spring	Rarely wet	30.8	36.2
	Occasionally wet	54.2	63.8
	Often wet	0.0	0.0
	Permanently wet	0.0	0.0
Summer	Rarely wet	74.5	87.6
	Occasionally wet	10.5	12.4
	Often wet	0.0	0.0
	Permanently wet	0.0	0.0
Autumn	Rarely wet	11.6	13.6
	Occasionally wet	44.7	52.6
	Often wet	25.0	29.4
	Permanently wet	3.7	4.4

2.11 Statistical Analysis

It is apparent that land use, farming practice, drainage and flooding are interrelated. Statistical methods were used to determine whether these relationships occurred more frequently than might be expected by pure chance. Full details of this analysis in which the 12 sites were grouped according to NRA Region, are presented in the Interim Report R&D 317/13/ST, presented to the NRA in December 1994.

The following observations can be made from the statistical analysis of fields in the benefit area of the River Yarty maintenance programme:

• Land management within the benefit area and land use are a function of the farming system followed. The dominant farming system influences land use within the benefit area.

Typically it is an area of pasture, devoted to dairy, sheep and beef and therefore even if the land is liable to flood and prone to wet conditions, land use reflects the dominant farming system; in this case dairy and lowland and livestock.

- A relationship exists between flooding and land use. The cereal / root crop production areas are not prone to flooding. Extensive grassland areas are prone to flooding. Flood duration is longer on extensive grassland (2 days) than on intensive grassland (1 day). (Statistically, there is a 40 % chance of correctly predicting the incidence of flooding on the basis of land use).
- A relationship exists between turnout dates for livestock and field wetness conditions in the spring. Land which is rarely wet in spring is grazed from late March or early April. The wetter land (occasionally wet) is grazed from mid to late April. (Statistically, there is an 85 % chance of correctly predicting livestock turnout dates on the basis of field wetness conditions in the spring).

3 HYDRAULIC AND HYDROLOGICAL INFORMATION

3.1 Introduction

Information on channel hydraulics and hydrological data has been used to determine the impact of maintenance on channel capacity and flood return periods.

3.2 Cross-section Surveys

Cross-sectional surveys of the River Yarty channel were taken at five points along the study reach at an average interval of 1.2 km (Figure 2). Channel capacity and freeboard were determined from these cross-sections. The channel cross-section remained unchanged following the tree and bush clearance programme and so a post-maintenance cross-sectional survey was not necessary.

Prior to maintenance, channel roughness was expressed in the form of Manning's n coefficient, in accordance with the methodology developed by Cowan (1956). This coefficient is composed of six elements which include the degree of irregularity of the channel bed, level of vegetation growth and relative effect of obstructions such as tree roots and fallen branches. Further details of this methodology are contained within the R&D Note 456 Appendix IV. The same procedure was followed post-maintenance in order to determine friction values for the 'with' and 'without' maintenance situation.

Stage/discharge curves for the 'with' and 'without' maintenance situation were constructed for each cross-section using the different values of Manning's 'n'. Channel cross-section information, stage/discharge curves and channel information are presented in Figure 6. The bankfull channel capacities and associated return periods for the 'with' and 'without' maintenance scenario are presented in Table 3.1.

The bankfull capacity figures obtained from the cross-sections indicate an average increase in capacity attributable to maintenance of 16 % and an average increase in the interval between flood events of 35 %.

Table 3.1 Bankfull capacity and return periods

Table 5:1 Damada capacity and rece				1045
	Without Maintenance		With Mair	ntenance
Cross-Section No.	Bankfull Capacity (m ³ /s)	Return Period (years)	Bankfull Capacity (m ³ /s)	Return Period (years)
1	16.7	3.0	20.8	8.0
2	5.6	0.3	7.1	0.4
3	10.3	0.9	11.5	1.1
4	10.1	0.8	11.5	1.0
5	14.5	2.0	17.2	3.8

(Source: modelled estimates)

3.3 Flood Return Period

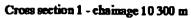
Throughout the period of study (1992 to 1995) river water level information was collected on a regular basis through the reading of three gauge boards which were installed in the reach at Longbridge, Case Bridge and Beckford Bridge. Information regarding frequency, duration and magnitude of flood flows were collected from interviews with local farmers and NRA staff. A flood return period curve has been compiled from this information, using the methodology contained within the Flood Studies Report (NERC, 1975). The frequency of floods of different magnitudes can be estimated from the flood return period curve (Figure 7).

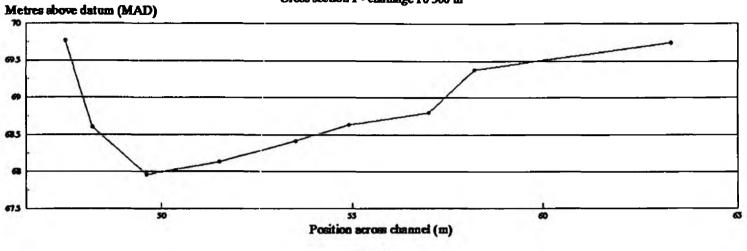
The flood return period for each block which floods and associated flooded areas are shown in Table 3.2. The 'without' maintenance return period is estimated by the farmer, the 'with' maintenance value is a modelled estimate using the cross-section information and Manning's n coefficient. It is assumed that the flooded area remains unchanged following maintenance.

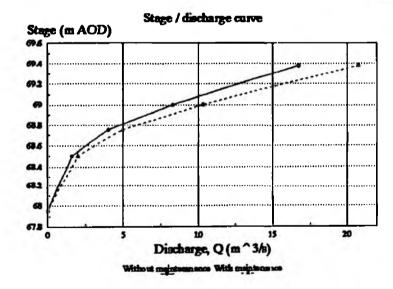
Table 3.2 Flood return periods and flooded areas

Block No.	Flooded Area (ha)	Flood Return Period (Years)		Block No.	Flooded Area (ha)	Flood Return Period (Years)	
(Size, ha)		Without Maintenance	With Maintenance	(Size, ha)		Without Maintenance	With Maintenance
101 (1.1)	0.88	0.3	3.0	801 (15.2)	1.90	0.3	3.5
201 (2.0)	1.60	1.0	3.0	901 (8.6)	2.00	0.3	3.0
202 (1.3)	0.33	1.0	3.0	1001 (1.90	0.23	0.5	2.0
203 (1.3)	1.00	0.5	3.0	1201 (0.5)	0.10	0.5	2.0
301 (0.5)	0.50	1.0	3.0	1301 (17.8)	3.56	0.5	1.0
501 (2.6)	2.08	0.5	1.0				
601 (3.3)	0.33	0.5	1.0				

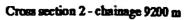
Figure 6

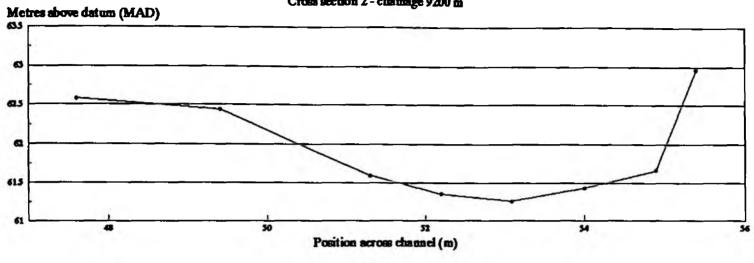


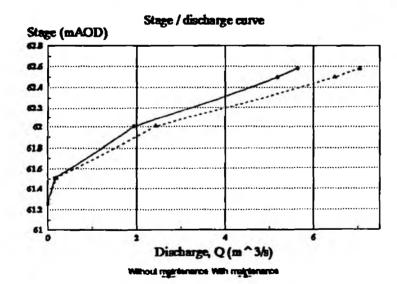




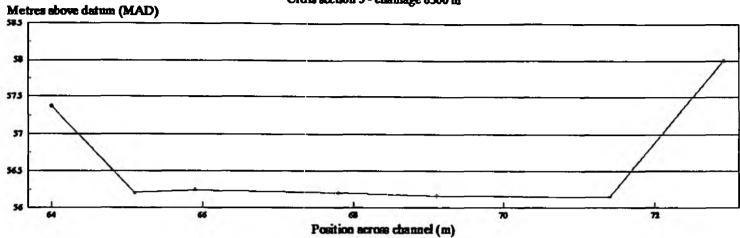
River channel information	Without Mainte	With ziance
Manning's n value	0.063	0.051
Bankfull capacity (cumecs)	16.7	20.8
Return period (years)	3	8







River channel information	Without Maint	
Manning's n value	0.05	0.04
Bankfull capacity (cumecs) .	56	7.1
Return period (years)	0.3	0.4



Stage (mAOD)

Stage (mAOD)

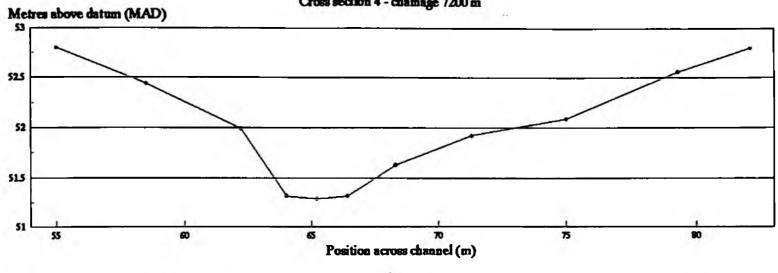
Stage (mAOD)

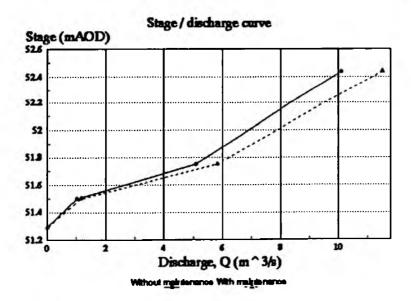
Discharge (Q) m 3/s

Without minimum on With might seaces

River channel information	Without maint	With
Manning's n value	0.05	0.045
Bankfull capacity (cumecs)	10.3	11.5
Return period (years)	0.85	1.1

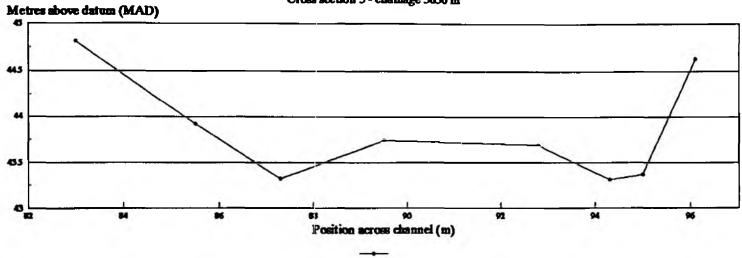
Cross section 4 - chainage 7200 m

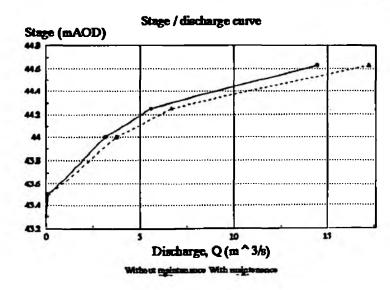




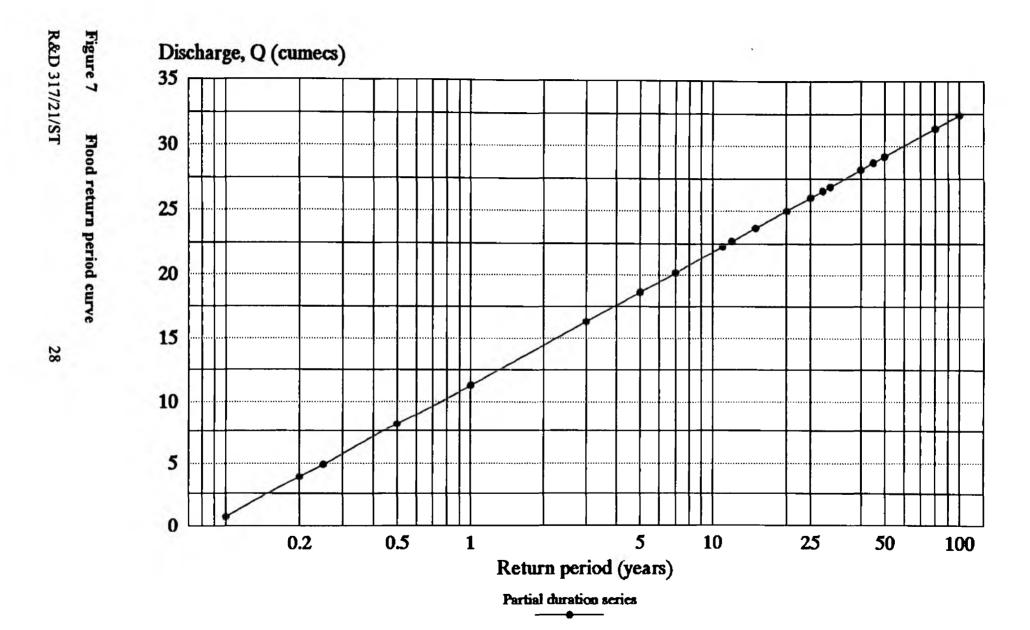
River channel information	Without Mainte	
Manning's n value	0.049	0.043
Bankfull capacity (cumeca)	10.1	11.5
Return period (years)	0.8	1.0

Cross section 5 - chainage 5650 m





River channel information		t With tenance
Manning's a value	0.062	0.052
Bankfull capacity (cumecs)	14.5	17.2
Return period (years)	20	3.8



4. LAND DRAINAGE

4.1 Field Drainage Status

Through an extensive literature review and farmer survey, the drainage status of agricultural land has been classified into three standards according to watertable depth. Three watertable bands have been identified:- > 0.5 m from the surface, between 0.3 to 0.5 m of the surface and < 0.3 m from the surface. According to the time the watertable lies within these bands, the drainage status is classed as good (G, no limitations to agriculture), bad (B, some restrictions on agriculture) or very bad (VB, severe limitations to agricultural productivity). Further details are presented in the R&D Note 456, Section 3.5.2.

The drainage status of the different land blocks within the benefit area of the River Yarty has been determined on a seasonal basis using a non-steady state watertable model which relates infield watertable levels (and hence drainage conditions) to observed water levels in the river and ditch system (see R&D Note 456, Section 3.5.2 for further details). The model has been run with river water levels for the 'with' and 'without' maintenance situation using the same climatic data to enable the isolation of the impact of maintenance on drainage status. An example of the input and output of the model is shown in Appendix I. An example of the classification of the weeks of each season which are under conditions of good, bad and very bad drainage status are shown in Appendix I.

In some cases, there may be a change in the number of weeks that the watertable lies within the good, bad or very bad drainage bands following maintenance. However, these changes may not be of sufficient magnitude to change the drainage status classification. Where a change in drainage status has occurred due to maintenance, the changes appear in bold print in Table 4.1.

The results of the model and the assessment of drainage status made by farmers are shown in Table 4.1. The results from the watertable model are consistent with the farmer assessment of drainage condition under dry and average rainfall conditions. In a wet season, the majority of farmers perceive the field drainage condition to be drier than predicted by the watertable model. In a wet season, there is 50 % agreement between farmer and modelled assessment of drainage conditions. During wet seasons, farmers attribute much of the drainage problem to surface runoff, antecedent rainfall, flooding from the river and the clay soil type. One farmer

reported that submerged outfalls for field drainage pipes contributed to the waterlogged conditions.

These assessments of watertable position in various seasons confirm that with maintenance, drainage status in the benefit area is generally bad in wet climatic conditions and good in average and dry seasons. If maintenance were not performed, the drainage status would generally remain unchanged. Without maintenance, under average weather conditions, farmers estimate that drainage conditions would deteriorate from good to bad over 5 % and from bad to very bad over 29 % of the benefit area.

Table 4.1 Drainage status for wet, average and dry seasons, without/with

	maintenance										
		Wet Sea	son *	Average	Season	Dry Sea	son *	Farn	ner Assessr	nent	
				*				Wit	h Maintena	nce	Without
Block		Without	With	Without	With	Without	With	Wet	Average	Dry	
No_											
101	Y	G	G	G	G	G	G	В	G	G	G
201	Y	В	В	G	G	G	G	G	G	G	G
202	Y	G	G	G	G	G	G	G	G	G	G
203	Y	G	G	G	G	G	G	G	G	G	G
301	N	В	В	G	G	G	G	В	G	G	G
302	Y	G	G	G	G	G	G	G	G	\mathbf{G}	G
401	Y	VB	VB	В	В	G	G	В	\boldsymbol{G}	G	В
402	N	В	В	G	G	G	G	В	G	G	G
403	N	В	В	G	G	G	G	G	G	G	G
501	N	В	В	G	G	G	G	VB	G	G	G
601	N	G	G	G	G	G	G	G	G	G	G
701	N	VB	VB	В	В	В	G	В	В	G	VB
702	N	VB	VB	В	В	G	G	В	В	G	В
801	Y	VB	VB	G	G	G	G	В	G	G	В
901	Y	В	В	G	G	G	G	В	G	G	G
902	N	VB	В	В	В	G	G	В	В	G	VB
1001	N	VB	В	G	G	G	G	В	G	G	В
1101	N	VB	VB	G	G	G	G	G	G	G	G
1201	N	VB	В	G	G	G	G	В	G	G	G
1301	N	В	В	G	G	G	G	G	G	G	G

NB: *Modelled results

Y or N refers to the presence or absence of field drainage Bold type indicates a change in drainage status as a result of maintenance Italics indicate a difference in drainage status predicted by the model and farmer assessment Current levels of maintenance activity prevent the deterioration of drainage status on 4 blocks of land. The percentage change of area by drainage status as a result of maintenance is estimated to be:

- in a wet season, maintenance prevents a deterioration in drainage status from B to VB on 9.9 ha (12 % of BA)
- in a dry season, maintenance prevents a deterioration from G to B on 2.2 ha (3 % of BA).

4.2 <u>Debris Dams</u>

The impact of maintenance on land drainage within the floodplain is negligible. This is expected as the trimming of trees and bushes which overhang the river will have minimal impact on channel friction and capacity unless debris dams form. Maintenance is carried out as a preventative measure to minimise the probability of fallen timber accumulating against bridges and thus causing localised flooding, increased water levels upstream of the debris dam, waterlogging, structural damage and risk to the general public using the road network.

4.2.1 Nature of debris dams

Debris dams are accumulations of organic matter within the river channel. Such dams form when a piece of woody material such as a tree limb falls into the channel and lodges against boulders or protrusions from the bed or bank(s). Smaller pieces of debris are caught against the original piece of debris. These provide the framework in which leaves and other debris accumulate.

4.2.2 Impact of debris dams

Unless removed, the accumulation of debris will form a dam and a barrier to flow causing the water upstream of the dam to 'back-up'. Ultimately, debris dams exert a resistance to flow and alter the roughness of the channel. Under low flows, when the water is shallow, irregularities in the dam are exposed and their effects more pronounced. The frictional drag exerted on the water is it crosses the dam reduces the flow slows water over the blockage. Water levels are thus raised upstream of the debris dam due to this 'back-up' effect. This may result in a localised increase in flooding and waterlogging as the watertable locally rises.

Under higher flows, the frictional drag of the debris dam is drowned out and the dam exerts less influence over river flow,

In addition to their impact on watertables, debris dams which partially or completely block the channel may exert control over local channel morphology. In meandering streams such as the River Yarty, the formation of debris dams may result in local erosion and scour of the bed and banks around the dam. This may serve to widen the channel thus diverting flow around the blockage. Mid-channel bars may develop immediately downstream of the blockage due to reduced flow levels and flow velocity in the lee of the dam. Stream ecology may be influenced by the dam through the creation of temporary habitats for such wildlife as otters.

4.3 Simulation of Debris Dams in the Channel

The impact of debris dams on land drainage has been determined through simulation modelling using FLUCOMP; a computational river model package produced by HR Wallingford. This model was used to predict the impact of debris dams on water level and discharge values along the study reach.

Debris dams were simulated via the imposition of fixed weirs along the channel section. Weirs are the closet approximation to debris dams available in the package. The height and breadth of the weir crest was altered to simulate varying degrees of channel restriction. The two sizes of dam simulated were 50 % and 75 % blockages of the cross-sectional area. The 50 % blockage of the cross-sectional area is deemed to be the lower limit for 'justifiable' debris removal (Bowles, 1992).

4.3.1 Physical effect of in-channel blockages

The location of the simulated debris dams are shown in Figure 5. The debris dams were located so as to be out of spatial influence of each other. The simulations showed that debris dams on the River Yarty affected river levels for a distance of approximately 300 m upstream of the dam irrespective of the season. The 50 % blockage is estimated to result in the change in drainage status over 28 ha (33 % of BA) whilst the 75 % blockages result in a change over 43 ha (51 % of the BA). The impact of debris dams on drainage status is shown in Tables 4.2 and 4.3.

Table 4.2	Impact o	Impact of 50 % debris dam blockage on drainage status										
Dam Location	Drainage Status		Drainage Status with debris dam	Area affected (ha)	Land Use							
1	Spring	G	В	2.8	Extensive grass							
1	Summer	G	В	0.9								
1	Autumn	G	В	0.94	"							
2	Spring	VB	VB	0	"							
2	Summer	VB	VB	0	¢¢							
2	Autumn	VB	VB	0	ce cc							
3	Spring	G	В	4.5	66 66							
3	Summer	G	В	2.7	££ ££							
3	Autumn	G	В	3.6	££ 44							
4	Spring	G	В	5.4	£¢							
4	Summer	G	В	2.7	44 44							
4	Autumn	G	В	4.41	66 66							

Table 4.3 Impact of 75 % debris dam blockage on drainage state								
Dam Location	Season	Current Drainage Drainage Status Status with debris dam		Area affected (ha)	Land Use			
1	Spring	G	В	5.85	Extensive grass			
1	Summer	G	В	2.16	" "			
1	Autumn	G	В	4.5	"			
2	Spring	VB	VB	0	"			
2	Summer	VB	VB	0	" "			
2	Autumn	VB	VB	0	66 66			
3	Spring	G	В	5.4	£6 46			
3	Summer	G	В	2.79	cc 4c			
3	Autumn	G	В	5.13	66 66			
4	Spring	G	В	6.3	دد دد			
4	Summer	G	В	5.4	££ ££			
4	Autumn	Ğ	В	5.85	66 66			

5 SCHEME APPRAISAL

5.1 Benefits of Tree and Bush Maintenance

The benefits of river maintenance on the Yarty comprises two elements. Firstly, the control of tree and bush growth has a direct influence, albeit small, on the hydraulic performance of the channel. Secondly, tree and bush work reduces the probability of debris falling into the channel and creating a debris dam. When dams do arise, it is customary to remove them to limit the potential damage to the channel, adjacent land and structures downstream. The following benefit assessment examines these two elements.

5.2 Maintenance Benefits

For each block of land, agricultural production scenarios were created which reflect different levels of field management under conditions of good, bad and very bad drainage (see R&D Note 456 Section 3.5.4). These scenarios are based on discussions with farmers in the benefit area over the period 1992-1994.

Changes in field drainage status as a result of maintenance under dry, average and wet climatic conditions have been identified. Changes in flood risk due to maintenance have also been determined. Estimates have been derived of the monetary value of changes in field management and productivity associated with changes in the standards of drainage service.

Two perspectives have been used to value agricultural performance. The first perspective is that of financial analysis which uses the prices paid and received by farmers to estimate the added-value associated with drainage. Financial analysis shows the benefits of maintenance to farmers in the benefit area.

The second perspective is that of economic analysis which modifies the financial analysis to make allowance for the direct and indirect subsidies paid to farmers by Government. In accordance with the MAFF Project Appraisal Guidance Notes on Flood Defence (PAGN, 1993), these modifications involve reductions in the financial value of output (including subsidies) by 10 % in the case of cereals, oil seeds and grain legumes, 35 % for beef and 25 % for sheep. Commodities subject to quota such as potatoes, sugar beet and milk are treated as

winter wheat. The set aside areas are also treated as wheat. The reasons for these adjustments are discussed in the R&D Note 456 Section 2.7.2.

Table 5.1 shows the financial net returns (1995/96 prices) for each block of land within the benefit area under conditions of good, bad and very bad drainage. Changes in net returns relating to a change in drainage status are also shown. Table 5.2 presents similar data using economic prices. Table 5.3 shows the flood costs for each block of land assuming 'with' and 'without' maintenance and specified field drainage conditions. It is assumed that there is no difference between financial and economic values in the case of flood damage to standing crops.

Table 5.4 combines data on changes in drainage status, flood risk and financial performance to determine the financial benefits and change in financial net returns due to maintenance for wet, average and dry weather conditions for each block of land in the benefit area. These benefits are the avoidance of losses which would occur in the absence of maintenance. Benefits weighted by field size for wet, average and dry seasons are multiplied by the relative probability of the occurrence of the season to give an average expected annual benefit. These are summed for the benefit area as a whole.

Table 5.4 estimates a total expected annual benefit of £ 382 in 1995 financial prices, equivalent to about £ 4.5/ha per year. These are very modest benefits which reflect the small direct impact of tree and bush work on drainage conditions in the flood plain. Table 5.5 shows the benefits attributable to maintenance using economic prices based on the current MAFF Project Appraisal Guidance Notes. Total average expected annual benefits are about £ 334 in economic prices for the benefit area, equivalent to £ 3.9/ha. On this basis, the benefit to the national economy is 87 % of the benefits which accrue to farmers. This difference reflects the adjustments required by MAFF to remove government subsidy from the assessment of benefits. These estimates require cautious interpretation as explained in the R&D Note 456 Section 2.7.2.

Table 5.1 Financial net returns

		Net Return (£/ha)			Change i	n Net Retur	n (£/ha)
Block	Area (ha)	G	В	VB	G-B	G - VB	B - VB
101	1.10	389	341	291	49	98	49
201	2.00	511	410	339	101	172	7 1
202	1.30	511	410	339	101	172	71
203	1.30	515	413	346	102	169	67
301	0.50	375	334	292	41	84	43
302	2.80	375	334	292	41	84	43
401	2.40	207	170	135	37	72	35
402	5.70	177	152	108	25	69	44
403	3.50	406	353	308	54	98	45
501	2.60	401	305	265	96	136	40
601	3.30	165	134	112	31	53	22
701	2.20	446	334	292	112	155	43
702	0.90	462	399	282	63	181	118
801	15.20	208	159	115	49	93	44
901	8.60	503	415	349	88	154	66
902	7.50	503	415	349	88	154	66
1001	1.90	182	149	118	33	64	31
1101	3.90	253	208	168	46	85	39
1201	0.50	607	316	101	291	506	216
1301	17.80	151	125	99	26	52	26

Table 5.2 Economic net returns

	į.	Net R	eturn (£/ha)		Change in	Net Return	n (£/ha)	
Block	Area (ha)	G	В	VB	G-B	G-VB	B-VB	
101	1.10	107	84	68	23	39	16	
201	2.00	126	89	68	37	58	21	
202	1.30	126	89	68	37	58	21	
203	1.30	130	92	74	38	56	18	
301	0.50	93	77	62	16	30	15	
302	2.80	93	77	62	16	30	15	
401	2.40	97	70	46	27	51	24	
402	5.70	45	32	17	13	28	15	
403	3.50	378	305	194	73	184	111	
501	2.60	7 9	54	42	25	37	12	
601	3.30	58	37	25	22	33	11	
701	2.20	110	77	62	33	48	15	
702	0.90	64	47	25	17	39	22	
801	15.20	7 5	45	18	29	57	27	
901	8.60	503	415	349	88	154	66	
902	7 .50	503	415	349	88	154	66	
1001	1.90	76	52	32	23	44	20	
1101	3.90	120	94	71	26	49	22	
1201	0.50	378	305	194	73	184	111	
1301	1 7 .80	62	43	26	19	36	17	

1 + 010 0	5 11000 00	343												
		<u>-</u>	GOOD DR	AINAGE	BAD DRA	INAGE	VERY BAD	DRAINAGE				CHANC	E IN FLOOD	COSTS
	Without maintenance	With maintenance	Without maintenance	With maintenance	Without maintenance	With maintenance	Without	With	GOOD	BAD	VERY	GOOD		GOOD TO VERY BAD
Block	FRP	FRP	flood	flood	flood		maintenance	maintenance	1154	115.1	BAD	TO BAD		Without
		FKF				flood	flood	flood	Without	Without	Without	Without	Without	
Number			cost	cost	cost	cost	cost	cost	-with	-with	-with	-with	-with	with
101	0.30	3.00	15.43	1.54	14.22	1.42	12.91	1.29	13.89	12.80	11.62	12.68	11.49	11.37
201	1.00	3.00	6.08	2.03	5.17	1.72	4.47	1.49	4.05	3.45	2.98	3.14	2.75	2.44
202	1.00	3.00	1.90	0.63	1.62	0.54	1.40	0.47	1.27	1.08	0.93	0.99	0.86	0.77
203	0.50	3.00	11.71	1.95	9.95	1.66	8.60	1.43	9.76	8.29	7.17	8.00	6.94	6.65
301	1.00	3.00	5.79	1.93	5.34	1.78	4,83	1.61	3.86	3.56	3.22	3.41	3.05	2.90
501	0.50	1.00	10.60	5.30	8,53	4.27	7.75	3.88	5.30	4.27	3.88	3.23	3.49	2.45
601	0.50	1.00	1.04	0.52	0.95	0.48	0.85	0.43	0.52	0.48	0.43	0.43	0.38	0.33
801	0.30	3.50	2.70	0.23	2.70	0.23	1.99	0.17	2.47	2.47	1.82	2.47	1.76	1.76
901	0.30	3.00	6.25	0.63	5.55	0.56	4.93	0.49	5.63	5.00	4.44	4.93	4.38	4.31
1001	0.50	2.00	1.25	0.31	1.14	0.29	1.02	0.26	0.94	0.86	0. <i>7</i> 7	0.83	0.74	0.71
1201	0.50	2.00	41.88	10.47	33.16	8.29	23.40	5.85	31.41	24.87	17.55	22.69	15.11	12.93
1301	0,50	1.00	1.76	0.88	1.62	0.81	1.46	0.73	0.88	0.81	0.73	0.74	0.65	0.58

			Wet Season		Α	verage Season			Dry Season		
Block	Area (ha)	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net	
		to drainage	flood	return due to	to drainage	flood	return due to	to drainage	flood	return due to	Total
		(£/ha/yr)	alleviation	maintenance	(£/ha/yr)	alleviation	maintenance	(£/ha/yr)	alleviation	maintenance	Change
			(£/ha)			(£/ha)			(£/ha)		(£/yr
101	1.10	0	14	14	0	14	14	0	14	14	15
201	2.00	o	3	3	0	4	4	l o	4	4	8
202	1.30	0	1	1	0	1	1	0	1	1	2
203	1.30	0	10	10	0	10	10	0	10	10	13
301	0.50	0	4	4	0	4	4	0	4	4	2
302	2.80	0	0	0	0	0	0	0	0	o	(
401	2.40	0	0	0	0	0	0	0	0	o	(
402	5.7	0	0	0	0	0	0	0	0	o	(
403	3,50	0	0	0	0	0	0	0	0	0	(
501	2.6	o	4.27	4	0	5.3	5	О .	5.3	5	13
601	3.3	0	0.52	1	0	0.52	1	О .	0.52	1	2
701	2.2	0	0	0	0	0	0	111.99	0	112	40
702	0.9	0	0	0	0	0	0	0	0	0	(
801	15.2	0	1.82	2	0	2.47	2	0	2.47	2	35
901	8.6	0	5	5	0	5.63	6	0	5.63	6	47
902	7.5	65.91	0	66	0	0	0	0	0	0	131
1001	1.9	30.91	0.74	32	٥	0.94	1	0	0.94	1	17
1101	3.9	0	0	0	0	0	.0	0	0	0	(
1201	0.5	215.65	15.11	231	0	31.41	31	0	31.41	31	42
1301	17.8	0	0.81	1	0	0.88	1	0	0.88	1	15
Total	85										382
Probability of		Wet season		0.265					1	Benefit (£/ha)	•
		Average seaso Dry season	n	0.572 0.163							

			Wet Season		Α	verage Season			Dry Season		
Block	Area (ha)	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net	
		to drainage	flood	return due to	to drainage	flood	return due to	to drainage	flood	return due to	Total
		(£/ha/yr)	alleviation	maintenance	(£/ha/yr)	alleviation	maintenance	(£/ha/yr)	alleviation	maintenance	Change
			(£/ha)			(£/ha)			(£/ha)		(£/yr)
101	1.10	О	14	14	0	14	14	o	14	14	15
201	2.00	0	3	3	0	4	4	l 0	4	4	8
202	1.30	0	1	1	o	1	1	ا	1	11	2
203	1.30	0	10	10	0	10	10	0	10	10	13
301	0.50	0	4	4	0	4	4	0	4	4	2
302	2.80	0	0	0	0	0	0	о	0	o	C
401	2.40	0	0	0	0	0	0	l о	0	0	C
402	5.7	0	0	0	0	0	0	О .	0	o	C
403	3.50	0	0	0	o	0	0	О .	0	0	C
501	2.6	0	4.27	4	0	5.3	5	О .	5.3	5	13
801	3.3	0	0.52	1	0	0.52	1	О .	0.52	1	2
701	2.2	0	0	0	0	0	0	32.86	0	33	12
702	0.9	0	0	0	0	0	0	0	0	0	(
801	15.2	0	1.82	2	0	2.47	2	0	2.47	2	35
901	8.6	0	5	5	0	5.63	6	0	5.63	6	47
902	7.5	65.91	0	66	0	0	0	0	0	0	131
1001	1.9	20.46	0.74	21	0	0.94	1	0	0.94	1	12
1101	3.9	0	0	0	0	0	0	0	0	0	C
1201	0.5	111.1	15.11	126	0	31.41	31	0	31.41	31	28
1301	17.8	0	0.81	1	0	0.88	1	0	0.88	1	15
Total	85										334
Probability (of :-	Wet seeson		0.265					(Benefit (£/he)	3.93
		Average seaso	n	0.572							
		Dry season		0.163							

As an alternative estimate to that based on watertable modelling, Table 5.6 estimates the benefits due to maintenance which were perceived by farmers (earlier reported in Table 4.1) where they identified a change in drainage conditions between the 'with' and 'without' maintenance situations in an average, representative season. These estimates include the flood damage costs identified in Table 5.3 which were based on a combination of farmer and modelled data.

Farmer assessment gave an average annual financial benefit of £ 1631 (£ 19/ha) and an economic benefit of £ 1252 (£ 15/ha).

Table 5.6 Farmer assessment of maintenance benefits

		A	verage Season		A	verage Season	
		F	inancial Prices		E	conomic Prices	!
Block	Area (ha)	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net
		to drainage	flood	return due to	to drainage	flood	return due to
		(£ /ha/y τ)	alleviation	mainten an ce	(£/ha/yr)	alleviation	mainten ance
			(£/ha)			(£/ha)	
101	1.10	0	14	15	0	14	15
201	2.00	0	3	7	0	4	8
202	1.30	0	1	2	0	1	2
203	1.30	0	10	13	0	10	13
301	0.50	0	4	2	0	4	2
302	2.80	0	0	o	0	0	0
401	2.40	37	0	89	27	0	65
402	5.7	0	0	o	0	0	0
403	3.50	0	0	0	0	0	0
501	2.6	0	4.27	11	0	5.3	14
601	3.3	0	0.52	2	0	0.52	2
701	2.2	43	0	95	15	0	33
702	0.9	0	0	0	0	0	0
801	15.2	49	1.82	772	2 9	2.47	478
901	8.6	0	5	43	0	5.63	48
902	7.5	66	0	495	66	0	495
1001	1.9	33	0.74	64	23	0.94	45
1101	3.9	0	0	0	0	0	0
1201	0.5	0	1 5 .11	8	0	31.41	16
1301	17.8	0	0.81	14	0	0.88	16
Total	85	Total fin an	cial benefit (£)	1631	Total econom	nic benefit (£)	1252
		В	enefit (£/ha)	19	E	Benefit (£/ha)	15

5.3 <u>Debris Dams</u>

Tree and bush work is partly justified as a means of avoiding the accumulation of debris in the channel with consequences for retained water levels and increased flood risk. The work is accompanied by debris removal as and when required. The influence of debris dams on land drainage was determined by simulation as previously described. The analysis showed that debris dams have greatest influence on land drainage conditions during spring. For this reason

spring has been used to assess the likely impacts of debris dams which form and are not removed.

Table 5.7 shows the reductions in financial and economic returns due to a reduction in field drainage conditions associated with debris dams. It is assumed that dams are formed at equidistant points along the reach, such that all the channel is affected in some way, but the dams are independent in their effect. The annual financial cost of a single dam at location 3 for instance is £ 401 in the case of a 50 % blockage and £ 481 for a 75 % blockage. If the whole channel was affected in some way by debris the annual financial costs would range between about £ 2576 and £ 3331 depending on the degree of blockage. Economic prices gives annual costs of £ 821 and £ 1060. The dams are also likely to result in an increase in flood incidence on land already subject to flooding, rather than significant increases in the aerial extent of flooding. Very high flows tend to move over, around, or sweep away debris material. Preliminary assessment suggests that flood costs will double from those identified in Table 5.3 above, equivalent to an additional £ 170/year. On this very rough assessment, a channel blocked with (75 %) debris dams would result in financial losses of about £ 3300 + £ 170 per year, about £ 41/ha, and economic losses of about £ 1060 + £ 170 per year (£14/ha).

These estimates indicate the order of benefits which could be attributable to a combined tree and bush and debris removal programme. The estimate excludes the benefits of avoiding damage to structures such as bridges and to the channel itself due to debris accumulating in or travelling down the channel.

5.3.1 Financial and economic impact of debris dams

Through simulation, the influence of debris dams on land drainage has been determined. Table 5.8 shows the change in financial net returns associated with the change in drainage status resulting from 50 % and 75 % blockage of the channel cross-sectional area.

Table 5.7 Net return with 50 % and 75 % blockage

Dam Site	50 %	75 %	Drainage Status		nt Net (£/ha)	Drainage Status With Dam		urn With (£/ha)	Total Char 50 % Bl		Total Cha 75 % Bl	
	BIO	ckage		F	Ε	With Date	F	E	F	E	F	E
1	2.80	5.85	G	578	124	В	457	86	339	106	708	222
2	0	0	No Cha	inge					1			
3	4.50	5.40	G	613	125	В	524	90	401	159	481	189
4	5.40	6.30	G	815	453	В	475	350	1836	556	2142	649
								Total	2576	821	3331	1060

NB: F = financial prices, E = economic prices

Areas of influence based on spring conditions

Dams are assumed to be beyond the influence of each other, but collectively influencing levels

throughout the reach

5.4 Maintenance Costs

Maintenance activities on the River Yarty involve the clearance and removal of overhanging trees and bushes, together with those which are at risk of falling into the channel. This work is carried out on a rolling programme with a return period of about 8 years. According to NRA records the cost for the 2 km reach was £ 1590 in 1995 prices. This is equivalent to an annual cost of £ 297 per year when spread over 8 years at 6 % rate of interest. In addition, the removal of debris dam material is carried out when deemed appropriate. Records of actual expenditure on debris removal are not available for the study reach, although average regional costs (based on the Severn Trent Region) are about £ 1500/km/year, equivalent to £ 3000/year for the 2 km reach.

5.5 Scheme Appraisal

The estimated annual benefits attributable to maintenance can be compared with estimated equivalent annual costs spread over the relevant maintenance interval to determine the justification for expenditure. Table 5.8 shows that the tree and bush work carried out on an 8 year cycle is viable in both financial and economic terms. Benefits exceed costs. Table 5.8 also shows that it is worth spending up to £ 3600 along the reach per year on all tree and bush related activities, including the removal of debris from the channel. This assumes that blockages would become a permanent feature of the channel if no works were carried out. The possible damage to structures is excluded from the assessment.

Table 5.8 Maintenance scheme appraisal: River Yarty							
Average Annual Benefit (£)	Average Annual Benefits (£)	Average Annual Costs (£)	Benefit: Cost Ratio				
Modelled Estimat	tes						
Tree and Bush W	ork Only						
Financial Prices	384	297	1.29				
Economic Prices	334	297	1.12				
Tree and Bush an	nd Debris Removal (75%	6 blockages)					
Financial Prices	3330	3000	1.10				
Economic Prices	1000	3000	0.33				
Farmer Estimates	s (Tree and Bush Work	Only)					
Financial Prices	1631	297	5.49				
Economic Prices	1252	297	4.22				

The farmer based estimate shows that, based on benefits in an average weather year, the maintenance scheme is viable. The scheme generates an annual benefit: cost ratio of 5.49 and 4.22 in financial and economic terms respectively.

This analysis requires cautious interpretation. There is little evidence to confidently explain the link between tree and bush work and the probability of debris dams forming in the channel. Furthermore the behaviour and impact of dams change according to flows. A major justification for dam removal is to avoid the risk of flood borne debris causing damage or serious blockage at sensitive points elsewhere in the drainage system. The maintenance scheme is marginal in financial and economic terms. This implies that it is not justified. The maintenance is actually performed on an 'ad hoc' basis, providing work if there is spare capacity amongst the labour gangs.

This conclusion must be interpreted cautiously as discussed in the R&D Note 456 Section 2.7.2.

6 ENVIRONMENT

6.1 Introduction

The environmental quality of the River Yarty is outlined in this chapter. Reference is made to river corridor surveys, public consultation and farmer assessment.

6.2 River Corridor Survey

Prior to the river maintenance works in 1992, a river corridor survey was completed (Appendix II) for the selected reach following the survey methodology developed by the Nature Conservancy Council (NCC, now English Nature, EN). Sketch maps and record cards have been produced for each 500 m section. The survey concentrated on the river corridor and adjacent land. Details concerning such features as channel dimensions, bed substrate, presence of structures, field drainage and bank vegetation were collected.

As river maintenance did not alter the channel characteristics, a complete post-maintenance corridor survey was not necessary. The post-maintenance survey took the form of a vegetational survey which concentrated on the banks and the areas on which tree and bush maintenance has been carried out (Appendix II). To date, two kilometres of the study reach have been subject to tree and bush maintenance.

6.3 Public Consultation

In the spring of each year a 'Conservation liaison Meeting' is held by the NRA to discuss the work programme for river maintenance in the following year. Representatives from various organisations such as the Countryside Commission (CC) and English Nature (EN) are invited to attend. Objections to the proposed work can be raised and if necessary modifications to the work programme made.

6.4 Farmer Assessment

Farmers interviewed within the benefit area were asked to identify any environmental features along the reach which they thought were likely to be disturbed or destroyed by the maintenance work.

All the farmers were aware of wildlife within the river corridor and mentioned kingfishers, herons as being particularly noticeable. The river is good for fishing - trout (brown and sea) and salmon frequent the river and spawn in shallow areas. The majority of those interviewed thought that the maintenance had a beneficial impact on the environment and encouraged tree regeneration.

6.5 Channel and Bank Quality

The environmental quality of the River Yarty has been determined by following the procedure outlined in the 'Guidelines for the Justification of River Maintenance' (R&D Note 511) produced within the framework of the NRA R&D Note 456 (River Maintenance Evaluation).

The quality of the river channel is classed as medium. There is a well developed pool and riffle sequence within the study reach and numerous minor habitats are created by tree roots and overhanging branches. The overall channel structure has developed and altered naturally over time and has been modified in only a few isolated areas by man.

The banks are of simple structure, consisting of predominantly three vegetation types including trees and bushes. Bank width is typically in the region of 5 - 10 m. The bank quality is classed as high. At times of low flow there is a well developed transitional zone between the river and channel edge and sediments are exposed. The structure of the bank vegetation is varied consisting of trees, bushes, scrub areas and grassland; some of which is grazed sheep and or cattle. Tree roots stabilise some banks and provide bank and underwater habitats. Earth cliffs provide ideal habitats for sand martins and kingfishers.

7 CONCLUSIONS

7.1 Scheme Appraisal

The existing maintenance scheme of tree and bush clearance every 8 to 10 years is viable in financial and economic terms. The average annual economic benefit of maintenance in terms of its prevention in a deterioration in drainage status and increase in flooding is £ 334. Average annual maintenance costs are £ 297. The benefit : cost ratio is therefore 1.12.

Debris removal is justifiable in financial terms but not in economic prices. The benefit : cost ratios are 1.10 and 0.33 respectively.

7.2 Maintenance Best Practice

The 'best practice' vegetation maintenance methods for the River Yarty were determined using the procedures outlined in the Guidelines (R&D Note 511), produced as a result of the Environmental Impact Assessment Study.

Channel

Best practice maintenance operations for emergent weed are identified as:

- Biennial cutting;
- Cutting on a 3 to 5 year rotation; and,
- Desilting / raking at an interval of 2 to 7 years.

Best practice maintenance operations for floating and submerged weed are identified as:

- Annual cutting in the autumn;
- Biennial cutting; and,
- Cutting on a 3 to 5 year rotation.

All these maintenance operations should be selective, concentrating on those areas which are particularly choked by vegetation or areas in which the weed is liable to cause an obstruction, hazard or restriction to flow.

Since the beginning of this study, tree and bush maintenance and construction of bank revetments are the only maintenance operations to have been performed on the River Yarty within the study reach. To date, the tree and bush work has been confined to the first two kilometres of the study reach. Little aquatic vegetation grows within the channel due to the mobile nature of the gravel substrate restricting root development and due to shading of the channel. Selective desilting of gravel shoals every seven years may be sufficient to enable the channel to provide the required standard of service. The maintenance regimes recommended as best practice in environmental terms for vegetation management are thus not applicable to this channel whilst the incidence of weed growth remains low.

Bank

Best practice maintenance operations for bank vegetation are identified as:

- Single bank mowing / flailing in spring / summer leaving a 1 m wide toe strip;
- Single bank mowing / flailing in autumn / winter leaving a toe strip > 0.25 m wide;
- Mowing / flailing every 3 5 years leaving a toe strip over 1 m wide or selective cutting (<
 20 %); and,
- Light grazing.

Since the start of the study, the only bank maintenance performed has been some revetment work to protect an eroding bank near a bridge. The majority of the banks are grazed lightly by sheep and or beef and are not mown.

This is in accordance with the bank maintenance regime recommended as best practice in environmental terms.

7.3 Recommendations

It is recommended that further research examines in detail:-

the impact of debris dams on flooding within the benefit area.

7.4 Epilogue

This report has assessed the impacts of the current maintenance regime on the study reach. It has been used along with other study sites to formulate guidelines on the appraisal of maintenance works and best environmental practice. These draft guidelines are summarised in Chapter 5 of the R&D Note 456 and presented in full under separate covers.

8. REFERENCES

Bowles, R. A and Morris, J. (1992). The Evaluation and Justification of Tree and Bush Maintenance. Report to the NRA, Severn Trent Region.

Findlay, D.C. Colborne, G.J.N. Cope, D.W. Harrod, T.R. Hogan, D.V and Staines, S.J (1984). Soils and their Use in South West England. SSEW, Harpenden.

MAFF (1993). Farm Incomes in the United Kingdom, 1991/92 Edition. MAFF, HMSO, London.

MAFF (1993). Project Appraisal Guidance Notes. HMSO, London.

Met Office (1990). Rainfall 1989. Met Office, Bracknell, Berkshire.

NERC (1975). Flood Studies Report. NERC, London.

Nix, J (1994). Farm Management Pocket Book, 25th ed. 1994/95., MAFF, HMSO, London.

NRA (1991). The Quality of Rivers, Canals and Estuaries in England and Wales. Report of the 1990 Survey, December 1991. NRA Water Quality Series No. 4, NRA, Bristol.

Map: Ordnance Survey Landranger 193. Taunton and Lyme Regis. 1: 50 000. Ordnance Survey, Southampton.

Map: Agricultural Land Classification, Sheet 177 (1974). MAFF.

APPENDIX I

Example of input and output data for the watertable model

River Yarty

Block Number 1001

Cross-section 5

29

43.51

	Input Data	Output Data
	River height (m AOD)	Watertable height (m AOD)
Week		
1993		
l	43.40	44.43
2	43.40	44.63
3	43.40	44.60
4	43.40	44.53
5	43.40	44.44
6	43.40	44.35
7	43.40	44.25
8	43.40	44.22
9	43.39	44.14
10	43.39	44.05
11	43.40	43.98
12	43.40	43.94
13	43.86	44.15
14	43.86	44.46
15	43.41	44.47
16	43.41	44.38
17	43.38	44.27
18	43.38	44.07
19	43.36	44.01
20	43.36	44.07
21	43.76	44.14
22	43.76	44.23
23	43.42	44.12
24	43.42	44.26
25	43.40	44.05
26	43.40	43.85
27	43.40	43.69
28	43.40	43.88

43.82

Example of drainage status classification, River Yarty

W W # # 1	•
With	maintenance
A 4 1071	THE PROPERTY OF

Block 1001	N	No. of weeks		No. of
	Watertable	1993	Spring 1993	weeks
	depth (m)			
>0.	5 44.13	38	44.13	13
0.3><0.5r	n 44,33	6	44.33	0
<0.3r	n 44.63	8	44.63	0

Drainage status classification, according to time watertable is within the G, B, VB drainage bands

Without maintenance

de	epth (m)			
>0.5	44.13	21	44.13	6
0.3><0.5m	44.33	9	44.33	4
<0.3m	44.63	22	44.63	3

No. of weeks

1993

No. of weeks

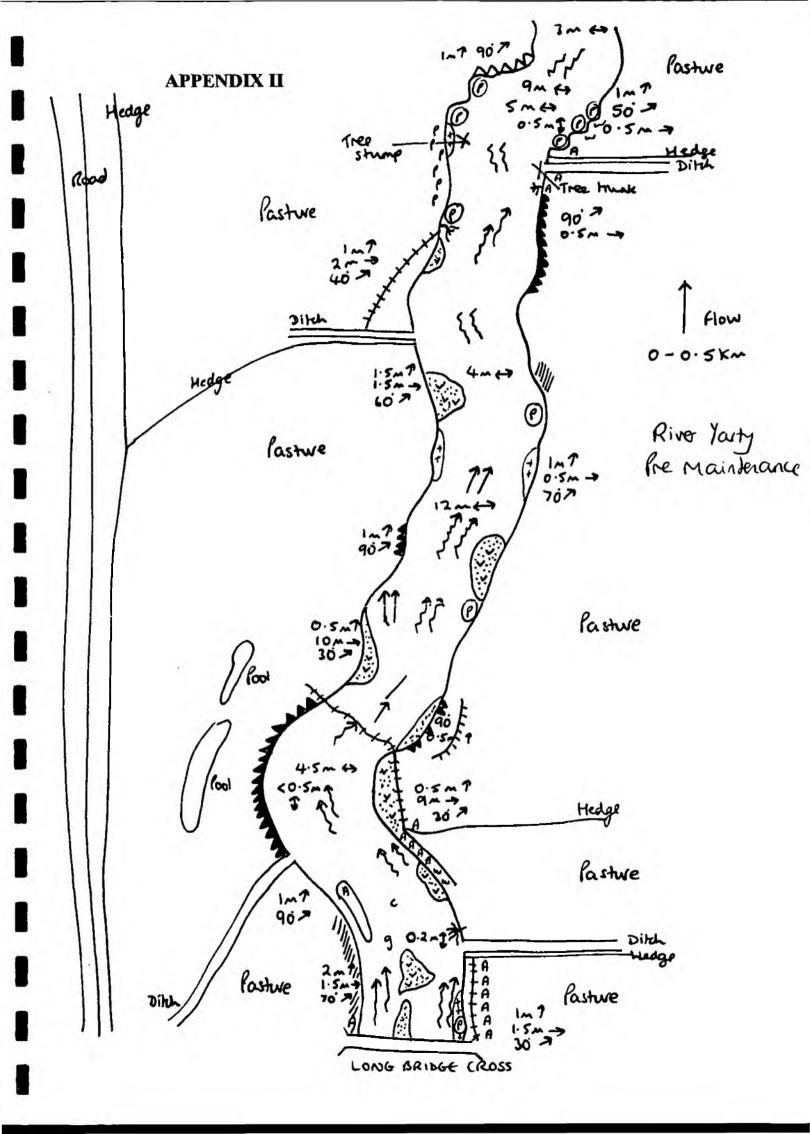
Bad

Spring 1993

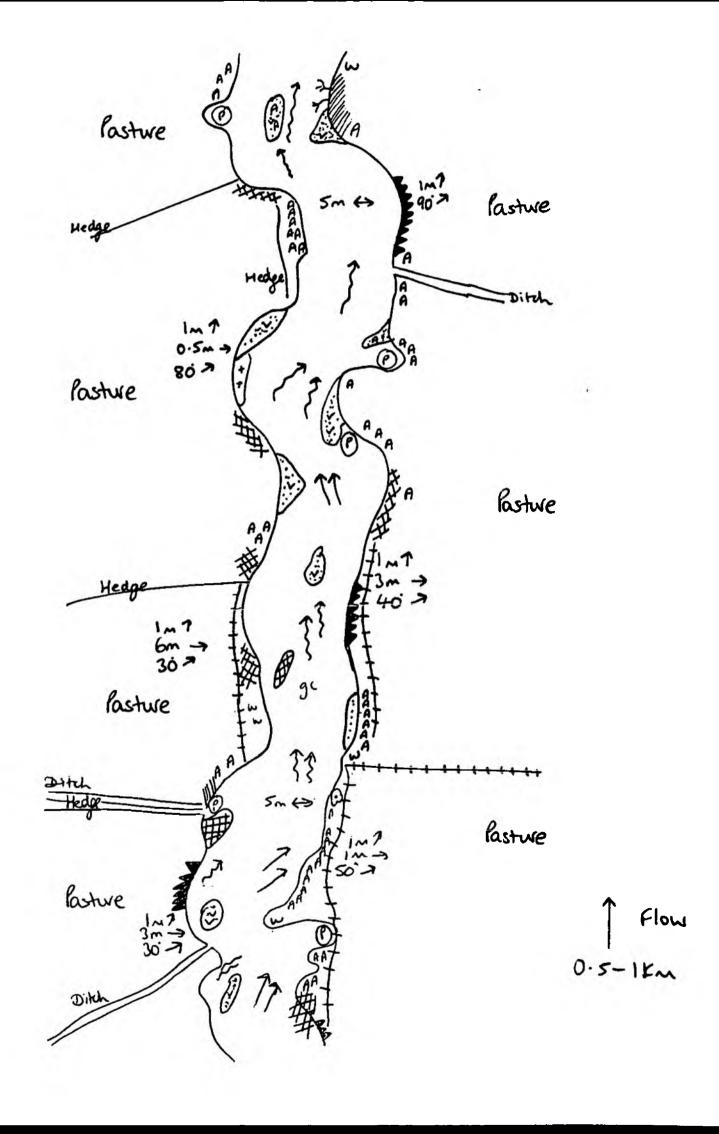
Drainage status classification, according to time watertable is within the G, B, VB drainage bands

Watertable

Summer 1993	No. of weeks	Autumn 1993	No. of weeks
44.13	13	44.13	7
44.33	0	44.33	3
44.63	0	44.63	3
	Good		Bad
Summer 1993	No. of weeks	Autumn 1993	No. of weeks
44.13	11	44.13	4
44.33	2	44.33	1
44.63	0	44.63	8
	Good		Very Bad

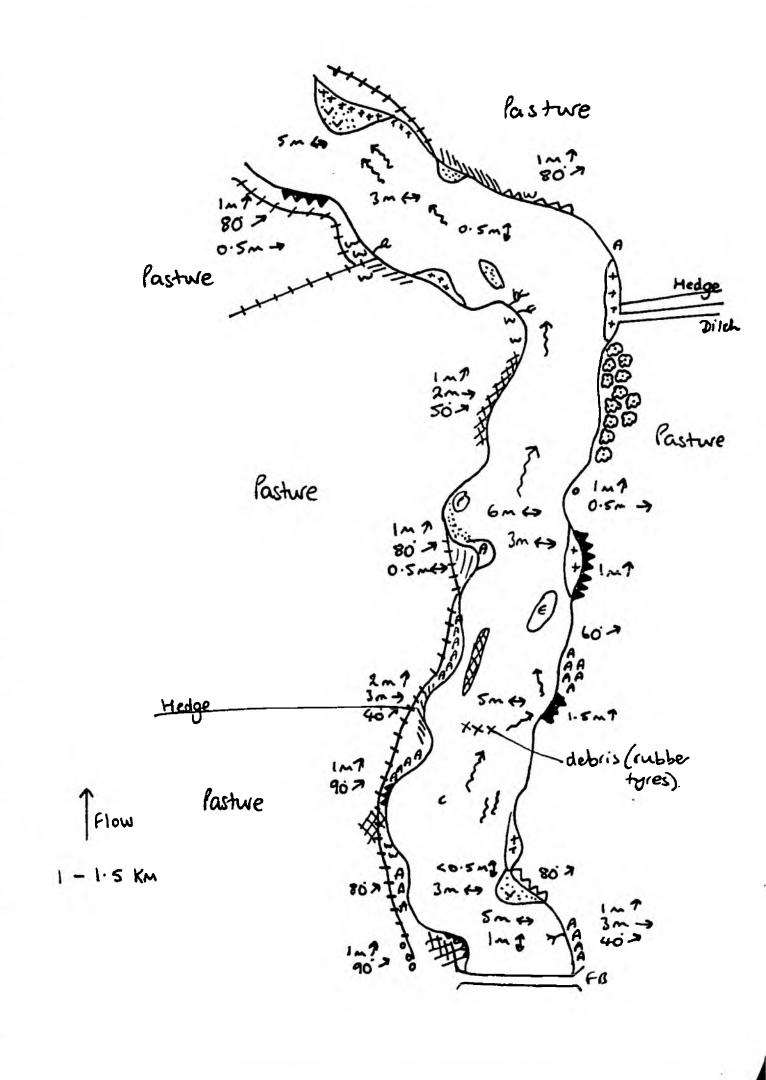


		LG	RE				2.5	LB	IRB		RV
л. 1. 2.	WOODLAND & SCRUB % Broad-leaved semi-nat. plantation Conferous semi-nat. plantation Mixed semi-natural plantation Scrub - dense				i u	RB	BANK PEATURES 7. The shell 7. AAA subdeath chil IAT } AAA soli earth chil IAT } AAA soli earth chil IAT } LUL rock chil ETH artificial The flood bank ach The flood bank set back levee	84	7	Dindger/500m Depth < 25m 25 < 5 0 5 < 1.0 >1.0m	15 85
3. 4 .	scattered Carr - alder willow Parkland Recently felled wood			G. OPEN WATER I. Slanding - canal + % of odicinal = land in eoch shretch dyke pond, pool, cul-off %	1 3	1	Height < Im 	90	55 88h	Width <1 1-<5 ←→ 5-<10 10-<20 >20	90
B. I.	GRASSLAND & MARSII % Acidic unimproved semi-improved Neutral unimproved semi-improved Calcateous unimproved semi-improved https://doi.org/10.1007/10.1	ω	100	lake % gravel pit % reservon % marma % 2. Rimning stream < 1m wide 1 5m 5 10m			25<5m , >5m Slop*: <30° 7 30 <60° 50 <90° >90° †7-† and 535 sand	\$\$ O	88 6	Substrates BR bed nock b boulders c cobbles p pebbles g gravel s 2md 4 silvinud	5
5. C. 1. 2. 3.	Maish/maishy grassland TALL HERB & FERN % Bracken Upland spp_rich veget. Other - tall ruderal non ruderal HERTHLAND %			> 10 I. ROCK I. chili scree innestone pavement cave other 2. arthroat/waste			bare sharele vegetated sharele carth animal cobbles bare stand boulders BANK VECETATION Comfer Coak, Ash, Sycamore Willow - recent pallard	100	100	Clay poal Clay poal Clabitats and Flow Prool Shock Striffe Proof tapids True T	1 20 52
1. 3. 4. 5.	Dwarf scrub - dry wet Licher/bryophyte Montane Heath/grassland - dry wet				ı	3	W Willow old, not pollard S Standard willows A Alder Other trees Young trees Thick Scrub/shrubs 7.	8	4 4 4 1	mm. waterfall AA profuding rocks Margins Slungle 1 bare Shingle, vegetated	10
E. 1.	MIRE, FLUSH AND SPRING % Mires - bog Feii - reed sedge sweet grass mixed Dog flushes SWAMP/INUNDATION Swamp - single sp. dom. Tall mixed assemblage			hedge = lence on bank fance set back wall building canavans fich farm silage clamp sewage works garden stack pile flood debus road railway disused	10		Sparse Scrub/shrubs 7. Here/Visedge 7. Demaropen 7. Sparse open 7. Researched or mown 7. Exposed free roots ISLANDS Rocky, vegetated rocky, 1 bare shingle and rock shingle, rock + veg earth - maturing earth - with trees	2	2	FLORA % cancergent veg < Im wide emergent 1-2m wide emergent > 2m wide total veget area b byophytes E emergents A submerged 100 P Boating algae 7. of stretch	3



		LGI	RB	3					4	LB	RB		RIVER
_		1		\top		-	- ;	илик	PEATURES /.			RIVER BABITATS	
Λ.	woodland & scrub %			l ni	WEIL RIVER YARTY "			l	shell %			∺ bridge:/500m	1 1
l.	Broad-leaved semi-nat.		1	""	Acti Kiocie IIIE I	1	1.5		solid earth chill [MT]	2	8	### wens/500m	1 1
••	plantation			Ke	mNo. 0-5-1 KM					-	0		1
0.1	Conferous semi-nat.	1 1		1	1 a E A 10 0 6				soft earth chill > 80 5			locks/500m inle/500m	100
	plantation	1 1	1	Da	··· 914)92		,		rock chill		1 †		-
	Mixed semi-natural	l	ĺ			- 9		_	artificial		1	Depth <.25m	100
	plantalion	1 1	1		HARAL JUID.	us	RB		Best Lank of	1		7 05.<1.0	1.~~
2.	Scrub - dense]]	1	-		<u></u>	1.0	1.17	flood bank set back			>1.0m	
۵.	scallered .]]	1	G.	. OPEN WATER		1	1	levue		l		
	Carr - alder	i I	1	1.	. Standing count և % վ թե		1 '	Height		اري.	احدا	Width <1	
	willow		Í	1.	munt - laste in	. '	1 '	1 个	1 <2in	الكر	100	l-<5	ICC
-			1		court chattle			1 1	>210	Ĭ	1	←→ 5·<10	
3.	Parkland Bases No. (a) Park was all	1)	1		dicii	2	1	141,-111,		50	\	10 < 20	
4.	Recently felled wood	1)	Í		dyke		'	Width		7		>20	
_	4 herney 0/	1 1	1		pond, pool, cut-off %		('	\rightarrow	1 < 2 5m	مما	Ø		
B.	Grassland & Marsii %	1 1	1		lake %	, ,	1 1	1	25. < Sm	# 0	20	Substrates	
l.	Acidic unimproved			1	gravel pil 🖔	, '	1 '		>5an	10	1	BR bed rock	
	semi-improved	i j	1	1	reservoir X	,	'	likojn:	•<30°	L	l_ i	b boulders	
	Neutral unimproved	1 1	i	١,	tooruia 7.	,	1 '	1	30 < 60"	88	70	C Cubbles	50
		100	ICC	2	-	, '	1 '	/	60 < 90"	ည	30	p pebbles	50
	Calcateous miniproved		1		Stream < litt wide		1 '		>70,	Ì	1	g · gravel	
	sem improved	1 1	1		1 5m	, '	1 🤳		annel		1 1	s Build	1 1
4.	lmproved/resedded	1 1	1		>10	,	-		sand	1	1 1	+ silVinud	1
5.	Maish/maishy grassland _	1 1	1		, in [į	'		bare should		\	69 clay	
		1	1	I.	поск	i	1 '	1.1	vegetated shingle	مضا	احدا	y peat	
C.	tall herb & Pern %	1 1	1			i	'		carth	ļω	$ \infty $	Habitats and Flow	
1.	lijacken	1	1	1.	chili	i	'		natural cobbles	Į	1 1		119
2.	Opland spp_nch veget.	4 1	1	1	scree	i	,	O	natural boulders	- 1	1 1	(P) pool	38
2. 3.	Other - tall rudgral	1 1	1		limestono pavement	i	'	BANK	VEGETATION			slack	১৪
.	non rudera)	1 1	1	1	cave	i	1		Condet			35 ulile	10
		1	1	١.	other	i	1 7	8	Oak, Ash, Sycamore 1	3	1.	171 rapids	10 50
D,	BEATBLAND %	1 1	1	2.	ārlificia/wasie	i	1 '	44	Willow recept pollard		'	M niii	حد
	•	1 1	1	1.		i	'	w	Willowold, not pollard	12	3	nnn, waterfall	
i.	Dwarf scrub - dry	1]	1	Į.	MISCELLANEOUS	1	'	s	Standard willows	1	ا دا	AA protriding rocks	1
_	wet	f = 1	i		arable		1 /	Å	Alder	15	12.		1
	Licher/bryophyto	1	i '		amenity grassland		1 1	60	Other frees	درا	31	Margins	
	Monlane	1 1	i '		ephemeral/short herb	, '	1 '	0	Young frees		1 1	shingle 1 bare	
	Health/grassland – dry	1 1	i '		•	3	1 /	11441	Thick Scrub/shrubs 'Z	2	8	shingle, vegetated	
6.	wel	1 1	, '		hedge =		1 '	101	Sparse Scrub/shrubs 7.		10	+14- unid	1 !
_		1	, ,	1		11	40		•	0		SSS sand	1
E.	MIRE, FLUSH AND SPRING %	1	, ,]	fence set back		*	- CHO	Reed/Sedge Z.	8	8		1
1.	Mires - bog	$t \perp 1$, ,		wall	. '		~	Dense open Y-	1	!	rlora %	1 :
	Fen-reed	(L	. '		baiking	. ,	I = I		Spanse open 7-		1 1		1 !
	sedge	1	, '	1	Cinhvines	. ,	(-1)	YY	Research or mown Z.	l	ا را	ennergent veg < Im wide	100
	sweet-grass	1 1	, '	ł	fish larin	. ,	()		Exposed tree roots	1	2	emergent 1-2m wide	
_	mixed	1 1	. '		sdage clamp	. ,	1	ISLAND	os e e e e e e e e e e e e e e e e e e e			emergent >2m wide	1_
2.	Bog flushes	1 - 1	, '	1	sewage works	. '	1 1		Rocky, vegetated	1	1 1	lotal veget area	12
_		1 - 1	<i>i</i> '	ļ	garden		1 1	1/20.	tocky, t bue			B bryophytes	17
۲,	SWAMP/INUNDATION %	1 1	i '		stick pile	i	1	7,76	slumple and rock	1		E emergents 100	17.
l.	Swamp - single sp. dom.	1 1	ı '		flood debus	i ,	1 '		slingle, rock + veg	3	l l	A submerged	
•	Tall mixed assemblage	1 1	ί ΄	1	road	i	1 '		earth - maturing	-	1 1	P floating	- Un 100
	I di i i di	1	4		radway disused	, ,	1 '		earth - with trees		1 1	- Taking 1. of stretch	1
		1 1	1	1	used		1 ,		developed		1 1		1

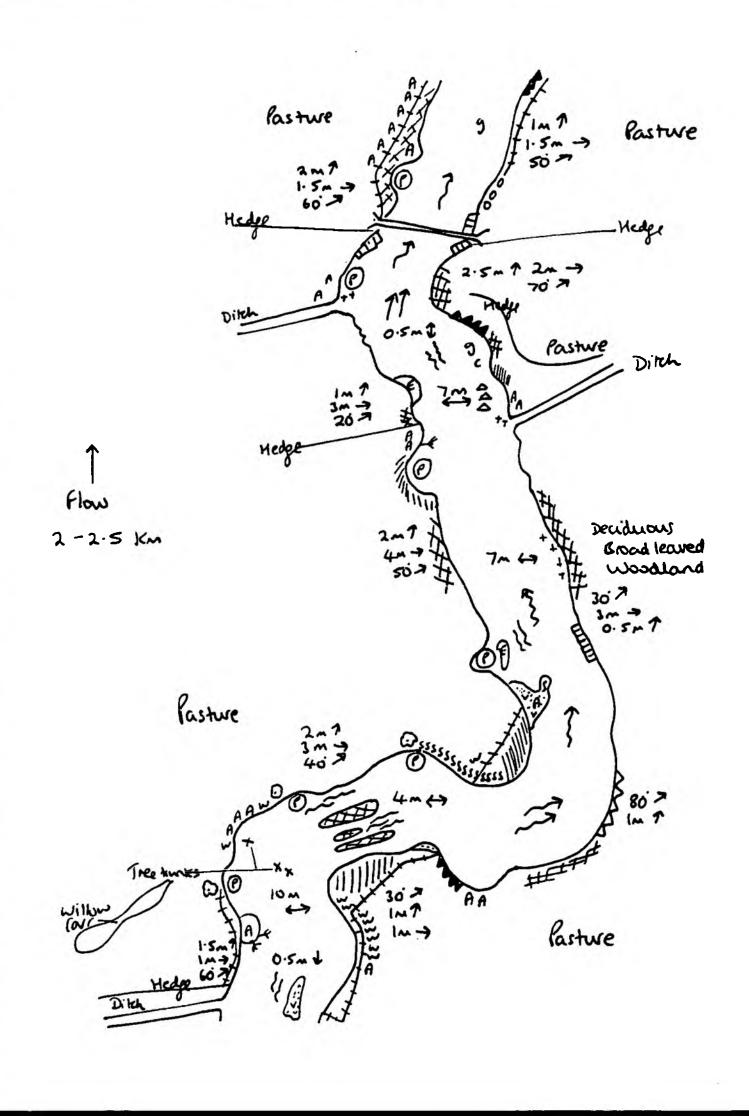
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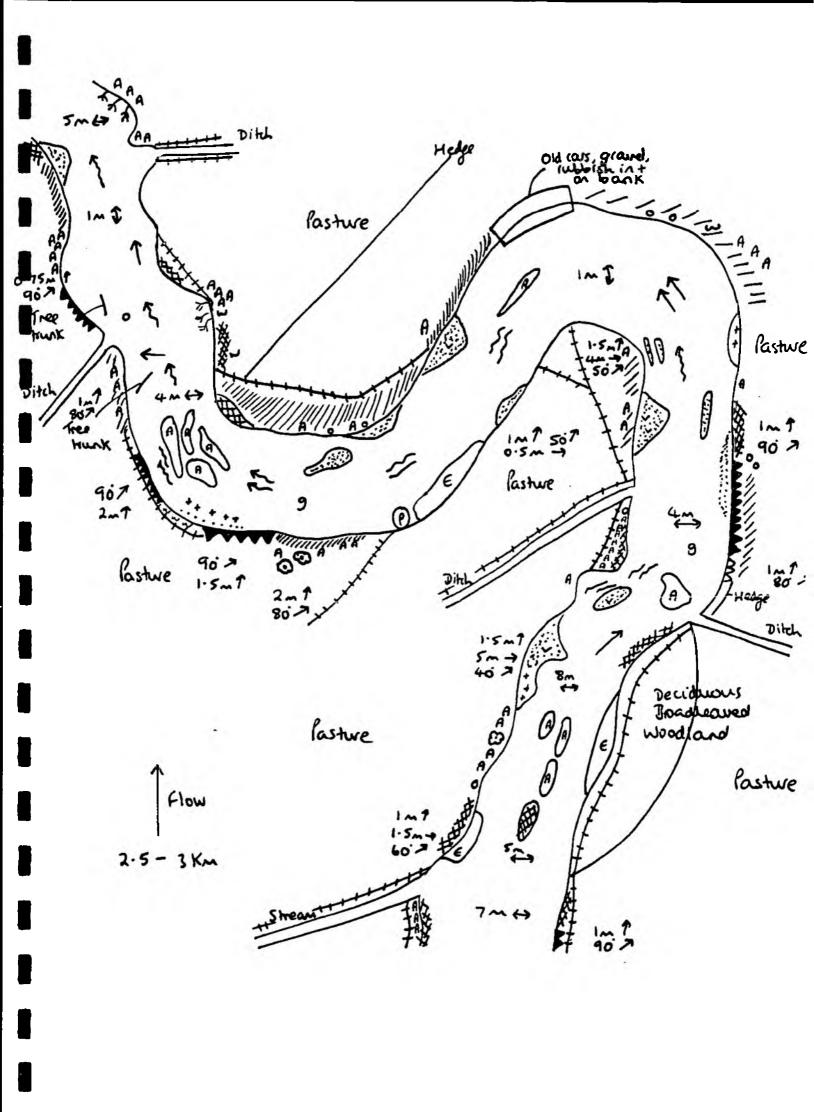
		LG.	RB					LB	RB		181
n.	MOODFUND & 2CHAR %	1		MIVER RIVER YARTY-"	1	÷	BANK FEATURES 7.			MIVER BABITATS indge:/500m	1
l.	Broad-leaved semi-nat.			Rm No. 1-1.5 Km	i	•	shell 7. AAA sold earth chill [AT] ACC soll earth chill 7 80	6	8	///// wens/500m	
	Conferous semi-nal. plantation			Date 9/4/92			UM rock chill		1	Depth <.25m	-
	Mixed semi-natural plantation			Surveyor JALD.	ſΩ	RB	FD 6 11 1)			1 .25 < .5 0 5 < 1.0	6
2.	Scrub - dense scattered			G. OPEN WATER			levee Height <im< td=""><td></td><td></td><td>>1.0m Width <1</td><td>4</td></im<>			>1.0m Width <1	4
	Carr - alder willow			1. Standing comal 1 % of adj canal = land in coch stretch			1 < 2m >2m	m	100		10
3. (.	Parkland Recently felled wood			dyke		1	Width < Inc	80	70	10·<20 >20	
3.	GRASSLAND & MARSII %			pand, pool, cut-off % lake=%			-> 1.<2 fm 25.<5m	20	30	Substrates	
l .	Acidic unimproved semi-improved			gravel pil 7. reservor 7.		- 1	, >Sur Slope -<:\ur			BR bedrock b bonders	
	Noutral unimproved semi-improved	00	ιω	marma 7, 2. Roming stream < Income:			90 < 90" > 90"	80	80	c cobbles p pebbles	5
١.	Calcareous miniproved semi-improved Improved/reseeded			1 5m 5 10m			tep-3- mul			g gravel s and	
5.	Maisi/maishy grassland			>10			535 smd (274 bare slungle (37) vegetated slungle			# sit/mid ## clay ## peat	
	TALL HERB & PERN %			1. ROCK 1. chii			carth V natural cobbles	KO		1	
]. Z. 3.	Bracken Upland spp. rich veget. Other - tall ruderal			scree linestono pavement			Datural boulders BANK VEGETATION			P pool stack 45 utile	10-
	non ruderal			cave other 2. arhherat/waste			Couler Oak, Ash, Sycamore		12	35 ullie ↑↑ rapids ↑↑ run	6
).	BEATULAND % Dwarf scrub - dry	} }		J. MISCELLANEOUS			P Willow recent pollard W Willowold, not pollard	7	1	nnn. waterfall	6
١,	wet Lichei/Eryophyto			arable anguty grazdand			5 Standard willows A Alder CO Other trees	13	ij.	Margins	
	Montane Healt/grassland - dry			ephemeraVshort herb hedge∃t	,	1	Young frees Will Thick Scrub/shrubs 7.	3	1	slungle 1 bare slungle, vegetated	1
	MIRE, FLUSH AND SPRING %				65	6	Sparse Scrub/shrubs 7. Recd/Sedge 7.	8		144- mud SSS sand	67
	Mires - bog			fence set back wall building			Dense open 7- Sparse open 7-	12		FLORA %	
	sedge sweet-grass			earnyans fish farm			XXY Reserded or mown Z.	3	1	emergent veg < fm wide emergent 1-2m wide	10
	mixed Bog flushes		A	silage clamp sewage works			ISLANDS Rocky, vegetated			emergent > 2m wide total veget area	1
	монтапинимими			garden stick pile fleet delver			Jiko tocky, t Isne shingle and tock			B bryophytes E emergents 90 A submerged 10	3
i.	Swamp – single sp. dom. Tall mixed assemblage			flood debris road railway - disused			shingle, rock + veg carth - mahuring carth - with trees			A submerged 10 P floating stretch	-)
	A]	used			developed				

2mt 507 Pastive 15 Ditch Hedge 807 1 m T 0.5 m Pasture Thee Hedge Pastwe 1mt 1.5m=1 607 '5 Flow IM T SO A 1.5-2 Km 307 Pasture 907 Pastwe

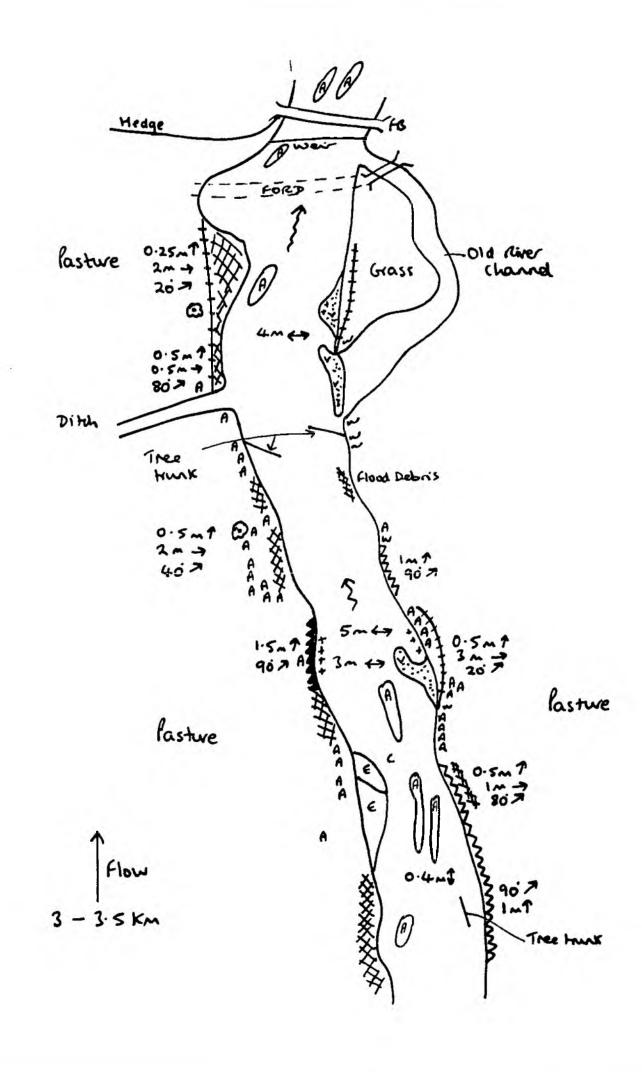
	S , RB	FR	RB		181
A. WOODLAND & SCRUB % 1. Broad-leaved semi-nat. plantation Conference semi-nat. plantation Mixed semi-natural	INVER RIVER YARTY Km No. 1.5 - 2 km Date 9/4/97 LIVER RIVER YARTY LIVER RIVER YARTY LIVER RIVER YARTY AMA solid earth chil In T. AMA solid earth chil In T. LIVER RIVER YARTY LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVER YARTY LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVER RIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. LIVERS Y. -1.— shell Y. AMA solid earth chil In T. AMA solid earth chil In T.	5	8	RIVER UNBITATS bidges/500m wens/500m locks/500m inlev/500m Depth < 25m 25<.5	- 93
plantation 2. Scrub - dense scallered	G. OPEN WATER			Y 05<1.0 >1.0m Width <1	10
Carr - alder willow J. Parkland Recently felled wood D. GRASSLAND & MARSH %	1. Standing - canal + 76 at any 1 < 2m > 2m > 2m > 2m		0 P B	1.<5 5.<10 10.<20 >20 Substrates	10
Acidic unimproved sem-improved Neutral unimproved semi-improved Calcareous unimproved semi-improved semi-improved semi-improved 4. Improved/resueded	Gravel pit 7,		70 30	fill bed neck b badders c cubbles p pelables g quavel s 2and	S
5. Marsivmarshy grassland C. TALL HERB & FERN % 1. Bracken 2. Upland spp. rich veget. 3. Other - tall juderal	Date shingle Date	ià	0	P pool slick	175
D. HEATHLAND %	Cave other 2. artificial/waste 1. MIGORIA MARCONIA Willow recept pollard Willow old, not pollard	6	2	介介 rapids する run rung, waterfall	12
1. Dwarf scrib - dry wet 2. Lichen/bryophyte 4. Montane 5. Heath/grassland - dry 6. Page 1991	1. MISCELLANEOUS arathe aniently quasified ephemeral/short herb hedge 4 3 Standard willows A Alder Collect nees Young trees Thick Scrub/shutbs 7.	9 21 N G	30	shingle 1 bare	3
6. wel E. MIRE, FLUSH AND SPRING % 1. Mires - bog Fen - reed	lerige = fence on bank lence set back wall building lence y Spanse Serub/shanbs 7, Recal/Sedge 7, Dense open 7, Spanse open 7, VVX Researched to make 2	15	4	SSS SAND	1
sedge sweet-grass mixed 2. Bog flushes	caravae: fish farm shage claim sewage works garden stick onle		9	emergent teg < lin wide emergent 1-2m wide emergent >2m wide total veget area lt bryophytes	0
F. SWAMP/INUNDATION % L. Swamp - single sp. dom. Tall mixed assemblage	slick pile flood debris road railway disused slick pile slingle and rock slingle, rock + veg earth - traituring earth - with frees			E energents A submerged P floating algae 7. of stretch	-);



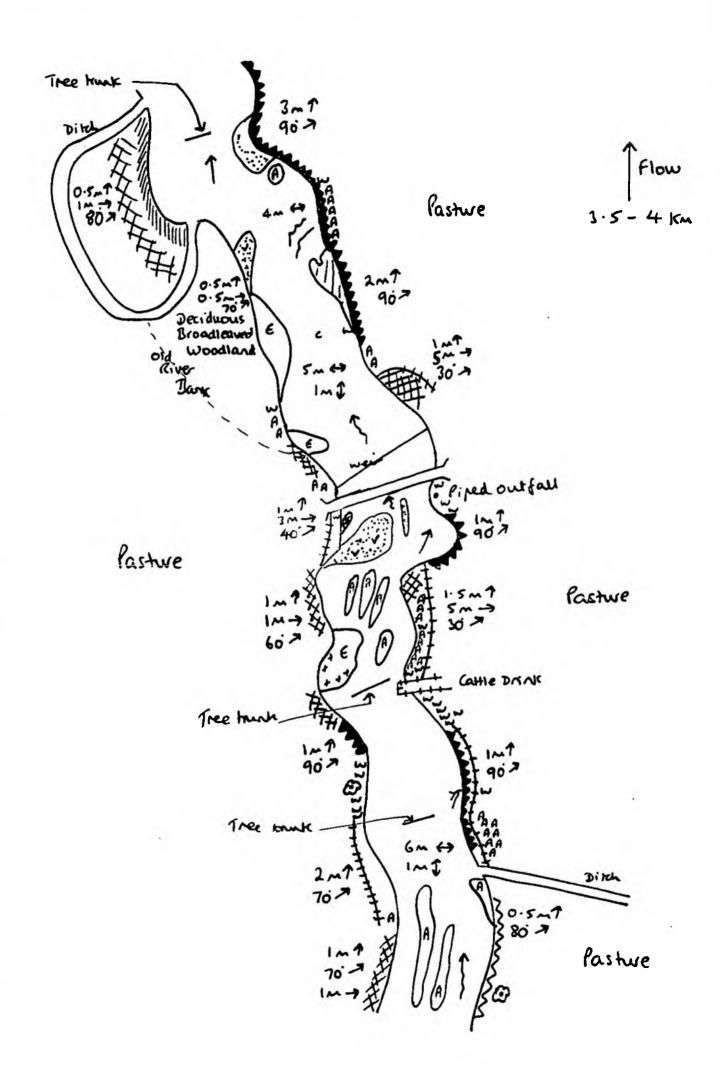
		6	RB		,		LB	KB		R
п	WOODLAND & SCRUD %		٠.	4044	1	BANK PEATURES 7.			RIVER HABITATS	1
١.	MOODPIED & SCEEDE NO	-	ŀ	RIVER RIVER YARTY -		-1_ shell %	1	1 _ 1	⊨ bridger/500m	1
1.	Broad-leaved semi-nal.	'	35		** .	sold eath chill [MT]	1	8	1111 wens/500m	
	planiation		37	Km Ho. 2 - 2-5 KM		soll gath chil > 80		4	locks/500m	
	Comferous semi-nat.								S inlet/500m	1
	plantation			Date 10/4/92	i			1		-
	Mixed semi-natural	Į.		Surveyor JALD		EEE actificial	1		Depth < 25m 7 1	
	plantation	1		TO T	QR	TB flood bank ach		1	7 05<1.0	IC
	•				***	TB flood bank set back		1		177
3.	Scrub - dense	Ì	1	G. OPEN WATER		levaa		L 1	>1.0m	
	scattered	!				Height < Im		OE	Width <1	
	Carr - alder	l	1	1. Standing canal + % 0 04)	1	个 1×2m	lιœ	60	1.<5	10
	willow	10	1	canal = land in				10		10
3.	Parkland	1		canal = land in the coch stretch	1	1 >2m	1	· · ·	⟨→⟩ 5.<10 10.<20	9
	Recently felled wood			dyke		Width < Im	1.	1 1	_	1
			,	pond, pool, cut-off %		1.<2.5m	40	OP	>20	
1	GRASSLAND & MARSH %	1		lake %	- 1	~> 25. <sm< td=""><td>60</td><td>10</td><td></td><td>- [</td></sm<>	60	10		- [
	•	1		gravel pil %		>5m			Substrates	
	Acidic unimproved			reservon %		17	20	j i	DR bed rock	-
	sem-improved			nama 7.		Sloper *130" A 30 < 60"	388	75	b boulders	
	Neutral unimproved	-	امدا	2. Rammo		00 <90°	-	125	e cobbles	
	semi-mptoved	40	ÜS	stream < Im wide	- }	>00,	1	1.0	p pebbles	5
	Calcareous unimproved			1 Sin			1		g gravel	1
	senn-improved			5 10m	- 60	the much			s Sand	
	Improved/reseéded	ì		>10		335 wint	1	1	4 silVinud	- 1
3.	Maist/maisty grassland ,	1	1	'10	,	bare shunde			② clay	
	n/	1		I. ROCK	Ì	(-V) - vegetated shingle			~ peat	1
3.	tall herb & tern 炎 👚			a. atock		carth	IIC		Habitats and Flow	
	Bracken			1. chtf	ł	${oldsymbol{\mathcal{Q}}}$ - natural cubbles			l .	-
	Upland spp-rich veget.	1		SCIECE	1	😉 natural boolders	1		(P) (Not	2
2. 3.	Other - tall ruderal	1	1	finestone pavement	1	BANK VEGETATION			slack	537
	tion inderal			Cave	Ì			1.7	35 nille	1.3
	NOW LONGING			ollien		Conden Oak, Ash, Sycamore	2		Tr rapids	7
) .	пелтигли %			2. arblicial/waste		P William recept pullard	3	-	33 100	3
•		1		1		W Willow old, not pollard	7	8	ηηη, waterfall	P
	Dwarf scriib - dry	1		J. MISCELLANEOUS			3		AA protruding rocks	1
	wel			arable	1	S Standard willows	19			
	lacher/bryophyte	ŀ	.	anging grassland		A Alder	16	5	Margins	
	Montane	1		ephemeral/short herb	J	(2) Other trees		150	shingle 1 bare	
i.	Healt/grassland - dry	1			2	Young kees		.3		
	wel			hedge i 3	^	Mills Thick Sembishnibs V.	10	6		
-				hedge =	20	// Sparse Scrub/shrubs 1/.	1	1		1
. 1	Mire, flush and spring %	ĺ			2	Recalledge V.	10	125	SSS sand	
	Mires - bog	1		fence set back	- 1	Denne open Y-	1.0	~	nr on # 0/	1
	. ·			wall		Sparse open 7-	1		rlorn %	
	Fatt - reed	1		Landelmer	ŀ	WY Reserved of mown 7.	1	1		
	sedge	1	i i	Chilivians		Exposed tree roots	3	1	emangent vert som wich:	10
	sweet-grass	}		Justo läimm		ISLANDS	٦		emergent 1-2m wate	
	nixed Dog Bushes			silage clamp			1		emergent >2m wide	1
•	Bog flushes			sewinge works		Rocky, vegetated			b	1
	CIU H RADITAULISITA MATERIAL DI	1		garden		o rocky, I bore	1		B bryophytes	13
	MAMPINUNDATION %	1	1	stick pile		A Shiring the rock		1	E enlergents 90	11
	Swamp – single sp. dom.	1	\ '	Rood detris		shingle, rock 1 veg			A submerged (O	1)
	Tall mixed assemblage	1		road	Ì	earth - maturing	ì		P floating	-Vi
	-	1	i	radway disused		earth - with trees	1	l	alyae % of stretch	
				used		-* developed				



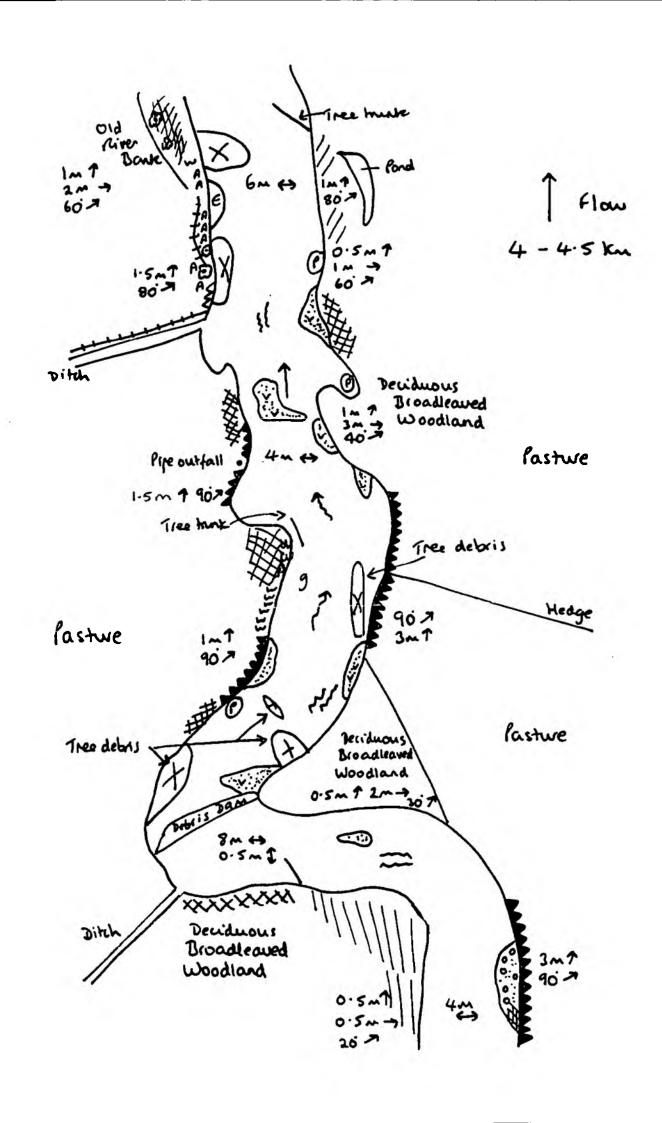
	16	RB					LB	KB		RIV
				1	¥	BANK PEATURES 7.			RIVER UADITATS	1
Droad-leaved senii-nat.		10			1.	Shell 7.	10	6	HH wens/500m	
plantation Conferous semi-nal						soli earthclift > 80 (locks/500m	
plantation						CCCC actificial		1 1	Depth <.25m	-
plantation	1		Surveyor JACD.	LB	RB	FB		{	V 05<1.0	10
scallered	1		G. OPEN WATER		i	levee	40			
Carr - alder						↑ 1 <2m			1.<5	9
Parkland	1	1	. ditch	th 3	1					'
Recently felled wood		e,	dyke pond, pool, cabull Z			. 1.<25m	10		>20	
GRASSLAND & MARSH %			lake %			* 85.<5m	20		Substrates	
Acidic unimproved semi-improved			reservon %			Slope -:30°			IIR bed tock In boulders	
Nuutral unimproved	100	an	10artua 7. 2. Romany			90 < 50.,	40	100	c cobbles	3
Calcareous unimproved	ļ.~	70	stream < Im wide			>90,	1	1	à duas b bennez	
			5 10ա	ľ	7		1 -		5 Sand	
Maislymaishy grassland			>10			15975 bare shingle				}
Tall herd & perm of			I. ROCK		ļ	cath	ia			
Biacken										١,
		ł	limestone pavenient			, -			slack	7
non rudetal		ł	Cave other			E Conde	1		1 //	7542
HEATHLAND %			2. artificial/waste			P Willow recept pollard			\$\$ run	2
Dwarf scrub - dry			J. MISCELLANEOUS	4		W Willow old, not pollard S Standard willows	3		AA protrading rocks	
Licher/bryophyto	ļ	1				A Alder	29	15	Margins	
	ĺ		ephemera/short berb	1		Oner rees	3	6	shagle 1 bare	Z
wel]	••		2	Thick Scrub/shrubs 7.	10	25		10
MIRE, FLUSH AND SPRING %			fence on bank	30	30		15	10	≤≤≤ Sand	
Mites - bog		J i	nince set back wall			Dense open Y-	-		FLORA %	1
Fen - reed			buldner	- {					1 7 p p	
sweel-grass			ligh facus			Diposed free roots حرج		6	emergent 1-2m wide	10
Bog flushes									emergent >2m wide total veget area	3
			garden			p rocky, I bine			li bryophyles	3
70			stick pilis flood debus			shingle and rock]		V suprierdence 20	(
Tall mixed assemblage			toad			earth - maturing			12 - floating / of stretch	- Ji
	1	1	railway disused	!	1	earth - with trees	- 1		aritic 1. of allegan	
	WOODLAND & SCRUB % Blood-leaved semi-nat. plantation Conferous semi-nat. plantation Mixed semi-natural plantation Mixed semi-natural plantation Scrub - dense scattered Carr - alder willow Parkland Recently felled wood GRASSLAND & MARSH % Acidic uninproved semi-improved Semi-improved Calcareous inimproved Improved/resolded Marsh/marshy grassland TALL HERR & FERN % Bracken Upland spp rich veget Other - tall ruderal non ruderal HEATHLAND % Dwarf scrub - dry wet Incher/bryophyto Montone Heath/grassland - dry wet MIRE, FLUSH AND SPRING % Mires - bog Fen - reed sedge sweet-grass mixed Bog flushes SWAMP/INUNDATION % Swamp - single sp. doin.	WOODLAND & SCRUB % Ilroad-leaved semi-nat. plantation Conferous semi-nat. plantation Mixed semi-natural plantation Mixed semi-natural plantation Scrub - dense scattered Carr - alder willow Parkland Recently felled wood GRASSLAND & MARSH % Acidic unimproved semi-improved semi-improved semi-improved Improved/reseded Improved/	Broad-leaved semi-nat. plantation	Invest Action Invest Action Invest Action Invest I	Montone Mont	MOODLAND & SCRUB % Investigation Investi	MOODLAND & SCRUB %	MOODLAND & SCRUB % Broad-leaved semi-mat. Individual management semi-management semi-m	MOODLAND & SCRUB % Dood leaved some nate plantation Dood leaved some nate planta	## WOODLAND & SCRUD 6/6 Blood-bewed some test plantation Conference seem final, plantation Confe



		6	RB						LB	RB		RIVE
Λ.	WOODLAND & SCRUB %						BANKER	extunes 7.			NIVER HABITATS	
	• •			RIVER YARTY "			-1 ; _{il:}	iell %			≓ bridge://500m	2
1.	Broad-leaved semi-nat.				1	**	AAA SHI	did carticul (MT)	5		APPH wens/500m	1
	plantation	1		11m No. 3 - 3-5 Km			600 St	It earth cliff 780 \		20	locks/500in	
	Conferous semi-nal. plantation	i I	ĺĺ	Date 10/4/92				ck cliff		1	S intev500m	 ∤
	Mixed semi-natural		1					tificial			Depth < 25in 7.	ia
	planlation	1		Surveyor JALD	ıß	RB	PB no	nal bank adj	- i	\	05<1.0	1.~
2.	Scrub - dense	Į.	ļ ŀ		<u> </u>	+		od bink set bick vec			>1.0m	
	scattered]	G. OPEN WATER		1				2		
	Carr - alder]	1. Standing canal + % 0 00	,		Height <		55	20	***************************************	100
	willow	Į		coupl = lass in)		1		<2m	4-5	30	1.<5 ←→ 5.<10	lα
	Parkland	1		ditch cock shetch	1	1	1 2	211)		1	←→ 5·<10 10·<20	ì
4.	Recently felled wood			dyke		5.	Width <		80	60	>20	1
2	AI		•	pond, pool, cut-off %		2		<2.5m	26	800	>20	- {
B.	Grassland & Marsh %			lake %				5-<5m	~		Substrates	i
1.	Acidic unimproved	1		gravet pit % reservor %			7.1	Sm		20	Bit bed rock	
	semi-improved		ll	marus 7				iur F≼tor	20		b builders	1.5
	Noutral unimproved semi-unproved	ico	اصا	2. Itaniung			. //) -: 90°	95	80	c cobbles	85
	Calcareous mimproved	اس	$ \omega $	stream < Im wide		1	>	90*	180	a	p pebbles g < gravel	50
	sem-improved			1 Sun			*f2j-f* 111	int		1 1	g gravel s and	بيوا
	Improved/resudded			5 10m >10			535 SH	and .	- 1	1	silvinud	
5.	Maistymaistry grassland	1		210		1		no shoule		1	Ø ckay	
_	THIS UPDO A PUDN O	i		I. ROCK		1		getated shingle	lion	100	~ peat	
C.	Tall hern & fern %	1		1. շին		1		nth		μω	Habitats and Flow	
I.	lliacken		1	5G16G			I 4~	dural cobldes dural boulders		1	(P) Hoot	
2.	Upland app. rich veget.	1	1 1	limestone pavement			1	EGETATION	1-6		shuck	80
J.	Other - tall ruderal			Cuvo					1	14	35 ulle	i
	ion ruderar	1		ollier				önder ak, Ash, Sycamore	2		↑↑ Tapids	\
D.	HEATHLAND %	1	1 1	2. arbheia//waste				fillow recent pullard	_		M 1900 Mm. Waterfall	20
,	Dwarfscrub - dry	ł		J. MISCELLANEOUS				fillowold, not pollard	ŀ	6	AA probuding tooks	
I.	wel			•		1		andard willows	4.5		promoting tocks	
3.	Lichen/Eryophyle	1	Ī	arable s ameinty quassland			A A1	lder	20	15	Margins	
	Montane	1 }		ephemeraVshort herb		1	V -	ther trees			::::: simule 1 bare	- 1
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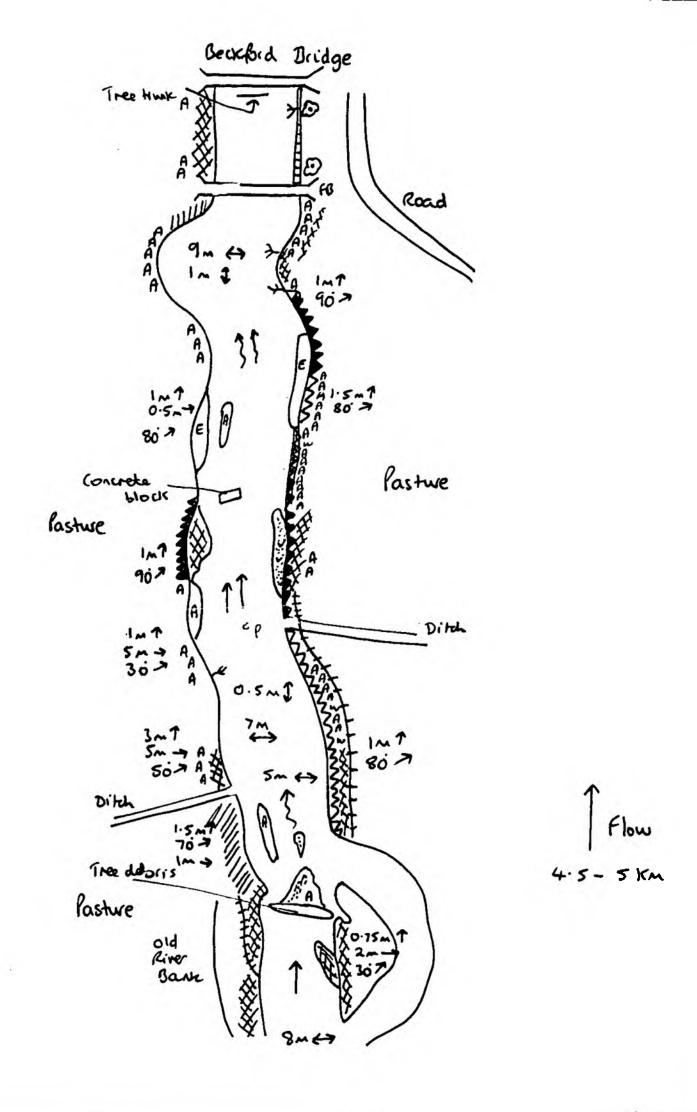


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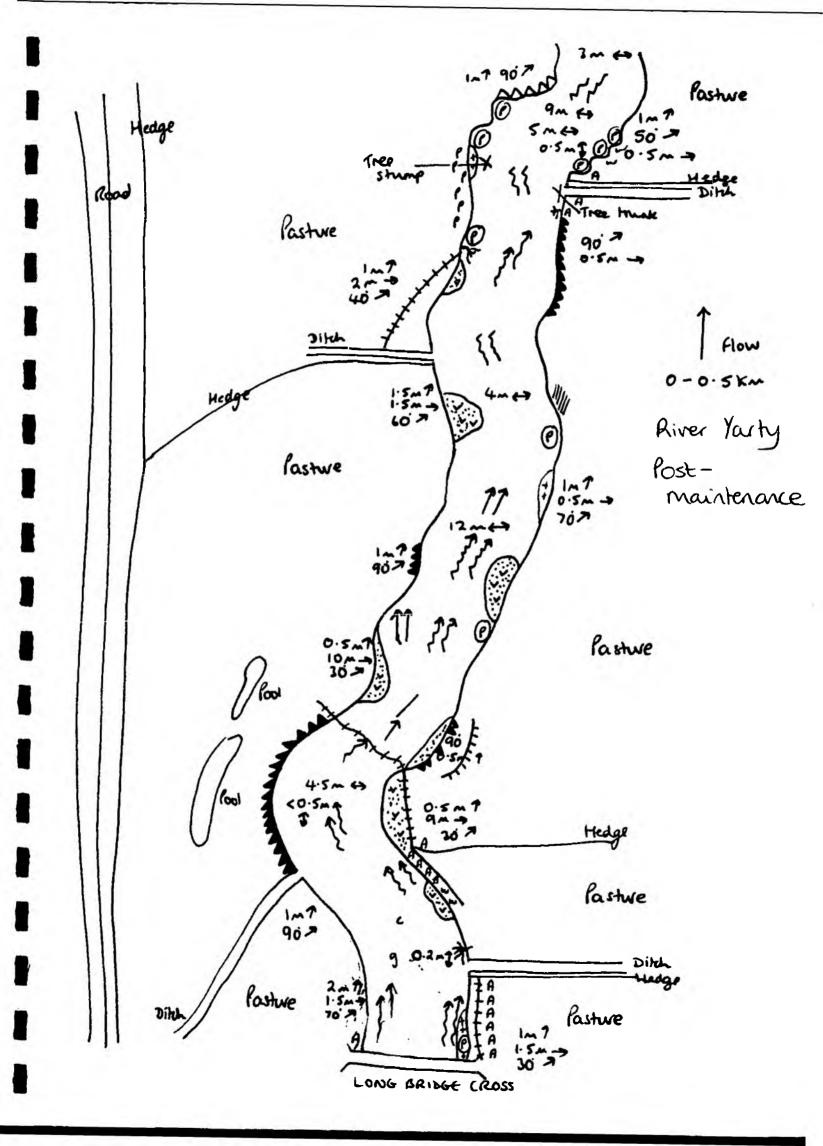


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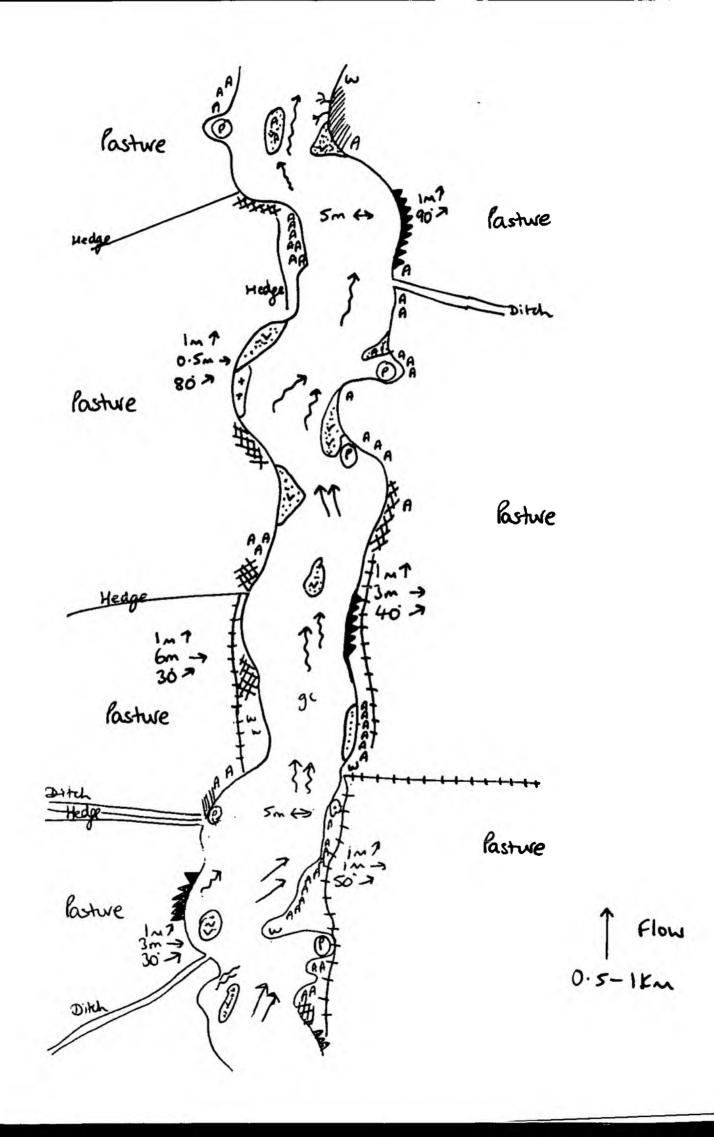
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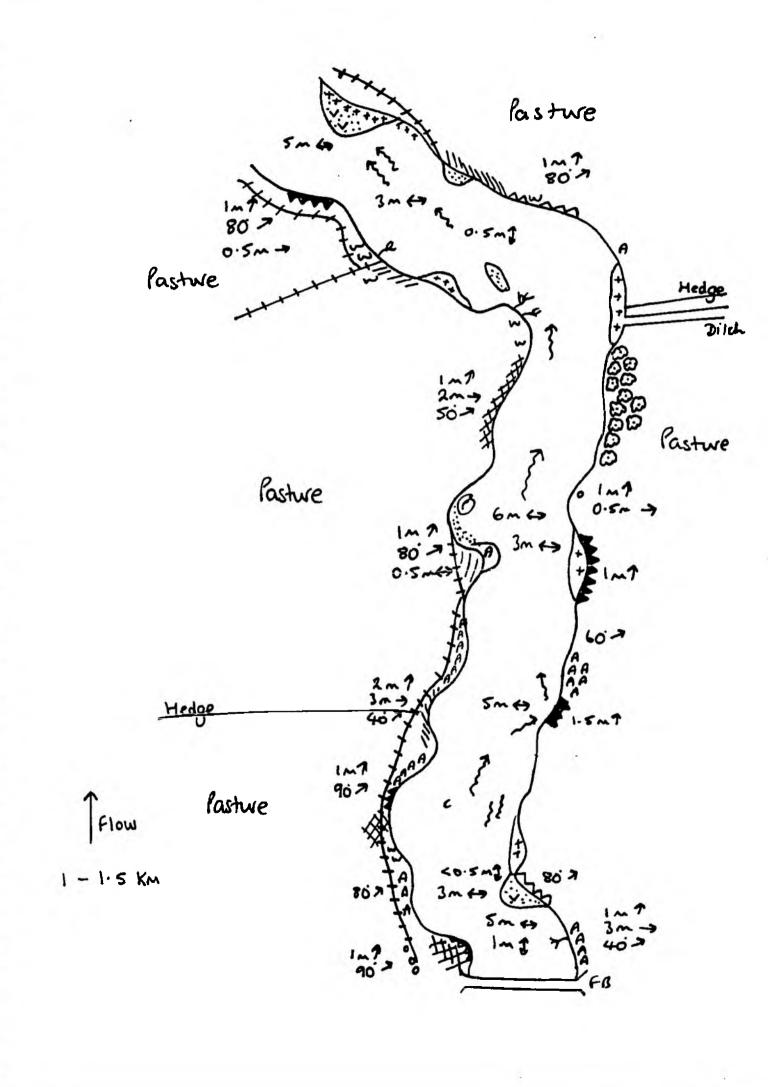
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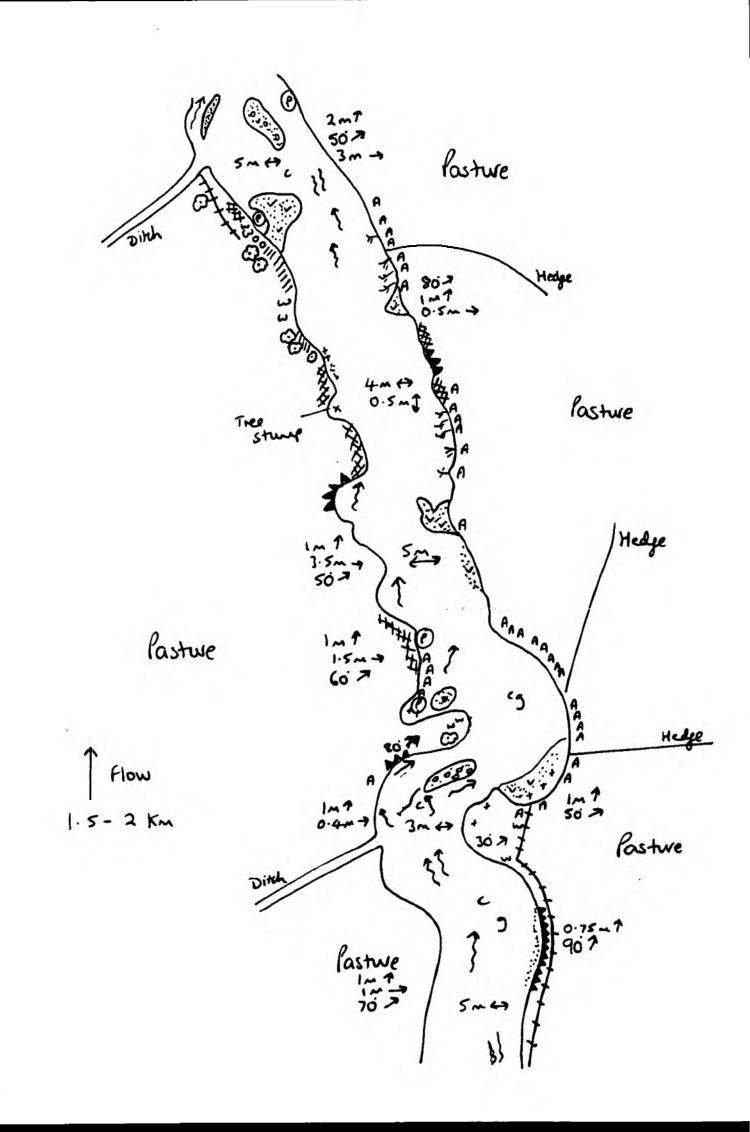
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SIR ARTHUR'S PILL

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SOUTH WEST SIR ARTHUR'S PILL

1. BACKGROUND

1.1 Introduction

Sir Arthur's Pill rises at Saunton, north west of Braunton village in North Devon. From source to mouth it is 6 km in length, draining a catchment of 11 square kilometres. The area is bounded to the north by the highland area of Saunton Down. The Taw-Torridge Estuary and the River Caen form the southern and eastern boundaries. The western boundary is formed by the sand dunes of Braunton Burrows which stretch for 5.75 km from the estuary to Saunton. The catchment area of Sir Arthur's Pill is small; approximately 15 km².

Sir Arthur's Pill flows through two distinctly different areas: an area of high grade arable land and an extensive area of permanent pasture (Braunton Marsh).

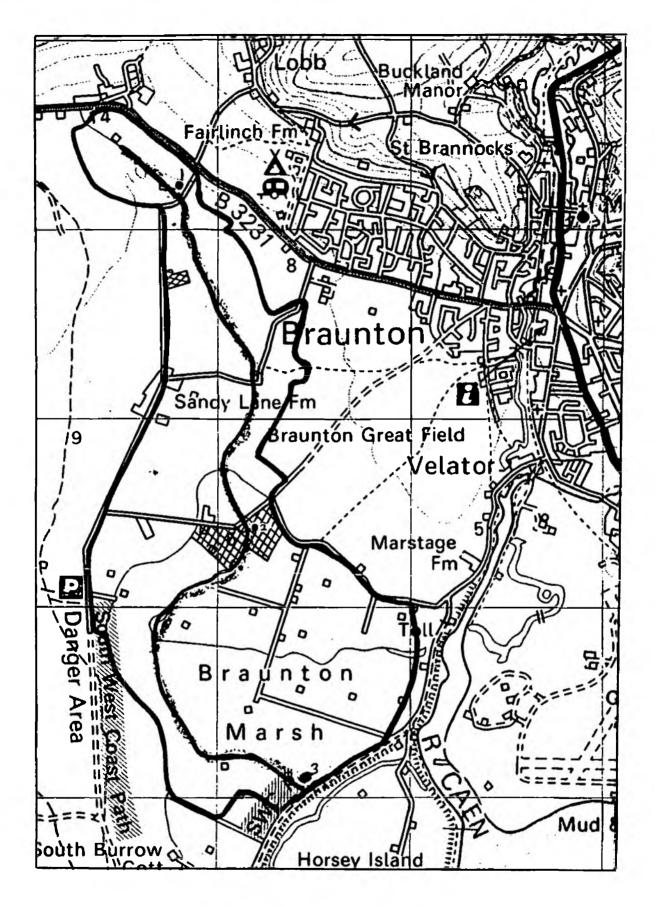
1.2 Study Reach

The section of river selected for study (Figure 1) runs for 5 km between Saunton (GR. 465 374) and the Great Sluice (GR. 474 341). Sir Arthur's Pill is a main river characteristic of those in the area on which weed clearance is regularly performed. The land area which derives a benefit from river maintenance in terms of reduced flooding and improved land drainage is 242 ha.

1.3 Braunton Marsh

Sir Arthur's Pill flows through two distinct areas in terms of land use. From the head of main river to 2.25 km downstream, it flows over an area of mainly arable land skirting the edge of the Great Field - a relic of the open-field strip farming cultivation, before flowing over Braunton Marsh.

Braunton Marsh is an extensive area of reclaimed salt marsh which was cut off from the sea by the creation of a large bank between 1811 and 1815 following an 1811 Act of Parliament which permitted the enclosure. The scheme was designed by James Green, a British Engineer and the Great Sea Bank was constructed by local labour and workers from Cornwall, Ireland and Holland. Some arable crops were traditionally grown on the marsh but now the area is used entirely for grazing.



 Legend
 Scale 1 : 6250

 ☐ Benefit Area
 Agricultural Land Classification Class 4

 ☐ Agricultural Land Classification Class 3
 Location of Soil Cores

Figure 1 Location of Sir Arthur's Pill and background information

1.4 River Characteristics

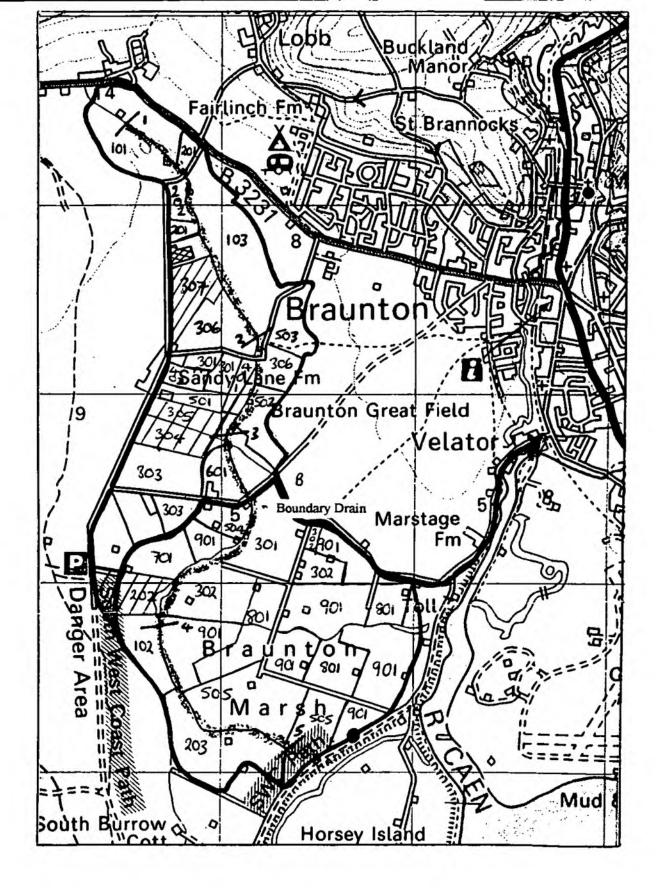
Sir Arthur's Pill is a straight drain, only meandering slightly over a wide floodplain when it reaches Braunton Marsh. The channel is trapezoidal in shape with its depth varying between 1 m at the head of main river to 2.5 m to the landward side of the Great Sluice. Channel width varies between 0.75 m at the head of main river to 2.5 m at the sluice. Freeboard averages 0.75 m north of the marsh but over the marsh itself this is reduced to 0.2 m and at particular points in the autumn and winter there is no freeboard and the water floods out of the drain and onto the marsh. The bed substrate is dominated by silt and sand - characteristic of the old salt marsh over which it flows.

1.5 Land Drainage

When the marsh was reclaimed, the routes of the main tidal creeks over the marsh were replaced by a series of artificial delphs (ditches). These drain the marsh and remove water flowing down from the highland area between Saunton and Lobb. Water is discharged out to sea through the Great Sluice in the sea embankment.

A comprehensive system of ditches traverse the marsh, marking field boundaries and creating barriers to stock. These are maintained (weed cut) by the Internal Drainage Board (IDB) every three years. Water levels in the ditches are controlled via a series of sluices which keep levels high in summer and lower in winter. One such sluice is located at Velator Bridge (GR. 485 358). From this structure, in times of low flow in Sir Arthur's Pill, water from the River Caen is diverted into it via the Boundary Drain. The Boundary Drain in turn feeds minor ditches within the marsh area, keeping their water levels high. The sluices are controlled and operated by the IDB.

Figure 2 indicates the areas of land in the benefit area which have field drainage pipes installed. Of the land surveyed, 36 % is underdrained with pipes. The remainder is naturally draining. Areas of horticulture are associated with the most intensively drained land. Further information is provided in Section 2.5.



Legend Scale 1 : 6250

Piped drainage Cross-section location Land use blocks

• Great sluice

Figure 2 Land drainage and location of cross-sections

Natural drainage

1.6 Geology, Soils and Land Capability

Sir Arthur's Pill flows over sand and silt deposits of marine and estuarine origin. The shaley silt stone with sandstone and limestone's to the north and shale and silt stones of Lower Carboniferous age in the south, form the boundaries to this alluvium which was laid down in recent and Pleistocene times.

The soil type is characterised by the Isleham Association containing both the Isleham and Crowdy series. The soils have developed over a permeable sandy drift which is typically waterlogged over long periods due to a high watertable. Humic sandy gleys are the typical soil type.

Soil profiles taken at three points within the benefit area are shown in Figure 3. Soil colour is a uniform dark brown. Sandy silt loams characterise the soil profile beneath the root zone. Some mottling and gleying is evident on the poorly drained soils.

The Crowdy series is perennially waterlogged and the risk of poaching (surface damage by livestock) is high. The soil profile is typically waterlogged within 0.4 m of the surface for over 50 % of the year and waterlogged within 0.7 m of the surface for over 90 % of the year. The Soil Survey of England and Wales (SSEW) classify such soils as having a Wetness Class of VI. Due to a high watertable the Wetness Class of the Isleham series is V. The soil is commonly waterlogged for 95 % of the year within 0.4 m of the surface (Findlay et al, 1984). According to precipitation records from the nearest meteorological station to Sir Arthur's Pill (Chivenor Met. Office), the average annual rainfall is high, averaging approximately 868 mm. This contributes to the high watertables in the area.

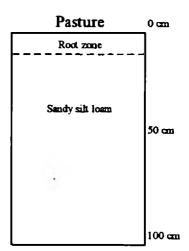
The Agricultural Land Classification of the Ministry of Agriculture Fisheries and Food (MAFF) characterises the area adjacent to Sir Arthur's Pill and Braunton Marsh as Grade 3 (Figure 1). The Great Field is classed as Grade 2 agricultural land. A small area on the northern boundary of the marsh area is classed as Grade 4.

Grid Reference 468 373

Soil Core Number 1

Soil Colour Dark brown

Comments Well drained, uniform profile

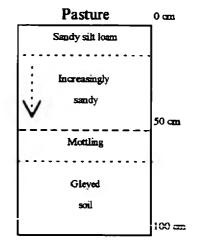


Grid Reference 472 345

Soil Core Number 2

Soil Colour Dark brown

Comments Increased gleying with depth



Grid Reference 475 341

Soil Core Number 3

Soil Colour Dark brown

Comments Well drained, uniform profile

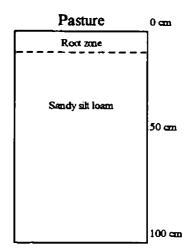


Figure 3 Soil profiles

1.7 Capital Works

In 1979 the channel was dredged to a design standard and re-graded. Local re-sectioning took place at the same time and the tidal flaps were replaced. Two water level control structures were refurbished in 1992/93. These consist of weirs which are used to control levels in Sir Arthur's Pill at various times in the year.

1.8 River Maintenance

Desilting and weed clearance along the entire length of Sir Arthur's Pill takes place approximately every 18 months for the benefit of land drainage. All the channel vegetation (100 %) is removed using a 360 degree excavator. The river banks are left untouched and are not flail mown. Debris from the channel is spread on the surrounding land. Repairs to structures such as the weirs and Great Sluice are carried out as required.

The main reason for carrying out regular weed clearance is that it is scheduled into a regular programme of maintenance due to site inspections highlighting the need for vegetation control. The availability of equipment/labour and customer demand also influence the scheduling of maintenance works. Custom and practice is the main reason for determining the standard of service maintained by weed clearance. Proven suitability and the cost of maintenance are the main factors in determining the maintenance method selected. Prior to maintenance, landowners/tenants are visited by a representative from the NRA. Pollution bodies are informed of imminent work via the telephone.

1.8.1 Farmers views on maintenance

During interviews with farmers in the benefit area, the majority of the farmers expressed satisfaction with both the timing and frequency of maintenance on Sir Arthur's Pill. However, one farmer expressed concern that a layer of clay was removed from the channel bed along with the weed. This deepened the channel which rendered the banks more unstable and prone to slippage and undercutting.

1.8.2 Alternative maintenance strategies

The only alternative method of maintenance suggested by the farmers was to flail mow the banks either annually or twice per year. This would aid access to the channel for grazing livestock.

1.9 Climate

The impact of river maintenance on watertable depth and river levels depends on the particular weather conditions, especially rainfall, which vary from season to season and year to year. The seasonal and yearly rainfall totals for the period of study in the area of Sir Arthur's Pill are shown in Table 1.1.

Table 1.1 Rainfall totals

Table 1.1	каштап тог	ais		
Period		Actual	Average	% of Average
		Rainfall (mm)	Rainfall (mm) *	Rainfall
1992	Spring	146	170	86
	Summer	244	199	123
	Autumn	307	308	100
1993	Spring	130	170	76
	Summer	343	199	173
	Autumn	272	308	88
1994	Spring	214	170	126
	Summer	166	199	84
	Autumn	412	308	134
1995	Spring	186	170	110
Total	1992	863	889	97
	1993	1042	889	117
	1994	1172	889	132

(Source: Chivenor Met. Station GR. 494 347)

This confirms the farmers comments that the summers of 1992 and 1993 and autumn of 1994 were wetter than normal. The summer of 1993 is classed as very wet. The rainfall data were collected from the meteorological stations at Chivenor (station number 395 162, GR. 494 347) and Lower Slade W.T.W (station number 395 607, GR. 5095 4588).

Monthly rainfall records covering a period of 14 years were used to determine the probability of wet, average and dry seasons and years occurring (Table 1.2) in the immediate area round Sir Arthur's Pill. The classification of seasons and years is based on that of the Food and Agricultural Organisation (FAO). Dry and wet seasons and years are classed as those with < 75 % of the mean and > 125 % of the mean respectively. Further details are contained in the R&D Note 456, Section 3.5.4.

Table 1.2 Probability of climatic conditions

THOIC TIE			
Season	Dry *	Average *	Wet *
Spring	0.22	0.62	0.16
Summer	0.46	0.39	0.15
Autumn	0.21	0.65	0.14
Year	0.54	0.38	0.08

^{* (}Based on records since 1980)

The Main Report (R&D Note 456, Section 3.5.4) describes the process by which financial benefits of maintenance are calculated according to the probability of each type of season occurring.

1.10 Aquatic Vegetation

Aquatic vegetation within the channel was identified prior to maintenance (Section 1.10.1 to 1.10.4). This vegetation has both hydraulic and environmental implications for the channel.

1.10.1 Floating plants

Lemna (Duckweed) and Azolla (Water fern) are common although the latter is predominately found in the Boundary Drain and not in Sir Arthur's Pill. Both are small and free-floating with rootlets on the underside of each leaf pad and often form dense mats.

Lemna and Azolla spread through vegetative reproduction by budding from pouches on the side of the leaves. Rapid growth often results in a dense cover over the water surface. Regrowth following removal through maintenance is thus rapid, especially as it is impossible for complete removal of the plant through mechanical methods alone. Chemical control may need to be considered if the growth reaches excessive rates. However, as Lemna and Azolla are purely floating plants, they poses little resistance to flow and do not restrict channel capacity. However, water quality may be affected as a dense mat may restrict the penetration of light into the water thus restricting activity of fish and invertebrates. As plant growth will also be restricted beneath the mat, its presence may actually reduce flow resistance through inhibiting plant growth.

1.10.2 Emergent plants

The emergent weeds include the narrow leafed *Phragmites australis* (Common reed), *Typha* (Reedmace or bull rush) and *Phalaris* (Reed Canary-Grass). Emergent plants pose a greater resistance to flow than floating species. If vegetation stands are dense, their stems and leaves provide a barrier to flow, causing the hydraulic resistance of the channel to increase and water levels to rise. If the stems are flexible, they will bend in the direction of flow and during high flows will exert minimal resistance to flow as their effect is drowned out.

1.10.3 Submerged plants

The submerged weed *Elodea* (Canadian pondweed) is abundant within Sir Arthur's Pill and the Boundary Drain. *Juncus* (Rush) is a submerged plant with fine hair-like leaves which can reach 300 cm in length. It is a streamlined plant and moves in the direction of flow. The greater the flow, the lower the resistance this plant poses to movement of water. At high flows, the hydraulic impact of *Juncus* is drowned out.

1.10.4 Algae

Filamentous algae is also found within Sir Arthur's Pill. It spreads rapidly through cell division (simple fission) and is difficult to completely remove. It grows up from the hydrosoil and often invades areas in which other aquatic plants have been removed.

2. FARM SURVEY

2.1 Introduction

Site survey, informal discussions and structured interviews with farmers indicate a benefit area of 242 ha (Figure 1). Detailed discussions have been held with nine farmers within this area. The benefit area is described as that which will derive a benefit from river maintenance in terms of improved drainage and reduced incidence of flooding. The benefit area is divided into different blocks (Figure 2) according to land use type (LUT) land management and drainage condition.

2.2 Farm Type, Size and Tenure

Seven farms within the benefit area are classed as lowland and livestock enterprises according to the European Union (EU) system of classification. One is a general horticultural enterprise and the remaining holding is classified as a specialist cereal farm. Farm sizes range from 4 ha to 324 ha, averaging 86 ha. The number of Standard Man Days (SMD) required for each farm ranges from five to 1630. The latter is for the largest farm; a lowland and livestock enterprise. The SMD (Man - Work Units) is a standard, approximate method for assessing the labour requirements for regular staff. It is assumed that 300 SMD are provided annually per man.

The largest farm within the benefit area is a managed farm. Two others are run as a partnership and the remainder are under sole proprietorship. The majority of land within the benefit area is owner occupied. One farmer has rented land within this area, comprising one 4 ha field held under a full tenancy agreement.

2.3 Livestock Enterprises

The system of livestock farming on Braunton Marsh follows a similar pattern over the whole marsh. Friesian beef kept under the 24 month system are most commonly found on the marsh. Beasts are bought at 125 kg and sold between 550-700 kg live weight. Five farms have beef herds of various sizes. Four of these have spring calving suckler herds, the herd size ranging from 32 to 140 beasts.

Five of the farms within the benefit area have flocks of sheep under the fat lamb system. Flock sizes range from 150 to 2400 ewes and are of mule and mixed breeds. The lambing rate ranges from 1 to 1.8 lambs/ewe tupped (average 1.5).

A small number of dairy followers are also grazed on the marsh as are some race horses. The stocking rate over the whole marsh is in the region of 10 beasts/ha.

2.4 Arable Enterprises

Four farms within the benefit area have some arable enterprises. Two grow winter cereals, potatoes (both early and main crop) and field vegetables under varying rotations. The general horticultural farm follows a fixed rotation of early potatoes and field vegetable crops which includes brassicas and leeks.

A fixed cropping rotation is practised by the specialist cereal enterprise under which field vegetables are followed by winter or spring barley, winter or spring wheat and early potatoes. Ten hectares are double cropped with field vegetables.

2.5 Land Use In The Benefit Area

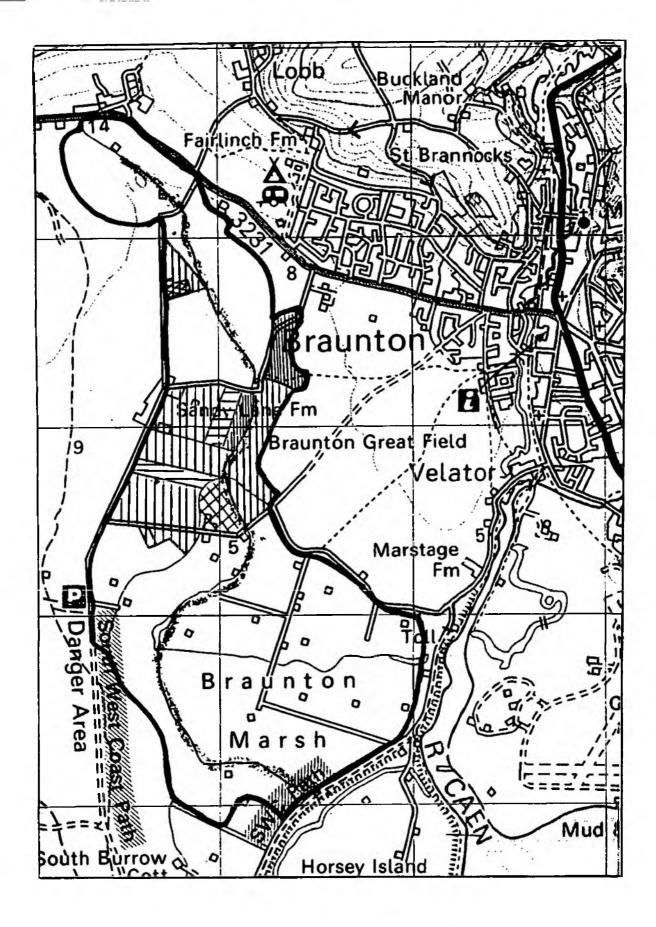
As Figure 4 illustrates, the majority of land surveyed within the benefit area (67 %) is under extensive grassland. Arable enterprises in the form of cereal/root crops account for 16 % of the benefit area. Holiday homes cover 4.5 ha of the benefit area (2 %). Table 2.1 provides detailed information regarding the percentage of land within the benefit area under the different land uses.

Table 2.1	Land	use in	the	benefit	area
I adde 2.1	Läuu	изе ш	ULC 8	DETICHT	21

Land Use	Area (ha)	% Benefit Area	% Land Drained
Extensive grass	162.0	67	10
Intensive grass	18.0	7	26
Cereal/roots	38.0	16	11
Horticulture	19.0	8	58
Other	4.5	2	0
Total	242.0	100	36

Extensive grassland is classified as that which receives low levels of nitrogen (typically < 50 kg/ha) and on which little or no grass conservation takes place. If conserved, one cut of hay is usually taken. The grass is grazed by beef and sheep, not dairy cattle. Grassland under the intensive system is high quality grazing land. It is usually well drained and receives moderate to high inputs of nitrogen. Multiple cuts of silage and/or hay are typically made.

Table 2.1 also shows the percentage of each land use which is drained by pipes. In total, 36 % of the benefit area is underdrainaed.



Legend Scale 1 : 6250

☐ Extensive grass ☐ Cereal / root crop rotation ☑ Other
☐ Intensive grass ☐ Horticulture

Figure 4 Land use in the benefit area

2.6 Turnout and Yarding Dates

Dates for the turnout and yarding of stock within the benefit area vary as Tables 2.2 and 2.3 illustrate. Stock is turned out to graze over the majority of the benefit area (42 %) in April. Over 5 % of the benefit area, livestock is turned out to graze after the grass has been cut for hay or silage. Twenty eight percent of the benefit area is grazed all year.

Table 2.2 Turnout dates

Turnout Date	Grassland Area (ha)	% Benefit Area
Early/mid April	12	5
Mid/late April	89	37
After hay cut	6	2.5
After silage cut	5	2
Grazed all year	68	28

Table 2.3 Yarding dates in Autumn

Yarding Date	Grassland Area (ha)	% Benefit Area
Mid / late October	61	25
Mid / late November	46	19
Mid/late December	5	2
Grazed all year	68	28

The majority of the stock which are yarded, are taken off the land in October. The land which is grazed all year is typically grazed by beef during the period April to October and by sheep over the winter months.

2.7 Grass Conservation

Table 2.4 shows the area of grassland which is cut for hay and silage. The majority of the grassland is grazed only (87 %). Silage is cut over 10 % of the grassland area and hay is cut over 3 %. The dates for the hay and silage cuts are early June and mid May respectively.

Table 2.4	Grass conservation				
Conservation System	Grassland Area (ha)	% Grassland Area			
Grazed only	156	87			
1 cut silage	18	10			
1 cut hay	6	3			

2.8 Nitrogen Application

Nitrogen is applied to all the grassland surveyed within the benefit area; mostly in the form of compound fertilisers, especially 20 N:10 P:10 K. Application rates range from 20 to 50 kg/ha. Further details are presented in Table 2.5.

The higher rates of nitrogen application correspond to the areas which are grazed by dairy cattle and followers (intensive grassland).

Table 2.5 Nitrogen application rates

Rate (kg/ha)	ate (kg/ha) Grassland Area (ha)	
0	0	0
1 - 20	85	47
21 - 35	63	35
36 - 50	32	18

2.9 Flooding

Land within the benefit area does not flood on a regular basis. No flooding has been experienced on the land during the time of this study. Water levels in Sir Arthur's Pill, the Boundary Drain and minor ditches are controlled by boards in the weirs which are lowered as required to minimise the incidence of flooding. The land adjacent to the river is expected to flood at times during the winter months when water levels are high. Farmers accept this threat as to be expected when working marsh land adjacent to a river.

2.10 Waterlogging

Throughout the benefit area the wetness condition follows a similar pattern throughout the year. Table 2.6 shows the area experiencing different levels of waterlogging during the spring, summer and autumn.

During the spring, 60 % and 38 % of land surveyed is rarely and occasionally wet. Only 2 % of the land is often wet and none permanently wet. Throughout the summer the marsh area dries and only 11 % experiences occasional wet conditions. During the winter, 47 % of the benefit area is permanently wet.

Table 2.6 Wetness condition of agricultural land

Season	Condition	Area (ha)	% Benefit Area
Spring	Rarely wet	145	60
	Occasionally wet	93	38
	Often wet	4	2
	Permanently wet	0	0
Summer	Rarely wet	215	89
	Occasionally wet	27	11
	Often wet	0	0
	Permanently wet	0	0
Autumn	Rarely wet	29	12
	Occasionally wet	53	22
	Often wet	46	19
	Permanently wet	114	47

The main factors responsible for these wet conditions are the limited freeboard in Sir Arthur's Pill and the low lying nature of the land. The area is marshland and so by nature it is characteristically wet throughout the winter months.

2.11 Statistical Analysis

It is apparent that land use, farming practice and drainage are interrelated. Statistical methods were used to determine whether these relationships occurred more frequently than might be expected by pure chance. Full details of this analysis in which the 12 sites were grouped

according to NRA Region, are presented in the Interim Report R&D 317/13/ST, presented to the NRA in December 1994.

The following observations can be made from the statistical analysis of fields in the benefit area of the Sir Arthur's Pill maintenance programme:

- The dominant farming system influences land use within the benefit area. In this case, the dominant farm type is lowland and livestock which is characterised by beef and sheep enterprises. This farm type determines the land use, which is unlikely to change from grass to arable even if drainage were to improve as a result of maintenance.
- A strong relationship exists between land use and installation of field drainage. Areas with field drainage are predominantly given over to horticulture whilst land under an extensive grass system is not drained by pipes. (Statistically, there is an 83 % chance of correctly predicting the incidence of field drainage on the basis of land use).
- Grazing seasons are a function of spring and autumn field wetness conditions and not soil type. This wetness condition is in itself a function of the presence of field drainage. Those fields which are drained by pipes are subject to longer grazing seasons than those which are naturally draining. Livestock are overwintered on the land which is classed as rarely wet. (Statistically, there is a 66 % and 91 % chance of correctly predicting turnout and yarding dates for livestock on the basis of field wetness conditions in the spring and autumn respectively).

3 HYDRAULIC AND HYDROLOGICAL DATA

3.1 Introduction

Information on channel hydraulics and hydrological data has been used to determine the impact of maintenance on channel capacity and flood return periods.

3.2 Cross-section Surveys

Cross-sectional surveys of the channel were completed at five points within the selected section (Figure 2). Channel capacity has been determined from these cross-sections. Because the channel dimensions were not altered during the weed clearance process, a post-maintenance cross-sectional survey of the channel was not necessary.

Before maintenance was carried out, channel roughness was expressed in the form of the Manning's n coefficient, using the methodology developed by Cowan (1956). This coefficient consists of six parameters which include the predominant bed material, degree of meandering and the level of vegetation growth. Further details of the methodology used are presented in the R&D Note 456, Appendix IV. The same procedure was followed after maintenance in order to determine values of channel friction in a 'with' (post)and 'without' (pre) maintenance situation.

Stage/discharge curves have been created for the 'with' and 'without' maintenance situation using these different values of Manning's n. The channel cross-section information including Manning's n values and stage/discharge curves are presented in Figure 5 and Table 3.1.

Table 3.1 Bankfull capacity

	Dankidi capacity	
	With Maintenance	Without
		Maintenance
Cross-	Bankfull Capacity	Bankfull Capacity
Section	(cumecs)	(cumecs)
1	8.6	4.4
2	1.6	0.8
3	2.0	1.0
4	7.5	4.5
5	2.1	1.0

(Source: modelled estimates)

The bankfull capacity figures obtained from the cross-sections indicate an average increase in capacity attributable to maintenance of 52 % (from 2.3 to 4.4 m³/s).

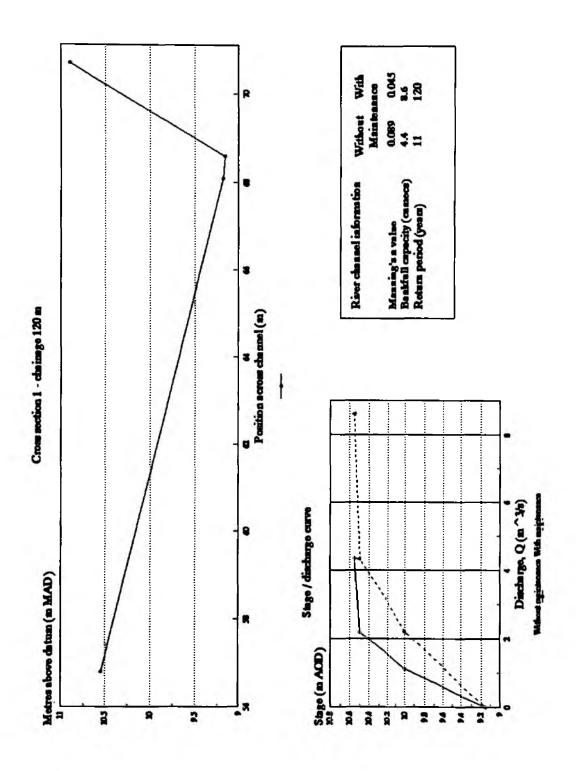
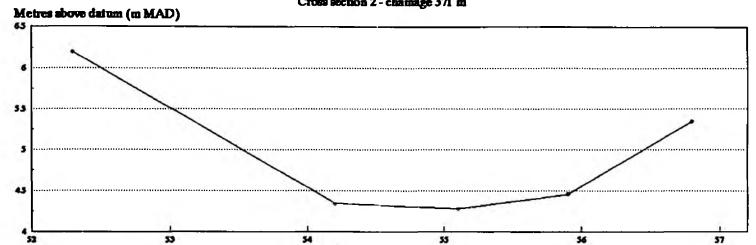
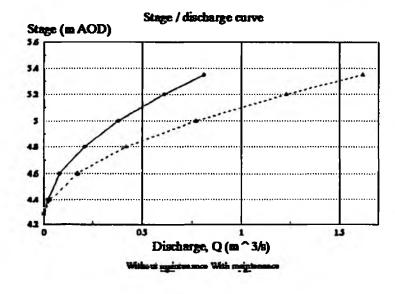


Figure 5 Sir Arthur's Pill channel information



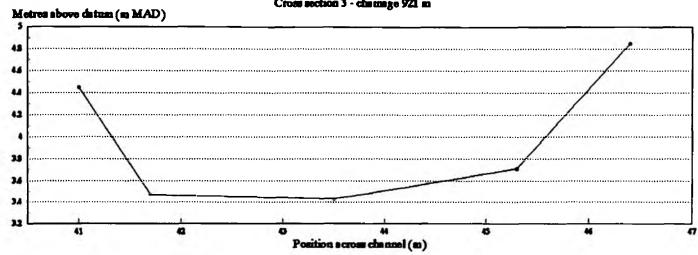
Position across channel (m)

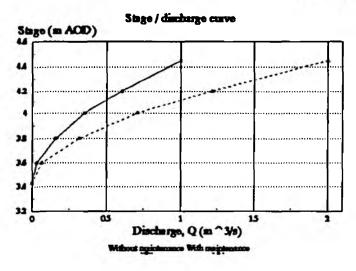


River channel information	Without Mainto	With 1200
Macaing's a value	0.08	0.04
Bankfull capacity (cameca)	0.6	1.5
Return period (years)	0.15	0.7

23

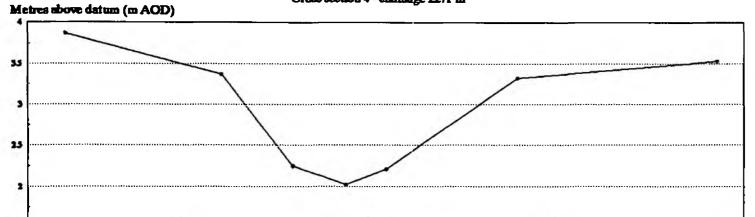
Cross section 3 - chaimsge 921 m



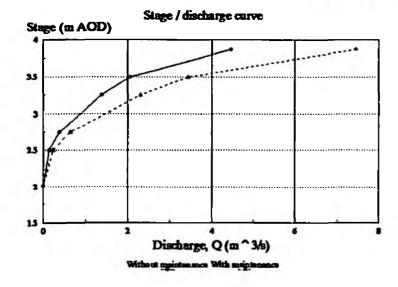


River channel information	Without	
Manaing's a value	0.08	0.04
Backfall capacity (cameca)	LØ	2.0
Ratura period (years)	0.2	1.0

25



165 Position across channel (m)

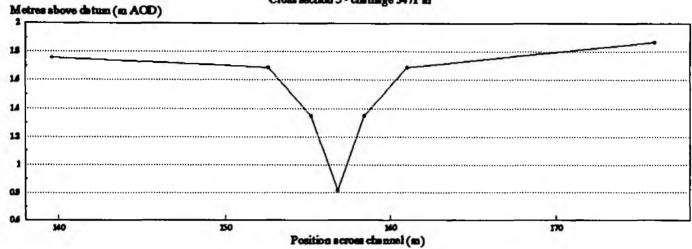


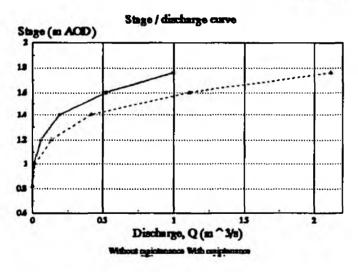
River channel information	Without Mainter	
Manaing's a value Backfull capacity (currors)	0.09 4.5	0.054 7.5
Return period (years)	12	90

170

173

Cross section 5 - chainage 3471 m





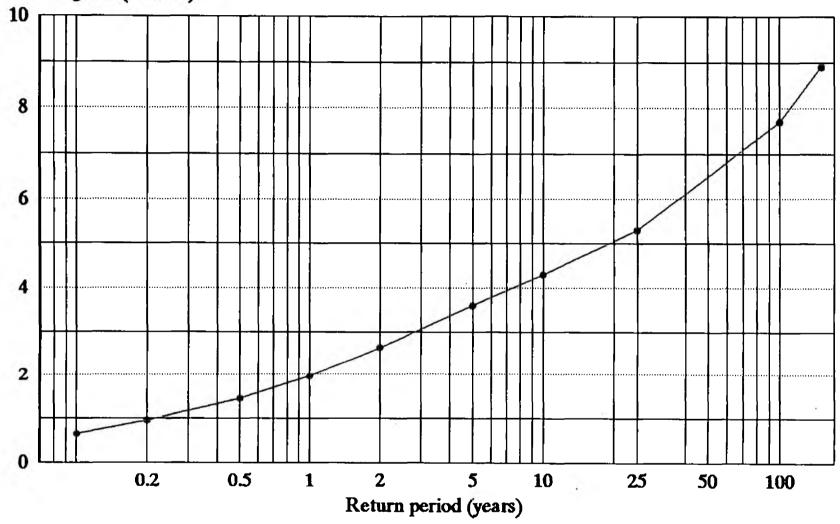
River channel information	Without	
Manaing's a value	0.085	10.0
Backfull capacity (camera)	1.0	2.1
Roturn period (years)	0.2	1.1

3.3 Flood Return Period

Throughout the period of the study (1993 - 1995), river water level information was collected on a fortnightly basis by reading off channel water levels from three gauge boards which were installed within the reach. General information regarding flood flows, frequency and duration were collected from farmers and NRA staff. This information was used to compile a flood return period curve for Sir Arthur's Pill using the methodology detailed within the Flood Studies Report (NERC, 1975).

Land within the benefit area is reported not to flood as levels in the channel and Boundary Drain are controlled by a series of sluice boards which are raised or lowered as required to regulate water levels in the channel. If the sluice boards were not operated and land were allowed to flood, the frequency of flooding could be ascertained from the flood return period curve in Figure 6.

Discharge, Q (cumecs)



Flood Studies Report Method

4. LAND DRAINAGE

4.1 Field Drainage Status

Through an extensive literature and farmer survey, drainage status of the land has been classified into three standards according to watertable depth. Three watertable bands have been identified as > 0.5 m from the surface, between 0.3 to 0.5 m of the surface and < 0.3 m from the surface. According to the time the watertable lies within these bands, the drainage standard is classed as good (G, no restrictions on land use), bad (B, some restrictions on agriculture) or very bad (VB, severe limitations to agriculture). Further details are presented in the R&D Note 456, Section 3.5.2.

The drainage status of fields within the benefit area has been determined on a seasonal basis using a non-steady state watertable model which relates infield watertable levels (and hence drainage conditions) to observed water levels in the river and ditch system (see R&D Note 456, Section 3.5.2 for further details). The model has been run using river water levels for the 'with' and 'without' maintenance scenario using the same climatic data in order to isolate the impact of maintenance on drainage status. An example of the input and output data of the model is shown in Appendix I.

The results of the watertable model and the assessment of drainage status made by farmers are shown in Table 4.1. In some cases, there may be a change in the number of weeks that the watertable lies within the good, bad and very bad drainage bands following maintenance. However, these changes may not be of sufficient magnitude to change the drainage status classification. Where a sufficient change in drainage status has occurred due to maintenance, resulting in a change in drainage status, the changes appear in bold print in Table 4.1.

Generally, the output from the watertable model is consistent with the farmers' assessment of drainage status under wet, dry and average climatic conditions for the 'with' maintenance situation. The differences appear to be in the distinction between the bad and very bad drainage condition. The farmers tend to class all the land broadly as bad and are unable to determine if the land is under very bad drainage conditions. Under average conditions, there is 88 % agreement between farmer and modelled assessment of drainage conditions with

maintenance. In wet and dry seasons, there is 79 % and 83 % agreement between farmer and modelled assessment of drainage condition for the with maintenance situation respectively.

The assessments confirm that the drainage status in the benefit area 'with' maintenance is generally good under wet, average and dry climatic conditions. If no maintenance were performed, drainage conditions would deteriorate towards bad in wet and average seasons. In a dry season land would remain under a good classification.

Examples of the classification of the weeks of each season which are under conditions of good, bad and very bad drainage status are shown in Appendix II.

Table	4.1	<u>Drainag</u>	e statu	is for wet,	averag	ge and dry	y seasoi	ns, with	out/with 1	naint	enance
•		Wet Sea	ason *	Average	Season	Dry Sea	son *	Farmer Assessment With Maintenance			Without
Block		Without	With	Without	With	Without	With	Wet	Average	Dry	
No											
101	N	G	G	G	G	G	G	G	G	G	В
102	Y	В	В	В	В	G	G	В	\boldsymbol{G}	G	В
103	N	В	В	В	G	G	G	G	G	G	G
201	N	G	G	G	G	G	G	G	G	G	В
202	N	В	В	В	G	G	G	В	G	G	В
203	Y	VB	В	VB	В	G	G	В	В	G	В
301	N	G	G	G	G	G	G	В	В	В	В
302	N	VB	VB	В	В	G	G	В	В	В	В
303	N	VB	G	В	G	G	G	G	G	G	В
304	Y	G	G	G	G	G	G	G	G	G	В
305	Y	G	G	G	G	G	G	G	G	G	В
306	N	B	G	В	G	G	G	G	G	G	В
307	Y	В	G	В	G	G	G	G	G	G	В
401	Y	В	G	В	G	G	G	G	G	G	G
402	N	G	G	G	G	G	G	G	G	G	G
501	Y	G	G	G	G	G	G	G	G	G	В
502	N	G	G	G	G	G	G	G	G	G	В
503	N	G	G	G	G	G	G	G	G	G	В
504	N	G	G	G	G	G	G	G	G	G	В
505	N	VB	VB	VB	В	В	В	B	В	\boldsymbol{G}	В
601	N	В	G	В	G	G	G	В	G	G	В
701	N	В	G	G	G	G	G	G	G	G	В
801	N	В	В	В	В	G	G	В	\boldsymbol{G}	G	В
901	N	VB	В	VB	В	В	В	В	В	\boldsymbol{G}	VB
											Ì

NB: * Modelled results, Y or N refers to the presence or absence of field drainage, bold type highlights changes in drainage status due to maintenance, italics show differences between modelled and farmer assessment of drainage with maintenance.

River maintenance results in the prevention of a deterioration in drainage status on 8 blocks of land in a wet season and on 10 blocks in an average season. The percentage change in drainage status by area as a result of maintenance activities is estimated below:

In a wet season maintenance prevents deterioration from :

B to VB over 29 ha (12 % of BA)

G to B over 28 ha (11 % of BA)

G to VB over 7 ha (3 % of BA).

• In an average season maintenance prevents deterioration from:

B to VB over 52 ha (21 % of BA)

G to B over 50 ha (21 % of BA).

The maintenance on Sir Arthur's Pill is preventing a deterioration of drainage standards on 42 % of the area in an average season and 26 % in wet seasons. Farmers assess that in the absence of maintenance, drainage status would deteriorate on 77 % of the area in an average season.

5 SCHEME APPRAISAL

5.1 Maintenance Benefits

For each block of land, agricultural production scenarios were created which reflect different levels of field management under conditions of good, bad and very bad drainage (see R&D Note 456 Section 3.5.4). These scenarios are based on discussions with farmers in the benefit area over the period 1992-1994.

Changes in field drainage status as a result of maintenance under dry, average and wet climatic conditions have been identified. Changes in flood risk due to maintenance have also been determined. Estimates have been derived of the monetary value of changes in field management and productivity associated with changes in the standards of drainage service.

Two perspectives have been used to value agricultural performance. The first perspective is that of financial analysis which uses the prices paid and received by farmers to estimate the added-value associated with drainage. Financial analysis shows the benefits of maintenance to farmers in the benefit area.

The second perspective is that of economic analysis which modifies the financial analysis to make allowance for the direct and indirect subsidies paid to farmers by Government. In accordance with the MAFF Project Appraisal Guidance Notes on Flood Defence (PAGN, 1993), these modifications involve reductions in the financial value of output (including subsidies) by 10 % in the case of cereals, oil seeds and grain legumes, 35 % for beef and 25 % for sheep. Commodities subject to quota such as potatoes, sugar beet and milk are treated as winter wheat. The set aside areas are also treated as wheat. The reasons for these adjustments are discussed in the R&D Note 456 Section 2.7.2.

Using the results of watertable modelling, Table 5.1 shows the financial net returns (1995/96 prices) for each block of land within the benefit area under conditions of good, bad and very bad drainage. Changes in net returns relating to a change in drainage status are also shown. Table 5.2 presents similar data using economic prices.

Table 5.	1	Financial	net	returns
I HUIC J.		CHIMINA	HEL	1 COM 12

1 8 Die 3.1	Livring in net 1							
Block	Net Ret	ım (L/ha)		Change	in net Return	(£∕hs)		
	Good	Bad	Very	Good to	Bad to	Good to		
			Bad	Bad	Very Bad	Very Bad		
101	135	93	69	43	24	66		
102	206	146	95	60	52	112		
103	190	137	94	53	43	95		
201	518	311	230	207	82	288		
202	207	156	152	51	4	55		
203	185	151	123	34	28	62		
301	146	116	73	29	43	73		
302	206	167	126	39	41	80		
303	554	303	233	252	70	321		
304	554	303	233	252	70	321		
305	137	108	64	28	45	73		
306	536	338	255	197	84	281		
307	108	84	63	24	20	44		
401	1247	543	151	705	392	1096		
402	1247	543	151	705	392	1096		
501	1037	514	174	523	339	863		
502	1037	514	174	523	339	863		
503	1038	515	175	524	339	863		
504	1046	524	175	522	348	871		
505	418	332	234	86	98	184		
601	Holiday homes							
701	351	292	244	59	48	110		
801	354	289	218	65	71	213		
901	431	285	262	146	23	-262		

Table 5.2 Economic net returns

Table 5.2	Economic net returns						
Block	Net Ret	um (£/ha)		Change	in net Return (£/ha)	
	Good	Bad	Very	Good to	Bad to	Good to	
			Bad	Bad	Very Bad	Very Bad	
101	1	-17	-20	18	3	21	
102	28	5	-12	23	17	40	
103	29	7	-12	22	19	41	
201	365	301	165	63	137	200	
202	66	44	35	22	8	30	
203	61	46	33	16	13	28	
301	-8	-14	-19	7	5	12	
302	66	48	33	18	15	33	
303	372	301	168	70	134	204	
304	372	301	168	70	134	204	
305	-9	-15	-24	7	8	15	
306	382	320	189	62	131	193	
307	-14	-20	-25	6	4	10	
401	1126	603	177	523	426	949	
402	1126	603	177	523	426	949	
501	743	897	177	-154	721	566	
502	743	897	1 77	-154	721	566	
503	933	898	177	35	721	756	
504	933	898	177	35	721	756	
505	375	309	177	67	132	198	
601	Holiday homes						
701	149	121	97	29	24	52	
801	130	96	63	33	33	66	
901	135	109	82	27	26	53	

Table 5.3 combines data on changes in drainage status and financial performance to determine the financial benefits and change in financial net returns due to maintenance for wet, average and dry weather conditions for each block of land in the benefit area. These benefits are the avoidance of losses which would occur in the absence of maintenance. Benefits, weighted by field size for wet, average and dry seasons are multiplied by the relative probability of the occurrence of the season to give an average expected annual benefit. These are summed for the benefit area as a whole.

Table 5.3 estimates a total expected annual benefit of about £ 7700 in 1995 financial prices, equivalent to about £ 32/ha per year. The benefits relate to watertable control. Table 5.4 shows the benefits attributable to maintenance using economic prices based on the current MAFF Project Appraisal Guidance Notes. Total average expected annual benefits are approximately £ 5000 in economic prices for the benefit area, equivalent to £ 21/ha. On this basis, the benefit to the national economy is 65 % of the benefits which accrue to farmers. This difference reflects the adjustments required by MAFF to remove government subsidy from the assessment of benefits.

As an alternative estimate to that based on watertable modelling, Table 5.5 estimates the benefits due to maintenance which were perceived by farmers (earlier reported in Table 4.1) where they identified a change in drainage conditions between the 'with' and 'without' maintenance situations in an average, representative season. Farmer assessment gave an average annual financial benefit of £ 23571 (£ 97/ha) and an economic benefit of £ 2483 (£ 10/ha).

According to the criteria used, these financial and economic benefit estimates show the limits which farmers and the nation respectively could justifiably spend on maintenance. These estimates require cautious interpretation as explained in the R&D Note 456 Section 2.7.2.

			Wet Season		A	verage Season	l		Dry Season		
Block	Area (ha)	Benefit due to drainage (£/ha/yr)	Benefits of flood alleviation (£/ha)	Change in net return due to maintenance	Benefit due to drainage (£/ha/yr)	Benefits of flood alleviation (£/ha)	Change in net return due to maintenance	Benefit due to drainage (£/ha/yr)	Benefits of flood alleviation (£/ha)	Change in net return due to maintenance	Total Change (£/yr)
101	14.60	0	0	0	o	0	0	0	0	0	c
102	5.80	о	0	0	0	o	0	0	0	o	C
103	11.60	0	0	0	53	0	53	0	0	0	349
201	4.70	0	0	0	o	0	0	0	0	0	C
202	6.80) 0	0	0	51	0	51	0	0	0)	198
203	9.00	27	0	27	27	0	27	0	0	0	206
301	13.70	0	0	0	0	0	0	0	0	0	C
302	16.2	0	0	0	0	0	0	0	0	0	C
3 03	6.80	321	0	321	252	0	252	0	0	0	1558
304	4.2	0	0	0	0	0	0	0	0	0	C
305	4.7	0	0	0	0	0	0	0	0	0	C
306	11.2	197	0	197	197	0	197	0	0	0	1848
307	6.3	24	0	24	24	0	24	0	0	0	127
401	2.8	705	0	705	705	0	705	0	0	0	1652
402	3.1	0	0	0	0	0	0	0	0	0	C
501	8	0	0	0	0	0	0	0	0	0	C
502	7.2	0	0	0	0	О	0	0	0	0	C
503	4.2	0	0	0	0	0	0	0	0	0	C
504	4.2	0	0	0	0	0	0	0	0	0	C
505	22.9	[· ·	0	0	98	0	98	0	0	0	1281
601	4.4	Holiday Homes	_		υ	_	_ '	_	_	_ 1	
7 01	3.6	59	0	59	6 0	0	0	0	0	0	.56
801 901	48.00 20.4	0 23	0	0 23	0 23	o 0	0 23	0 0	0	0	393 393
Total	242.40										7666
Probability		Wet season	_	0.265					1	Benefit (£/ha)	32
		Average season Dry season	n	0.572 0.163							

			Wet Season		A	verage Season			Dry Season		
Block	Area (ha)	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net	
		to drainage	flood	return due to	to drainage	flood	return due to	to drainage	flood	return due to	Total
		(£/ha/yr)	alleviation	maintenance	(£/ha/yr)	alleviation	maintenance	(£/ha/yr)	alleviation	maintenance	Change
			(£/ha)			(£/ha)		`	(£/ha)		(£/yr)
101	14.60	0	0	0	0	0	0	0	0	٥	0
102	5.80	0	0	0	o	0	o	o	0	o	0
103	11.60	0	0	0	22	0	22	o	0	o	146
201	4.70	0	0	0	0	0	0	0	0	٥	0
202	6.80	0	0	0	22	0	22	o	0	o	86
203	9.00	13	0	13	13	0	13	o	0	0	98
301	13.70	0	0	0	0	0	0	0	0	0	0
302	16.2	0	0	0	0	0	0	0	0	0	0
303	6.80	204	0	204	70	0	70	0	0	٥	640
304	4.2	0	0	0	0	0	0	0	0	0	0
305	4.7	0	0	0	0	O	0	0	0	0	0
306	11.2	62	0	62	62	0	62	0	0	0	581
307	6.3	6	0	6	6	0	6	0	0	0	32
401	2.8	523	0	523	523	0	523	0	0	0	1226
402	3.1	0	0	0	0	0	0	0	0	0	0
501	8	0	0	0	0	0	0	0	0	0	0
502	7.2	0	0	0	0	0	0	0	0	0	0
503	4.2	0	0	0	0	0	0	0	0	0	0
504	4.2	0	0	0	0	0	0	0	0	0	0
505	22.9	[· · ·	0	0	132	0	132	0	0	0	1729
601	4.4	Holiday Homes		20	_	•			•		
701	3.6 46.00	29	0	29	0	0	0	0	0	0	28
801		0	0	0	0	0	0	0	0	0	0
901	20.4	26	0	26	26	0	26	0	0	0	444
Total	242.40										5009
Probability	of :-	Wet season		0.265						Benefit (£/ha)	21
		Average seaso	n	0.572							
		Dry season		0.163					•		

Table 5.5 Farmer assssment of maintenance benefits

			verage Season			verage Season	
		Fi	inancial Prices			conomic Prices	1.0
Block	Area (ba)	Benefit due	Benefits of	Change in net	Benefit due	Benefits of	Change in net
		to drainage	flood	return due to	to drainage	flood	return due to
		(£/ha/yr)	alleviation	mainten an ce	(£/ha/yr)	alleviation	mainten an ce
			(£/ba)			(£/ha)	
101	14.60	43	0	628	18	0	263
102	5.80	60	0	348	23	0	133
103	11.60	0	0	o	0	0	0
201	4.70	207	0	973	63	0	296
202	6.80	51	0	347	22	0	150
203	9.00	0	0	o	0	0	0
301	13.70	0	0	0	0	0	0
302	16.2	0	0	0	0	0	0
303	6.80	252	0	1714	70	0	476
304	4.2	252	0	1058	70	0	294
305	4.7	28	0	132	7	0	33
306	11.2	197	0	2206	62	0	694
307	6.3	24	0	151	6	0	38
401	2.8	0	0	0	0	0	0
402	3.1	0	0	0	0	0	0
501	8	523	0	4184	-154	0	-1232
502	7.2	523	0	3766	-154	0	-1109
503	4.2	524	0	2201	35	0	147
504	4.2	522	0	2192	35	0	147
505	22.9	0	0	0	0	0	0
601		Holiday Homes					
701	3.6		0	212	2 9	0	104
801	46.00		0	2990	33	0	1518
901	20.4	23	0	469	26	0	530
Total	242	Total finan	cial benefit (£)	23571	Total econom	nichenefit (£)	2483
		В	enefit (£/ha)	97	В	enefit (£/ha)	10

5.2 Maintenance Costs

Maintenance activities on the Sir Arthur's Pill involve desilting and weed clearance carried out on an 18 month cycle. According to NRA sources, the 1992/93 cycle cost £ 7700, equivalent to an annual average cost of £ 5430 in 1995 prices, about £ 23/ha of benefit.

5.3 Scheme Appraisal

The estimated benefits attributable to maintenance can be compared with estimated costs to determine the justification for expenditure. Maintenance costs have been amortised to derive annual costs in order for the appraisal to involve a simple comparison of annual benefits and costs.

Table 5.6 shows that according to the modelled results, the existing maintenance scheme is viable in financial terms and almost breaks even in economic terms:

Table 5.6 Maintenance scheme appraisal: Sir Arthur's Pill

Average Annual Benefit (£)	Average Annual Benefits (£)	Average Annual Costs (£)	Benefit : Cost Ratio
Modelled Estimates			
Financial Prices	7700	5430	1.42
Economic Prices	5000	5430	0.92
Farmer Estimates			
Financial Prices	23571	5430	4.34
Economic Prices	2483	5430	0.46

Farmer assessment gave an average annual financial benefit of £ 23571 (£ 97/ha) and an economic benefit of £ 2483 (£ 10/ha) under average seasons. The scheme generates an annual benefit: cost ratio of 4.34 and 0.46 in financial and economic terms respectively.

These conclusions must be interpreted cautiously as discussed in the R&D Note 456 Section 2.7.2.

6 ENVIRONMENT

6.1 Introduction

The environmental quality of the Sir Arthur's Pill is outlined in this chapter. Reference is made to river corridor surveys, public consultation and farmer assessment.

6.2 Sites of Specific Scientific Interest

Three sites within the benefit area were bought by English Nature in April 1991. These sites are designated as the Braunton Swampool Site of Specific Scientific Interest (SSSI) part owned by the Devon Wildlife Trust, and the Greenaways and Freshmarsh SSSI sites (Figure 7). The Braunton Swampool site is one of only three remaining herb rich grazing meadows in Devon. The SSSI is flat and low lying with a high watertable. The soil is derived from marine alluvium with peaty horizons.

All three sites support a rich and diverse flora including local rarities such as the Marsh Arrowgrass (*Triglochin palustris*) and Tasteless Water-Pepper (*Polygonum mite*). The flora is thought to be typical of a traditional grazing marsh of which less than 24 000 ha remain in Great Britain.

In the past, management of the land resulted in the development of two different vegetation communities; MG11 and MG10 under the National Vegetation Classification (NVC). Land management deteriorated and fen vegetation developed (NVC M27/28). The aim of English Nature and the Devon Wildlife Trust is to resume traditional management of the land to encourage the development of the traditional vegetation community. At present, the land is not grazed but simulated hay cutting is practised in the summer.

6.3 River Corridor Survey

Prior to the river maintenance works in 1992, a river corridor survey was completed (Appendix II) for the selected reach following the survey methodology developed by the Nature Conservancy Council (NCC, now English Nature, EN). Sketch maps and record cards have been produced for each 500 m section. The survey concentrated on the river corridor

and adjacent land. Details concerning such features as channel dimensions, bed substrate, presence of structures, field drainage and bank and in channel vegetation were recorded.

As river maintenance did not alter the channel characteristics, especially as the banks were not flail mown, a complete post-maintenance corridor survey was not necessary. The post-maintenance survey took the form of a vegetational survey which concentrated on the location and percentage cover of channel vegetation (Appendix II).

6.4 Public Consultation

In the spring of each year a 'Conservation liaison Meeting' is held by the NRA to discuss the work programme for river maintenance in the following year. Representatives from various organisations such as EN, Countryside Commission (CC), English Heritage (EH), the Internal Drainage Board (IDB) and Royal Society for the Protection of Birds (RSPB) are invited to attend. Objections to the proposed work can be raised and if necessary modifications to the work programme made.

6.5 Farmer Assessment

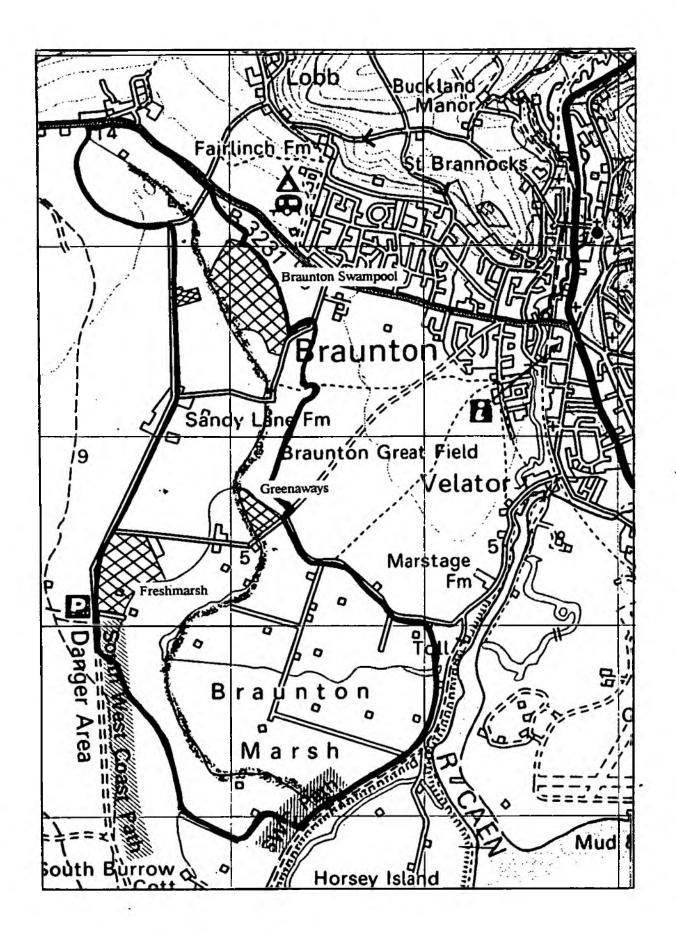
Farmers interviewed within the benefit area were asked to identify any environmental features along the reach which they thought were likely to be disturbed or destroyed by the maintenance work. Only one thought that river maintenance would have a detrimental impact on the environment. The young trees growing on the river banks were thought to be destroyed or damaged by machinery.

6.6 Channel and Bank Quality

The environmental quality of the Sir Arthur's Pill has been determined by following the procedure outlined in the 'Guidelines for the Justification of River Maintenance' (R&D Note 511) produced within the framework of the NRA R&D Note 456 (River Maintenance Evaluation).

The quality of both the channel and bank is classed as low. There is no transitional zone between the channel edge and the river at times of low flow, the sediment is uniform, no riffles and pools are present and the channel is of a uniform habitat.

The banks are of uniform structure, consisting of predominantly one vegetation type and no trees or scrub. Bank width is typically less than 2 m. The banks over the marsh area consist of uniform grass cover which is grazed by sheep and cattle. The bank structure is not varied and there are no dense stands of single species or flowering herbs. Channel banks of the upper section of the Sir Arthur's Pill which flows through the arable area are also uniform in structure and cleared of vegetation during the maintenance programme.



Scale 1:6250

Figure 7 Sites of Specific Scientific Interest

7 CONCLUSIONS

7.1 Scheme Appraisal

The existing maintenance scheme of weed clearance and desilting is viable in financial terms. The average annual benefit of maintenance in terms of its prevention in a deterioration in drainage status is £ 7700. Average annual maintenance costs are approximately £ 5430. The benefit: cost ratio is therefore 1.42. In economic prices, the benefit: cost ratio is 0.92; the scheme almost breaks even.

7.2 Guidelines for River Maintenance

The 'Guidelines for the Justification of River Maintenance' (R&D Note 511), produced as a result of this River Maintenance Evaluation Study were used to provide an alternative method for justification of river maintenance on Sir Arthur's Pill.

According to this method, the economic benefit: cost ratio is 2.1. This value is more than that derived from the detailed analysis; the results of which are summarised in Section 7.1. The differences in result may be due to the fact that average channel dimensions were taken for the whole study reach. If the study reach is divided up into sub-reaches, the benefit: cost ratio produced using the Guidelines is more comparable to that produced under detailed analysis.

7.3 Impact of Maintenance on Channel Vegetation

The types of vegetation found within Sir Arthur's Pill are discussed in Section 1.10. The impact of the submerged and emergent vegetation on channel capacity is also discussed. Different vegetation types respond to maintenance in different ways.

The floating vegetation Lemna and Azolla reproduce vegetatively and unless every fragment of this vegetation is removed from the channel, vegetative reproduction will occur and the weed will rapidly regrow. Chemical control is the most effective method of control in this case. However, Lemna and Azolla do not affect channel capacity as they are free-floating plants and offer no resistance to flow. They can however, reduce water quality.

The Canadian pondweed (Elodea) reproduces through a system of rhizomes (underground stems). The current method of maintenance - regular cutting, actually stimulates regrowth of

this vegetation. Desilting of the channel every few years is necessary in order to remove the rhizomes in the channel sediments.

The current maintenance regime is appropriate in controlling much of the channel vegetation. The vegetation is cut and removed from the channel and the channel is desilted every 18 months. Desilting reduces the rhizome and seed bank in the channel sediments. Regular cutting of the reeds and Canary grass stimulates regrowth. Through cutting every 18 months, vegetation regrowth is likely to occur at a slower rate than if cutting was on an annual basis.

7.4 Maintenance Best Practice

The 'best practice' vegetation maintenance methods for Sir Arthur's Pill were determined using procedures outlined in the Guidelines for the Justification of River Maintenance' (R&D Note 511), produced as a result of the Environmental Impact Assessment Study.

Channel

Best practice maintenance operations for emergent weed are identified as:

- Annual autumn cutting;
- Biennial cutting; and,
- Cutting on a 3 to 5 year rotation.

Best practice maintenance operations for floating and submerged weed are identified as:

- Biennial cutting;
- Cutting on a 3 to 5 year rotation; and,
- Desilting / raking on a 2 to 7 year rotation.

All these maintenance operations should be selective, concentrating on those areas which are particularly choked by vegetation or areas in which the weed is liable to cause an obstruction, hazard or restriction to flow.

Since the beginning of this study, weed maintenance has been performed at an interval of approximately 18 months during the autumn or winter. All the channel vegetation is removed. Generally, in terms of timing, the maintenance regimes recommended as best practice in environmental terms for vegetation management are currently being applied to this reach of the

Sir Arthur's Pill. However, if some vegetation were left un-cut along the channel margins this would improve the environmental quality of the channel.

Bank

Best practice maintenance operations for bank vegetation are identified as:

• Light grazing.

The majority of the banks in the grassland areas are grazed by sheep, cattle or horses and are not flail mown. In arable areas, the banks are not flail mown. Grazing regimes are relatively intensive and if the bank is un-fenced, the bank vegetation remains short and uniform in structure.

If the bank maintenance regime recommended as best practice in environmental terms were implemented, the grazing intensity of the banks should be reduced. This may entail the fencing of banks adjacent to the watercourse.

7.5 Recommendations

It is recommended that further research examines:-

- the impact of a reduced maintenance frequency (cutting every 2 years) on land drainage within the benefit area; and,
- the impact of reduced channel maintenance on channel environmental quality.

7.6 Epilogue

This report has assessed the impacts of the current maintenance regime on the study reach. It has been used along with other study sites to formulate guidelines on the appraisal of maintenance works and best environmental practice. These draft guidelines are summarised in Chapter 5 of the R&D Note 456 and presented in full under separate covers.

8. REFERENCES

Findlay, D.C. Colborne, G.J.N. Cope, D.W. Harrod, T.R. Hogan, D.V and Staines, S.J (1984). Soils and their Use in South West England. SSEW, Harpenden.

MAFF (1993). Farm Incomes in the United Kingdom, 1991/92 Edition. MAFF, HMSO, London.

Met Office (1979). Monthly and Annual Totals of Rainfall 1969 for the United Kingdom. Met Office, Bracknell, Berkshire.

NERC (1975). Flood Studies Report. NERC, London.

Nix, J (1994). Farm Management Pocket Book, 25th ed. 1994/95., MAFF, HMSO, London.

Map: Agricultural Land Classification. Sheet 163 (1974). MAFF.

Map: Ordnance Survey Landranger 180. Barnstaple and Ilfracombe Area. 1:50 000. Ordnance Survey, Southampton.

APPENDIX I

Example of input and output data for the watertable model

Sir Arthur's Pill

Block Number 901

Cross-section 5

	Input Data	Output Data
	River height (m AOD)	Watertable height (m AOD)
Weel	- '	
1993		
1	1.44	1.49
2	1.44	1.69
3	1.37	1.66
4	1.44	1.61
5	1.44	1.51
6	1.37	1.44
7	1.37	1.39
8	1.37	1.38
9	1.43	1.37
10	1.43	1.35
11	1.40	1.32
12	1.40	1.37
13	1.40	1.34
14	1.40	1.46
15	1.40	1.40
16	1.40	1.35
17	1.37	1.22
18	1.37	1.18
19	1.28	1.24
20	1.28	1.37
21	1.40	1.30
22	1.40	1.69
23	1.40	1.69
24	1.40	1.40
25	1.60	1.28
26	1.60	1.35
27	1.60	1.69

1.62

1.67

1.60

1.51

28 29

Example of drainage status classification, Sir Arthur's Pill

With maintenance

Block 901			No. of weeks	
	7	Watertable	1993	Spring 1993
	Ċ	lepth (m)		
	>0.5	1.22	19	1.22
0.3	3><0.5m	1.42	11	1.42
	<0.3m	1.72	22	1.72

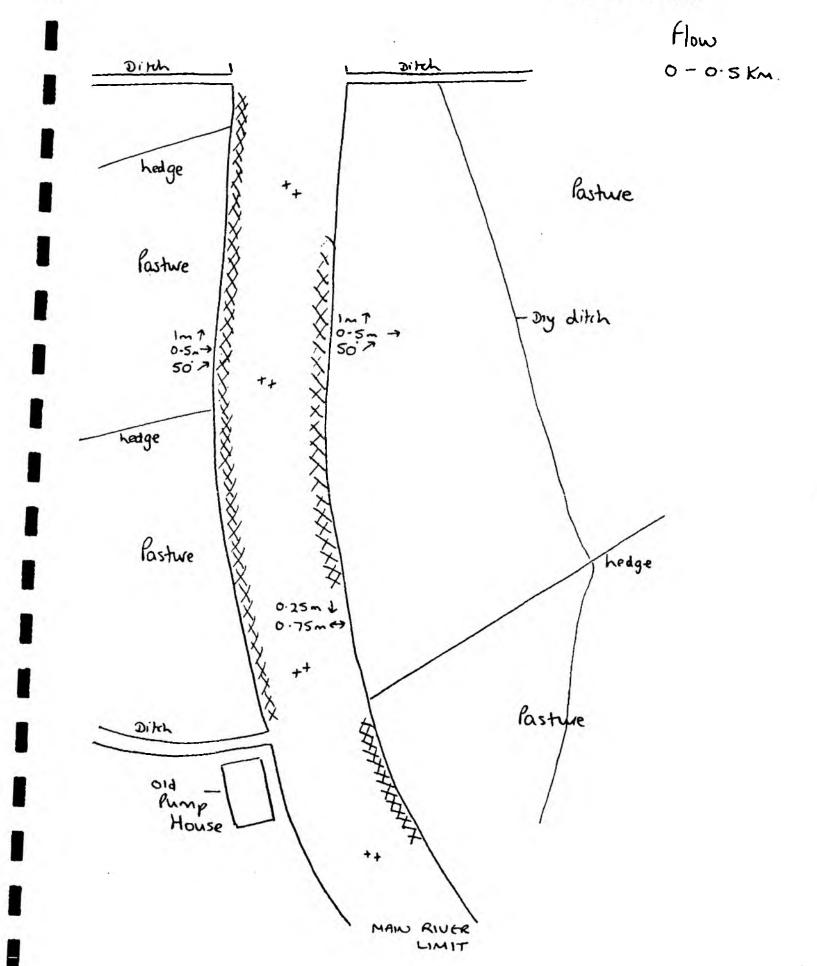
Drainage status classification, according to time watertable is within the G, B, VB drainage bands

Without maintenance

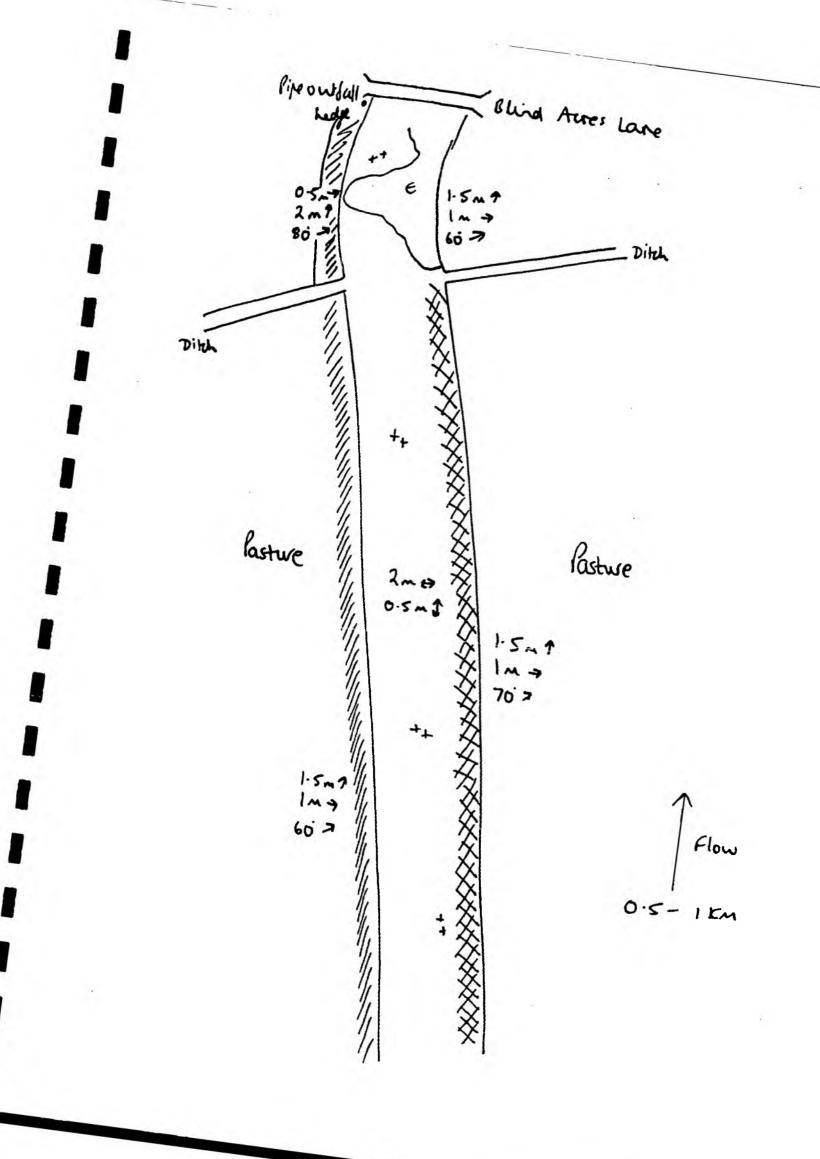
		No. of weeks	
	Watertable	1993	Spring 1993
	depth (m)		
>0.5	1.22	2	1.22
0.3><0.5m	1.42	18	1.42
<0.3m	1.72	32	1.72

Drainage status classification, according to time watertable is within the G, B, VB drainage bands

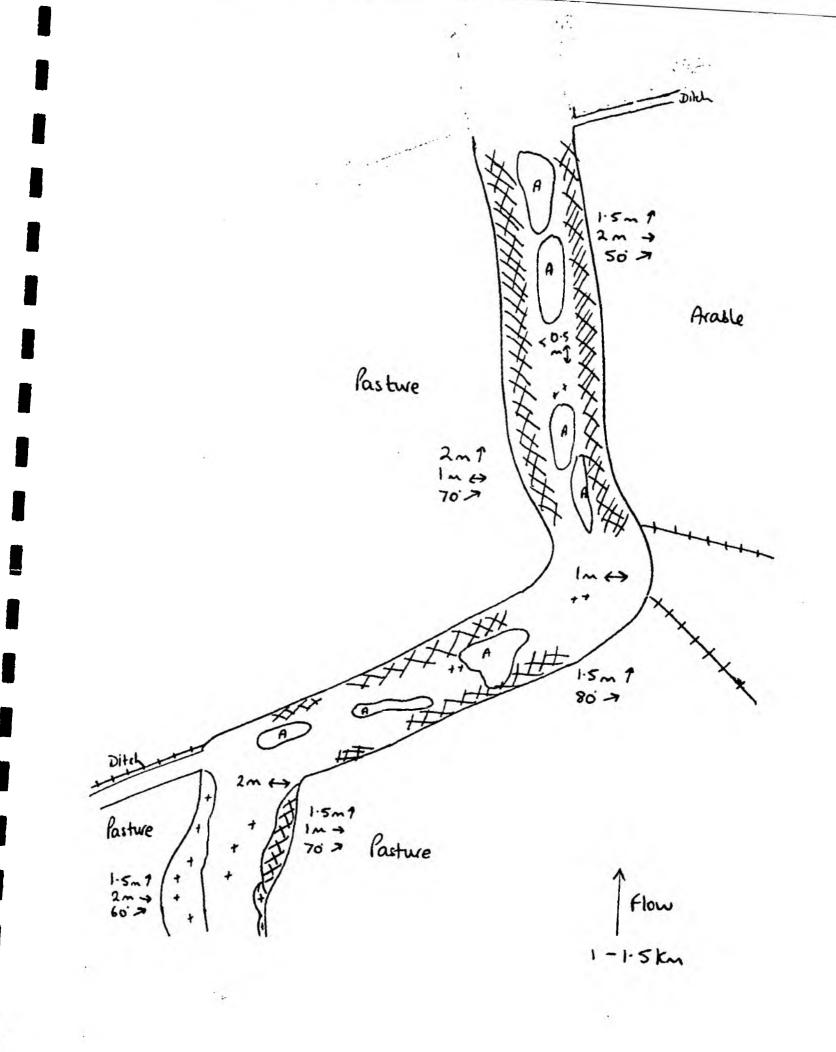
No. of		No. of	0.0	No. of
weeks	Autumn 1993	weeks	Summer 1993	weeks
1	1.22	4	1.22	12
3	1.42	4	1.42	1
9	1.72	5	1.72	0
Very Bad	•	Bad		Good
No. of		No. of		No. of
weeks	Autumn 1993	weeks	Summer 1993	weeks
0	1.22	0	1.22	2
1	1.42	5	1.42	10
12	1.72	8	1.72	0
			V	Bad



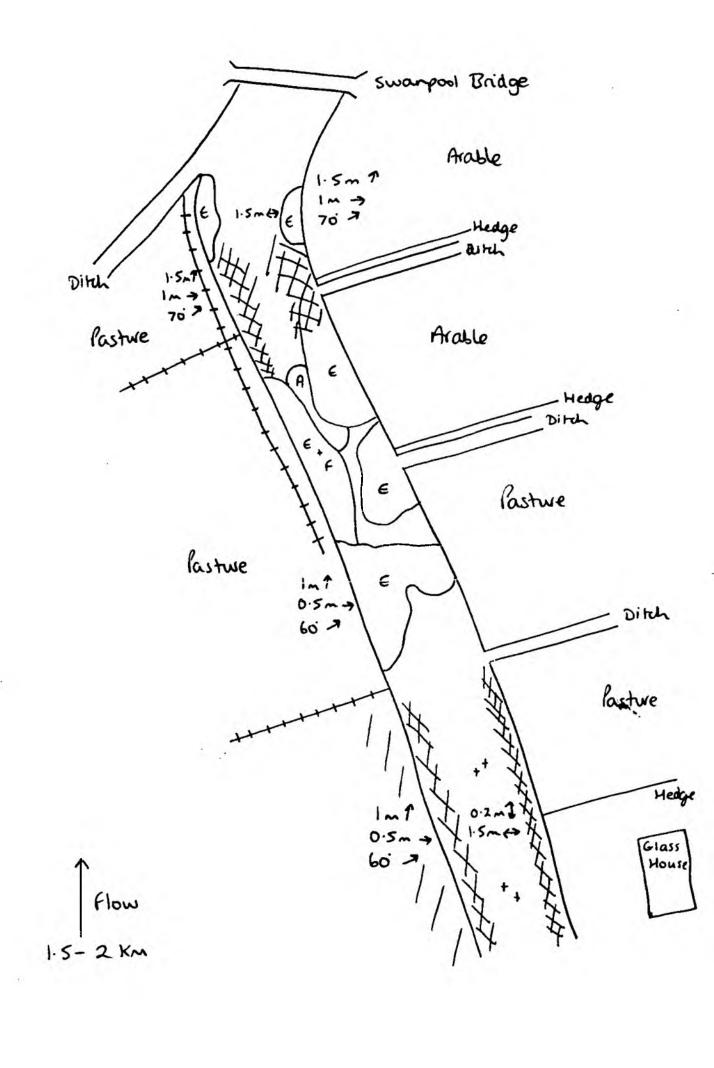
	transaction of the second second	LG	RB				LB	RB		RIVE
	WOOM THE A	T				BANK PRATURES 7.			RIVER HABITATS	1
١.	MOODIVING & 2CHAR %			NIVER BRAUNTON MARS	in	1-1- shell %			⊨ bridge:/500m	1
	Broad-leaved semi-nat.		1	01(F) OV 10/0 10/11CS	377.	solid earth chill (MT)			WAY wens/500m	1
	plantation			Km No. 0 - 0 - 5 Km		soft earth chill > 80			locks/500m	
	Comferous semi-nal.			Date 6/4/92		UU 10ck chill			intev500m	_1
	plantation	1		* '		CELLI ambient		1	Depth < 25m	10
	Mixed semi-natural	1	['	Surveyor JALD.		= 1 120 0 11	ĺ	1	1 .25 < 5	
	plantation	ļ		(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	BR	I TB flood bank set back	i		Ŷ 05·<1.0	Į
) •	Scrub - dense		1			levee	Ì		>1.0m	
	scattered	1	ł	G. OPEN WATER					Width <1	10
	Carr - alder			1. Standing canal + % of od;		Height < Im	100	100	1.<5	1,0
	willow	1		canal = land in a	- 1		[]			1
١.	Parkland			canal = land in each sheeth	1	\ \ \ >2m	- 1		↔ 5.<10	1
i.	Recently felled wood			dyke		Width < Ini	lioc) IOC	10-<20	1
•				pond, pool, cut-off %		1-<25m	ľ	1	>20	Ì
	GRASSLAND & MARSH %			lake %	i i	25.<5m	į			
•	•			gravel pit %	1	. >Sm	1		Substrates	1
•	Acidic unimproved		1	reservoir %		Slope - SU'			BR bedrock	
	semi-improved	1	ام.م. ا	444.4411.75	- 1	30 < 60°	100	100		
	Neutral unimproved	lico	$ \infty $	2. Running	1	60 < 90"		•	c cobbles	
	semi-improved		!	stream < lim wide -		>90°]	1	p pebbles	
	Calcareous unimproved semi-improved		i	1 Sin		tert and	l l	1	g gravel	
	linproved/respéded		ł	S 10m	- 1	555 Sad		1	s Suid + silvinid	110
	Maish/maishy grassland	ì	i	>10		bare shingle	1	1	② clay	
	_	1	i			vegetated should		1	peat peat	1
3.	TALL HERN & FERN %		ì	r. vocr	ļ	earth	100	1		
	Biacken		1	1. chil		97 natural colibles	الم	$ \infty $		
}.	Dpland spp_rich veget.	1		Stree		(b) natural boulders			(D) [NOO]	1. ~
s.),	Other - tall rudgraf		1	limestone pavement		BANK VEGETATION	Y		slack	110
•	pon ruderal	1	1	Cave					35 nille	
		1	1	office	1	Condet Oak, Ash, Sycamore	, }		↑↑ rapids	ì
).	BEATBLAND %	1] ,	2. artificial/waste	- 1	P Willow recent pollard	Sec.		TT run	-
-	•	1		l	-	W Willowold, not pollard			inn, waterful	1
•	Dwarfscrub - dry	1	j l	J. MISCELLANEOUS		5 Standard willows	.		AA protruding rocks	-
	wet			arable		A Alder			Maraina	1
•	Lichen/bryophyte			amenity grassland		Other trees			Margins	
•	Monlane			ephemeral/short herb	- [9 Young trees			slongle 1 bare	1
	Healt/grassland - dry			hedge #		Willy Thick Scrub/shrubs 7.			shingle, vegetated	
	wel			hedge =)	// Sparse Scrub/shrubs 7.			total mend	
	MIDE STREET HUN SPRING OF			lence on bank		5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	\$7	200	SSS Sand	1
	MIRE, FLUSH AND SPRING %			fence set back	ļ	MASSION.	100	100	1	
	Mires - bog	1		wall	,	Spanso open 7			rlora %	
	Fen - reed	1		budding 2	-	XXX Reseeded or mown Z.		1		1
	sedge	1		Catavanes forte force		Exposed free roots			energent very salm wide	110
	mixed		i i	lish lam sitage clamp		ISLANDS			emergent 1-2m wide emergent >2m wide	
	Bog flushes			Sewage works			1		lolal veget area	20
	9			datden		Rocky, vegetated			B bryothyles	1)
•	SWAMP/INUNDATION %			stick pile		slangle and rock		1	E emergents 100	12
	10			flood debus		shingle and rock shingle, rock + yea	1		A submerged	110
٠.	Swamp - single sp. dom. Tall mixed assemblage	[']	beot		X e earth - maturing	Ι	1	F floating	- Vin
	ron mixed assemblage	1	I	railway disused		earth - with trees			- algue % of stratch	Γ'
			I '	used		developed			3.00	
		1	1	other						1



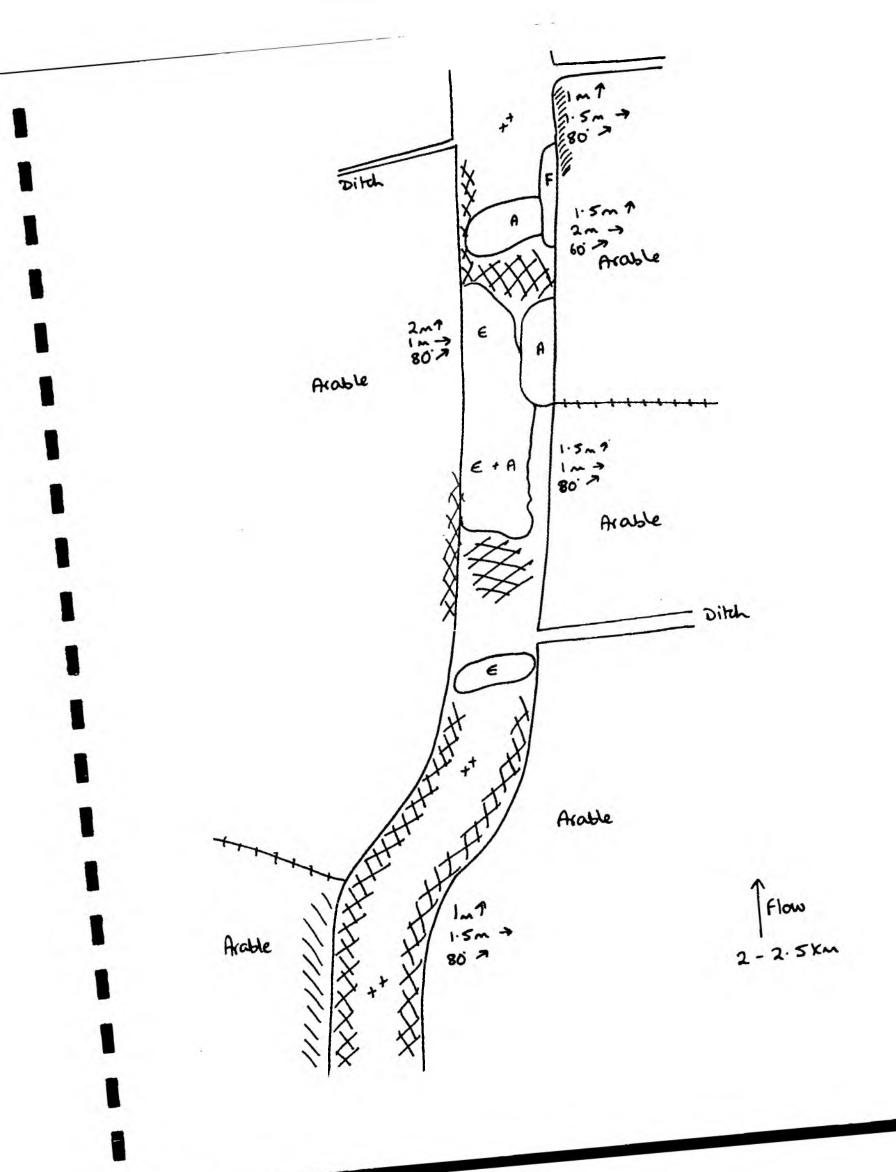
	LGIRB	LBIRB	18
A. WOODLAND & SCRUB % 1. Broad-leaved semi-nat. plantation Conferous semi-nat. plantation Mixed semi-natural plantation 2. Scrub - dense scattered Carr - alder willow 3. Parkland 4. Receptly felled wood B. GRASSLAND & MARSH % 1. Acidic unimproved	RIVER Brownton Marsh Rm No. 0 - 5 - 1 km Date 6/4/92 Surveyor JALD C. OPEN WATER 1. Standing - canal + % of adj canal = land in the distribution of the distribut	RIVER HABITATS	100
semi-improved Neutral unimproved semi-improved Calcareous unimproved semi-improved 4. Improved/resueded 5. Marsh/marshy grassland 6. TALL HERR & FERN % 1. Itracken 2. Upland spp. rich veget 3. Other - tall ruderal non ruderal D. REATHLAND %	Slope <30°	b boulders c cubbles p pebbles q gravel s and t silvinud clay peat Habitats and Flow D puol slack f rapids t rap mm. waterfall	10
1. Dwarf scrub - dry wet 3. Licher/Eryophyte 4. Montano 5. Healt/grassland - dry 6. wet 6. wet 6. MIRE, FLUSH AND SPRING % 1. Mites - bog Fen - reed sedge sweet-grass mixed 2. Dog flushes 6. SWAMP/INUNDATION 6. Swamp - single sp. dom.	J. MISCELLANEOUS arable amenty grassland ephemera/short herb hedge + hedge = lence on bank fence set back wall building caravins lish farm silinge clamp sewage works quirden stick pile flood debris	Shingle 1 bute shingle, vegetated title mind sss sand FLORA % currengent veg < Im wide emergent 1-2m wide emergent > 2m wide total veget area b bryophytes E emergents A submerged	MA 3~



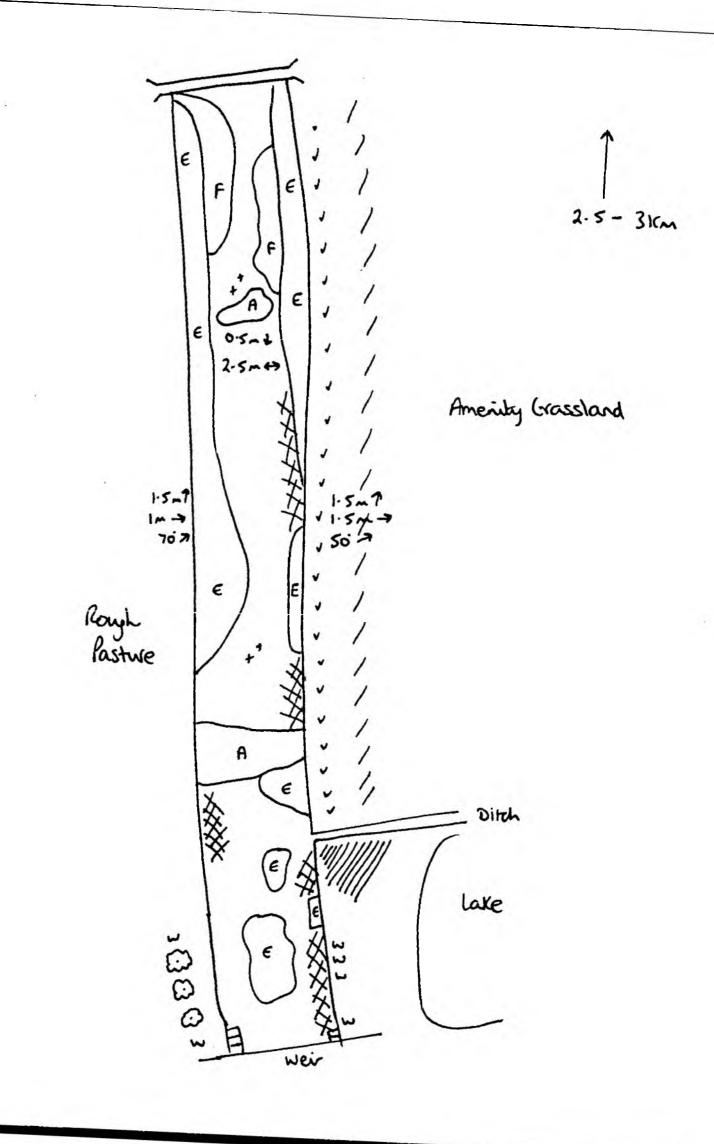
A. WOODLAND & SCRUB % 1. Droad-leaved semi-nat. plantation Conferous semi-nat. plantation Mixed semi-natural plantation Mixed semi-natural plantation 2. Scrub - dense scattered Carr - alder willow 3. Parkland 4. Recently lelled wood 8. GRASSLAND & MARSH % 1. Acidic mainproved semi-improved Neutral unimproved semi-improved Semi-improved Semi-improved Semi-improved 4. Improved/reseded 5. Maislymaisly grassland 6. TALL HERB & FERN 6. Upland app. rich veget 7. Other - tall ruderal non ruderal 7. Dwarf scrub - dry wet 8. Licher/Unyophyte 9. Montane 9. Licher/Unyophyte 9. Montane 1. Mires - bog Fen - reed scdge sweet-grass nixed 1. Dog flushes 7. SWAMP/INUNDATION 7.



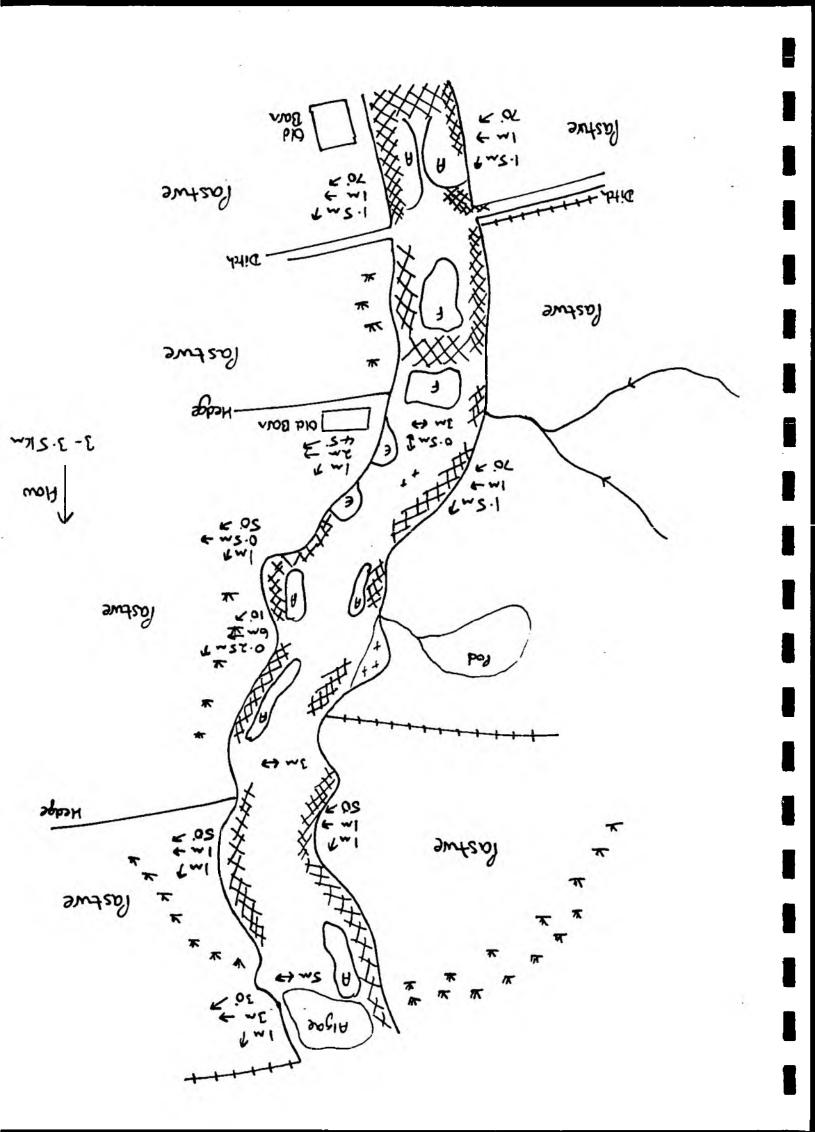
		LG IKE			r R	KR		KIA
1. 2. 3. 4. B. 1. 4. 5. C. 1. 2. 3. D. 1. 5. 6.	WOODLAND & SCRUB % Broad-leaved semi-nat. plantation Conterous semi-nat. plantation Mixed semi-natural plantation Scrub - dense scattered Carr - alder willow Parkland Recently felted wood GRASSLAND & MARSH % Acidic unimproved semi-improved semi-improved semi-improved Multial unimproved semi-improved Improved/respeded Marshymarshy grassland TALL HERR & FERN % Bracken Upland spp ruch veget. Other - tall ruderal non ruderal HEATHLAND % Dwarf scrub - dry wet Lichen/bryophyte Montane Heath/grassland - dry wet MIRE, FLUSH AND SPRING %	100 40	niver Brown Mash Km No. 1.5 - 2 KM Date 6/4/92 Surveyor JALD. G. OPEN WATER 1. Slanding - canal + % of odj canal = loud in canal = loud in dich dich dyke pond, pool, cul-olf % lake % gravel pit % reservor % marina % 2. Itoming stream < Int wide 1 Sin 5 10m > 10 1. ROCK 1. chiff scree limestone pavement cave other 2. artificial/waste 1. MISCELLANEOUS arable amently grassland epicemeral/short herb hedge + hedge = lence on bank 45 60	BANK PEATURES 7.	75.25	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Substrates filt bed rock b Emilders c cobbles p pebbles g gravet s Suid 4 silvinud © clay	100
1. 3. 4. 5. 6. E. 1	Dwarf scrub - dry wet Licher/bryophyte Montane Healt/grassland - dry		arable amenty grassland ephemeral/short herb hedge + hedge =	W Willow old, not pollard S Standard willows A Alder Other trees Young trees Thick Scrub/shrubs 7. Sparse Scrub/shrubs 7. Read/Scalge 7. Dense open 7. Sparse open 7. Resected or nown 7.	35		Margins Shingle 1 bine Shingle, vegetated	30
r. :	sodge sweet-grass mixed Bog flushes SWAMP/INUNDATION Swamp - single sp. dom. Tall mixed assemblage		caravans fish form silage clamp sewinge works garden stick jule flood debris road railway disused used other	Exposed tree roots ISLANDS Rucky, vegetated Procky, 1 bare Simple and rock shingle, rock + veg earth - maturing earth - with trees developed			emergent very < fin wide emergent 1-2m wide emergent >2m wide for the form of the first very find the firs	55 8- ET



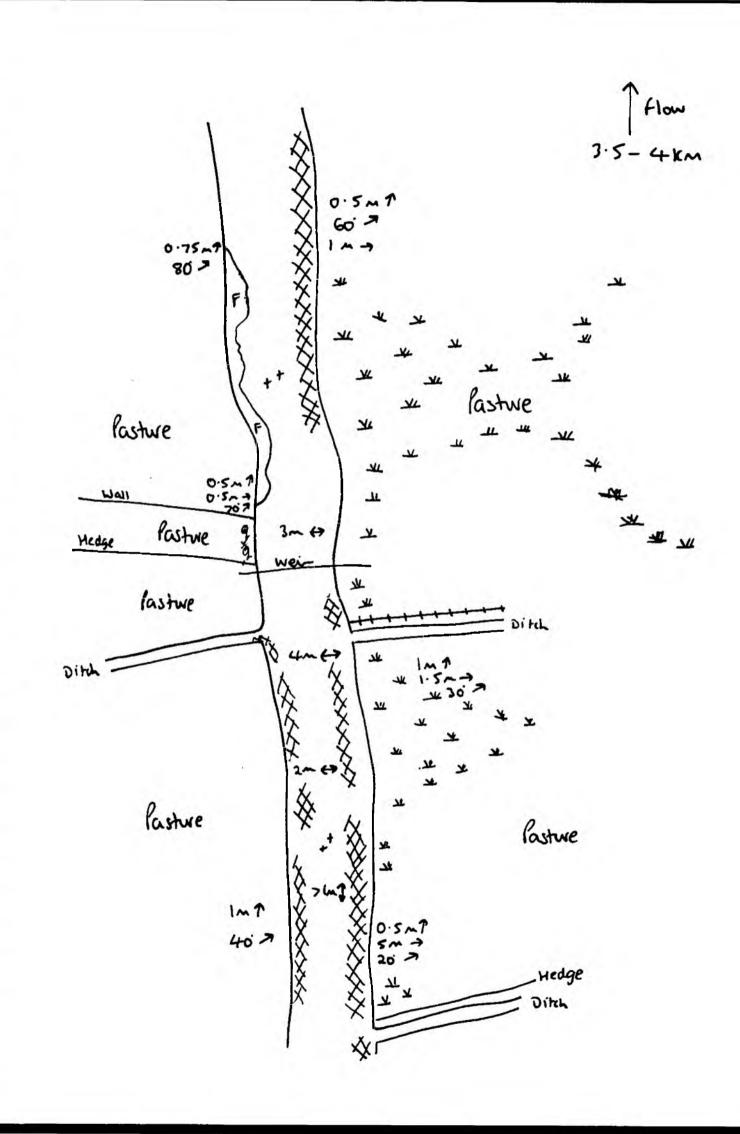
		LGI	RB					LB	RB		RIVE
Л.	MOODPUND & 2CHAR %			niver Braunton Motis	L:	1	BANK FEATURES /.			RIVER HABITATS H budges/500m	
1.	Broad-leaved semi-nat.		- 1		1	1.	solid earth chil [MT]	1		HAW wens/500m	1
	plantation	1 1		Ilm No. 2 - 2 . 5 km			solt earth chill > 80 (locks/500m	
	Comferous semi-nat.			Date 6/4/92			ULI rock chill		.	S inlev500m	_
	plantation	1 1					EEGIA actificial	i		Depth < 25m	1.~
	Mixed semi-natural	1 1	- 1	Surveyor JALD	. 12	RB	1′B - Ուշոք հան ակ	i		1 .0.1. 7.0	100
2	plantation Scrub - dense	1 [1		(I)	145	1'B Bood bank set back			Y 05-<1.0	
2.	scattered			G. OPEN WATER		1	.levee		i	>1.0m	
	Carr - alder	i l	1	1. Standing canal + % of od;			Height < Im			Width <1	ا
	willow		i	munt - lade in			↑ 1 < 2m	Ια	∞ık	1-<5	ΙO
Э.	Parkland		- 1	ditch each sherth	. 1	1	\ >2m			←→ 5·<10	
4.	Recently lelled wood	1 1	- I	dyke		-	Width < his	ĺ		10.<20	
•-	, and a second s			pond, pool, cut-off %			1.<25m	ltar		>20	1
B.	Crassland & Marsh %			lake %	İ	}	25-<5m	"		Substrates	
1.	Acidic unimproved	[gravel pit %	1	}	, >5m	- 1			
٠.	semi-improved			reservou 🔏			Slope *130"		[BR bedrock b boulders	
	Noutral unimproved	1 1		marma 7.			A 30 < 60°	h~	liω		
	semi-upproved	1 1		2. Running			60 < 90"	li 🗸	ابص	p pebbles	
	Calcareous mamproved	1 [stream < fm wide 1 Sm	1		>50.		1	g gravel	ł
	sem-improved	1 1		5 1004			tet mud			s Sincl	١. ـ
4. 5.	Improved/reseeded Marsh/marshy grassland	1 1		>10			555 sand	- 1		4 silvinud	10
IJ.	maisivinaisily grassiand ,	1 1			i	1	bare shingle AV: ** vegetated shingle **	1 .		Ø clay → peat	1
C.	Tall herb & Fern %			I. ROCK			carth	10	$\frac{1}{2}$		
١.	Bracken	1		i. chii]		W natural cobbles	۱۱۸	۰,۰۰۰	The Shall Street	-
2.	Upland spp_nch veget.	1 1		scree		1	Bahiral boulders	1		(D) twol	م ا
J.	Other - tall ruderal			limestone pavement		1	BANK VEGETATION			slack	ic
	tion ruderal			cave	1		淮 Comles	i		35 tille 11 trapids	
		1 1		other 2. artificial/waste			Comlet Oak, Ash, Sycamore 1	1		↑↑ rapids	
D.	HEATHLAND %	1 1				ł	P Willow recent pollard			nnn, waterfall	
١.	Dwarf scrub - dry	1 1		J. MISCELLANEOUS			W Willow old, not pollard			AA protruding rocks	1
	wel	1 1	- 1	arable		مرا	S Standard willows ' A Alder	1		A 5	1
3.	Licher/bryophyto	1 1		amenty quasiland	Jice	100	A Alder Other trees			Margins .	ł
4.	Montane	! !		ephemera/short herb	ĺ	1	O Young Irees			shingle 1 bare	
5.	Heath/grassland - dry		- [hedge 4			Milly Thick Scrub/shrubs 7.		8	### shingle, vegetated	
5.	wel	1 1	- {	hedge =			// Sparse Scrub/shrubs 7.	20	, `	4-4-(- naid	
Ε.	MIRE, FLUSH AND SPRING %	1 1	- 1	lence on bank	11	1	l ''	18		55≤ sand	
	Mires - bog	1 1		fence set back			Recalibring 7.	۲		FLORA %	
1.	Fen - reed	1 1		wall buiking			Sparse open %			r Loidi /o	
	sedge	il	Į.	Catavans			VV Reseeded or mown 7.	i		emengent veg ~ tor wide	10
	sweet-grass		- 1	fish larm			Exposed free roots			emergent 1-2m wide	
	mixed	1 1	- 1	silage clamp		1	IZTVNDZ		1	emergent >2m wide	100
۵.	Bog flushes			sewage works	ļ		Rocky, vegetated			lotal veget area	60
r.	SWAMP/INUNDATION %	1		garden etrek rata	1		d'o tucky, i bine	i	1	B bryophytes E emergents	15
				stick pile Rood debris			slingle and rock shingle, rock + yea			E emergents A submerged 19 P floating	H
١.	Swamp - single sp. doin.	1	- 1	toad				ì			- /10
	Tall mixed assemblage			railway disosed			garth - with trees	- }		- algae % of stratch	1
				used			4. developed				
	•			office		1			1		



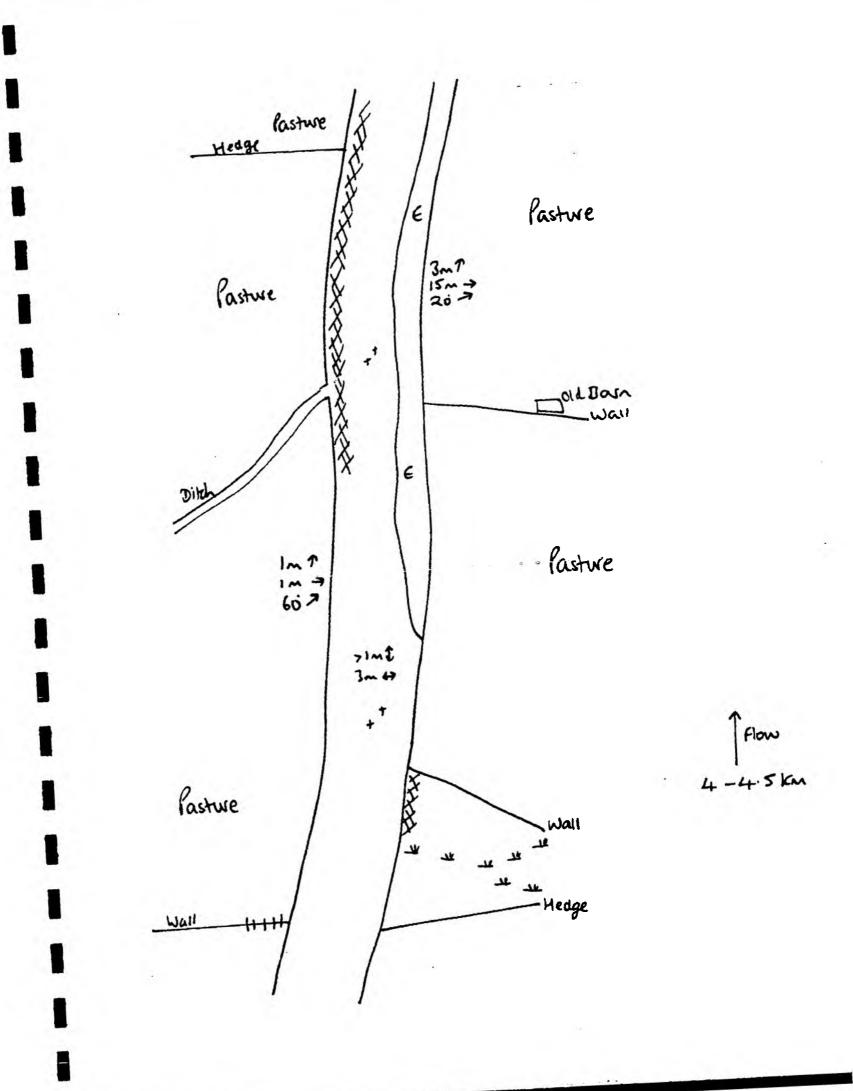
		LG	RB				Jan 1997	LB	RB		RIVE
_		T				V	BANK PEATURES 7.	1		RIVER BABITATS	
N.	WOODLAND & SCRUB %			MIVER Brownton Moth			1- shell 7.	1		≓ bridges/\$00m	1
ı.	Broad-leaved semi-nat.		ĺ	min Diamondo Harry			AAA solid earth chil [m1]	1		///// weits/500m	
	plantation		j	Ilm No. 2.5 - 3 KM		35	i and Chilichy Ist		1 1	locks/500m	
	Conferous semi-nat.									S inlev500m	
	plantation			Dale 7/4/92					1		-
	Mixed semi-natural						CCCM artificial	1	1	Depth < 25m ↑ .25 < .5	100
	plantation		1	Surveyor JALD	LIST	an	PB Boot Lank adj			¥ 05<1.0	1,00
2	Scrub - dense				(1)	11.7	1'B flood bank set back				-
2.	scattered	1		G. OPEN WATER			, levee			>1.0m	1
		i		l con at at at at	•		Height < Im			Width <1	
	Carr - alder	1		1. Standing canal + % of ody	li		本 I sain	lico	$ \omega $	1.<5	$ i\infty$
3	willow	ı	1	canal = land in	1 1		>2m	.~~	1.00	←→ 5-<10	
3.	Parkland		1	. dich	1 1	£				10 < 20	- 1
4.	Recently felled wood			dyke			Width <1m	l	امما	>20	Ì
				pond, pool, cut-off %	1		1-<25m	-100	100	260	- 1
3.	GRASSLAND & MARSII 🥠			lake %	1	10	25.<5m	- 1		Substrates	
	Audinumanund			gravel pit %			, >Sm	1			
	Acidic unimproved semi-improved	1		reservon X	[[Shiper -CHO"	- [BR bed ock	[
	Neutral unimproved	ماا	.	шаньа 7,	1		# 30 <60°	- 1	100	h bonders	
	semi-improved	Iα	4	2. Running			/ GO <90°	100	al I	c cobbles	
	Calcareous unimproved		1	stream < lm wide	1 1		>90,		1	p publics	ı
	sem-improved		1	1 5m	1		-ty-t- unit			g gravel	1
١.	Improved/resueded]	5 10m	1		12f2 mid 555 said	1	1	s Band	10
5.	Maish/maishy grassland	ì	1	>10	ll		bare shoulde	1	1	of sit/mud O clay	1.0
٠.	Midial Mi	- [1		ll		vegelated shingle		1		
C.	TALL DEAD & FERN %		1	I. ROCK	li		Carth	100			
٠.			1	1. cliff	l i		2 Gam	/~	~با√	Habitats and Flow	
I,	Bracken			Scied	i I					(P) pool	
2.	Upland spp-rich veget.			limestone pavement	ll			l.		slock	100
3.	Other - tall ruderal			ı ·			BANK VEGETATION	1		35 idle	ļ
	non ruderal	1		Cave other	l I		1 Conder			↑↑ rapids	
	0/			2. artificial/waste	ll		Conder Oak, Ash, Sycamore (
D.	HEATBLAND %			a. attricia virale			P Willow recent pollard			mm. waterfall	
	Dwarf scrub - dry	1		J. MISCELLANEOUS			W Willowold, not pollard	2	4	AA probuding rocks	ì
١.	•	ď	1		1 1		S Standard willows	-		profiteding tocks	
	wel		i	arable	Ī		A Alder			Margins	í
3.	Lichen/bryophyto	ĺ		amenity grassland	l ľ	90	← Other frees	3		wat Atto	
	Montane			ephemeral/short herb	1 !		Young frees	1.3		shingle 1 bare	
j .	Heath/grassland – dry	1		hedge +			#### Thick Somb/shrubs 1/2		5	shingle, vegetated	1
.	wel			hedge =			// Sparse Scrub/shrubs 7.		8 C	tole mud	
_			1	fence on bank	. 1				00	S≤≤ sand	ĺ
	MIRE, FLUSII AND SPRING %			lence set back			Reed/Gedge V.		1		
١.	Mires - bog		1	walt			Dense open y-	1		rlora %	
	Fen - reed		Į į	1nnkluuj			Sparse open 7.		80		
	sedge	1	1	Catavans			YVY Research or mown Z.		100	Chicalcia veri < tili wick	80
	sweel-grass			fish farro			Exposed tree roots			emergent 1-2m wide	120
	mixed ,			sitage clamp			ISLANDS	i		emergent >2m wide	
Z.	Bog flushes			sewage works			. Rucky, vegetated			lolal veget area	50
			1	garden			o tocky, I bire			II bryophytes	1
Г.	SWAMP/INUNDATION %		1	stick pile			shingle and rock	- (17
	Swamp – single sp. dom.	1		flood debris			shingle, rock + veg			F emergents 80 A submerged 45 F floating	10
••	Tall mixed assemblage	1	Ì	baot			X earth - mahring	- 1	1	P floating 5	-)
	ran mikeu assembiage		Į	tailway disused			earth - maturing earth - with trees developed]		algae % of stretch	-
		1	Ì	used	l		developed	- 1		1-10-1-10-1-10-1-10-1-1	
			1	other			· ucveloped	- 1	1		



A. WOODLAND & SCRUB % 1. Broad-leaved semi-nat. plantation Comletous semi-nat. plantation Mixed semi-natural plantation 2. Scrub - dense scattered Carr - alder willow 3. Parkland 4. Recently felled wood B. GRASSLAND & MARSH % 1. Acidic miniproved semi-improved Semi-improved Semi-improved Semi-improved Semi-improved 4. Improved/resudded 5. Marsh/marshy grassland 6. TALL HERR & FERN % 1. Bracken 2. Upland spp rich veget 3. Other - tall ruderal non ruderal D. HEATHLAND % 1. Dwarf scrub - dry wet 3. Lichen/bryophyte 4. Montane 5. Healh/grassland - dry wet 6. wet E. MIRE, FLUSH AND SPRING % 1. Mires - bog Ten - reed sedge sweet-grass mixed 2. Bog flushes F. SWAMP/INUNDATION % 1. Swainp - single sp. doin.



			IRB			LB	RB	A	RIVE
	n. WOODLAND & SCRUB % 1. Broad-leaved semi-nat. plantation Conferent semi-nat. plantation			RIVER Brownton Mossh; Km No. 3.5-4 Km Date 7/4/92	BANK PEATURES 7. The shell 7. AAA sold carth chill lad? Out ook chill ETTIU atthical			HIVER HABITATS bindges/500m wens/500m locks/500m inlev/500m Depth < 25m	1
	Mixed semi-natural plantation 2. Scrub - dense scattered			C. OPEN WATER	TB flood bank adj TB flood bank set back levee	Icc	49	Y 05 < 1.0 >1.0m	ıα
	Carr - alder willow J. Parkland Recently felled wood			1. Standing - conal + % a od ; canal = land in duch duch dyke	Height < lin 	100	60	Width <1 1 < 5 ←> 5 < 10 10 < 20	100
	B. GRASSLAND & MARSH %			pond, pool, cut-off % lake % gravel pit %	-> 1 < 2 5m 2 5 < 5m > 5m		30 30	>20 Substrates BR bed neck	
1.	semi-improved Neutral unimproved semi-improved Calcareous unimproved semi-improved	lα		reservon % marma 7. 2. Ramning stream < Inrwide 1 Sm	Slobe <30" 30 <50" 30 < 50"	40	100	b boulders c cubbles p pebbles g gravel	
Y	4. Improved/reseded B. Marsi/marshy grassland C. TALL HERR & FERN %		8	2 10an > 10	157 mod 535 sand 167 bare shingle 597 vegetated shingle earth			s Durd d silvinud D clay peal	10
	Bracken Upland spp. rich veget. Other - tall ruderal non ruderal	i		1. chiff scree himestone pavement cave other	## natural colibles ## natural boulders ### Conden ### Conden ### Oak, Ash, Sycamore			Habitats and Flow	10
	D. HEATHLAND % 1. Dwarf scrub - dry wet 3. Licher/bryophyto		ă	J. MISCELLANEOUS arable	P Willow recent pollard W Willow old, not pollard S Standard willows A Alder			nnn waterfall A protruding rocks Margins	İ
	4. Moniane 5. Health/grassland – dry 6. wel			ameinty grassland ephemeral/short herb hedge + hedge =	Other trees Young trees Thick Scrub/slimbs 7. Sparse Scrub/slimbs 7.			shingle 1 bare Shingle, vegetated	
	E. MIRE, FLUSH AND SPRING 9. 1. Mires - bog Fen - reed sedge	•		wall	Real/Sedge 7. Dense open 7. Sparse open 7. WY Reseeded or nown 7.	2		FLORA % chargentvice In wide	ıα
	sweet grass mixed 2. Bog flushes			fish farm	Imposed tree roots ISLANDS Rocky, vegetated Procky, 1 bare			emergent 1-2m wide emergent >-2m wide emergent >-2m wide total veget area the bryophytes	25
	I. Swamp - single sp. dom. Tall mixed assemblage			stick pile Acod debris road railway dishised	shingle and rock shingle, rock + veg earth - maturing carth - with trees			F. emergents A submerged P floating algae 7. of stretch	- J:
	4	- 1	1 1	used other	** developed				



Sluve base	
	Road
J 60 > 2.5 m ↑ 2 m →	

2m7 1m -> 70 ->	77 77 77 TT
	€ 34
$ \epsilon $	71m1 20m ->
	4m (2) x4
	++ / Pasture
lasture	سے
2m7 5m → 30 >	E
$ \epsilon $	_ v _
	*
Hedge	Wall

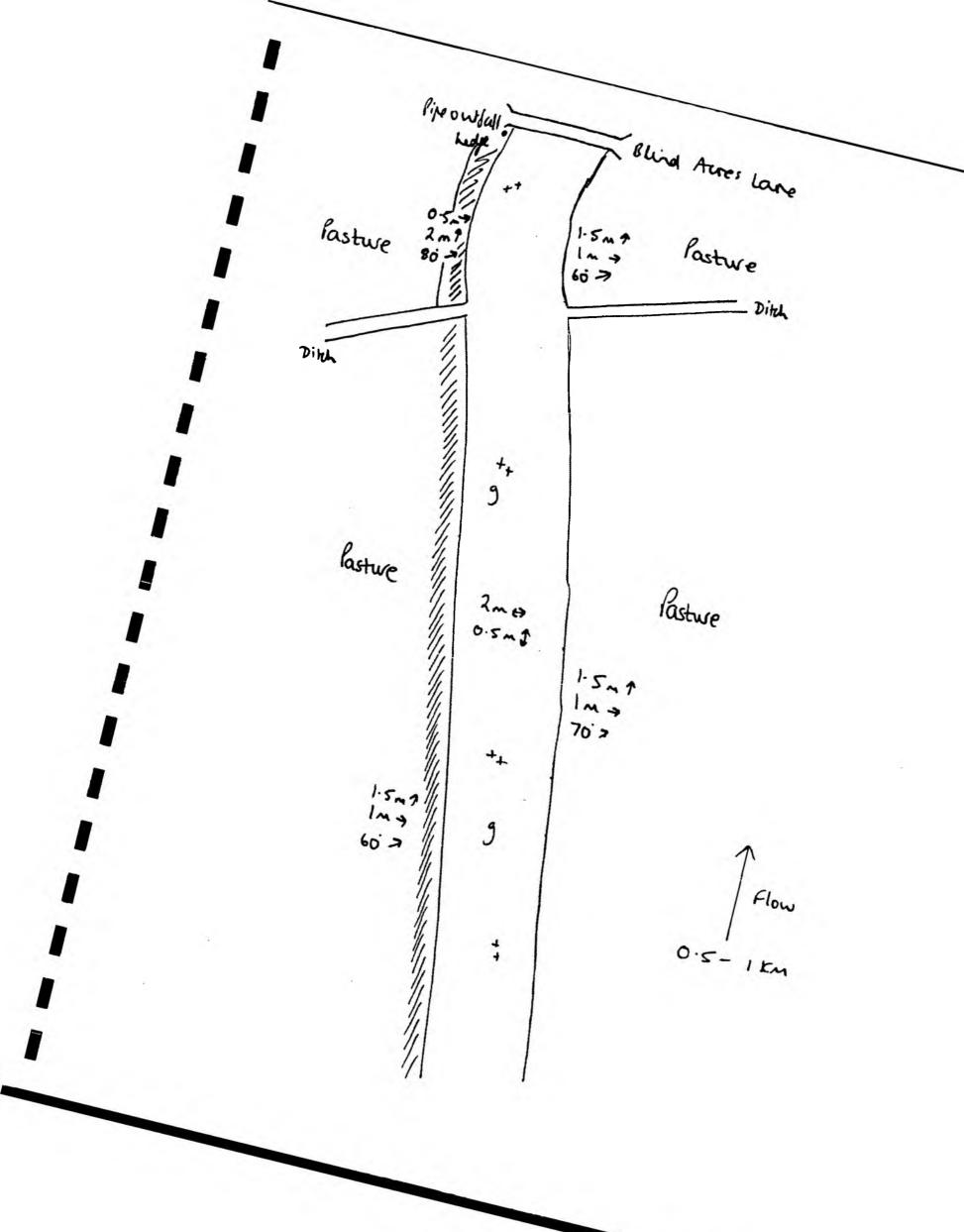
	, R6	ı	LBIRB	RIVE
Broad-leaved semi-nat. plantation Conferous semi-nat. plantation Mixed semi-natural plantation Scrub - dense scattered Carr - alder willow Parkland Recently felled wood GRASSLAND & MARSH % Acidic unimproved semi-improved	REBIOLATION MEUSE Rem No. 4. 5 - 5 Km Date 8 4 92 Surveyor JALD G. OPEN WATER 1. Standing - canal + % of odical canal = landing the condition of the condition of the condition of the condition of the canal c	BANK PEATURES 7. The shell 7. solid earth chill 1 A 7. MM solid earth chill 1 A 7. MM solid earth chill 1 A 7. MM solid earth chill 1 A 7. LIM rock chill EEM arthcal I'll flood bank set back levee Height < Im 1 < 2m > 2m Width < Im 1 < 2 5m 2 5 < 5m > 5m Slope: < 30° 30 < 40° 60 < 90° > 90° Tep-1 must 5 3 5 sand bare shundle A 1 < vegetated shungle	HIVER HABITATS bindges/500m wens/500m locks/500m locks/500m inter/500m Depth < 25m 25 < .5 0 5 < 1.0 >1.0m Width <1 1 < 5 5 < 10 10 < 20 >20 Substrates BR bed rock b boulders c cobbles probbles gravel s bind sil/mid clay peat Habitats and Flow (D) pool slack 35 riffle rip tapids rim nine waterfall AD protruding rocks Margins shingle ± bare shingle, vegetated	IC IC
MIRE, FLUSH AND SPRING % Mires - bog Fen - reed sedge sweet-grass mixed Bog flushes SWAMP/INUNDATION Swamp - single sp. dom. Tall mixed assemblage	fence on bank fence set back wall building Caravane: fish farm silage clamp sewage works garden suck pile flood debris road railway disused	Recel/Sedge 7. Dense open 7. Spanse open 7. WY Reseeded or nown 7. Exposed free roots ISLANDS Rocky, vegetated rocky, 1 bare shingle and rock shingle, rock + veg earth - maturing earth - with trees	FLORA % emergent very \ \text{in wide} cmergent \ \cdot \ \text{2m wide} cmergent \ \cdot \ \text{2m wide} chergent \ \cdot \ \text{2m wide} \text{lotal wirel area} B \text{by rephytes} E \text{cmergents} A \text{submerged} \text{A \text{submerged}} \text{Bouling} \text{algae % of stretch}	466

Post Maintenance. flow 1 0-0.5 Km. Ditch Dirth Pasture hedge Pastwe Dry ditch 1~7 0-5~ -> 1m7 0.5m7 ++ hedge hedge Pasture 0.25m 1 0.75 ~ 47 Pasture 9 Ditch Pump House Pasture MAIN RIVER LIMIT

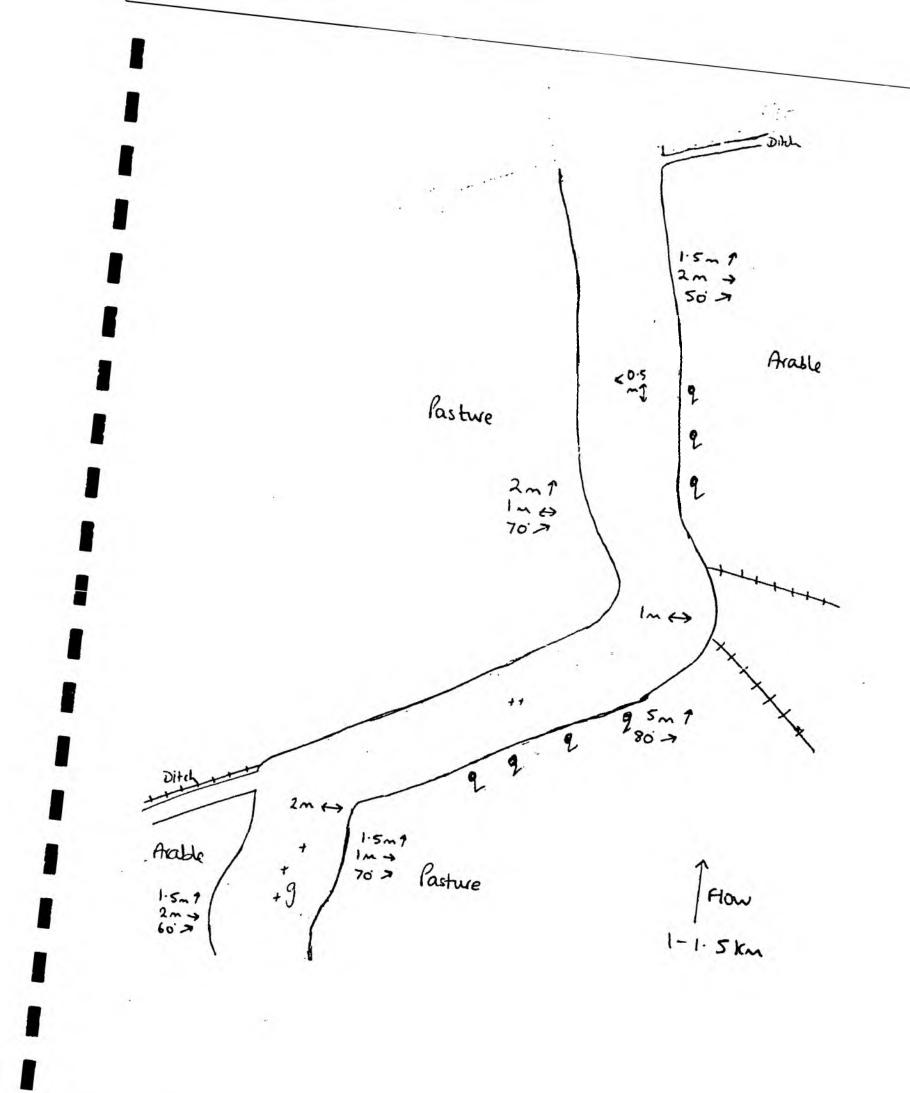
Braunton Marsh

		LG.	RB					LB	RB		RIVE
л. 1.	WOODLAND & SCRUB % Broad-leaved semi-nal. plantation Conferous semi-nat. plantation Mixed semi-natural plantation Scrub - dense			RIVER BRAUNTON M KIRNO. O - O. S KM Date 29/3/93 Surveyor JALD.	res H	RB	4 10 man bank samback			hidge:/500m	ια
3. 4.	scattered Carr - alder willow Parkland Recently felled wood GRASSLAND & MARSH % Acidic unimproved sent-improved Sent-improved Calcareous miniproved sent-improved	100	lœ	dyke pond, pool, cut-off Z lake Z gravet pit Z reservon Z			levee leight < lm	iœ	8 8	Width <1 1.<5 ←> 5.<10	100
1. 2. 3.	Improved/resueded Marsh/marshy grassland TALL HERB & FERN % Bracken Upland spp. rich veget. Other - tall rinderal non ruderal HEATHLAND % Dwarf scrub - dry			> 10 I. ROCK I. chil screet himestone pavement cave often 2. artificial/waste J. MISCELLANEOUS			bare shingle vegetated shingle cauth ratural cobbbes bank vegetated shingle cauth cauth Conder Cander Oak, Ash, Sycamore P Willow recept pollard W Willow old, not pollard S Standard willows	io	v 00	+ sittinud O clay peat Habitats and Flow P pool stack from rapids from rapids from waterfall A profunding rocks	10
l.	wel lacher/bryophyle Monlane Ileath/grassland - dry wel MIRE, FLUSH AND SPRING % Mires - bog Fen - reed sedge sweet-grass mixed Bog flushes			mable amently grassland ephemeral/short herb hedge + hedge = lence on bonts fence set bach wall bontding canavins heldann sitage clump sewage works	1 2	ı	A Alder Other trees Young trees Thick Scrub/shrubs 7. Sparse Scrub/shrubs 7. Reculfication 7. Dense open 7. YV Research or mown 7. Exposed tree roots ISLANDS Rocky, vegetated			Margins shingle 1 bare shingle, vegetated 1-14 mind 555 sand FLORA % emergent veg < for wide emergent 1-2m wide emergent > 2m wide total veget area	
	SWAMP/INUNDATION % Swamp - single sp. doin. Tall mixed assemblage			garden slick jule flowl debris road railway disused used			shingle and rock shingle, rock + veg earth - maturing earth - with trees developed			Disophytes E emergents A submerged P floating stretch) re

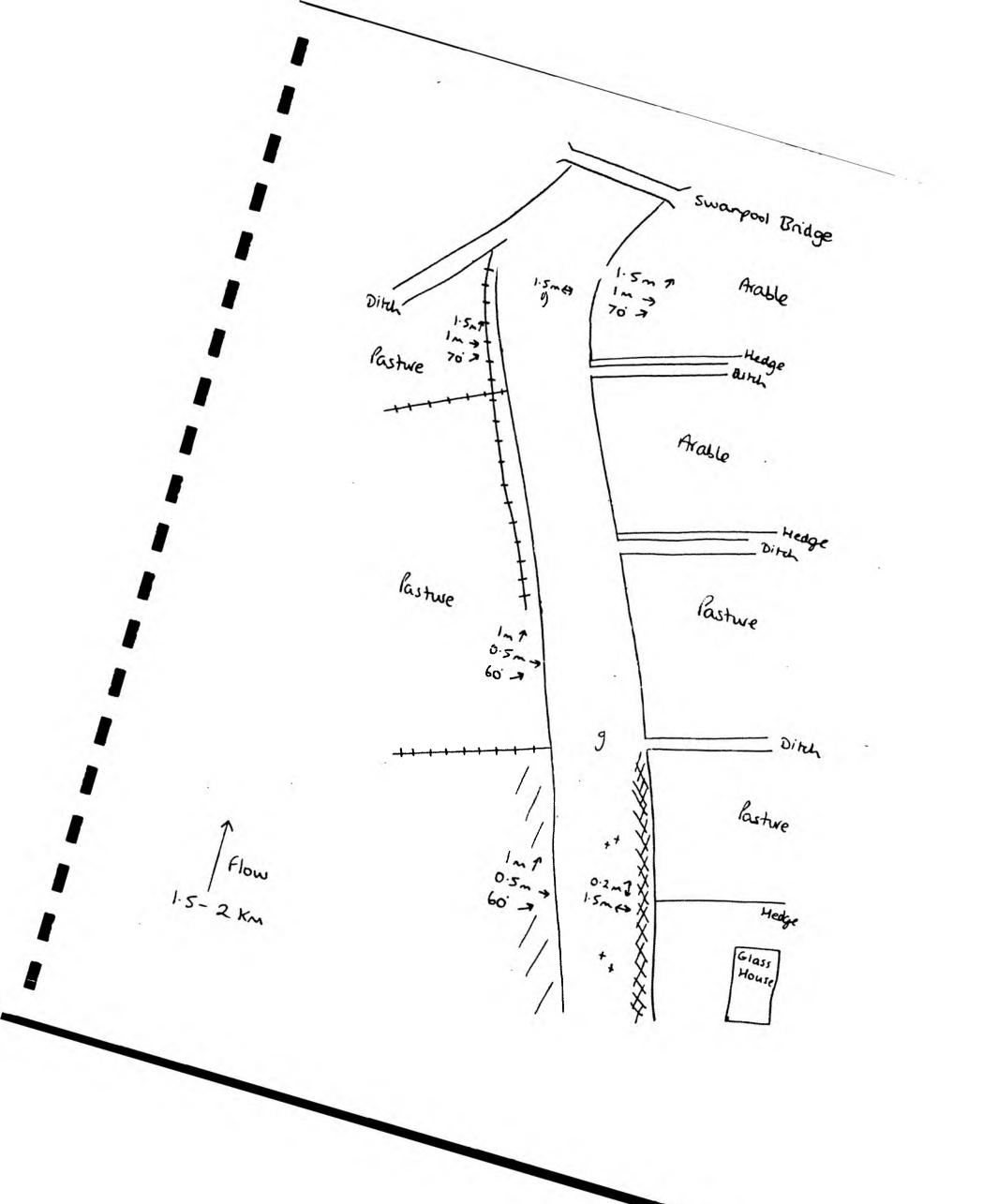
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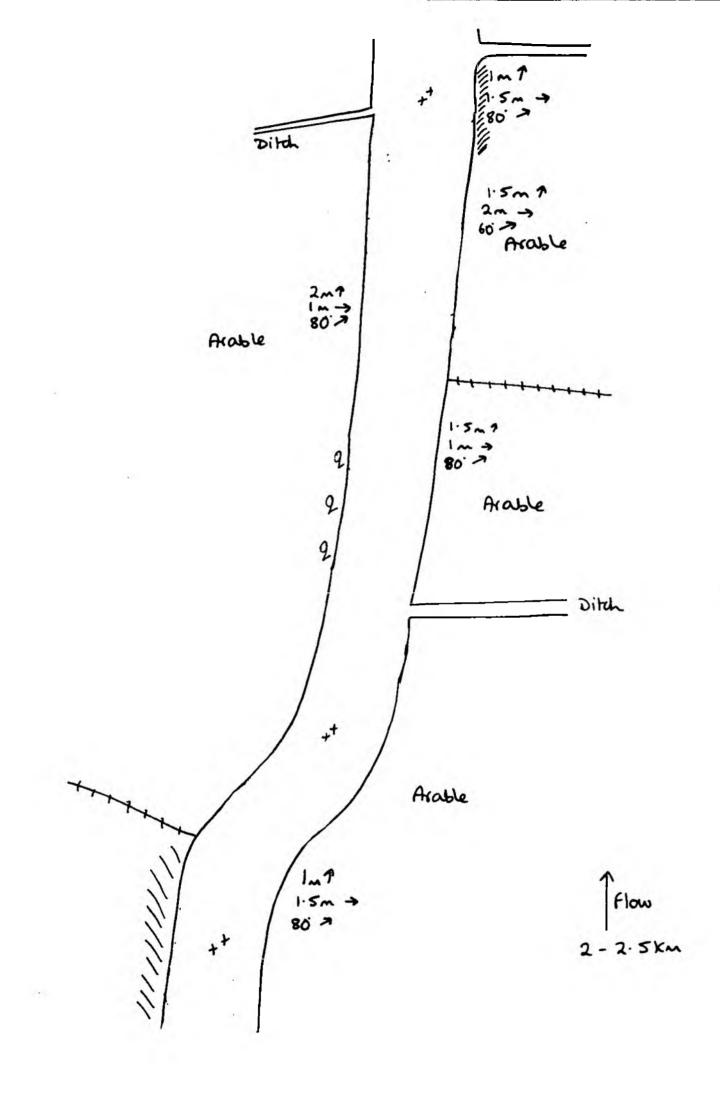
		LG	RO	3				L B	RB		RIVE
л. 1.	WOODLAND & SCRUB % Broad-leaved semi-nat. plantation Conferous semi-nat. plantation Mixed semi-natural plantation			,	ILIVER BRAUNTON MARSH : ILINI 210. 0 'S - 1 KM DAIN 29/3/93 GUIVEYOF JALD LIS	10	BANK FEATURES 7. Shell 7. AAA solid authorit 1AT } AAA solid authorit 280 } UNI rock chill CETHI addical The flood bank adj		•	HIVER HABITATS bidges/500m wens/500m locks/500m links/500m Depth < 25m 25 < .5 0 5 < 1.0	1
3.	Scrub - dense scattered Carr - alder willow Parkland				G. OPEN WATER 1. Standing - canal + % of adj const = ladd in chich	,	levee Heaght < 1m	va		>1.0m >1.0m Width <1 1 < 5 ← 5 < 10 10 < 20	ια
	Recently lefted wood GRASSLAND & MARSH % Acidic miniproved semi-improved		•		dyke pood, pool, cut off % lake		Width < Im 1 < 2.5m 2.5 < 5m > 5m Shipe < 300° ✓ 30 < 60°	30		>20 Substrates IIR bed rock to booklers	
4. 5.	Noutral miniproved semi-improved Calcareous miniproved semi-improved linproved/resolded Marsivmarshy grassland	100	100) ;	2. Romany stream < Im wide 1 Sm 5 10m >10		60 < 90" >90" Sp-1" mul 535 send (40) bare sharde	20		c colibles pebtiles gravel s sidvinud G clay	10
C. 1. 2, 3.	TALL HERB & FERN % Illiacken Upland spp. rich veget. Other - tall toderal non ruderal			1	L ROCK L chill screet minestone pavement cave other		Control Country Cou)(201 00	peat Habitats and Flow P (200) Slack S (100) C (200)	ıc
D. 1. 3.	UEATULAND % Dwarf scrub - dry wet bichen/bryophyte] 1	2. artificial/waste J. MISCELL/ANEOUS arable amenty grassland		P Willow recept pollard W Willow old, not pollard S Standard willows A Alder			mn. waterfull A profruding rocks Margins	
4, 5. 6.	Montane Health/grassland - dry wel MIRE, FLUSH AND SPRING Yo				epheneral/short herb hedge + ledge = lenge on Isin): fence set back		Other trees Voung trees Thick Cambridge V. Space Sambridge V. Recalledge V.	ıc	Ø	shingle 1 bare shingle, vegetated tild-mid sss sand	
l.	Miles - bog Fen - reed sedge sweet-grass mixed				wall Dinkhing Carawans fest facu Salage Ching		Over open 7- Spatte open 7- YY Resceded in nown 7- Expended free roots			CLORA % concepted veg < he wide concepted 1-2m wide concepted >2m wide	
г.	Bog Rushes SWAMP/INUNDATION % Swamp – single sp. dom. Tall mixed assemblage				sewage works garden stick pile flooif defins road railway - disased		Rocky, vegetated stand rock stander tock stander tock y earth - maturing			lotal veget area	-

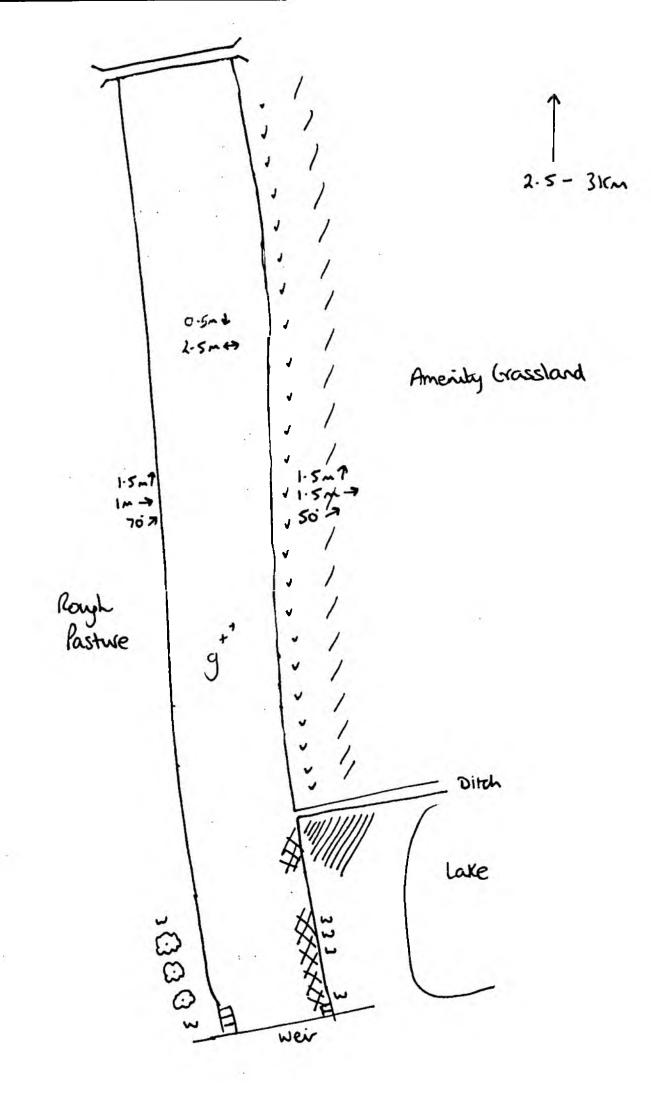


		LG R	B			7 4 7 5 4	LB	RB		RV
л. 1. 2.	WOODLAND & SCRUB % Broad-leaved semi-nat. plantation Conferents semi-nat. plantation Mixed semi-natural plantation Scrub - dense		tite Un Da	VEYOU JALD	s Ro	BANK PEATURES 7. The shell 7. AAA solid controlled by 7. AAA solid controlled by 7. AAA solid controlled by 80. LETT nock chill LETT artificial Ph. flood bank set back levee			RIVER HABITATS	- 100
3.	scattered Cart - alder willow Parkland Recently felled wood) i.	Standing - comal + % of odj Comal = look in Chich dyke pond, pool, cut-off %		Height < Im 1 < Zim > Zim Width < Im 1 < Zim 1 < Zim		0100	Width <1 1.<5 ←→ 5.<10 10.<20	ıα
D. 1.	GRASSLAND & MARSH % Acidic unimproved semi-improved Neutral unimproved semi-improved	100 60	2.	lake % gravel pit % reservor % marma %		2.5 < 5m >5m Slope: < 30° 50 < 50° >90°	20	40	Substrates IR bed neck to boulders c cobbles p pebbles	
4. 5. C.	Calcareous unimproved semi-improved Improved/reseeded Marsh/marshy grassland TALL HERR & FERN		1.	1 Sur 5 10m >10 ROCK		the must said bare sharely said we regulated sharely carth			g grave) 5 Dind 1 silvinud 6 Clay Peat	9
1. 2. 3.	Bracken Upland spp-rich veget. Other - fall ruderal non ruderal			chil sarea limestone paveniant cave other		Institute colobes Institute colobes BANK VEGETATION Condex Oak, Ash, Sygamore			P pool skack	IC
J.	Dwarf scrib - dry wet tacher/bryophyte] 2.]].	artificial/waste MISCELLANEOUS arable simently grassland	40	P Willow recent pollard W Willowold, not pollard S Standard willows:			mnn, waterfall ΔΔ profunding rocks Margins	
4. 5. 6. E.	Montane Health/grassland - dry wel MIRE, FLUSH AND SPRING %			ephemeraVshortherb hedge 4 hedge = fence on tymb fence set bach	1	Young frees Thick Scrub/shrubs 7. Spanse Scrub/shrubs 7. Recul/Scalge 7.			slungle 1 bare Shugle, vegetated 1-14- mul 555 said	
1.	Mires - bog Pen - reed sedge sweet-grass mixed			wall building caravans lish farm silage clamp		Demar open V- Spanse open V- NXY Resceded or mown V- Exposed tree roots ISLANDS	ļ	20	PLORA % emengent vert < 1m wick emergent 1-2m wide emergent > 2m wide	
1	Bog flushes SWAMPINUMDATION %			sewinge works garden stick jule		Bocky, vegetated by nocky, 1 bine should and rock			B bryoghytes E emergents	3
1.	Swamp – single sp. dom. Tall mixed assemblage			flood debus road railway - disused		shingle, rock + veg earth - maturing earth - with trees			A submerged P floating aligne // of stretch	-);

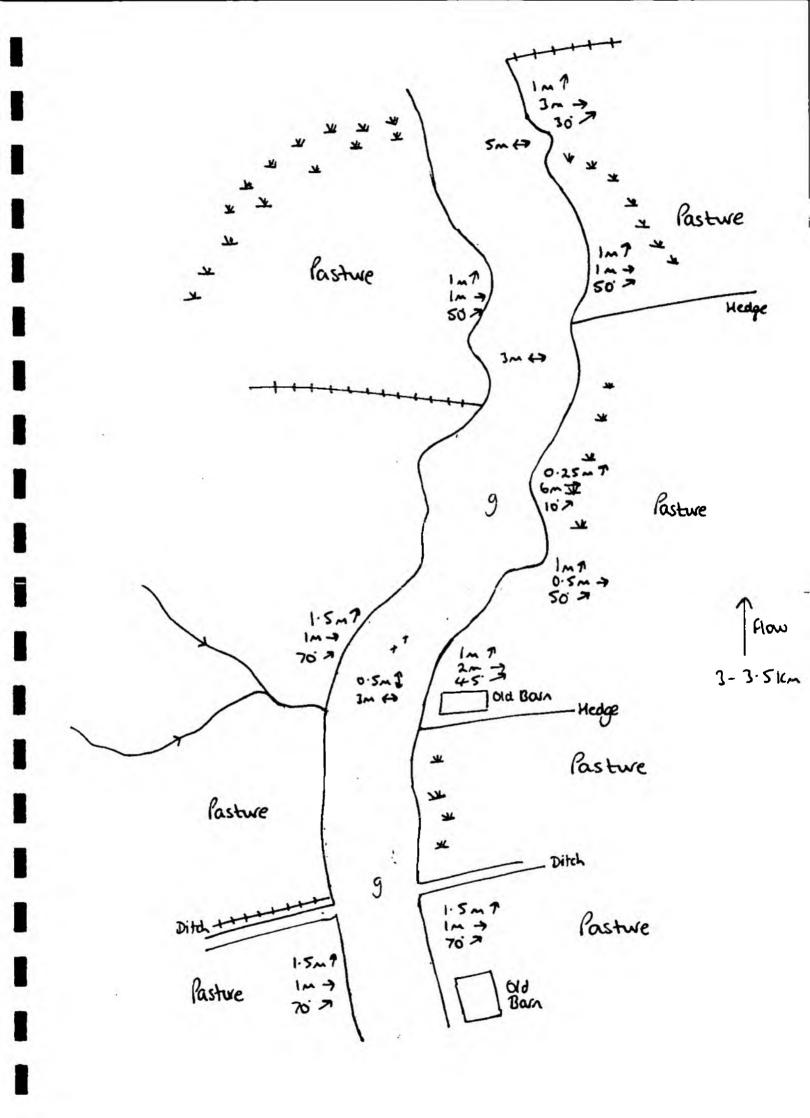


		16	RE	3				LB	RB		RV
90 10		-					BANK PEATURES 7-			RIVER HABITATS	1.
Λ.	MOODPUND & 2CHAR &			MINER ADALIANTON AND			71 shell 7.		1	≓ bridges/500m	
1.	Broad-leaved semi-nat.			HIVER BRAUNTON MAR	SH		AAA sold catheld [MT]		!	//// weits/500m	
	plantation			Km Ho. 1.5 - 2 Km			603 sult earth chill 780			locks/500m	
	Conferous semi-nat.	1	1	1145 24 1-15-			1111 rock chill			S inlev500m	_
	plantation	1		30/3/93			EELE artificial	1	l	Depth < 25m	110
	Mixed semi-natural	1	1	Surveyor JALD	- 1	100	1'D flood bank adj			.6.1	1
	plantation			of to D	LIS	RB	TB flood bank set back	Ì	l i	Y 05 < 1.0	
2.	Scrub - dense	1		G. OPEN WATER		4	levee			>1.0m	- 1
	scallered	!	1				Height <tm< td=""><td></td><td></td><td>Width <1</td><td></td></tm<>			Width <1	
	Carr - alder	1	1	1. Standing canal + % of ody			本 I < Zan	100	ισ		10
	willow			לאוווי – מיינג נותיו	ik	20	>201	Ι"	, •	←→ 5 < 10	
	Parkland	-	1	Guca	1	3	· ·		li	10.<20	
4.	Recently felled wood	1	[dyke		_	Width < Im	75	ارحما		-
_	COREST THE PARTIE OF			pond, pool, init-off %			→ 1.<25m	75	100		ı
D.	Grassland & Marsh %	1		lake %			2.5.<5m . >5m	Ì		Substrates	
1.	Acidic unimproved	1		gravel pil 7. reservor 7.	į		Shane «Cur	į.	1	BR bed rock	
	senulimproved	اسما	ا		l		2 30 -com		l i	b boolders	
	Neutral mimproved semi-improved	lω	440	Z. Romany		1	00 -: 90"	100	$ \omega $	c colibles	1
	Calcareous miniproved		1	stream < lm wide	- 1		>00.		1	p pebbles g 's gavet	2
	seminproved)	1 Sm	- 1		"ty-1" and		1 1	s and	٦٤
4.	Improved/resedded		1	5 10m >10		9	335 sand		1 1	t silvinud	8
5.	Maist/maishy grassland .		1	>10			bare slungle		1	€D clay	`
_	0/	1		I. ROCK	1		150 vegetated shingle	100	l	~ peat	
C.	Tall herd & Fern $$						earth	$- \log$	1∞	Habitats and Flow	
1.	Bracken	l	1	1. chili	- 1		autural cobldes in natural boulders	Ì		(P) puol	- 1
2.	Upland spp. rich veget.	1	1	SCIEC				- 1		slack	110
Э.	Other - fall nucleial	1		hmestone pavenient cave	- 1		HANK VEGETATION	i		35 utile	- [' '
	non ruderal			offing			Conder Oak, Ash, Sycamore		[Art aquids	
11	иелти і лир %	1	ļ	2. artificial/waste	1	7.4	P Willow recept pollard	1		33 1100	
	· •	1					W Willowold, not pollard			ingo, waterfall	J
1.	Dwarfsemb - dry	1	1	I. MISCELLANEOUS			5 Standard willows	- 1		AA protruding rocks	
	wel]	arable		1	A Alder	1		Maria A	i
	lacher/bryophyto Montano	ľ		amenity graesland			(37 Other trees		'	Margins	
	l leath/grassland – dry		l l	ophomera/short horb			Young trees	J		shingle 1 bare	
G.	Wel			hedge 4		3	Mille Thick Scrub/shods: 7.			shingle, vegetated	
		1		hedge =	45	60	// Sparse Scrub/shrobs 7.	35		tolde maid	
E.	Mire, flush and spring 🍫 🗀		t	leace on bont: leace set back			apply Recalledge Z			≶4≶ sand	
	Mires - Dog		1	wall			Denne open Y-	-		TLORA %	1
	Fen - reed			building		2	Sparse open Z			7.0	
	sedge			Caravaes		-	KY Reseeded or mown Z. Exposed tree roots	- {		enorment vest < his wich:	3
	sweel-grass	1	\	hish ku m			ISLANDS		1 !	emergent 1-2m wide	٦
2	mixed Boy flushes	1	[sdage cloup						emergent >2m wide	
-			l	sewage works garden			Rocky, vegetated	Ì		h total veget area	,
Г.	% поітлининічими	1	1	garden stick jule	- 1		Shortocky, I brue Sharple and rock			E energiests	15
	Swainp - single sp. doin.	1	1	Bood debris	i		shingle, rock 1 veg			A submerged	1
	Tall mixed assemblage	1	1	ioad			Z carth - maturing	1		12 floating	- /
	· · · · · · · · · · · · · · · · · · ·	1	1	railway disased			earth - with trees	- }		- algae % of stretch	
				used			The second secon				

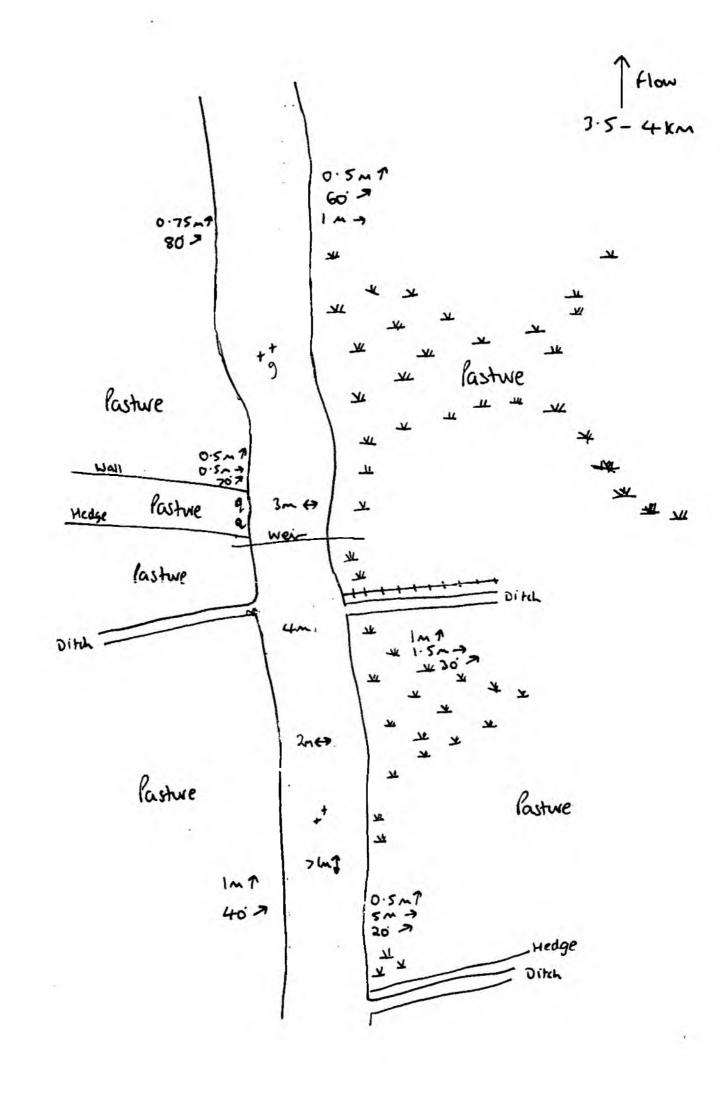




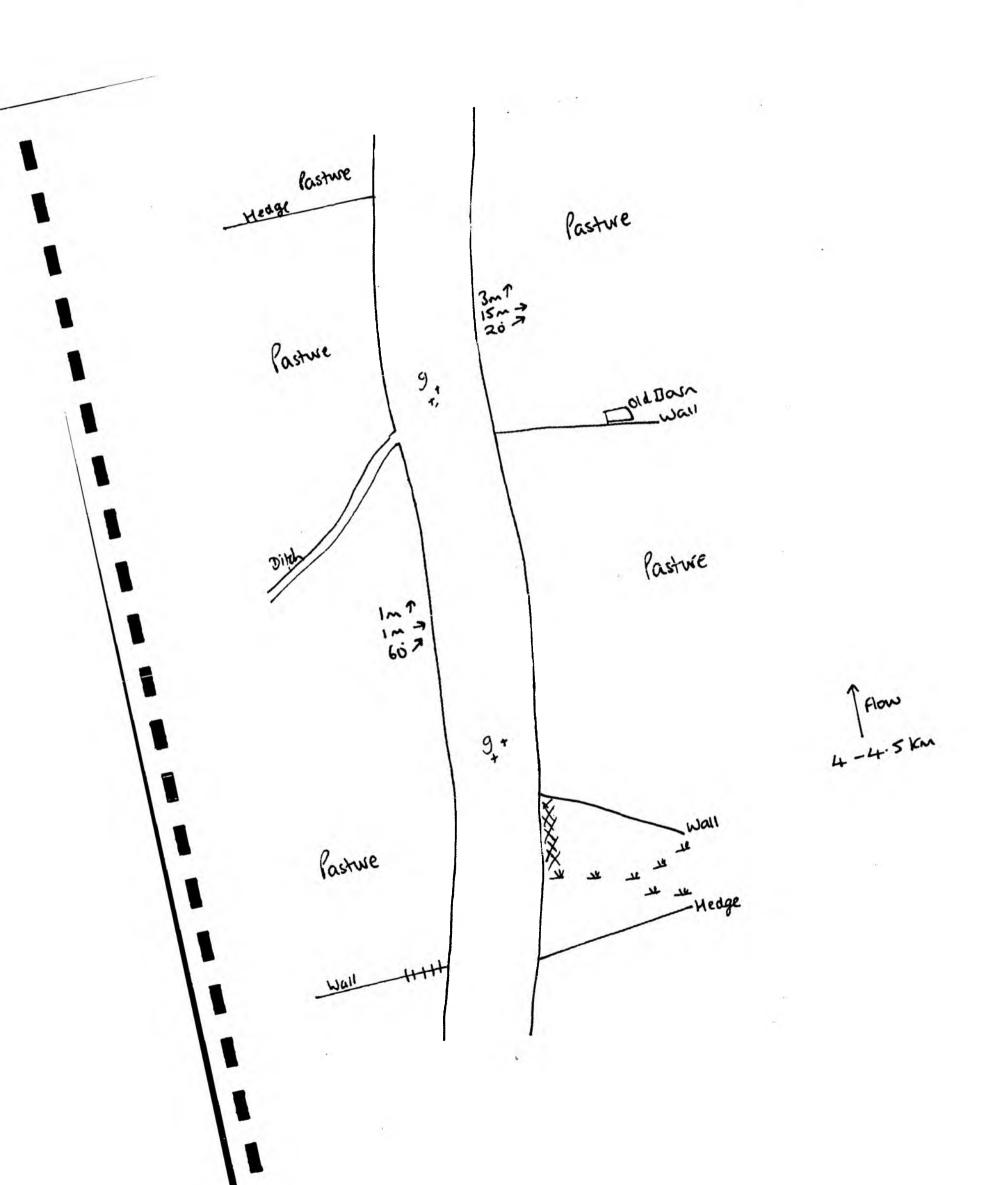
		LGIR	રહ					LB	RB		181
л. i.	WOODLAND & SCRUB % Broad-leaved semi-nat, plantation Conferous semi-nat, plantation Mixed semi-natural plantation			RIVER BRAUNTON MARSH KIII No. 2:5-3 KM Date 30/3/93 Suiveyer JALD	us l	RB	HANG PEATURES 7. The shell 7. Add sold controlled [AT] AND sold controlled [AT] (1) rock chill (EXTH) antificial The flood bank set back	1		RIVER HABITATS	10
	Scrub - dense scattered Carr - alder willow Parkland Recently felled wood			G. OPEN WATER L. Standing canal : % of odj Canal = lack in Cock stretch dyke		ı	levee Height < Im 		100	<-> 5.<10 10.<20	14
	GRASSLAND & MARSII % Acidic Unimproved			pond, pool, cut-off % lake % gravet pit %		10	→ 1.<25m 25.<5m , >5m	100	100	Substrates OR brid orck	
4.	semi-improved Noutral mimproved semi-improved Calcareous mimproved semi-improved Improved/resuéded	100		1689 VOI X			30 < to" 30 < to" 50 < 90" >90" 17:15 mod 33.5 smd	ıα	8	ti boulders c colbiles p pebbles gravel s Suid d silvand	3
1,000	Maislymaishy grassland TALL HERB & FERN % Illiacken Upland spp. rich veget. Other - tall ruderal non ruderal			I. ROCK I. cliff screet Innestone pavement cave			bare shingle Very verestated slungle earth talural cobbles annal boolders BANK VEGETATION E. Conder	10	0 100	P pool slack	ı
D.	HEATHLAND %			2. artificial/waste			Oak, Ash, Sycamore P Willow recent pollard W Willowold, not pollard	2	4	Tr rapids Truit Ann. Waterfall A proteeding tooks	
3. 4. 5. 6.	wel Licher/Bryophylo Montane Heath/grassland - dry wel MIRE, FLUSH AND SPRING %			arable amenty graesland ephemeral/short herb hedge 1 hedge = hence on (xon):		90	S. Standard willows A. Alder S. Other trees Voung trees Trick Scrab/shrubs 7, Spanse Scrab/shrubs 7, Reed/Sedge 7.	3	5	Margins shingle 1 bare shingle, vegetated 1-14 mind 545 sand	
l.	Mires - bog Fen - reed sedge sweet-grass mixed			lence set back wall badding caravare: lish larra silage clomp			Denise open Y Spatse open Z XX Resceded or mown Z Exposed free roots ISLANDS		80	emergent ver; < hn wide emergent 3:2m wide emergent >2m wide	
r.	SWAMP/INUNDATION % Swamp = single sp. dom. Tall mixed assemblage			sewage works garden stick pile flood debris road railway - disused			Rincky, vegetated strong rocky. I bare shingle and rock shingle, rock I veg carth - maturing earth - with trees			total veget area If bryophytes E emergents A submerged P floating stretch	- 3



	LGIRE	E-2.55.00	LB RB RNV
A. WOODLAND & SCRUB % 1. Broad-leaved semi-nal. plantation Conferous semi-nat. plantation Mixed semi-natural plantation 2. Scrub - dense scattered Carr - alder willow 3. Parkland 4. Recently felled wood B. GRASSLAND & MARSH % 1. Acidic unimproved	LGRO	BRNK BRAUNTON NATESH BRNK AAA BAIR BAIR BRNK TI AAA BAIR BRNK TI AAA BAIR CHIB CHIB CB RO FB CB RO FB CB RO	1 < 2m
semi-improved Noutral unimproved Semi-improved Calcareous unimproved 4. Improved/resueded 5. Marslymarshy grassland C. TALL HERH & FERN 1. Bracken 2. Upland spp. rich veget 3. Other - fall ruderal pon ruderal D. HEATHLAND	90100	1	30 < 40° 60 < 90° > 90° nord sand bare shoughe very stated shoughe earth natural colobies natural boulders (VEGETATION Conter Oak, Ash, Sycamore Willow repeat valland
1. Dwallscrub - dry wet 3. Licher/bryophyte 4. Montane 5. Heath/grassland - dry 6. wel E. MIRE, FLUSH AND SPRING % 1. Mires - bog Fen - reed sedge sweet-grass mixed 2. Bog flushes F. SWAMP/INUNDATION 1. Swamp - single sp. doin.		tence set back wall building consecue fish large schaige clamp sewage works garden	Willow old, not pollard Standard willows Alder Other trees Young frees Thick Scrub/shrubs 7. Sparse Scrub/shrubs 7. Recel/Gedge 7. Dense open 7. Reseeded on mown 7. Expossed free roots Wargins Shingle ± bare shingle, vegelated 1444—mid 555—sand FLORA % Consequent veg—bo wich energent tellowabe



		16	RB				LB	RB		BING
л. 1.				HIVER BRAUNTON MARSH KINRO. 3-5- 4 KM Date 30/3/93	` ',;	HANK PEATURES /. The shell /. AAA solid sathrold IAT AAA solid sathrold IAT [IVI nuck chill ETHII authoral			RIVER HABITATS bridges/500m wens/500m locks/500m inter/500m Depth < 25m 25 < .5	_
2.	plantation Scrub - dense			G. OPEN WATER	RB.	FB			7 05 < 1.0 >1.0m	103
J. 4.	scattered Carr - alder willow Parkland Recently felled wood			1. Standing canal (% of od) canal = lockly in clack datch dyke	1	Deght < Im 	Iα	38	Width <1 1 < 5 ←→ 5 < 10 10 < 20 >20	100
D.	Grassland & Marsh %			pond, poal, cut-off % lake=%		25-<5m	ł	88	Substrates	
1.	Acidic unimproved semi-improved Neutral mimproved semi-improved Calcareous unimproved	180		gravel pit 7. reservon 7. marina 7. 2. Rinanny stream < hir wide 1 5m		500 < 500° 500 < 500° 500 < 500° 500°	88	100	Bll bed nek b boulders c cultibles p pebbles q = gravel	
4.	semi-improved Improved/resolded Maislymaishy grassland		100	5 10m	4.	19-1 mod 338 sand bare sharde			s And 1 silvimid @ clay	ica
C. 1. 2. 3.	tracken Upland spp rich veget. Other - latt ruderal non ruderal			I. ROCK I. chif Street Innestone privement cave other		vegetated shingle carth Vegetated shingle united cobbles united bonders BANK VEGETATION Contes Oak, Ash, Sycamore	icc	100	Habitats and Flow Pool Slack 35 Hille The rapids	100
D.	иелтиглир %			2. artificial/waste		P Willow recent pollard			M mm. Waterfall	
1. 3. 4. 5. 6.	Dwarf scriib - dry wet Licher/Eryophyle Montane Heath/grassland - dry wet			J. MISCELLANEOUS arable amenty (practical) ephemera/short herb herige + herige = fence on (sock	1	W Willow old, not pollard S Standard willows A Alder Other frees Young frees Thick Scrubyshrubs 7,			Margins Shingle 1 bare Shingle, vegetated 144-mind 555 sand	
1.	MIRE, FLUSH AND SPRING % Mires - bog Fen - reed sedge sweet-grass mixed			fence set back wall Inolding caravors list farm silage clamp		Recalification V. Densa open V- Sparse open V- VY Recarded or movie V. Deposed free roots ISLANDS	2		FLORA % etnergent veg < hir wide emergent 1-2m wide etnergent >2m wide	
	Bog flushes .			sewacją works garden		Rocky, vegetated			B bryophyles	3
1.0	SWAMP/INUNDATION % Swamp - single sp. dom. Tall mixed assemblage			stick pile Bood delins road raiway - disped		sharple and rock sharple, rock (veg earth - maturing earth - with trees			A salmerged G	-



	IRB LB	BIRB	RIVE
A. WOODLAND & SCRUB % 1. Broad-leaved semi-nal. plantation Conferous semi-nal. plantation Mixed semi-natural plantation 2. Scrub - dense scattered Carr - alder willow 3. Parkland 4. Recently felled wood B. GRASSLAND & MARSH % 1. Acidic unimproved semi-improved Neutral unimproved Semi-improved Semi-improved Semi-improved 4. Improved/resueded 5. Marslymarshy grassland C. TALL HERB & FERN % 1. Bracken 2. Upland spp. nch veget 3. Other - tall inderal non ruderal D. HEATHLAND % 1. Dwarf scrub - dry wel 3. Licherybryophyte 4. Montane 5. Heallygrassland - dry 6. wel E. MIRE, FLUSH AND SPRING % 1. Mires - bog Fen - reed sedge sweet-grass mixed 2. Bog flushes F. SWAMP/INUNDATION % 1. Swamp - single sp. dom. Tall mixed assemblage	INTERFORMES 7. INTERFORMES 7.	Briver HABITATS badge:/S00m badge:/S00m locks/S00m locks/S00m	100

Flow 4.5-5Km

Shire Gake Road 160 × 2.5mT 2 - 1 703 >IMI 4 44 Pasture Pastwe 2m 1 5 - + 30 > ¥ Wall

	LG.	,RB				4.	LB	RB		181
					- 3	DANK PEATURES 7.	1		RIVER HABITATS	
MOODPVND & 2CHAIL			MIVE BRAUNTON MARS	4		71- shell 7.			H bridges/500m	
Droad-leaved senti-nat.				. 1		[Twi life drug biles AAA	1		HHY wens/500m	1
plantation			Kin Ha. 4.5 - 5 KM			600 soft earth chil > 80°			locks/500m	
Conderous semi-nat.		i I	Date 29/3/93			(11) rock cliff			S inlevS00m	-{
plantation	1	1				EEDU anticol	1		Depth <.25m	1
Mixed semi-natural	1 .		Surveyor JALD		100	TD Bood bank adj	1		1 .60. 4.0	1
plantation	1			CIS	RB	TB Bood bank set back			Y 05-<1.0	1
Scrub - dense			G. OPEN WATER			levee			>1.0m	K
scattered -	!	1 .				Height < Im	1		Width <1	
Carr - alder	1		1. Standing canal + % of odj			小 1 ≪2m	ارما	lια	1.<5	1
willow			canal = load in		10.1	>2m	∞	ľ	←→ 5 < 10	1,0
Parkland	1		, auch						10.<20	1
Recently felled wood			dyka	1		Width < In	-	!	>20	1
			pond, pool, cut-off %			→ 1·<25m	40	100	3.0	1
GRASSLAND & MARSII %			lake %	i	I	2.5. < 5m	60		Substrates	1
Acidic unimproved			gravel pit X			>Sin		I.	INC bed tock	
sem-improved		1 1	reservou X norma 7.	1	1	Hope 430° 20 400°	, _	8	b boulders	1
Neutral mimproved	lω	1	2. Hounng		1	60 ::90"	39		c cobbles	
semi-improved			stream < hu wide		Ì	>00,	140	40		
Calcareous mimproved		1	1 Sim			CONTRACTOR OF THE PROPERTY OF	-}		g gravel	4
sem-improved Improved/resedded	'		5 10m		100	14-11 mad 335 sand		l	s And	
Maish/maishy grassland		60	>10			535 gand 1007 bare shingle	1	1	() sil/mid () clay	4
merenantant Ameannin .	1 :			1		2012 vegetaled shingle			O clay peat	1
TALL HERD & FERN %			I. ROCK	1		cath		سا		
			1. chit	1	1	9 natural cobbles	ĮΨ	$ \omega $	Habitats and Flow	
Bracken			suee	1		(b) natural bouldings		1	(€) µool	1
Upland spp. rich veget.	1		limestone pavement	1	1	BANK VEGETATION	-{	1	slack	110
Other - tall ruderal non ruderal	1		Cirve	1	1				- 35 mile	1,
non raderar			otlagi	1		E. Comlei Oak, Ash, Sycamore		1	of capads	1
BEATBLAND %			2. artificial/waste			P Willow recent pollard			**** 1800	1
•	}			1		W Willowold, not pollard			nno. walerfall	
Dwarf scrub - dry]	1. MISCELLANEOUS	1	1	5 Standard willows			protruding rocks	1
wel	1		nrable		1	A Alder		1	Margins	1
Licher/bryophyle Montane			amenty grazdand			32 Other frees			2 T -	
Healt/grassland – dry			ephemeraVsbort herb			Sy Young liges .			shingle 1 bare	
Mel			budge t	1		Wille Thick Scrub/shode: 7.			shingle, vegetated	
W CI	1 1	}	liedge =	1		// Sparse Semb/shrubs 7.		1	1-14- and	
MIRE, FLUSH AND SPRING %			lence on bank	1		apple Recalibedge 7.	40	-	\$5\$ Sand	
Mires - bou	1		fence set back			Denne open Y-	140	3	17 (AD H 0/	
Miles - Bog Fen - reed			wali Dankhan		1	Spanse open 7.		1	riona %	1
sedge	1	J	Cagarate:	}		MXY Regregled or mown 7.			enargent ven < hn wida	
sweel-grass			lish facin	1		Imposed tree room		1	emergent 1-2m wate	1
mixed	} [[silage clamp	1		เวเนทกร			emergent > 2m wide	
Bog flushes	1		sewieje works	1		Rocky, vegetated			total veget area	
			garden			So tocky, I bare	İ	l	B bryophytes	3
SWAMININUNDATION %	1		suck pile	}		2. simple and rock		[E emergents	1
Swamp - single sp. dom.	1 1	1 1	flood delms			annique, rock i veg		1	A submerged	16
Tall mixed assemblage		1 1	toad		40	x carth - maturing	1		P - floating - shall	- Ji
			railway disased	1		earth - with trees			- aligne % of stretch	1
	1 '	1	used	1	1	developed	- 1	1		